**PYTHON**

Python is a popular programming language.

Python can be used on a server to create web applications.

**Learning by Examples**

print("Hello, World!")

**OUTPUT**

Hello, World!

## Python

Python is a popular programming language. It was created by Guido van Rossum, and released in 1991.

**It is used for**:

* web development (server-side),
* software development,
* mathematics,
* system scripting.

### **What can Python do?**

* Python can be used on a server to create web applications.
* Python can be used alongside software to create workflows.
* Python can connect to database systems. It can also read and modify files.
* Python can be used to handle big data and perform complex mathematics.
* Python can be used for rapid prototyping, or for production-ready software development.

### **Why Python?**

* Python works on different platforms (Windows, Mac, Linux, Raspberry Pi, etc).
* Python has a simple syntax similar to the English language.
* Python has syntax that allows developers to write programs with fewer lines than some other programming languages.
* Python runs on an interpreter system, meaning that code can be executed as soon as it is written. This means that prototyping can be very quick.
* Python can be treated in a procedural way, an object-oriented way or a functional way.

### **Good to know**

* The most recent major version of Python is Python 3. However, Python 2, although not being updated with anything other than security updates, is still quite popular.
* Python will be written in a text editor. It is possible to write Python in an Integrated Development Environment, such as Thonny, Pycharm, Netbeans or Eclipse which are particularly useful when managing larger collections of Python files.

### **Python Syntax compared to other programming languages**

* Python was designed for readability, and has some similarities to the English language with influence from mathematics.
* Python uses new lines to complete a command, as opposed to other programming languages which often use semicolons or parentheses.
* Python relies on indentation, using whitespace, to define scope; such as the scope of loops, functions and classes. Other programming languages often use curly-brackets for this purpose.

## Python Install

Many PCs and Macs will have python already installed.

To check if you have python installed on a Windows PC, search in the start bar for Python or run the following on the Command Line (cmd.exe):

C:\Users\Your Name>python --version

To check if you have python installed on a Linux or Mac, then on linux open the command line or on Mac open the Terminal and type:

python --version

If you find that you do not have Python installed on your computer, then you can download it for free from the following website: <https://www.python.org/>

## Python Quickstart

Python is an interpreted programming language, this means that as a developer you write Python (.py) files in a text editor and then put those files into the python interpreter to be executed.

The way to run a python file is like this on the command line:

C:\Users\Your Name>python helloworld.py

Where "helloworld.py" is the name of your python file.

Let's write our first Python file, called helloworld.py, which can be done in any text editor.

**helloworld.py**

print("Hello, World!")

Simple as that. Save your file. Open your command line, navigate to the directory where you saved your file, and run:

C:\Users\Your Name>python helloworld.py

The output should read:

Hello, World!

Congratulations, you have written and executed your first Python program.

## The Python Command Line

To test a short amount of code in python sometimes it is quickest and easiest not to write the code in a file. This is made possible because Python can be run as a command line itself.

Type the following on the Windows, Mac or Linux command line:

C:\Users\Your Name>python

Or, if the "python" command did not work, you can try "py":

C:\Users\Your Name>py

From there you can write any python, including our hello world example from earlier in the tutorial:

C:\Users\Your Name>python  
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32  
Type "help", "copyright", "credits" or "license" for more information.  
>>> print("Hello, World!")

Which will write "Hello, World!" in the command line:

C:\Users\Your Name>python  
Python 3.6.4 (v3.6.4:d48eceb, Dec 19 2017, 06:04:45) [MSC v.1900 32 bit (Intel)] on win32  
Type "help", "copyright", "credits" or "license" for more information.  
>>> print("Hello, World!")  
Hello, World!

Whenever you are done in the python command line, you can simply type the following to quit the python command line interface:

exit()

## Execute Python Syntax

Python syntax can be executed by writing directly in the Command Line:

>>> print("Hello, World!")  
Hello, World!

[**Execute Python Syntax**](https://www.w3schools.com/python/python_syntax.asp#execute_python_syntax)[**Python Indentation**](https://www.w3schools.com/python/python_syntax.asp#python_indentation)

[**Python Variables**](https://www.w3schools.com/python/python_syntax.asp#python_variables)[**Python Comments**](https://www.w3schools.com/python/python_syntax.asp#python_comments)[**Exercises**](https://www.w3schools.com/python/python_syntax.asp#exercises)

Or by creating a python file on the server, using the .py file extension, and running it in the Command Line:

C:\Users\Your Name>python myfile.py

## Python Indentation

Indentation refers to the spaces at the beginning of a code line.

Where in other programming languages the indentation in code is for readability only, the indentation in Python is very important.

Python uses indentation to indicate a block of code.

### **Example**

if 5 > 2:  
  print("Five is greater than two!")

**OUTPUT**

Five is greater than two!

Python will give you an error if you skip the indentation:

### **Example**

Syntax Error:

if 5 > 2:  
print("Five is greater than two!")

**OUTPUT**

File "demo\_indentation\_test.py", line 2  
    print("Five is greater than two!")  
        ^  
IndentationError: expected an indented block

The number of spaces is up to you as a programmer, the most common use is four, but it has to be at least one.

### **Example**

if 5 > 2:  
 print("Five is greater than two!")   
if 5 > 2:  
        print("Five is greater than two!")

**OUTPUT**

Five is greater than two!

Five is greater than two!

You have to use the same number of spaces in the same block of code, otherwise Python will give you an error:

### **Example**

**Syntax Error**:

if 5 > 2:  
 print("Five is greater than two!")  
        print("Five is greater than two!")

**OUTPUT**

File "demo\_indentation2\_error.py", line 3  
    print("Five is greater than two!")  
    ^  
IndentationError: unexpected indent

## Python Variables

In Python, variables are created when you assign a value to it:

### **Example**

Variables in Python:

x = 5  
y = "Hello, World!"

**OUTPUT**

5

Hello, World!

Python has no command for declaring a variable.

## Comments

Python has commenting capability for the purpose of in-code documentation.

Comments start with a #, and Python will render the rest of the line as a comment:

### **Example**

Comments in Python:

#This is a comment.  
print("Hello, World!")

# **Python Comments**

Comments can be used to explain Python code.

Comments can be used to make the code more readable.

Comments can be used to prevent execution when testing code.

## Creating a Comment

Comments starts with a #, and Python will ignore them:

### **Example**

#This is a comment  
print("Hello, World!")

**OUTPUT**

Hello, World!

Comments can be placed at the end of a line, and Python will ignore the rest of the line:

### **Example**

print("Hello, World!") #This is a comment

**OUTPUT**

Hello, World!

A comment does not have to be text that explains the code, it can also be used to prevent Python from executing code:

### **Example**

#print("Hello, World!")  
print("Cheers, Mate!")

**OUTPUT**

Cheers, Mate!

## Multiline Comments

Python does not really have a syntax for multiline comments.

To add a multiline comment you could insert a # for each line:

### **Example**

#This is a comment  
#written in  
#more than just one line  
print("Hello, World!")

**OUTPUT**

Hello, World!

Or, not quite as intended, you can use a multiline string.

Since Python will ignore string literals that are not assigned to a variable, you can add a multiline string (triple quotes) in your code, and place your comment inside it:

### **Example**

"""  
This is a comment  
written in  
more than just one line  
"""  
print("Hello, World!")

**OUTPUT**

Hello, World!

# **Python Variables**

## Variables

Variables are containers for storing data values.

## Creating Variables

Python has no command for declaring a variable.

A variable is created the moment you first assign a value to it.

### **Example**

x = 5  
y = "John"  
print(x)  
print(y)

**OUTPUT**

5

John

Variables do not need to be declared with any particular type, and can even change type after they have been set.

### **Example**

x = 4       # x is of type int  
x = "Sally" # x is now of type str  
print(x)

**OUTPUT**

Sally

## Casting

If you want to specify the data type of a variable, this can be done with casting.

### **Example**

x = str(3)    # x will be '3'  
y = int(3)    # y will be 3  
z = float(3)  # z will be 3.0

**OUTPUT**

3

3

3.0

## Get the Type

You can get the data type of a variable with the type() function.

### **Example**

x = 5  
y = "John"  
print(type(x))  
print(type(y))

**OUTPUT**

<class ‘int’ >

<class ‘str’ >

## Single or Double Quotes?

String variables can be declared either by using single or double quotes:

### **Example**

x = "John"

print(x)

#double quotes are the same as single quotes:

x = 'John'

print(x)

**OUTPUT**

John

John

## Case-Sensitive

Variable names are case-sensitive.

### **Example**

This will create two variables:

a = 4

A = "Sally"

print(a)

print(A)

**OUTPUT**

4

Sally

# **Python - Variable Names**

## Variable Names

A variable can have a short name (like x and y) or a more descriptive name (age, carname, total\_volume). Rules for Python variables:

* A variable name must start with a letter or the underscore character
* A variable name cannot start with a number
* A variable name can only contain alpha-numeric characters and underscores (A-z, 0-9, and \_ )
* Variable names are case-sensitive (age, Age and AGE are three different variables)
* A variable name cannot be any of the [Python keywords](https://www.w3schools.com/python/python_ref_keywords.asp).

### **Example**

Legal variable names:

myvar = "John"

my\_var = "John"

\_my\_var = "John"

myVar = "John"

MYVAR = "John"

myvar2 = "John"

print(myvar)

print(my\_var)

print(\_my\_var)

print(myVar)

print(MYVAR)

print(myvar2)

**OUTPUT**

John

John

John

John

John

John

### **Example**

Illegal variable names:

2myvar = "John"  
my-var = "John"  
my var = "John"

#This example will produce an error in the result

Traceback (most recent call last):

File "/usr/lib/python3.7/py\_compile.py", line 143, in compile

\_optimize=optimize)

File "<frozen importlib.\_bootstrap\_external>", line 791, in source\_to\_code

File "<frozen importlib.\_bootstrap>", line 219, in \_call\_with\_frames\_removed

File "./prog.py", line 1

2myvar = "John"

^

SyntaxError: invalid syntax

During handling of the above exception, another exception occurred:

Traceback (most recent call last):

File "<string>", line 1, in <module>

File "/usr/lib/python3.7/py\_compile.py", line 147, in compile

raise py\_exc

py\_compile.PyCompileError: File "./prog.py", line 1

2myvar = "John"

^

SyntaxError: invalid syntax

Remember that variable names are case-sensitive

## Multi Words Variable Names

Variable names with more than one word can be difficult to read.

There are several techniques you can use to make them more readable:

## Camel Case

Each word, except the first, starts with a capital letter:

myVariableName = "John"

## Pascal Case

Each word starts with a capital letter:

MyVariableName = "John"

## Snake Case

Each word is separated by an underscore character:

my\_variable\_name = "John"

# **Python Variables - Assign Multiple Values**

## Many Values to Multiple Variables

Python allows you to assign values to multiple variables in one line:

### **Example**

x, y, z = "Orange", "Banana", "Cherry"  
print(x)  
print(y)  
print(z)

**OUTPUT**

Orange

Banana

Cherry

**Note:** Make sure the number of variables matches the number of values, or else you will get an error.

## One Value to Multiple Variables

And you can assign the same value to multiple variables in one line:

### **Example**

x = y = z = "Orange"  
print(x)  
print(y)  
print(z)

**OUTPUT**

Orange

Orange

Orange

## Unpack a Collection

If you have a collection of values in a list, tuple etc. Python allows you to extract the values into variables. This is called unpacking.

### **Example**

Unpack a list:

fruits = ["Apple", "Banana", "Cherry"]  
x, y, z = fruits  
print(x)  
print(y)  
print(z)

**OUTPUT**

Apple

Banana

Cherry

# **Python - Output Variables**

## Output Variables

The Python print() function is often used to output variables.

### **Example**

x = "Python is awesome"  
print(x)

**OUTPUT**

Python is awesome

In the print() function, you output multiple variables, separated by a comma:

### **Example**

x = "Python"  
y = "is"  
z = "awesome"  
print(x, y, z)

**OUTPUT**

Python is awesome

# **Python - Global Variables**

## Global Variables

Variables that are created outside of a function (as in all of the examples above) are known as global variables.

Global variables can be used by everyone, both inside of functions and outside.

### **Example**

Create a variable outside of a function, and use it inside the function

x = "awesome"  
def myfunc():  
  print("Python is " + x)  
myfunc()

**OUTPUT**

Python is awesome

If you create a variable with the same name inside a function, this variable will be local, and can only be used inside the function. The global variable with the same name will remain as it was, global and with the original value.

### **Example**

Create a variable inside a function, with the same name as the global variable

x = "awesome"  
def myfunc():  
  x = "fantastic"  
  print("Python is " + x)  
myfunc()  
print("Python is " + x)

**OUTPUT**

Python is fantastic

Python is awesome

## The global Keyword

Normally, when you create a variable inside a function, that variable is local, and can only be used inside that function.

To create a global variable inside a function, you can use the global keyword.

### **Example**

If you use the global keyword, the variable belongs to the global scope:

def myfunc():  
  global x  
  x = "fantastic"  
myfunc()  
print("Python is " + x)

**OUTPUT**

Python is awesome

Also, use the global keyword if you want to change a global variable inside a function.

### **Example**

To change the value of a global variable inside a function, refer to the variable by using the global keyword:

x = "awesome"  
def myfunc():  
  global x  
  x = "fantastic"  
myfunc()  
print("Python is " + x)

**OUTPUT**

Python is fantastic

# **Python Data Types**

## Built-in Data Types

In programming, data type is an important concept.

Variables can store data of different types, and different types can do different things.

Python has the following data types built-in by default, in these categories:

|  |  |
| --- | --- |
| Text Type: | str |
| Numeric Types: | int, float, complex |
| Sequence Types: | list, tuple, range |
| Mapping Type: | dict |
| Set Types: | set, frozenset |
| Boolean Type: | bool |
| Binary Types: | bytes, bytearray, memoryview |
| None Type: | NoneType |

## Getting the Data Type

You can get the data type of any object by using the type() function:

### **Example**

Print the data type of the variable x:

x = 5  
print(type(x))

**OUTPUT**

**<**class ‘int’**>**

## Setting the Data Type

In Python, the data type is set when you assign a value to a variable:

|  |  |  |
| --- | --- | --- |
| **Example** | **Data Type** | **Output** |
| x = "Hello World" | str | Hello World <class 'str'> |
| x = 20 | int | 20 <class 'int'> |
| x = 20.5 | float | 20.5 <class 'float'> |
| x = 1j | complex | lj <class 'complex'> |
| x = ["apple", "banana", "cherry"] | list | ['apple', 'banana', 'cherry'] <class 'list'> |
| x = ("apple", "banana", "cherry") | tuple | ('apple', 'banana', 'cherry') <class 'tuple'> |
| x = range(6) | range | {'name': 'John', 'age': 36} <class 'dict'> |
| x = {"name" : "John", "age" : 36} | dict | {'name': 'John', 'age': 36} <class 'dict'> |
| x = {"apple", "banana", "cherry"} | set | frozenset({'cherry', 'banana', 'apple'}) <class 'frozenset'> |
| x = frozenset({"apple", "banana", "cherry"}) | frozenset | frozenset({'apple', 'banana', 'cherry'}) <class 'frozenset'> |
| x = True | bool | True <class 'bool'> |
| x = b"Hello" | bytes | b'Hello' <class 'bytes'> |
| x = bytearray(5) | bytearray | bytearray(b'\x00\x00\x00\x00\x00') <class 'bytearray'> |
| x = memoryview(bytes(5)) | memoryview | <memory at 0x00D58FA0> <class 'memoryview'> |
| x = None | NoneType | None  <class 'NoneType'> |

## Setting the Specific Data Type

|  |  |  |
| --- | --- | --- |
| **Example** | **Data Type** | **Try it** |
| x = str("Hello World") | str | Hello World <class 'str'> |
| x = int(20) | int | 20 <class 'int'> |
| x = float(20.5) | float | 20.5 <class 'float'> |
| x = complex(1j) | complex | lj <class 'complex'> |
| x = list(("apple", "banana", "cherry")) | list | ['apple', 'banana', 'cherry'] <class 'list'> |
| x = tuple(("apple", "banana", "cherry")) | tuple | ('apple', 'banana', 'cherry') <class 'tuple'> |
| x = range(6) | range | range(0, 6) <class 'range'> |
| x = dict(name="John", age=36) | dict | {'name': 'John', 'age': 36} <class 'dict'> |
| x = set(("apple", "banana", "cherry")) | set | {'apple', 'banana', 'cherry'} <class 'set'> |
| x = frozenset(("apple", "banana", "cherry")) | frozenset | frozenset({'cherry', 'banana', 'apple'}) <class 'frozenset'> |
| x = bool(5) | bool | True <class 'bool'> |
| x = bytes(5) | bytes | b'\x00\x00\x00\x00\x00' <class 'bytes'> |
| x = bytearray(5) | bytearray | bytearray(b'\x00\x00\x00\x00\x00') <class 'bytearray'> |
| x = memoryview(bytes(5)) | memoryview | <memory at 0x00A78FA0> <class 'memoryview'> |

## Python Numbers

There are three numeric types in Python:

* int
* float
* complex

Variables of numeric types are created when you assign a value to them:

### **Example**

x = 1    # int  
y = 2.8  # float  
z = 1j   # complex

To verify the type of any object in Python, use the type() function:

### **Example**

print(type(x))  
print(type(y))  
print(type(z))  
**OUTPUT**

<class ‘int’ >

<class ‘float’ >

<class ‘complex’ >

## Int

Int, or integer, is a whole number, positive or negative, without decimals, of unlimited length.

### **Example**

Integers:

x = 1  
y = 35656222554887711  
z = -3255522  
  
print(type(x))  
print(type(y))  
print(type(z))

**OUTPUT**

<class ‘int’ >

<class ‘int’ >

<class ‘int’ >

## Float

Float, or "floating point number" is a number, positive or negative, containing one or more decimals.

### **Example**

Floats:

x = 1.10  
y = 1.0  
z = -35.59  
  
print(type(x))  
print(type(y))  
print(type(z))

**OUTPUT**

<class ‘float’ >

<class ‘float’ >

<class ‘float’ >

Float can also be scientific numbers with an "e" to indicate the power of 10.

### **Example**

**Floats**:

x = 35e3  
y = 12E4  
z = -87.7e100  
  
print(type(x))  
print(type(y))  
print(type(z))

**OUTPUT**

<class ‘float’ >

<class ‘float’ >

<class ‘float’ >

## Complex

Complex numbers are written with a "j" as the imaginary part:

### **Example**

Complex:

x = 3+5j  
y = 5j  
z = -5j  
  
print(type(x))  
print(type(y))  
print(type(z))

**OUTPUT**

<class ‘complex’ >

<class ‘complex’ >

<class ‘complex’ >

## Type Conversion

You can convert from one type to another with the int(), float(), and complex() methods:

### **Example**

Convert from one type to another:

x = 1    # int  
y = 2.8  # float  
z = 1j   # complex  
  
#convert from int to float:  
a = float(x)  
  
#convert from float to int:  
b = int(y)  
  
#convert from int to complex:  
c = complex(x)  
  
print(a)  
print(b)  
print(c)  
  
print(type(a))  
print(type(b))  
print(type(c))

**OUTPUT**

1.0

2

(1+0j)

<class ‘int’ >

<class ‘float’ >

<class ‘complex’ >

**Note:** You cannot convert complex numbers into another number type.

## Random Number

Python does not have a random() function to make a random number, but Python has a built-in module called random that can be used to make random numbers:

### **Example**

Import the random module, and display a random number between 1 and 9:

import random  
  
print(random.randrange(1, 10))

**OUTPUT**

**8**

# **Python Casting**

## Specify a Variable Type

There may be times when you want to specify a type on to a variable. This can be done with casting. Python is an object-orientated language, and as such it uses classes to define data types, including its primitive types.

Casting in python is therefore done using constructor functions:

* int() - constructs an integer number from an integer literal, a float literal (by removing all decimals), or a string literal (providing the string represents a whole number)
* float() - constructs a float number from an integer literal, a float literal or a string literal (providing the string represents a float or an integer)
* str() - constructs a string from a wide variety of data types, including strings, integer literals and float literals

### **Example**

Integers:

x = int(1)   # x will be 1  
y = int(2.8) # y will be 2  
z = int("3") # z will be 3

print(x)

print(y)

print(z)

**OUTPUT**

1

2

3

### **Example**

**Floats**:

x = float(1)     # x will be 1.0  
y = float(2.8)   # y will be 2.8  
z = float("3")   # z will be 3.0  
w = float("4.2") # w will be 4.2

print(x)

print(y)

print(z)

print(w)

**OUTPUT**

1.0

2.8

3.0

4.2

### **Example**

**Strings**:

x = str("S1") # x will be 'S1'  
y = str(2)    # y will be '2'  
z = str(3.0)  # z will be '3.0'

print(x)

print(y)

print(z)

**OUTPUT**

S1

2

3.0

# **Python Strings**

## Strings

Strings in python are surrounded by either single quotation marks, or double quotation marks.

'hello' is the same as "hello".

You can display a string literal with the print() function:

### **Example**

print("Hello")  
print('Hello')

**OUTPUT**

Hello

Hello

## Assign String to a Variable

Assigning a string to a variable is done with the variable name followed by an equal sign and the string:

### **Example**

a = "Hello"  
print(a)

**OUTPUT**

Hello

## Multiline Strings

You can assign a multiline string to a variable by using three quotes:

### **Example**

You can use three double quotes:

a = """Lorem ipsum dolor sit amet,  
consectetur adipiscing elit,  
sed do eiusmod tempor incididunt  
ut labore et dolore magna aliqua."""  
print(a)

**OUTPUT**

Lorem ipsum dolor sit amet,  
consectetur adipiscing elit,  
sed do eiusmod tempor incididunt  
ut labore et dolore magna aliqua.

**Or three single quotes:**

### **Example**

a = '''Lorem ipsum dolor sit amet,  
consectetur adipiscing elit,  
sed do eiusmod tempor incididunt  
ut labore et dolore magna aliqua.'''  
print(a)

**OUTPUT**

Lorem ipsum dolor sit amet,  
consectetur adipiscing elit,  
sed do eiusmod tempor incididunt  
ut labore et dolore magna aliqua.

**Note:** in the result, the line breaks are inserted at the same position as in the code

## Strings are Arrays

Like many other popular programming languages, strings in Python are arrays of bytes representing unicode characters.

However, Python does not have a character data type, a single character is simply a string with a length of 1.

Square brackets can be used to access elements of the string.

### **Example**

Get the character at position 1 (remember that the first character has the position 0):

a = "Hello, World!"  
print(a[1])

**OUTPUT**

e

## Looping Through a String

Since strings are arrays, we can loop through the characters in a string, with a for loop.

### **Example**

Loop through the letters in the word " BANANA ":

for x in "BANANA":  
  print(x)

**OUTPUT**

B

A

N

A

N

A

## String Length

To get the length of a string, use the len() function.

### **Example**

The len() function returns the length of a string:

a = "Hello, World!"  
print(len(a))

**OUTPUT**

13

## Check String

To check if a certain phrase or character is present in a string, we can use the keyword in.

### **Example**

Check if "free" is present in the following text:

txt = "The best things in life are free!"  
print("free" in txt)

**OUTPUT**

True

Use it in an if statement:

### **Example**

Print only if "free" is present:

txt = "The best things in life are free!"  
if "free" in txt:  
  print("Yes, 'free' is present.")

**OUTPUT**

Yes, 'free' is present.

## Check if NOT

To check if a certain phrase or character is NOT present in a string, we can use the keyword not in.

### **Example**

Check if "expensive" is NOT present in the following text:

txt = "The best things in life are free!"  
print("expensive" not in txt)

**OUTPUT**

True

Use it in an if statement:

### **Example**

print only if "expensive" is NOT present:

txt = "The best things in life are free!"  
if "expensive" not in txt:  
  print("No, 'expensive' is NOT present.")

**OUTPUT**

No, 'expensive' is NOT present.

# **Python - Slicing Strings**

## Slicing

You can return a range of characters by using the slice syntax.

Specify the start index and the end index, separated by a colon, to return a part of the string.

### **Example**

Get the characters from position 2 to position 5 (not included):

b = "Hello, World!"  
print(b[2:5])

**OUTPUT**

Llo

**Note:**The first character has index 0.

## Slice From the Start

By leaving out the start index, the range will start at the first character:

### **Example**

Get the characters from the start to position 5 (not included):

b = "Hello, World!"  
print(b[:5])

**OUTPUT**

Hello

## Slice To the End

By leaving out the end index, the range will go to the end:

### **Example**

Get the characters from position 2, and all the way to the end:

b = "Hello, World!"  
print(b[2:])

**OUTPUT**

llo, World!

## Negative Indexing

Use negative indexes to start the slice from the end of the string:

### **Example**

Get the characters:

From: "o" in "World!" (position -5)

To, but not included: "d" in "World!" (position -2):

b = "Hello, World!"  
print(b[-5:-2])

**OUTPUT**

orl

# **Python - Modify Strings**

Python has a set of built-in methods that you can use on strings.

## Upper Case

### **Example**

The upper() method returns the string in upper case:

a = "Hello, World!"  
print(a.upper())

**OUTPUT**

HELLO, WORLD!

**Lower Case**

### **Example**

The lower() method returns the string in lower case:

a = "Hello, World!"  
print(a.lower())

**OUTPUT**

hello, world!

## Remove Whitespace

Whitespace is the space before and/or after the actual text, and very often you want to remove this space.

### **Example**

The strip() method removes any whitespace from the beginning or the end:

a = " Hello, World! "  
print(a.strip()) # returns "Hello, World!"

**OUTPUT**

Hello, World!

## Replace String

### **Example**

The replace() method replaces a string with another string:

a = "Hello, World!"  
print(a.replace("H", "J"))

**OUTPUT**

Jello, World!

## Split String

The split() method returns a list where the text between the specified separator becomes the list items.

### **Example**

The split() method splits the string into substrings if it finds instances of the separator:

a = "Hello, World!"  
print(a.split(",")) # returns ['Hello', ' World!']

**OUTPUT**

[‘Hello’, ‘ World!’]

# **Python - String Concatenation**

## String Concatenation

To concatenate, or combine, two strings you can use the + operator.

### **Example**

Merge variable a with variable b into variable c:

a = "Hello"  
b = "World"  
c = a + b  
print(c)

**OUTPUT**

HelloWorld

### **Example**

To add a space between them, add a " ":

a = "Hello"  
b = "World"  
c = a + " " + b  
print(c)

**OUTPUT**

Hello World

# **Python - Format – Strings**

## String Format

As we learned in the Python Variables chapter, we cannot combine strings and numbers like this:

### **Example**

age = 36  
txt = "My name is John, I am " + age  
print(txt)

**OUTPUT**

Traceback (most recent call last):  
  File "demo\_string\_format\_error.py", line 2, in <module>  
    txt = "My name is John, I am " + age  
TypeError: must be str, not int

But we can combine strings and numbers by using the format() method!

The format() method takes the passed arguments, formats them, and places them in the string where the placeholders {} are:

### **Example**

Use the format() method to insert numbers into strings:

age = 36  
txt = "My name is John, and I am {}"  
print(txt.format(age))

**OUTPUT**

My name is John, and I am 36

The format() method takes unlimited number of arguments, and are placed into the respective placeholders:

### **Example**

quantity = 3  
itemno = 567  
price = 49.95  
myorder = "I want {} pieces of item {} for {} dollars."  
print(myorder.format(quantity, itemno, price))

**OUTPUT**

I want 3 pieces of item 567 for 49.95dollars.

You can use index numbers {0} to be sure the arguments are placed in the correct placeholders:

### **Example**

quantity = 3  
itemno = 567  
price = 49.95  
myorder = "I want to pay {2} dollars for {0} pieces of item {1}."  
print(myorder.format(quantity, itemno, price))

**OUTPUT**

I want to pay 49.95 dollars for 3 pieces of item 567

# **Python - Escape Characters**

## Escape Character

To insert characters that are illegal in a string, use an escape character.

An escape character is a backslash \ followed by the character you want to insert.

An example of an illegal character is a double quote inside a string that is surrounded by double quotes:

### **Example**

You will get an error if you use double quotes inside a string that is surrounded by double quotes:

txt = "We are the so-called "Vikings" from the north."

#You will get an error if you use double quotes inside a string that are surrounded by double quotes:

**OUTPUT**

 File "demo\_string\_escape\_error.py", line 1  
    txt = "We are the so-called "Vikings" from the north."  
                                       ^  
SyntaxError: invalid syntax

To fix this problem, use the escape character \":

### **Example**

The escape character allows you to use double quotes when you normally would not be allowed:

txt = "We are the so-called \"Vikings\" from the north."

print(txt)

**OUTPUT**

We are the so-called "Vikings" from the north

## Escape Characters

|  |  |  |
| --- | --- | --- |
| **Code** | **Result** | **Try it** |
| \' | Single Quote | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_escape2) |
| \\ | Backslash | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_backslash) |
| \n | New Line | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_newline) |
| \r | Carriage Return | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_r) |
| \t | Tab | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_t) |
| \b | Backspace | [Try it »](https://www.w3schools.com/python/showpython.asp?filename=demo_string_b) |
| \f | Form Feed |  |
| \ooo | Octal value | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_octal) |
| \xhh | Hex value | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_string_hex) |

Other escape characters used in Python:

## String Methods

Python has a set of built-in methods that you can use on strings.

**Note:** All string methods return new values. They do not change the original string.

|  |  |
| --- | --- |
| **Method** | **Description** |
| [capitalize()](https://www.w3schools.com/python/ref_string_capitalize.asp) | Converts the first character to upper case |
| [casefold()](https://www.w3schools.com/python/ref_string_casefold.asp) | Converts string into lower case |
| [center()](https://www.w3schools.com/python/ref_string_center.asp) | Returns a centered string |
| [count()](https://www.w3schools.com/python/ref_string_count.asp) | Returns the number of times a specified value occurs in a string |
| [encode()](https://www.w3schools.com/python/ref_string_encode.asp) | Returns an encoded version of the string |
| [endswith()](https://www.w3schools.com/python/ref_string_endswith.asp) | Returns true if the string ends with the specified value |
| [expandtabs()](https://www.w3schools.com/python/ref_string_expandtabs.asp) | Sets the tab size of the string |
| [find()](https://www.w3schools.com/python/ref_string_find.asp) | Searches the string for a specified value and returns the position of where it was found |
| [format()](https://www.w3schools.com/python/ref_string_format.asp) | Formats specified values in a string |
| format\_map() | Formats specified values in a string |
| [index()](https://www.w3schools.com/python/ref_string_index.asp) | Searches the string for a specified value and returns the position of where it was found |
| [isalnum()](https://www.w3schools.com/python/ref_string_isalnum.asp) | Returns True if all characters in the string are alphanumeric |
| [isalpha()](https://www.w3schools.com/python/ref_string_isalpha.asp) | Returns True if all characters in the string are in the alphabet |
| [isascii()](https://www.w3schools.com/python/ref_string_isascii.asp) | Returns True if all characters in the string are ascii characters |
| [isdecimal()](https://www.w3schools.com/python/ref_string_isdecimal.asp) | Returns True if all characters in the string are decimals |
| [isdigit()](https://www.w3schools.com/python/ref_string_isdigit.asp) | Returns True if all characters in the string are digits |
| [isidentifier()](https://www.w3schools.com/python/ref_string_isidentifier.asp) | Returns True if the string is an identifier |
| [islower()](https://www.w3schools.com/python/ref_string_islower.asp) | Returns True if all characters in the string are lower case |
| [isnumeric()](https://www.w3schools.com/python/ref_string_isnumeric.asp) | Returns True if all characters in the string are numeric |
| [isprintable()](https://www.w3schools.com/python/ref_string_isprintable.asp) | Returns True if all characters in the string are printable |
| [isspace()](https://www.w3schools.com/python/ref_string_isspace.asp) | Returns True if all characters in the string are whitespaces |
| [istitle()](https://www.w3schools.com/python/ref_string_istitle.asp) | Returns True if the string follows the rules of a title |
| [isupper()](https://www.w3schools.com/python/ref_string_isupper.asp) | Returns True if all characters in the string are upper case |
| [join()](https://www.w3schools.com/python/ref_string_join.asp) | Joins the elements of an iterable to the end of the string |
| [ljust()](https://www.w3schools.com/python/ref_string_ljust.asp) | Returns a left justified version of the string |
| [lower()](https://www.w3schools.com/python/ref_string_lower.asp) | Converts a string into lower case |
| [lstrip()](https://www.w3schools.com/python/ref_string_lstrip.asp) | Returns a left trim version of the string |
| [maketrans()](https://www.w3schools.com/python/ref_string_maketrans.asp) | Returns a translation table to be used in translations |
| [partition()](https://www.w3schools.com/python/ref_string_partition.asp) | Returns a tuple where the string is parted into three parts |
| [replace()](https://www.w3schools.com/python/ref_string_replace.asp) | Returns a string where a specified value is replaced with a specified value |
| [rfind()](https://www.w3schools.com/python/ref_string_rfind.asp) | Searches the string for a specified value and returns the last position of where it was found |
| [rindex()](https://www.w3schools.com/python/ref_string_rindex.asp) | Searches the string for a specified value and returns the last position of where it was found |
| [rjust()](https://www.w3schools.com/python/ref_string_rjust.asp) | Returns a right justified version of the string |
| [rpartition()](https://www.w3schools.com/python/ref_string_rpartition.asp) | Returns a tuple where the string is parted into three parts |
| [rsplit()](https://www.w3schools.com/python/ref_string_rsplit.asp) | Splits the string at the specified separator, and returns a list |
| [rstrip()](https://www.w3schools.com/python/ref_string_rstrip.asp) | Returns a right trim version of the string |
| [split()](https://www.w3schools.com/python/ref_string_split.asp) | Splits the string at the specified separator, and returns a list |
| [splitlines()](https://www.w3schools.com/python/ref_string_splitlines.asp) | Splits the string at line breaks and returns a list |
| [startswith()](https://www.w3schools.com/python/ref_string_startswith.asp) | Returns true if the string starts with the specified value |
| [strip()](https://www.w3schools.com/python/ref_string_strip.asp) | Returns a trimmed version of the string |
| [swapcase()](https://www.w3schools.com/python/ref_string_swapcase.asp) | Swaps cases, lower case becomes upper case and vice versa |
| [title()](https://www.w3schools.com/python/ref_string_title.asp) | Converts the first character of each word to upper case |
| [translate()](https://www.w3schools.com/python/ref_string_translate.asp) | Returns a translated string |
| [upper()](https://www.w3schools.com/python/ref_string_upper.asp) | Converts a string into upper case |
| [zfill()](https://www.w3schools.com/python/ref_string_zfill.asp) | Fills the string with a specified number of 0 values at the beginning |

# **Python Booleans**

## Boolean Values

In programming you often need to know if an expression is True or False.

You can evaluate any expression in Python, and get one of two answers, True or False.

When you compare two values, the expression is evaluated and Python returns the Boolean answer:

### **Example**

print(10 > 9)  
print(10 == 9)  
print(10 < 9)

**OUTPUT**

True

False

False

When you run a condition in an if statement, Python returns True or False:

### **Example**

Print a message based on whether the condition is True or False:

a = 200  
b = 33  
  
if b > a:  
  print("b is greater than a")  
else:  
  print("b is not greater than a")

## Evaluate Values and Variables

The bool() function allows you to evaluate any value, and give you True or False in return,

### **Example**

Evaluate a string and a number:

print(bool("Hello"))  
print(bool(15))

**OUTPUT**

True

True

## Most Values are True

Almost any value is evaluated to True if it has some sort of content.

Any string is True, except empty strings.

Any number is True, except 0.

Any list, tuple, set, and dictionary are True, except empty ones.

### **Example**

The following will return True:

bool("abc")  
bool(123)  
bool(["apple", "cherry", "banana"])

**OUTPUT**

True

True

True

## Some Values are False

In fact, there are not many values that evaluate to False, except empty values, such as (), [], {}, "", the number 0, and the value None. And of course the value False evaluates to False.

### **Example**

The following will return False:

bool(False)  
bool(None)  
bool(0)  
bool("")  
bool(())  
bool([])  
bool({})

**OUTPUT**

False

False

False

False

False

False

One more value, or object in this case, evaluates to False, and that is if you have an object that is made from a class with a \_\_len\_\_ function that returns 0 or False:

### **Example**

class myclass():  
  def \_\_len\_\_(self):  
    return 0  
  
myobj = myclass()  
print(bool(myobj))

**OUTPUT**

False

## Functions can Return a Boolean

You can create functions that returns a Boolean Value:

### **Example**

Print the answer of a function:

def myFunction() :  
  return True  
print(myFunction())

**OUTPUT**

True

You can execute code based on the Boolean answer of a function:

### **Example**

Print "YES!" if the function returns True, otherwise print "NO!":

def myFunction() :  
  return True  
if myFunction():  
  print("YES!")  
else:  
  print("NO!")

**OUTPUT**

False

Python also has many built-in functions that return a boolean value, like the isinstance() function, which can be used to determine if an object is of a certain data type:

### **Example**

Check if an object is an integer or not:

x = 200  
print(isinstance(x, int))

**OUTPUT**

True

## Python Operators

Operators are used to perform operations on variables and values.

In the example below, we use the + operator to add together two values:

### **Example**

print(10 + 5)

**OUTPUT**

15

Python divides the operators in the following groups:

* Arithmetic operators
* Assignment operators
* Comparison operators
* Logical operators
* Identity operators
* Membership operators
* **Bitwise operators**

## Python Arithmetic Operators

Arithmetic operators are used with numeric values to perform common mathematical operations:

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Name** | **Example** | **Try it** |
| + | Addition | x + y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_add) |
| - | Subtraction | x - y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_sub) |
| \* | Multiplication | x \* y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_mult) |
| / | Division | x / y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_div) |
| % | Modulus | x % y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_mod) |
| \*\* | Exponentiation | x \*\* y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_exp) |
| // | Floor division | x // y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_floordiv) |

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Example** | **Same As** | **Try it** |
| = | x = 5 | x = 5 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass1) |
| += | x += 3 | x = x + 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass2) |
| -= | x -= 3 | x = x - 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass3) |
| \*= | x \*= 3 | x = x \* 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass4) |
| /= | x /= 3 | x = x / 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass5) |
| %= | x %= 3 | x = x % 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass6) |
| //= | x //= 3 | x = x // 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass7) |
| \*\*= | x \*\*= 3 | x = x \*\* 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass8) |
| &= | x &= 3 | x = x & 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass9) |
| |= | x |= 3 | x = x | 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass10) |
| ^= | x ^= 3 | x = x ^ 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass11) |
| >>= | x >>= 3 | x = x >> 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass12) |
| <<= | x <<= 3 | x = x << 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_ass13) |

## Python Logical Operators

Logical operators are used to combine conditional statements:

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Description** | **Example** | **Try it** |
| and | Returns True if both statements are true | x < 5 and  x < 10 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_logical1) |
| or | Returns True if one of the statements is true | x < 5 or x < 4 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_logical2) |
| not | Reverse the result, returns False if the result is true | not(x < 5 and x < 10) | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_logical3) |

## Python Identity Operators

Identity operators are used to compare the objects, not if they are equal, but if they are actually the same object, with the same memory location:

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Description** | **Example** | **Try it** |
| is | Returns True if both variables are the same object | x is y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_identity1) |
| is not | Returns True if both variables are not the same object | x is not y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_identity2) |

## Python Membership Operators

|  |  |  |  |
| --- | --- | --- | --- |
| **Operator** | **Description** | **Example** | **Try it** |
| in | Returns True if a sequence with the specified value is present in the object | x in y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_membership1) |
| not in | Returns True if a sequence with the specified value is not present in the object | x not in y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_membership2) |

Membership operators are used to test if a sequence is presented in an object:

## Python Bitwise Operators

Bitwise operators are used to compare (binary) numbers:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operator** | **Name** | **Description** | **Example** | **Try it** |
| & | AND | Sets each bit to 1 if both bits are 1 | x & y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_and) |
| | | OR | Sets each bit to 1 if one of two bits is 1 | x | y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_or) |
| ^ | XOR | Sets each bit to 1 if only one of two bits is 1 | x ^ y | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_xor) |
| ~ | NOT | Inverts all the bits | ~x | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_not) |
| << | Zero fill left shift | Shift left by pushing zeros in from the right and let the leftmost bits fall off | x << 2 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_left_shift) |
| >> | Signed right shift | Shift right by pushing copies of the leftmost bit in from the left, and let the rightmost bits fall off | x >> 2 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_oper_right_shift) |

## Operator Precedence

Operator precedence describes the order in which operations are performed.

### **Example**

Parentheses has the highest precedence, meaning that expressions inside parentheses must be evaluated first:

print((6 + 3) - (6 + 3))

**OUTPUT**

0

### **Example**

Multiplication \* has higher precedence than addition +, and therefor multiplications are evaluated before additions:

print(100 + 5 \* 3)

**OUTPUT**

115

The precedence order is described in the table below, starting with the highest precedence at the top:

|  |  |  |
| --- | --- | --- |
| **Operator** | **Description** | **Try it** |
| () | Parentheses | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_parentheses) |
| \*\* | Exponentiation | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_exponent) |
| +x  -x  ~x | Unary plus, unary minus, and bitwise NOT | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_bitwise_not) |
| \*  /  //  % | Multiplication, division, floor division, and modulus | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_multiplication) |
| +  - | Addition and subtraction | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_subtraction) |
| <<  >> | Bitwise left and right shifts | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_shift) |
| & | Bitwise AND | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_bitwise_and) |
| ^ | Bitwise XOR | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_bitwise_xor) |
| | | Bitwise OR | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_bitwise_or) |
| ==  !=  >  >=  <  <=  is  is not  in  not in | Comparisons, identity, and membership operators | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_like) |
| not | Logical NOT | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_not) |
| and | AND | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_and) |
| or | OR | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_precedence_or) |

If two operators have the same precedence, the expression is evaluated from left to right.

### **Example**

Addition + and subtraction - has the same precedence, and therefor we evaluate the expression from left to right:

print(5 + 4 - 7 + 3)

**OUTPUT**

**5**

# **Python Lists**

mylist = ["apple", "banana", "cherry"]

## List

Lists are used to store multiple items in a single variable.

Lists are one of 4 built-in data types in Python used to store collections of data, the other 3 are [Tuple](https://www.w3schools.com/python/python_tuples.asp), [Set](https://www.w3schools.com/python/python_sets.asp), and [Dictionary](https://www.w3schools.com/python/python_dictionaries.asp), all with different qualities and usage.

Lists are created using square brackets:

### **Example**

Create a List:

thislist = ["apple", "banana", "cherry"]  
print(thislist)

**OUTPUT**

[‘apple’, ‘banana’,’cherry’]

## List Items

List items are ordered, changeable, and allow duplicate values.

List items are indexed, the first item has index [0], the second item has index [1] etc.

## Ordered

When we say that lists are ordered, it means that the items have a defined order, and that order will not change.

If you add new items to a list, the new items will be placed at the end of the list.

**Note:** There are some [list methods](https://www.w3schools.com/python/python_lists_methods.asp) that will change the order, but in general: the order of the items will not change.

## Changeable

The list is changeable, meaning that we can change, add, and remove items in a list after it has been created.

## Allow Duplicates

Since lists are indexed, lists can have items with the same value:

### **Example**

Lists allow duplicate values:

thislist = ["apple", "banana", "cherry", "apple", "cherry"]  
print(thislist)

**OUTPUT**

[‘apple’, ‘banana’, ‘cherry’, ‘apple’, ‘cherry’]

## List Length

To determine how many items a list has, use the len() function:

### **Example**

Print the number of items in the list:

thislist = ["apple", "banana", "cherry"]  
print(len(thislist))

**OUTPUT**

3

## List Items - Data Types

List items can be of any data type:

### **Example**

String, int and boolean data types:

list1 = ["apple", "banana", "cherry"]  
list2 = [1, 5, 7, 9, 3]  
list3 = [True, False, False]

**OUTPUT**

['apple', 'banana', 'cherry']

[1, 5, 7, 9, 3]

[True, False, False]

A list can contain different data types:

### **Example**

A list with strings, integers and boolean values:

list1 = ["abc", 34, True, 40, "male"]

**OUTPUT**

[‘abc’, 34, True, 40, ‘male’]

## type()

From Python's perspective, lists are defined as objects with the data type 'list':

<class 'list'>

### **Example**

What is the data type of a list?

mylist = ["apple", "banana", "cherry"]  
print(type(mylist))

**OUTPUT**

<class 'list'>

## The list() Constructor

It is also possible to use the list() constructor when creating a new list.

### **Example**

Using the list() constructor to make a List:

thislist = list(("apple", "banana", "cherry")) # note the double round-brackets  
print(thislist)

**OUTPUT**

**[‘**apple’,’banana’,’cherry’]

## Python Collections (Arrays)

There are four collection data types in the Python programming language:

* **List** is a collection which is ordered and changeable. Allows duplicate members.
* [**Tuple**](https://www.w3schools.com/python/python_tuples.asp) is a collection which is ordered and unchangeable. Allows duplicate members.
* [**Set**](https://www.w3schools.com/python/python_sets.asp) is a collection which is unordered, unchangeable\*, and unindexed. No duplicate members.
* [**Dictionary**](https://www.w3schools.com/python/python_dictionaries.asp) is a collection which is ordered\*\* and changeable. No duplicate members.

\*Set items are unchangeable, but you can remove and/or add items whenever you like.

\*\*As of Python version 3.7, dictionaries are ordered. In Python 3.6 and earlier, dictionaries are unordered.

When choosing a collection type, it is useful to understand the properties of that type. Choosing the right type for a particular data set could mean retention of meaning, and, it could mean an increase in efficiency or security.

# **Python - Access List Items**

## Access Items

List items are indexed and you can access them by referring to the index number:

### **Example**

Print the second item of the list:

thislist = ["apple", "banana", "cherry"]  
print(thislist[1])

**OUTPUT**

Banana

**Note:**The first item has index 0.

### **Negative Indexing**

Negative indexing means start from the end

-1 refers to the last item, -2 refers to the second last item etc.

### **Example**

Print the last item of the list:

thislist = ["apple", "banana", "cherry"]  
print(thislist[-1])

**OUTPUT**

Cherry

### **Range of Indexes**

You can specify a range of indexes by specifying where to start and where to end the range.

When specifying a range, the return value will be a new list with the specified items.

### **Example**

Return the third, fourth, and fifth item:

thislist = ["apple", "banana", "cherry", "orange", "kiwi", "melon", "mango"]  
print(thislist[2:5])

**OUTPUT**

[‘cherry’, ‘orange’, ‘kiwi’]

**Note:** The search will start at index 2 (included) and end at index 5 (not included).

Remember that the first item has index 0.

By leaving out the start value, the range will start at the first item:

### **Example**

This example returns the items from the beginning to, but NOT including, "kiwi":

thislist = ["apple", "banana", "cherry", "orange", "kiwi", "melon", "mango"]  
print(thislist[:4])

**OUTPUT**

[‘apple’, ‘banana’, ‘cherry’, ‘orange’]

By leaving out the end value, the range will go on to the end of the list:

### **Example**

This example returns the items from "cherry" to the end:

thislist = ["apple", "banana", "cherry", "orange", "kiwi", "melon", "mango"]  
print(thislist[2:])

#This will return the items from index 2 to the end.

#Remember that index 0 is the first item, and index 2 is the third

**OUTPUT**

['cherry', 'orange', 'kiwi', 'melon', 'mango']

### **Range of Negative Indexes**

Specify negative indexes if you want to start the search from the end of the list:

### **Example**

This example returns the items from "orange" (-4) to, but NOT including "mango" (-1):

thislist = ["apple", "banana", "cherry", "orange", "kiwi", "melon", "mango"]  
print(thislist[-4:-1])

#Negative indexing means starting from the end of the list.

#This example returns the items from index -4 (included) to index -1 (excluded)

#Remember that the last item has the index -1,

**OUTPUT**

['orange', 'kiwi', 'melon']

## Check if Item Exists

To determine if a specified item is present in a list use the in keyword:

### **Example**

Check if "apple" is present in the list:

thislist = ["apple", "banana", "cherry"]  
if "apple" in thislist:  
  print("Yes, 'apple' is in the fruits list")

**OUTPUT**

Yes, 'apple' is in the fruits list

# **Python - Change List Items**

## Change Item Value

To change the value of a specific item, refer to the index number:

### **Example**

Change the second item:

thislist = ["apple", "banana", "cherry"]  
thislist[1] = "blackcurrant"  
print(thislist)

**OUTPUT**

['apple', 'blackcurrant', 'cherry']

## Change a Range of Item Values

To change the value of items within a specific range, define a list with the new values, and refer to the range of index numbers where you want to insert the new values:

### **Example**

Change the values "banana" and "cherry" with the values "blackcurrant" and "watermelon":

thislist = ["apple", "banana", "cherry", "orange", "kiwi", "mango"]  
thislist[1:3] = ["blackcurrant", "watermelon"]  
print(thislist)

**OUTPUT**

['apple', 'blackcurrant', 'watermelon', 'orange', 'kiwi', 'mango']

If you insert more items than you replace, the new items will be inserted where you specified, and the remaining items will move accordingly:

### **Example**

Change the second value by replacing it with two new values:

thislist = ["apple", "banana", "cherry"]  
thislist[1:2] = ["blackcurrant", "watermelon"]  
print(thislist)

**OUTPUT**

['apple', 'blackcurrant', 'watermelon', 'cherry']

**Note:** The length of the list will change when the number of items inserted does not match the number of items replaced.

If you insert less items than you replace, the new items will be inserted where you specified, and the remaining items will move accordingly:

### **Example**

Change the second and third value by replacing it with one value:

thislist = ["apple", "banana", "cherry"]  
thislist[1:3] = ["watermelon"]  
print(thislist)

**OUTPUT**

['apple', 'watermelon']

## Insert Items

To insert a new list item, without replacing any of the existing values, we can use the insert() method.

The insert() method inserts an item at the specified index:

### **Example**

Insert "watermelon" as the third item:

thislist = ["apple", "banana", "cherry"]  
thislist.insert(2, "watermelon")  
print(thislist)

**OUTPUT**

['apple', 'banana', 'watermelon', 'cherry']

# **Python - Add List Items**

## Append Items

To add an item to the end of the list, use the append() method:

### **Example**

Using the append() method to append an item:

thislist = ["apple", "banana", "cherry"]  
thislist.append("orange")  
print(thislist)

['apple', 'banana', 'cherry', 'orange']

## Insert Items

To insert a list item at a specified index, use the insert() method.

The insert() method inserts an item at the specified index:

### **Example**

Insert an item as the second position:

thislist = ["apple", "banana", "cherry"]  
thislist.insert(1, "orange")  
print(thislist)

['apple', 'orange', 'banana', 'cherry']

**Note:** As a result of the examples above, the lists will now contain 4 items.

## Extend List

To append elements from another list to the current list, use the extend() method.

### **Example**

Add the elements of tropical to thislist:

thislist = ["apple", "banana", "cherry"]  
tropical = ["mango", "pineapple", "papaya"]  
thislist.extend(tropical)  
print(thislist)

['apple', 'banana', 'cherry', 'mango', 'pineapple', 'papaya']

The elements will be added to the end of the list.

## Add Any Iterable

The extend() method does not have to append lists, you can add any iterable object (tuples, sets, dictionaries etc.).

### **Example**

Add elements of a tuple to a list:

thislist = ["apple", "banana", "cherry"]  
thistuple = ("kiwi", "orange")  
thislist.extend(thistuple)  
print(thislist)

['apple', 'banana', 'cherry', 'kiwi', 'orange']

# **Python - Remove List Items**

## Remove Specified Item

The remove() method removes the specified item.

### **Example**

Remove "banana":

thislist = ["apple", "banana", "cherry"]  
thislist.remove("banana")  
print(thislist)

['apple', 'cherry']

If there are more than one item with the specified value, the remove() method removes the first occurance:

### **Example**

Remove the first occurance of "banana":

thislist = ["apple", "banana", "cherry", "banana", "kiwi"]  
thislist.remove("banana")  
print(thislist)

['apple', 'cherry', 'banana', 'kiwi']

## Remove Specified Index

The pop() method removes the specified index.

### **Example**

Remove the second item:

thislist = ["apple", "banana", "cherry"]  
thislist.pop(1)  
print(thislist)

['apple', 'cherry']

If you do not specify the index, the pop() method removes the last item.

### **Example**

Remove the last item:

thislist = ["apple", "banana", "cherry"]  
thislist.pop()  
print(thislist)

['apple', 'banana']

The del keyword also removes the specified index:

### **Example**

Remove the first item:

thislist = ["apple", "banana", "cherry"]  
del thislist[0]  
print(thislist)

['banana', 'cherry']

The del keyword can also delete the list completely.

### **Example**

Delete the entire list:

thislist = ["apple", "banana", "cherry"]  
del thislist

Traceback (most recent call last):  
  File "demo\_list\_del2.py", line 3, in <module>  
    print(thislist) #this will cause an error because you have succsesfully deleted "thislist".  
NameError: name 'thislist' is not defined

## Clear the List

The clear() method empties the list.

The list still remains, but it has no content.

### **Example**

Clear the list content:

thislist = ["apple", "banana", "cherry"]  
thislist.clear()  
print(thislist)

[]

# **Python - Loop Lists**

## Loop Through a List

You can loop through the list items by using a for loop:

### **Example**

Print all items in the list, one by one:

thislist = ["apple", "banana", "cherry"]  
for x in thislist:  
  print(x)

apple  
banana  
cherry

## Loop Through the Index Numbers

You can also loop through the list items by referring to their index number.

Use the range() and len() functions to create a suitable iterable.

### **Example**

Print all items by referring to their index number:

thislist = ["apple", "banana", "cherry"]  
for i in range(len(thislist)):  
  print(thislist[i])

The iterable created in the example above is [0, 1, 2].

## Using a While Loop

You can loop through the list items by using a while loop.

Use the len() function to determine the length of the list, then start at 0 and loop your way through the list items by referring to their indexes.

Remember to increase the index by 1 after each iteration.

### **Example**

Print all items, using a while loop to go through all the index numbers

thislist = ["apple", "banana", "cherry"]  
i = 0  
while i < len(thislist):  
  print(thislist[i])  
  i = i + 1

apple

banana

cherry

## Looping Using List Comprehension

List Comprehension offers the shortest syntax for looping through lists:

### **Example**

A short hand for loop that will print all items in a list:

thislist = ["apple", "banana", "cherry"]  
[print(x) for x in thislist]

apple

banana

cherry

# **Python - List Comprehension**

## List Comprehension

List comprehension offers a shorter syntax when you want to create a new list based on the values of an existing list.

**Example**:

Based on a list of fruits, you want a new list, containing only the fruits with the letter "a" in the name.

Without list comprehension you will have to write a for statement with a conditional test inside:

### **Example**

fruits = ["apple", "banana", "cherry", "kiwi", "mango"]  
newlist = []  
  
for x in fruits:  
  if "a" in x:  
    newlist.append(x)  
  
print(newlist)

['apple', 'banana', 'mango']

With list comprehension you can do all that with only one line of code:

### **Example**

fruits = ["apple", "banana", "cherry", "kiwi", "mango"]  
  
newlist = [x for x in fruits if "a" in x]  
  
print(newlist)

['apple', 'banana', 'mango']

## The Syntax

newlist = [expression for item in iterable if condition == True]

The return value is a new list, leaving the old list unchanged.

### **Condition**

The condition is like a filter that only accepts the items that valuate to True.

### **Example**

Only accept items that are not "apple":

newlist = [x for x in fruits if x != "apple"]

['banana', 'cherry', 'kiwi', 'mango']

The condition if x != "apple"  will return True for all elements other than "apple", making the new list contain all fruits except "apple".

The condition is optional and can be omitted:

### **Example**

With no if statement:

newlist = [x for x in fruits]

['apple', 'banana', 'cherry', 'kiwi', 'mango']

### **Iterable**

The iterable can be any iterable object, like a list, tuple, set etc.

### **Example**

You can use the range() function to create an iterable:

newlist = [x for x in range(10)]

[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]

Same example, but with a condition:

### **Example**

Accept only numbers lower than 5:

newlist = [x for x in range(10) if x < 5]

[0, 1, 2, 3, 4]

### **Expression**

The expression is the current item in the iteration, but it is also the outcome, which you can manipulate before it ends up like a list item in the new list:

### **Example**

Set the values in the new list to upper case:

newlist = [x.upper() for x in fruits]

['APPLE', 'BANANA', 'CHERRY', 'KIWI', 'MANGO']

You can set the outcome to whatever you like:

### **Example**

Set all values in the new list to 'hello':

newlist = ['hello' for x in fruits]

['APPLE', 'BANANA', 'CHERRY', 'KIWI', 'MANGO']

The expression can also contain conditions, not like a filter, but as a way to manipulate the outcome:

### **Example**

Return "orange" instead of "banana":

newlist = [x if x != "banana" else "orange" for x in fruits]

['apple', 'orange', 'cherry', 'kiwi', 'mango']

The expression in the example above says:

"Return the item if it is not banana, if it is banana return orange".

# **Python - Sort Lists**

## Sort List Alphanumerically

List objects have a sort() method that will sort the list alphanumerically, ascending, by default:

### **Example**

Sort the list alphabetically:

thislist = ["orange", "mango", "kiwi", "pineapple", "banana"]  
thislist.sort()  
print(thislist)

['banana', 'kiwi', 'mango', 'orange', 'pineapple']

### **Example**

Sort the list numerically:

thislist = [100, 50, 65, 82, 23]  
thislist.sort()  
print(thislist)

[23, 50, 65, 82, 100]

## Sort Descending

To sort descending, use the keyword argument reverse = True:

### **Example**

Sort the list descending:

thislist = ["orange", "mango", "kiwi", "pineapple", "banana"]  
thislist.sort(reverse = True)  
print(thislist)

### **Example**

Sort the list descending:

thislist = [100, 50, 65, 82, 23]  
thislist.sort(reverse = True)  
print(thislist)

['pineapple', 'orange', 'mango', 'kiwi', 'banana']

## Customize Sort Function

You can also customize your own function by using the keyword argument key = function.

The function will return a number that will be used to sort the list (the lowest number first):

### **Example**

Sort the list based on how close the number is to 50:

def myfunc(n):  
  return abs(n - 50)  
  
thislist = [100, 50, 65, 82, 23]  
thislist.sort(key = myfunc)  
print(thislist)

[50, 65, 23, 82, 100]

## Case Insensitive Sort

By default the sort() method is case sensitive, resulting in all capital letters being sorted before lower case letters:

### **Example**

Case sensitive sorting can give an unexpected result:

thislist = ["banana", "Orange", "Kiwi", "cherry"]  
thislist.sort()  
print(thislist)

['Kiwi', 'Orange', 'banana', 'cherry']

Luckily we can use built-in functions as key functions when sorting a list.

So if you want a case-insensitive sort function, use str.lower as a key function:

### **Example**

Perform a case-insensitive sort of the list:

thislist = ["banana", "Orange", "Kiwi", "cherry"]  
thislist.sort(key = str.lower)  
print(thislist)

['banana', 'cherry', 'Kiwi', 'Orange']

## Reverse Order

What if you want to reverse the order of a list, regardless of the alphabet?

The reverse() method reverses the current sorting order of the elements.

Reverse the order of the list items:

thislist = ["banana", "Orange", "Kiwi", "cherry"]  
thislist.reverse()  
print(thislist)

['cherry', 'Kiwi', 'Orange', 'banana']

# **Python - Copy Lists**

## Copy a List

You cannot copy a list simply by typing list2 = list1, because: list2 will only be a reference to list1, and changes made in list1 will automatically also be made in list2.

There are ways to make a copy, one way is to use the built-in List method copy().

### **Example**

Make a copy of a list with the copy() method:

thislist = ["apple", "banana", "cherry"]  
mylist = thislist.copy()  
print(mylist)

['apple', 'banana', 'cherry']

Another way to make a copy is to use the built-in method list().

### **Example**

Make a copy of a list with the list() method:

thislist = ["apple", "banana", "cherry"]  
mylist = list(thislist)  
print(mylist)

['apple', 'banana', 'cherry']

# **Python - Join Lists**

## Join Two Lists

There are several ways to join, or concatenate, two or more lists in Python.

One of the easiest ways are by using the + operator.

### **Example**

Join two list:

list1 = ["a", "b", "c"]  
list2 = [1, 2, 3]  
  
list3 = list1 + list2  
print(list3)

['a', 'b', 'c', 1, 2, 3]

Another way to join two lists is by appending all the items from list2 into list1, one by one:

### **Example**

Append list2 into list1:

list1 = ["a", "b" , "c"]  
list2 = [1, 2, 3]  
  
for x in list2:  
  list1.append(x)  
  
print(list1)

['a', 'b', 'c', 1, 2, 3]

Or you can use the extend() method, where the purpose is to add elements from one list to another list:

### **Example**

Use the extend() method to add list2 at the end of list1:

list1 = ["a", "b" , "c"]  
list2 = [1, 2, 3]  
  
list1.extend(list2)  
print(list1)

['a', 'b', 'c', 1, 2, 3]

# **Python - List Methods**

## List Methods

Python has a set of built-in methods that you can use on lists.

|  |  |
| --- | --- |
| **Method** | **Description** |
| [append()](https://www.w3schools.com/python/ref_list_append.asp) | Adds an element at the end of the list |
| [clear()](https://www.w3schools.com/python/ref_list_clear.asp) | Removes all the elements from the list |
| [copy()](https://www.w3schools.com/python/ref_list_copy.asp) | Returns a copy of the list |
| [count()](https://www.w3schools.com/python/ref_list_count.asp) | Returns the number of elements with the specified value |
| [extend()](https://www.w3schools.com/python/ref_list_extend.asp) | Add the elements of a list (or any iterable), to the end of the current list |
| [index()](https://www.w3schools.com/python/ref_list_index.asp) | Returns the index of the first element with the specified value |
| [insert()](https://www.w3schools.com/python/ref_list_insert.asp) | Adds an element at the specified position |
| [pop()](https://www.w3schools.com/python/ref_list_pop.asp) | Removes the element at the specified position |
| [remove()](https://www.w3schools.com/python/ref_list_remove.asp) | Removes the item with the specified value |
| [reverse()](https://www.w3schools.com/python/ref_list_reverse.asp) | Reverses the order of the list |
| [sort()](https://www.w3schools.com/python/ref_list_sort.asp) | Sorts the list |

# **Python Tuples**

mytuple = ("apple", "banana", "cherry")

## Tuple

Tuples are used to store multiple items in a single variable.

Tuple is one of 4 built-in data types in Python used to store collections of data, the other 3 are [List](https://www.w3schools.com/python/python_lists.asp), [Set](https://www.w3schools.com/python/python_sets.asp), and [Dictionary](https://www.w3schools.com/python/python_dictionaries.asp), all with different qualities and usage.

A tuple is a collection which is ordered and **unchangeable**.

Tuples are written with round brackets.

### **Example**

Create a Tuple:

thistuple = ("apple", "banana", "cherry")  
print(thistuple)

## Tuple Items

Tuple items are ordered, unchangeable, and allow duplicate values.

Tuple items are indexed, the first item has index [0], the second item has index [1] etc.

## Ordered

When we say that tuples are ordered, it means that the items have a defined order, and that order will not change.

## Unchangeable

Tuples are unchangeable, meaning that we cannot change, add or remove items after the tuple has been created.

## Allow Duplicates

Since tuples are indexed, they can have items with the same value:

### **Example**

Tuples allow duplicate values:

thistuple = ("apple", "banana", "cherry", "apple", "cherry")  
print(thistuple)

## Tuple Length

To determine how many items a tuple has, use the len() function:

### **Example**

Print the number of items in the tuple:

thistuple = ("apple", "banana", "cherry")  
print(len(thistuple))

## Create Tuple With One Item

To create a tuple with only one item, you have to add a comma after the item, otherwise Python will not recognize it as a tuple.

### **Example**

One item tuple, remember the comma:

thistuple = ("apple",)  
print(type(thistuple))  
  
#NOT a tuple  
thistuple = ("apple")  
print(type(thistuple))

## Tuple Items - Data Types

Tuple items can be of any data type:

### **Example**

String, int and boolean data types:

tuple1 = ("apple", "banana", "cherry")  
tuple2 = (1, 5, 7, 9, 3)  
tuple3 = (True, False, False)

A tuple can contain different data types:

### **Example**

A tuple with strings, integers and boolean values:

tuple1 = ("abc", 34, True, 40, "male")

## type()

From Python's perspective, tuples are defined as objects with the data type 'tuple':

<class 'tuple'>

### **Example**

What is the data type of a tuple?

mytuple = ("apple", "banana", "cherry")  
print(type(mytuple))

## The tuple() Constructor

It is also possible to use the tuple() constructor to make a tuple.

### **Example**

Using the tuple() method to make a tuple:

thistuple = tuple(("apple", "banana", "cherry")) # note the double round-brackets  
print(thistuple)

**Python Collections (Arrays)**

There are four collection data types in the Python programming language:

* [**List**](https://www.w3schools.com/python/python_lists.asp) is a collection which is ordered and changeable. Allows duplicate members.
* **Tuple** is a collection which is ordered and unchangeable. Allows duplicate members.
* [**Set**](https://www.w3schools.com/python/python_sets.asp) is a collection which is unordered, unchangeable\*, and unindexed. No duplicate members.
* [**Dictionary**](https://www.w3schools.com/python/python_dictionaries.asp) is a collection which is ordered\*\* and changeable. No duplicate members.

\*Set items are unchangeable, but you can remove and/or add items whenever you like.

When choosing a collection type, it is useful to understand the properties of that type. Choosing the right type for a particular data set could mean retention of meaning, and, it could mean an increase in efficiency or security.

# **Python - Access Tuple Items**

## Access Tuple Items

You can access tuple items by referring to the index number, inside square brackets:

### **Example**

Print the second item in the tuple:

thistuple = ("apple", "banana", "cherry")  
print(thistuple[1])

**Note:** The first item has index 0.

## Negative Indexing

Negative indexing means start from the end.

-1 refers to the last item, -2 refers to the second last item etc.

### **Example**

Print the last item of the tuple:

thistuple = ("apple", "banana", "cherry")  
print(thistuple[-1])

## Range of Indexes

You can specify a range of indexes by specifying where to start and where to end the range.

When specifying a range, the return value will be a new tuple with the specified items.

### **Example**

Return the third, fourth, and fifth item:

thistuple = ("apple", "banana", "cherry", "orange", "kiwi", "melon", "mango")  
print(thistuple[2:5])

**Note:** The search will start at index 2 (included) and end at index 5 (not included).

Remember that the first item has index 0.

By leaving out the start value, the range will start at the first item:

### **Example**

This example returns the items from the beginning to, but NOT included, "kiwi":

thistuple = ("apple", "banana", "cherry", "orange", "kiwi", "melon", "mango")  
print(thistuple[:4])

By leaving out the end value, the range will go on to the end of the tuple:

### **Example**

This example returns the items from "cherry" and to the end:

thistuple = ("apple", "banana", "cherry", "orange", "kiwi", "melon", "mango")  
print(thistuple[2:])

## Range of Negative Indexes

Specify negative indexes if you want to start the search from the end of the tuple:

### **Example**

This example returns the items from index -4 (included) to index -1 (excluded)

thistuple = ("apple", "banana", "cherry", "orange", "kiwi", "melon", "mango")  
print(thistuple[-4:-1])

## Check if Item Exists

To determine if a specified item is present in a tuple use the in keyword:

### **Example**

Check if "apple" is present in the tuple:

thistuple = ("apple", "banana", "cherry")  
if "apple" in thistuple:  
  print("Yes, 'apple' is in the fruits tuple")

# **Python - Update Tuples**

Tuples are unchangeable, meaning that you cannot change, add, or remove items once the tuple is created.

But there are some workarounds.

## Change Tuple Values

Once a tuple is created, you cannot change its values. Tuples are **unchangeable**, or **immutable** as it also is called.

But there is a workaround. You can convert the tuple into a list, change the list, and convert the list back into a tuple.

### **Example**

Convert the tuple into a list to be able to change it:

x = ("apple", "banana", "cherry")  
y = list(x)  
y[1] = "kiwi"  
x = tuple(y)  
print(x)

## Add Items

Since tuples are immutable, they do not have a built-in append() method, but there are other ways to add items to a tuple.

1. **Convert into a list**: Just like the workaround for changing a tuple, you can convert it into a list, add your item(s), and convert it back into a tuple.

### **Example**

Convert the tuple into a list, add "orange", and convert it back into a tuple:

thistuple = ("apple", "banana", "cherry")  
y = list(thistuple)  
y.append("orange")  
thistuple = tuple(y)

2. **Add tuple to a tuple**. You are allowed to add tuples to tuples, so if you want to add one item, (or many), create a new tuple with the item(s), and add it to the existing tuple:

### **Example**

Create a new tuple with the value "orange", and add that tuple:

thistuple = ("apple", "banana", "cherry")  
y = ("orange",)  
thistuple += y  
  
print(thistuple)

**Note:** When creating a tuple with only one item, remember to include a comma after the item, otherwise it will not be identified as a tuple.

## Remove Items

**Note:** You cannot remove items in a tuple.

Tuples are **unchangeable**, so you cannot remove items from it, but you can use the same workaround as we used for changing and adding tuple items:

### **Example**

Convert the tuple into a list, remove "apple", and convert it back into a tuple:

thistuple = ("apple", "banana", "cherry")  
y = list(thistuple)  
y.remove("apple")  
thistuple = tuple(y)

Or you can delete the tuple completely:

### **Example**

The del keyword can delete the tuple completely:

thistuple = ("apple", "banana", "cherry")  
del thistuple  
print(thistuple) #this will raise an error because the tuple no longer exists

# **Python - Unpack Tuples**

## Unpacking a Tuple

When we create a tuple, we normally assign values to it. This is called "packing" a tuple:

### **Example**

Packing a tuple:

fruits = ("apple", "banana", "cherry")

But, in Python, we are also allowed to extract the values back into variables. This is called "unpacking":

### **Example**

Unpacking a tuple:

fruits = ("apple", "banana", "cherry")  
  
(green, yellow, red) = fruits  
  
print(green)  
print(yellow)  
print(red)

**Note:** The number of variables must match the number of values in the tuple, if not, you must use an asterisk to collect the remaining values as a list.

## Using Asterisk\*

If the number of variables is less than the number of values, you can add an \* to the variable name and the values will be assigned to the variable as a list:

### **Example**

Assign the rest of the values as a list called "red":

fruits = ("apple", "banana", "cherry", "strawberry", "raspberry")  
  
(green, yellow, \*red) = fruits  
  
print(green)  
print(yellow)  
print(red)

If the asterisk is added to another variable name than the last, Python will assign values to the variable until the number of values left matches the number of variables left.

### **Example**

Add a list of values the "tropic" variable:

fruits = ("apple", "mango", "papaya", "pineapple", "cherry")  
  
(green, \*tropic, red) = fruits  
  
print(green)  
print(tropic)  
print(red)

# **Python - Loop Tuples**

## Loop Through a Tuple

You can loop through the tuple items by using a for loop.

### **Example**

Iterate through the items and print the values:

thistuple = ("apple", "banana", "cherry")  
for x in thistuple:  
  print(x)

## Loop Through the Index Numbers

You can also loop through the tuple items by referring to their index number.

Use the range() and len() functions to create a suitable iterable.

### **Example**

Print all items by referring to their index number:

thistuple = ("apple", "banana", "cherry")  
for i in range(len(thistuple)):  
  print(thistuple[i])

## Using a While Loop

You can loop through the tuple items by using a while loop.

Use the len() function to determine the length of the tuple, then start at 0 and loop your way through the tuple items by referring to their indexes.

Remember to increase the index by 1 after each iteration.

### **Example**

Print all items, using a while loop to go through all the index numbers:

thistuple = ("apple", "banana", "cherry")  
i = 0  
while i < len(thistuple):  
  print(thistuple[i])  
  i = i + 1

# **Python - Loop Tuples**

## Loop Through a Tuple

You can loop through the tuple items by using a for loop.

### **Example**

Iterate through the items and print the values:

thistuple = ("apple", "banana", "cherry")  
for x in thistuple:  
  print(x)

## Loop Through the Index Numbers

You can also loop through the tuple items by referring to their index number.

Use the range() and len() functions to create a suitable iterable.

### **Example**

Print all items by referring to their index number:

thistuple = ("apple", "banana", "cherry")  
for i in range(len(thistuple)):  
  print(thistuple[i]

## Using a While Loop

You can loop through the tuple items by using a while loop.

Use the len() function to determine the length of the tuple, then start at 0 and loop your way through the tuple items by referring to their indexes.

Remember to increase the index by 1 after each iteration.

### **Example**

Print all items, using a while loop to go through all the index numbers:

thistuple = ("apple", "banana", "cherry")  
i = 0  
while i < len(thistuple):  
  print(thistuple[i])  
  i = i + 1

# **Python - Join Tuples**

## Join Two Tuples

To join two or more tuples you can use the + operator:

### **Example**

Join two tuples:

tuple1 = ("a", "b" , "c")  
tuple2 = (1, 2, 3)  
  
tuple3 = tuple1 + tuple2  
print(tuple3)

('a', 'b', 'c', 1, 2, 3)

## Multiply Tuples

If you want to multiply the content of a tuple a given number of times, you can use the \* operator:

### **Example**

Multiply the fruits tuple by 2:

fruits = ("apple", "banana", "cherry")  
mytuple = fruits \* 2  
  
print(mytuple)

('apple', 'banana', 'cherry', 'apple', 'banana', 'cherry')

## Tuple Methods

Python has two built-in methods that you can use on tuples.

|  |  |
| --- | --- |
| **Method** | **Description** |
| [count()](https://www.w3schools.com/python/ref_tuple_count.asp) | Returns the number of times a specified value occurs in a tuple |
| [index()](https://www.w3schools.com/python/ref_tuple_index.asp) | Searches the tuple for a specified value and returns the position of where it was found |

# **Python Sets**

myset = {"apple", "banana", "cherry"}

## Set

Sets are used to store multiple items in a single variable.

Set is one of 4 built-in data types in Python used to store collections of data, the other 3 are [List](https://www.w3schools.com/python/python_lists.asp), [Tuple](https://www.w3schools.com/python/python_tuples.asp), and [Dictionary](https://www.w3schools.com/python/python_dictionaries.asp), all with different qualities and usage.

A set is a collection which is unordered, unchangeable\*, and unindexed.

**\* Note:** Set items are unchangeable, but you can remove items and add new items.

Sets are written with curly brackets.

### **Example**

Create a Set:

thisset = {"apple", "banana", "cherry"}  
print(thisset)

# Note: the set list is unordered, meaning: the items will appear in a random order.

​

# Refresh this page to see the change in the result.

​

{'banana', 'apple', 'cherry'}

**Note:** Sets are unordered, so you cannot be sure in which order the items will appear.

## Set Items

Set items are unordered, unchangeable, and do not allow duplicate values.

## Unordered

Unordered means that the items in a set do not have a defined order.

Set items can appear in a different order every time you use them, and cannot be referred to by index or key.

## Unchangeable

Set items are unchangeable, meaning that we cannot change the items after the set has been created.

Once a set is created, you cannot change its items, but you can remove items and add new items.

## Duplicates Not Allowed

Sets cannot have two items with the same value.

### **Example**

Duplicate values will be ignored:

thisset = {"apple", "banana", "cherry", "apple"}  
  
print(thisset)

{'banana', 'cherry', 'apple'}

**Note:** The values True and 1 are considered the same value in sets, and are treated as duplicates:

### **Example**

True and 1 is considered the same value:

thisset = {"apple", "banana", "cherry", True, 1, 2}  
  
print(thisset)

{True, 2, 'banana', 'cherry', 'apple'}

**Note:** The values False and 0 are considered the same value in sets, and are treated as duplicates:

### **Example**

False and 0 is considered the same value:

thisset = {"apple", "banana", "cherry", False, True, 0}  
  
print(thisset)

{False, True, 'cherry', 'apple', 'banana'}

## Get the Length of a Set

To determine how many items a set has, use the len() function.

### **Example**

Get the number of items in a set:

thisset = {"apple", "banana", "cherry"}  
  
print(len(thisset))

3

## Set Items - Data Types

Set items can be of any data type:

### **Example**

String, int and boolean data types:

set1 = {"apple", "banana", "cherry"}  
set2 = {1, 5, 7, 9, 3}  
set3 = {True, False, False}

{'cherry', 'apple', 'banana'}

{1, 3, 5, 7, 9}

{False, True}

A set can contain different data types:

### **Example**

A set with strings, integers and boolean values:

set1 = {"abc", 34, True, 40, "male"}

{True, 34, 40, 'male', 'abc'}

## type()

From Python's perspective, sets are defined as objects with the data type 'set':

<class 'set'>

### **Example**

What is the data type of a set?

myset = {"apple", "banana", "cherry"}  
print(type(myset))

<class 'set'>

## The set() Constructor

It is also possible to use the set() constructor to make a set.

### **Example**

Using the set() constructor to make a set:

thisset = set(("apple", "banana", "cherry")) # note the double round-brackets  
print(thisset)

{'apple', 'banana', 'cherry'}

## Python Collections (Arrays)

There are four collection data types in the Python programming language:

* [**List**](https://www.w3schools.com/python/python_lists.asp) is a collection which is ordered and changeable. Allows duplicate members.
* [**Tuple**](https://www.w3schools.com/python/python_tuples.asp) is a collection which is ordered and unchangeable. Allows duplicate members.
* **Set** is a collection which is unordered, unchangeable\*, and unindexed. No duplicate members.
* [**Dictionary**](https://www.w3schools.com/python/python_dictionaries.asp) is a collection which is ordered\*\* and changeable. No duplicate members.

\*Set items are unchangeable, but you can remove items and add new items.

\*\*As of Python version 3.7, dictionaries are ordered. In Python 3.6 and earlier, dictionaries are unordered.

When choosing a collection type, it is useful to understand the properties of that type. Choosing the right type for a particular data set could mean retention of meaning, and, it could mean an increase in efficiency or security.

## Access Items

You cannot access items in a set by referring to an index or a key.

But you can loop through the set items using a for loop, or ask if a specified value is present in a set, by using the in keyword.

### **Example**

Loop through the set, and print the values:

thisset = {"apple", "banana", "cherry"}  
  
for x in thisset:  
  print(x)

cherry  
banana  
apple

### **Example**

Check if "banana" is present in the set:

thisset = {"apple", "banana", "cherry"}  
  
print("banana" in thisset)

True

## Change Items

Once a set is created, you cannot change its items, but you can add new items.

# **Python - Add Set Items**

## Add Items

Once a set is created, you cannot change its items, but you can add new items.

To add one item to a set use the add() method.

### **Example**

Add an item to a set, using the add() method:

thisset = {"apple", "banana", "cherry"}  
  
thisset.add("orange")  
  
print(thisset)

{'banana', 'cherry', 'apple', 'orange'}

## Add Sets

To add items from another set into the current set, use the update() method.

### **Example**

Add elements from tropical into thisset:

thisset = {"apple", "banana", "cherry"}  
tropical = {"pineapple", "mango", "papaya"}  
  
thisset.update(tropical)  
  
print(thisset)

{'apple', 'mango', 'cherry', 'pineapple', 'banana', 'papaya'}

## Add Any Iterable

The object in the update() method does not have to be a set, it can be any iterable object (tuples, lists, dictionaries etc.).

### **Example**

Add elements of a list to at set:

thisset = {"apple", "banana", "cherry"}  
mylist = ["kiwi", "orange"]  
  
thisset.update(mylist)  
  
print(thisset)

{'banana', 'cherry', 'apple', 'orange', 'kiwi'}

# **Python - Remove Set Items**

## Remove Item

To remove an item in a set, use the remove(), or the discard() method.

### **Example**

Remove "banana" by using the remove() method:

thisset = {"apple", "banana", "cherry"}  
  
thisset.remove("banana")  
  
print(thisset)

{'apple', 'cherry'}

**Note:** If the item to remove does not exist, remove() will raise an error.

### **Example**

Remove "banana" by using the discard() method:

thisset = {"apple", "banana", "cherry"}  
  
thisset.discard("banana")  
  
print(thisset)

{'apple', 'cherry'}

**Note:** If the item to remove does not exist, discard() will **NOT** raise an error.

You can also use the pop() method to remove an item, but this method will remove a random item, so you cannot be sure what item that gets removed.

The return value of the pop() method is the removed item.

### **Example**

Remove a random item by using the pop() method:

thisset = {"apple", "banana", "cherry"}  
  
x = thisset.pop()  
  
print(x)  
  
print(thisset)

apple  
{'banana', 'cherry'}

**Note:** Sets are unordered, so when using the pop() method, you do not know which item that gets removed.

### **Example**

The clear() method empties the set:

thisset = {"apple", "banana", "cherry"}  
  
thisset.clear()  
  
print(thisset)

set()

### **Example**

The del keyword will delete the set completely:

thisset = {"apple", "banana", "cherry"}  
  
del thisset  
  
print(thisset)

Traceback (most recent call last):  
  File "demo\_set\_del.py", line 5, in <module>  
    print(thisset) #this will raise an error because the set no longer exists  
NameError: name 'thisset' is not defined

# **Python - Join Sets**

## Join Two Sets

There are several ways to join two or more sets in Python.

You can use the union() method that returns a new set containing all items from both sets, or the update() method that inserts all the items from one set into another:

### **Example**

The union() method returns a new set with all items from both sets:

set1 = {"a", "b" , "c"}  
set2 = {1, 2, 3}  
  
set3 = set1.union(set2)  
print(set3)

### {2, 'a', 1, 'b', 3, 'c'}

### **Example**

The update() method inserts the items in set2 into set1:

set1 = {"a", "b" , "c"}  
set2 = {1, 2, 3}  
  
set1.update(set2)  
print(set1)

{3, 2, 'b', 1, 'c', 'a'}

**Note:** Both union() and update() will exclude any duplicate items.

## Keep ONLY the Duplicates

The intersection\_update() method will keep only the items that are present in both sets.

### **Example**

Keep the items that exist in both set x, and set y:

x = {"apple", "banana", "cherry"}  
y = {"google", "microsoft", "apple"}  
  
x.intersection\_update(y)  
  
print(x)

​

{'apple'}

The intersection() method will return a new set, that only contains the items that are present in both sets.

### **Example**

Return a set that contains the items that exist in both set x, and set y:

x = {"apple", "banana", "cherry"}  
y = {"google", "microsoft", "apple"}  
  
z = x.intersection(y)  
  
print(z)

{'apple'}

## Keep All, But NOT the Duplicates

The symmetric\_difference\_update() method will keep only the elements that are NOT present in both sets.

### **Example**

Keep the items that are not present in both sets:

x = {"apple", "banana", "cherry"}  
y = {"google", "microsoft", "apple"}  
  
x.symmetric\_difference\_update(y)  
  
print(x)

{'google', 'banana', 'microsoft', 'cherry'}

The symmetric\_difference() method will return a new set, that contains only the elements that are NOT present in both sets.

### **Example**

Return a set that contains all items from both sets, except items that are present in both:

x = {"apple", "banana", "cherry"}  
y = {"google", "microsoft", "apple"}  
  
z = x.symmetric\_difference(y)  
  
print(z)

{'google', 'banana', 'microsoft', 'cherry'}

**Note:** The values True and 1 are considered the same value in sets, and are treated as duplicates:

### **Example**

True and 1 is considered the same value:

x = {"apple", "banana", "cherry", True}  
y = {"google", 1, "apple", 2}  
  
z = x.symmetric\_difference(y)  
  
print(z)

{2, 'google', 'cherry', 'banana'}

# **Python - Set Methods**

## Set Methods

Python has a set of built-in methods that you can use on sets.

|  |  |
| --- | --- |
| **Method** | **Description** |
| [add()](https://www.w3schools.com/python/ref_set_add.asp) | Adds an element to the set |
| [clear()](https://www.w3schools.com/python/ref_set_clear.asp) | Removes all the elements from the set |
| [copy()](https://www.w3schools.com/python/ref_set_copy.asp) | Returns a copy of the set |
| [difference()](https://www.w3schools.com/python/ref_set_difference.asp) | Returns a set containing the difference between two or more sets |
| [difference\_update()](https://www.w3schools.com/python/ref_set_difference_update.asp) | Removes the items in this set that are also included in another, specified set |
| [discard()](https://www.w3schools.com/python/ref_set_discard.asp) | Remove the specified item |
| [intersection()](https://www.w3schools.com/python/ref_set_intersection.asp) | Returns a set, that is the intersection of two other sets |
| [intersection\_update()](https://www.w3schools.com/python/ref_set_intersection_update.asp) | Removes the items in this set that are not present in other, specified set(s) |
| [isdisjoint()](https://www.w3schools.com/python/ref_set_isdisjoint.asp) | Returns whether two sets have a intersection or not |
| [issubset()](https://www.w3schools.com/python/ref_set_issubset.asp) | Returns whether another set contains this set or not |
| [issuperset()](https://www.w3schools.com/python/ref_set_issuperset.asp) | Returns whether this set contains another set or not |
| [pop()](https://www.w3schools.com/python/ref_set_pop.asp) | Removes an element from the set |
| [remove()](https://www.w3schools.com/python/ref_set_remove.asp) | Removes the specified element |
| [symmetric\_difference()](https://www.w3schools.com/python/ref_set_symmetric_difference.asp) | Returns a set with the symmetric differences of two sets |
| [symmetric\_difference\_update()](https://www.w3schools.com/python/ref_set_symmetric_difference_update.asp) | inserts the symmetric differences from this set and another |
| [union()](https://www.w3schools.com/python/ref_set_union.asp) | Return a set containing the union of sets |
| [update()](https://www.w3schools.com/python/ref_set_update.asp) | Update the set with the union of this set and others |

# **Python Dictionaries**

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964

## Dictionary

Dictionaries are used to store data values in key:value pairs.

A dictionary is a collection which is ordered\*, changeable and do not allow duplicates.

As of Python version 3.7, dictionaries are ordered. In Python 3.6 and earlier, dictionaries are unordered.

Dictionaries are written with curly brackets, and have keys and values:

### **Example**

Create and print a dictionary:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
print(thisdict)

## Dictionary Items

Dictionary items are ordered, changeable, and does not allow duplicates.

Dictionary items are presented in key:value pairs, and can be referred to by using the key name.

### **Example**

Print the "brand" value of the dictionary:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
print(thisdict["brand"])

## Ordered or Unordered?

As of Python version 3.7, dictionaries are ordered. In Python 3.6 and earlier, dictionaries are unordered.

When we say that dictionaries are ordered, it means that the items have a defined order, and that order will not change.

Unordered means that the items does not have a defined order, you cannot refer to an item by using an index.

## Changeable

Dictionaries are changeable, meaning that we can change, add or remove items after the dictionary has been created

## Duplicates Not Allowed

Dictionaries cannot have two items with the same key:

### **Example**

Duplicate values will overwrite existing values:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964,  
  "year": 2020  
}  
print(thisdict)

## Dictionary Length

To determine how many items a dictionary has, use the len() function:

### **Example**

Print the number of items in the dictionary:

print(len(thisdict))

## Dictionary Items - Data Types

The values in dictionary items can be of any data type:

### **Example**

String, int, boolean, and list data types:

thisdict = {  
  "brand": "Ford",  
  "electric": False,  
  "year": 1964,  
  "colors": ["red", "white", "blue"]  
}

## type()

From Python's perspective, dictionaries are defined as objects with the data type 'dict':

<class 'dict'>

### **Example**

Print the data type of a dictionary:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
print(type(thisdict))

**The dict() Constructor**

It is also possible to use the dict() constructor to make a dictionary.

### **Example**

Using the dict() method to make a dictionary:

thisdict = dict(name = "John", age = 36, country = "Norway")  
print(thisdict)

## Python Collections (Arrays)

There are four collection data types in the Python programming language:

* [**List**](https://www.w3schools.com/python/python_lists.asp) is a collection which is ordered and changeable. Allows duplicate members.
* [**Tuple**](https://www.w3schools.com/python/python_tuples.asp) is a collection which is ordered and unchangeable. Allows duplicate members.
* [**Set**](https://www.w3schools.com/python/python_sets.asp) is a collection which is unordered, unchangeable\*, and unindexed. No duplicate members.
* **Dictionary** is a collection which is ordered\*\* and changeable. No duplicate members.

\*Set items are unchangeable, but you can remove and/or add items whenever you like.

\*\*As of Python version 3.7, dictionaries are ordered. In Python 3.6 and earlier, dictionaries are unordered.

When choosing a collection type, it is useful to understand the properties of that type. Choosing the right type for a particular data set could mean retention of meaning, and, it could mean an increase in efficiency or security.

# **Python - Access Dictionary Items**

## Accessing Items

You can access the items of a dictionary by referring to its key name, inside square brackets:

### **Example**

Get the value of the "model" key:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
x = thisdict["model"]

There is also a method called get() that will give you the same result:

### **Example**

Get the value of the "model" key:

x = thisdict.get("model")

## Get Keys

The keys() method will return a list of all the keys in the dictionary.

### **Example**

Get a list of the keys:

x = thisdict.keys()

The list of the keys is a view of the dictionary, meaning that any changes done to the dictionary will be reflected in the keys list.

### **Example**

Add a new item to the original dictionary, and see that the keys list gets updated as well:

car = {  
"brand": "Ford",  
"model": "Mustang",  
"year": 1964  
}  
  
x = car.keys()  
  
print(x) #before the change  
  
car["color"] = "white"  
  
print(x) #after the change

The values() method will return a list of all the values in the dictionary.

### **Example**

Get a list of the values:

x = thisdict.values()

The list of the values is a view of the dictionary, meaning that any changes done to the dictionary will be reflected in the values list.

### **Example**

Make a change in the original dictionary, and see that the values list gets updated as well:

car = {  
"brand": "Ford",  
"model": "Mustang",  
"year": 1964  
}  
  
x = car.values()  
  
print(x) #before the change  
  
car["year"] = 2020  
  
print(x) #after the change

### **Example**

Add a new item to the original dictionary, and see that the values list gets updated as well:

car = {  
"brand": "Ford",  
"model": "Mustang",  
"year": 1964  
}  
  
x = car.values()  
  
print(x) #before the change  
  
car["color"] = "red"  
  
print(x) #after the change

## Get Items

The items() method will return each item in a dictionary, as tuples in a list.

### **Example**

Get a list of the key:value pairs

x = thisdict.items()

The returned list is a view of the items of the dictionary, meaning that any changes done to the dictionary will be reflected in the items list.

### **Example**

Make a change in the original dictionary, and see that the items list gets updated as well:

car = {  
"brand": "Ford",  
"model": "Mustang",  
"year": 1964  
}  
  
x = car.items()  
  
print(x) #before the change  
  
car["year"] = 2020  
  
print(x) #after the change

### **Example**

Add a new item to the original dictionary, and see that the items list gets updated as well:

car = {  
"brand": "Ford",  
"model": "Mustang",  
"year": 1964  
}  
  
x = car.items()  
  
print(x) #before the change  
  
car["color"] = "red"  
  
print(x) #after the change

## Check if Key Exists

To determine if a specified key is present in a dictionary use the in keyword:

### **Example**

Check if "model" is present in the dictionary:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
if "model" in thisdict:  
  print("Yes, 'model' is one of the keys in the thisdict dictionary")

# **Python - Change Dictionary Items**

## Change Values

You can change the value of a specific item by referring to its key name:

### **Example**

Change the "year" to 2018:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict["year"] = 2018  
{'brand': 'Ford', 'model': 'Mustang', 'year': 2018}

## Update Dictionary

The update() method will update the dictionary with the items from the given argument.

The argument must be a dictionary, or an iterable object with key:value pairs.

### **Example**

Update the "year" of the car by using the update() method:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict.update({"year": 2020})

{'brand': 'Ford', 'model': 'Mustang', 'year': 2020}

# **Python - Add Dictionary Items**

## Adding Items

Adding an item to the dictionary is done by using a new index key and assigning a value to it:

### **Example**

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict["color"] = "red"  
print(thisdict)

{'brand': 'Ford', 'model': 'Mustang', 'year': 1964, 'color': 'red'}

## Update Dictionary

The update() method will update the dictionary with the items from a given argument. If the item does not exist, the item will be added.

The argument must be a dictionary, or an iterable object with key:value pairs.

### **Example**

Add a color item to the dictionary by using the update() method:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict.update({"color": "red"})

{'brand': 'Ford', 'model': 'Mustang', 'year': 1964, 'color': 'red'}

# **Python - Remove Dictionary Items**

## Removing Items

There are several methods to remove items from a dictionary:

### **Example**

The pop() method removes the item with the specified key name:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict.pop("model")  
print(thisdict)

{'brand': 'Ford', 'year': 1964}

### **Example**

The popitem() method removes the last inserted item (in versions before 3.7, a random item is removed instead):

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict.popitem()  
print(thisdict)

{'brand': 'Ford', 'model': 'Mustang'}

### **Example**

The del keyword removes the item with the specified key name:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
del thisdict["model"]  
print(thisdict)

{'brand': 'Ford', 'year': 1964}

### **Example**

The del keyword can also delete the dictionary completely:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
del thisdict  
print(thisdict) #this will cause an error because "thisdict" no longer exists.

Traceback (most recent call last):  
  File "demo\_dictionary\_del3.py", line 7, in <module>  
    print(thisdict) #this will cause an error because "thisdict" no longer exists.  
NameError: name 'thisdict' is not defined

### **Example**

The clear() method empties the dictionary:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
thisdict.clear()  
print(thisdict)

{}

# **Python - Loop Dictionaries**

## Loop Through a Dictionary

You can loop through a dictionary by using a for loop.

When looping through a dictionary, the return value are the keys of the dictionary, but there are methods to return the values as well.

### **Example**

Print all key names in the dictionary, one by one:

for x in thisdict:  
  print(x)

Ford  
Mustang  
1964

### **Example**

Print all values in the dictionary, one by one:

for x in thisdict:  
  print(thisdict[x])

### **Example**

You can also use the values() method to return values of a dictionary:

for x in thisdict.values():  
  print(x)

Ford  
Mustang  
1964

### **Example**

You can use the keys() method to return the keys of a dictionary:

for x in thisdict.keys():  
  print(x)

brand  
model  
year

### **Example**

Loop through both keys and values, by using the items() method:

for x, y in thisdict.items():  
  print(x, y)

brand Ford  
model Mustang  
year 1964

## Copy a Dictionary

You cannot copy a dictionary simply by typing dict2 = dict1, because: dict2 will only be a reference to dict1, and changes made in dict1 will automatically also be made in dict2.

There are ways to make a copy, one way is to use the built-in Dictionary method copy().

### **Example**

Make a copy of a dictionary with the copy() method:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
mydict = thisdict.copy()  
print(mydict)

{'brand': 'Ford', 'model': 'Mustang', 'year': 1964}

Another way to make a copy is to use the built-in function dict().

### **Example**

Make a copy of a dictionary with the dict() function:

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
mydict = dict(thisdict)  
print(mydict)

{'brand': 'Ford', 'model': 'Mustang', 'year': 1964}

## Nested Dictionaries

A dictionary can contain dictionaries, this is called nested dictionaries.

### **Example**

Create a dictionary that contain three dictionaries:

myfamily = {  
  "child1" : {  
    "name" : "Emil",  
    "year" : 2004  
  },  
  "child2" : {  
    "name" : "Tobias",  
    "year" : 2007  
  },  
  "child3" : {  
    "name" : "Linus",  
    "year" : 2011  
  }  
}

{'child1': {'name': 'Emil', 'year': 2004}, 'child2': {'name': 'Tobias', 'year': 2007}, 'child3': {'name': 'Linus', 'year': 2011}}

Or, if you want to add three dictionaries into a new dictionary:

### **Example**

Create three dictionaries, then create one dictionary that will contain the other three dictionaries:

child1 = {  
  "name" : "Emil",  
  "year" : 2004  
}  
child2 = {  
  "name" : "Tobias",  
  "year" : 2007  
}  
child3 = {  
  "name" : "Linus",  
  "year" : 2011  
}  
  
myfamily = {  
  "child1" : child1,  
  "child2" : child2,  
  "child3" : child3  
}

{'child1': {'name': 'Emil', 'year': 2004}, 'child2': {'name': 'Tobias', 'year': 2007}, 'child3': {'name': 'Linus', 'year': 2011}}

## Access Items in Nested Dictionaries

To access items from a nested dictionary, you use the name of the dictionaries, starting with the outer dictionary:

### **Example**

Print the name of child 2:

print(myfamily["child2"]["name"])

Tobias

## Dictionary Methods

Python has a set of built-in methods that you can use on dictionaries.

|  |  |
| --- | --- |
| **Method** | **Description** |
| [clear()](https://www.w3schools.com/python/ref_dictionary_clear.asp) | Removes all the elements from the dictionary |
| [copy()](https://www.w3schools.com/python/ref_dictionary_copy.asp) | Returns a copy of the dictionary |
| [fromkeys()](https://www.w3schools.com/python/ref_dictionary_fromkeys.asp) | Returns a dictionary with the specified keys and value |
| [get()](https://www.w3schools.com/python/ref_dictionary_get.asp) | Returns the value of the specified key |
| [items()](https://www.w3schools.com/python/ref_dictionary_items.asp) | Returns a list containing a tuple for each key value pair |
| [keys()](https://www.w3schools.com/python/ref_dictionary_keys.asp) | Returns a list containing the dictionary's keys |
| [pop()](https://www.w3schools.com/python/ref_dictionary_pop.asp) | Removes the element with the specified key |
| [popitem()](https://www.w3schools.com/python/ref_dictionary_popitem.asp) | Removes the last inserted key-value pair |
| [setdefault()](https://www.w3schools.com/python/ref_dictionary_setdefault.asp) | Returns the value of the specified key. If the key does not exist: insert the key, with the specified value |
| [update()](https://www.w3schools.com/python/ref_dictionary_update.asp) | Updates the dictionary with the specified key-value pairs |
| [values()](https://www.w3schools.com/python/ref_dictionary_values.asp) | Returns a list of all the values in the dictionary |

# **Python If ... Else**

## Python Conditions and If statements

Python supports the usual logical conditions from mathematics:

* Equals: a == b
* Not Equals: a != b
* Less than: a < b
* Less than or equal to: a <= b
* Greater than: a > b
* Greater than or equal to: a >= b

These conditions can be used in several ways, most commonly in "if statements" and loops.

An "if statement" is written by using the if keyword.

### **Example**

If statement:

a = 33  
b = 200  
if b > a:  
  print("b is greater than a")

b is greater than a

In this example we use two variables, a and b, which are used as part of the if statement to test whether b is greater than a. As a is 33, and b is 200, we know that 200 is greater than 33, and so we print to screen that "b is greater than a".

## Indentation

Python relies on indentation (whitespace at the beginning of a line) to define scope in the code. Other programming languages often use curly-brackets for this purpose.

### **Example**

If statement, without indentation (will raise an error):

a = 33  
b = 200  
if b > a:  
print("b is greater than a") # you will get an error

## Elif

The elif keyword is Python's way of saying "if the previous conditions were not true, then try this condition".

### **Example**

a = 33  
b = 33  
if b > a:  
  print("b is greater than a")  
elif a == b:  
  print("a and b are equal")  
File "demo\_if\_error.py", line 4  
    print("b is greater than a")  
        ^  
IndentationError: expected an indented block

In this example a is equal to b, so the first condition is not true, but the elif condition is true, so we print to screen that "a and b are equal".

## Else

The else keyword catches anything which isn't caught by the preceding conditions.

### **Example**

a = 200  
b = 33  
if b > a:  
  print("b is greater than a")  
elif a == b:  
  print("a and b are equal")  
else:  
  print("a is greater than b")

a and b are equal

In this example a is greater than b, so the first condition is not true, also the elif condition is not true, so we go to the else condition and print to screen that "a is greater than b".

You can also have an else without the elif:

### **Example**

a = 200  
b = 33  
if b > a:  
  print("b is greater than a")  
else:  
  print("b is not greater than a")

## Short Hand If

If you have only one statement to execute, you can put it on the same line as the if statement.

### **Example**

One line if statement:

if a > b: print("a is greater than b")

## Short Hand If ... Else

If you have only one statement to execute, one for if, and one for else, you can put it all on the same line:

### **Example**

One line if else statement:

a = 2  
b = 330  
print("A") if a > b else print("B")

B

This technique is known as **Ternary Operators**, or **Conditional Expressions**.

You can also have multiple else statements on the same line:

### **Example**

One line if else statement, with 3 conditions:

a = 330  
b = 330  
print("A") if a > b else print("=") if a == b else print("B")

=

## And

The and keyword is a logical operator, and is used to combine conditional statements:

### **Example**

Test if a is greater than b, AND if c is greater than a:

a = 200  
b = 33  
c = 500  
if a > b and c > a:  
  print("Both conditions are True")  
Both conditions are True

## Or

The or keyword is a logical operator, and is used to combine conditional statements:

### **Example**

Test if a is greater than b, OR if a is greater than c:

a = 200  
b = 33  
c = 500  
if a > b or a > c:  
  print("At least one of the conditions is True")  
At least one of the conditions is True

## Not

The not keyword is a logical operator, and is used to reverse the result of the conditional statement:

### **Example**

Test if a is NOT greater than b:

a = 33  
b = 200  
if not a > b:  
  print("a is NOT greater than b")  
a is NOT greater than b

## Nested If

You can have if statements inside if statements, this is called nested if statements.

### **Example**

x = 41  
  
if x > 10:  
  print("Above ten,")  
  if x > 20:  
    print("and also above 20!")  
  else:  
    print("but not above 20.")

Above ten,  
and also above 20!

## The pass Statement

if statements cannot be empty, but if you for some reason have an if statement with no content, put in the pass statement to avoid getting an error.

### **Example**

a = 33  
b = 200  
  
if b > a:  
  pass

# **Python While Loops**

## Python Loops

Python has two primitive loop commands:

* while loops
* for loops

## The while Loop

With the while loop we can execute a set of statements as long as a condition is true.

### **Example**

Print i as long as i is less than 6:

i = 1  
while i < 6:  
  print(i)  
  i += 1  
1  
2  
3  
4  
5

**Note:** remember to increment i, or else the loop will continue forever.

The while loop requires relevant variables to be ready, in this example we need to define an indexing variable, i, which we set to 1.

## The break Statement

With the break statement we can stop the loop even if the while condition is true:

### **Example**

Exit the loop when i is 3:

i = 1  
while i < 6:  
  print(i)  
  if i == 3:  
    break  
  i += 1

1  
2  
3

## The continue Statement

With the continue statement we can stop the current iteration, and continue with the next:

### **Example**

Continue to the next iteration if i is 3:

i = 0  
while i < 6:  
  i += 1  
  if i == 3:  
    continue  
  print(i)  
1  
2  
4  
5  
6

## The else Statement

With the else statement we can run a block of code once when the condition no longer is true:

### **Example**

Print a message once the condition is false:

i = 1  
while i < 6:  
  print(i)  
  i += 1  
else:  
  print("i is no longer less than 6")

1  
2  
3  
4  
5  
i is no longer less than 6

# **Python For Loops**

## Python For Loops

A for loop is used for iterating over a sequence (that is either a list, a tuple, a dictionary, a set, or a string).

This is less like the for keyword in other programming languages, and works more like an iterator method as found in other object-orientated programming languages.

With the for loop we can execute a set of statements, once for each item in a list, tuple, set etc.

### **Example**

Print each fruit in a fruit list:

fruits = ["apple", "banana", "cherry"]  
for x in fruits:  
  print(x)

The for loop does not require an indexing variable to set beforehand.

## Looping Through a String

Even strings are iterable objects, they contain a sequence of characters:

### **Example**

Loop through the letters in the word "banana":

for x in "banana":  
  print(x)

apple  
banana  
cherry

## The break Statement

With the break statement we can stop the loop before it has looped through all the items:

### **Example**

Exit the loop when x is "banana":

fruits = ["apple", "banana", "cherry"]  
for x in fruits:  
  print(x)  
  if x == "banana":  
    break  
b  
a  
n  
a  
n  
a

### **Example**

Exit the loop when x is "banana", but this time the break comes before the print:

fruits = ["apple", "banana", "cherry"]  
for x in fruits:  
  if x == "banana":  
    break  
  print(x)

apple

## The continue Statement

With the continue statement we can stop the current iteration of the loop, and continue with the next:

### **Example**

Do not print banana:

fruits = ["apple", "banana", "cherry"]  
for x in fruits:  
  if x == "banana":  
    continue  
  print(x)

apple  
cherry

## The range() Function

To loop through a set of code a specified number of times, we can use the range() function,

The range() function returns a sequence of numbers, starting from 0 by default, and increments by 1 (by default), and ends at a specified number.

### **Example**

Using the range() function:

for x in range(6):  
  print(x)

0  
1  
2  
3  
4  
5

Note that range(6) is not the values of 0 to 6, but the values 0 to 5.

The range() function defaults to 0 as a starting value, however it is possible to specify the starting value by adding a parameter: range(2, 6), which means values from 2 to 6 (but not including 6):

### **Example**

Using the start parameter:

for x in range(2, 6):  
  print(x)

2  
3  
4  
5

The range() function defaults to increment the sequence by 1, however it is possible to specify the increment value by adding a third parameter: range(2, 30, **3**):

### **Example**

Increment the sequence with 3 (default is 1):

for x in range(2, 30, 3):  
  print(x)

2  
5  
8  
11  
14  
17  
20  
23  
26  
29

## Else in For Loop

The else keyword in a for loop specifies a block of code to be executed when the loop is finished:

### **Example**

Print all numbers from 0 to 5, and print a message when the loop has ended:

for x in range(6):  
  print(x)  
else:  
  print("Finally finished!")

**Note:** The else block will NOT be executed if the loop is stopped by a break statement.

### **Example**

Break the loop when x is 3, and see what happens with the else block:

for x in range(6):  
  if x == 3: break  
  print(x)  
else:  
  print("Finally finished!")

## Nested Loops

A nested loop is a loop inside a loop.

The "inner loop" will be executed one time for each iteration of the "outer loop":

### **Example**

Print each adjective for every fruit:

adj = ["red", "big", "tasty"]  
fruits = ["apple", "banana", "cherry"]  
  
for x in adj:  
  for y in fruits:  
    print(x, y)

## The pass Statement

for loops cannot be empty, but if you for some reason have a for loop with no content, put in the pass statement to avoid getting an error.

### **Example**

for x in [0, 1, 2]:  
  pass

# **Python Functions**

A function is a block of code which only runs when it is called.

You can pass data, known as parameters, into a function.

A function can return data as a result.

## Creating a Function

In Python a function is defined using the def keyword:

### **Example**

def my\_function():  
  print("Hello from a function")

## Calling a Function

To call a function, use the function name followed by parenthesis:

### **Example**

def my\_function():  
  print("Hello from a function")  
  
**my\_function()**

## Arguments

Information can be passed into functions as arguments.

Arguments are specified after the function name, inside the parentheses. You can add as many arguments as you want, just separate them with a comma.

The following example has a function with one argument (fname). When the function is called, we pass along a first name, which is used inside the function to print the full name:

### **Example**

def my\_function(**fname**):  
  print(fname + " Refsnes")  
  
my\_function(**"Emil"**)  
my\_function(**"Tobias"**)  
my\_function(**"Linus"**)

Arguments are often shortened to args in Python documentations.

## Parameters or Arguments?

The terms parameter and argument can be used for the same thing: information that are passed into a function.

From a function's perspective:

A parameter is the variable listed inside the parentheses in the function definition.

An argument is the value that is sent to the function when it is called.

## Number of Arguments

By default, a function must be called with the correct number of arguments. Meaning that if your function expects 2 arguments, you have to call the function with 2 arguments, not more, and not less.

### **Example**

This function expects 2 arguments, and gets 2 arguments:

def my\_function(fname, lname):  
  print(fname + " " + lname)  
  
my\_function("Emil", "Refsnes")If you try to call the function with 1 or 3 arguments, you will get an error:

### **Example**

This function expects 2 arguments, but gets only 1:

def my\_function(fname, lname):  
  print(fname + " " + lname)  
  
my\_function("Emil")

## Arbitrary Arguments, \*args

If you do not know how many arguments that will be passed into your function, add a \* before the parameter name in the function definition.

This way the function will receive a tuple of arguments, and can access the items accordingly:

### **Example**

If the number of arguments is unknown, add a \* before the parameter name:

def my\_function(\*kids):  
  print("The youngest child is " + kids[2])  
  
my\_function("Emil", "Tobias", "Linus")

Arbitrary Arguments are often shortened to \*args in Python documentations.

## Keyword Arguments

You can also send arguments with the key = value syntax.

This way the order of the arguments does not matter.

### **Example**

def my\_function(child3, child2, child1):  
  print("The youngest child is " + child3)  
  
my\_function(child1 = "Emil", child2 = "Tobias", child3 = "Linus")

The phrase Keyword Arguments are often shortened to kwargs in Python documentations.

## Arbitrary Keyword Arguments, \*\*kwargs

If you do not know how many keyword arguments that will be passed into your function, add two asterisk: \*\* before the parameter name in the function definition.

This way the function will receive a dictionary of arguments, and can access the items accordingly:

### **Example**

If the number of keyword arguments is unknown, add a double \*\* before the parameter name:

def my\_function(\*\*kid):  
  print("His last name is " + kid["lname"])  
  
my\_function(fname = "Tobias", lname = "Refsnes")

Arbitrary Kword Arguments are often shortened to \*\*kwargs in Python documentations.

## Default Parameter Value

The following example shows how to use a default parameter value.

If we call the function without argument, it uses the default value:

### **Example**

def my\_function(**country = "Norway"**):  
  print("I am from " + country)  
  
my\_function("Sweden")  
my\_function("India")  
my\_function()  
my\_function("Brazil")

## Passing a List as an Argument

You can send any data types of argument to a function (string, number, list, dictionary etc.), and it will be treated as the same data type inside the function.

E.g. if you send a List as an argument, it will still be a List when it reaches the function:

### **Example**

def my\_function(food):  
  for x in food:  
    print(x)  
  
fruits = ["apple", "banana", "cherry"]  
  
my\_function(fruits)

## Return Values

To let a function return a value, use the return statement:

### **Example**

def my\_function(x):  
  **return 5 \* x**  
print(my\_function(3))  
print(my\_function(5))  
print(my\_function(9)

## The pass Statement

function definitions cannot be empty, but if you for some reason have a function definition with no content, put in the pass statement to avoid getting an error.

### **Example**

def myfunction():  
  pass

## Positional-Only Arguments

You can specify that a function can have ONLY positional arguments, or ONLY keyword arguments.

To specify that a function can have only positional arguments, add , / after the arguments:

### **Example**

def my\_function(x, /):  
  print(x)  
  
my\_function(3)

Without the , / you are actually allowed to use keyword arguments even if the function expects positional arguments:

### **Example**

def my\_function(x):  
  print(x)  
  
my\_function(x = 3)

But when adding the , / you will get an error if you try to send a keyword argument:

### **Example**

def my\_function(x, /):  
  print(x)  
  
my\_function(x = 3)

## Keyword-Only Arguments

To specify that a function can have only keyword arguments, add \*, before the arguments:

### **Example**

def my\_function(\*, x):  
  print(x)  
  
my\_function(x = 3)

Without the \*, you are allowed to use positionale arguments even if the function expects keyword arguments:

### **Example**

def my\_function(x):  
  print(x)  
  
my\_function(3)

But when adding the \*, / you will get an error if you try to send a positional argument:

### **Example**

def my\_function(\*, x):  
  print(x)  
  
my\_function(3)

## Combine Positional-Only and Keyword-Only

You can combine the two argument types in the same function.

Any argument before the / , are positional-only, and any argument after the \*, are keyword-only.

### **Example**

def my\_function(a, b, /, \*, c, d):  
  print(a + b + c + d)  
  
my\_function(5, 6, c = 7, d = 8)

## Recursion

Python also accepts function recursion, which means a defined function can call itself.

Recursion is a common mathematical and programming concept. It means that a function calls itself. This has the benefit of meaning that you can loop through data to reach a result.

The developer should be very careful with recursion as it can be quite easy to slip into writing a function which never terminates, or one that uses excess amounts of memory or processor power. However, when written correctly recursion can be a very efficient and mathematically-elegant approach to programming.

In this example, tri\_recursion() is a function that we have defined to call itself ("recurse"). We use the k variable as the data, which decrements (-1) every time we recurse. The recursion ends when the condition is not greater than 0 (i.e. when it is 0).

To a new developer it can take some time to work out how exactly this works, best way to find out is by testing and modifying it.

### **Example**

Recursion Example

def tri\_recursion(k):  
  if(k > 0):  
    result = k + tri\_recursion(k - 1)  
    print(result)  
  else:  
    result = 0  
  return result  
  
print("\n\nRecursion Example Results")  
tri\_recursion(6)

# **Python Lambda**

A lambda function is a small anonymous function.

A lambda function can take any number of arguments, but can only have one expression.

## Syntax

lambda arguments : expression

The expression is executed and the result is returned:

### **Example**

Add 10 to argument a, and return the result:

x = lambda a : a + 10  
print(x(5))

Lambda functions can take any number of arguments:

### **Example**

Multiply argument a with argument b and return the result:

x = lambda a, b : a \* b  
print(x(5, 6))

13

### **Example**

Summarize argument a, b, and c and return the result:

x = lambda a, b, c : a + b + c  
print(x(5, 6, 2))

## Why Use Lambda Functions?

The power of lambda is better shown when you use them as an anonymous function inside another function.

Say you have a function definition that takes one argument, and that argument will be multiplied with an unknown number:

def myfunc(n):  
  return lambda a : a \* n

Use that function definition to make a function that always doubles the number you send in:

### **Example**

def myfunc(n):  
  return lambda a : a \* n  
  
mydoubler = myfunc(2)  
  
print(mydoubler(11))

22

Or, use the same function definition to make a function that always triples the number you send in:

### **Example**

def myfunc(n):  
  return lambda a : a \* n  
  
mytripler = myfunc(3)  
  
print(mytripler(11))

33

Or, use the same function definition to make both functions, in the same program:

### **Example**

def myfunc(n):  
  return lambda a : a \* n  
  
mydoubler = myfunc(2)  
mytripler = myfunc(3)  
  
print(mydoubler(11))  
print(mytripler(11))

22  
33

Use lambda functions when an anonymous function is required for a short period of time.

# **Python Arrays**

**Note:** Python does not have built-in support for Arrays, but [Python Lists](https://www.w3schools.com/python/python_lists.asp) can be used instead.

## Arrays

**Note:** This page shows you how to use LISTS as ARRAYS, however, to work with arrays in Python you will have to import a library, like the [NumPy library](https://www.w3schools.com/python/numpy/default.asp).

Arrays are used to store multiple values in one single variable:

### **Example**

Create an array containing car names:

cars = ["Ford", "Volvo", "BMW"]

## What is an Array?

An array is a special variable, which can hold more than one value at a time.

If you have a list of items (a list of car names, for example), storing the cars in single variables could look like this:

car1 = "Ford"  
car2 = "Volvo"  
car3 = "BMW"

However, what if you want to loop through the cars and find a specific one? And what if you had not 3 cars, but 300?

The solution is an array!

An array can hold many values under a single name, and you can access the values by referring to an index number.

## Access the Elements of an Array

You refer to an array element by referring to the index number.

### **Example**

Get the value of the first array item:

x = cars[0]

### **Example**

Modify the value of the first array item:

cars[0] = "Toyota"

## The Length of an Array

Use the len() method to return the length of an array (the number of elements in an array).

### **Example**

Return the number of elements in the cars array:

x = len(cars)

**Note:** The length of an array is always one more than the highest array index

## Looping Array Elements

You can use the for in loop to loop through all the elements of an array.

### **Example**

Print each item in the cars array:

for x in cars:  
  print(x)

Ford  
Volvo  
BMW

## Adding Array Elements

You can use the append() method to add an element to an array.

### **Example**

Add one more element to the cars array:

cars.append("Honda")

['Ford', 'Volvo', 'BMW', 'Honda']

## Removing Array Elements

You can use the pop() method to remove an element from the array.

### **Example**

Delete the second element of the cars array:

cars.pop(1)

['Ford', 'BMW']

You can also use the remove() method to remove an element from the array.

### **Example**

Delete the element that has the value "Volvo":

cars.remove("Volvo")

['Ford', 'BMW']

**Note:** The list's remove() method only removes the first occurrence of the specified value.

## Array Methods

Python has a set of built-in methods that you can use on lists/arrays.

|  |  |
| --- | --- |
| **Method** | **Description** |
| [append()](https://www.w3schools.com/python/ref_list_append.asp) | Adds an element at the end of the list |
| [clear()](https://www.w3schools.com/python/ref_list_clear.asp) | Removes all the elements from the list |
| [copy()](https://www.w3schools.com/python/ref_list_copy.asp) | Returns a copy of the list |
| [count()](https://www.w3schools.com/python/ref_list_count.asp) | Returns the number of elements with the specified value |
| [extend()](https://www.w3schools.com/python/ref_list_extend.asp) | Add the elements of a list (or any iterable), to the end of the current list |
| [index()](https://www.w3schools.com/python/ref_list_index.asp) | Returns the index of the first element with the specified value |
| [insert()](https://www.w3schools.com/python/ref_list_insert.asp) | Adds an element at the specified position |
| [pop()](https://www.w3schools.com/python/ref_list_pop.asp) | Removes the element at the specified position |
| [remove()](https://www.w3schools.com/python/ref_list_remove.asp) | Removes the first item with the specified value |
| [reverse()](https://www.w3schools.com/python/ref_list_reverse.asp) | Reverses the order of the list |
| [sort()](https://www.w3schools.com/python/ref_list_sort.asp) | Sorts the list |

**Note:** Python does not have built-in support for Arrays, but Python Lists can be used instead.

# **Python Classes and Objects**

## Python Classes/Objects

Python is an object oriented programming language.

Almost everything in Python is an object, with its properties and methods.

A Class is like an object constructor, or a "blueprint" for creating objects.

## Create a Class

To create a class, use the keyword class:

### **Example**[**Get your own Python Server**](https://www.w3schools.com/python/python_server.asp)

Create a class named MyClass, with a property named x:

class MyClass:  
  x = 5

<class '\_\_main\_\_.MyClass'>

## Create Object

Now we can use the class named MyClass to create objects:

### **Example**

Create an object named p1, and print the value of x:

p1 = MyClass()  
print(p1.x)

5

## The \_\_init\_\_() Function

The examples above are classes and objects in their simplest form, and are not really useful in real life applications.

To understand the meaning of classes we have to understand the built-in \_\_init\_\_() function.

All classes have a function called \_\_init\_\_(), which is always executed when the class is being initiated.

Use the \_\_init\_\_() function to assign values to object properties, or other operations that are necessary to do when the object is being created:

### **Example**

Create a class named Person, use the \_\_init\_\_() function to assign values for name and age:

class Person:  
  def \_\_init\_\_(self, name, age):  
    self.name = name  
    self.age = age  
  
p1 = Person("John", 36)  
  
print(p1.name)  
print(p1.age)

John  
36

**Note:** The \_\_init\_\_() function is called automatically every time the class is being used to create a new object.

## The \_\_str\_\_() Function

The \_\_str\_\_() function controls what should be returned when the class object is represented as a string.

If the \_\_str\_\_() function is not set, the string representation of the object is returned:

### **Example**

The string representation of an object WITHOUT the \_\_str\_\_() function:

class Person:  
  def \_\_init\_\_(self, name, age):  
    self.name = name  
    self.age = age  
  
p1 = Person("John", 36)  
  
print(p1)

<\_\_main\_\_.Person object at 0x15039e602100>

### **Example**

The string representation of an object WITH the \_\_str\_\_() function:

class Person:  
  def \_\_init\_\_(self, name, age):  
    self.name = name  
    self.age = age  
  
  def \_\_str\_\_(self):  
    return f"{self.name}({self.age})"  
  
p1 = Person("John", 36)  
  
print(p1)

John(36)

## Object Methods

Objects can also contain methods. Methods in objects are functions that belong to the object.

Let us create a method in the Person class:

### **Example**

Insert a function that prints a greeting, and execute it on the p1 object:

class Person:  
  def \_\_init\_\_(self, name, age):  
    self.name = name  
    self.age = age  
  
  def myfunc(self):  
    print("Hello my name is " + self.name)  
  
p1 = Person("John", 36)  
p1.myfunc()

Hello my name is John

**Note:** The self parameter is a reference to the current instance of the class, and is used to access variables that belong to the class.

## The self Parameter

The self parameter is a reference to the current instance of the class, and is used to access variables that belongs to the class.

It does not have to be named self , you can call it whatever you like, but it has to be the first parameter of any function in the class:

### **Example**

Use the words mysillyobject and abc instead of self:

class Person:  
  def \_\_init\_\_(mysillyobject, name, age):  
    mysillyobject.name = name  
    mysillyobject.age = age  
  
  def myfunc(abc):  
    print("Hello my name is " + abc.name)  
  
p1 = Person("John", 36)  
p1.myfunc()

Hello my name is John

## Modify Object Properties

You can modify properties on objects like this:

### **Example**

Set the age of p1 to 40:

p1.age = 40

**40**

## Delete Object Properties

You can delete properties on objects by using the del keyword:

### **Example**

Delete the age property from the p1 object:

del p1.age

Traceback (most recent call last):  
  File "demo\_class7.py", line 13, in <module>  
    print(p1.age)  
AttributeError: 'Person' object has no attribute 'age'

## Delete Objects

You can delete objects by using the del keyword:

### **Example**

Delete the p1 object:

del p1

Traceback (most recent call last):  
  File "demo\_class8.py", line 13, in <module>  
    print(p1)  
NameError: 'p1' is not defined

## The pass Statement

class definitions cannot be empty, but if you for some reason have a class definition with no content, put in the pass statement to avoid getting an error.

### **Example**

class Person:  
  pass

# **Python Inheritance**

## Python Inheritance

Inheritance allows us to define a class that inherits all the methods and properties from another class.

**Parent class** is the class being inherited from, also called base class.

**Child class** is the class that inherits from another class, also called derived class.

## Create a Parent Class

Any class can be a parent class, so the syntax is the same as creating any other class:

### **Example**

Create a class named Person, with firstname and lastname properties, and a printname method:

class Person:  
  def \_\_init\_\_(self, fname, lname):  
    self.firstname = fname  
    self.lastname = lname  
  
  def printname(self):  
    print(self.firstname, self.lastname)  
  
#Use the Person class to create an object, and then execute the printname method:  
  
x = Person("John", "Doe")  
x.printname()

John Doe

## Create a Child Class

To create a class that inherits the functionality from another class, send the parent class as a parameter when creating the child class:

### **Example**

Create a class named Student, which will inherit the properties and methods from the Person class:

class Student(Person):  
  pass

**Note:** Use the pass keyword when you do not want to add any other properties or methods to the class.

Now the Student class has the same properties and methods as the Person class.

### **Example**

Use the Student class to create an object, and then execute the printname method:

x = Student("Mike", "Olsen")  
x.printname()

## Add the \_\_init\_\_() Function

So far we have created a child class that inherits the properties and methods from its parent.

We want to add the \_\_init\_\_() function to the child class (instead of the pass keyword).

**Note:** The \_\_init\_\_() function is called automatically every time the class is being used to create a new object.

### **Example**

Add the \_\_init\_\_() function to the Student class:

class Student(Person):  
  def \_\_init\_\_(self, fname, lname):  
    #add properties etc.

When you add the \_\_init\_\_() function, the child class will no longer inherit the parent's \_\_init\_\_() function.

**Note:** The child's \_\_init\_\_() function **overrides** the inheritance of the parent's \_\_init\_\_() function.

To keep the inheritance of the parent's \_\_init\_\_() function, add a call to the parent's \_\_init\_\_() function:

### **Example**

class Student(Person):  
  def \_\_init\_\_(self, fname, lname):  
    Person.\_\_init\_\_(self, fname, lname)

Now we have successfully added the \_\_init\_\_() function, and kept the inheritance of the parent class, and we are ready to add functionality in the \_\_init\_\_() function.

## Use the super() Function

Python also has a super() function that will make the child class inherit all the methods and properties from its parent:

### **Example**

class Student(Person):  
  def \_\_init\_\_(self, fname, lname):  
    super().\_\_init\_\_(fname, lname)

By using the super() function, you do not have to use the name of the parent element, it will automatically inherit the methods and properties from its parent.

## Add Properties

### **Example**

Add a property called graduationyear to the Student class:

class Student(Person):  
  def \_\_init\_\_(self, fname, lname):  
    super().\_\_init\_\_(fname, lname)  
    self.graduationyear = 2019

2019

In the example below, the year 2019 should be a variable, and passed into the Student class when creating student objects. To do so, add another parameter in the \_\_init\_\_() function:

### **Example**

Add a year parameter, and pass the correct year when creating objects:

class Student(Person):  
  def \_\_init\_\_(self, fname, lname, year):  
    super().\_\_init\_\_(fname, lname)  
    self.graduationyear = year  
  
x = Student("Mike", "Olsen", 2019)

2019

## Add Methods

### **Example**

Add a method called welcome to the Student class:

class Student(Person):  
  def \_\_init\_\_(self, fname, lname, year):  
    super().\_\_init\_\_(fname, lname)  
    self.graduationyear = year  
  
  def welcome(self):  
    print("Welcome", self.firstname, self.lastname, "to the class of", self.graduationyear)

Welcome Mike Olsen to the class of 2019

If you add a method in the child class with the same name as a function in the parent class, the inheritance of the parent method will be overridden.

# **Python Iterators**

## Python Iterators

An iterator is an object that contains a countable number of values.

An iterator is an object that can be iterated upon, meaning that you can traverse through all the values.

Technically, in Python, an iterator is an object which implements the iterator protocol, which consist of the methods \_\_iter\_\_() and \_\_next\_\_().

## Iterator vs Iterable

Lists, tuples, dictionaries, and sets are all iterable objects. They are iterable containers which you can get an iterator from.

All these objects have a iter() method which is used to get an iterator:

### **Example**

Return an iterator from a tuple, and print each value:

mytuple = ("apple", "banana", "cherry")  
myit = iter(mytuple)  
  
print(next(myit))  
print(next(myit))  
print(next(myit))

apple  
banana  
cherry

Even strings are iterable objects, and can return an iterator:

### **Example**

Strings are also iterable objects, containing a sequence of characters:

mystr = "banana"  
myit = iter(mystr)  
print(next(myit))  
print(next(myit))  
print(next(myit))  
print(next(myit))  
print(next(myit))  
print(next(myit))  
b  
a  
n  
a  
n  
a

## Looping Through an Iterator

We can also use a for loop to iterate through an iterable object:

### **Example**

Iterate the values of a tuple:

mytuple = ("apple", "banana", "cherry")  
  
for x in mytuple:  
  print(x)

apple  
banana  
cherry

### **Example**

Iterate the characters of a string:

mystr = "banana"  
  
for x in mystr:  
  print(x)

b  
a  
n  
a  
n  
a

The for loop actually creates an iterator object and executes the next() method for each loop.

## Create an Iterator

To create an object/class as an iterator you have to implement the methods \_\_iter\_\_() and \_\_next\_\_() to your object.

As you have learned in the [Python Classes/Objects](https://www.w3schools.com/python/python_classes.asp) chapter, all classes have a function called \_\_init\_\_(), which allows you to do some initializing when the object is being created.

The \_\_iter\_\_() method acts similar, you can do operations (initializing etc.), but must always return the iterator object itself.

The \_\_next\_\_() method also allows you to do operations, and must return the next item in the sequence.

### **Example**

Create an iterator that returns numbers, starting with 1, and each sequence will increase by one (returning 1,2,3,4,5 etc.):

class MyNumbers:  
  def \_\_iter\_\_(self):  
    self.a = 1  
    return self  
  
  def \_\_next\_\_(self):  
    x = self.a  
    self.a += 1  
    return x  
  
myclass = MyNumbers()  
myiter = iter(myclass)  
  
print(next(myiter))  
print(next(myiter))  
print(next(myiter))  
print(next(myiter))  
print(next(myiter))

1  
2  
3  
4  
5

## StopIteration

The example above would continue forever if you had enough next() statements, or if it was used in a for loop.

To prevent the iteration from going on forever, we can use the StopIteration statement.

In the \_\_next\_\_() method, we can add a terminating condition to raise an error if the iteration is done a specified number of times:

### **Example**

Stop after 20 iterations:

class MyNumbers:  
  def \_\_iter\_\_(self):  
    self.a = 1  
    return self  
  
  def \_\_next\_\_(self):  
    if self.a <= 20:  
      x = self.a  
      self.a += 1  
      return x  
    else:  
      raise StopIteration  
  
myclass = MyNumbers()  
myiter = iter(myclass)  
  
for x in myiter:  
  print(x)

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20

# **Python Polymorphism:-**

The word "polymorphism" means "many forms", and in programming it refers to methods/functions/operators with the same name that can be executed on many objects or classes.

## Function Polymorphism

An example of a Python function that can be used on different objects is the len() function.

### **String**

For strings len() returns the number of characters:

### **Example**

x = "Hello World!"  
  
print(len(x))

**Output:**

12

### **Tuple**

For tuples len() returns the number of items in the tuple:

### **Example**

mytuple = ("apple", "banana", "cherry")  
  
print(len(mytuple))

Output:

3

### **Dictionary**

For dictionaries len() returns the number of key/value pairs in the dictionary:

### **Example**

thisdict = {  
  "brand": "Ford",  
  "model": "Mustang",  
  "year": 1964  
}  
  
print(len(thisdict))

**Output**:

3

## Class Polymorphism

Polymorphism is often used in Class methods, where we can have multiple classes with the same method name.

For example, say we have three classes: Car, Boat, and Plane, and they all have a method called move():

### **Example**

Different classes with the same method:

class Car:  
  def \_\_init\_\_(self, brand, model):  
    self.brand = brand  
    self.model = model  
  
  def move(self):  
    print("Drive!")  
  
class Boat:  
  def \_\_init\_\_(self, brand, model):  
    self.brand = brand  
    self.model = model  
  
  def move(self):  
    print("Sail!")  
  
class Plane:  
  def \_\_init\_\_(self, brand, model):  
    self.brand = brand  
    self.model = model  
  
  def move(self):  
    print("Fly!")  
  
car1 = Car("Ford", "Mustang")       #Create a Car class  
boat1 = Boat("Ibiza", "Touring 20") #Create a Boat class  
plane1 = Plane("Boeing", "747")     #Create a Plane class  
  
for x in (car1, boat1, plane1):  
  x.move()

Output:

Drive!

Sail!

Fly!

Look at the for loop at the end. Because of polymorphism we can execute the same method for all three classes.

**Inheritance Class Polymorphism**

What about classes with child classes with the same name? Can we use polymorphism there?

Yes. If we use the example above and make a parent class called Vehicle, and make Car, Boat, Plane child classes of Vehicle, the child classes inherits the Vehicle methods, but can override them:

### **Example**

Create a class called Vehicle and make Car, Boat, Plane child classes of Vehicle:

class Vehicle:  
  def \_\_init\_\_(self, brand, model):  
    self.brand = brand  
    self.model = model  
  
  def move(self):  
    print("Move!")  
  
class Car(Vehicle):  
  pass  
  
class Boat(Vehicle):  
  def move(self):  
    print("Sail!")  
  
class Plane(Vehicle):  
  def move(self):  
    print("Fly!")  
  
car1 = Car("Ford", "Mustang") #Create a Car object  
boat1 = Boat("Ibiza", "Touring 20") #Create a Boat object  
plane1 = Plane("Boeing", "747") #Create a Plane object  
  
for x in (car1, boat1, plane1):  
  print(x.brand)  
  print(x.model)  
  x.move()

**Output**:

Ford!

Mustang!

Move!

Ibiza!

Touring 20

Sail!

Boeing!

747

Fly!

Child classes inherits the properties and methods from the parent class.

In the example above you can see that the Car class is empty, but it inherits brand, model, and move() from Vehicle.

The Boat and Plane classes also inherit brand, model, and move() from Vehicle, but they both override the move() method.

# Because of polymorphism we can execute the same method for all classes. **Python Scope:-**

A variable is only available from inside the region it is created. This is called **scope**.

## Local Scope

## A variable created inside a function belongs to the local scope of that function, and can only be used inside that function.

### **Example**

A variable created inside a function is available inside that function:

def myfunc():  
  x = 300  
  print(x)  
  
myfunc()

**Output**:

300

### **Function Inside Function**

As explained in the example above, the variable x is not available outside the function, but it is available for any function inside the function:

### **Example**

The local variable can be accessed from a function within the function:

def myfunc():  
  x = 300  
  def myinnerfunc():  
    print(x)  
  myinnerfunc()  
  
myfunc()

**Output**:

300

## Global Scope

A variable created in the main body of the Python code is a global variable and belongs to the global scope.

Global variables are available from within any scope, global and local.

### **Example**

A variable created outside of a function is global and can be used by anyone:

x = 300  
  
def myfunc():  
  print(x)  
  
myfunc()  
  
print(x)

**Output**:

300

300

### **Naming Variables**

If you operate with the same variable name inside and outside of a function, Python will treat them as two separate variables, one available in the global scope (outside the function) and one available in the local scope (inside the function):

### **Example**

The function will print the local x, and then the code will print the global x:

x = 300  
def myfunc():  
  x = 200  
  print(x)  
myfunc()  
print(x)

**Output**:

200

300

## Global Keyword

If you need to create a global variable, but are stuck in the local scope, you can use the global keyword.

The global keyword makes the variable global.

### **Example**

If you use the global keyword, the variable belongs to the global scope:

def myfunc():  
  global x  
  x = 300  
myfunc()  
print(x)

**Output**:

300

Also, use the global keyword if you want to make a change to a global variable inside a function.

### **Example**

To change the value of a global variable inside a function, refer to the variable by using the global keyword:

x = 300  
  
def myfunc():  
  global x  
  x = 200  
myfunc()  
print(x)

output:

200

# **Python Modules:-**

## What is a Module?

Consider a module to be the same as a code library.

A file containing a set of functions you want to include in your application.

## Create a Module

To create a module just save the code you want in a file with the file extension .py:

### **Example**

Save this code in a file named mymodule.py

def greeting(name):  
  print("Hello, " + name)

## Use a Module

Now we can use the module we just created, by using the import statement:

### **Example**

Import the module named mymodule, and call the greeting function:

import mymodule  
  
mymodule.greeting("Jonathan")

**Output**:

Hello,Jonathan

**Note:** When using a function from a module, use the syntax: module\_name.function\_name.

## Variables in Module:-

The module can contain functions, as already described, but also variables of all types (arrays, dictionaries, objects etc):

### **Example**

Save this code in the file mymodule.py

person1 = {  
  "name": "John",  
  "age": 36,  
  "country": "Norway"  
}

### **Example**

Import the module named mymodule, and access the person1 dictionary:

import mymodule  
  
a = mymodule.person1["age"]  
print(a)

**Output**:

36

# **Python Datetime**

## Python Dates

A date in Python is not a data type of its own, but we can import a module named datetime to work with dates as date objects.

### **Example**

Import the datetime module and display the current date:

import datetime  
  
x = datetime.datetime.now()  
print(x)

2024-01-13 09:31:02.855479

## Date Output

When we execute the code from the example above the result will be:

2024-01-13 09:29:40.289998

The date contains year, month, day, hour, minute, second, and microsecond.

The datetime module has many methods to return information about the date object.

Here are a few examples, you will learn more about them later in this chapter:

### **Example**

Return the year and name of weekday:

import datetime  
  
x = datetime.datetime.now()  
  
print(x.year)  
print(x.strftime("%A"))

2024  
Saturday

## Creating Date Objects

To create a date, we can use the datetime() class (constructor) of the datetime module.

The datetime() class requires three parameters to create a date: year, month, day.

### **Example**

Create a date object:

import datetime  
  
x = datetime.datetime(2020, 5, 17)  
  
print(x)

2024  
Saturday

The datetime() class also takes parameters for time and timezone (hour, minute, second, microsecond, tzone), but they are optional, and has a default value of 0, (None for timezone).

## The strftime() Method

The datetime object has a method for formatting date objects into readable strings.

The method is called strftime(), and takes one parameter, format, to specify the format of the returned string:

### **Example**

Display the name of the month:

import datetime  
  
x = datetime.datetime(2018, 6, 1)  
  
print(x.strftime("%B"))

June

A reference of all the legal format codes:

|  |  |  |  |
| --- | --- | --- | --- |
| **Directive** | **Description** | **Example** | **Try it** |
| %a | Weekday, short version | Wed | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_a) |
| %A | Weekday, full version | Wednesday | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_a2) |
| %w | Weekday as a number 0-6, 0 is Sunday | 3 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_w) |
| %d | Day of month 01-31 | 31 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_d) |
| %b | Month name, short version | Dec | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_b) |
| %B | Month name, full version | December | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_b2) |
| %m | Month as a number 01-12 | 12 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_m) |
| %y | Year, short version, without century | 18 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_y) |
| %Y | Year, full version | 2018 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_y2) |
| %H | Hour 00-23 | 17 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_h2) |
| %I | Hour 00-12 | 05 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_i2) |
| %p | AM/PM | PM | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_p) |
| %M | Minute 00-59 | 41 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_m2) |
| %S | Second 00-59 | 08 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_s2) |
| %f | Microsecond 000000-999999 | 548513 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_f) |
| %z | UTC offset | +0100 |  |
| %Z | Timezone | CST |  |
| %j | Day number of year 001-366 | 365 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_j) |
| %U | Week number of year, Sunday as the first day of week, 00-53 | 52 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_u2) |
| %W | Week number of year, Monday as the first day of week, 00-53 | 52 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_w2) |
| %c | Local version of date and time | Mon Dec 31 17:41:00 2018 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_c) |
| %C | Century | 20 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_century) |
| %x | Local version of date | 12/31/18 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_x) |
| %X | Local version of time | 17:41:00 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_x2) |
| %% | A % character | % | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_percent) |
| %G | ISO 8601 year | 2018 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_g) |
| %u | ISO 8601 weekday (1-7) | 1 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_u) |
| %V | ISO 8601 weeknumber (01-53) | 01 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_datetime_strftime_v) |

# **Python Math**

Python has a set of built-in math functions, including an extensive math module, that allows you to perform mathematical tasks on numbers.

## Built-in Math Functions

The min() and max() functions can be used to find the lowest or highest value in an iterable:

### **Example**

x = min(5, 10, 25)  
y = max(5, 10, 25)  
print(x)  
print(y)

5  
25

The abs() function returns the absolute (positive) value of the specified number:

### **Example**

x = abs(-7.25)  
print(x)

7.25

The pow(x, y) function returns the value of x to the power of y (xy).

### **Example**

Return the value of 4 to the power of 3 (same as 4 \* 4 \* 4):

x = pow(4, 3)  
  
print(x)

64

## The Math Module

Python has also a built-in module called math, which extends the list of mathematical functions.

To use it, you must import the math module:

**import math**

When you have imported the math module, you can start using methods and constants of the module.

The math.sqrt() method for example, returns the square root of a number:

### **Example**

import math  
  
x = math.sqrt(64)  
  
print(x)

8.0

The math.ceil() method rounds a number upwards to its nearest integer, and the math.floor() method rounds a number downwards to its nearest integer, and returns the result:

### **Example**

import math  
x = math.ceil(1.4)  
y = math.floor(1.4)  
  
print(x) # returns 2  
print(y) # returns 1

2  
1

The math.pi constant, returns the value of PI (3.14...):

### **Example**

import math  
  
x = math.pi  
  
print(x)

3.141592653589793

# **Python JSON**

JSON is a syntax for storing and exchanging data.

JSON is text, written with JavaScript object notation.

## JSON in Python

Python has a built-in package called json, which can be used to work with JSON data.

### **Example**

### Import the json module:

import json

## Parse JSON - Convert from JSON to Python

If you have a JSON string, you can parse it by using the json.loads() method.

The result will be a [Python dictionary](https://www.w3schools.com/python/python_dictionaries.asp).

### **Example**

Convert from JSON to Python:

import json  
  
# some JSON:  
x =  '{ "name":"John", "age":30, "city":"New York"}'  
  
# parse x:  
y = json.loads(x)  
  
# the result is a Python dictionary:  
print(y["age"])

## Convert from Python to JSON

If you have a Python object, you can convert it into a JSON string by using the json.dumps() method.

### **Example**

Convert from Python to JSON:

import json  
  
# a Python object (dict):  
x = {  
  "name": "John",  
  "age": 30,  
  "city": "New York"  
}  
  
# convert into JSON:  
y = json.dumps(x)  
  
# the result is a JSON string:  
print(y)

30

You can convert Python objects of the following types, into JSON strings:

* dict
* list
* tuple
* string
* int
* float
* True
* False
* None

### **Example**

Convert Python objects into JSON strings, and print the values:

import json  
  
print(json.dumps({"name": "John", "age": 30}))  
print(json.dumps(["apple", "bananas"]))  
print(json.dumps(("apple", "bananas")))  
print(json.dumps("hello"))  
print(json.dumps(42))  
print(json.dumps(31.76))  
print(json.dumps(True))  
print(json.dumps(False))  
print(json.dumps(None))

{"name": "John", "age": 30}  
["apple", "bananas"]  
["apple", "bananas"]  
"hello"  
42  
31.76  
true  
false  
null

When you convert from Python to JSON, Python objects are converted into the JSON (JavaScript) equivalent:

|  |  |
| --- | --- |
| **Python** | **JSON** |
| dict | Object |
| list | Array |
| tuple | Array |
| str | String |
| int | Number |
| float | Number |
| True | true |
| False | false |
| None | null |

### **Example**

Convert a Python object containing all the legal data types:

import json  
  
x = {  
  "name": "John",  
  "age": 30,  
  "married": True,  
  "divorced": False,  
  "children": ("Ann","Billy"),  
  "pets": None,  
  "cars": [  
    {"model": "BMW 230", "mpg": 27.5},  
    {"model": "Ford Edge", "mpg": 24.1}  
  ]  
}  
  
print(json.dumps(x))  
{"name": "John", "age": 30, "married": true, "divorced": false, "children": ["Ann","Billy"], "pets": null, "cars": [{"model": "BMW 230", "mpg": 27.5}, {"model": "Ford Edge", "mpg": 24.1}]}

## Format the Result

The example above prints a JSON string, but it is not very easy to read, with no indentations and line breaks.

The json.dumps() method has parameters to make it easier to read the result:

### **Example**

Use the indent parameter to define the numbers of indents:

json.dumps(x, indent=4)

import json

x = {

"name": "John",

"age": 30,

"married": True,

"divorced": False,

"children": ("Ann","Billy"),

"pets": None,

"cars": [

{"model": "BMW 230", "mpg": 27.5},

{"model": "Ford Edge", "mpg": 24.1}

]

}

# use four indents to make it easier to read the result:

print(json.dumps(x, indent=4))

{  
    "name": "John",  
    "age": 30,  
    "married": true,  
    "divorced": false,  
    "children": [  
        "Ann",  
        "Billy"  
    ],  
    "pets": null,  
    "cars": [  
        {  
            "model": "BMW 230",  
            "mpg": 27.5  
        },  
        {  
            "model": "Ford Edge",  
            "mpg": 24.1  
        }  
    ]  
}

You can also define the separators, default value is (", ", ": "), which means using a comma and a space to separate each object, and a colon and a space to separate keys from values:

### **Example**

Use the separators parameter to change the default separator:

json.dumps(x, indent=4, separators=(". ", " = "))  
{  
    "name" = "John".  
    "age" = 30.

{  
    "name" = "John".  
    "age" = 30.  
    "married" = true.  
    "divorced" = false.  
    "children" = [  
        "Ann".  
        "Billy"  
    ].  
    "pets" = null.  
    "cars" = [  
        {  
            "model" = "BMW 230".  
            "mpg" = 27.5  
        }.  
        {  
            "model" = "Ford Edge".  
            "mpg" = 24.1  
        }  
    ]  
}    "divorced" = false.  
    "children" = [  
        "Ann".  
        "Billy"  
    ].  
    "pets" = null.  
    "cars" = [  
        {  
            "model" = "BMW 230".  
            "mpg" = 27.5  
        }.  
        {  
            "model" = "Ford Edge".  
            "mpg" = 24.1  
        }  
    ]  
}

## Order the Result

The json.dumps() method has parameters to order the keys in the result:

### **Example**

Use the sort\_keys parameter to specify if the result should be sorted or not:

json.dumps(x, indent=4, sort\_keys=True)

import json

x = {

"name": "John",

"age": 30,

"married": True,

"divorced": False,

"children": ("Ann","Billy"),

"pets": None,

"cars": [

{"model": "BMW 230", "mpg": 27.5},

{"model": "Ford Edge", "mpg": 24.1}

]

}

# sort the result alphabetically by keys:

print(json.dumps(x, indent=4, sort\_keys=True))

{  
    "age": 30,  
    "cars": [  
        {  
            "model": "BMW 230",  
            "mpg": 27.5  
        },  
        {  
            "model": "Ford Edge",  
            "mpg": 24.1  
        }  
    ],  
    "children": [  
        "Ann",  
        "Billy"  
    ],  
    "divorced": false,  
    "married": true,  
    "name": "John",  
    "pets": null  
}

# **Python RegEx**

A RegEx, or Regular Expression, is a sequence of characters that forms a search pattern.

RegEx can be used to check if a string contains the specified search pattern.

## RegEx Module

Python has a built-in package called re, which can be used to work with Regular Expressions.

Import the re module:

import re

## RegEx in Python

When you have imported the re module, you can start using regular expressions:

### **Example**

Search the string to see if it starts with "The" and ends with "Spain":

import re  
  
txt = "The rain in Spain"  
x = re.search("^The.\*Spain$", txt)

## RegEx Functions

The re module offers a set of functions that allows us to search a string for a match:

|  |  |
| --- | --- |
| **Function** | **Description** |
| [findall](https://www.w3schools.com/python/python_regex.asp#findall) | Returns a list containing all matches |
| [search](https://www.w3schools.com/python/python_regex.asp#search) | Returns a [Match object](https://www.w3schools.com/python/python_regex.asp#matchobject) if there is a match anywhere in the string |
| [split](https://www.w3schools.com/python/python_regex.asp#split) | Returns a list where the string has been split at each match |
| [sub](https://www.w3schools.com/python/python_regex.asp#sub) | Replaces one or many matches with a string |

## Metacharacters

Metacharacters are characters with a special meaning:

|  |  |  |  |
| --- | --- | --- | --- |
| **Character** | **Description** | **Example** | **Try it** |
| [] | A set of characters | "[a-m]" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta1) |
| \ | Signals a special sequence (can also be used to escape special characters) | "\d" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta2) |
| . | Any character (except newline character) | "he..o" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta3) |
| ^ | Starts with | "^hello" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta4) |
| $ | Ends with | "planet$" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta5) |
| \* | Zero or more occurrences | "he.\*o" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta6) |
| + | One or more occurrences | "he.+o" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta7) |
| ? | Zero or one occurrences | "he.?o" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta10) |
| {} | Exactly the specified number of occurrences | "he.{2}o" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta8) |
| | | Either or | "falls|stays" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_meta9) |
| () | Capture and group |  |  |

## Special Sequences

A special sequence is a \ followed by one of the characters in the list below, and has a special meaning:

|  |  |  |  |
| --- | --- | --- | --- |
| **Character** | **Description** | **Example** | **Try it** |
| \A | Returns a match if the specified characters are at the beginning of the string | "\AThe" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq1) |
| \b | Returns a match where the specified characters are at the beginning or at the end of a word (the "r" in the beginning is making sure that the string is being treated as a "raw string") | r"\bain"  r"ain\b" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq2)  [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq2-2) |
| \B | Returns a match where the specified characters are present, but NOT at the beginning (or at the end) of a word (the "r" in the beginning is making sure that the string is being treated as a "raw string") | r"\Bain"  r"ain\B" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq3)  [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq3-2) |
| \d | Returns a match where the string contains digits (numbers from 0-9) | "\d" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq4) |
| \D | Returns a match where the string DOES NOT contain digits | "\D" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq5) |
| \s | Returns a match where the string contains a white space character | "\s" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq6) |
| \S | Returns a match where the string DOES NOT contain a white space character | "\S" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq7) |
| \w | Returns a match where the string contains any word characters (characters from a to Z, digits from 0-9, and the underscore \_ character) | "\w" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq8) |
| \W | Returns a match where the string DOES NOT contain any word characters | "\W" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq9) |
| \Z | Returns a match if the specified characters are at the end of the string | "Spain\Z" | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_seq10) |

## Sets

A set is a set of characters inside a pair of square brackets [] with a special meaning:

|  |  |  |
| --- | --- | --- |
| **Set** | **Description** | **Try it** |
| [arn] | Returns a match where one of the specified characters (a, r, or n) is present | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set1) |
| [a-n] | Returns a match for any lower case character, alphabetically between a and n | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set2) |
| [^arn] | Returns a match for any character EXCEPT a, r, and n | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set3) |
| [0123] | Returns a match where any of the specified digits (0, 1, 2, or 3) are present | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set4) |
| [0-9] | Returns a match for any digit between 0 and 9 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set5) |
| [0-5][0-9] | Returns a match for any two-digit numbers from 00 and 59 | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set6) |
| [a-zA-Z] | Returns a match for any character alphabetically between a and z, lower case OR upper case | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set7) |
| [+] | In sets, +, \*, ., |, (), $,{} has no special meaning, so [+] means: return a match for any + character in the string | [Try it »](https://www.w3schools.com/python/trypython.asp?filename=demo_regex_set8) |

## The findall() Function

The findall() function returns a list containing all matches.

### **Example**

Print a list of all matches:

import re  
  
txt = "The rain in Spain"  
x = re.findall("ai", txt)  
print(x)

['ai', 'ai']

The list contains the matches in the order they are found.

If no matches are found, an empty list is returned:

### **Example**

Return an empty list if no match was found:

import re  
  
txt = "The rain in Spain"  
x = re.findall("Portugal", txt)  
print(x)

[]  
No match

## The search() Function

The search() function searches the string for a match, and returns a [Match object](https://www.w3schools.com/python/python_regex.asp#matchobject) if there is a match.

If there is more than one match, only the first occurrence of the match will be returned:

### **Example**

Search for the first white-space character in the string:

import re  
  
txt = "The rain in Spain"  
x = re.search("\s", txt)  
  
print("The first white-space character is located in position:", x.start())

If no matches are found, the value None is returned:

### **Example**

Make a search that returns no match:

import re  
  
txt = "The rain in Spain"  
x = re.search("Portugal", txt)  
print(x)

​

None

## The split() Function

The split() function returns a list where the string has been split at each match:

### **Example**

Split at each white-space character:

import re  
  
txt = "The rain in Spain"  
x = re.split("\s", txt)  
print(x)

['The', 'rain', 'in', 'Spain']

You can control the number of occurrences by specifying the maxsplit parameter:

### **Example**

Split the string only at the first occurrence:

import re  
txt = "The rain in Spain"  
x = re.split("\s", txt, 1)  
print(x)

['The', 'rain in Spain']

## The sub() Function

The sub() function replaces the matches with the text of your choice:

### **Example**

Replace every white-space character with the number 9:

import re  
  
txt = "The rain in Spain"  
x = re.sub("\s", "9", txt)  
print(x)

The9rain9in Spain

You can control the number of replacements by specifying the count parameter:

### **Example**

Replace the first 2 occurrences:

import re  
  
txt = "The rain in Spain"  
x = re.sub("\s", "9", txt, 2)  
print(x)

The9rain9in Spain

## Match Object

A Match Object is an object containing information about the search and the result.

**Note:** If there is no match, the value None will be returned, instead of the Match Object.

### **Example**

Do a search that will return a Match Object:

import re  
txt = "The rain in Spain"  
x = re.search("ai", txt)  
print(x) #this will print an object

<\_sre.SRE\_Match object; span=(5, 7), match='ai'>

The Match object has properties and methods used to retrieve information about the search, and the result:

.span() returns a tuple containing the start-, and end positions of the match.  
.string returns the string passed into the function  
.group() returns the part of the string where there was a match

### **Example**

Print the position (start- and end-position) of the first match occurrence.

The regular expression looks for any words that starts with an upper case "S":

import re  
  
txt = "The rain in Spain"  
x = re.search(r"\bS\w+", txt)  
print(**x.span()**)

(12, 17)

### **Example**

Print the string passed into the function:

import re  
txt = "The rain in Spain"  
x = re.search(r"\bS\w+", txt)  
print(**x.string**)

The rain in Spain

### **Example**

Print the part of the string where there was a match.

The regular expression looks for any words that starts with an upper case "S":

import re  
  
txt = "The rain in Spain"  
x = re.search(r"\bS\w+", txt)  
print(**x.group()**)

Spain

**Note:** If there is no match, the value None will be returned, instead of the Match Object.

## What is PIP?

PIP is a package manager for Python packages, or modules if you like.

**Note:** If you have Python version 3.4 or later, PIP is included by default.

## What is a Package?

A package contains all the files you need for a module.

Modules are Python code libraries you can include in your project.

## Check if PIP is Installed

Navigate your command line to the location of Python's script directory, and type the following:

### **Example**

Check PIP version

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-**32\Scripts>pip --version**

## Install PIP

If you do not have PIP installed, you can download and install it from this page: <https://pypi.org/project/pip/>

## Download a Package

Downloading a package is very easy.

Open the command line interface and tell PIP to download the package you want.

Navigate your command line to the location of Python's script directory, and type the following:

### **Example**

Download a package named "camelcase":

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>pip install camelcase

Now you have downloaded and installed your first package!

## Using a Package

Once the package is installed, it is ready to use.

Import the "camelcase" package into your project.

### **Example**

Import and use "camelcase":

import camelcase  
  
c = camelcase.CamelCase()  
  
txt = "hello world"  
  
print(c.hump(txt))

import camelcase

c = camelcase.CamelCase()

txt = "lorem ipsum dolor sit amet"

print(c.hump(txt))

Lorem Ipsum Dolor Sit Amet

#This method capitalizes the first letter of each word.

## Find Packages

Find more packages at <https://pypi.org/>.

## Remove a Package

Use the uninstall command to remove a package:

### **Example**

Uninstall the package named "camelcase":

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>pip uninstall camelcase

The PIP Package Manager will ask you to confirm that you want to remove the camelcase package:

Uninstalling camelcase-02.1:  
  **Would remove**:  
    c:\users\Your Name\appdata\local\programs\python\python36-32\lib\site-packages\camelcase-0.2-py3.6.egg-info  
    c:\users\Your Name\appdata\local\programs\python\python36-32\lib\site-packages\camelcase\\*  
Proceed (y/n)?

Press y and the package will be removed.

## List Packages

Use the list command to list all the packages installed on your system:

### **Example**

List installed packages:

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>pip list

Result:

Package         Version  
-----------------------  
camelcase       0.2  
mysql-connector 2.1.6  
pip             18.1  
pymongo         3.6.1  
setuptools      39.0.1

# **Python Try Except**

The try block lets you test a block of code for errors.

The except block lets you handle the error.

The else block lets you execute code when there is no error.

The finally block lets you execute code, regardless of the result of the try- and except blocks.

## Exception Handling

When an error occurs, or exception as we call it, Python will normally stop and generate an error message.

These exceptions can be handled using the try statement:

### **Example**

The try block will generate an exception, because x is not defined:

try:  
  print(x)  
except:  
  print("An exception occurred")

An exception occurred

Since the try block raises an error, the except block will be executed.

Without the try block, the program will crash and raise an error:

### **Example**

This statement will raise an error, because x is not defined:

print(x)

Traceback (most recent call last):  
  File "demo\_try\_except\_error.py", line 3, in <module>  
    print(x)  
NameError: name 'x' is not defined

## Many Exceptions

You can define as many exception blocks as you want, e.g. if you want to execute a special block of code for a special kind of error:

### **Example**

Print one message if the try block raises a NameError and another for other errors:

try:  
  print(x)  
except NameError:  
  print("Variable x is not defined")  
except:  
  print("Something else went wrong"

Variable x is not defined

## Else

You can use the else keyword to define a block of code to be executed if no errors were raised:

### **Example**

In this example, the try block does not generate any error:

try:  
  print("Hello")  
except:  
  print("Something went wrong")  
else:  
  print("Nothing went wrong")

Hello  
Nothing went wrong

## Finally

The finally block, if specified, will be executed regardless if the try block raises an error or not.

### **Example**

try:  
  print(x)  
except:  
  print("Something went wrong")  
finally:  
  print("The 'try except' is finished")

Something went wrong  
The 'try except' is finished

This can be useful to close objects and clean up resources:

### **Example**

Try to open and write to a file that is not writable:

try:  
  f = open("demofile.txt")  
  try:  
    f.write("Lorum Ipsum")  
  except:  
    print("Something went wrong when writing to the file")  
  finally:  
    f.close()  
except:  
  print("Something went wrong when opening the file")

Something went wrong when writing to the file

The program can continue, without leaving the file object open.

## Raise an exception

As a Python developer you can choose to throw an exception if a condition occurs.

To throw (or raise) an exception, use the raise keyword.

### **Example**

Raise an error and stop the program if x is lower than 0:

x = -1  
  
if x < 0:  
  raise Exception("Sorry, no numbers below zero")

Traceback (most recent call last):  
  File "demo\_ref\_keyword\_raise.py", line 4, in <module>  
    raise Exception("Sorry, no numbers below zero")  
Exception: Sorry, no numbers below zero

The raise keyword is used to raise an exception.

You can define what kind of error to raise, and the text to print to the user.

### **Example**

Raise a TypeError if x is not an integer:

x = "hello"  
  
if not type(x) is int:  
  raise TypeError("Only integers are allowed")

Traceback (most recent call last):  
  File "demo\_ref\_keyword\_raise2.py", line 4, in <module>  
    raise TypeError("Only integers are allowed")  
TypeError: Only integers are allowed

# ***Python User Input***

## User Input

Python allows for user input.

That means we are able to ask the user for input.

The method is a bit different in Python 3.6 than Python 2.7.

Python 3.6 uses the input() method.

Python 2.7 uses the raw\_input() method.

The following example asks for the username, and when you entered the username, it gets printed on the screen:

Enter username:

### **Python 3.6**

username = input("Enter username:")  
print("Username is: " + username)  
Enter username:

### **Python 2.7**

username = raw\_input("Enter username:")  
print("Username is: " + username)  
Enter username:

Python stops executing when it comes to the input() function, and continues when the user has given some input.

# **Python String Formatting**

To make sure a string will display as expected, we can format the result with the format() method.

## String format()

The format() method allows you to format selected parts of a string.

Sometimes there are parts of a text that you do not control, maybe they come from a database, or user input?

To control such values, add placeholders (curly brackets {}) in the text, and run the values through the format() method:

### **Example**

Add a placeholder where you want to display the price:

price = 49  
txt = "The price is {} dollars"  
print(txt.format(price))

The price is 49 dollars

You can add parameters inside the curly brackets to specify how to convert the value:

### **Example**

Format the price to be displayed as a number with two decimals:

txt = "The price is {:.2f} dollars"

The price is 49.00 dollars

Check out all formatting types in our [String format() Reference](https://www.w3schools.com/python/ref_string_format.asp).

## Multiple Values

If you want to use more values, just add more values to the format() method:

print(txt.format(price, itemno, count))

And add more placeholders:

### **Example**

quantity = 3  
itemno = 567  
price = 49  
myorder = "I want {} pieces of item number {} for {:.2f} dollars."  
print(myorder.format(quantity, itemno, price))

I want 3 pieces of item number 567 for 49.00 dollars.

## Index Numbers

You can use index numbers (a number inside the curly brackets {0}) to be sure the values are placed in the correct placeholders:

### **Example**

quantity = 3  
itemno = 567  
price = 49  
myorder = "I want {0} pieces of item number {1} for {2:.2f} dollars."  
print(myorder.format(quantity, itemno, price))

I want 3 pieces of item number 567 for 49.00 dollars.

Also, if you want to refer to the same value more than once, use the index number:

### **Example**

age = 36  
name = "John"  
txt = "His name is {1}. {1} is {0} years old."  
print(txt.format(age, name))

His name is John. John is 36 years old.

## Named Indexes

You can also use named indexes by entering a name inside the curly brackets {carname}, but then you must use names when you pass the parameter values txt.format(carname = "Ford"):

### **Example**

myorder = "I have a {carname}, it is a {model}."  
print(myorder.format(carname = "Ford", model = "Mustang"))

I have a Ford, it is a Mustang.

**File Handling**

# **Python File Open:-**

File handling is an important part of any web application.

Python has several functions for creating, reading, updating, and deleting files.

## File Handling

The key function for working with files in Python is the open() function.

The open() function takes two parameters; filename, and mode.

There are four different methods (modes) for opening a file:

"r" - Read - Default value. Opens a file for reading, error if the file does not exist

"a" - Append - Opens a file for appending, creates the file if it does not exist

"w" - Write - Opens a file for writing, creates the file if it does not exist

"x" - Create - Creates the specified file, returns an error if the file exists

In addition you can specify if the file should be handled as binary or text mode

"t" - Text - Default value. Text mode

"b" - Binary - Binary mode (e.g. images)

## Syntax:-

To open a file for reading it is enough to specify the name of the file:

f = open("demofile.txt")

The code above is the same as:

f = open("demofile.txt", "rt")

Because "r" for read, and "t" for text are the default values, you do not need to specify them

**Python File Open:-**

**Open a File on the Server:-**

Assume we have the following file, located in the same folder as Python:

demofile.txt

Hello! Welcome to demofile.txt  
This file is for testing purposes.  
Good Luck!

To open the file, use the built-in open() function.

The open() function returns a file object, which has a read() method for reading the content of the file:

### **Example:-**

Open a file on a different location:

f = open("D:\\myfiles\welcome.txt", "r")  
print(f.read())

**Output:-**

Hello Welcome to demofile.txt

This file is for testing purposes

Good luck!

### **Example:-**

Return the 5 first characters of the file:

f = open("demofile.txt", "r")  
print(f.read(**5**))

**Output:-**

Hello

## Read Lines:-

## You can return one line by using the readline() method:

### **Example:-**

Read one line of the file:

f = open("demofile.txt", "r")  
print(f.readline())

Output:

Hello welcome to demofile.txt

By calling readline() two times, you can read the two first lines:

### **Example:-**

Read two lines of the file:

f = open("demofile.txt", "r")  
print(f.readline())  
print(f.readline())

Output:-

Hello welcome to demofile.txt

This file is for testing purposes

Good luck!

By looping through the lines of the file, you can read the whole file, line by line:

### Example:

### Loop through the file line

### by line:

f = open("demofile.txt", "r")  
for x in f:  
  print(x)

Output:

Hello welcome to demofile.txt

This file is for testing purposes

Good luck!

## Close Files:-

It is a good practice to always close the file when you are done with it.

### **Example:-**

Close the file when you are finish with it:

f = open("demofile.txt", "r")  
print(f.readline())  
f.close()

**Output:**

Hello welcome to demofile.txt

# **Python File Write:-**

## Write to an Existing File

To write to an existing file, you must add a parameter to the open() function:

"a" - Append - will append to the end of the file

"w" - Write - will overwrite any existing content

### **Example:-**

Open the file "demofile2.txt" and append content to the file:

f = open("demofile2.txt", "a")  
f.write("Now the file has more content!")  
f.close()  
  
#open and read the file after the appending:  
f = open("demofile2.txt", "r")  
print(f.read())

Output:

Hello welcome to demofile2.txt

This file is for testing purposes

Good luck! Now the files is more than content

### **Example**

Open the file "demofile3.txt" and overwrite the content:

f = open("demofile3.txt", "w")  
f.write("Woops! I have deleted the content!")  
f.close()  
  
#open and read the file after the overwriting:  
f = open("demofile3.txt", "r")  
print(f.read())

**Output:**

Woops! I have deleted the content

**Note:** the "w" method will overwrite the entire file.

## Create a New File

To create a new file in Python, use the open() method, with one of the following parameters:

"x" - Create - will create a file, returns an error if the file exist

"a" - Append - will create a file if the specified file does not exist

"w" - Write - will create a file if the specified file does not exist

### **Example**

Create a file called "myfile.txt":

f = open("myfile.txt", "x")

Result: a new empty file is created!

### **Example**

Create a new file if it does not exist:

f = open("myfile.txt", "w")

# **Python Delete File:-**

## Delete a File:

## Check if File exist:

To avoid getting an error, you might want to check if the file exists before you try to delete it:

**Example**

Check if file exists, then delete it:

import os  
if os.path.exists("demofile.txt"):  
  os.remove("demofile.txt")  
else:  
  print("The file does not exist")

**Delete Folder**

To delete an entire folder, use the os.rmdir() method:

### **Example**

Remove the folder "myfolder":

import os  
os.rmdir("myfolder")

**Note:** You can only remove empty folders.

To delete a file, you must import the OS module, and run its os.remove() function:

### **Example**

Remove the file "demofile.txt":

import os  
os.remove("demofile.txt")

# **Machine Learning**

Machine Learning is making the computer learn from studying data and statistics.

Machine Learning is a step into the direction of artificial intelligence (AI).

Machine Learning is a program that analyses data and learns to predict the outcome.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Carname | Color | Age | Speed | AutoPass |
| BMW | red | 5 | 99 | Y |
| Volvo | black | 7 | 86 | Y |
| VW | gray | 8 | 87 | N |
| VW | white | 7 | 88 | Y |
| Ford | white | 2 | 111 | Y |
| VW | white | 17 | 86 | Y |
| Tesla | red | 2 | 103 | Y |
| BMW | black | 9 | 87 | Y |
| Volvo | gray | 4 | 94 | N |
| Ford | white | 11 | 78 | N |
| Toyota | gray | 12 | 77 | N |
| VW | white | 9 | 85 | N |
| Toyota | blue | 6 | 86 | Y |

## Where To Start?

In this tutorial we will go back to mathematics and study statistics, and how to calculate important numbers based on data sets.

We will also learn how to use various Python modules to get the answers we need.

And we will learn how to make functions that are able to predict the outcome based on what we have learned.

## Data Set

In the mind of a computer, a data set is any collection of data. It can be anything from an array to a complete database.

Example of an array:

[99,86,87,88,111,86,103,87,94,78,77,85,86]

Example of a database:

By looking at the array, we can guess that the average value is probably around 80 or 90, and we are also able to determine the highest value and the lowest value, but what else can we do?

And by looking at the database we can see that the most popular color is white, and the oldest car is 17 years, but what if we could predict if a car had an AutoPass, just by looking at the other values?

That is what Machine Learning is for! Analyzing data and predicting the outcome!

In Machine Learning it is common to work with very large data sets. In this tutorial we will try to make it as easy as possible to understand the different concepts of machine learning, and we will work with small easy-to-understand data sets.

## Data Types

To analyze data, it is important to know what type of data we are dealing with.

We can split the data types into three main categories:

* **Numerical**
* **Categorical**
* **Ordinal**

**Numerical** data are numbers, and can be split into two numerical categories:

* Discrete Data  
  - counted data that are limited to integers. Example: The number of cars passing by.
* Continuous Data  
  - measured data that can be any number. Example: The price of an item, or the size of an item

**Categorical** data are values that cannot be measured up against each other. Example: a color value, or any yes/no values.

**Ordinal** data are like categorical data, but can be measured up against each other. Example: school grades where A is better than B and so on.

By knowing the data type of your data source, you will be able to know what technique to use when analyzing them.

You will learn more about statistics and analyzing data in the next chapters.

# **Machine Learning - Mean Median Mode**

## Mean, Median, and Mode

What can we learn from looking at a group of numbers?

In Machine Learning (and in mathematics) there are often three values that interests us:

* **Mean** - The average value
* **Median** - The mid point value
* **Mode** - The most common value

Example: We have registered the speed of 13 cars:

speed = [99,86,87,88,111,86,103,87,94,78,77,85,86]

What is the average, the middle, or the most common speed value?

## Mean

The mean value is the average value.

To calculate the mean, find the sum of all values, and divide the sum by the number of values:

(99+86+87+88+111+86+103+87+94+78+77+85+86) / 13 = 89.77

The NumPy module has a method for this. Learn about the NumPy module in our [NumPy Tutorial](https://www.w3schools.com/python/numpy/default.asp).

### **Example**

Use the NumPy mean() method to find the average speed:

import numpy  
  
speed = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
x = numpy.mean(speed)  
  
print(x)

## Median

The median value is the value in the middle, after you have sorted all the values:

77, 78, 85, 86, 86, 86, 87, 87, 88, 94, 99, 103, 111

It is important that the numbers are sorted before you can find the median.

The NumPy module has a method for this:

### **Example**

Use the NumPy median() method to find the middle value:

import numpy  
  
speed = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
x = numpy.median(speed)  
  
print(x)

If there are two numbers in the middle, divide the sum of those numbers by two.

77, 78, 85, 86, 86, 86, 87, 87, 94, 98, 99, 103  
  
(86 + 87) / 2 = 86.5

### **Example**

Using the NumPy module:

import numpy  
  
speed = [99,86,87,88,86,103,87,94,78,77,85,86]  
  
x = numpy.median(speed)  
  
print(x)

## Mode

The Mode value is the value that appears the most number of times:

99, 86, 87, 88, 111, 86, 103, 87, 94, 78, 77, 85, 86 = 86

The SciPy module has a method for this. Learn about the SciPy module in our [SciPy Tutorial](https://www.w3schools.com/python/scipy_intro.asp).

### **Example**

Use the SciPy mode() method to find the number that appears the most:

from scipy import stats  
  
speed = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
x = stats.mode(speed)  
  
print(x)

# **Machine Learning - Standard Deviation**

## What is Standard Deviation?

Standard deviation is a number that describes how spread out the values are.

A low standard deviation means that most of the numbers are close to the mean (average) value.

A high standard deviation means that the values are spread out over a wider range.

Example: This time we have registered the speed of 7 cars:

speed = [86,87,88,86,87,85,86]

The standard deviation is:

0.9

Meaning that most of the values are within the range of 0.9 from the mean value, which is 86.4.

Let us do the same with a selection of numbers with a wider range:

speed = [32,111,138,28,59,77,97]

The standard deviation is:

37.85

Meaning that most of the values are within the range of 37.85 from the mean value, which is 77.4.

As you can see, a higher standard deviation indicates that the values are spread out over a wider range.

The NumPy module has a method to calculate the standard deviation:

### **Example**

Use the NumPy std() method to find the standard deviation:

import numpy  
  
speed = [86,87,88,86,87,85,86]  
  
x = numpy.std(speed)  
  
print(x)

### **Example**

import numpy  
  
speed = [32,111,138,28,59,77,97]  
  
x = numpy.std(speed)  
  
print(x)

## Variance

Variance is another number that indicates how spread out the values are.

In fact, if you take the square root of the variance, you get the standard deviation!

Or the other way around, if you multiply the standard deviation by itself, you get the variance!

To calculate the variance you have to do as follows:

1. Find the mean:

(32+111+138+28+59+77+97) / 7 = 77.4

2. For each value: find the difference from the mean:

 32 - 77.4 = -45.4  
111 - 77.4 =  33.6  
138 - 77.4 =  60.6  
 28 - 77.4 = -49.4  
 59 - 77.4 = -18.4  
 77 - 77.4 = - 0.4  
 97 - 77.4 =  19.6

3. For each difference: find the square value:

(-45.4)2 = 2061.16  
 (33.6)2 = 1128.96  
 (60.6)2 = 3672.36  
(-49.4)2 = 2440.36  
(-18.4)2 =  338.56  
(- 0.4)2 =    0.16  
 (19.6)2 =  384.16

4. The variance is the average number of these squared differences:

(2061.16+1128.96+3672.36+2440.36+338.56+0.16+384.16) / 7 = 1432.2

Luckily, NumPy has a method to calculate the variance:

### **Example**

Use the NumPy var() method to find the variance:

import numpy  
  
speed = [32,111,138,28,59,77,97]  
  
x = numpy.var(speed)  
  
print(x)

## Standard Deviation

As we have learned, the formula to find the standard deviation is the square root of the variance:

√1432.25 = 37.85

Or, as in the example from before, use the NumPy to calculate the standard deviation:

### **Example**

Use the NumPy std() method to find the standard deviation:

import numpy  
  
speed = [32,111,138,28,59,77,97]  
  
x = numpy.std(speed)  
  
print(x)

## Symbols

Standard Deviation is often represented by the symbol Sigma: σ

Variance is often represented by the symbol Sigma Squared: σ2

# **Machine Learning - Percentiles**

## What are Percentiles?

Percentiles are used in statistics to give you a number that describes the value that a given percent of the values are lower than.

Example: Let's say we have an array of the ages of all the people that live in a street.

ages = [5,31,43,48,50,41,7,11,15,39,80,82,32,2,8,6,25,36,27,61,31]

What is the 75. percentile? The answer is 43, meaning that 75% of the people are 43 or younger.

The NumPy module has a method for finding the specified percentile:

### **Example**

Use the NumPy percentile() method to find the percentiles:

import numpy  
  
ages = [5,31,43,48,50,41,7,11,15,39,80,82,32,2,8,6,25,36,27,61,31]  
  
x = numpy.percentile(ages, 75)  
  
print(x)

### **Example**

What is the age that 90% of the people are younger than?

import numpy  
  
ages = [5,31,43,48,50,41,7,11,15,39,80,82,32,2,8,6,25,36,27,61,31]  
  
x = numpy.percentile(ages, 90)  
  
print(x)

# **Machine Learning - Data Distribution**

## Data Distribution

Earlier in this tutorial we have worked with very small amounts of data in our examples, just to understand the different concepts.

In the real world, the data sets are much bigger, but it can be difficult to gather real world data, at least at an early stage of a project.

### **How Can we Get Big Data Sets?**

To create big data sets for testing, we use the Python module NumPy, which comes with a number of methods to create random data sets, of any size.

### **Example**

Create an array containing 250 random floats between 0 and 5:

import numpy  
  
x = numpy.random.uniform(0.0, 5.0, 250)  
  
print(x)

## Histogram

To visualize the data set we can draw a histogram with the data we collected.

We will use the Python module Matplotlib to draw a histogram.

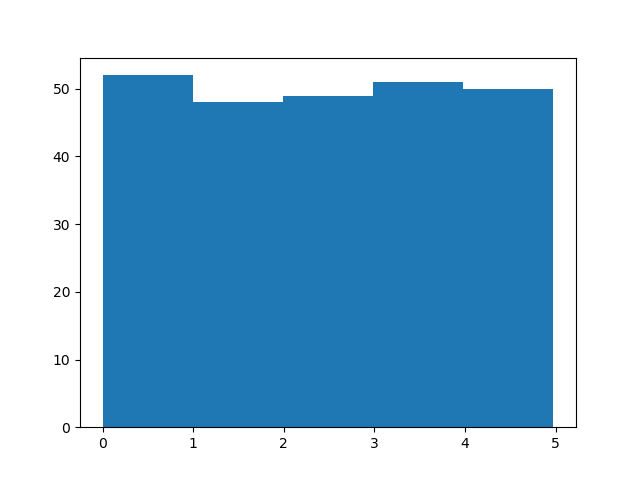
Learn about the Matplotlib module in our [Matplotlib Tutorial](https://www.w3schools.com/python/matplotlib_intro.asp).

### **Example**

Draw a histogram:

import numpy  
import matplotlib.pyplot as plt  
  
x = numpy.random.uniform(0.0, 5.0, 250)  
  
plt.hist(x, 5)  
plt.show()

### **Result:**



### **Histogram Explained**

We use the array from the example above to draw a histogram with 5 bars.

The first bar represents how many values in the array are between 0 and 1.

The second bar represents how many values are between 1 and 2.

Etc.

Which gives us this result:

* 52 values are between 0 and 1
* 48 values are between 1 and 2
* 49 values are between 2 and 3
* 51 values are between 3 and 4
* 50 values are between 4 and 5

**Note:** The array values are random numbers and will not show the exact same result on your computer.

## Big Data Distributions

An array containing 250 values is not considered very big, but now you know how to create a random set of values, and by changing the parameters, you can create the data set as big as you want.

### **Example**

Create an array with 100000 random numbers, and display them using a histogram with 100 bars:

import numpy  
import matplotlib.pyplot as plt  
  
x = numpy.random.uniform(0.0, 5.0, 100000)  
  
plt.hist(x, 100)  
plt.show()

# **Machine Learning - Normal Data Distribution**

## Normal Data Distribution

In the previous chapter we learned how to create a completely random array, of a given size, and between two given values.

In this chapter we will learn how to create an array where the values are concentrated around a given value.

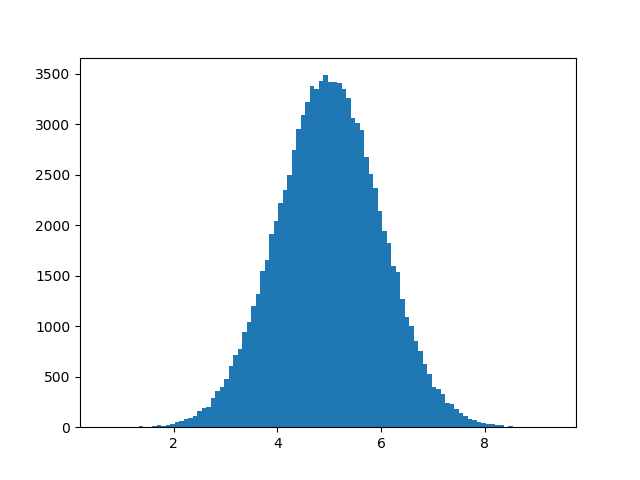
In probability theory this kind of data distribution is known as the normal data distribution, or the Gaussian data distribution, after the mathematician Carl Friedrich Gauss who came up with the formula of this data distribution.

### **Example**

A typical normal data distribution:

import numpy  
import matplotlib.pyplot as plt  
  
x = numpy.random.normal(5.0, 1.0, 100000)  
  
plt.hist(x, 100)  
plt.show()

### **Result:**



**Note:** A normal distribution graph is also known as the bell curve because of it's characteristic shape of a bell.

### **Histogram Explained**

We use the array from the numpy.random.normal() method, with 100000 values,  to draw a histogram with 100 bars.

We specify that the mean value is 5.0, and the standard deviation is 1.0.

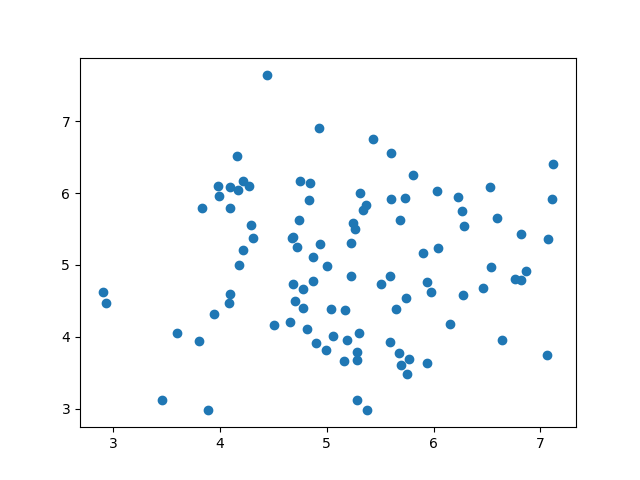
Meaning that the values should be concentrated around 5.0, and rarely further away than 1.0 from the mean.

And as you can see from the histogram, most values are between 4.0 and 6.0, with a top at approximately 5.0.

# **Machine Learning - Scatter Plot**

## Scatter Plot

A scatter plot is a diagram where each value in the data set is represented by a dot.



The Matplotlib module has a method for drawing scatter plots, it needs two arrays of the same length, one for the values of the x-axis, and one for the values of the y-axis:

x = [5,7,8,7,2,17,2,9,4,11,12,9,6]

y = [99,86,87,88,111,86,103,87,94,78,77,85,86]

The x array represents the age of each car.

The y array represents the speed of each car.

### **Example**

Use the scatter() method to draw a scatter plot diagram:

import matplotlib.pyplot as plt  
  
x = [5,7,8,7,2,17,2,9,4,11,12,9,6]  
y = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
plt.scatter(x, y)  
plt.show()

### **Result:**



### **Scatter Plot Explained**

The x-axis represents ages, and the y-axis represents speeds.

What we can read from the diagram is that the two fastest cars were both 2 years old, and the slowest car was 12 years old.

**Note:** It seems that the newer the car, the faster it drives, but that could be a coincidence, after all we only registered 13 cars.

## Random Data Distributions

In Machine Learning the data sets can contain thousands-, or even millions, of values.

You might not have real world data when you are testing an algorithm, you might have to use randomly generated values.

As we have learned in the previous chapter, the NumPy module can help us with that!

Let us create two arrays that are both filled with 1000 random numbers from a normal data distribution.

The first array will have the mean set to 5.0 with a standard deviation of 1.0.

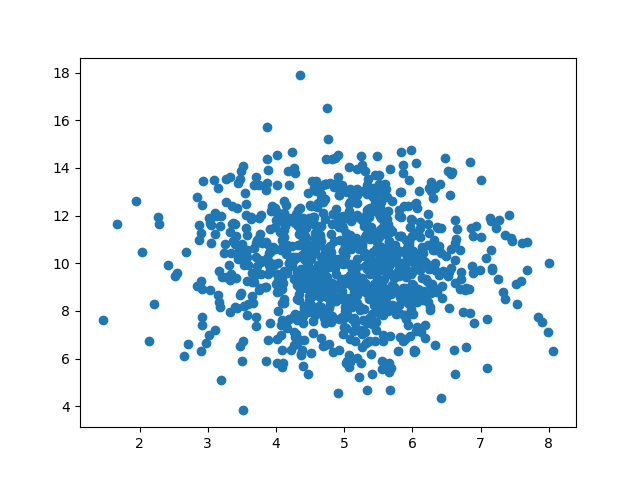
The second array will have the mean set to 10.0 with a standard deviation of 2.0:

### **Example**

A scatter plot with 1000 dots:

import numpy  
import matplotlib.pyplot as plt  
  
x = numpy.random.normal(5.0, 1.0, 1000)  
y = numpy.random.normal(10.0, 2.0, 1000)  
  
plt.scatter(x, y)  
plt.show()

### **Result:**



### **Scatter Plot Explained**

We can see that the dots are concentrated around the value 5 on the x-axis, and 10 on the y-axis.

We can also see that the spread is wider on the y-axis than on the x-axis.

# **Machine Learning - Linear Regression**

## Regression

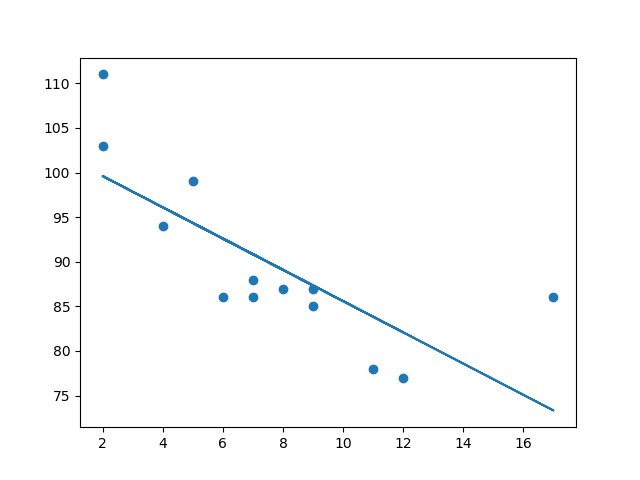
The term regression is used when you try to find the relationship between variables.

In Machine Learning, and in statistical modeling, that relationship is used to predict the outcome of future events.

## Linear Regression

Linear regression uses the relationship between the data-points to draw a straight line through all them.

This line can be used to predict future values.



In Machine Learning, predicting the future is very important.

## How Does it Work?

Python has methods for finding a relationship between data-points and to draw a line of linear regression. We will show you how to use these methods instead of going through the mathematic formula.

In the example below, the x-axis represents age, and the y-axis represents speed. We have registered the age and speed of 13 cars as they were passing a tollbooth. Let us see if the data we collected could be used in a linear regression:

### **Example**

Start by drawing a scatter plot:

import matplotlib.pyplot as plt  
  
x = [5,7,8,7,2,17,2,9,4,11,12,9,6]  
y = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
plt.scatter(x, y)  
plt.show()

### **Result:**

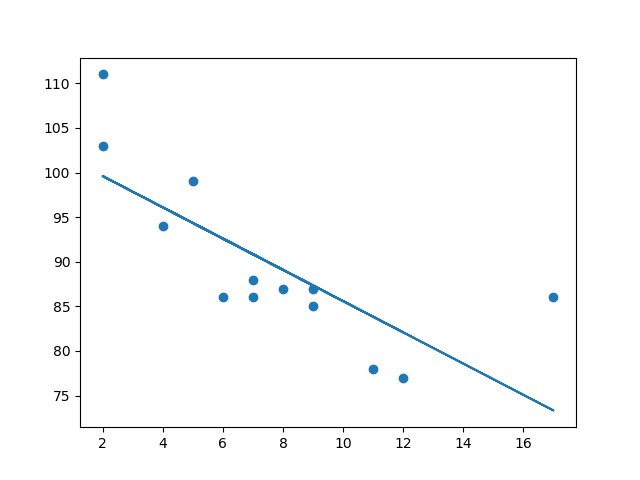


### **Example**

Import scipy and draw the line of Linear Regression:

import matplotlib.pyplot as plt  
from scipy import stats  
  
x = [5,7,8,7,2,17,2,9,4,11,12,9,6]  
y = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
slope, intercept, r, p, std\_err = stats.linregress(x, y)  
  
def myfunc(x):  
  return slope \* x + intercept  
  
mymodel = list(map(myfunc, x))  
  
plt.scatter(x, y)  
plt.plot(x, mymodel)  
plt.show()

### **Result:**



### **Example Explained**

Import the modules you need.

You can learn about the Matplotlib module in our [Matplotlib Tutorial](https://www.w3schools.com/python/matplotlib_intro.asp).

You can learn about the SciPy module in our [SciPy Tutorial](https://www.w3schools.com/python/scipy_intro.asp).

import matplotlib.pyplot as plt  
from scipy import stats

Create the arrays that represent the values of the x and y axis:

x = [5,7,8,7,2,17,2,9,4,11,12,9,6]  
y = [99,86,87,88,111,86,103,87,94,78,77,85,86]

Execute a method that returns some important key values of Linear Regression:

slope, intercept, r, p, std\_err = stats.linregress(x, y)

Create a function that uses the slope and intercept values to return a new value. This new value represents where on the y-axis the corresponding x value will be placed:

def myfunc(x):  
  return slope \* x + intercept

Run each value of the x array through the function. This will result in a new array with new values for the y-axis:

mymodel = list(map(myfunc, x))

Draw the original scatter plot:

plt.scatter(x, y)

Draw the line of linear regression:

plt.plot(x, mymodel)

Display the diagram:

plt.show()

## R for Relationship

It is important to know how the relationship between the values of the x-axis and the values of the y-axis is, if there are no relationship the linear regression can not be used to predict anything.

This relationship - the coefficient of correlation - is called r.

The r value ranges from -1 to 1, where 0 means no relationship, and 1 (and -1) means 100% related.

Python and the Scipy module will compute this value for you, all you have to do is feed it with the x and y values.

### **Example**

How well does my data fit in a linear regression?

from scipy import stats  
  
x = [5,7,8,7,2,17,2,9,4,11,12,9,6]  
y = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
slope, intercept, r, p, std\_err = stats.linregress(x, y)  
  
print(r)

**Note:** The result -0.76 shows that there is a relationship, not perfect, but it indicates that we could use linear regression in future predictions.

## Predict Future Values

Now we can use the information we have gathered to predict future values.

Example: Let us try to predict the speed of a 10 years old car.

To do so, we need the same myfunc() function from the example above:

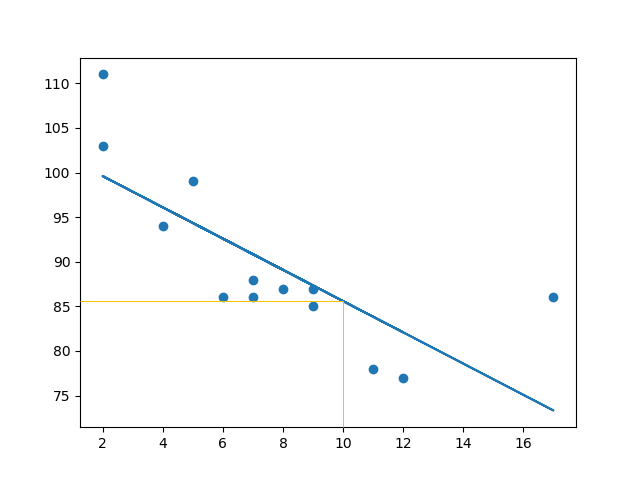
def myfunc(x):  
  return slope \* x + intercept

### **Example**

Predict the speed of a 10 years old car:

from scipy import stats  
  
x = [5,7,8,7,2,17,2,9,4,11,12,9,6]  
y = [99,86,87,88,111,86,103,87,94,78,77,85,86]  
  
slope, intercept, r, p, std\_err = stats.linregress(x, y)  
  
def myfunc(x):  
  return slope \* x + intercept  
  
speed = myfunc(10)  
  
print(speed)

The example predicted a speed at 85.6, which we also could read from the diagram:



## Bad Fit?

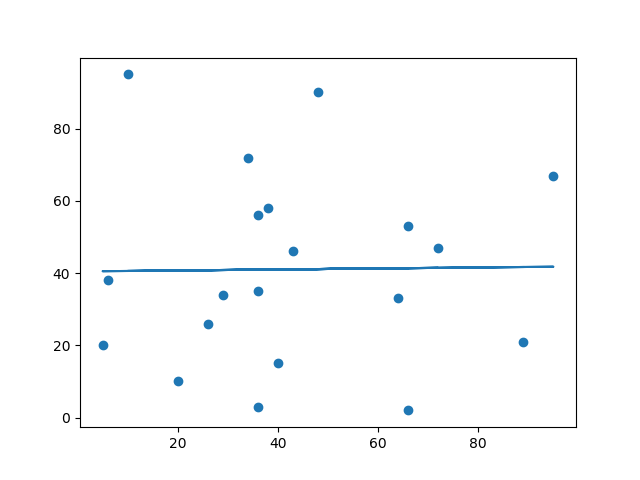
Let us create an example where linear regression would not be the best method to predict future values.

### **Example**

These values for the x- and y-axis should result in a very bad fit for linear regression:

import matplotlib.pyplot as plt  
from scipy import stats  
  
x = [89,43,36,36,95,10,66,34,38,20,26,29,48,64,6,5,36,66,72,40]  
y = [21,46,3,35,67,95,53,72,58,10,26,34,90,33,38,20,56,2,47,15]  
  
slope, intercept, r, p, std\_err = stats.linregress(x, y)  
  
def myfunc(x):  
  return slope \* x + intercept  
  
mymodel = list(map(myfunc, x))  
  
plt.scatter(x, y)  
plt.plot(x, mymodel)  
plt.show()

### **Result:**



And the r for relationship?

### **Example**

You should get a very low r value.

import numpy  
from scipy import stats  
  
x = [89,43,36,36,95,10,66,34,38,20,26,29,48,64,6,5,36,66,72,40]  
y = [21,46,3,35,67,95,53,72,58,10,26,34,90,33,38,20,56,2,47,15]  
  
slope, intercept, r, p, std\_err = stats.linregress(x, y)  
  
print(r)

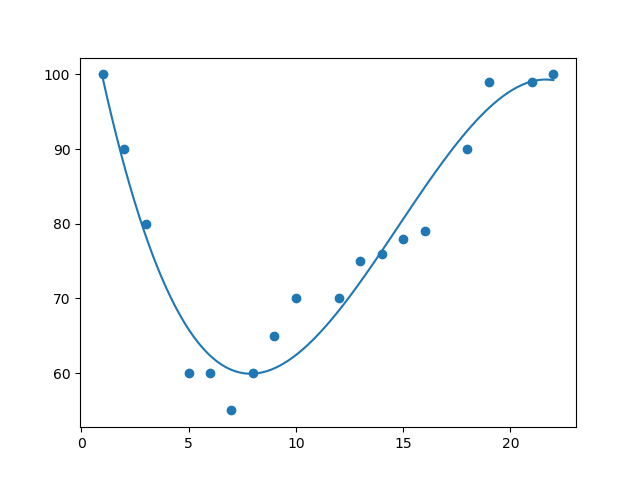
The result: 0.013 indicates a very bad relationship, and tells us that this data set is not suitable for linear regression.

# **Machine Learning - Polynomial Regression**

## Polynomial Regression

If your data points clearly will not fit a linear regression (a straight line through all data points), it might be ideal for polynomial regression.

Polynomial regression, like linear regression, uses the relationship between the variables x and y to find the best way to draw a line through the data points.



## How Does it Work?

Python has methods for finding a relationship between data-points and to draw a line of polynomial regression. We will show you how to use these methods instead of going through the mathematic formula.

In the example below, we have registered 18 cars as they were passing a certain tollbooth.

We have registered the car's speed, and the time of day (hour) the passing occurred.

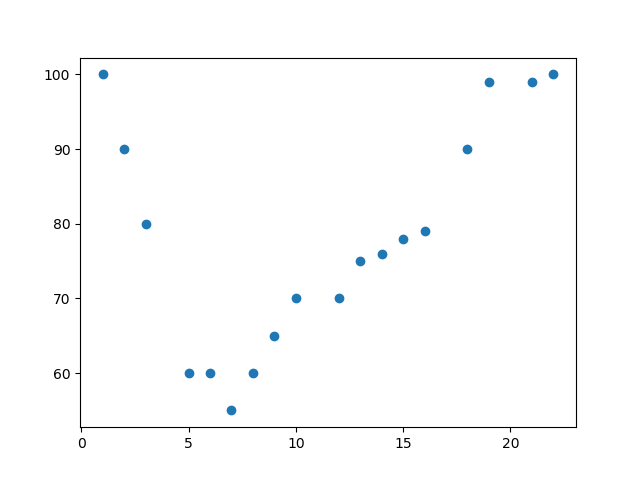
The x-axis represents the hours of the day and the y-axis represents the speed:

### **Example**

Start by drawing a scatter plot:

import matplotlib.pyplot as plt  
  
x = [1,2,3,5,6,7,8,9,10,12,13,14,15,16,18,19,21,22]  
y = [100,90,80,60,60,55,60,65,70,70,75,76,78,79,90,99,99,100]  
  
plt.scatter(x, y)  
plt.show()

### **Result:**

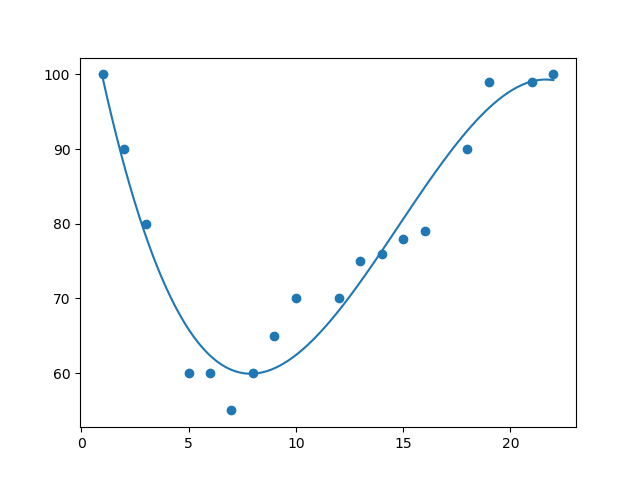


### **Example**

Import numpy and matplotlib then draw the line of Polynomial Regression:

import numpy  
import matplotlib.pyplot as plt  
  
x = [1,2,3,5,6,7,8,9,10,12,13,14,15,16,18,19,21,22]  
y = [100,90,80,60,60,55,60,65,70,70,75,76,78,79,90,99,99,100]  
  
mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))  
  
myline = numpy.linspace(1, 22, 100)  
  
plt.scatter(x, y)  
plt.plot(myline, mymodel(myline))  
plt.show()

### **Result:**



### **Example Explained**

Import the modules you need.

You can learn about the NumPy module in our [NumPy Tutorial](https://www.w3schools.com/python/numpy/default.asp).

You can learn about the SciPy module in our [SciPy Tutorial](https://www.w3schools.com/python/scipy_intro.asp).

import numpy  
import matplotlib.pyplot as plt

Create the arrays that represent the values of the x and y axis:

x = [1,2,3,5,6,7,8,9,10,12,13,14,15,16,18,19,21,22]  
y = [100,90,80,60,60,55,60,65,70,70,75,76,78,79,90,99,99,100]

NumPy has a method that lets us make a polynomial model:

mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))

Then specify how the line will display, we start at position 1, and end at position 22:

myline = numpy.linspace(1, 22, 100)

Draw the original scatter plot:

plt.scatter(x, y)

Draw the line of polynomial regression:

plt.plot(myline, mymodel(myline))

Display the diagram:

plt.show()

## R-Squared

It is important to know how well the relationship between the values of the x- and y-axis is, if there are no relationship the polynomial regression can not be used to predict anything.

The relationship is measured with a value called the r-squared.

The r-squared value ranges from 0 to 1, where 0 means no relationship, and 1 means 100% related.

Python and the Sklearn module will compute this value for you, all you have to do is feed it with the x and y arrays:

### **Example**

How well does my data fit in a polynomial regression?

import numpy  
from sklearn.metrics import r2\_score  
  
x = [1,2,3,5,6,7,8,9,10,12,13,14,15,16,18,19,21,22]  
y = [100,90,80,60,60,55,60,65,70,70,75,76,78,79,90,99,99,100]  
  
mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))  
  
print(r2\_score(y, mymodel(x)))

**Note:** The result 0.94 shows that there is a very good relationship, and we can use polynomial regression in future predictions.

## Predict Future Values

Now we can use the information we have gathered to predict future values.

Example: Let us try to predict the speed of a car that passes the tollbooth at around the time 17:00:

To do so, we need the same mymodel array from the example above:

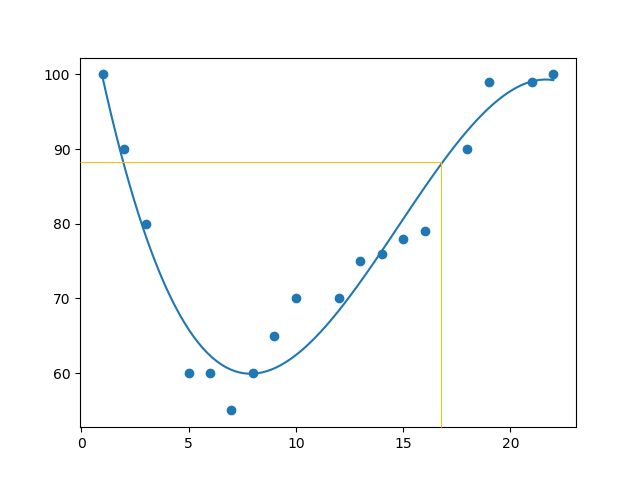
mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))

### **Example**

Predict the speed of a car passing at 17:00:

import numpy  
from sklearn.metrics import r2\_score  
  
x = [1,2,3,5,6,7,8,9,10,12,13,14,15,16,18,19,21,22]  
y = [100,90,80,60,60,55,60,65,70,70,75,76,78,79,90,99,99,100]  
  
mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))  
  
speed = mymodel(17)  
print(speed)

The example predicted a speed to be 88.87, which we also could read from the diagram:



## Bad Fit?

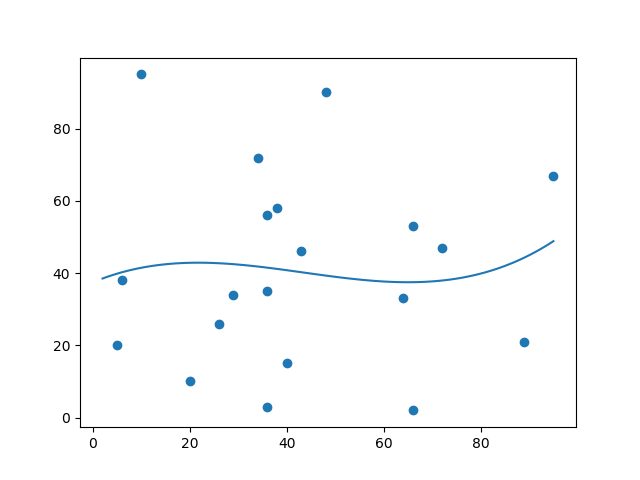
Let us create an example where polynomial regression would not be the best method to predict future values.

### **Example**

These values for the x- and y-axis should result in a very bad fit for polynomial regression:

import numpy  
import matplotlib.pyplot as plt  
  
x = [89,43,36,36,95,10,66,34,38,20,26,29,48,64,6,5,36,66,72,40]  
y = [21,46,3,35,67,95,53,72,58,10,26,34,90,33,38,20,56,2,47,15]  
  
mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))  
myline = numpy.linspace(2, 95, 100)  
plt.scatter(x, y)  
plt.plot(myline, mymodel(myline))  
plt.show()

**Result:**



| Car | Model | Volume | Weight | CO2 |  |
| --- | --- | --- | --- | --- | --- |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Toyota | Aygo | 1000 | 790 | 99 |
| Mitsubishi | Space Star | 1200 | 1160 | 95 |
| Skoda | Citigo | 1000 | 929 | 95 |
| Fiat | 500 | 900 | 865 | 90 |
| Mini | Cooper | 1500 | 1140 | 105 |
| VW | Up! | 1000 | 929 | 105 |
| Skoda | Fabia | 1400 | 1109 | 90 |
| Mercedes | A-Class | 1500 | 1365 | 92 |
| Ford | Fiesta | 1500 | 1112 | 98 |
| Audi | A1 | 1600 | 1150 | 99 |
| Hyundai | I20 | 1100 | 980 | 99 |
| Suzuki | Swift | 1300 | 990 | 101 |
| Ford | Fiesta | 1000 | 1112 | 99 |
| Honda | Civic | 1600 | 1252 | 94 |
| Hundai | I30 | 1600 | 1326 | 97 |
| Opel | Astra | 1600 | 1330 | 97 |
| BMW | 1 | 1600 | 1365 | 99 |
| Mazda | 3 | 2200 | 1280 | 104 |
| Skoda | Rapid | 1600 | 1119 | 104 |
| Ford | Focus | 2000 | 1328 | 105 |
| Ford | Mondeo | 1600 | 1584 | 94 |
| Opel | Insignia | 2000 | 1428 | 99 |
| Mercedes | C-Class | 2100 | 1365 | 99 |
| Skoda | Octavia | 1600 | 1415 | 99 |
| Volvo | S60 | 2000 | 1415 | 99 |
| Mercedes | CLA | 1500 | 1465 | 102 |
| Audi | A4 | 2000 | 1490 | 104 |
| Audi | A6 | 2000 | 1725 | 114 |
| Volvo | V70 | 1600 | 1523 | 109 |
| BMW | 5 | 2000 | 1705 | 114 |
| Mercedes | E-Class | 2100 | 1605 | 115 |
| Volvo | XC70 | 2000 | 1746 | 117 |
| Ford | B-Max | 1600 | 1235 | 104 |
| BMW | 2 | 1600 | 1390 | 108 |
| Opel | Zafira | 1600 | 1405 | 109 |
| Mercedes | SLK | 2500 | 1395 | 120 |

### **Example**

You should get a very low r-squared value.

import numpy  
from sklearn.metrics import r2\_score  
  
x = [89,43,36,36,95,10,66,34,38,20,26,29,48,64,6,5,36,66,72,40]  
y = [21,46,3,35,67,95,53,72,58,10,26,34,90,33,38,20,56,2,47,15]  
  
mymodel = numpy.poly1d(numpy.polyfit(x, y, 3))  
  
print(r2\_score(y, mymodel(x)))

The result: 0.00995 indicates a very bad relationship, and tells us that this data set is not suitable for polynomial regression.

# **Machine Learning - Multiple Regression**

## Multiple Regression

Multiple regression is like [linear regression](https://www.w3schools.com/python/python_ml_linear_regression.asp), but with more than one independent value, meaning that we try to predict a value based on **two or more** variables.

Take a look at the data set below, it contains some information about cars.

We can predict the CO2 emission of a car based on the size of the engine, but with multiple regression we can throw in more variables, like the weight of the car, to make the prediction more accurate.

## How Does it Work?

In Python we have modules that will do the work for us. Start by importing the Pandas module.

import pandas

Learn about the Pandas module in our [Pandas Tutorial](https://www.w3schools.com/python/pandas_tutorial.asp).

The Pandas module allows us to read csv files and return a DataFrame object.

The file is meant for testing purposes only, you can download it here: [data.csv](https://www.w3schools.com/python/data.csv)

df = pandas.read\_csv("data.csv")

Then make a list of the independent values and call this variable X.

Put the dependent values in a variable called y.

X = df[['Weight', 'Volume']]  
y = df['CO2']

**Tip:** It is common to name the list of independent values with a upper case X, and the list of dependent values with a lower case y.

We will use some methods from the sklearn module, so we will have to import that module as well:

from sklearn import linear\_model

From the sklearn module we will use the LinearRegression() method to create a linear regression object.

This object has a method called fit() that takes the independent and dependent values as parameters and fills the regression object with data that describes the relationship:

regr = linear\_model.LinearRegression()  
regr.fit(X, y)

Now we have a regression object that are ready to predict CO2 values based on a car's weight and volume:

#predict the CO2 emission of a car where the weight is 2300kg, and the volume is 1300cm3:  
predictedCO2 = regr.predict([[2300, 1300]])

### **Example**

See the whole example in action:

import pandas  
from sklearn import linear\_model  
  
df = pandas.read\_csv("data.csv")  
  
X = df[['Weight', 'Volume']]  
y = df['CO2']  
  
regr = linear\_model.LinearRegression()  
regr.fit(X, y)  
  
#predict the CO2 emission of a car where the weight is 2300kg, and the volume is 1300cm3:  
predictedCO2 = regr.predict([[2300, 1300]])  
  
print(predictedCO2)

### **Result:**

[107.2087328]

We have predicted that a car with 1.3 liter engine, and a weight of 2300 kg, will release approximately 107 grams of CO2 for every kilometer it drives.

## Coefficient

The coefficient is a factor that describes the relationship with an unknown variable.

Example: if x is a variable, then 2x is x two times. x is the unknown variable, and the number 2 is the coefficient.

In this case, we can ask for the coefficient value of weight against CO2, and for volume against CO2. The answer(s) we get tells us what would happen if we increase, or decrease, one of the independent values.

### **Example**

Print the coefficient values of the regression object:

import pandas  
from sklearn import linear\_model  
  
df = pandas.read\_csv("data.csv")  
  
X = df[['Weight', 'Volume']]  
y = df['CO2']  
  
regr = linear\_model.LinearRegression()  
regr.fit(X, y)  
  
print(regr.coef\_)

### **Result:**

[0.00755095 0.00780526]

## Result Explained

The result array represents the coefficient values of weight and volume.

Weight: 0.00755095  
Volume: 0.00780526

These values tell us that if the weight increase by 1kg, the CO2 emission increases by 0.00755095g.

And if the engine size (Volume) increases by 1 cm3, the CO2 emission increases by 0.00780526 g.

I think that is a fair guess, but let test it!

We have already predicted that if a car with a 1300cm3 engine weighs 2300kg, the CO2 emission will be approximately 107g.

What if we increase the weight with 1000kg?

### **Example**

Copy the example from before, but change the weight from 2300 to 3300:

import pandas  
from sklearn import linear\_model  
  
df = pandas.read\_csv("data.csv")  
  
X = df[['Weight', 'Volume']]  
y = df['CO2']  
  
regr = linear\_model.LinearRegression()  
regr.fit(X, y)  
  
predictedCO2 = regr.predict([[3300, 1300]])  
  
print(predictedCO2)

### **Result:**

[114.75968007]

We have predicted that a car with 1.3 liter engine, and a weight of 3300 kg, will release approximately 115 grams of CO2 for every kilometer it drives.

Which shows that the coefficient of 0.00755095 is correct:

107.2087328 + (1000 \* 0.00755095) = 114.75968

# **Machine Learning - Scale**

## Scale Features

When your data has different values, and even different measurement units, it can be difficult to compare them. What is kilograms compared to meters? Or altitude compared to time?

The answer to this problem is scaling. We can scale data into new values that are easier to compare.

Take a look at the table below, it is the same data set that we used in the [multiple regression chapter](https://www.w3schools.com/python/python_ml_multiple_regression.asp), but this time the **volume** column contains values in liters instead of cm3 (1.0 instead of 1000).

| Car | Model | Volume | Weight | CO2 |  |
| --- | --- | --- | --- | --- | --- |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Toyota | Aygo | 1.0 | 790 | 99 |
| Mitsubishi | Space Star | 1.2 | 1160 | 95 |
| Skoda | Citigo | 1.0 | 929 | 95 |
| Fiat | 500 | 0.9 | 865 | 90 |
| Mini | Cooper | 1.5 | 1140 | 105 |
| VW | Up! | 1.0 | 929 | 105 |
| Skoda | Fabia | 1.4 | 1109 | 90 |
| Mercedes | A-Class | 1.5 | 1365 | 92 |
| Ford | Fiesta | 1.5 | 1112 | 98 |
| Audi | A1 | 1.6 | 1150 | 99 |
| Hyundai | I20 | 1.1 | 980 | 99 |
| Suzuki | Swift | 1.3 | 990 | 101 |
| Ford | Fiesta | 1.0 | 1112 | 99 |
| Honda | Civic | 1.6 | 1252 | 94 |
| Hundai | I30 | 1.6 | 1326 | 97 |
| Opel | Astra | 1.6 | 1330 | 97 |
| BMW | 1 | 1.6 | 1365 | 99 |
| Mazda | 3 | 2.2 | 1280 | 104 |
| Skoda | Rapid | 1.6 | 1119 | 104 |
| Ford | Focus | 2.0 | 1328 | 105 |
| Ford | Mondeo | 1.6 | 1584 | 94 |
| Opel | Insignia | 2.0 | 1428 | 99 |
| Mercedes | C-Class | 2.1 | 1365 | 99 |
| Skoda | Octavia | 1.6 | 1415 | 99 |
| Volvo | S60 | 2.0 | 1415 | 99 |
| Mercedes | CLA | 1.5 | 1465 | 102 |
| Audi | A4 | 2.0 | 1490 | 104 |
| Audi | A6 | 2.0 | 1725 | 114 |
| Volvo | V70 | 1.6 | 1523 | 109 |
| BMW | 5 | 2.0 | 1705 | 114 |
| Mercedes | E-Class | 2.1 | 1605 | 115 |
| Volvo | XC70 | 2.0 | 1746 | 117 |
| Ford | B-Max | 1.6 | 1235 | 104 |
| BMW | 2 | 1.6 | 1390 | 108 |

It can be difficult to compare the volume 1.0 with the weight 790, but if we scale them both into comparable values, we can easily see how much one value is compared to the other.

There are different methods for scaling data, in this tutorial we will use a method called standardization.

The standardization method uses this formula:

z = (x - u) / s

Where z is the new value, x is the original value, u is the mean and s is the standard deviation.

If you take the **weight** column from the data set above, the first value is 790, and the scaled value will be:

(790 - [1292.23](https://www.w3schools.com/python/trypandas.asp?filename=demo_ml_scale_mean1)) / [238.74](https://www.w3schools.com/python/trypandas.asp?filename=demo_ml_scale_std1) = -2.1

If you take the **volume** column from the data set above, the first value is 1.0, and the scaled value will be:

(1.0 - [1.61](https://www.w3schools.com/python/trypandas.asp?filename=demo_ml_scale_mean2)) / [0.38](https://www.w3schools.com/python/trypandas.asp?filename=demo_ml_scale_std2) = -1.59

Now you can compare -2.1 with -1.59 instead of comparing 790 with 1.0.

You do not have to do this manually, the Python sklearn module has a method called StandardScaler() which returns a Scaler object with methods for transforming data sets.

### **Example**

Scale all values in the Weight and Volume columns:

import pandas  
from sklearn import linear\_model  
from sklearn.preprocessing import StandardScaler  
scale = StandardScaler()  
  
df = pandas.read\_csv("data.csv")  
  
X = df[['Weight', 'Volume']]  
  
scaledX = scale.fit\_transform(X)  
  
print(scaledX)

### **Result:**

Note that the first two values are -2.1 and -1.59, which corresponds to our calculations:

[[-2.10389253 -1.59336644]

[-0.55407235 -1.07190106]

[-1.52166278 -1.59336644]

[-1.78973979 -1.85409913]

[-0.63784641 -0.28970299]

[-1.52166278 -1.59336644]

[-0.76769621 -0.55043568]

[ 0.3046118 -0.28970299]

[-0.7551301 -0.28970299]

[-0.59595938 -0.0289703 ]

[-1.30803892 -1.33263375]

[-1.26615189 -0.81116837]

[-0.7551301 -1.59336644]

[-0.16871166 -0.0289703 ]

[ 0.14125238 -0.0289703 ]

[ 0.15800719 -0.0289703 ]

[ 0.3046118 -0.0289703 ]

[-0.05142797 1.53542584]

[-0.72580918 -0.0289703 ]

[ 0.14962979 1.01396046]

[ 1.2219378 -0.0289703 ]

[ 0.5685001 1.01396046]

[ 0.3046118 1.27469315]

[ 0.51404696 -0.0289703 ]

[ 0.51404696 1.01396046]

[ 0.72348212 -0.28970299]

[ 0.8281997 1.01396046]

[ 1.81254495 1.01396046]

[ 0.96642691 -0.0289703 ]

[ 1.72877089 1.01396046]

[ 1.30990057 1.27469315]

[ 1.90050772 1.01396046]

[-0.23991961 -0.0289703 ]

[ 0.40932938 -0.0289703 ]

[ 0.47215993 -0.0289703 ]

[ 0.4302729 2.31762392]]

## Predict CO2 Values

The task in the [Multiple Regression chapter](https://www.w3schools.com/python/python_ml_multiple_regression.asp) was to predict the CO2 emission from a car when you only knew its weight and volume.

When the data set is scaled, you will have to use the scale when you predict values:

### **Example**

Predict the CO2 emission from a 1.3 liter car that weighs 2300 kilograms:

import pandas  
from sklearn import linear\_model  
from sklearn.preprocessing import StandardScaler  
scale = StandardScaler()  
  
df = pandas.read\_csv("data.csv")  
  
X = df[['Weight', 'Volume']]  
y = df['CO2']  
  
scaledX = scale.fit\_transform(X)  
  
regr = linear\_model.LinearRegression()  
regr.fit(scaledX, y)  
  
scaled = scale.transform([[2300, 1.3]])  
  
predictedCO2 = regr.predict([scaled[0]])  
print(predictedCO2)

### **Result:**

[107.2087328]

# **Machine Learning - Train/Test**

## Evaluate Your Model

In Machine Learning we create models to predict the outcome of certain events, like in the previous chapter where we predicted the CO2 emission of a car when we knew the weight and engine size.

To measure if the model is good enough, we can use a method called Train/Test.

## What is Train/Test

Train/Test is a method to measure the accuracy of your model.

It is called Train/Test because you split the data set into two sets: a training set and a testing set.

80% for training, and 20% for testing.

You train the model using the training set.

You test the model using the testing set.

Train the model means create the model.

## Start With a Data Set

Start with a data set you want to test.

Our data set illustrates 100 customers in a shop, and their shopping habits.

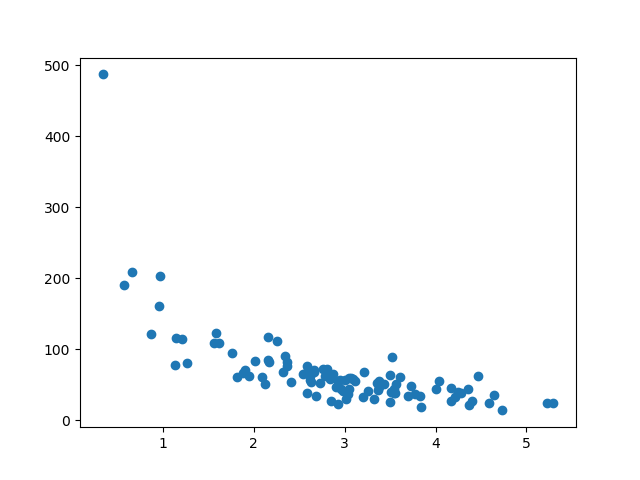
### **Example**

import numpy  
import matplotlib.pyplot as plt  
numpy.random.seed(2)  
  
x = numpy.random.normal(3, 1, 100)  
y = numpy.random.normal(150, 40, 100) / x  
  
plt.scatter(x, y)  
plt.show()

### **Result:**

The x axis represents the number of minutes before making a purchase.

The y axis represents the amount of money spent on the purchase.



## Split Into Train/Test

The training set should be a random selection of 80% of the original data.

The testing set should be the remaining 20%.

train\_x = x[:80]  
train\_y = y[:80]  
  
test\_x = x[80:]  
test\_y = y[80:]

## Display the Training Set

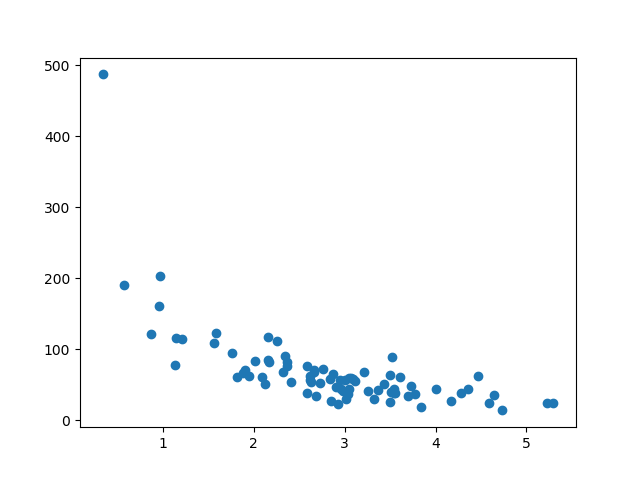
Display the same scatter plot with the training set:

### **Example**

plt.scatter(train\_x, train\_y)  
plt.show()

### **Result:**

It looks like the original data set, so it seems to be a fair selection:



## Display the Testing Set

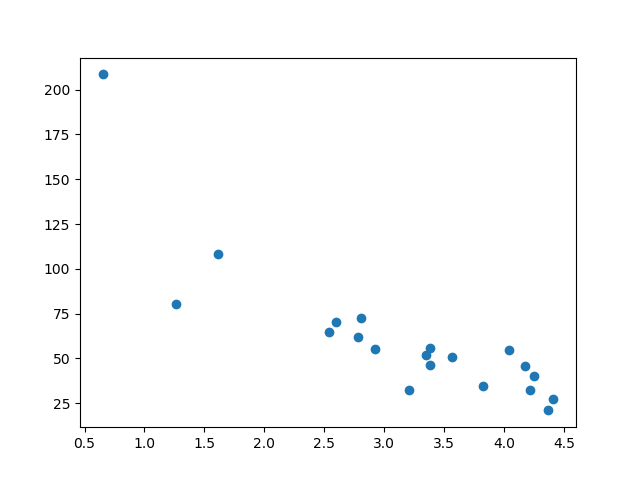
To make sure the testing set is not completely different, we will take a look at the testing set as well.

### **Example**

plt.scatter(test\_x, test\_y)  
plt.show()

### **Result:**

The testing set also looks like the original data set:



## Fit the Data Set

What does the data set look like? In my opinion I think the best fit would be a [polynomial regression](https://www.w3schools.com/python/python_ml_polynomial_regression.asp), so let us draw a line of polynomial regression.

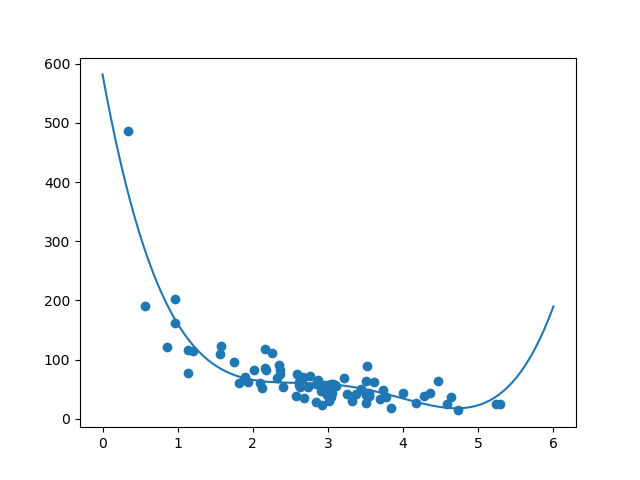
To draw a line through the data points, we use the plot() method of the matplotlib module:

### **Example**

Draw a polynomial regression line through the data points:

import numpy  
import matplotlib.pyplot as plt  
numpy.random.seed(2)  
  
x = numpy.random.normal(3, 1, 100)  
y = numpy.random.normal(150, 40, 100) / x  
  
train\_x = x[:80]  
train\_y = y[:80]  
  
test\_x = x[80:]  
test\_y = y[80:]  
  
mymodel = numpy.poly1d(numpy.polyfit(train\_x, train\_y, 4))  
  
myline = numpy.linspace(0, 6, 100)  
  
plt.scatter(train\_x, train\_y)  
plt.plot(myline, mymodel(myline))  
plt.show()

### **Result:**



The result can back my suggestion of the data set fitting a polynomial regression, even though it would give us some weird results if we try to predict values outside of the data set. Example: the line indicates that a customer spending 6 minutes in the shop would make a purchase worth 200. That is probably a sign of overfitting.

But what about the R-squared score? The R-squared score is a good indicator of how well my data set is fitting the model.

## R2

Remember R2, also known as R-squared?

It measures the relationship between the x axis and the y axis, and the value ranges from 0 to 1, where 0 means no relationship, and 1 means totally related.

The sklearn module has a method called r2\_score() that will help us find this relationship.

In this case we would like to measure the relationship between the minutes a customer stays in the shop and how much money they spend.

### **Example**

How well does my training data fit in a polynomial regression?

import numpy  
from sklearn.metrics import r2\_score  
numpy.random.seed(2)  
  
x = numpy.random.normal(3, 1, 100)  
y = numpy.random.normal(150, 40, 100) / x  
  
train\_x = x[:80]  
train\_y = y[:80]  
  
test\_x = x[80:]  
test\_y = y[80:]  
  
mymodel = numpy.poly1d(numpy.polyfit(train\_x, train\_y, 4))  
  
r2 = r2\_score(train\_y, mymodel(train\_x))  
  
print(r2)

**Note:** The result 0.799 shows that there is a OK relationship.

## Bring in the Testing Set

Now we have made a model that is OK, at least when it comes to training data.

Now we want to test the model with the testing data as well, to see if gives us the same result.

### **Example**

Let us find the R2 score when using testing data:

import numpy  
from sklearn.metrics import r2\_score  
numpy.random.seed(2)  
  
x = numpy.random.normal(3, 1, 100)  
y = numpy.random.normal(150, 40, 100) / x  
  
train\_x = x[:80]  
train\_y = y[:80]  
  
test\_x = x[80:]  
test\_y = y[80:]  
  
mymodel = numpy.poly1d(numpy.polyfit(train\_x, train\_y, 4))  
  
r2 = r2\_score(test\_y, mymodel(test\_x))  
  
print(r2)

**Note:** The result 0.809 shows that the model fits the testing set as well, and we are confident that we can use the model to predict future values.

## Predict Values

Now that we have established that our model is OK, we can start predicting new values.

### **Example**

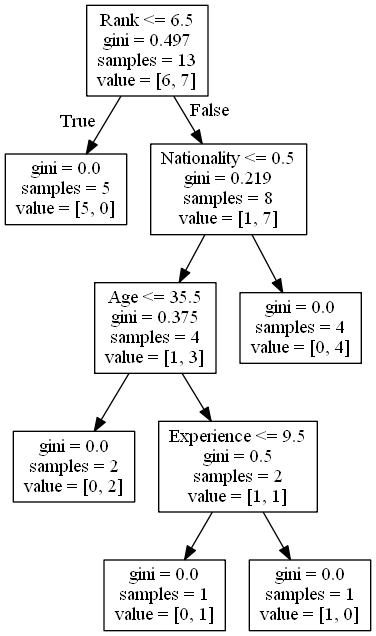
How much money will a buying customer spend, if she or he stays in the shop for 5 minutes?

print(mymodel(5))

The example predicted the customer to spend 22.88 dollars, as seems to correspond to the diagram:

# 

# **Machine Learning - Decision Tree**



## Decision Tree

In this chapter we will show you how to make a "Decision Tree". A Decision Tree is a Flow Chart, and can help you make decisions based on previous experience.

In the example, a person will try to decide if he/she should go to a comedy show or not.

Luckily our example person has registered every time there was a comedy show in town, and registered some information about the comedian, and also registered if he/she went or not.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Age | Experience | Rank | Nationality | Go |
| 36 | 10 | 9 | UK | NO |
| 42 | 12 | 4 | USA | NO |
| 23 | 4 | 6 | N | NO |
| 52 | 4 | 4 | USA | NO |
| 43 | 21 | 8 | USA | YES |
| 44 | 14 | 5 | UK | NO |
| 66 | 3 | 7 | N | YES |
| 35 | 14 | 9 | UK | YES |
| 52 | 13 | 7 | N | YES |
| 35 | 5 | 9 | N | YES |
| 24 | 3 | 5 | USA | NO |
| 18 | 3 | 7 | UK | YES |
| 45 | 9 | 9 | UK | YES |

Now, based on this data set, Python can create a decision tree that can be used to decide if any new shows are worth attending to.

## How Does it Work?

First, read the dataset with pandas:

### **Example**

Read and print the data set:

import pandas  
  
df = pandas.read\_csv("data.csv")  
  
print(df)

To make a decision tree, all data has to be numerical.

We have to convert the non numerical columns 'Nationality' and 'Go' into numerical values.

Pandas has a map() method that takes a dictionary with information on how to convert the values.

{'UK': 0, 'USA': 1, 'N': 2}

Means convert the values 'UK' to 0, 'USA' to 1, and 'N' to 2.

### **Example**

Change string values into numerical values:

d = {'UK': 0, 'USA': 1, 'N': 2}  
df['Nationality'] = df['Nationality'].map(d)  
d = {'YES': 1, 'NO': 0}  
df['Go'] = df['Go'].map(d)  
  
print(df)

Then we have to separate the feature columns from the target column.

The feature columns are the columns that we try to predict from, and the target column is the column with the values we try to predict.

### **Example**

X is the feature columns, y is the target column:

## features = ['Age', 'Experience', 'Rank', 'Nationality'] X = df[features]

y = df['Go']  
  
print(X)  
print(y)

Now we can create the actual decision tree, fit it with our details. Start by importing the modules we need:

### **Example**

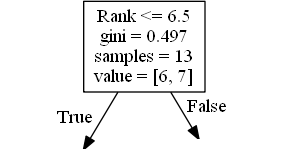
Create and display a Decision Tree:

import pandas  
from sklearn import tree  
from sklearn.tree import DecisionTreeClassifier  
import matplotlib.pyplot as plt  
  
df = pandas.read\_csv("data.csv")  
  
d = {'UK': 0, 'USA': 1, 'N': 2}  
df['Nationality'] = df['Nationality'].map(d)  
d = {'YES': 1, 'NO': 0}  
df['Go'] = df['Go'].map(d)  
  
features = ['Age', 'Experience', 'Rank', 'Nationality']  
  
X = df[features]  
y = df['Go']  
  
dtree = DecisionTreeClassifier()  
dtree = dtree.fit(X, y)  
  
tree.plot\_tree(dtree, feature\_names=features)

## Result Explained

The decision tree uses your earlier decisions to calculate the odds for you to wanting to go see a comedian or not.

Let us read the different aspects of the decision tree:



### **Rank**

Rank <= 6.5 means that every comedian with a rank of 6.5 or lower will follow the True arrow (to the left), and the rest will follow the False arrow (to the right).

gini = 0.497 refers to the quality of the split, and is always a number between 0.0 and 0.5, where 0.0 would mean all of the samples got the same result, and 0.5 would mean that the split is done exactly in the middle.

samples = 13 means that there are 13 comedians left at this point in the decision, which is all of them since this is the first step.

value = [6, 7] means that of these 13 comedians, 6 will get a "NO", and 7 will get a "GO".

### **Gini**

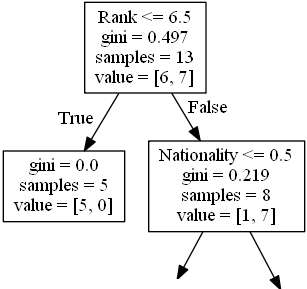
There are many ways to split the samples, we use the GINI method in this tutorial.

The Gini method uses this formula:

Gini = 1 - (x/n)2 - (y/n)2

Where x is the number of positive answers("GO"), n is the number of samples, and y is the number of negative answers ("NO"), which gives us this calculation:

1 - (7 / 13)2 - (6 / 13)2 = 0.497



The next step contains two boxes, one box for the comedians with a 'Rank' of 6.5 or lower, and one box with the rest.

### **True - 5 Comedians End Here:**

gini = 0.0 means all of the samples got the same result.

samples = 5 means that there are 5 comedians left in this branch (5 comedian with a Rank of 6.5 or lower).

value = [5, 0] means that 5 will get a "NO" and 0 will get a "GO".

### **False - 8 Comedians Continue:**

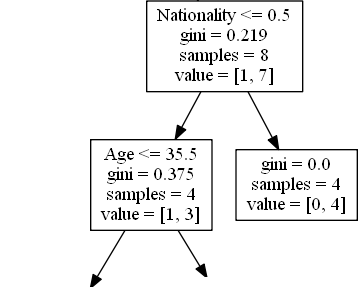
### **Nationality**

Nationality <= 0.5 means that the comedians with a nationality value of less than 0.5 will follow the arrow to the left (which means everyone from the UK, ), and the rest will follow the arrow to the right.

gini = 0.219 means that about 22% of the samples would go in one direction.

samples = 8 means that there are 8 comedians left in this branch (8 comedian with a Rank higher than 6.5).

value = [1, 7] means that of these 8 comedians, 1 will get a "NO" and 7 will get a "GO".



### **True - 4 Comedians Continue:**

### **Age**

Age <= 35.5 means that comedians at the age of 35.5 or younger will follow the arrow to the left, and the rest will follow the arrow to the right.

gini = 0.375 means that about 37,5% of the samples would go in one direction.

samples = 4 means that there are 4 comedians left in this branch (4 comedians from the UK).

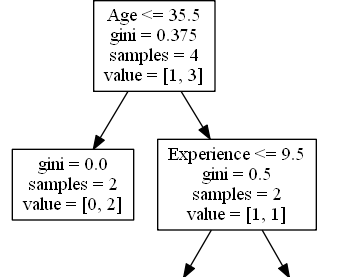
value = [1, 3] means that of these 4 comedians, 1 will get a "NO" and 3 will get a "GO".

### **False - 4 Comedians End Here:**

gini = 0.0 means all of the samples got the same result.

samples = 4 means that there are 4 comedians left in this branch (4 comedians not from the UK).

value = [0, 4] means that of these 4 comedians, 0 will get a "NO" and 4 will get a "GO".



### **True - 2 Comedians End Here:**

gini = 0.0 means all of the samples got the same result.

samples = 2 means that there are 2 comedians left in this branch (2 comedians at the age 35.5 or younger).

value = [0, 2] means that of these 2 comedians, 0 will get a "NO" and 2 will get a "GO".

### **False - 2 Comedians Continue:**

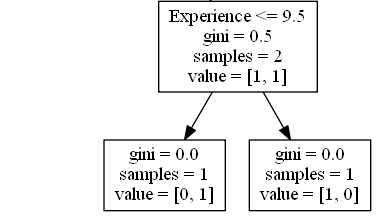
### **Experience**

Experience <= 9.5 means that comedians with 9.5 years of experience, or less, will follow the arrow to the left, and the rest will follow the arrow to the right.

gini = 0.5 means that 50% of the samples would go in one direction.

samples = 2 means that there are 2 comedians left in this branch (2 comedians older than 35.5).

value = [1, 1] means that of these 2 comedians, 1 will get a "NO" and 1 will get a "GO".



### **True - 1 Comedian Ends Here:**

gini = 0.0 means all of the samples got the same result.

samples = 1 means that there is 1 comedian left in this branch (1 comedian with 9.5 years of experience or less).

value = [0, 1] means that 0 will get a "NO" and 1 will get a "GO".

### **False - 1 Comedian Ends Here:**

gini = 0.0 means all of the samples got the same result.

samples = 1 means that there is 1 comedians left in this branch (1 comedian with more than 9.5 years of experience).

value = [1, 0] means that 1 will get a "NO" and 0 will get a "GO".

## Predict Values

We can use the Decision Tree to predict new values.

Example: Should I go see a show starring a 40 years old American comedian, with 10 years of experience, and a comedy ranking of 7?

### **Example**

Use predict() method to predict new values:

print(dtree.predict([[40, 10, 7, 1]]))

### **Example**

What would the answer be if the comedy rank was 6?

print(dtree.predict([[40, 10, 6, 1]]))

### **Different Results**

You will see that the Decision Tree gives you different results if you run it enough times, even if you feed it with the same data.

That is because the Decision Tree does not give us a 100% certain answer. It is based on the probability of an outcome, and the answer will vary.

# **Machine Learning - Confusion Matrix**

On this page, W3schools.com collaborates with [NYC Data Science Academy](https://t.sidekickopen01.com/s3t/c/5/f18dQhb0S7kv8c7RP2W1z75qk59hl3kW7_k2847tBZxCVvfv0f1GTV9PW2RxlDT2bzNMYdZ8s8G01?te=W3R5hFj4cm2zwW41-DxM3zhrr_W3F7ZBj3F6bSSW43T4N94hMnzcW3F4Fvd3zbTMqW2fgYK73F7y_5W3Zp0KM3_Qh5fW4hLxLG2f1Dw_W3F7y_53Zp0KMW3_QgzD3H6xvkW2dTzCR3SYMmGW1mp5CL3ZWTYrW4cbSf23_Qh9QW49NMw73HdlCPW3Hbzjf4fKWwkW43TDjD41YtR1W3zbVlf1S1tRf38WL2&si=6321147182055424&pi=566c78b2-d5c2-45ad-ad0c-74291c07630b), to deliver digital training content to our students.

## What is a confusion matrix?

It is a table that is used in classification problems to assess where errors in the model were made.

The rows represent the actual classes the outcomes should have been. While the columns represent the predictions we have made. Using this table it is easy to see which predictions are wrong.

## Creating a Confusion Matrix

Confusion matrixes can be created by predictions made from a logistic regression.

For now we will generate actual and predicted values by utilizing NumPy:

import numpy

Next we will need to generate the numbers for "actual" and "predicted" values.

actual = numpy.random.binomial(1, 0.9, size = 1000)  
predicted = numpy.random.binomial(1, 0.9, size = 1000)

In order to create the confusion matrix we need to import metrics from the sklearn module.

from sklearn import metrics

Once metrics is imported we can use the confusion matrix function on our actual and predicted values.

confusion\_matrix = metrics.confusion\_matrix(actual, predicted)

To create a more interpretable visual display we need to convert the table into a confusion matrix display.

cm\_display = metrics.ConfusionMatrixDisplay(confusion\_matrix = confusion\_matrix, display\_labels = [False, True])

Vizualizing the display requires that we import pyplot from matplotlib.

import matplotlib.pyplot as plt

Finally to display the plot we can use the functions plot() and show() from pyplot.

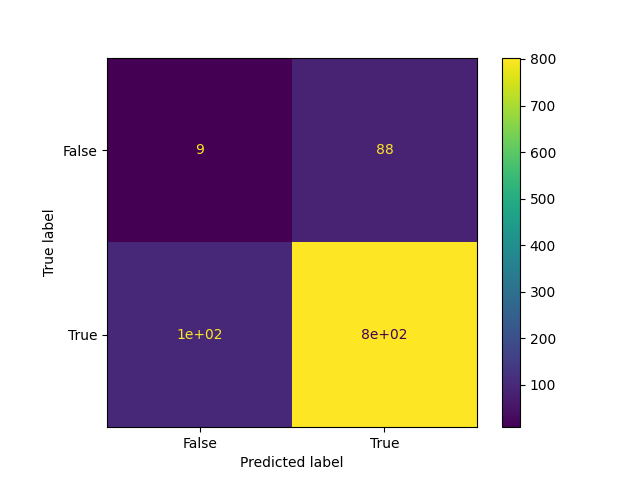
cm\_display.plot()  
plt.show()

See the whole example in action:

### **Example**

import matplotlib.pyplot as plt  
import numpy  
from sklearn import metrics  
  
actual = numpy.random.binomial(1,.9,size = 1000)  
predicted = numpy.random.binomial(1,.9,size = 1000)  
  
confusion\_matrix = metrics.confusion\_matrix(actual, predicted)  
  
cm\_display = metrics.ConfusionMatrixDisplay(confusion\_matrix = confusion\_matrix, display\_labels = [False, True])  
  
cm\_display.plot()  
plt.show()

### **Result**



## Results Explained

The Confusion Matrix created has four different quadrants:

False Negative (Top-Left Quadrant)  
False Positive (Top-Right Quadrant)  
True Negative (Bottom-Left Quadrant)  
True Positive (Bottom-Right Quadrant)

True means that the values were accurately predicted, False means that there was an error or wrong prediction.

Now that we have made a Confusion Matrix, we can calculate different measures to quantify the quality of the model. First, lets look at Accuracy.

## Created Metrics

The matrix provides us with many useful metrics that help us to evaluate out classification model.

The different measures include: Accuracy, Precision, Sensitivity (Recall), Specificity, and the F-score, explained below.

## Accuracy

Accuracy measures how often the model is correct.

### **How to Calculate**

(True Positive + True Negative) / Total Predictions

### **Example**

Accuracy = metrics.accuracy\_score(actual, predicted)

## Precision

Of the positives predicted, what percentage is truly positive?

### **How to Calculate**

True Positive / (True Positive + False Positive)

Precision does not evaluate the correctly predicted negative cases:

### **Example**

Precision = metrics.precision\_score(actual, predicted)

## Sensitivity (Recall)

Of all the positive cases, what percentage are predicted positive?

Sensitivity (sometimes called Recall) measures how good the model is at predicting positives.

This means it looks at true positives and false negatives (which are positives that have been incorrectly predicted as negative).

### **How to Calculate**

True Positive / (True Positive + False Negative)

Sensitivity is good at understanding how well the model predicts something is positive:

### **Example**

Sensitivity\_recall = metrics.recall\_score(actual, predicted)

## Specificity

How well the model is at prediciting negative results?

Specificity is similar to sensitivity, but looks at it from the persepctive of negative results.

### **How to Calculate**

True Negative / (True Negative + False Positive)

Since it is just the opposite of Recall, we use the recall\_score function, taking the opposite position label:

### **Example**

Specificity = metrics.recall\_score(actual, predicted, pos\_label=0)

## F-score

F-score is the "harmonic mean" of precision and sensitivity.

It considers both false positive and false negative cases and is good for imbalanced datasets.

### **How to Calculate**

2 \* ((Precision \* Sensitivity) / (Precision + Sensitivity))

This score does not take into consideration the True Negative values:

### **Example**

F1\_score = metrics.f1\_score(actual, predicted)

All calulations in one:

### **Example**

#metrics  
print({"Accuracy":Accuracy,"Precision":Precision,"Sensitivity\_recall":Sensitivity\_recall,"Specificity":Specificity,"F1\_score":F1\_score})

# **Machine Learning - Hierarchical Clustering**

On this page, W3schools.com collaborates with [NYC Data Science Academy](https://t.sidekickopen01.com/s3t/c/5/f18dQhb0S7kv8c7RP2W1z75qk59hl3kW7_k2847tBZxCVvfv0f1GTV9PW2RxlDT2bzNMYdZ8s8G01?te=W3R5hFj4cm2zwW41-DxM3zhrr_W3F7ZBj3F6bSSW43T4N94hMnzcW3F4Fvd3zbTMqW2fgYK73F7y_5W3Zp0KM3_Qh5fW4hLxLG2f1Dw_W3F7y_53Zp0KMW3_QgzD3H6xvkW2dTzCR3SYMmGW1mp5CL3ZWTYrW4cbSf23_Qh9QW49NMw73HdlCPW3Hbzjf4fKWwkW43TDjD41YtR1W3zbVlf1S1tRf38WL2&si=6321147182055424&pi=566c78b2-d5c2-45ad-ad0c-74291c07630b), to deliver digital training content to our students.

## Hierarchical Clustering

Hierarchical clustering is an unsupervised learning method for clustering data points. The algorithm builds clusters by measuring the dissimilarities between data. Unsupervised learning means that a model does not have to be trained, and we do not need a "target" variable. This method can be used on any data to visualize and interpret the relationship between individual data points.

Here we will use hierarchical clustering to group data points and visualize the clusters using both a dendrogram and scatter plot.

## How does it work?

We will use Agglomerative Clustering, a type of hierarchical clustering that follows a bottom up approach. We begin by treating each data point as its own cluster. Then, we join clusters together that have the shortest distance between them to create larger clusters. This step is repeated until one large cluster is formed containing all of the data points.

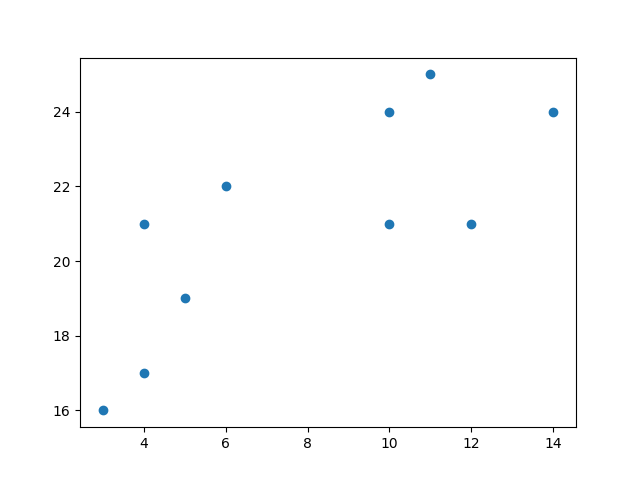
Hierarchical clustering requires us to decide on both a distance and linkage method. We will use euclidean distance and the Ward linkage method, which attempts to minimize the variance between clusters.

### **Example**

Start by visualizing some data points:

import numpy as np  
import matplotlib.pyplot as plt  
x = [4, 5, 10, 4, 3, 11, 14 , 6, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]  
plt.scatter(x, y)  
plt.show()

### **Result**

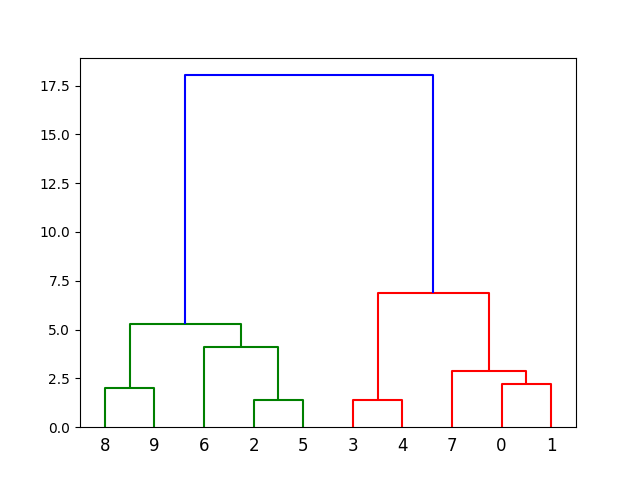


Now we compute the ward linkage using euclidean distance, and visualize it using a dendrogram:

### **Example**

import numpy as np  
import matplotlib.pyplot as plt  
from scipy.cluster.hierarchy import dendrogram, linkage  
  
x = [4, 5, 10, 4, 3, 11, 14 , 6, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]  
  
data = list(zip(x, y))  
  
linkage\_data = linkage(data, method='ward', metric='euclidean')  
dendrogram(linkage\_data)  
  
plt.show()

### **Result**

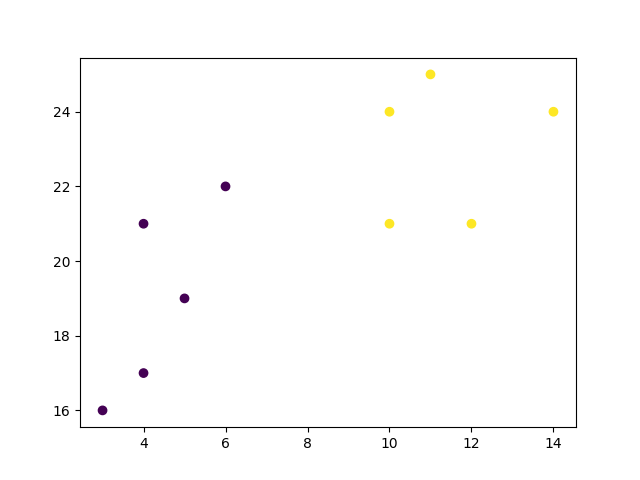


Here, we do the same thing with Python's scikit-learn library. Then, visualize on a 2-dimensional plot:

### **Example**

import numpy as np  
import matplotlib.pyplot as plt  
from sklearn.cluster import AgglomerativeClustering  
  
x = [4, 5, 10, 4, 3, 11, 14 , 6, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]  
  
data = list(zip(x, y))  
  
hierarchical\_cluster = AgglomerativeClustering(n\_clusters=2, affinity='euclidean', linkage='ward')  
labels = hierarchical\_cluster.fit\_predict(data)  
  
plt.scatter(x, y, c=labels)  
plt.show()

### **Result**



## Example Explained

Import the modules you need.

import numpy as np  
import matplotlib.pyplot as plt  
from scipy.cluster.hierarchy import dendrogram, linkage  
from sklearn.cluster import AgglomerativeClustering

You can learn about the Matplotlib module in our ["Matplotlib Tutorial](https://www.w3schools.com/python/matplotlib_intro.asp).

You can learn about the SciPy module in our [SciPy Tutorial](https://www.w3schools.com/python/scipy/index.php).

NumPy is a library for working with arrays and matricies in Python, you can learn about the NumPy module in our [NumPy Tutorial](https://www.w3schools.com/python/numpy/default.asp).

scikit-learn is a popular library for machine learning.

Create arrays that resemble two variables in a dataset. Note that while we only use two variables here, this method will work with any number of variables:

x = [4, 5, 10, 4, 3, 11, 14 , 6, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]

Turn the data into a set of points:

data = list(zip(x, y))  
print(data)

Result:

[(4, 21), (5, 19), (10, 24), (4, 17), (3, 16), (11, 25), (14, 24), (6, 22), (10, 21), (12, 21)]

Compute the linkage between all of the different points. Here we use a simple euclidean distance measure and Ward's linkage, which seeks to minimize the variance between clusters.

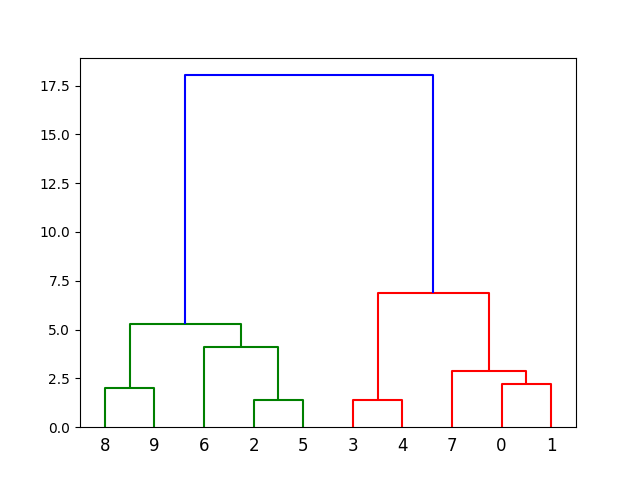
linkage\_data = linkage(data, method='ward', metric='euclidean')

Finally, plot the results in a dendrogram. This plot will show us the hierarchy of clusters from the bottom (individual points) to the top (a single cluster consisting of all data points).

plt.show() lets us visualize the dendrogram instead of just the raw linkage data.

dendrogram(linkage\_data)  
plt.show()

Result:



The scikit-learn library allows us to use hierarchichal clustering in a different manner. First, we initialize the AgglomerativeClustering class with 2 clusters, using the same euclidean distance and Ward linkage.

hierarchical\_cluster = AgglomerativeClustering(n\_clusters=2, affinity='euclidean', linkage='ward')

The .fit\_predict method can be called on our data to compute the clusters using the defined parameters across our chosen number of clusters.

labels = hierarchical\_cluster.fit\_predict(data) print(labels)

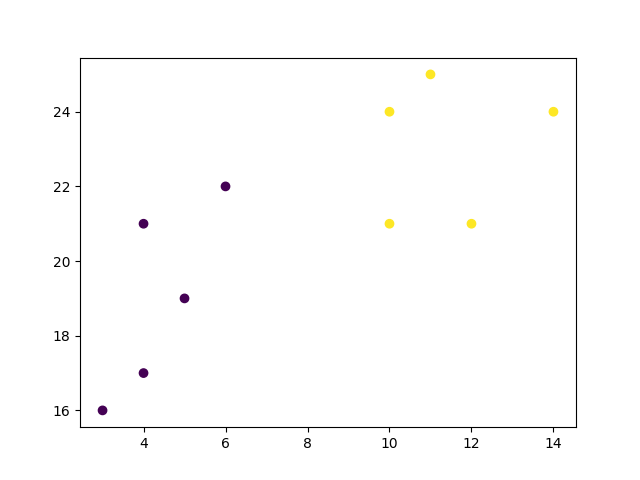
Result:

[0 0 1 0 0 1 1 0 1 1]

Finally, if we plot the same data and color the points using the labels assigned to each index by the hierarchical clustering method, we can see the cluster each point was assigned to:

plt.scatter(x, y, c=labels)  
plt.show()

Result:



# **Machine Learning - Logistic Regression**

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## Logistic Regression

Logistic regression aims to solve classification problems. It does this by predicting categorical outcomes, unlike linear regression that predicts a continuous outcome.

In the simplest case there are two outcomes, which is called binomial, an example of which is predicting if a tumor is malignant or benign. Other cases have more than two outcomes to classify, in this case it is called multinomial. A common example for multinomial logistic regression would be predicting the class of an iris flower between 3 different species.

Here we will be using basic logistic regression to predict a binomial variable. This means it has only two possible outcomes.

## How does it work?

In Python we have modules that will do the work for us. Start by importing the NumPy module.

import numpy

Store the independent variables in X.

Store the dependent variable in y.

Below is a sample dataset:

#X represents the size of a tumor in centimeters.  
X = numpy.array([3.78, 2.44, 2.09, 0.14, 1.72, 1.65, 4.92, 4.37, 4.96, 4.52, 3.69, 5.88]).reshape(-1,1)  
  
#Note: X has to be reshaped into a column from a row for the LogisticRegression() function to work.  
#y represents whether or not the tumor is cancerous (0 for "No", 1 for "Yes").  
y = numpy.array([0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1])

We will use a method from the sklearn module, so we will have to import that module as well:

from sklearn import linear\_model

From the sklearn module we will use the LogisticRegression() method to create a logistic regression object.

This object has a method called fit() that takes the independent and dependent values as parameters and fills the regression object with data that describes the relationship:

logr = linear\_model.LogisticRegression()  
logr.fit(X,y)

Now we have a logistic regression object that is ready to whether a tumor is cancerous based on the tumor size:

#predict if tumor is cancerous where the size is 3.46mm:  
predicted = logr.predict(numpy.array([3.46]).reshape(-1,1))

### **Example**

See the whole example in action:

import numpy  
from sklearn import linear\_model  
  
#Reshaped for Logistic function.  
X = numpy.array([3.78, 2.44, 2.09, 0.14, 1.72, 1.65, 4.92, 4.37, 4.96, 4.52, 3.69, 5.88]).reshape(-1,1)  
y = numpy.array([0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1])  
  
logr = linear\_model.LogisticRegression()  
logr.fit(X,y)  
  
#predict if tumor is cancerous where the size is 3.46mm:  
predicted = logr.predict(numpy.array([3.46]).reshape(-1,1))  
print(predicted)

### **Result**

We have predicted that a tumor with a size of 3.46mm will not be cancerous.

## Coefficient

In logistic regression the coefficient is the expected change in log-odds of having the outcome per unit change in X.

This does not have the most intuitive understanding so let's use it to create something that makes more sense, odds.

### **Example**

See the whole example in action:

import numpy  
from sklearn import linear\_model  
  
#Reshaped for Logistic function.  
X = numpy.array([3.78, 2.44, 2.09, 0.14, 1.72, 1.65, 4.92, 4.37, 4.96, 4.52, 3.69, 5.88]).reshape(-1,1)  
y = numpy.array([0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1])  
  
logr = linear\_model.LogisticRegression()  
logr.fit(X,y)  
  
log\_odds = logr.coef\_  
odds = numpy.exp(log\_odds)  
  
print(odds)

### **Result**

[4.03541657]

This tells us that as the size of a tumor increases by 1mm the odds of it being a cancerous tumor increases by 4x.

## Probability

The coefficient and intercept values can be used to find the probability that each tumor is cancerous.

Create a function that uses the model's coefficient and intercept values to return a new value. This new value represents probability that the given observation is a tumor:

def logit2prob(logr,x):  
  log\_odds = logr.coef\_ \* x + logr.intercept\_  
  odds = numpy.exp(log\_odds)  
  probability = odds / (1 + odds)  
  return(probability)

## Function Explained

To find the log-odds for each observation, we must first create a formula that looks similar to the one from linear regression, extracting the coefficient and the intercept.

log\_odds = logr.coef\_ \* x + logr.intercept\_

To then convert the log-odds to odds we must exponentiate the log-odds.

odds = numpy.exp(log\_odds)

Now that we have the odds, we can convert it to probability by dividing it by 1 plus the odds.

probability = odds / (1 + odds)

Let us now use the function with what we have learned to find out the probability that each tumor is cancerous.

### **Example**

See the whole example in action:

import numpy  
from sklearn import linear\_model  
  
X = numpy.array([3.78, 2.44, 2.09, 0.14, 1.72, 1.65, 4.92, 4.37, 4.96, 4.52, 3.69, 5.88]).reshape(-1,1)  
y = numpy.array([0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1])  
  
logr = linear\_model.LogisticRegression()  
logr.fit(X,y)  
  
def logit2prob(logr, X):  
  log\_odds = logr.coef\_ \* X + logr.intercept\_  
  odds = numpy.exp(log\_odds)  
  probability = odds / (1 + odds)  
  return(probability)  
  
print(logit2prob(logr, X))

### **Result**

[[0.60749955]

[0.19268876]

[0.12775886]

[0.00955221]

[0.08038616]

[0.07345637]

[0.88362743]

[0.77901378]

[0.88924409]

[0.81293497]

[0.57719129]

[0.96664243]]

## Results Explained

3.78 0.61 The probability that a tumor with the size 3.78cm is cancerous is 61%.

2.44 0.19 The probability that a tumor with the size 2.44cm is cancerous is 19%.

2.09 0.13 The probability that a tumor with the size 2.09cm is cancerous is 13%.

# **Machine Learning - Grid Search**

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## Grid Search

The majority of machine learning models contain parameters that can be adjusted to vary how the model learns. For example, the logistic regression model, from sklearn, has a parameter C that controls regularization,which affects the complexity of the model.

How do we pick the best value for C? The best value is dependent on the data used to train the model.

## How does it work?

One method is to try out different values and then pick the value that gives the best score. This technique is known as a **grid search**. If we had to select the values for two or more parameters, we would evaluate all combinations of the sets of values thus forming a grid of values.

Before we get into the example it is good to know what the parameter we are changing does. Higher values of C tell the model, the training data resembles real world information, place a greater weight on the training data. While lower values of C do the opposite.

## Using Default Parameters

First let's see what kind of results we can generate without a grid search using only the base parameters.

To get started we must first load in the dataset we will be working with.

from sklearn import datasets  
iris = datasets.load\_iris()

Next in order to create the model we must have a set of independent variables X and a dependant variable y.

X = iris['data']  
y = iris['target']

Now we will load the logistic model for classifying the iris flowers.

from sklearn.linear\_model import LogisticRegression

Creating the model, setting max\_iter to a higher value to ensure that the model finds a result.

Keep in mind the default value for C in a logistic regression model is 1, we will compare this later.

In the example below, we look at the iris data set and try to train a model with varying values for C in logistic regression.

logit = LogisticRegression(max\_iter = 10000)

After we create the model, we must fit the model to the data.

print(logit.fit(X,y))

To evaluate the model we run the score method.

print(logit.score(X,y))

### **Example**

from sklearn import datasets  
from sklearn.linear\_model import LogisticRegression  
  
iris = datasets.load\_iris()  
  
X = iris['data']  
y = iris['target']  
  
logit = LogisticRegression(max\_iter = 10000)  
  
print(logit.fit(X,y))  
  
print(logit.score(X,y))

With the default setting of C = 1, we achieved a score of 0.973.

Let's see if we can do any better by implementing a grid search with difference values of 0.973.

## Implementing Grid Search

We will follow the same steps of before except this time we will set a range of values for C.

Knowing which values to set for the searched parameters will take a combination of domain knowledge and practice.

Since the default value for C is 1, we will set a range of values surrounding it.

C = [0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2]

Next we will create a for loop to change out the values of C and evaluate the model with each change.

First we will create an empty list to store the score within.

scores = []

To change the values of C we must loop over the range of values and update the parameter each time.

for choice in C:  
  logit.set\_params(C=choice)  
  logit.fit(X, y)  
  scores.append(logit.score(X, y))

With the scores stored in a list, we can evaluate what the best choice of C is.

print(scores)

### **Example**

from sklearn import datasets  
from sklearn.linear\_model import LogisticRegression  
  
iris = datasets.load\_iris()  
  
X = iris['data']  
y = iris['target']  
  
logit = LogisticRegression(max\_iter = 10000)  
  
C = [0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2]  
  
scores = []  
  
for choice in C:  
  logit.set\_params(C=choice)  
  logit.fit(X, y)  
  scores.append(logit.score(X, y))  
  
print(scores)

## Results Explained

We can see that the lower values of C performed worse than the base parameter of 1. However, as we increased the value of C to 1.75 the model experienced increased accuracy.

It seems that increasing C beyond this amount does not help increase model accuracy.

## Note on Best Practices

We scored our logistic regression model by using the same data that was used to train it. If the model corresponds too closely to that data, it may not be great at predicting unseen data. This statistical error is known as **over fitting**.

To avoid being misled by the scores on the training data, we can put aside a portion of our data and use it specifically for the purpose of testing the model. Refer to the lecture on train/test splitting to avoid being misled and overfitting.

# **Preprocessing - Categorical Data**

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## Categorical Data

When your data has categories represented by strings, it will be difficult to use them to train machine learning models which often only accepts numeric data.

Instead of ignoring the categorical data and excluding the information from our model, you can tranform the data so it can be used in your models.

Take a look at the table below, it is the same data set that we used in the [multiple regression](https://www.w3schools.com/python/python_ml_multiple_regression.asp) chapter.

### **Example**

import pandas as pd  
  
cars = pd.read\_csv('data.csv')  
print(cars.to\_string())

### **Result**

Car Model Volume Weight CO2

0 Toyoty Aygo 1000 790 99

1 Mitsubishi Space Star 1200 1160 95

2 Skoda Citigo 1000 929 95

3 Fiat 500 900 865 90

4 Mini Cooper 1500 1140 105

5 VW Up! 1000 929 105

6 Skoda Fabia 1400 1109 90

7 Mercedes A-Class 1500 1365 92

8 Ford Fiesta 1500 1112 98

9 Audi A1 1600 1150 99

10 Hyundai I20 1100 980 99

11 Suzuki Swift 1300 990 101

12 Ford Fiesta 1000 1112 99

13 Honda Civic 1600 1252 94

14 Hundai I30 1600 1326 97

15 Opel Astra 1600 1330 97

16 BMW 1 1600 1365 99

17 Mazda 3 2200 1280 104

18 Skoda Rapid 1600 1119 104

19 Ford Focus 2000 1328 105

20 Ford Mondeo 1600 1584 94

21 Opel Insignia 2000 1428 99

22 Mercedes C-Class 2100 1365 99

23 Skoda Octavia 1600 1415 99

24 Volvo S60 2000 1415 99

25 Mercedes CLA 1500 1465 102

26 Audi A4 2000 1490 104

27 Audi A6 2000 1725 114

28 Volvo V70 1600 1523 109

29 BMW 5 2000 1705 114

30 Mercedes E-Class 2100 1605 115

31 Volvo XC70 2000 1746 117

32 Ford B-Max 1600 1235 104

33 BMW 216 1600 1390 108

34 Opel Zafira 1600 1405 109

35 Mercedes SLK 2500 1395 120

In the multiple regression chapter, we tried to predict the CO2 emitted based on the volume of the engine and the weight of the car but we excluded information about the car brand and model.

The information about the car brand or the car model might help us make a better prediction of the CO2 emitted.

## One Hot Encoding

We cannot make use of the Car or Model column in our data since they are not numeric. A linear relationship between a categorical variable, Car or Model, and a numeric variable, CO2, cannot be determined.

To fix this issue, we must have a numeric representation of the categorical variable. One way to do this is to have a column representing each group in the category.

For each column, the values will be 1 or 0 where 1 represents the inclusion of the group and 0 represents the exclusion. This transformation is called one hot encoding.

You do not have to do this manually, the Python Pandas module has a function that called get\_dummies() which does one hot encoding.

Learn about the Pandas module in our [Pandas Tutorial](https://www.w3schools.com/python/pandas/default.asp).

### **Example**

One Hot Encode the Car column:

import pandas as pd  
  
cars = pd.read\_csv('data.csv')  
ohe\_cars = pd.get\_dummies(cars[['Car']])  
  
print(ohe\_cars.to\_string())

### **Result**

Car\_Audi Car\_BMW Car\_Fiat Car\_Ford Car\_Honda Car\_Hundai Car\_Hyundai Car\_Mazda Car\_Mercedes Car\_Mini Car\_Mitsubishi Car\_Opel Car\_Skoda Car\_Suzuki Car\_Toyoty Car\_VW Car\_Volvo

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0

1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0

2 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0

3 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0

4 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0

5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0

6 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0

7 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

8 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

9 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

10 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0

11 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0

12 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

13 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0

14 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

15 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0

16 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

17 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0

18 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0

19 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

20 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

21 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0

22 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

23 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0

24 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

25 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

26 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

27 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

28 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

29 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

30 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

31 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

32 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0

33 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

34 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0

35 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0

## Results

A column was created for every car brand in the Car column.

## Predict CO2

We can use this additional information alongside the volume and weight to predict CO2

To combine the information, we can use the concat() function from pandas.

First we will need to import a couple modules.

We will start with importing the Pandas.

import pandas

The pandas module allows us to read csv files and manipulate DataFrame objects:

cars = pandas.read\_csv("data.csv")

It also allows us to create the dummy variables:

ohe\_cars = pandas.get\_dummies(cars[['Car']])

Then we must select the independent variables (X) and add the dummy variables columnwise.

Also store the dependent variable in y.

X = pandas.concat([cars[['Volume', 'Weight']], ohe\_cars], axis=1)  
y = cars['CO2']

We also need to import a method from sklearn to create a linear model

Learn about [linear regression](https://www.w3schools.com/python/python_ml_linear_regression.asp).

from sklearn import linear\_model

Now we can fit the data to a linear regression:

regr = linear\_model.LinearRegression()  
regr.fit(X,y)

Finally we can predict the CO2 emissions based on the car's weight, volume, and manufacturer.

##predict the CO2 emission of a Volvo where the weight is 2300kg, and the volume is 1300cm3:  
predictedCO2 = regr.predict([[2300, 1300,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0]])

### **Example**

import pandas  
from sklearn import linear\_model  
  
cars = pandas.read\_csv("data.csv")  
ohe\_cars = pandas.get\_dummies(cars[['Car']])  
  
X = pandas.concat([cars[['Volume', 'Weight']], ohe\_cars], axis=1)  
y = cars['CO2']  
  
regr = linear\_model.LinearRegression()  
regr.fit(X,y)  
  
##predict the CO2 emission of a Volvo where the weight is 2300kg, and the volume is 1300cm3:  
predictedCO2 = regr.predict([[2300, 1300,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0]])  
  
print(predictedCO2)

### **Result**

[122.45153299]

We now have a coefficient for the volume, the weight, and each car brand in the data set

## Dummifying

It is not necessary to create one column for each group in your category. The information can be retained using 1 column less than the number of groups you have.

For example, you have a column representing colors and in that column, you have two colors, red and blue.

### **Example**

import pandas as pd  
  
colors = pd.DataFrame({'color': ['blue', 'red']})  
  
print(colors)

### **Result**

color

0 blue

1 red

You can create 1 column called red where 1 represents red and 0 represents not red, which means it is blue.

To do this, we can use the same function that we used for one hot encoding, get\_dummies, and then drop one of the columns. There is an argument, drop\_first, which allows us to exclude the first column from the resulting table.

### **Example**

import pandas as pd  
  
colors = pd.DataFrame({'color': ['blue', 'red']})  
dummies = pd.get\_dummies(colors, drop\_first=True)  
  
print(dummies)

### **Result**

color\_red

0 0

1 1

What if you have more than 2 groups? How can the multiple groups be represented by 1 less column?

Let's say we have three colors this time, red, blue and green. When we get\_dummies while dropping the first column, we get the following table.

### **Example**

import pandas as pd  
  
colors = pd.DataFrame({'color': ['blue', 'red', 'green']})  
dummies = pd.get\_dummies(colors, drop\_first=True)  
dummies['color'] = colors['color']  
  
print(dummies)

### **Result**

color\_green color\_red color

0 0 0 blue

1 0 1 red

2 1 0 green

# **Machine Learning - K-means**

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## K-means

K-means is an unsupervised learning method for clustering data points. The algorithm iteratively divides data points into K clusters by minimizing the variance in each cluster.

Here, we will show you how to estimate the best value for K using the elbow method, then use K-means clustering to group the data points into clusters.

## How does it work?

First, each data point is randomly assigned to one of the K clusters. Then, we compute the centroid (functionally the center) of each cluster, and reassign each data point to the cluster with the closest centroid. We repeat this process until the cluster assignments for each data point are no longer changing.

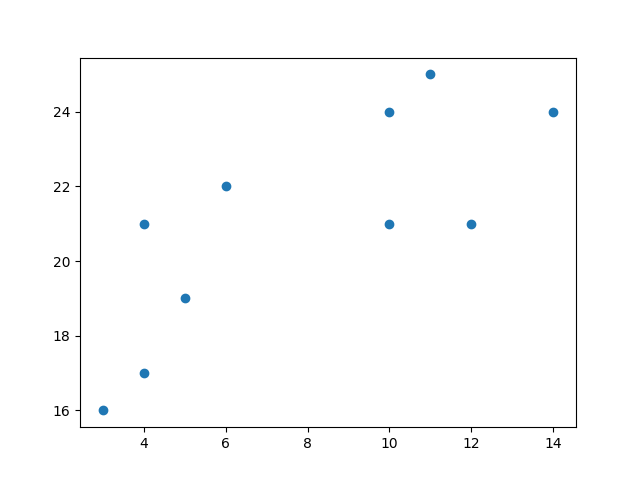
K-means clustering requires us to select K, the number of clusters we want to group the data into. The elbow method lets us graph the inertia (a distance-based metric) and visualize the point at which it starts decreasing linearly. This point is referred to as the "eblow" and is a good estimate for the best value for K based on our data.

### **Example**

Start by visualizing some data points:

import matplotlib.pyplot as plt  
  
x = [4, 5, 10, 4, 3, 11, 14 , 6, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]  
  
plt.scatter(x, y)  
plt.show()

### **Result**

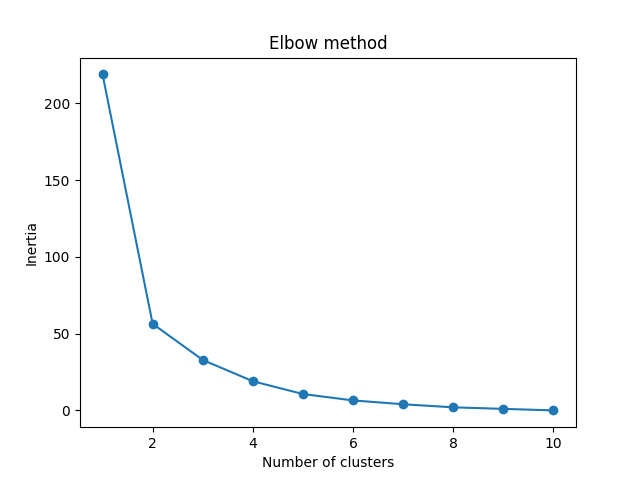


Now we utilize the elbow method to visualize the intertia for different values of K:

### **Example**

from sklearn.cluster import KMeans  
  
data = list(zip(x, y))  
inertias = []  
  
for i in range(1,11):  
    kmeans = KMeans(n\_clusters=i)  
    kmeans.fit(data)  
    inertias.append(kmeans.inertia\_)  
  
plt.plot(range(1,11), inertias, marker='o')  
plt.title('Elbow method')  
plt.xlabel('Number of clusters')  
plt.ylabel('Inertia')  
plt.show()

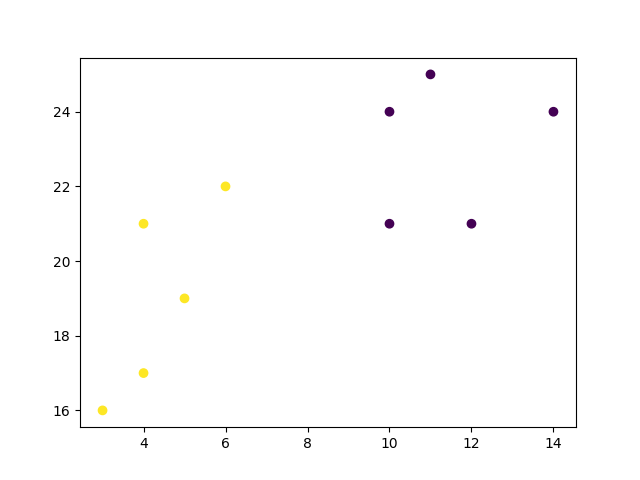
### **Result**



The elbow method shows that 2 is a good value for K, so we retrain and visualize the result:**Example**

kmeans = KMeans(n\_clusters=2)  
kmeans.fit(data)  
plt.scatter(x, y, c=kmeans.labels\_)  
plt.show()

### **Result**



## Example Explained

Import the modules you need.

import matplotlib.pyplot as plt  
from sklearn.cluster import KMeans

You can learn about the Matplotlib module in our ["Matplotlib Tutorial](https://www.w3schools.com/python/matplotlib_intro.asp).

scikit-learn is a popular library for machine learning.

Create arrays that resemble two variables in a dataset. Note that while we only use two variables here, this method will work with any number of variables:

x = [4, 5, 10, 4, 3, 11, 14 , 6, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]

Turn the data into a set of points:

data = list(zip(x, y))  
print(data)

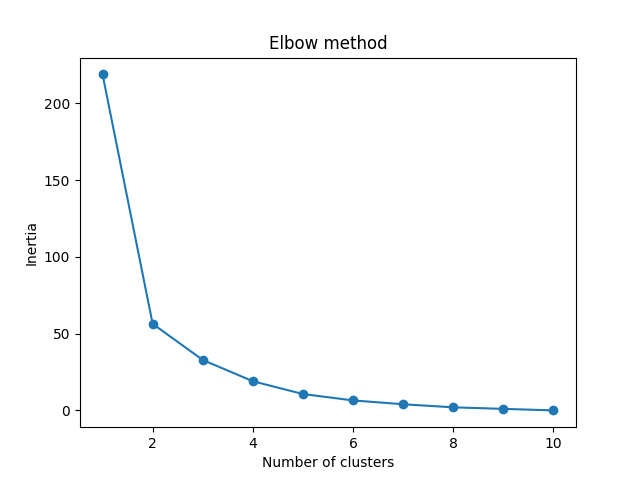
Result:

[(4, 21), (5, 19), (10, 24), (4, 17), (3, 16), (11, 25), (14, 24), (6, 22), (10, 21), (12, 21)]

In order to find the best value for K, we need to run K-means across our data for a range of possible values. We only have 10 data points, so the maximum number of clusters is 10. So for each value K in range(1,11), we train a K-means model and plot the intertia at that number of clusters:

inertias = []  
  
for i in range(1,11):  
    kmeans = KMeans(n\_clusters=i)  
    kmeans.fit(data)  
    inertias.append(kmeans.inertia\_)  
  
plt.plot(range(1,11), inertias, marker='o')  
plt.title('Elbow method')  
plt.xlabel('Number of clusters')  
plt.ylabel('Inertia')  
plt.show()

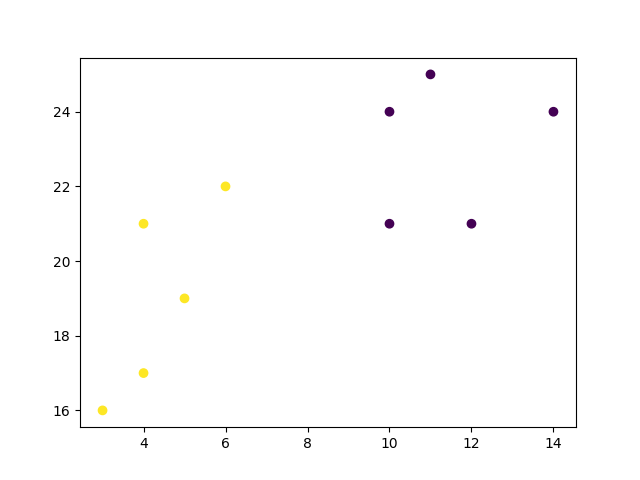
Result:



We can see that the "elbow" on the graph above (where the interia becomes more linear) is at K=2. We can then fit our K-means algorithm one more time and plot the different clusters assigned to the data:

kmeans = KMeans(n\_clusters=2)  
kmeans.fit(data)  
  
plt.scatter(x, y, c=kmeans.labels\_)  
plt.show()

Result:



# **Machine Learning - Bootstrap Aggregation (Bagging)**

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## Bagging

Methods such as Decision Trees, can be prone to overfitting on the training set which can lead to wrong predictions on new data.

Bootstrap Aggregation (bagging) is a ensembling method that attempts to resolve overfitting for classification or regression problems. Bagging aims to improve the accuracy and performance of machine learning algorithms. It does this by taking random subsets of an original dataset, with replacement, and fits either a classifier (for classification) or regressor (for regression) to each subset. The predictions for each subset are then aggregated through majority vote for classification or averaging for regression, increasing prediction accuracy.

## Evaluating a Base Classifier

To see how bagging can improve model performance, we must start by evaluating how the base classifier performs on the dataset. If you do not know what decision trees are review the lesson on decision trees before moving forward, as bagging is an continuation of the concept.

We will be looking to identify different classes of wines found in Sklearn's wine dataset.

Let's start by importing the necessary modules.

from sklearn import datasets  
from sklearn.model\_selection import train\_test\_split  
from sklearn.metrics import accuracy\_score  
from sklearn.tree import DecisionTreeClassifier

Next we need to load in the data and store it into X (input features) and y (target). The parameter as\_frame is set equal to True so we do not lose the feature names when loading the data. (sklearn version older than 0.23 must skip the as\_frame argument as it is not supported)

data = datasets.load\_wine(as\_frame = True)  
  
X = data.data  
y = data.target

In order to properly evaluate our model on unseen data, we need to split X and y into train and test sets. For information on splitting data, see the Train/Test lesson.

X\_train, X\_test, y\_train, y\_test = train\_test\_split(X, y, test\_size = 0.25, random\_state = 22)

With our data prepared, we can now instantiate a base classifier and fit it to the training data.

dtree = DecisionTreeClassifier(random\_state = 22)  
dtree.fit(X\_train,y\_train)

Result:

DecisionTreeClassifier(random\_state=22)

We can now predict the class of wine the unseen test set and evaluate the model performance.

y\_pred = dtree.predict(X\_test)  
  
print("Train data accuracy:",accuracy\_score(y\_true = y\_train, y\_pred = dtree.predict(X\_train)))  
print("Test data accuracy:",accuracy\_score(y\_true = y\_test, y\_pred = y\_pred))

Result:

Train data accuracy: 1.0  
Test data accuracy: 0.8222222222222222

### **Example**

Import the necessary data and evaluate base classifier performance.

from sklearn import datasets  
from sklearn.model\_selection import train\_test\_split  
from sklearn.metrics import accuracy\_score  
from sklearn.tree import DecisionTreeClassifier  
  
data = datasets.load\_wine(as\_frame = True)  
  
X = data.data  
y = data.target  
  
X\_train, X\_test, y\_train, y\_test = train\_test\_split(X, y, test\_size = 0.25, random\_state = 22)  
  
dtree = DecisionTreeClassifier(random\_state = 22)  
dtree.fit(X\_train,y\_train)  
  
y\_pred = dtree.predict(X\_test)  
  
print("Train data accuracy:",accuracy\_score(y\_true = y\_train, y\_pred = dtree.predict(X\_train)))  
print("Test data accuracy:",accuracy\_score(y\_true = y\_test, y\_pred = y\_pred))

The base classifier performs reasonably well on the dataset achieving 82% accuracy on the test dataset with the current parameters (Different results may occur if you do not have the random\_state parameter set).

Now that we have a baseline accuracy for the test dataset, we can see how the Bagging Classifier out performs a single Decision Tree Classifier.

## Creating a Bagging Classifier

For bagging we need to set the parameter n\_estimators, this is the number of base classifiers that our model is going to aggregate together.

For this sample dataset the number of estimators is relatively low, it is often the case that much larger ranges are explored. Hyperparameter tuning is usually done with a [grid search](https://www.w3schools.com/python/python_ml_grid_search.asp), but for now we will use a select set of values for the number of estimators.

We start by importing the necessary model.

from sklearn.ensemble import BaggingClassifier

Now lets create a range of values that represent the number of estimators we want to use in each ensemble.

estimator\_range = [2,4,6,8,10,12,14,16]

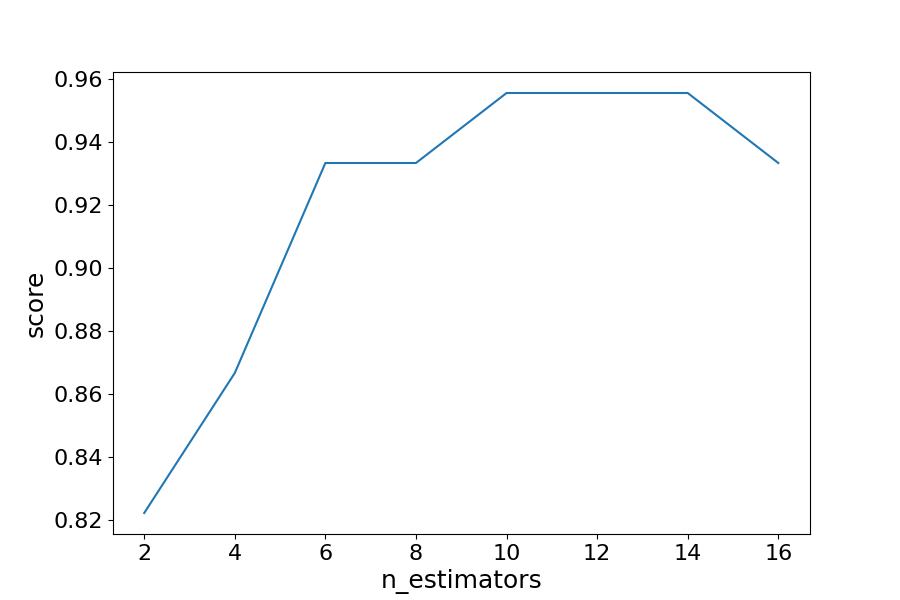
To see how the Bagging Classifier performs with differing values of n\_estimators we need a way to iterate over the range of values and store the results from each ensemble. To do this we will create a for loop, storing the models and scores in separate lists for later vizualizations.

Note: The default parameter for the base classifier in BaggingClassifier is the DicisionTreeClassifier therefore we do not need to set it when instantiating the bagging model.

models = []  
scores = []  
  
for n\_estimators in estimator\_range:  
  
    # Create bagging classifier  
    clf = BaggingClassifier(n\_estimators = n\_estimators, random\_state = 22)  
  
    # Fit the model  
    clf.fit(X\_train, y\_train)  
  
    # Append the model and score to their respective list  
    models.append(clf)  
    scores.append(accuracy\_score(y\_true = y\_test, y\_pred = clf.predict(X\_test)))

With the models and scores stored, we can now visualize the improvement in model performance.

import matplotlib.pyplot as plt  
  
# Generate the plot of scores against number of estimators  
plt.figure(figsize=(9,6))  
plt.plot(estimator\_range, scores)  
  
# Adjust labels and font (to make visable)  
plt.xlabel("n\_estimators", fontsize = 18)  
plt.ylabel("score", fontsize = 18)  
plt.tick\_params(labelsize = 16)  
  
# Visualize plot  
plt.show()

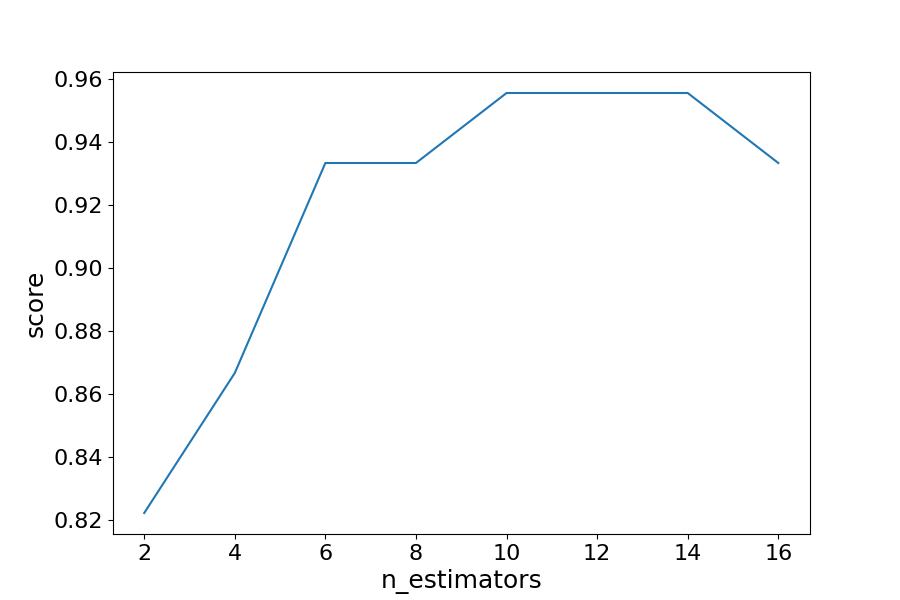


### **Example**

Import the necessary data and evaluate the BaggingClassifier performance.

import matplotlib.pyplot as plt  
from sklearn import datasets  
from sklearn.model\_selection import train\_test\_split  
from sklearn.metrics import accuracy\_score  
from sklearn.ensemble import BaggingClassifier  
  
data = datasets.load\_wine(as\_frame = True)  
  
X = data.data  
y = data.target  
  
X\_train, X\_test, y\_train, y\_test = train\_test\_split(X, y, test\_size = 0.25, random\_state = 22)  
  
estimator\_range = [2,4,6,8,10,12,14,16]  
  
models = []  
scores = []  
  
for n\_estimators in estimator\_range:  
  
    # Create bagging classifier  
    clf = BaggingClassifier(n\_estimators = n\_estimators, random\_state = 22)  
  
    # Fit the model  
    clf.fit(X\_train, y\_train)  
  
    # Append the model and score to their respective list  
    models.append(clf)  
    scores.append(accuracy\_score(y\_true = y\_test, y\_pred = clf.predict(X\_test)))  
  
# Generate the plot of scores against number of estimators  
plt.figure(figsize=(9,6))  
plt.plot(estimator\_range, scores)  
  
# Adjust labels and font (to make visable)  
plt.xlabel("n\_estimators", fontsize = 18)  
plt.ylabel("score", fontsize = 18)  
plt.tick\_params(labelsize = 16)  
  
# Visualize plot  
plt.show()

### **Result**



## Results Explained

By iterating through different values for the number of estimators we can see an increase in model performance from 82.2% to 95.5%. After 14 estimators the accuracy begins to drop, again if you set a different random\_state the values you see will vary. That is why it is best practice to use [cross validation](https://www.w3schools.com/python/python_ml_cross_validation.asp) to ensure stable results.

In this case, we see a 13.3% increase in accuracy when it comes to identifying the type of the wine.

## Another Form of Evaluation

As bootstrapping chooses random subsets of observations to create classifiers, there are observations that are left out in the selection process. These "out-of-bag" observations can then be used to evaluate the model, similarly to that of a test set. Keep in mind, that out-of-bag estimation can overestimate error in binary classification problems and should only be used as a compliment to other metrics.

We saw in the last exercise that 12 estimators yielded the highest accuracy, so we will use that to create our model. This time setting the parameter oob\_score to true to evaluate the model with out-of-bag score.

### **Example**

Create a model with out-of-bag metric.

from sklearn import datasets  
from sklearn.model\_selection import train\_test\_split  
from sklearn.ensemble import BaggingClassifier  
  
data = datasets.load\_wine(as\_frame = True)  
  
X = data.data  
y = data.target  
  
X\_train, X\_test, y\_train, y\_test = train\_test\_split(X, y, test\_size = 0.25, random\_state = 22)  
  
oob\_model = BaggingClassifier(n\_estimators = 12, oob\_score = True,random\_state = 22)  
  
oob\_model.fit(X\_train, y\_train)  
  
print(oob\_model.oob\_score\_)

Since the samples used in OOB and the test set are different, and the dataset is relatively small, there is a difference in the accuracy. It is rare that they would be exactly the same, again OOB should be used quick means for estimating error, but is not the only evaluation metric.

## Generating Decision Trees from Bagging Classifier

As was seen in the [Decision Tree](https://www.w3schools.com/python/python_ml_decision_tree.asp) lesson, it is possible to graph the decision tree the model created. It is also possible to see the individual decision trees that went into the aggregated classifier. This helps us to gain a more intuitive understanding on how the bagging model arrives at its predictions.

Note: This is only functional with smaller datasets, where the trees are relatively shallow and narrow making them easy to visualize.

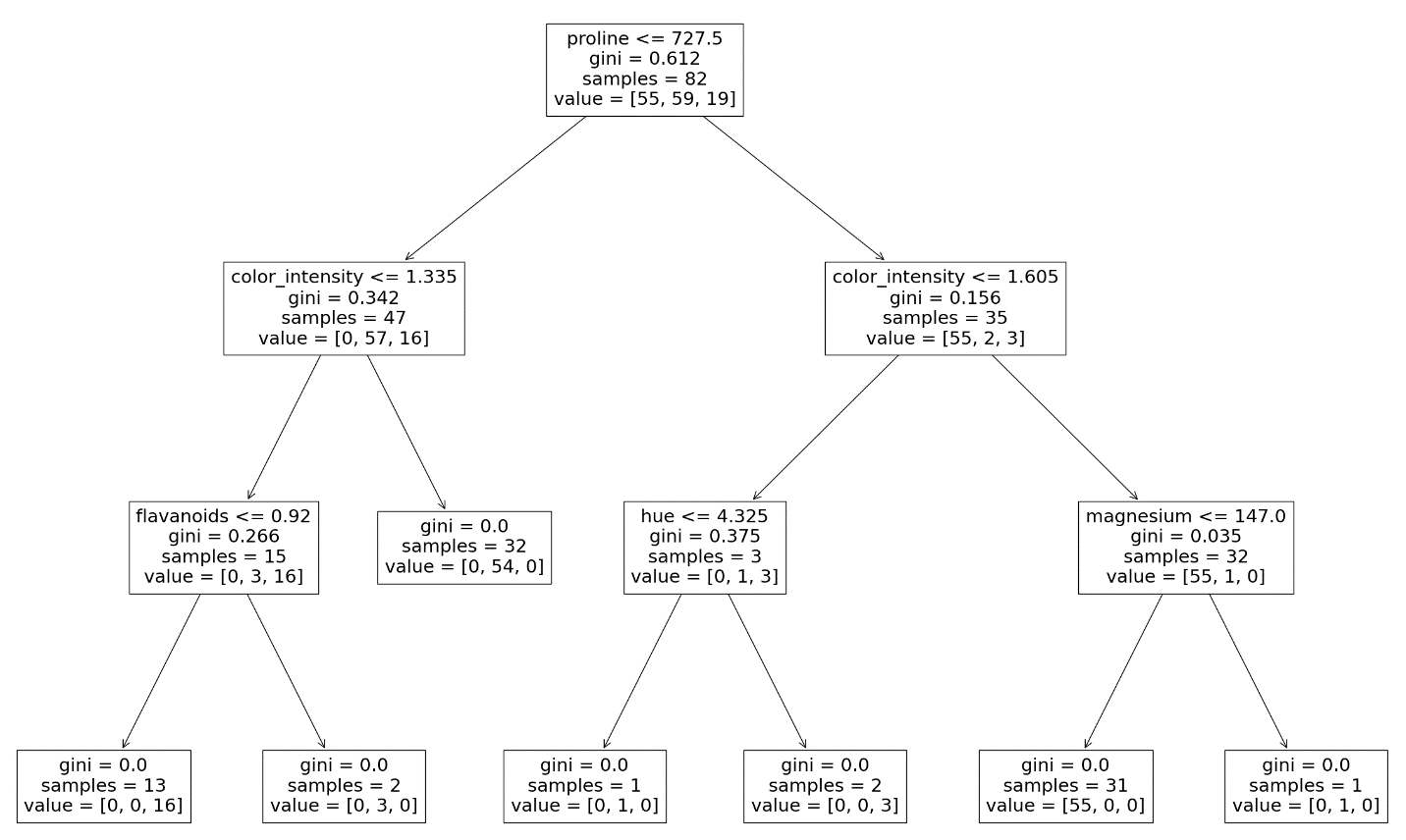
We will need to import plot\_tree function from sklearn.tree. The different trees can be graphed by changing the estimator you wish to visualize.

### **Example**

Generate Decision Trees from Bagging Classifier

from sklearn import datasets  
from sklearn.model\_selection import train\_test\_split  
from sklearn.ensemble import BaggingClassifier  
from sklearn.tree import plot\_tree  
  
X = data.data  
y = data.target  
  
X\_train, X\_test, y\_train, y\_test = train\_test\_split(X, y, test\_size = 0.25, random\_state = 22)  
  
clf = BaggingClassifier(n\_estimators = 12, oob\_score = True,random\_state = 22)  
  
clf.fit(X\_train, y\_train)  
  
plt.figure(figsize=(30, 20))  
  
plot\_tree(clf.estimators\_[0], feature\_names = X.columns)

### **Result**



Here we can see just the first decision tree that was used to vote on the final prediction. Again, by changing the index of the classifier you can see each of the trees that have been aggregated.

# **Machine Learning - Cross Validation**

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## Cross Validation

When adjusting models we are aiming to increase overall model performance on unseen data. Hyperparameter tuning can lead to much better performance on test sets. However, optimizing parameters to the test set can lead information leakage causing the model to preform worse on unseen data. To correct for this we can perform cross validation.

To better understand CV, we will be performing different methods on the iris dataset. Let us first load in and separate the data.

from sklearn import datasets  
  
X, y = datasets.load\_iris(return\_X\_y=True)

There are many methods to cross validation, we will start by looking at k-fold cross validation.

## K-Fold

The training data used in the model is split, into k number of smaller sets, to be used to validate the model. The model is then trained on k-1 folds of training set. The remaining fold is then used as a validation set to evaluate the model.

As we will be trying to classify different species of iris flowers we will need to import a classifier model, for this exercise we will be using a DecisionTreeClassifier. We will also need to import CV modules from sklearn.

from sklearn.tree import DecisionTreeClassifier  
from sklearn.model\_selection import KFold, cross\_val\_score

With the data loaded we can now create and fit a model for evaluation.

clf = DecisionTreeClassifier(random\_state=42)

Now let's evaluate our model and see how it performs on each k-fold.

k\_folds = KFold(n\_splits = 5)  
  
scores = cross\_val\_score(clf, X, y, cv = k\_folds)

It is also good pratice to see how CV performed overall by averaging the scores for all folds.

### **Example**

Run k-fold CV:

from sklearn import datasets  
from sklearn.tree import DecisionTreeClassifier  
from sklearn.model\_selection import KFold, cross\_val\_score  
  
X, y = datasets.load\_iris(return\_X\_y=True)  
  
clf = DecisionTreeClassifier(random\_state=42)  
  
k\_folds = KFold(n\_splits = 5)  
  
scores = cross\_val\_score(clf, X, y, cv = k\_folds)  
  
print("Cross Validation Scores: ", scores)  
print("Average CV Score: ", scores.mean())  
print("Number of CV Scores used in Average: ", len(scores))

## Stratified K-Fold

In cases where classes are imbalanced we need a way to account for the imbalance in both the train and validation sets. To do so we can stratify the target classes, meaning that both sets will have an equal proportion of all classes.

### **Example**

from sklearn import datasets  
from sklearn.tree import DecisionTreeClassifier  
from sklearn.model\_selection import StratifiedKFold, cross\_val\_score  
  
X, y = datasets.load\_iris(return\_X\_y=True)  
  
clf = DecisionTreeClassifier(random\_state=42)  
  
sk\_folds = StratifiedKFold(n\_splits = 5)  
  
scores = cross\_val\_score(clf, X, y, cv = sk\_folds)  
  
print("Cross Validation Scores: ", scores)  
print("Average CV Score: ", scores.mean())  
print("Number of CV Scores used in Average: ", len(scores))

While the number of folds is the same, the average CV increases from the basic k-fold when making sure there is stratified classes.

## Leave-One-Out (LOO)

Instead of selecting the number of splits in the training data set like k-fold LeaveOneOut, utilize 1 observation to validate and n-1 observations to train. This method is an exaustive technique.

### **Example**

Run LOO CV:

from sklearn import datasets  
from sklearn.tree import DecisionTreeClassifier  
from sklearn.model\_selection import LeaveOneOut, cross\_val\_score  
  
X, y = datasets.load\_iris(return\_X\_y=True)  
  
clf = DecisionTreeClassifier(random\_state=42)  
  
loo = LeaveOneOut()  
  
scores = cross\_val\_score(clf, X, y, cv = loo)  
  
print("Cross Validation Scores: ", scores)  
print("Average CV Score: ", scores.mean())  
print("Number of CV Scores used in Average: ", len(scores))

We can observe that the number of cross validation scores performed is equal to the number of observations in the dataset. In this case there are 150 observations in the iris dataset.

The average CV score is 94%.

## Leave-P-Out (LPO)

Leave-P-Out is simply a nuanced diffence to the Leave-One-Out idea, in that we can select the number of p to use in our validation set.

### **Example**

Run LPO CV:

from sklearn import datasets  
from sklearn.tree import DecisionTreeClassifier  
from sklearn.model\_selection import LeavePOut, cross\_val\_score  
  
X, y = datasets.load\_iris(return\_X\_y=True)  
  
clf = DecisionTreeClassifier(random\_state=42)  
  
lpo = LeavePOut(p=2)  
  
scores = cross\_val\_score(clf, X, y, cv = lpo)  
  
print("Cross Validation Scores: ", scores)  
print("Average CV Score: ", scores.mean())  
print("Number of CV Scores used in Average: ", len(scores))

As we can see this is an exhaustive method we many more scores being calculated than Leave-One-Out, even with a p = 2, yet it achieves roughly the same average CV score.

## Shuffle Split

Unlike KFold, ShuffleSplit leaves out a percentage of the data, not to be used in the train or validation sets. To do so we must decide what the train and test sizes are, as well as the number of splits.

### **Example**

Run Shuffle Split CV:

from sklearn import datasets  
from sklearn.tree import DecisionTreeClassifier  
from sklearn.model\_selection import ShuffleSplit, cross\_val\_score  
  
X, y = datasets.load\_iris(return\_X\_y=True)  
  
clf = DecisionTreeClassifier(random\_state=42)  
  
ss = ShuffleSplit(train\_size=0.6, test\_size=0.3, n\_splits = 5)  
  
scores = cross\_val\_score(clf, X, y, cv = ss)  
  
print("Cross Validation Scores: ", scores)  
print("Average CV Score: ", scores.mean())  
print("Number of CV Scores used in Average: ", len(scores))

## Ending Notes

These are just a few of the CV methods that can be applied to models. There are many more cross validation classes, with most models having their own class. Check out sklearns cross validation for more CV options.

# **Machine Learning - AUC - ROC Curve**

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## AUC - ROC Curve

In classification, there are many different evaluation metrics. The most popular is **accuracy**, which measures how often the model is correct. This is a great metric because it is easy to understand and getting the most correct guesses is often desired. There are some cases where you might consider using another evaluation metric.

Another common metric is **AUC**, area under the receiver operating characteristic (**ROC**) curve. The Reciever operating characteristic curve plots the true positive (**TP**) rate versus the false positive (**FP**) rate at different classification thresholds. The thresholds are different probability cutoffs that separate the two classes in binary classification. It uses probability to tell us how well a model separates the classes.

## Imbalanced Data

Suppose we have an imbalanced data set where the majority of our data is of one value. We can obtain high accuracy for the model by predicting the majority class.

### **Example**

import numpy as np  
from sklearn.metrics import accuracy\_score, confusion\_matrix, roc\_auc\_score, roc\_curve  
  
n = 10000  
ratio = .95  
n\_0 = int((1-ratio) \* n)  
n\_1 = int(ratio \* n)  
  
y = np.array([0] \* n\_0 + [1] \* n\_1)  
# below are the probabilities obtained from a hypothetical model that always predicts the majority class  
# probability of predicting class 1 is going to be 100%  
y\_proba = np.array([1]\*n)  
y\_pred = y\_proba > .5  
  
print(f'accuracy score: {accuracy\_score(y, y\_pred)}')  
cf\_mat = confusion\_matrix(y, y\_pred)  
print('Confusion matrix')  
print(cf\_mat)  
print(f'class 0 accuracy: {cf\_mat[0][0]/n\_0}')  
print(f'class 1 accuracy: {cf\_mat[1][1]/n\_1}')

Although we obtain a very high accuracy, the model provided no information about the data so it's not useful. We accurately predict class 1 100% of the time while inaccurately predict class 0 0% of the time. At the expense of accuracy, it might be better to have a model that can somewhat separate the two classes.

### **Example**

# below are the probabilities obtained from a hypothetical model that doesn't always predict the mode  
y\_proba\_2 = np.array(  
    np.random.uniform(0, .7, n\_0).tolist() +  
    np.random.uniform(.3, 1, n\_1).tolist()  
)  
y\_pred\_2 = y\_proba\_2 > .5  
  
print(f'accuracy score: {accuracy\_score(y, y\_pred\_2)}')  
cf\_mat = confusion\_matrix(y, y\_pred\_2)  
print('Confusion matrix')  
print(cf\_mat)  
print(f'class 0 accuracy: {cf\_mat[0][0]/n\_0}')  
print(f'class 1 accuracy: {cf\_mat[1][1]/n\_1}')

For the second set of predictions, we do not have as high of an accuracy score as the first but the accuracy for each class is more balanced. Using accuracy as an evaluation metric we would rate the first model higher than the second even though it doesn't tell us anything about the data.

In cases like this, using another evaluation metric like AUC would be preferred.

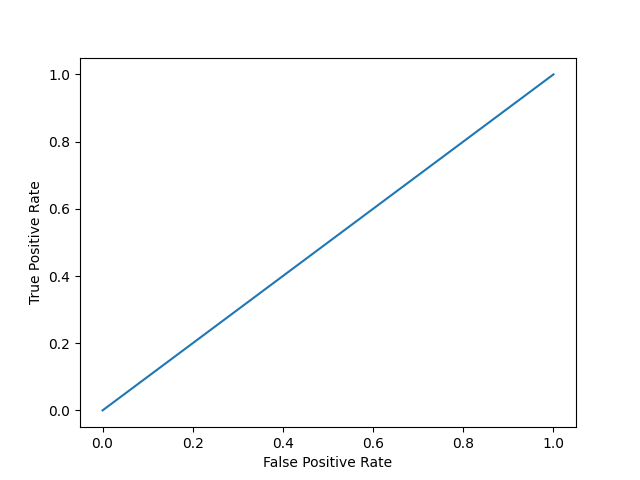
import matplotlib.pyplot as plt  
  
def plot\_roc\_curve(true\_y, y\_prob):  
    """  
    plots the roc curve based of the probabilities  
    """  
  
    fpr, tpr, thresholds = roc\_curve(true\_y, y\_prob)  
    plt.plot(fpr, tpr)  
    plt.xlabel('False Positive Rate')  
    plt.ylabel('True Positive Rate')

### **Example**

Model 1:

plot\_roc\_curve(y, y\_proba)  
print(f'model 1 AUC score: {roc\_auc\_score(y, y\_proba)}')

### **Result**

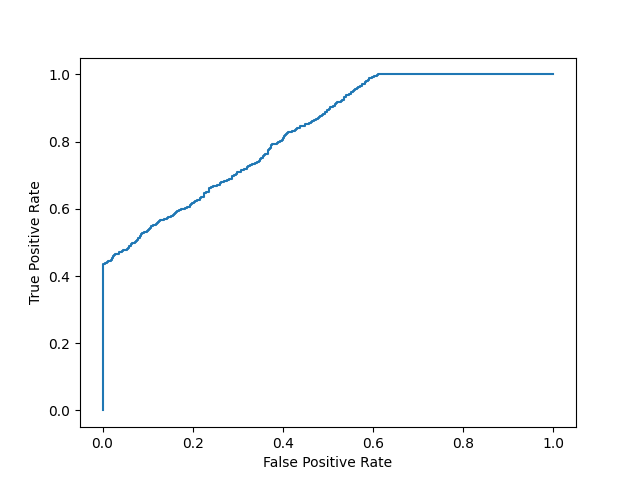
  
model 1 AUC score: 0.5

### **Example**

Model 2:

plot\_roc\_curve(y, y\_proba\_2)  
print(f'model 2 AUC score: {roc\_auc\_score(y, y\_proba\_2)}')

### **Result**

  
model 2 AUC score: 0.8270551578947367

An AUC score of around .5 would mean that the model is unable to make a distinction between the two classes and the curve would look like a line with a slope of 1. An AUC score closer to 1 means that the model has the ability to separate the two classes and the curve would come closer to the top left corner of the graph.

## Probabilities

Because AUC is a metric that utilizes probabilities of the class predictions, we can be more confident in a model that has a higher AUC score than one with a lower score even if they have similar accuracies.

In the data below, we have two sets of probabilites from hypothetical models. The first has probabilities that are not as "confident" when predicting the two classes (the probabilities are close to .5). The second has probabilities that are more "confident" when predicting the two classes (the probabilities are close to the extremes of 0 or 1).

### **Example**

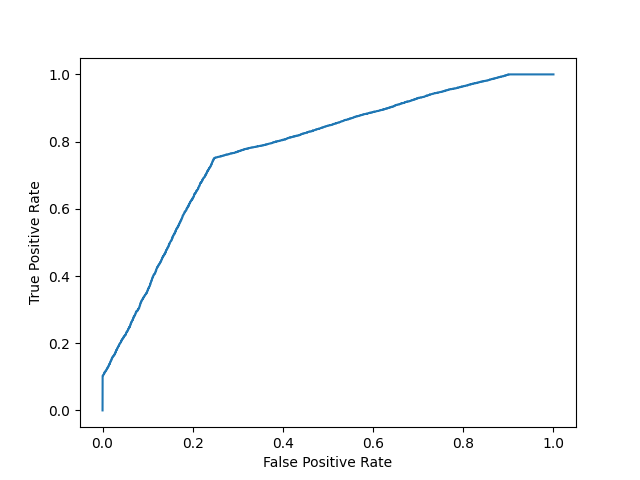
import numpy as np  
  
n = 10000  
y = np.array([0] \* n + [1] \* n)  
#  
y\_prob\_1 = np.array(  
    np.random.uniform(.25, .5, n//2).tolist() +  
    np.random.uniform(.3, .7, n).tolist() +  
    np.random.uniform(.5, .75, n//2).tolist()  
)  
y\_prob\_2 = np.array(  
    np.random.uniform(0, .4, n//2).tolist() +  
    np.random.uniform(.3, .7, n).tolist() +  
    np.random.uniform(.6, 1, n//2).tolist()  
)  
  
print(f'model 1 accuracy score: {accuracy\_score(y, y\_prob\_1>.5)}')  
print(f'model 2 accuracy score: {accuracy\_score(y, y\_prob\_2>.5)}')  
  
print(f'model 1 AUC score: {roc\_auc\_score(y, y\_prob\_1)}')  
print(f'model 2 AUC score: {roc\_auc\_score(y, y\_prob\_2)}')

### **Example**

Plot model 1:

plot\_roc\_curve(y, y\_prob\_1)

### **Result**

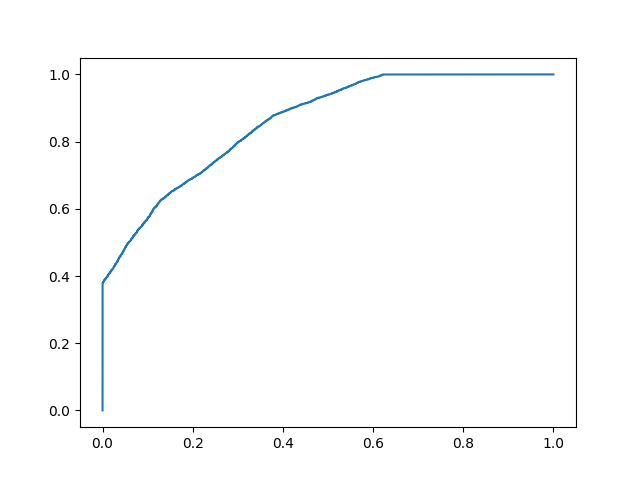


### **Example**

Plot model 2:

fpr, tpr, thresholds = roc\_curve(y, y\_prob\_2)  
plt.plot(fpr, tpr)

### **Result**



Even though the accuracies for the two models are similar, the model with the higher AUC score will be more reliable because it takes into account the predicted probability. It is more likely to give you higher accuracy when predicting future data.

# **Machine Learning - K-nearest neighbors (KNN)**

On this page, W3schools.com collaborates with [NYC Data Science Academy](https://t.sidekickopen01.com/s3t/c/5/f18dQhb0S7kv8c7RP2W1z75qk59hl3kW7_k2847tBZxCVvfv0f1GTV9PW2RxlDT2bzNMYdZ8s8G01?te=W3R5hFj4cm2zwW41-DxM3zhrr_W3F7ZBj3F6bSSW43T4N94hMnzcW3F4Fvd3zbTMqW2fgYK73F7y_5W3Zp0KM3_Qh5fW4hLxLG2f1Dw_W3F7y_53Zp0KMW3_QgzD3H6xvkW2dTzCR3SYMmGW1mp5CL3ZWTYrW4cbSf23_Qh9QW49NMw73HdlCPW3Hbzjf4fKWwkW43TDjD41YtR1W3zbVlf1S1tRf38WL2&si=6321147182055424&pi=566c78b2-d5c2-45ad-ad0c-74291c07630b), to deliver digital training content to our students.

## KNN

KNN is a simple, supervised machine learning (ML) algorithm that can be used for classification or regression tasks - and is also frequently used in missing value imputation. It is based on the idea that the observations closest to a given data point are the most "similar" observations in a data set, and we can therefore classify unforeseen points based on the values of the closest existing points. By choosing K, the user can select the number of nearby observations to use in the algorithm.

Here, we will show you how to implement the KNN algorithm for classification, and show how different values of K affect the results.

## How does it work?

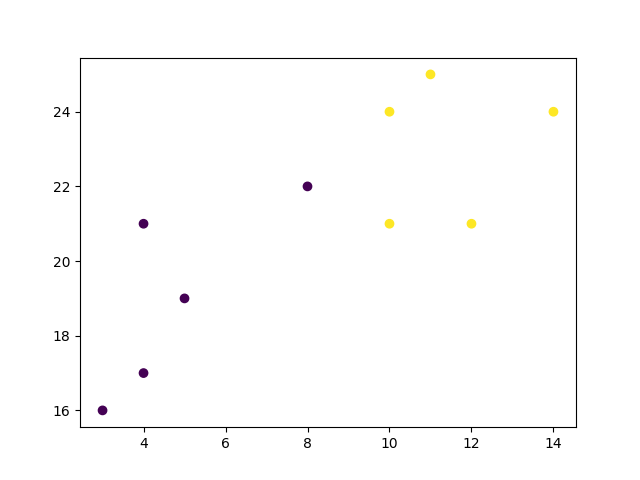
K is the number of nearest neighbors to use. For classification, a majority vote is used to determined which class a new observation should fall into. Larger values of K are often more robust to outliers and produce more stable decision boundaries than very small values (K=3 would be better than K=1, which might produce undesirable results.

### **Example**

Start by visualizing some data points:

import matplotlib.pyplot as plt  
  
x = [4, 5, 10, 4, 3, 11, 14 , 8, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]  
classes = [0, 0, 1, 0, 0, 1, 1, 0, 1, 1]  
  
plt.scatter(x, y, c=classes)  
plt.show()

### **Result**



Now we fit the KNN algorithm with K=1:

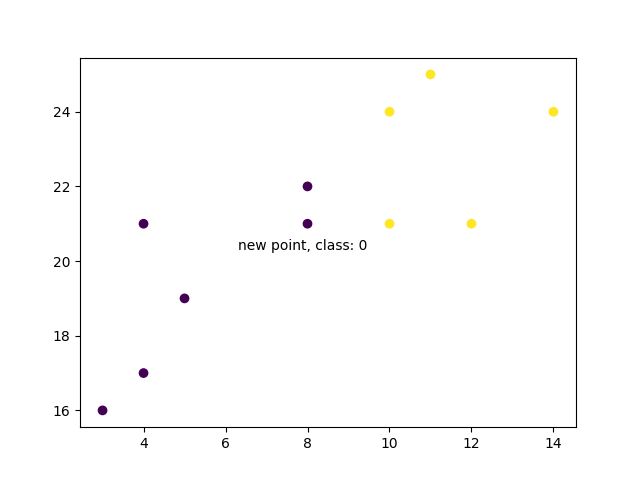
from sklearn.neighbors import KNeighborsClassifier  
  
data = list(zip(x, y))  
knn = KNeighborsClassifier(n\_neighbors=1)  
  
knn.fit(data, classes)

And use it to classify a new data point:

### **Example**

new\_x = 8  
new\_y = 21  
new\_point = [(new\_x, new\_y)]  
  
prediction = knn.predict(new\_point)  
  
plt.scatter(x + [new\_x], y + [new\_y], c=classes + [prediction[0]])  
plt.text(x=new\_x-1.7, y=new\_y-0.7, s=f"new point, class: {prediction[0]}")  
plt.show()

### **Result**

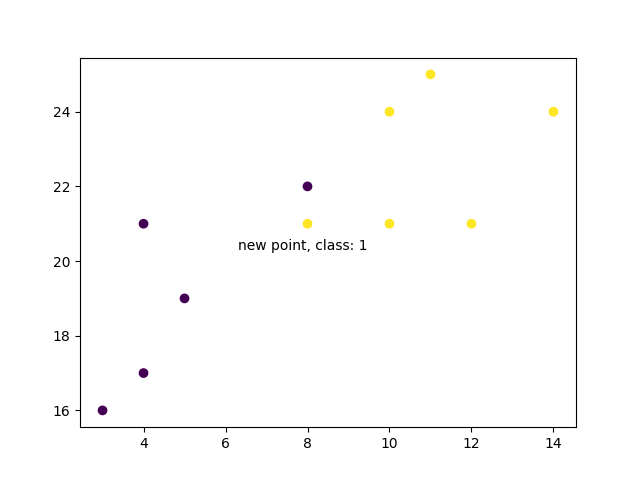


Now we do the same thing, but with a higher K value which changes the prediction:

### **Example**

knn = KNeighborsClassifier(n\_neighbors=5)  
  
knn.fit(data, classes)  
  
prediction = knn.predict(new\_point)  
  
plt.scatter(x + [new\_x], y + [new\_y], c=classes + [prediction[0]])  
plt.text(x=new\_x-1.7, y=new\_y-0.7, s=f"new point, class: {prediction[0]}")  
plt.show()

### **Result**



## Example Explained

Import the modules you need.

You can learn about the Matplotlib module in our ["Matplotlib Tutorial](https://www.w3schools.com/python/matplotlib_intro.asp).

scikit-learn is a popular library for machine learning in Python.

import matplotlib.pyplot as plt  
from sklearn.neighbors import KNeighborsClassifier

Create arrays that resemble variables in a dataset. We have two input features (x and y) and then a target class (class). The input features that are pre-labeled with our target class will be used to predict the class of new data. Note that while we only use two input features here, this method will work with any number of variables:

x = [4, 5, 10, 4, 3, 11, 14 , 8, 10, 12]  
y = [21, 19, 24, 17, 16, 25, 24, 22, 21, 21]  
classes = [0, 0, 1, 0, 0, 1, 1, 0, 1, 1]

Turn the input features into a set of points:

data = list(zip(x, y))  
print(data)

### **Result:**

[(4, 21), (5, 19), (10, 24), (4, 17), (3, 16), (11, 25), (14, 24), (8, 22), (10, 21), (12, 21)]

Using the input features and target class, we fit a KNN model on the model using 1 nearest neighbor:

knn = KNeighborsClassifier(n\_neighbors=1)  
knn.fit(data, classes)

Then, we can use the same KNN object to predict the class of new, unforeseen data points. First we create new x and y features, and then call knn.predict() on the new data point to get a class of 0 or 1:

new\_x = 8  
new\_y = 21  
new\_point = [(new\_x, new\_y)]  
prediction = knn.predict(new\_point)  
print(prediction)

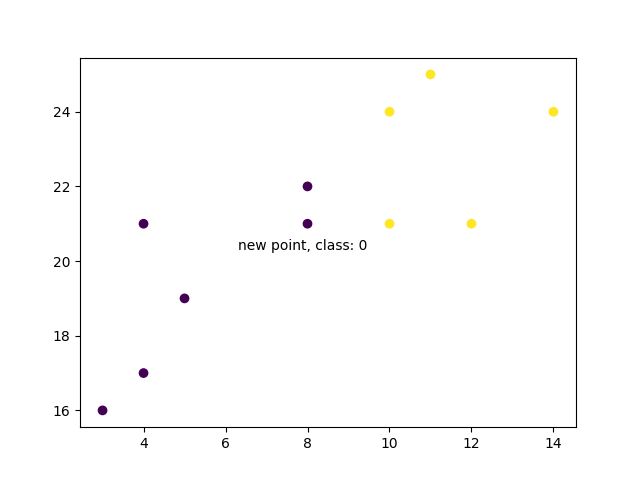
### **Result:**

[0]

When we plot all the data along with the new point and class, we can see it's been labeled blue with the 1 class. The text annotation is just to highlight the location of the new point:

plt.scatter(x + [new\_x], y + [new\_y], c=classes + [prediction[0]])  
plt.text(x=new\_x-1.7, y=new\_y-0.7, s=f"new point, class: {prediction[0]}")  
plt.show()

### **Result:**



However, when we changes the number of neighbors to 5, the number of points used to classify our new point changes. As a result, so does the classification of the new point:

knn = KNeighborsClassifier(n\_neighbors=5)  
knn.fit(data, classes)  
prediction = knn.predict(new\_point)  
print(prediction)

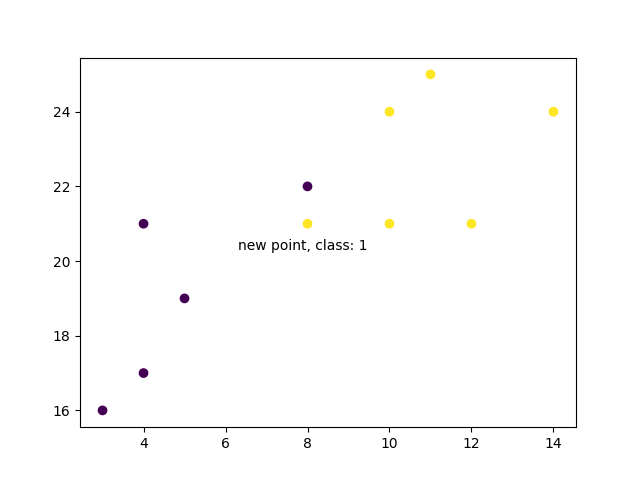
### **Result:**

[1]

When we plot the class of the new point along with the older points, we note that the color has changed based on the associated class label:

plt.scatter(x + [new\_x], y + [new\_y], c=classes + [prediction[0]])  
plt.text(x=new\_x-1.7, y=new\_y-0.7, s=f"new point, class: {prediction[0]}")  
plt.show()

### **Result:**



# **Python MySQL**

Python can be used in database applications.

One of the most popular databases is MySQL.

## MySQL Database

To be able to experiment with the code examples in this tutorial, you should have MySQL installed on your computer.

You can download a MySQL database at <https://www.mysql.com/downloads/>.

## Install MySQL Driver

Python needs a MySQL driver to access the MySQL database.

In this tutorial we will use the driver "MySQL Connector".

We recommend that you use PIP to install "MySQL Connector".

PIP is most likely already installed in your Python environment.

Navigate your command line to the location of PIP, and type the following:

Download and install "MySQL Connector":

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>python -m pip install mysql-connector-python

Now you have downloaded and installed a MySQL driver.

## Test MySQL Connector

To test if the installation was successful, or if you already have "MySQL Connector" installed, create a Python page with the following content:

demo\_mysql\_test.py:

import mysql.connector

If the above code was executed with no errors, "MySQL Connector" is installed and ready to be used.

## Create Connection

Start by creating a connection to the database.

Use the username and password from your MySQL database:

demo\_mysql\_connection.py:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword"  
)  
  
print(mydb)

Now you can start querying the database using SQL statements.

# **Python MySQL Create Database**

## Creating a Database

To create a database in MySQL, use the "CREATE DATABASE" statement:

### **Example**

create a database named "mydatabase":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("CREATE DATABASE mydatabase")

If the above code was executed with no errors, you have successfully created a database.

## Check if Database Exists

You can check if a database exist by listing all databases in your system by using the "SHOW DATABASES" statement:

### **Example**

Return a list of your system's databases:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("SHOW DATABASES")  
  
for x in mycursor:  
  print(x)

Or you can try to access the database when making the connection:

### **Example**

Try connecting to the database "mydatabase":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
**database="mydatabase"**  
)

If the database does not exist, you will get an error.

# **Python MySQL Create Table**

## Creating a Table

To create a table in MySQL, use the "CREATE TABLE" statement.

Make sure you define the name of the database when you create the connection

### **Example**

Create a table named "customers":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("CREATE TABLE customers (name VARCHAR(255), address VARCHAR(255))")

If the above code was executed with no errors, you have now successfully created a table.

## Check if Table Exists

You can check if a table exist by listing all tables in your database with the "SHOW TABLES" statement:

### **Example**

Return a list of your system's databases:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("SHOW TABLES")  
  
for x in mycursor:  
  print(x)

## Primary Key

When creating a table, you should also create a column with a unique key for each record.

This can be done by defining a PRIMARY KEY.

We use the statement "INT AUTO\_INCREMENT PRIMARY KEY" which will insert a unique number for each record. Starting at 1, and increased by one for each record.

### **Example**

Create primary key when creating the table:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("CREATE TABLE customers (id INT AUTO\_INCREMENT PRIMARY KEY, name VARCHAR(255), address VARCHAR(255))")

If the table already exists, use the ALTER TABLE keyword:

### **Example**

Create primary key on an existing table:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("ALTER TABLE customers ADD COLUMN id INT AUTO\_INCREMENT PRIMARY KEY")

# **Python MySQL Insert Into Table**

## Insert Into Table

To fill a table in MySQL, use the "INSERT INTO" statement.

### **Example**

Insert a record in the "customers" table:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "INSERT INTO customers (name, address) VALUES (%s, %s)"  
val = ("John", "Highway 21")  
mycursor.execute(sql, val)  
 **mydb.commit()**  
print(mycursor.rowcount, "record inserted.")

**Important!:** Notice the statement: mydb.commit(). It is required to make the changes, otherwise no changes are made to the table.

## Insert Multiple Rows

To insert multiple rows into a table, use the executemany() method.

The second parameter of the executemany() method is a list of tuples, containing the data you want to insert:

### **Example**

Fill the "customers" table with data:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "INSERT INTO customers (name, address) VALUES (%s, %s)"  
val = [  
  ('Peter', 'Lowstreet 4'),  
  ('Amy', 'Apple st 652'),  
  ('Hannah', 'Mountain 21'),  
  ('Michael', 'Valley 345'),  
  ('Sandy', 'Ocean blvd 2'),  
  ('Betty', 'Green Grass 1'),  
  ('Richard', 'Sky st 331'),  
  ('Susan', 'One way 98'),  
  ('Vicky', 'Yellow Garden 2'),  
  ('Ben', 'Park Lane 38'),  
  ('William', 'Central st 954'),  
  ('Chuck', 'Main Road 989'),  
  ('Viola', 'Sideway 1633')  
]  
  
mycursor.executemany(sql, val)  
  
mydb.commit()  
  
print(mycursor.rowcount, "was inserted.")

## Get Inserted ID

You can get the id of the row you just inserted by asking the cursor object.

**Note:** If you insert more than one row, the id of the last inserted row is returned.

### **Example**

Insert one row, and return the ID:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "INSERT INTO customers (name, address) VALUES (%s, %s)"  
val = ("Michelle", "Blue Village")  
mycursor.execute(sql, val)  
  
mydb.commit()  
  
print("1 record inserted, ID:", mycursor.lastrowid)

# **Python MySQL Select From**

## Select From a Table

To select from a table in MySQL, use the "SELECT" statement:

### **Example**

Select all records from the "customers" table, and display the result:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("SELECT \* FROM customers")  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

**Note:** We use the fetchall() method, which fetches all rows from the last executed statement.

## Selecting Columns

To select only some of the columns in a table, use the "SELECT" statement followed by the column name(s):

### **Example**

Select only the name and address columns:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("SELECT name, address FROM customers")  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

## Using the fetchone() Method

If you are only interested in one row, you can use the fetchone() method.

The fetchone() method will return the first row of the result:

### **Example**

Fetch only one row:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("SELECT \* FROM customers")  
  
myresult = mycursor.fetchone()  
  
print(myresult)

# **Python MySQL Where**

## Select With a Filter

When selecting records from a table, you can filter the selection by using the "WHERE" statement:

### **Example**

Select record(s) where the address is "Park Lane 38": result:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "SELECT \* FROM customers WHERE address ='Park Lane 38'"  
  
mycursor.execute(sql)  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

## Wildcard Characters

You can also select the records that starts, includes, or ends with a given letter or phrase.

Use the %  to represent wildcard characters:

### **Example**

Select records where the address contains the word "way":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "SELECT \* FROM customers WHERE address LIKE '%way%'"  
  
mycursor.execute(sql)  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

## Prevent SQL Injection

When query values are provided by the user, you should escape the values.

This is to prevent SQL injections, which is a common web hacking technique to destroy or misuse your database.

The mysql.connector module has methods to escape query values:

### **Example**

Escape query values by using the placholder %s method:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "SELECT \* FROM customers WHERE address = %s"  
adr = ("Yellow Garden 2", )  
  
mycursor.execute(sql, adr)  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

# **Python MySQL Order By**

## Sort the Result

Use the ORDER BY statement to sort the result in ascending or descending order.

The ORDER BY keyword sorts the result ascending by default. To sort the result in descending order, use the DESC keyword.

### **Example**

Sort the result alphabetically by name: result:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "SELECT \* FROM customers ORDER BY name"  
  
mycursor.execute(sql)  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

## ORDER BY DESC

Use the DESC keyword to sort the result in a descending order.

### **Example**

Sort the result reverse alphabetically by name:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "SELECT \* FROM customers ORDER BY name DESC"  
  
mycursor.execute(sql)  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

# **Python MySQL Delete From By**

## Delete Record

You can delete records from an existing table by using the "DELETE FROM" statement:

### **Example**

Delete any record where the address is "Mountain 21":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "DELETE FROM customers WHERE address = 'Mountain 21'"  
  
mycursor.execute(sql)  
  
mydb.commit()  
  
print(mycursor.rowcount, "record(s) deleted")

**Important!:** Notice the statement: mydb.commit(). It is required to make the changes, otherwise no changes are made to the table.

**Notice the WHERE clause in the DELETE syntax:** The WHERE clause specifies which record(s) that should be deleted. If you omit the WHERE clause, all records will be deleted!

## Prevent SQL Injection

It is considered a good practice to escape the values of any query, also in delete statements.

This is to prevent SQL injections, which is a common web hacking technique to destroy or misuse your database.

The mysql.connector module uses the placeholder %s to escape values in the delete statement:

### **Example**

Escape values by using the placeholder %s method:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "DELETE FROM customers WHERE address = %s"  
adr = ("Yellow Garden 2", )  
  
mycursor.execute(sql, adr)  
  
mydb.commit()  
  
print(mycursor.rowcount, "record(s) deleted")

# **Python MySQL Drop Table**

## Delete a Table

You can delete an existing table by using the "DROP TABLE" statement:

### **Example**

Delete the table "customers":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "DROP TABLE customers"  
  
mycursor.execute(sql)

## Drop Only if Exist

If the table you want to delete is already deleted, or for any other reason does not exist, you can use the IF EXISTS keyword to avoid getting an error.

### **Example**

Delete the table "customers" if it exists:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "DROP TABLE IF EXISTS customers"  
  
mycursor.execute(sql)

# **Python MySQL Update Table**

## Update Table

You can update existing records in a table by using the "UPDATE" statement:

### **Example**

Overwrite the address column from "Valley 345" to "Canyon 123":

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "UPDATE customers SET address = 'Canyon 123' WHERE address = 'Valley 345'"  
  
mycursor.execute(sql)  
  
mydb.commit()  
  
print(mycursor.rowcount, "record(s) affected")

**Important!:** Notice the statement: mydb.commit(). It is required to make the changes, otherwise no changes are made to the table.

**Notice the WHERE clause in the UPDATE syntax:** The WHERE clause specifies which record or records that should be updated. If you omit the WHERE clause, all records will be updated!

## Prevent SQL Injection

It is considered a good practice to escape the values of any query, also in update statements.

This is to prevent SQL injections, which is a common web hacking technique to destroy or misuse your database.

The mysql.connector module uses the placeholder %s to escape values in the delete statement:

### **Example**

Escape values by using the placeholder %s method:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "UPDATE customers SET address = %s WHERE address = %s"  
val = ("Valley 345", "Canyon 123")  
  
mycursor.execute(sql, val)  
  
mydb.commit()  
  
print(mycursor.rowcount, "record(s) affected")

# **Python MySQL Limit**

## Limit the Result

You can limit the number of records returned from the query, by using the "LIMIT" statement:

### **Example**

Select the 5 first records in the "customers" table:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
mycursor.execute("SELECT \* FROM customers LIMIT 5")  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

## Start From Another Position

If you want to return five records, starting from the third record, you can use the "OFFSET" keyword:

### **Example**

Start from position 3, and return 5 records:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
mycursor = mydb.cursor()  
  
mycursor.execute("SELECT \* FROM customers LIMIT 5 OFFSET 2")  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

# **Python MySQL Join**

## Join Two or More Tables

You can combine rows from two or more tables, based on a related column between them, by using a JOIN statement.

Consider you have a "users" table and a "products" table:

### **users**

{ id: 1, name: 'John', fav: 154},  
{ id: 2, name: 'Peter', fav: 154},  
{ id: 3, name: 'Amy', fav: 155},  
{ id: 4, name: 'Hannah', fav:},  
{ id: 5, name: 'Michael', fav:}

### **products**

{ id: 154, name: 'Chocolate Heaven' },  
{ id: 155, name: 'Tasty Lemons' },  
{ id: 156, name: 'Vanilla Dreams' }

These two tables can be combined by using users' fav field and products' id field.

### **Example**

Join users and products to see the name of the users favorite product:

import mysql.connector  
  
mydb = mysql.connector.connect(  
  host="localhost",  
  user="yourusername",  
  password="yourpassword",  
  database="mydatabase"  
)  
  
mycursor = mydb.cursor()  
  
sql = "SELECT \  
  users.name AS user, \  
  products.name AS favorite \  
  FROM users \  
  INNER JOIN products ON users.fav = products.id"  
  
mycursor.execute(sql)  
  
myresult = mycursor.fetchall()  
  
for x in myresult:  
  print(x)

**Note:** You can use JOIN instead of INNER JOIN. They will both give you the same result.

## LEFT JOIN

In the example above, Hannah, and Michael were excluded from the result, that is because INNER JOIN only shows the records where there is a match.

If you want to show all users, even if they do not have a favorite product, use the LEFT JOIN statement:

### **Example**

Select all users and their favorite product:

sql = "SELECT \  
  users.name AS user, \  
  products.name AS favorite \  
  FROM users \  
  LEFT JOIN products ON users.fav = products.id"

## RIGHT JOIN

If you want to return all products, and the users who have them as their favorite, even if no user have them as their favorite, use the RIGHT JOIN statement:

### **Example**

Select all products, and the user(s) who have them as their favorite:

sql = "SELECT \  
  users.name AS user, \  
  products.name AS favorite \  
  FROM users \  
  RIGHT JOIN products ON users.fav = products.id"

**Note:** Hannah and Michael, who have no favorite product, are not included in the result.

## 

# **Python MongoDB**

Python can be used in database applications.

One of the most popular NoSQL database is MongoDB.

## MongoDB

MongoDB stores data in JSON-like documents, which makes the database very flexible and scalable.

To be able to experiment with the code examples in this tutorial, you will need access to a MongoDB database.

You can download a free MongoDB database at [https://www.mongodb.com](https://www.mongodb.com/).

Or get started right away with a MongoDB cloud service at <https://www.mongodb.com/cloud/atlas>.

## PyMongo

Python needs a MongoDB driver to access the MongoDB database.

In this tutorial we will use the MongoDB driver "PyMongo".

We recommend that you use PIP to install "PyMongo".

PIP is most likely already installed in your Python environment.

Navigate your command line to the location of PIP, and type the following:

Download and install "PyMongo":

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>python -m pip install pymongo

Now you have downloaded and installed a mongoDB driver.

## Test PyMongo

To test if the installation was successful, or if you already have "pymongo" installed, create a Python page with the following content:

demo\_mongodb\_test.py:

import pymongo

If the above code was executed with no errors, "pymongo" is installed and ready to be used.

# **Python MongoDB Create Database**

## Creating a Database

To create a database in MongoDB, start by creating a MongoClient object, then specify a connection URL with the correct ip address and the name of the database you want to create.

MongoDB will create the database if it does not exist, and make a connection to it.

### **Example**

Create a database called "mydatabase":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
  
mydb = myclient["mydatabase"]

**Important:** In MongoDB, a database is not created until it gets content!

MongoDB waits until you have created a collection (table), with at least one document (record) before it actually creates the database (and collection).

## Check if Database Exists

**Remember:** In MongoDB, a database is not created until it gets content, so if this is your first time creating a database, you should complete the next two chapters (create collection and create document) before you check if the database exists!

You can check if a database exist by listing all databases in you system:

### **Example**

Return a list of your system's databases:

print(myclient.list\_database\_names())

['admin', 'local', 'mydatabase']

Or you can check a specific database by name:

### **Example**

Check if "mydatabase" exists:

dblist = myclient.list\_database\_names()  
if "mydatabase" in dblist:  
  print("The database exists.")

The database exists.

# **Python MongoDB Create Collection**

A **collection** in MongoDB is the same as a **table** in SQL databases.

## Creating a Collection

To create a collection in MongoDB, use database object and specify the name of the collection you want to create.

MongoDB will create the collection if it does not exist.

### **Example**

Create a collection called "customers":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
  
mycol = mydb["customers"]

**Important:** In MongoDB, a collection is not created until it gets content!

MongoDB waits until you have inserted a document before it actually creates the collection.

## Check if Collection Exists

**Remember:** In MongoDB, a collection is not created until it gets content, so if this is your first time creating a collection, you should complete the next chapter (create document) before you check if the collection exists!

You can check if a collection exist in a database by listing all collections:

### **Example**

Return a list of all collections in your database:

print(mydb.list\_collection\_names())

['customers']

Or you can check a specific collection by name:

### **Example**

Check if the "customers" collection exists:

collist = mydb.list\_collection\_names()  
if "customers" in collist:  
  print("The collection exists.")

The collection exists.

# **Python MongoDB Insert Document**

A **document** in MongoDB is the same as a **record** in SQL databases.

## Insert Into Collection

To insert a record, or document as it is called in MongoDB, into a collection, we use the insert\_one() method.

The first parameter of the insert\_one() method is a dictionary containing the name(s) and value(s) of each field in the document you want to insert.

### **Example**

Insert a record in the "customers" collection:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
mydict = { "name": "John", "address": "Highway 37" }  
  
x = mycol.insert\_one(mydict)

<pymongo.results.InsertOneResult object at 0x03D62918>

## Return the \_id Field

The insert\_one() method returns a InsertOneResult object, which has a property, inserted\_id, that holds the id of the inserted document.

### **Example**

Insert another record in the "customers" collection, and return the value of the \_id field:

mydict = { "name": "Peter", "address": "Lowstreet 27" }  
  
x = mycol.insert\_one(mydict)  
  
print(x.inserted\_id)

5b1910482ddb101b7042fcd7

If you do not specify an \_id field, then MongoDB will add one for you and assign a unique id for each document.

In the example above no \_id field was specified, so MongoDB assigned a unique \_id for the record (document).

## Insert Multiple Documents

To insert multiple documents into a collection in MongoDB, we use the insert\_many() method.

The first parameter of the insert\_many() method is a list containing dictionaries with the data you want to insert:

### **Example**

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
mylist = [  
  { "name": "Amy", "address": "Apple st 652"},  
  { "name": "Hannah", "address": "Mountain 21"},  
  { "name": "Michael", "address": "Valley 345"},  
  { "name": "Sandy", "address": "Ocean blvd 2"},  
  { "name": "Betty", "address": "Green Grass 1"},  
  { "name": "Richard", "address": "Sky st 331"},  
  { "name": "Susan", "address": "One way 98"},  
  { "name": "Vicky", "address": "Yellow Garden 2"},  
  { "name": "Ben", "address": "Park Lane 38"},  
  { "name": "William", "address": "Central st 954"},  
  { "name": "Chuck", "address": "Main Road 989"},  
  { "name": "Viola", "address": "Sideway 1633"}  
]  
  
x = mycol.insert\_many(mylist)  
  
#print list of the \_id values of the inserted documents:  
print(x.inserted\_ids)

[ObjectId('5b19112f2ddb101964065487'), ObjectId('5b19112f2ddb101964065488'), ObjectId('5b19112f2ddb101964065489'), ObjectId('5b19112f2ddb10196406548a'), ObjectId('5b19112f2ddb10196406548b'), ObjectId('5b19112f2ddb10196406548c'), ObjectId('5b19112f2ddb10196406548d'), ObjectId('5b19112f2ddb10196406548e'), ObjectId('5b19112f2ddb10196406548f'), ObjectId('5b19112f2ddb101964065490'), ObjectId('5b19112f2ddb101964065491'), ObjectId('5b19112f2ddb101964065492')]

The insert\_many() method returns a InsertManyResult object, which has a property, inserted\_ids, that holds the ids of the inserted documents.

## Insert Multiple Documents, with Specified IDs

If you do not want MongoDB to assign unique ids for you document, you can specify the \_id field when you insert the document(s).

Remember that the values has to be unique. Two documents cannot have the same \_id.

### **Example**

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
mylist = [  
  { "\_id": 1, "name": "John", "address": "Highway 37"},  
  { "\_id": 2, "name": "Peter", "address": "Lowstreet 27"},  
  { "\_id": 3, "name": "Amy", "address": "Apple st 652"},  
  { "\_id": 4, "name": "Hannah", "address": "Mountain 21"},  
  { "\_id": 5, "name": "Michael", "address": "Valley 345"},  
  { "\_id": 6, "name": "Sandy", "address": "Ocean blvd 2"},  
  { "\_id": 7, "name": "Betty", "address": "Green Grass 1"},  
  { "\_id": 8, "name": "Richard", "address": "Sky st 331"},  
  { "\_id": 9, "name": "Susan", "address": "One way 98"},  
  { "\_id": 10, "name": "Vicky", "address": "Yellow Garden 2"},  
  { "\_id": 11, "name": "Ben", "address": "Park Lane 38"},  
  { "\_id": 12, "name": "William", "address": "Central st 954"},  
  { "\_id": 13, "name": "Chuck", "address": "Main Road 989"},  
  { "\_id": 14, "name": "Viola", "address": "Sideway 1633"}  
]  
  
x = mycol.insert\_many(mylist)  
  
#print list of the \_id values of the inserted documents:  
print(x.inserted\_ids)

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]

# **Python MongoDB Find**

In MongoDB we use the find() and find\_one() methods to find data in a collection.

Just like the **SELECT** statement is used to find data in a table in a MySQL database.

## Find One

To select data from a collection in MongoDB, we can use the find\_one() method.

The find\_one() method returns the first occurrence in the selection.

### **Example**

Find the first document in the customers collection:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
x = mycol.find\_one()  
  
print(x)

{'\_id': 1, 'name': 'John', 'address': 'Highway37'}

## Find All

To select data from a table in MongoDB, we can also use the find() method.

The find() method returns all occurrences in the selection.

The first parameter of the find() method is a query object. In this example we use an empty query object, which selects all documents in the collection.

No parameters in the find() method gives you the same result as **SELECT \*** in MySQL.

### **Example**

Return all documents in the "customers" collection, and print each document:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
for x in mycol.find():  
  print(x)

{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}  
{'\_id': 4, 'name': 'Hannah', 'address': 'Mountain 21'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}  
{'\_id': 6, 'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'\_id': 7, 'name': 'Betty', 'address': 'Green Grass 1'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 9, 'name': 'Susan', 'address': 'One way 98'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}  
{'\_id': 12, 'name': 'William', 'address': 'Central st 954'}  
{'\_id': 13, 'name': 'Chuck', 'address': 'Main Road 989'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}

## Return Only Some Fields

The second parameter of the find() method is an object describing which fields to include in the result.

This parameter is optional, and if omitted, all fields will be included in the result.

### **Example**

Return only the names and addresses, not the \_ids:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
for x in mycol.find({},{ "\_id": 0, "name": 1, "address": 1 }):  
  print(x)

{'name': 'John', 'address': 'Highway37'}  
{'name': 'Peter', 'address': 'Lowstreet 27'}  
{'name': 'Amy', 'address': 'Apple st 652'}  
{'name': 'Hannah', 'address': 'Mountain 21'}  
{'name': 'Michael', 'address': 'Valley 345'}  
{'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'name': 'Betty', 'address': 'Green Grass 1'}  
{'name': 'Richard', 'address': 'Sky st 331'}  
{'name': 'Susan', 'address': 'One way 98'}  
{'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'name': 'Ben', 'address': 'Park Lane 38'}  
{'name': 'William', 'address': 'Central st 954'}  
{'name': 'Chuck', 'address': 'Main Road 989'}  
{'name': 'Viola', 'address': 'Sideway 1633'}

You are not allowed to specify both 0 and 1 values in the same object (except if one of the fields is the \_id field). If you specify a field with the value 0, all other fields get the value 1, and vice versa:

### **Example**

This example will exclude "address" from the result:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
for x in mycol.find({},{ "address": 0 }):  
  print(x)

{'\_id': 1, 'name': 'John'}  
{'\_id': 2, 'name': 'Peter'}  
{'\_id': 3, 'name': 'Amy'}  
{'\_id': 4, 'name': 'Hannah'}  
{'\_id': 5, 'name': 'Michael'}  
{'\_id': 6, 'name': 'Sandy'}  
{'\_id': 7, 'name': 'Betty'}  
{'\_id': 8, 'name': 'Richard'}  
{'\_id': 9, 'name': 'Susan'}  
{'\_id': 10, 'name': 'Vicky'}  
{'\_id': 11, 'name': 'Ben'}  
{'\_id': 12, 'name': 'William'}  
{'\_id': 13, 'name': 'Chuck'}  
{'\_id': 14, 'name': 'Viola'}

### **Example**

You get an error if you specify both 0 and 1 values in the same object (except if one of the fields is the \_id field):

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
for x in mycol.find({},{ "name": 1, "address": 0 }):  
  print(x)

{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}

# **Python MongoDB Query**

## Filter the Result

When finding documents in a collection, you can filter the result by using a query object.

The first argument of the find() method is a query object, and is used to limit the search.

### **Example**

Find document(s) with the address "Park Lane 38":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": "Park Lane 38" }  
  
mydoc = mycol.find(myquery)  
  
for x in mydoc:  
  print(x)

{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}

## Advanced Query

To make advanced queries you can use modifiers as values in the query object.

E.g. to find the documents where the "address" field starts with the letter "S" or higher (alphabetically), use the greater than modifier: {"$gt": "S"}:

### **Example**

Find documents where the address starts with the letter "S" or higher:

import pymongo  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": { "$gt": "S" } }  
  
mydoc = mycol.find(myquery)  
  
for x in mydoc:  
  print(x)

{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}

## Filter With Regular Expressions

You can also use regular expressions as a modifier.

**Regular expressions can only be used to query strings.**

To find only the documents where the "address" field starts with the letter "S", use the regular expression {"$regex": "^S"}:

### **Example**

Find documents where the address starts with the letter "S":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": { "$regex": "^S" } }  
  
mydoc = mycol.find(myquery)  
  
for x in mydoc:  
  print(x)

{'\_id': 10, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}

# **Python MongoDB Sort**

## Sort the Result

Use the sort() method to sort the result in ascending or descending order.

The sort() method takes one parameter for "fieldname" and one parameter for "direction" (ascending is the default direction).

### **Example**

Sort the result alphabetically by name:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
mydoc = mycol.find().sort("name")  
  
for x in mydoc:  
  print(x)

{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}  
{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}  
{'\_id': 7, 'name': 'Betty', 'address': 'Green Grass 1'}  
{'\_id': 13, 'name': 'Chuck', 'address': 'Main Road 989'}  
{'\_id': 4, 'name': 'Hannah', 'address': 'Mountain 21'}  
{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 6, 'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'\_id': 9, 'name': 'Susan', 'address': 'One way 98'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}  
{'\_id': 12, 'name': 'William', 'address': 'Central st 954'}

## Sort Descending

Use the value -1 as the second parameter to sort descending.

sort("name", 1) #ascending  
sort("name", -1) #descending

### **Example**

Sort the result reverse alphabetically by name:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
mydoc = mycol.find().sort("name", -1)  
  
for x in mydoc:  
  print(x)

{'\_id': 12, 'name': 'William', 'address': 'Central st 954'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 9, 'name': 'Susan', 'address': 'One way 98'}  
{'\_id': 6, 'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}  
{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 4, 'name': 'Hannah', 'address': 'Mountain 21'}  
{'\_id': 13, 'name': 'Chuck', 'address': 'Main Road 989'}  
{'\_id': 7, 'name': 'Betty', 'address': 'Green Grass 1'}  
{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}  
{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}

# **Python MongoDB Delete Document**

## Delete Document

To delete one document, we use the delete\_one() method.

The first parameter of the delete\_one() method is a query object defining which document to delete.

**Note:** If the query finds more than one document, only the first occurrence is deleted.

### **Example**

Delete the document with the address "Mountain 21":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": "Mountain 21" }  
  
mycol.delete\_one(myquery)

{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}  
{'\_id': 6, 'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'\_id': 7, 'name': 'Betty', 'address': 'Green Grass 1'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 9, 'name': 'Susan', 'address': 'One way 98'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}  
{'\_id': 12, 'name': 'William', 'address': 'Central st 954'}  
{'\_id': 13, 'name': 'Chuck', 'address': 'Main Road 989'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}

## Delete Many Documents

To delete more than one document, use the delete\_many() method.

The first parameter of the delete\_many() method is a query object defining which documents to delete.

### **Example**

Delete all documents were the address starts with the letter S:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": {"$regex": "^S"} }  
  
x = mycol.delete\_many(myquery)  
  
print(x.deleted\_count, " documents deleted.")

2 documents deleted.

## Delete All Documents in a Collection

To delete all documents in a collection, pass an empty query object to the delete\_many() method:

### **Example**

Delete all documents in the "customers" collection:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
x = mycol.delete\_many({})  
  
print(x.deleted\_count, " documents deleted.")

11 documents deleted.

# **Python MongoDB Drop Collection**

## Delete Collection

You can delete a table, or collection as it is called in MongoDB, by using the drop() method.

### **Example**

Delete the "customers" collection

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
mycol.drop()

The drop() method returns true if the collection was dropped successfully, and false if the collection does not exist.

# **Python MongoDB Update**

**Update Collection**

You can update a record, or document as it is called in MongoDB, by using the update\_one() method.

The first parameter of the update\_one() method is a query object defining which document to update.

**Note:** If the query finds more than one record, only the first occurrence is updated.

The second parameter is an object defining the new values of the document.

### **Example**

Change the address from "Valley 345" to "Canyon 123":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": "Valley 345" }  
newvalues = { "$set": { "address": "Canyon 123" } }  
  
mycol.update\_one(myquery, newvalues)  
  
#print "customers" after the update:  
for x in mycol.find():  
  print(x)

{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}  
{'\_id': 4, 'name': 'Hannah', 'address': 'Mountain 21'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Canyon 123'}  
{'\_id': 6, 'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'\_id': 7, 'name': 'Betty', 'address': 'Green Grass 1'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 9, 'name': 'Susan', 'address': 'One way 98'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}  
{'\_id': 12, 'name': 'William', 'address': 'Central st 954'}  
{'\_id': 13, 'name': 'Chuck', 'address': 'Main Road 989'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}

## Update Many

To update all documents that meets the criteria of the query, use the update\_many() method.

### **Example**

Update all documents where the address starts with the letter "S":

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myquery = { "address": { "$regex": "^S" } }  
newvalues = { "$set": { "name": "Minnie" } }  
  
x = mycol.update\_many(myquery, newvalues)  
  
print(x.modified\_count, "documents updated.")

2 documents updated.

# **Python MongoDB Limit**

## Limit the Result

To limit the result in MongoDB, we use the limit() method.

The limit() method takes one parameter, a number defining how many documents to return.

Consider you have a "customers" collection:

### **Customers**

{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}  
{'\_id': 4, 'name': 'Hannah', 'address': 'Mountain 21'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}  
{'\_id': 6, 'name': 'Sandy', 'address': 'Ocean blvd 2'}  
{'\_id': 7, 'name': 'Betty', 'address': 'Green Grass 1'}  
{'\_id': 8, 'name': 'Richard', 'address': 'Sky st 331'}  
{'\_id': 9, 'name': 'Susan', 'address': 'One way 98'}  
{'\_id': 10, 'name': 'Vicky', 'address': 'Yellow Garden 2'}  
{'\_id': 11, 'name': 'Ben', 'address': 'Park Lane 38'}  
{'\_id': 12, 'name': 'William', 'address': 'Central st 954'}  
{'\_id': 13, 'name': 'Chuck', 'address': 'Main Road 989'}  
{'\_id': 14, 'name': 'Viola', 'address': 'Sideway 1633'}

### **Example**

Limit the result to only return 5 documents:

import pymongo  
  
myclient = pymongo.MongoClient("mongodb://localhost:27017/")  
mydb = myclient["mydatabase"]  
mycol = mydb["customers"]  
  
myresult = mycol.find().limit(5)  
  
#print the result:  
for x in myresult:  
  print(x)

{'\_id': 1, 'name': 'John', 'address': 'Highway37'}  
{'\_id': 2, 'name': 'Peter', 'address': 'Lowstreet 27'}  
{'\_id': 3, 'name': 'Amy', 'address': 'Apple st 652'}  
{'\_id': 4, 'name': 'Hannah', 'address': 'Mountain 21'}  
{'\_id': 5, 'name': 'Michael', 'address': 'Valley 345'}