

B.Tech II Year IV sem
Basic of Python
Programming

Prepared by S.VENKATA LAKSHMI .,M.TECH

Course Code:20AES0509

PYTHON PROGRAMMING

Unit – I

Introduction: What is a program, Running python, Arithmetic operators, Value and Types. Variables, Assignments and Statements: Assignment statements, Script mode, Order of operations, string operations, comments. Functions: Function calls, Math functions, Composition, Adding new Functions, Definitions and Uses, Flow of Execution, Parameters and Arguments, Variables and Parameters are local, Stack diagrams, Fruitful Functions and Void Functions, Why Functions.

Unit – II

Case study: The turtle module, Simple Repetition, Encapsulation, Generalization, Interface design, Refactoring, docstring. Conditionals and Recursion: floor division and modulus, Boolean expressions, Logical operators, Conditional execution, Alternative execution, Chained conditionals, Nested conditionals, Recursion, Infinite Recursion, Keyboard input. Fruitful Functions: Return values, Incremental development, Composition, Boolean functions, More recursion, Leap of Faith, Checking types.

Unit – III

Iteration: Reassignment, Updating variables, The while statement, Break, Square roots, Algorithms. Strings: A string is a sequence, len, Traversal with a for loop, String slices, Strings are immutable, Searching, Looping and Counting, String methods, The in operator, String comparison. Case Study: Reading word lists, Search, Looping with indices. Lists: List is a sequence, Lists are mutable, Traversing a list, List operations, List slices, List methods, Map filter and reduce, Deleting elements, Lists and Strings, Objects and values, Aliasing, List arguments.

Unit – IV

Dictionaries: A dictionary is a mapping, Dictionary as a collection of counters, Looping and dictionaries, Reverse Lookup, Dictionaries and lists, Memos, Global Variables. Tuples: Tuples are immutable, Tuple Assignment, Tuple as Return values, Variable-length argument tuples, Lists and tuples, Dictionaries and tuples, Sequences of sequences. Files: Persistence, Reading and writing, Format operator, Filename and paths, Catching exceptions, Databases, Pickling, Pipes, Writing modules. Classes and Objects: Programmer-defined types, Attributes, Instances as Return values, Objects are mutable, Copying.

Unit – V

Classes and Functions: Time, Pure functions, Modifiers, Prototyping versus Planning Classes and Methods: Object oriented features, Printing objects, The init method, The_str_method, Operator overloading, Type-based Dispatch, Polymorphism, Interface and Implementation Inheritance: Card objects, Class attributes, Comparing cards, decks, Printing the Deck, Add Remove shuffle and sort, Inheritance, Class diagrams, Data encapsulation. The Goodies: Conditional expressions, List comprehensions, Generator expressions, any and all, Sets, Counters, defaultdict, Named tuples, Gathering keyword Args,

Unit 1

Chapter-1

INTRODUCTION

What Is a Program

A program is a sequence of instructions that specifies how to perform a computation.

The computation might be something mathematical, such as solving a system of equations or finding the roots of a polynomial, but it can also be a symbolic computation, such as searching and replacing text in a document or something graphical, like processing an image or playing a video.

few basic instructions appear in just about every language:

input:

Get data from the keyboard, a file, the network, or some other device.

output:

Display data on the screen, save it in a file, send it over the network, etc.

math:

Perform basic mathematical operations like addition and multiplication.

conditional execution:

Check for certain conditions and run the appropriate code.

repetition:

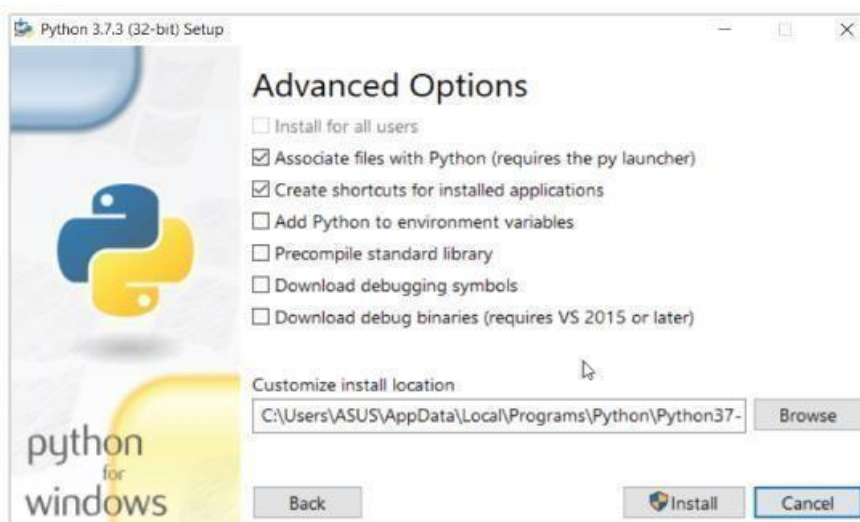
Perform some action repeatedly, usually with some variation.

Install and Run Python:

Installing Python

Download the [latest version of Python](#).

Run the installer file and follow the steps to install Python. During the install process, check Add Python to environment variables. This will add Python to environment variables, and you can run Python from any part of the computer. Also, you can choose the path where Python is installed.



Installing Python on the computer

Once you finish the installation process, you can run Python.

1. Run Python in Immediate mode

Once Python is installed, typing python in the command line will invoke the interpreter in immediate mode. We can directly type in Python code, and press Enter to get the output.

Try typing in $1 + 1$ and press enter. We get 2 as the output. This prompt can be used as a

calculator. To exit this mode, type `quit()` and press enter.

```
Microsoft Windows [Version 10.0.17134.648]
(c) 2018 Microsoft Corporation. All rights reserved.

C:\Users\ASUS>python
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 22:20:52)
[MSC v.1916 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for more
information.
>>> 1 + 1
2
>>> quit()

C:\Users\ASUS>_
```

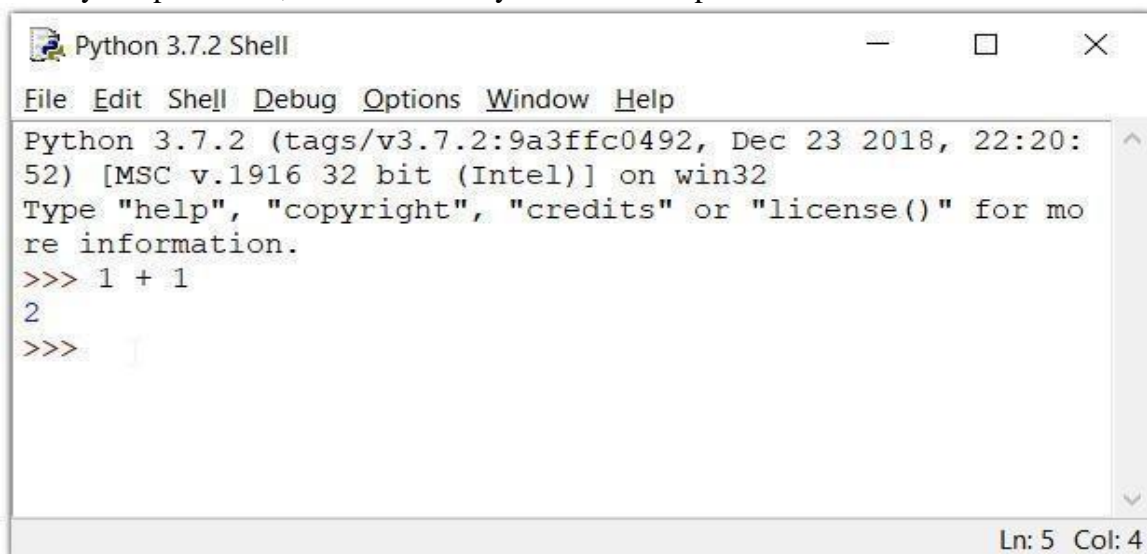
Running Python on the Command Line

2. Run Python in the Integrated Development Environment (IDE)

IDE is a piece of software that provides useful features like code hinting, syntax highlighting and checking, file explorers, etc. to the programmer for application development.

By the way, when you install Python, an IDE named **IDLE** is also installed. You can use it to run Python on your computer. It's a decent IDE for beginners.

When you open IDLE, an interactive Python Shell is opened.



```
Python 3.7.2 Shell
File Edit Shell Debug Options Window Help
Python 3.7.2 (tags/v3.7.2:9a3ffc0492, Dec 23 2018, 22:20:
52) [MSC v.1916 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license()" for mo
re information.
>>> 1 + 1
2
>>>
```

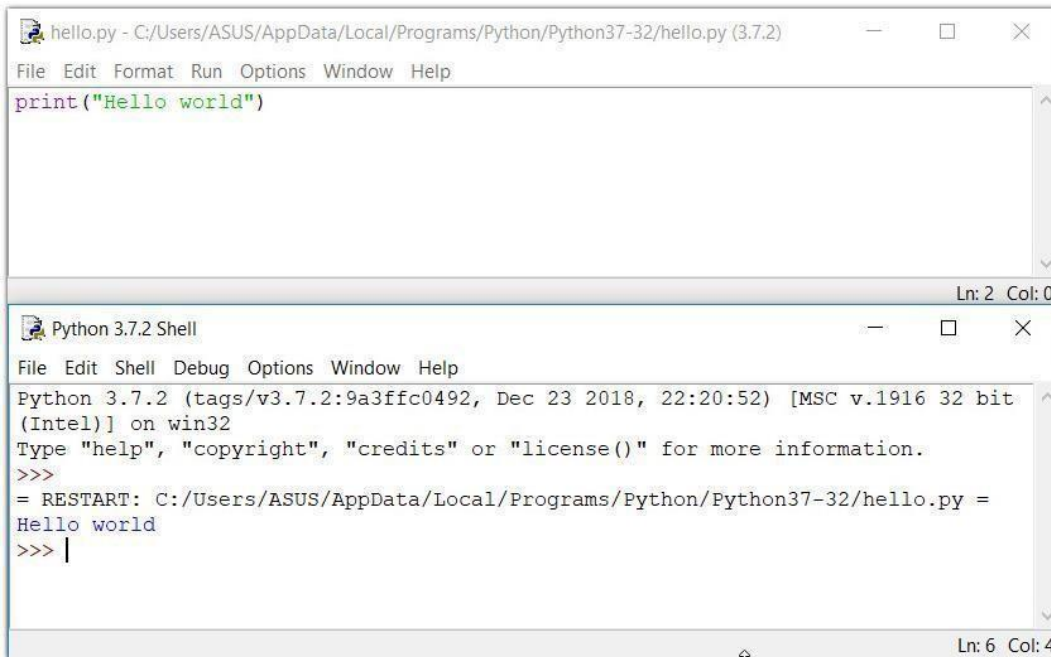
Python IDLE

Now you can create a new file and save it with **.py** extension.

For example, **hello.py**

Write Python code in the file and save it.

To run the file, go to **Run > Run Module** or simply click **F5**.



Running a Python program in IDLE

The First Program:

```
>>> print('Hello, World!')
```

This is an example of a **print statement**

the result is the words Hello, World!

The quotation marks in the program mark the beginning and end of the text to be displayed; they don't appear in the result.

The parentheses indicate that print is a function.

Operators:

Python language supports the following types of operators.

Arithmetic Operators

Comparison (Relational) Operators

Assignment Operators

Logical Operators

Bitwise Operators

Membership Operators

Identity Operators

Let us have a look on all operators one by one.

Python Arithmetic Operators

Assume variable a holds 10 and variable b holds 20, then –

Operator	Description	Example
+ Addition	Adds values on either side of the operator.	$a + b = 30$
- Subtraction	Subtracts right hand operand from left hand operand.	$a - b = -10$

* Multiplication	Multiplies values on either side of the operator	$a * b = 200$
/ Division	Divides left hand operand by right hand operand	$b / a = 2$
% Modulus	Divides left hand operand by right hand operand and returns remainder	$b \% a = 0$
** Exponent	Performs exponential (power) calculation on operators	$a^{**}b = 10$ to the power 20
//	Floor Division - The division of operands where the result is the quotient in which the digits after the decimal point are removed. But if one of the operands is negative, the result is floored, i.e., rounded away from zero (towards negative infinity) –	$9//2 = 4$ and $9.0//2.0 = 4.0$, $-11//3 = -4$, $-11.0//3 = -4.0$

Values and Types

A **value** is one of the basic things a program works with, like a letter or a number.

Some values we have seen so far are 2, 42.0, and 'Hello, World!'

These values belong to different **types**: 2 is an **integer**, 42.0 is a **floating-point number** and 'Hello, World!' is a **string**

If you are not sure what type a value has, the interpreter can tell you:

```
>>> type(2)
<class 'int'>
>>> type(42.0)
<class 'float'>
>>> type('Hello, World!')
<class 'str'>
```

In these results, the word “class” is used in the sense of a category; a type is a category of values.

What about values like '2' and '42.0'? They look like numbers, but they are in quotation marks like strings:

```
>>> type('2')
<class 'str'>
>>> type('42.0')
<class 'str'>
```

Therefore they're strings.

Chapter-2

Variables, Assignments and Statements

1.An assignment statement creates a new variable and gives it a value:

```
>>> message = 'And now for something completely different'  
>>> n = 17  
>>> pi = 3.141592653589793
```

This example makes three assignments.

The first assigns a string to a new variable named message; the second gives the integer 17 to n; the third assigns the (approximate) value of π to pi

Variable Names

Programmers generally choose names for their variables that are meaningful Variable names can be as long as you like.

Rules for naming :

They can contain both letters and numbers, but they can't begin with a number. Can use both lower and uppercase letters. The underscore character, `_`, can appear in a name. Keywords should not use as a variable name.

Note: If you give a variable an illegal name, you get a syntax error:

```
>>> 76trombones = 'big parade'  
SyntaxError: invalid syntax b' coz it begins with a number  
>>> more@ = 1000000  
SyntaxError: invalid syntax b' coz it contains illegal character @.  
>>> class = 'Adanced Theoretical Zymurgy'
```

Keywords in Python:

False, class, finally, is, return, None, continue, for, lambda, try, True, def, from, nonlocal, while, and, del, global, not, with, as, elif, if, or, yield, assert, else, import, pass, break, except, in, raise.

Expressions and Statements:

An **expression** is a combination of values, variables, and operators. A value all by itself is considered an expression, and so is a variable, so the following are all legal expressions:

```
>> 42  
42  
>>> n  
17  
>>> n + 25  
42
```

When you type an expression at the prompt, the interpreter **evaluates** it, which means that it finds the value of the expression. In this example, n has the value 17 and n + 25 has the value 42.

A **statement** is a unit of code that has an effect, like creating a variable or displaying a value.

```
>>> n = 17  
>>> print(n)
```

The first line is an assignment statement that gives a value to n. The second line is a print statement that displays the value of n.

2. Script Mode:

In script mode type code in a file called a **script** and savefile with .py extension. **script mode** to execute the script. By convention, Python scripts have names that end with .py.
for ex: if you type the following code into a script and run it, you get no output at all. Why because but it doesn't display the value unless you tell it to. But it displays in interactive mode.

```
miles = 26.2
miles * 1.61
Sol is:
miles = 26.2
print(miles * 1.61)
```

3. Order of perations:

When an expression contains more than one operator, the order of evaluation depends on the **order of operations**. For mathematical operators, Python follows order **PEMDAS**.

P- parentheses,

E- Exponentiation,

M- Multiplication

D- Division

A- Addition,

S- Substraction

- Parentheses have the highest precedence.

For ex in the following expressions in parentheses are evaluated first,

Ex:1. $2 * (3-1)$ is 4, and

Ex: 2. $(1+1)**(5-2)$ is 8.

- Exponentiation has the next highest precedence,

For ex: $1 + 2**3$ is 9, not 27, and

$2 * 3**2$ is 18, not 36.

- Multiplication and Division have higher precedence than Addition and Subtraction.

For ex: $2*3-1$ is 5, not 4, and $6+4/2$ is 8, not 5.

Note: Operators with the same precedence are evaluated from left to right (except exponentiation). So in the expression $degrees / 2 * pi$, the division happens first and the result is multiplied by pi.

4. Operations on strings:

Note : Mathematical operations on strings are not allowed so the following are illegal:

```
'2'-1' 'eggs'/'easy' 'third'*'a charm'
```

How to Create Strings in Python?

Creating strings is easy as you only need to enclose the characters either in single or double-quotes.

In the following example, we are providing different ways to initialize strings. To share an important note that you can also use triple quotes to create strings. However, programmers use them to mark multi-line strings and docstrings.

Python string examples - all assignments are identical.

```
String_var = 'Python'  
String_var = "Python"  
String_var = """Python"""
```

with Triple quotes Strings can extend to multiple lines

```
String_var = """ This document will help you to explore all the concepts of Python  
Strings!!! """
```

Replace "document" with "tutorial" and store in another variable

```
substr_var = String_var.replace("document", "tutorial")  
print (substr_var)
```

String Operators in Python

Concatenation (+): It combines two strings into one.

example

```
var1 = 'Python'  
var2 = 'String'
```

print (var1+var2) # PythonString
Repetition (*): This operator creates a new string by repeating it a given number of times.

example

```
var1 = 'Python'  
print (var1*3)
```

PythonPythonPython

Slicing []: The slice operator prints the character at a given index.

example

```
var1 = 'Python'  
print (var1[2]) # t
```

Range Slicing [x:y]

It prints the characters present in the given range.

example

```
var1 = 'Python'  
print (var1[2:5]) # tho
```

Membership (in): This operator returns 'True' value if the character is present in the given String.

example

```
var1 = 'Python'  
print ('n' in var1) # True
```

Membership (not in):

:

It returns 'True' value if the character is not present in the given String.

```
# example
var1 = 'Python'
print ('N' not in var1)
# True
```

Iterating (for): With this operator, we can iterate through all the characters of a string.

```
# example
for var in var1:    print (var, end = "") # Python
```

Raw String (r/R): We can use it to ignore the actual meaning of Escape characters inside a string. For this, we add 'r' or 'R' in front of the String.

```
# example
print (r'\n') # \n
print (R'\n') # \n
```

Unicode String support in Python

Regular Strings stores as the 8-bit ASCII value, whereas Unicode String follows the 16-bit ASCII standard. This extension allows the strings to include characters from the different languages of the world. In Python, the letter 'u' works as a prefix to distinguish between Unicode and usual strings.

```
print (u' Hello Python!!')
```

OUTPUT:

```
#Hello Python
```

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

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

Method	Description
capitalize()	Converts the first character to upper case
casefold()	Converts string into lower case

[center\(\)](#)

Returns a centered string

[count\(\)](#)

Returns the number of times a specified value occurs in a string

[encode\(\)](#)

Returns an encoded version of the string

[endswith\(\)](#)

Returns true if the string ends with the specified value

[expandtabs\(\)](#)

Sets the tab size of the string

[find\(\)](#)

Searches the string for a specified value and returns the position of where it was found

[format\(\)](#)

Formats specified values in a string

`format_map()`

Formats specified values in a string

[index\(\)](#)

Searches the string for a specified value and returns the position of where it was found

[isalnum\(\)](#)

Returns True if all characters in the string are alphanumeric

[isalpha\(\)](#)

Returns True if all characters in the string are in the alphabet

[isdecimal\(\)](#)

Returns True if all characters in the string are decimals

[isdigit\(\)](#)

Returns True if all characters in the string are digits

[isidentifier\(\)](#)

Returns True if the string is an identifier

[islower\(\)](#)

Returns True if all characters in the string are lower case

[isnumeric\(\)](#)

Returns True if all characters in the string are numeric

[isprintable\(\)](#)

Returns True if all characters in the string are printable

[isspace\(\)](#)

Returns True if all characters in the string are whitespaces

[istitle\(\)](#)

Returns True if the string follows the rules of a title

[isupper\(\)](#)

Returns True if all characters in the string are upper case

[join\(\)](#)

Joins the elements of an iterable to the end of the string

[ljust\(\)](#)

Returns a left justified version of the string

[lower\(\)](#)

Converts a string into lower case

[lstrip\(\)](#)

Returns a left trim version of the string

[maketrans\(\)](#)

Returns a translation table to be used in translations

[partition\(\)](#)

Returns a tuple where the string is parted into three parts

[replace\(\)](#)

Returns a string where a specified value is replaced with a specified value

[rfind\(\)](#)

Searches the string for a specified value and returns the last position of where it was found

[rindex\(\)](#)

Searches the string for a specified value and returns the last position of where it was found

[rjust\(\)](#)

Returns a right justified version of the string

[rpartition\(\)](#)

Returns a tuple where the string is parted into three parts

[rsplit\(\)](#)

Splits the string at the specified separator, and returns a list

[rstrip\(\)](#)

Returns a right trim version of the string

split()	Splits the string at the specified separator, and returns a list
splitlines()	Splits the string at line breaks and returns a list
startswith()	Returns true if the string starts with the specified value
strip()	Returns a trimmed version of the string
swapcase()	Swaps cases, lower case becomes upper case and vice versa
title()	Converts the first character of each word to upper case
translate()	Returns a translated string
upper()	Converts a string into upper case
zfill()	Fills the string with a specified number of 0 values at the beginning

But there are two **exceptions**, + and *.

The + operator performs **string concatenation**,

For example:

```
>>> first = 'throat'
```

```
>>> second = 'warbler'
```

```
>>> first + second
```

```
throatwarbler
```

The * operator also works on strings; it performs **repetition**.

For example, 'Spam'*3 is 'SpamSpamSpam'.

EXAMPLE1:

```
var1 = 'Hello World!'
var2 = "Python Programming"
```

```
print "var1[0]: ", var1[0]
print "var2[1:5]: ", var2[1:5]
```

When the above code is executed, it produces the following result –
var1[0]: H
var2[1:5]: ytho

EXAMPLE2:

```
var1 = 'Hello World!'
print "Updated String :- ", var1[:6] + 'Python'
```

When the above code is executed, it produces the following result –
Updated String :- Hello Python

5. Comments:

Comments are of two types .

Single-line comments

Multi line Comments

Single-line comments are created simply by beginning a line with the hash (#) character, and they are automatically terminated by the end of line.

For Ex: #This would be a comment in Python

Multi Line Comments that span multiple lines and are created by adding a delimiter (“””) on each end of the comment

For Ex:

```
"""
```

This would be a multiline comment in Python that spans several lines and describes your code, your day, or anything you want it to """

Chapter-3 Functions

What is a Function in Python?

A Function in Python is used to utilize the code in more than one place in a program. It is also called method or procedures. Python provides you many inbuilt functions like print(), but it also gives freedom to create your own functions.

Functions:

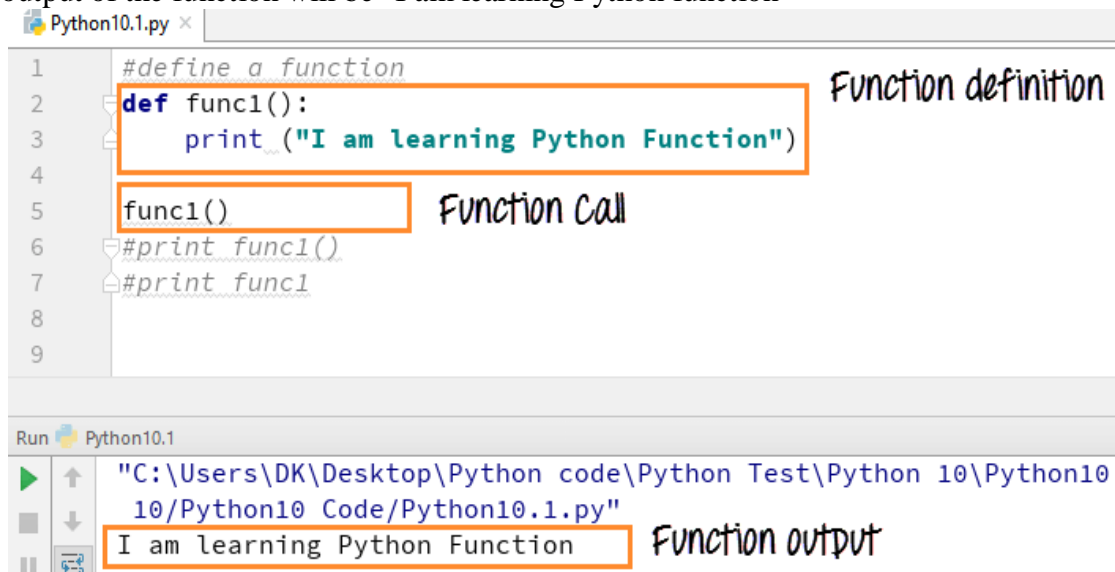
A function is a named sequence of statements that performs a computation.

How to define and call a function in Python

Function in Python is defined by the "def " statement followed by the function name and parentheses ())

Example:

Let us define a function by using the command " def func1():" and call the function. The output of the function will be "I am learning Python function"



```
Python10.1.py x
1 #define a function
2 def func1():
3     print("I am learning Python Function")
4
5 func1()
6 #print func1()
7 #print func1
8
9
```

Function definition

Function Call

Run Python10.1

"C:\Users\DK\Desktop\Python code\Python Test\Python 10\Python10
10\Python10 Code\Python10.1.py"

I am learning Python Function

Function output

The function print func1() calls our def func1(): and print the command " I am learning Python function None."There are set of rules in Python to define a function.Any args or input parameters should be placed within these parentheses.The function first statement can be an optional statement- docstring or the documentation string of the function The code within every function starts with a colon (:) and should be indented (space) The statement return (expression) exits a function, optionally passing back a value to the caller. A return statement with no args is the same as return None.

Significance of Indentation (Space) in Python:

Before we get familiarize with Python functions, it is important that we understand the indentation rule to declare Python functions and these rules are applicable to other elements of Python as well like declaring conditions, loops or variable.

Python follows a particular style of indentation to define the code, since Python functions don't have any explicit begin or end like curly braces to indicate the start and stop for the function, they have to rely on this indentation. Here we take a simple example with "print" command. When we write "print" function right below the def func 1 (): It will show an "indentation error: expected an indented block".


```
Python10.1.py x
1 #define a function
2 def func1():
3 print ("I am Learning Python Function")
4
5 func1()
6
7
8
9
```

When "print" function is declared right below the def func1():, it will show indent error

Run Python10.1
"C:\Users\DK\Desktop\Python code\Python Test\Python 10\Python10 Code\ven10\Python10 Code\Python10.1.py"
File "C:/Users/DK/Desktop/Python code/Python Test/Python 10/Python10 C
print ("I am learning Python Function")
^
IndentationError: expected an indented block

Now, when you add the indent (space) in front of "print" function, it should print as expected.

```
Python10.1.py x
1 #define a function
2 def func1():
3     print ("I am Learning Python Function")
4
5 func1()
```

When you leave indent (space) in front of "print" function, it will give the expected output

Run Python10.1
"C:\Users\DK\Desktop\Python code\Python Test\Pytho
10\Python10 Code\Python10.1.py"
I am learning Python Function

How Function Return Value?

Return command in Python specifies what value to give back to the caller of the function.

Let's understand this with the following example

Step 1) Here - we see when function is not "return". For example, we want the square of 4, and it should give answer "16" when the code is executed. Which it gives when we simply use "print x*x" code, but when you call function "print square" it gives "None" as an output. This is because when you call the function, recursion does not happen and fall off the end of the function. Python returns "None" for failing off the end of the function.

```
Python10.2.py x
1 #define return function
2 def square(x):
3     print(x*x)
4
5     print(square(4))
6
7
```

The function does not return anything. Hence output is None

Run Python10.2

```
"C:\Users\DK\Desktop\Python code\Python10.2.py"
16
None
```

Step 2) To make this clearer we replace the print command with assignment command. Let's check the output.

```
Python10.2.py x
1 def square(x):
2     y=x*x
3
4     print(square(4))
5
6
```

square()

Run Python10.2

```
"C:\Users\DK\Desktop\Python code\Python10.2.py"
None
```

When you run the command "print square (4)" it actually returns the value of the object since we don't have any specific function to run over here it returns "None".

Step 3) Now, here we will see how to retrieve the output using "return" command. When you use the "return" function and execute the code, it will give the output "16."

```
Python10.2.py x
1 def square(x):
2     return x*x
3
4     print(square(4))
5
6
```

Here we have used "return command" to return the value of function, which is square of (4) i.e 16

Run Python10.2

```
"C:\Users\DK\Desktop\Python code\Python10.2.py"
16
```

Step 4) Functions in Python are themselves an object, and an object has some value. We will here see how Python treats an object. When you run the command "print square" it returns the value of the object. Since we have not passed any argument, we don't have any specific function to run over here it returns a default value (0x021B2D30) which is the location of the object. **In practical Python program, you probably won't ever need to do this.**

```

Python10.2.py x
1 def square(x):
2     return x*x
3
4 print(square)

```

Run Python10.2

```

"C:\Users\DK\Desktop\Python code"
<function square at 0x036EE9C0>

```

Arguments in Functions

The argument is a value that is passed to the function when it's called. In other words on the calling side, it is an argument and on the function side it is a parameter. Let see how Python Args works -
 Step 1) Arguments are declared in the function definition. While calling the function, you can pass the values for that args as shown below

```

Python10.2.py x
1 def multiply(x,y):
2     print(x*y)
3
4 multiply(2,8)
5
6

```

Run Python10.2

```

"C:\Users\DK\Desktop\Python code\Python Test\Python
16

```

Declaring arguments (pointing to line 1)

Passing arguments (pointing to line 4)

Step 2) To declare a default value of an argument, assign it a value at function definition.

```

1 def multiply(x,y=0):

```

Example: x has no default values. Default values of y=0. When we supply only one argument while calling multiply function, Python assigns the supplied value to x while keeping the value of y=0. Hence the multiply of x*y=0

```
Python10.2.py x
1 def multiply(x,y=0):
2     return x*y
3
4 print(multiply(4))
5
6
```

Run Python10.2

"C:\Users\DK\Desktop\Python 10.2" 0

Process finished with

Default value of argument (y=0), when calling multiply function, in our case (4x0) gives the expected result 0.

Step 3) This time we will change the value to y=2 instead of the default value y=0, and it will return the output as (4x2)=8.

```
Python10.2.py x
1 def multiply(x,y=0):
2     return x*y
3
4 print(multiply(4,y=2))
5
6
```

Run Python10.2

"C:\Users\DK\Desktop\Python 10.2" 8

When we change the default value for multiply function "y=0" to "y=2" and declare x as 4, we get the expected result, 4x2=8

Step 4) You can also change the order in which the arguments can be passed in Python. Here we have reversed the order of the value x and y to x=4 and y=2.

```

Python10.2.py x
1 def multiply(x,y=0):
2     print("value of x=",x)
3     print("value of y=",y)
4
5     return x*y
6
7     print(multiply(y=2,x=4))
8
9
Run Python10.2
"C:\Users\DK\Desktop\Python code\Python Test\Python 10\Python10.2.py"
value of x= 4
value of y= 2
8

```

Here we have reversed the order of the value for x and y.

Step 5) Multiple Arguments can also be passed as an array. Here in the example we call the multiple args (1,2,3,4,5) by calling the (*args) function.

Example: We declared multiple args as number (1,2,3,4,5) when we call the (*args) function; it prints out the output as (1,2,3,4,5)

```

Python0.3.py x
1 #passing multiple arguments
2 def guru99(*args):
3
4     print(args)
5
6     guru99(1,2,3,4,5)
7
8
Run Python0.3
"C:\Users\DK\Desktop\Python code\Python 0.3\Python0.3.py"
(1, 2, 3, 4, 5)

```

you can pass multiple arguments

Rules to define a function in Python.

Function blocks begin with the keyword def followed by the function name and parentheses (). Any input parameters or arguments should be placed within these parentheses. You can also define parameters inside these parentheses. The code block within every function starts with a colon (:) and is indented. The statement return [expression] exits a function, but it is optional

Syntax:

```

def functionname( parameters ):
    function_suite
    return [expression]

```

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() #calling function
```

Scope and Lifetime of variables

Scope of a variable is the portion of a program where the variable is recognized. Parameters and variables defined inside a function are not visible from outside the function. Hence, they have a local scope.

The lifetime of a variable is the period throughout which the variable exists in the memory. The lifetime of variables inside a function is as long as the function executes. They are destroyed once we return from the function. Hence, a function does not remember the value of a variable from its previous calls. Here is an example to illustrate the scope of a variable inside a function.

```
def my_func():  
    x = 10  
    print("Value inside function:",x)
```

```
x = 20  
my_func()  
print("Value outside function:",x)
```

Output

```
Value inside function: 10  
Value outside function: 20
```

2.Math Functions:

Python has a `math` module that provides mathematical functions. A module is a file that contains a collection of related functions. Before we can use the functions in a module, we have to import it with an `import` statement:

```
>>> import math
```

Note: The module object contains the functions and variables defined in the module. To access one of the functions, you have to specify the name of the module and the name of the function, separated by a dot (also known as a period). This format is called dot notation.

For ex:

```
>>> ratio = signal_power / noise_power  
>>> decibels = 10 * math.log10(ratio)  
>>> radians = 0.7  
>>> height = math.sin(radians)
```

Some Constants

These constants are used to put them into our calculations.

Sr.No.	Constants & Description
1	pi - Return the value of pi: 3.141592
4	inf - Returns the infinite
5	nan - Not a number type.

Numbers and Numeric Representation

These functions are used to represent numbers in different forms. The methods are like below

Sr.No.	Function & Description
1	ceil(x) Return the Ceiling value. It is the smallest integer, greater or equal to the number x.
3	fabs(x) Returns the absolute value of x.
4	factorial(x) Returns factorial of x. where $x \geq 0$
5	floor(x) Return the Floor value. It is the largest integer, less or equal to the number x.
6	fsum(iterable) Find sum of the elements in an iterable object
7	gcd(x, y) Returns the Greatest Common Divisor of x and y
8	isfinite(x) Checks whether x is neither an infinity nor nan.
9	isinf(x) Checks whether x is infinity
10	isnan(x) Checks whether x is not a number.
11	remainder(x, y)

Find remainder after dividing x by y

Example program:

```
import math
print(math.ceil(23.56) )

my_list = [12, 4.25, 89, 3.02, -65.23, -7.2, 6.3]
print(math.fsum(my_list))
print('The GCD of 24 and 56 : ' + str(math.gcd(24, 56)))
x = float('nan')
if math.isnan(x):
    print('It is not a number')
x = float('inf')
y = 45
if math.isinf(x):
    print('It is Infinity')
print(math.isfinite(x)) #x is not a finite number
print(math.isfinite(y)) #y is a finite number
```

O/P:

```
24
42.139999999999999
The GCD of 24 and 56 : 8
It is not a number
It is Infinity
False
True
>>>
```

Power and Logarithmic Functions

These functions are used to calculate different power related and logarithmic related tasks.

Sr.No.	Function & Description
1	pow(x, y) Return the x to the power y value.
2	sqrt(x) Finds the square root of x
3	exp(x) Finds xe, where e = 2.718281
4	log(x[, base]) Returns the Log of x, where base is given. The default base is e
5	log2(x) Returns the Log of x, where base is 2

6	log10(x) Returns the Log of x, where base is 10
---	--

Example Code

```
import math
print("The value of 5^8: " + str(math.pow(5, 8)))
print("Square root of 400: " + str(math.sqrt(400)))
print("The value of 5^e: " + str(math.exp(5)))
print("The value of Log(625), base 5: " + str(math.log(625, 5)))
print("The value of Log(1024), base 2: " + str(math.log2(1024)))
print("The value of Log(1024), base 10: " + str(math.log10(1024)))
```

Output

The value of 5^8: 390625.0
 Square root of 400: 20.0
 The value of 5^e: 148.4131591025766
 The value of Log(625), base 5: 4.0
 The value of Log(1024), base 2: 10.0
 The value of Log(1024), base 10: 3.010299956639812

Trigonometric & Angular Conversion Functions

These functions are used to calculate different trigonometric operations.

Sr.No.	Function & Description
1	sin(x) Return the sine of x in radians
2	cos(x) Return the cosine of x in radians
3	tan(x) Return the tangent of x in radians
4	asin(x) This is the inverse operation of the sine, there are acos, atan also.
5	degrees(x) Convert angle x from radian to degrees
6	radians(x) Convert angle x from degrees to radian

Example Code

```
import math
print("The value of Sin(60 degree): " + str(math.sin(math.radians(60))))
print("The value of cos(pi): " + str(math.cos(math.pi)))
print("The value of tan(90 degree): " + str(math.tan(math.pi/2)))
print("The angle of sin(0.8660254037844386): " + str(math.degrees(math.asin(0.8660254037844386))))
```

Output

The value of Sin(60 degree): 0.8660254037844386

The value of $\cos(\pi)$: -1.0

The value of $\tan(90 \text{ degree})$: 1.633123935319537e+16

The angle of $\sin(0.8660254037844386)$: 59.99999999999999

3. Composition:

So far, we have looked at the elements of a program—variables, expressions, and statements—in isolation, without talking about how to combine (Composition) them. For example, the argument of a function can be any kind of expression, including arithmetic operators:

```
x = math.sin(degrees / 360.0 * 2 * math.pi)
```

And even function calls:

```
x = math.exp(math.log(x+1))
```

4. Adding new functions:

Pass by reference vs value: All parameters (arguments) in the Python language are passed by reference. It means if you change what a parameter refers to within a function, the change also reflects back in the calling function. For example –

```
#!/usr/bin/python
```

```
# Function definition is here
```

```
def changeme( mylist ):  
    "This changes a passed list into this function"  
    mylist.append([1,2,3,4]);  
    print "Values inside the function: ", mylist  
    return
```

```
# Now you can call changeme function
```

```
mylist = [10,20,30];  
changeme( mylist );  
print "Values outside the function: ", mylist
```

Here, we are maintaining reference of the passed object and appending values in the same object. So, this would produce the following result –

Values inside the function: [10, 20, 30, [1, 2, 3, 4]]

Values outside the function: [10, 20, 30, [1, 2, 3, 4]]

Scope of Variables: All variables in a program may not be accessible at all locations in that program. This depends on where you have declared a variable. The scope of a variable determines the portion of the program where you can access a particular identifier. There are two basic scopes of variables in Python –

Global variables

Local variables

Global vs. Local variables: Variables that are defined inside a function body have a local scope, and those defined outside have a global scope. This means that local variables can be accessed only inside the function in which they are declared, whereas global variables can be accessed throughout the program body by all functions. When you call a function, the variables declared inside it are brought into scope. Following is a simple example –

```
#!/usr/bin/python
```

```
total = 0; # This is global variable.  
# Function definition is here  
def sum( arg1, arg2 ):  
    # Add both the parameters and return them."  
    total = arg1 + arg2; # Here total is local variable.  
    print "Inside the function local total : ", total  
    return total;
```

```
# Now you can call sum function
```

```
sum( 10, 20 );  
print "Outside the function global total : ", total
```

When the above code is executed, it produces the following result –
Inside the function local total : 30
Outside the function global total : 0

The *import* Statement

You can use any Python source file as a module by executing an import statement in some other Python source file. The *import* has the following syntax –
import module1[, module2[,... moduleN]

When the interpreter encounters an import statement, it imports the module if the module is present in the search path. A search path is a list of directories that the interpreter searches before importing a module. For example, to import the module support.py, you need to put the following command at the top of the script –

```
#!/usr/bin/python
```

```
# Import module support  
import support
```

```
# Now you can call defined function that module as follows
```

```
support.print_func("Zara")
```

When the above code is executed, it produces the following result –
Hello : Zara

5. Flow of Execution

- The order in which statements are executed is called the flow of execution
- Execution always begins at the first statement of the program.
- Statements are executed one at a time, in order, from top to bottom.
- Function definitions do not alter the flow of execution of the program, but remember that statements inside the function are not executed until the function is called.
- Function calls are like a bypass in the flow of execution. Instead of going to the next statement, the flow jumps to the first line of the called function, executes all the statements there, and then comes back to pick up where it left off.

6. Parameters and Arguments:

Parameter: 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. Arguments
You can call a function by using the following types of formal arguments –

- 1.Required arguments
- 2.Keyword arguments
- 3.Default arguments
- 4.Variable-length arguments

Required arguments

Required arguments are the arguments passed to a function in correct positional order. Here, the number of arguments in the function call should match exactly with the function definition.

To call the function *printme()*, you definitely need to pass one argument, otherwise it gives a syntax error as follows –

```
#!/usr/bin/python
```

```
# Function definition is here
```

```
def printme( str ):
    "This prints a passed string into this function"
    print str
    return;
```

```
# Now you can call printme function
```

```
printme()
```

When the above code is executed, it produces the following result –

Traceback (most recent call last):

```
File "test.py", line 11, in <module>
    printme();
```

TypeError: printme() takes exactly 1 argument (0 given)

Keyword arguments

Keyword arguments are related to the function calls. When you use keyword arguments in a function call, the caller identifies the arguments by the parameter name.

This allows you to skip arguments or place them out of order because the Python interpreter is able to use the keywords provided to match the values with parameters. You can also make keyword calls to the *printme()* function in the following ways –

```
#!/usr/bin/python
```

```
# Function definition is here
```

```
def printme( str ):
    "This prints a passed string into this function"
    print str
    return;
```

```
# Now you can call printme function
```

```
printme( str = "My string")
```

When the above code is executed, it produces the following result –

My string

The following example gives more clear picture. Note that the order of parameters does not matter.

```
#!/usr/bin/python
```

```
# Function definition is here
```

```
def printinfo( name, age ):  
    "This prints a passed info into this function"  
    print "Name: ", name  
    print "Age ", age  
    return;
```

```
# Now you can call printinfo function
```

```
printinfo( age=50, name="miki" )
```

When the above code is executed, it produces the following result –

```
Name: miki
```

```
Age 50
```

Default arguments

A default argument is an argument that assumes a default value if a value is not provided in the function call for that argument. The following example gives an idea on default arguments, it prints default age if it is not passed –

```
#!/usr/bin/python
```

```
# Function definition is here
```

```
def printinfo( name, age = 35 ):  
    "This prints a passed info into this function"  
    print "Name: ", name  
    print "Age ", age  
    return;
```

```
# Now you can call printinfo function
```

```
printinfo( age=50, name="miki" )
```

```
printinfo( name="miki" )
```

When the above code is executed, it produces the following result –

```
Name: miki
```

```
Age 50
```

```
Name: miki
```

```
Age 35
```

Variable-length arguments

You may need to process a function for more arguments than you specified while defining the function. These arguments are called *variable-length* arguments and are not named in the function definition, unlike required and default arguments. Syntax for a function with non-keyword variable arguments is this – `def functionname([formal_args,] *var_args_tuple):`

```
"function_docstring"
```

```
function_suite
```

```
return [expression]
```

An asterisk (*) is placed before the variable name that holds the values of all nonkeyword variable arguments. This tuple remains empty if no additional arguments are specified during the function call. Following is a simple example –

```
#!/usr/bin/python

# Function definition is here
def printinfo( arg1, *vartuple ):
    "This prints a variable passed arguments"
    print "Output is: "
    print arg1
    for var in vartuple:
        print var
    return;
```

Now you can call printinfo function

```
printinfo( 10 )
printinfo( 70, 60, 50 )
```

When the above code is executed, it produces the following result –

Output is:

10

Output is:

70

60

50

Example

```
def my_function(fname):
    print(fname + " krishna")
my_function("Rama")
my_function("Siva")
my_function("Hari")
o/p: Ramakrishna
     Sivakrishna
     Harikrishna.
```

Parameters Vs Arguments

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

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("Srinu", "vasulu")
```

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("raju", "somu", "vijay")
O/p: vijay
```

Default Parameter Value:

When 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")
#o/p: Norway
```

Passing a List as an Argument:

You can send any data types of argument to a function (string, number, list, dictionary etc.)

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 return a value, we use the `return` statement:

Example

```
def my_function(x):
    return 5 * x
print(my_function(3)) # o/p: 15
print(my_function(5)) # o/p: 25
print(my_function(9)) # o/p: 45
```

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
```

7. Variables and Parameters Are Local

When you create a variable inside a function, it is local, which means that it only exists inside the function.

For example:

```
def cat_twice(part1, part2):
```



```
cat = part1 + part2
print_twice(cat)
```

```
line1 = 'Bing tiddle '
line2 = 'tiddle bang.'
cat_twice(line1, line2)
print(cat) #error
```

here cat_twice terminates, the variable cat is destroyed. If we try to print it, we get an exception:

```
>>> NameError: name 'cat' is not defined
```

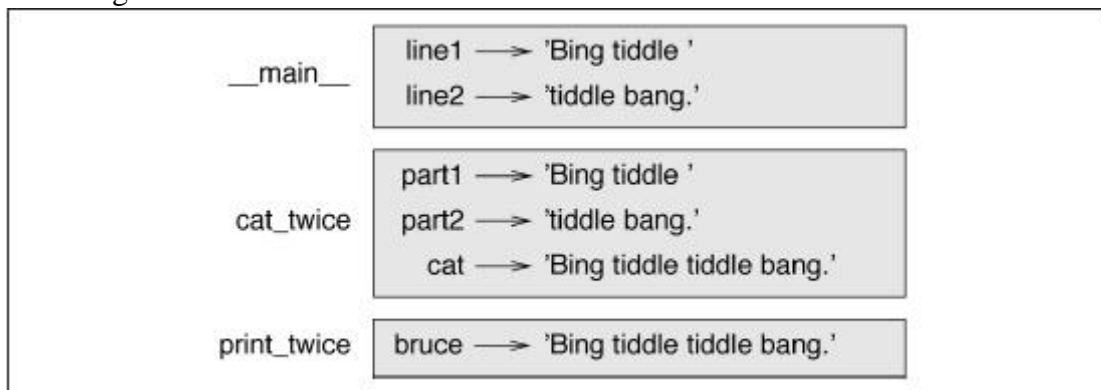
8.Stack Diagrams:

Stack diagram used to keep track of which variables can be used which function. For ex, consider the following code:

```
def cat_twice(part1, part2):
    cat = part1 + part2
    print_twice(cat)
```

```
line1 = 'Bing tiddle '
line2 = 'tiddle bang.'
cat_twice(line1, line2)
```

Stack diagram for above code is:



Here each function is represented by a frame. A frame is a box with the name of a function beside it and the parameters and variables of the function inside it.

The frames are arranged in a stack that indicates which function called which, and so on. In this example, print_twice was called by cat_twice, and cat_twice was called by __main__, which is a special name for the topmost frame. When you create a variable outside of any function, it belongs to __main__.

9.Fruitful Functions and Void Functions

The function that returns a value is called fruitful function.

The function that does not returns any value is called void function.

Fruitful Functions:

Ex :def add(x,y):

```
return (x+y)
```

```
Z  
=  
a  
d  
d  
(  
1  
,  
2  
)
```

```
p  
r  
i  
n  
t  
(  
z  
)
```

void Functions:

```
Ex : def add(x,y):  
        print(x+y)
```

```
add(1,2)
```

10. Why Functions?

There are several reasons for why functions:

- *improves readability*: Creating a new function gives you an opportunity to name a group of statements, which makes your program easier to read and debug.
- *debugging easy* : Functions can make a program smaller by eliminating repetitive code. Later, if you make a change, you only have to make it in one place.
- *modularity*: Dividing a long program into functions allows you to debug the parts one at a time and then assemble them into a working whole.
- *reusability* : Well-designed functions are often useful for many programs. Once you write and debug one, you can reuse it.

Unit-2
Chapter-1
Case Study

1 Turtle Module: in python turtle is a module, which allows you to create images using turtle graphics

How to use turtle module:

To work with turtle we follow the below steps
Import the turtle module
Create a turtle to control.
Draw around using the turtle methods. Run

Import the turtle module:

To make use of the turtle methods and functionalities, we need to import turtle. from turtle import *
or
import turtle

Create a turtle to control:

After importing the turtle library and making all the turtle functionalities available to us, we need to create a new drawing board(window) and a turtle. Let's call the window as wn and the turtle as skk. So we code as:

```
wn = turtle.Screen()
wn.bgcolor("light green")
wn.title("Turtle")
skk = turtle.Turtle()
```

Draw around using the turtle methods:

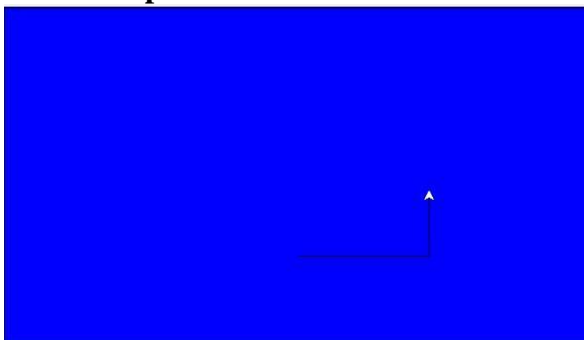
METHOD	PARAMETER	DESCRIPTION
Turtle()	None	It creates and returns a new turtle object
forward()	Amount	It moves the turtle forward by the specified amount
backward()	Amount	It moves the turtle backward by the specified amount
right()	Angle	It turns the turtle clockwise
left()	Angle	It turns the turtle counter clockwise
penup()	None	It picks up the turtle's Pen
pendown()	None	Puts down the turtle's Pen
up()	None	Picks up the turtle's Pen

down()	None	Puts down the turtle's Pen
color()	Color name	Changes the color of the turtle's pen
fillcolor()	Color name	Changes the color of the turtle will use to fill a polygon
heading()	None	It returns the current heading
position()	None	It returns the current position
goto()	x, y	It moves the turtle to position x,y
begin_fill()	None	Remember the starting point for a filled polygon
end_fill()	None	It closes the polygon and fills with the current fill color
dot()	None	Leaves the dot at the current position
stamp()	None	Leaves an impression of a turtle shape at the current location
shape()	shapename	Should be 'arrow', 'classic', 'turtle' or 'circle'

Example code

```
# import turtle
library import turtle
my_window =
turtle.Screen()
my_window.bgcolor("blue") # creates a graphics
window my_pen = turtle.Turtle()
my_pen.forward(150)
my_pen.left(90)
my_pen.forward(75)
my_pen.color("white")
my_pen.pensize(12)
```

Output



Run :

To run the turtle we call the method **turtle.done()**.

2 Simple Repetition:

Performing the same action repeatedly is called simple repetition.

For ex let's consider a square or rectangle to draw. The following steps to be performed repeatedly.

```
bob.fd(100)
bob.lt(90)
```

```
bob.fd(100)
bob.lt(90)
```

```
bob.fd(100)
bob.lt(90)
```

```
bob.fd(100)
```

the above steps can be reduced using simple repetition statement for as follows.

```
for i in range(4):
    bob.fd(100)
    bob.lt(90)
```

3 Encapsulation :

Wrapping a piece of code up in a function is called **encapsulation**. The benefits of encapsulation are, it attaches a name to the code. We can reuse the code, (i.e we can call a function instead of copy and paste the body)

For ex: code to drawing the square

```
def square(t):
    for i in range(4):
        t.fd(100)
        t.lt(90)

bob = turtle.Turtle()
square(bob)
```

4 Generalization:

Adding a parameter to a function is called **generalization**. because it makes the function more general: in the previous version, the square is always the same size; in this version it can be any size.

```
def square(t, length):
    for i in range(4):
        t.fd(length)
        t.lt(90)
```

```
bob = turtle.Turtle()
square(bob, 100)
```

the following one also a **generalization**. Instead of drawing squares, polygon draws regular polygons with any number of sides.

Here is a solution:

```
def polygon(t, n, length):
    angle = 360 / n
    for i in
range(n):
```

```
t.fd(length)
t.lt(angle)
```

```
bob = turtle.Turtle()
polygon(bob, 7, 70)
```

5. Interface Design:

The **interface** of a function is a summary of how it is used: what are the parameters? What does the function do? And what is the return value? An interface is “clean” if it allows the caller to do what they want without dealing with unnecessary details.

For ex: write circle, which takes a radius, r, as a parameter.
Here is a simple solution that uses polygon to draw a 50-sided

```
polygon: import math

def circle(t, r):
    circumference = 2 * math.pi * r
    n = 50
    length = circumference / n

    polygon(t, n, length)
```

The first line computes the circumference of a circle with radius r using the formula $2\pi r$. n is the number of line segments in our approximation of a circle, so length is the length of each segment. Thus, polygon draws a 50-sided polygon that approximates a circle with radius r.

One limitation of this solution is that n is a constant, which means that for very big circles, the line segments are too long, and for small circles, we waste time drawing very small segments. One solution would be to generalize the function by taking n as a parameter.

```
def circle(t, r):
    circumference = 2 * math.pi * r
    n = int(circumference / 3) + 1
    length = circumference / n
    polygon(t, n, length)
```

6. Refactoring:

process of rearranging a program to improve interfaces and facilitate code reuse is called **refactoring** for ex: Lets take above discussion , When we write circle, we can able to reuse polygon because a many-sided polygon is a good approximation of a circle. But arc is not as cooperative; we can't use polygon or circle to draw an arc. One alternative is to start with a copy of polygon and transform it into arc. The result might look like this:

```
def polygon(t, n, length):
    angle = 360.0 / n
    polyline(t, n,
            length, angle)

def arc(t, r, angle):
    arc_length = 2 * math.pi * r *
```

```

angle / 360 n = int(arc_length / 3)
+ 1
step_length = arc_length / n
step_angle = float(angle) / n
polyline(t, n, step_length,
step_angle)

```

Finally, we can rewrite circle to use arc:

```

def circle(t, r):
arc(t, r, 360)

```

7. Docstring:

docstring is a string at the beginning of a function that explains the interface (“doc” is short for “documentation”).

Here is an example:

```

def polyline(t, n, length, angle):
"""Draws n line segments with the given length and angle (in degrees) between
them. t is a turtle.
"""
for i in range(n):
t.fd(length)
t.lt(angle)

```

By convention, all docstrings are triple-quoted strings, also known as multiline strings because the triple quotes allow the string to span more than one line.

Chapter-2 Conditionals and Recursion

1. floor division and modulus:

The floor division operator ‘//’ divides two numbers and rounds down to an integer. For example:

Conventional division returns a floating-point number as follows

```

>>> minutes = 105
>>>
minutes /
60 1.75

```

But Floor division returns the integer number of hours, dropping the fraction part:

```

>>> minutes = 105
>>> hours = minutes // 60
>>
>
hours
1

```

modulus operator, %, which divides two numbers and returns the remainder:

```

>>> remainder = minutes % 60

```

```
>>>
remain
der 45
```

2. Boolean Expressions:

A boolean expression is an expression that is either true or false. The following examples use the operator `==`, which compares two operands and produces True if they are equal and False otherwise:

```
>>> 5 == 5
True
>>> 5 == 6
False
```

True and False are special values that belong to the type `bool`; they are not strings:

```
>>> type(True)
<class 'bool'>
>>> type(False)
<class 'bool'>
```

The `==` operator is one of the relational operators; the others are:

```
x != y # x is not
equal to y
x > y # x
is greater than y
x < y # x is less than
y
x >= y # x is greater than or
equal to y
x <= y # x is less
than or equal to y
```

3. Logical Operators:

There are three logical operators: and, or, and not. The semantics (meaning) of these operators is similar to their meaning in English.

For example:

`x > 0 and x < 10` is true only if `x` is greater than 0 *and* less than 10.

`n%2 == 0 or n%3 == 0` is true if *either or both* of the conditions is true, that is, if the number is divisible by 2 *or* 3.

`not` : operator negates a boolean expression,

`not (x > y)` is true, if `x > y` is false, that is, if `x` is less than or equal to `y`. In Python, Any nonzero number is interpreted as True:

```
>>> 42
and True
True
```

4. Conditional Execution:

In order to write useful programs, we almost always need the ability to check conditions and change the behavior of the program accordingly. Conditional statements give us this ability. `if` statement:

`if` test expression:

statement(s)

Here, the program `test expression` and will execute statement(s) only if evaluates the expression the test is True.

If the test expression is False, the statement(s) is not executed.

F
o

r
e
x
:
n
u
m
=

3

```

if num > 0:
    print(num, "is a positive
number.") print("This is
always printed.")

```

5. Alternative Execution:

A second form of the if statement is “alternative execution”, in which there are two possibilities and the condition determines which one runs. The syntax looks like this:

Syntax of
if...else if
test
expression
:

Body of
if
else:

Body of else

`if..else` statement `test expression` and will execute the `if` only when the
body of

test `True`.
condition is `False`, the body of `else` is executed. Indentation is used to separate
the
the
condition
blocks.

For ex:

```
num = 3
```

```

if num >= 0:
    print("Positive or Zero")
else:
    print("Negative number")

```

6. Chained Conditionals

Sometimes there are more than two possibilities and we need more than two branches. One way to express a computation like that is a chained conditional: to implement chained conditional we use keyword “elif”.

Syntax of
if...elif...else if
test expression:

Body of if

elif test expression:

Body of
elif
else:

Body of else

`elif`

If the condition is False, it checks the condition of the next block and so on.

If all the conditions are the body of else is executed.

For Ex:

```
x
=
1
0
```

```
y
=
2
0
```

```
if x < y:
    print('x is less than y')
elif x > y:
    print('x is greater than y')
else:
    print('x and y are equal')
```

7. Nested Conditionals

One conditional can also be nested within another. For ex:

```
if x == y:
    print('x and y are equal')
else:
    if x < y:
        print('x is less than y')
    else:
        print('x is greater than y')
```

8. Recursion

Recursion means a function to call itself. For example:

```
def countdown(n):
    if n <= 0:
        print('Blastoff!')
    else:
        print(n)
        countdown(n-1)
```

```
countdown(3)
```

The output looks like this:

```
3
2
1
Blastoff!
```

9. Infinite Recursion:

If a recursion never reaches a base case, it goes on making recursive calls forever, and the program never terminates. This is known as infinite recursion. Here is a minimal program with an infinite recursion:

```
def recurse():
    recurse()
```

10. Keyboard Input:

Python provides a built-in function called `input()` to read a value from keyboard. For ex

```
print('Enter  
x  
Hello, ' + x)
```

Your

Definition and Usage

The `input()` function allows user input.

Syntax `input(prompt)` Parameter Values

Parameter	Description
<code>prompt</code>	A String, representing a default message before the input.

Example

Use the prompt parameter to write a message before the input:

```
x= input('Enter your name:')  
print('Hello, ' + x)
```

Note: `input()` function always reads string input. There to read int or float input values we should convert string input to the respective types using functions `int()`, `float()` ect..

For ex:

```
str_a = input('enter value')  
b = 10  
c = int(str_a) + b  
print ("The value of c = ",c)
```

o/p:

enter value:

42

The value of c =52

Chapter-3

Fruitful Functions

1. Return values:

The `return` keyword is to exit a function and return a value.

Syntax:

Return or return value:

For ex :

```
def myfunction():  
return 3+3  
print("Hello, World!")
```

```
print(myfun
ction())
output:
6.
```

2. Incremental Development:

incremental development is to avoid long debugging sessions by adding and testing only a small amount of code at a time (i.e. develop complex programs step by step).

For ex develop a program to find distance between two points

$$\text{distance} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

In Step1 we just define function with empty body as

```
follows def distance(x1, y1, x2, y2):
return 0.0
```

To test the new function, call it with sample arguments:

```
>>> distance(1, 2, 4, 6)
```

The output is 0.0 as there is no code to compute distance.

At this point we have confirmed that the function is syntactically correct, and we can start adding code to the body.

So in step 2 it is to find the differences $x_2 - x_1$ and $y_2 - y_1$. The next version stores those values in temporary variables and prints them:

```
def distance(x1, y1, x2, y2):
dx = x2 - x1
dy = y2 - y1
print('dx is', dx)
print('dy
is', dy)
return
0.0
```

in step 3 we compute the sum of squares of dx and dy:

```
def distance(x1, y1, x2, y2):
dx =
x2 -
x1
dy =
y2 -
y1
dsquared = dx**2 +
dy**2 print('dsquared
is: ', dsquared) return
0.0
```

Again, you would run the program at this stage and check the output (which should be 25).

Finally in step 4, you can use `math.sqrt` to compute and return the result: `def distance(x1, y1, x2, y2):`

```
dx =
x2 -
x1 dy
= y2
```

```

- y1
dsquared = dx**2 +
dy**2    result =
math.sqrt(dsquared)
return result

```

The key aspects of the process are:

1. Start with a working program and make small incremental changes. At any point, if there is an error, you should have a good idea where it is.
2. Use variables to hold intermediate values so you can display and check them.
3. Once the program is working, you might want to remove some of the scaffolding or consolidate multiple statements into compound expressions, but only if it does not make the program difficult to read.

3. Composition:

A complex program developed in small functions separately and write function calls to them in proper sequence to achieve the functionality of complex program is called composition.

For ex: we want a function to compute the area of the circle.

Assume that the center point is stored in the variables `xc` and `yc`, and the perimeter point is in `xp` and `yp`.

The first step is to find the radius of the circle, which is the distance between the two points.

We just wrote a function, `distance`, that does that:

```
radius = distance(xc, yc, xp, yp)
```

The next step is to find the area of a circle with that radius; we just wrote that, too:

```
result = area(radius)
```

Encapsulating these steps in a function, we get:

```
def circle_area(xc, yc, xp, yp):
    radius = distance(xc, yc,
xp, yp)    result =
    area(radius)
    return result

```

The temporary variables `radius` and `result` are useful for development and debugging, but once the program is working, we can make it more concise by composing the function calls:

```
def circle_area(xc, yc, xp, yp):
    return area(distance(xc, yc,
xp, yp))

```

4. Boolean Functions

Functions can return Booleans. For example:

```
def is_divisible(x, y):
    if x % y == 0:

        return
        True
    else:
        return False

```

```
>>>
is_divisible(6,
```

```
4) False
>>>
is_divisible(6,
3) True
```

5. More Recursion:

The function calls it self is called recursion . For ex consider factorial of a number.

The definition of factorial says that the factorial of 0 is 1, and the factorial of any other value n is, n multiplied by the factorial of $n-1$.

```
def factorial(n):
if n == 0:
r
e
t
u
r
n
1
e
l
s
e
:
recurse =
factorial(n-1)
result = n *
recurse return
result
```


Figure 6-1 shows what the stack diagram looks like for this sequence of function calls.

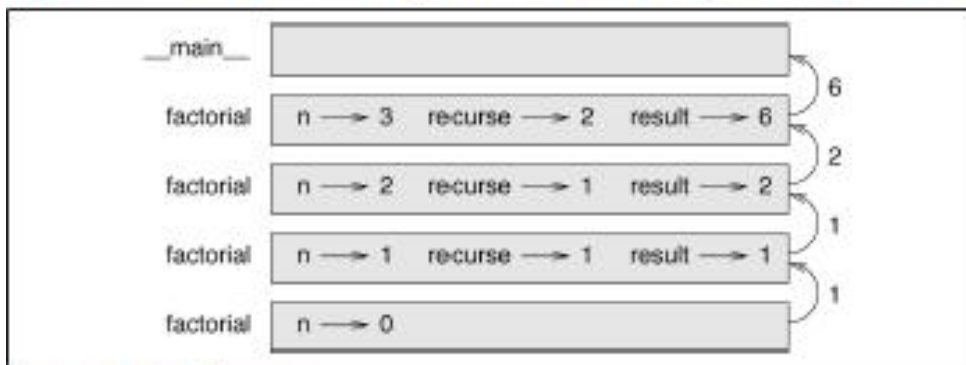


Figure 6-1. Stack diagram.

6. Leap of Faith:

Leap of Faith means when you come to a function call, instead of following the flow of execution, you *assume* that the function works correctly and returns the right result.

For example built in functions .i.e. When you call `math.cos` or `math.exp`, you don't examine the bodies of those functions.

7. Checking Types

What happens if we call `factorial` and give it 1.5 as an argument?

```
>>> factorial(1.5)
```

`RuntimeError: Maximum recursion depth exceeded` Why because In the first recursive call, the value of `n` is 0.5. In the next, it is -0.5. From there, it gets smaller (more negative), but it will never be 0.

To avoid this situation we have to check input type.using the built-in function `isinstance` to verify the type of the argument.

For ex:

```
def factorial (n):
    if not isinstance(n, int):
        print('Factorial is only defined for
        integers.') return None
    elif n < 0:
        print('Factorial is not defined for negative
        integers.') return None
    elif n == 0:
        r
        e
        t
        u
        r
        n

    1

    e
    l
    s
    e
    :
    return n * factorial(n-1)
```

The first base case handles nonintegers; the second handles negative integers. In both cases, the program prints an error message and returns `None` to indicate that something went wrong: Checking Types | 69

```
>>> factorial('fred')
```

```
Factorial is only defined for integers. None
```

```
>>> factorial(-2)
```

```
Factorial is not defined for negative integers. None
```

If we get past both checks, we know that n is positive or zero, so we can prove that the recursion terminates. This program demonstrates a pattern sometimes called a guardian. The first two conditionals act as guardians, protecting the code that follows from values that might cause an error. The guardians make it possible to prove the correctness of the code.

UNIT 3

Chapter-1 Iteration

1. Re Assignment:

In python it is legal to make more than one assignment to the same variable. A new assignment makes an existing variable refer to a new value (and stop referring to the old value).

```
>>> x = 5
>
>
>
```

x

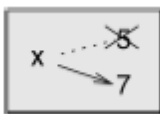
5

```
>>> x = 7
>
>
>
```

x

7

The first time we display x, its value is 5; the second time, its value is 7. **Figure 7-1** shows what reassignment looks like in a



state diagram.

2. Updating Variables:

A common kind of reassignment is an update, where the new value of the variable depends on the old.

```
>>> x = x + 1
```

This means “get the current value of x, add one, and then update x with the new value.” If you try to update a variable that doesn’t exist, you get an error, because Python evaluates the right side before it assigns a value to x:

```
>>> x = x + 1
```

NameError: name 'x' is not defined

Before you can update a variable, you have to initialize it, usually with a simple assignment:

```
>>> x = 0
```

```
>>> x = x + 1
```

Updating a variable by adding 1 is called an increment; subtracting 1 is called a decrement.

3. The While Statement:

A while loop statement in Python programming language repeatedly executes a target statement as long as a given condition is true.

Syntax

The syntax of a while loop in Python programming language is – while expression:
statement(s)

Here, statement(s) may be a single statement or a block of statements.

The condition may be any expression, and true is any non-zero value. The loop iterates while the condition is true.

When the condition becomes false, program control passes to the line immediately following the loop.

For Ex:

```
count = 0
while (count < 9):
    print "The count is:",
count count = count + 1

print "Good bye!"
```

When the above code is executed, it produces the following result – The count is: 0

The count is: 1

The count is: 2

The count is: 3

The count is: 4

The count is: 5

The count is: 6

The count is: 7

The count is: 8

Good bye!

Using else Statement with While Loop

Python supports to have an else statement associated with a loop statement.

If the else statement is used with a while loop, the else statement is executed when the condition becomes false.

The following example illustrates the combination of an else statement with a while statement that prints a number as long as it is less than 5, otherwise else statement gets executed.

```
count = 0
while count < 5:
    print count, " is less than 5"
count = count + 1
else:
    print count, " is not less than 5"
```

When the above code is executed, it produces the following result – 0 is less than 5

1 is less than 5

2 is less than 5

3 is less than 5

4 is less than 5

5 is not less than 5

3. Break :

It terminates the current loop and resumes execution at the next statement, just like the traditional break statement in C.

Syntax

The syntax for a break statement in Python is as follows – break

Note: If you use nested loops, the break statement stops the execution of the innermost loop and starts executing the next line of code after the block.

For ex:

```
for letter in 'Python': # First Example
    if letter == 'h':
        break
    print 'Current Letter :', letter

    var = 10 # Second Example
    while var > 0:
        print 'Current variable value :',
        var var = var - 1
    if var == 5:
        break
```

```
print "Good bye!"
```

When the above code is executed, it produces the following result –

```
Current Letter : P
Current Letter : y
Current Letter : t
Current variable value : 10
Current variable value : 9
Current variable value : 8
Current variable value : 7
Current variable value : 6
Good bye!
```

4. Square Roots:

Python number method sqrt() returns the square root of x

for $x > 0$. Syntax

Following is the syntax for sqrt()

method – import math

```
math.sqrt( x )
```

Note – This function is not accessible directly, so we need to import math module and then we need to call this function using math static object.

Parameters

x – This is a numeric expression.

Return Value

This method returns square root of x for $x > 0$.

Example

The following example shows the usage of sqrt() method.

```
#!/usr/bin/python
```

```
import math # This will import math module
```

```
print "math.sqrt(100) : ",  
math.sqrt(100) print  
"math.sqrt(7) : ", math.sqrt(7)  
print "math.sqrt(math.pi) : ", math.sqrt(math.pi)
```

When we run above program, it produces following result –

```
math.sqrt(100) : 10.0  
math.sqrt(7) : 2.64575131106  
math.sqrt(math.pi) :
```

```
1.77245385091
```

Algorithms

Newton's method is an example of an **algorithm**: it is a mechanical process for solving a category of problems (in this case, computing square roots). Some kinds of knowledge are not algorithmic. For example, learning dates from history or your multiplication tables involves memorization of specific solutions. But the techniques you learned for addition with carrying, subtraction with borrowing, and long division are all algorithms. Or if you are an avid Sudoku puzzle solver, you might have some specific set of steps that you always follow.

One of the characteristics of algorithms is that they do not require any intelligence to carry out. They are mechanical processes in which each step follows from the last according to a simple set of rules. And they're designed to solve a general class or category of problems, not just a single problem. Understanding that hard problems can be solved by step-by-step algorithmic processes (and having technology to execute these algorithms for us) is one of the major breakthroughs that has had enormous benefits. So while the execution of the algorithm may be boring and may require no intelligence, algorithmic or computational thinking — i.e. using algorithms and automation as the basis for approaching problems — is rapidly transforming our society. Some claim that this shift towards algorithmic thinking and processes is going to have even more impact on our society than the invention of the printing press. And the process of designing algorithms is interesting, intellectually challenging, and a central part of what we call programming.

Some of the things that people do naturally, without difficulty or conscious thought, are the hardest to express algorithmically. Understanding natural language is a good example. We all do it, but so far no one has been able to explain *how* we do it, at least not in the form of a step-by-step mechanical algorithm.

Chapter-2 Strings

A string is a sequence

A string is a sequence of characters. You can access the characters one at a time with the bracket operator:

```
>>> fruit = 'banana'
>>> letter = fruit[1]
```

The second statement selects character number 1 from fruit and assigns it to letter. The expression in brackets is called an index. The index indicates which character in the sequence you want len.

len is a built-in function that returns the number of characters in a string:

```
>>> fruit = 'banana'
>>>
len(fruit)
6
```

To get the last letter of a string, you might be tempted to try something like this:

```
>>> length = len(fruit)
>>> last = fruit[length]
```

IndexError: string index out of range

The reason for the IndexError is that there is no letter in 'banana' with the index 6.

Since we started counting at zero, the six letters are numbered 0 to 5. To get the last character, you have to subtract 1 from length:

```
>>> last = fruit[length-1]
>
>
>
la
st
'a
'
```

Or you can use negative indices, which count backward from the end of the string.

The expression fruit[-1] yields the last letter, fruit[-2] yields the second to last, and so on.

2. Traversal With A For Loop:

Traversal : visiting each character in the string is called string traversal. We can do string traversing with either while or for statements.

For ex:

```
for letter in 'Python':      # First Example print
'Current Letter :', letter
out put:
P

Y

T

H

O
n
```

3. String Slicing In Python:

Python slicing is about obtaining a sub-string from the given string by slicing it respectively from start to end.

Python slicing can be done in two ways.

slice()

Constructor

Extending

Indexing

slice()

Constructor

The slice() constructor creates a slice object representing the set of indices specified by range(start, stop, step).

Syntax:

slice(stop)

slice(start, stop, step)

Parameters:

start: Starting index where the slicing of object starts.

stop: Ending index where the slicing of object stops.

step: It is an optional argument that determines the increment between each index for slicing.

Return Type: Returns a sliced object containing elements in the given range only.

Example

```
# Python program to demonstrate
```

```
# string slicing
```

```
# String slicing String ='ASTRING'
```

```
# Using slice constructor
```

```
s1 =slice(3)
```

```
s2 = slice(1, 5, 2)
```

```
s3 = slice(-1, -12, -2)
```

```
print("String slicing")
```

```
print(String[s1])
```

```
print(String[s2])
```

```
print(String[s3])
```

Output:

String

slicing

AST

S

R

G

I

T

A

Extending indexing

In Python, indexing syntax can be used as a substitute for the slice object. This is an easy and convenient way to slice a string both syntax wise and execution wise.

Syntax

```
string[start:end:step]
```

start, end and step have the same mechanism as slice() constructor.

Example

```
# Python program to demonstrate string
```

```
slicing String ='ASTRING'
```

```
# Using indexing sequence
```



```

print(String[:3])
print(String[1:5:2])
print(String[-1:-12:-2])
# Prints string in reverse
print("\nReverse String")
print(String[::-1])

```

Output:

```

A
S
T

```

```

S
R

```

```

G
I
T
A

```

```

Reverse
String
GNIRT
SA

```

4. Strings Are Immutable :

In python, the string data types are immutable. Which means a string value cannot be updated. We can verify this by trying to update a part of the string which will led us to an error.

```

# Can not
reassign t=
"Tutorialsp
oint" print
type(t)
t[0] = "M"

```

When we run the above program, we get the following output –

```

t[0] = "M"

```

TypeError: 'str' object does not support item assignment

5. Searching: Traversing in sequence and returning a character when we find what we are looking for—is called a search.

For ex:

```

def find(word, letter):
index = 0
while index < len(word):
if word[index] == letter:
return
index
index =
index + 1
return -1

```

String functions for searching:

find():

The `find()` method finds the first occurrence of the specified value. The `find()`

method returns -1 if the value is not found.

Syntax

`string.find(value, start, end)`

Parameter Values

Parameter	Description
<i>Value</i>	Required. The value to search for
<i>Start</i>	Optional. Where to start the search. Default is 0
<i>End</i>	Optional. Where to end the search. Default is to the end of the string

More Examples

Example

Where in the text is the first occurrence of the letter "e"?:

```
txt = "Hello, welcome to my world."
x = txt.find("e")
```

```
print(
in
t(
x)
E
xa
m
pl
e
```

Where in the text is the first occurrence of the letter "e" when you only search between position 5 and 10?:

```
txt = "Hello, welcome to my world."
x = txt.find("e", 5, 10)
```

```
print(x)
```

7. Looping And Counting

The following program counts the number of times the letter a appears in a

string: `word = 'banana'`

`count = 0`

for letter in word:

```

if letter == 'a':
    count = count + 1
print(count)

```

This program demonstrates another pattern of computation called a counter. The variable count is initialized to 0 and then incremented each time an a is found. When the loop exits, count contains the result—the total number of a’s.

8. String Methods

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

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

Method	Description
<u>capitalize()</u>	Converts the first character to upper case
<u>casefold()</u>	Converts string into lower case
<u>center()</u>	Returns a centered string
<u>count()</u>	Returns the number of times a specified value occurs in a string
<u>encode()</u>	Returns an encoded version of the string
<u>endswith()</u>	Returns true if the string ends with the specified value
<u>expandtabs()</u>	Sets the tab size of the string
<u>find()</u>	Searches the string for a specified value and returns the position of where it was found
<u>format()</u>	Formats specified values in a string
<u>format_map()</u>	Formats specified values in a string
<u>index()</u>	Searches the string for a specified value and returns the position of where it was found
<u>isalnum()</u>	Returns True if all characters in the string are alphanumeric
<u>isalpha()</u>	Returns True if all characters in the string are in the alphabet
<u>isdecimal()</u>	Returns True if all characters in the string are decimals
<u>isdigit()</u>	Returns True if all characters in the string are digits
<u>isidentifier()</u>	Returns True if the string is an identifier
<u>islower()</u>	Returns True if all characters in the string are lower case
<u>isnumeric()</u>	Returns True if all characters in the string are numeric

<u>isprintable()</u>	Returns True if all characters in the string are printable
<u>isspace()</u>	Returns True if all characters in the string are whitespaces
<u>istitle()</u>	Returns True if the string follows the rules of a title
<u>isupper()</u>	Returns True if all characters in the string are upper case
<u>join()</u>	Joins the elements of an iterable to the end of the string
<u>ljust()</u>	Returns a left justified version of the string
<u>lower()</u>	Converts a string into lower case
<u>lstrip()</u>	Returns a left trim version of the string
<u>maketrans()</u>	Returns a translation table to be used in translations
<u>partition()</u>	Returns a tuple where the string is parted into three parts
<u>replace()</u>	Returns a string where a specified value is replaced with a specified value
<u>rfind()</u>	Searches the string for a specified value and returns the last position of where it was found
<u>rindex()</u>	Searches the string for a specified value and returns the last position of where it was found
<u>rjust()</u>	Returns a right justified version of the string
<u>rpartition()</u>	Returns a tuple where the string is parted into three parts
<u>rsplit()</u>	Splits the string at the specified separator, and returns a list
<u>rstrip()</u>	Returns a right trim version of the string
<u>split()</u>	Splits the string at the specified separator, and returns a list
<u>splitlines()</u>	Splits the string at line breaks and returns a list
<u>startswith()</u>	Returns true if the string starts with the specified value
<u>strip()</u>	Returns a trimmed version of the string
<u>swapcase()</u>	Swaps cases, lower case becomes upper case and vice versa
<u>title()</u>	Converts the first character of each word to upper case
<u>translate()</u>	Returns a translated string

<code>upper()</code>	Converts a string into upper case
<code>zfill()</code>	Fills the string with a specified number of 0 values at the beginning

9. The In Operator:

The word `in` is a boolean operator that takes two strings and returns `True` if the first appears as a substring in the second:

```
>>> 'a' in
'banana'
True
>>> 'seed' in
'banana'
False
```

10. STRING COMPARISON

The relational operators work on strings. To see if two strings are equal:

```
if word == 'banana':
```

```
print('All right, bananas.')
```

Other relational operations are useful for putting words in alphabetical order:

```
if word < 'banana':
```

```
print('Your word, ' + word + ', comes before banana.')
```

```
elif word > 'banana':
```

```
print('Your word, ' + word + ', comes after banana.')
```

```
else:
```

```
print('All right, bananas.')
```

Python does not handle uppercase and lowercase letters the same way people do.

All the uppercase letters come before all the lowercase letters, so:

Your word, Pineapple, comes before banana.

Chapter-3

Case study

1. Reading word lists:

There are lots of word lists available on the Web, but the one most suitable for our purpose is one of the word lists collected and contributed to the public domain by Grady Ward as part of the Moby lexicon project¹. It is a list of 113,809 official crosswords; that is, words that are considered valid in crossword puzzles and other word games.

In the Moby collection, the filename is `113809of.fic`; I include a copy of this file, with the simpler name `words.txt`, along with Swampy.

This file is in plain text, so you can open it with a text editor, but you can also read it from Python. The built-in function `open` takes the name of the file as a parameter and returns a **file object** you can use to read the file.

```
>>> fin = open('words.txt')
```

```
>>> print fin
```

```
<open file 'words.txt', mode 'r' at 0xb7f4b380>
```

fin is a common name for a file object used for input. Mode 'r' indicates that this file is open for reading (as opposed to 'w' for writing).

The file object provides several methods for reading, including `readline`, which reads characters from the file until it gets to a newline and returns the result as a string:

```
>>>
fin.readline
() 'aa\r\n'
```

The first word in this particular list is “aa,” which is a kind of lava. The sequence `\r\n` represents two whitespace characters, a carriage return and a newline, that separate this word from the next.

The file object keeps track of where it is in the file, so if you call `readline` again, you get the next word:

```
>>>
fin.readlin
e() 'aah\r\n'
```

The next word is “aah,” which is a perfectly legitimate word, so stop looking at me like that. Or, if it’s the whitespace that’s bothering you, we can get rid of it with the string method `strip`:

```
>>> line = fin.readline()
>>> word = line.strip()
>>> print word
aahed
```

You can also use a file object as part of a for loop. This program reads `words.txt` and prints each word, one per line:

```
fin = open('words.txt')
for line in fin:
```

```
    word = line.strip()
    print word
```

2. Search

All of the exercises in the previous section have something in common; The simplest example is:

```
def has_no_e(word):
    for letter in word:
        if letter == 'e':
            return False
    return True
```

The for loop traverses the characters in `word`. If we find the letter “e”, we can immediately return `False`; otherwise we have to go to the next letter. If we exit the loop normally, that means we didn’t find an “e”, so we return `True`.

You can write this function more concisely using the `in` operator, but I started with this version because it demonstrates the logic of the search pattern.

`avoids` is a more general version of `has_no_e` but it has the same structure: `def avoids(word, forbidden):`

```
for letter in word:
    if letter in forbidden:
        return False
return True
```

We can return `False` as soon as we find a forbidden letter; if we get to the end of the loop, we return `True`.

`uses_only` is similar except that the sense of the condition is reversed: `def uses_only(word, available):`

```
for letter in word:
```

```

if letter not in
available: return
False
return True

```

Instead of a list of forbidden words, we have a list of available words. If we find a letter in word that is not in available, we can return False. `uses_all` is similar except that we reverse the role of the word and the string of letters:

```

def uses_all(word, required):
for letter in
required: if letter
not in word:
return False
return True

```

Instead of traversing the letters in word, the loop traverses the required letters. If any of the required letters do not appear in the word, we can return False.

If you were really thinking like a computer scientist, you would have recognized that `uses_all` was an instance of a previously-solved problem, and you would have written:

```

def uses_all(word, required):
return uses_only(required, word)

```

This is an example of a program development method called **problem recognition**, which means that you recognize the problem you are working on as an instance of a previously-solved problem, and apply a previously-developed solution.

3. Looping with indices

I wrote the functions in the previous section with for loops because I only needed the characters in the strings; I didn't have to do anything with the indices. For `is_abecedarian` we have to compare adjacent letters, which is a little tricky with a for loop:

```

Def is_abecedarian(word):
previous = word[0]
for c in word:
if c < previous:
return False
previous = c
return True

```

An alternative is to use recursion:

```

def is_abecedarian(word):
if len(word) <= 1:
return True
if word[0] > word[1]:
return False
return is_abecedarian(word[1:])

```

Another option is to use a while loop:

```

def is_abecedarian(word):
i = 0
while i < len(word)-1:
if word[i+1] < word[i]:
return False
i = i+1
return True

```

The loop starts at `i=0` and ends when `i=len(word)-1`. Each time through the loop, it compares the *i*th character (which you can think of as the current character) to the *i+1*th character (which you can think of as the next).

If the next character is less than (alphabetically before) the current one, then we have discovered a break in the abecedarian trend, and we return False.

If we get to the end of the loop without finding a fault, then the word passes the test. To convince yourself that the loop ends correctly, consider an example like 'flossy'. The length of the word is 6, so the last time the loop runs is when i is 4, which is the index of the second- to-last character. On the last iteration, it compares the second-to-last character to the last, which is what we want.

Here is a version of `is_palindrome` (see Exercise 6.6) that uses two indices; one starts at the beginning and goes up; the other starts at the end and goes down.

```
def is_palindrome(word):
    i = 0
    j = len(word)-1

    while i<j:
        if word[i] != word[j]:
            return False
        i = i+1
        j = j-1

    return True
```

Or, if you noticed that this is an instance of a previously-solved problem, you might have written:

```
def is_palindrome(word):
    return is_reverse(word, word)
```

Chapter-4

LIST

Python offers a range of compound datatypes often referred to as sequences. List is one of the most frequently used and very versatile datatype used in Python.

How to create a list?

In Python programming, a list is created by placing all the items (elements) inside a square bracket [], separated by commas. It can have any number of items and they may be of different types (integer, float, string etc.).

```
# empty list
my_list = []
# list of integers
my_list = [1, 2, 3]
# list with mixed datatypes
my_list = [1, "Hello", 3.4]
```

Also, a list can even have another list as an item. This is called nested list. # nested list

```
my_list = ["mouse", [8, 4, 6], ['a']]
```


How to access elements from a list?

There are various ways in which we can access the elements of a list.

List Index

We can use the index operator [] to access an item in a list. Index starts from 0. So, a list having 5 elements will have index from 0 to 4.

Trying to access an element other than this will raise an IndexError. The index must be an integer. We can't use float or other types, this will result into TypeError.

Nested lists are accessed using nested indexing.

```
my_list = ['p','r','o','b','e']
# Output: p
print(my_list[0])

# Output: o
print(my_list[2])

# Output: e
print(my_list[4])

# Error! Only integer can be used for indexing
# my_list[4.0]

# Nested List
n_list = ["Happy", [2,0,1,5]]

# Nested indexing

# Output: a
print(n_list[0][1])

# Output: 5
print(n_list[1][3])
```

Negative indexing

Python allows negative indexing for its sequences. The index of -1 refers to the last item, -2 to the second last item and so on.

```
my_list = ['p','r','o','b','e']

# Output: e
print(my_list[-1])

# Output: p
print(my_list[-5])
```

4. List Slices:

How to slice lists in Python?

We can access a range of items in a list by using the slicing operator (colon).

```
my_list = ['p','r','o','g','r','a','m','i','z']
# elements 3rd to 5th
print(my_list[2:5])
```

```

# elements beginning to 4th
print(my_list[:-5])

# elements 6th to end
print(my_list[5:])

# elements beginning to end
print(my_list[:])

```

Slicing can be best visualized by considering the index to be between the elements as shown below. So if we want to access a range, we need two index that will slice that portion from the list.

P	R	O	G	R	A	M	I	Z	
0	1	2	3	4	5	6	7	8	9
-9	-8	-7	-6	-5	-4	-3	-2	-1	

1. List is a sequence:

The most basic data structure in Python is the **sequence**. Each element of a sequence is assigned a number - its position or index. The first index is zero, the second index is one, and so forth. Python has six built-in types of sequences, but the most common ones are lists and tuples, which we would see in this tutorial.

There are certain things you can do with all sequence types. These operations include indexing, slicing, adding, multiplying, and checking for membership. In addition, Python has built-in functions for finding the length of a sequence and for finding its largest and smallest elements.

Python Lists

The list is a most versatile datatype available in Python which can be written as a list of comma-separated values (items) between square brackets. Important thing about a list is that items in a list need not be of the same type.

Creating a list is as simple as putting different comma-separated values between square brackets. For example –

```

list1 = ['physics', 'chemistry', 1997, 2000];
list2 = [1, 2, 3, 4, 5 ];
list3 = ["a", "b", "c", "d"]

```

Similar to string indices, list indices start at 0, and lists can be sliced, concatenated and so on.

Accessing Values in Lists

To access values in lists, use the square brackets for slicing along with the index or indices to obtain value available at that index. For example –

```

#!/usr/bin/python

list1 = ['physics', 'chemistry', 1997, 2000];
list2 = [1, 2, 3, 4, 5, 6, 7 ];
print "list1[0]: ", list1[0]
print "list2[1:5]: ", list2[1:5]

```

When the above code is executed, it produces the following result –
list1[0]: physics
list2[1:5]: [2, 3, 4, 5]

Updating Lists

You can update single or multiple elements of lists by giving the slice on the left-hand side of the assignment operator, and you can add to elements in a list with the append() method. For example –

```
#!/usr/bin/python
```

```
list = ['physics', 'chemistry', 1997, 2000];  
print "Value available at index 2 : "  
print list[2] list[2] = 2001;  
print "New value available at index 2 : "  
print list[2]
```

Note – append() method is discussed in subsequent section.

When the above code is executed, it produces the following result –
Value available at index 2 :1997
New value available at index 2 :2001

Lists are Mutable

Unlike strings, lists are **mutable**. This means we can change an item in a list by accessing it directly as part of the assignment statement. Using the indexing operator (square brackets) on the left side of an assignment, we can update one of the list items.
fruit = ["banana", "apple", "cherry"]
print(fruit)

```
fruit[0] = "pear"  
fruit[-1] = "orange"  
print(fruit)
```

output:

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

An assignment to an element of a list is called **item assignment**. Item assignment does not work for strings. Recall that strings are immutable.

Here is the same example in codeLens so that you can step through the statements and see the changes to the list elements.

By combining assignment with the slice operator we can update several elements

at once. alist = ['a', 'b', 'c', 'd', 'e', 'f']

```
alist[1:3] = ['x', 'y']
```

```
print(alist)
```

output:

```
['a', 'x', 'y', 'd', 'e', 'f']
```

We can also remove elements from a list by assigning the empty list to them.

```
alist = ['a', 'b', 'c', 'd', 'e', 'f']
```

```
alist[1:3] = []
```

```
print(alist)
```

output:

```
['a', 'd', 'e', 'f']
```

6.map(), filter(), and reduce() in Python

Introduction

The `map()`, `filter()` and `reduce()` functions bring a bit of functional programming to Python. All three of these are convenience functions that can be replaced with [List Comprehensions](#) or loops, but provide a more elegant and short-hand approach to some problems.

Before continuing, we'll go over a few things you should be familiar with before reading about the aforementioned methods:

What is an anonymous function/method or lambda?

An anonymous method is a method without a name, i.e. not bound to an identifier like when we define a method using `def method:`.

Note: Though most people use the terms "*anonymous function*" and "*lambda function*" interchangeably - they're not the same. This mistake happens because in most programming languages lambdas *are* anonymous and all anonymous functions *are* lambdas. This is also the case in Python. Thus, we won't go into this distinction further in this article.

What is the syntax of a lambda function (or lambda operator)?

`lambda arguments: expression`

Think of lambdas as one-line methods without a name. They work practically the same as any other method in Python, for example:

```
def add(x,y):  
    return x + y
```

Can be translated to:

```
lambda x, y: x + y
```

Lambdas differ from normal Python methods because they can have only one expression, can't contain any statements and their return type is a `function` object. So the line of code above doesn't exactly return the value `x + y` but the function that calculates `x + y`.

Why are lambdas relevant to `map()`, `filter()` and `reduce()`?

All three of these methods expect a `function` object as the first argument. This `function` object can be a pre-defined method with a name (like `def add(x,y)`). Though, more often than not, functions passed to `map()`, `filter()`, and `reduce()` are the ones you'd use only once, so there's often no point in defining a referenceable function.

To avoid defining a new function for your different `map()/filter()/reduce()` needs - a more elegant solution would be to use a short, disposable, anonymous function that you will only use once and never again - a lambda.

The `map()` Function

The `map()` function iterates through all items in the given iterable and executes the `function` we passed as an argument on each of them.

The syntax is:

```
map(function, iterable(s))
```

We can pass as many iterable objects as we want after passing the `function` we want to use:

```
# Without using lambdas  
def starts_with_A(s):
```

```
return s[0] == "A"
```

```
fruit = ["Apple", "Banana", "Pear", "Apricot",  
"Orange"]  
map_object = map(starts_with_A,  
fruit)
```

```
print(list(map_o  
bject))
```

This code will result in:

```
[True, False, False, True, False]
```

As we can see, we ended up with a new list where the function `starts_with_A()` was evaluated for each of the elements in the list `fruit`. The results of this function were added to the list sequentially.

A prettier way to do this exact same thing is by using lambdas:

```
fruit = ["Apple", "Banana", "Pear", "Apricot", "Orange"]  
map_object = map(lambda s: s[0] == "A", fruit)
```

```
print(list(map_ob  
ject))
```

We get the same output:

```
[True, False, False, True, False]
```

Note: You may have noticed that we've cast `map_object` to a list to print each element's value. We did this because calling `print()` on a list will print the actual values of the elements. Calling `print()` on `map_object` would print the memory addresses of the values instead.

The `map()` function returns the `map_object` type, which is an iterable and we could have printed the results like this as well:

```
for value in map_object:  
    print(value)
```

If you'd like the `map()` function to return a list instead, you can just cast it when calling the function:

```
result_list = list(map(lambda s: s[0] == "A",  
fruit))
```

The `filter()` Function

Similar to `map()`, `filter()` takes a `function` object and an iterable and creates a new list. As the name suggests, `filter()` forms a new list that contains only elements that satisfy a certain condition, i.e. the `function` we passed returns `True`.

The syntax is:

```
filter(function, iterable(s))
```

Using the previous example, we can see that the new list will only contain elements for which the `starts_with_A()` function returns `True`:

```
# Without using lambdas
```

```
def starts_with_A(s):  
    return s[0] == "A"
```

```
fruit = ["Apple", "Banana", "Pear", "Apricot",  
"Orange"]  
filter_object = filter(starts_with_A,  
fruit)
```

```
print(list(filter_object))
```

Running this code will result in a shorter list:

```
['Apple', 'Apricot']
```

Or, rewritten using a lambda:

```
fruit = ["Apple", "Banana", "Pear", "Apricot",
```

```
"Orange"] filter_object = filter(lambda s: s[0] ==  
"A", fruit)
```

```
print(list(filter_object))
```

Printing gives us the same
output: ['Apple', 'Apricot']

The reduce() Function

`reduce()` works differently than `map()` and `filter()`. It does not return a new list based on the `function` and iterable we've passed. Instead, it returns a single value. Also, in Python `reduce()` isn't a built-in function anymore, and it can be found in the `functools` module.

The syntax is:

```
reduce(function, sequence[, initial])
```

`reduce()` works by calling the `function` we passed for the first two items in the sequence. The result returned by the `function` is used in another call to `function` alongside with the next (third in this case), element.

This process repeats until we've gone through all the elements in the sequence.

The optional argument `initial` is used, when present, at the beginning of this "loop" with the first element in the first call to `function`. In a way, the `initial` element is the 0th element, before the first one, when provided.

`reduce()` is a bit harder to understand than `map()` and `filter()`, so let's look at a step by step example:

We start with a list `[2, 4, 7, 3]` and pass the `add(x, y)` function to `reduce()` alongside this list, without an `initial` value

`reduce()` calls `add(2, 4)`, and `add()` returns `6`

`reduce()` calls `add(6, 7)` (result of the previous call to `add()` and the next element in the list as parameters), and `add()` returns `13`

`reduce()` calls `add(13, 3)`, and `add()` returns `16`

Since no more elements are left in the sequence, `reduce()` returns `16`

The only difference, if we had given an `initial` value would have been an additional step - `1.5`. where `reduce()` would call `add(initial, 2)` and use that return value in step `2`. Let's go ahead and use the `reduce()` function:

```
from functools import reduce
```

```
def add(x, y):  
    return x + y
```

```
list = [2, 4, 7, 3]  
print(reduce(add, list))
```

Running this code would yield: `16`

Again, this could be written using lambdas:

```
from functools import reduce
```

```
list = [2, 4, 7, 3]  
print(reduce(lambda x, y: x + y, list))  
print("With an initial value: " + str(reduce(lambda x, y: x + y,  
list, 10)))
```

And the code would result in: `16`

```
With an initial value: 26
```

Delete List Elements

To remove a list element, you can use either the del statement if you know exactly which element(s) you are deleting or the remove() method if you do not know. For example –

```
#!/usr/bin/python
list1 = ['physics', 'chemistry', 1997, 2000]; print list1
del list1[2];
print "After deleting value at index 2 : "
print list1
```

When the above code is executed, it produces following result –
['physics', 'chemistry', 1997, 2000]

After deleting value at index 2 :

```
['physics', 'chemistry', 2000]
```

Note – remove() method is discussed in subsequent section.

4. Basic List Operations

Lists respond to the + and * operators much like strings; they mean concatenation and repetition here too, except that the result is a new list, not a string.

In fact, lists respond to all of the general sequence operations we used on strings in the prior chapter.

Python Expression	Results	Description
len([1, 2, 3])	3	Length
[1, 2, 3] + [4, 5, 6]	[1, 2, 3, 4, 5, 6]	Concatenation
['Hi!'] * 4	['Hi!', 'Hi!', 'Hi!', 'Hi!']	Repetition
3 in [1, 2, 3]	True	Membership
for x in [1, 2, 3]: print x,	1 2 3	Iteration

List Operations:

How to change or add elements to a list?

List are mutable, meaning, their elements can be changed unlike string or tuple.

We can use assignment operator (=) to change an item or a range of items.

```
# mistake values
odd = [2, 4, 6, 8]

# change the 1st item
odd[0] = 1

# Output: [1, 4, 6, 8]
print(odd)

# change 2nd to 4th items
odd[1:4] = [3, 5, 7]

# Output: [1, 3, 5, 7]
print(odd)
```

We can add one item to a list using append() method or add several items using extend() method. odd = [1, 3, 5]

```
odd.append(7)
# Output: [1, 3, 5, 7]
print(odd)
```

```
odd.extend([9,
```

```
11, 13])
```

```
# Output: [1, 3, 5, 7, 9, 11, 13]
```

```
print(odd)
```

We can also use + operator to combine two lists. This is also called concatenation. The * operator repeats a list for the given number of times.

```
odd = [1, 3, 5]
```

```
# Output: [1, 3, 5, 9, 7, 5]
```

```
print(odd + [9, 7, 5])
```

```
#Output: ["re", "re", "re"]
```

```
print(["re"] * 3)
```

Furthermore, we can insert one item at a desired location by using the method insert() or insert multiple items by squeezing it into an empty slice of a list.

```
odd = [1, 9]
odd.insert(1,3)
```

```
# Output: [1, 3, 9]
```

```
print(odd)
```

```
odd[2:2] = [5, 7]
```

```
# Output: [1, 3, 5, 7, 9]
```

```
print(odd)
```

How to delete or remove elements from a list?

We can delete one or more items from a list using the keyword del. It can even delete the list entirely.

```
my_list = ['p','r','o','b','l','e','m']
```

```
# delete one item
```

```
del my_list[2]
```

```
# Output: ['p', 'r', 'b', 'l', 'e', 'm']
```

```
print(my_list)
```

```
# delete multiple items
```

```
del my_list[1:5]
```

```
# Output: ['p', 'm']
```

```
print(my_list)
```

```
# delete entire list
```

```
del my_list
```



```
# Error: List not defined
print(my_list)
```

We can use `remove()` method to remove the given item or `pop()` method to remove an item at the given index. The `pop()` method removes and returns the last item if index is not provided. This helps us implement lists as stacks (first in, last out data structure).

We can also use the `clear()` method to empty a list.

```
my_list = ['p','r','o','b','l','e','m']
my_list.remove('p')
```

```
# Output: ['r', 'o', 'b', 'l', 'e', 'm']
print(my_list)
```

```
# Output: 'o'
print(my_list.pop(1))
```

```
# Output: ['r', 'b', 'l', 'e', 'm']
print(my_list)
```

```
# Output: 'm'
print(my_list.pop())
```

```
# Output: ['r', 'b', 'l', 'e']
print(my_list)
```

```
my_list.clear()
```

```
# Output: []
print(my_list)
```

Finally, we can also delete items in a list by assigning an empty list to a slice of elements.

```
>>> my_list = ['p','r','o','b','l','e','m']
>>> my_list[2:3] = []
>>> my_list
['p', 'r', 'b', 'l', 'e', 'm']
>>> my_list[2:5] = []
>>> my_list
['p', 'r', 'm']
```

5. Indexing, Slicing, and Matrixes

Because lists are sequences, indexing and slicing work the same way for lists as they do for strings. Assuming following input – `L = ['spam', 'Spam', 'SPAM!']`

Python Expression	Results	Description
<code>L[2]</code>	SPAM!	Offsets start at zero

L[-2]	Spam	Negative: count from the right
L[1:]	['Spam', 'SPAM!']	Slicing fetches sections

6. Python List Methods

Methods that are available with list object in Python programming are tabulated below. They are accessed as list.method(). Some of the methods have already been used above.

Python List Methods
append() - Add an element to the end of the list
extend() - Add all elements of a list to the another list
insert() - Insert an item at the defined index
remove() - Removes an item from the list
pop() - Removes and returns an element at the given index
clear() - Removes all items from the list
index() - Returns the index of the first matched item
count() - Returns the count of number of items passed as an argument
sort() - Sort items in a list in ascending order
reverse() - Reverse the order of items in the list
copy() - Returns a shallow copy of the list

Some examples of Python list methods:

```
my_list = [3, 8, 1, 6, 0, 8, 4]
```

```
# Output: 1
```

```
print(my_list.index(8))
```

```
# Output: 2
```

```
print(my_list.count(8))
```

```
my_list.sort()
```

```
# Output: [0, 1, 3, 4, 6, 8, 8]
```

```
print(my_list)
```

```
my_list.reverse()
```

```
# Output: [8, 8, 6, 4, 3, 1, 0]  
print(my_list)
```

Built-in Functions with List

Built-in functions like `all()`, `any()`, `enumerate()`, `len()`, `max()`, `min()`, `list()`, `sorted()` etc. are commonly used with list to perform different tasks.

Built-in Functions with List	
Function	Description
<code>all()</code>	Return True if all elements of the list are true (or if the list is empty).
<code>any()</code>	Return True if any element of the list is true. If the list is empty, return False.
<code>enumerate()</code>	Return an enumerate object. It contains the index and value of all the items of list as a tuple.
<code>len()</code>	Return the length (the number of items) in the list.
<code>list()</code>	Convert an iterable (tuple, string, set, dictionary) to a list.
<code>max()</code>	Return the largest item in the list.
<code>min()</code>	Return the smallest item in the list
<code>sorted()</code>	Return a new sorted list (does not sort the list itself).
<code>sum()</code>	Return the sum of all elements in the list.

Strings in Python A string is a sequence of characters. It can be declared in python by using double-quotes. Strings are immutable, i.e., they cannot be changed.

```
# Assigning string to a variable a = "This is a string"  
print (a)
```

Lists in Python Lists are one of the most powerful tools in python. They are just like the arrays declared in other languages. But the most powerful thing is that list need not be always homogeneous. A single list can contain strings, integers, as well as objects. Lists can also be used for implementing stacks and queues. Lists are mutable, i.e., they can be altered once declared.

```
# Declaring a list  
L = [1, "a", "string", 1+2]
```

```
print L
L.append(6) print
L L.pop() print L
print L[1]
```

The output is :

```
[1, 'a', 'string', 3]
[1, 'a', 'string', 3, 6]
[1, 'a', 'string', 3] a
```

Objects and values

Objects are Python's abstraction for data. All data in a Python program is represented by objects or by relations between objects. (In a sense, and in conformance to Von Neumann's model of a "stored program computer," code is also represented by objects.)

Every object has an identity, a type and a value. An object's *identity* never changes once it has been created; you may think of it as the object's address in memory. The ``is'` operator compares the identity of two objects; the `id()` function returns an integer representing its identity (currently implemented as its address). An object's *type* is also unchangeable. It determines the operations that an object supports (e.g., "does it have a length?") and also defines the possible values for objects of that type. The `type()` function returns an object's type (which is an object itself). The *value* of some objects can change. Objects whose value can change are said to be *mutable*; objects whose value is unchangeable once they are created are called *immutable*. (The value of an immutable container object that contains a reference to a mutable object can change when the latter's value is changed; however the container is still considered immutable, because the collection of objects it contains cannot be changed. So, immutability is not strictly the same as having an unchangeable value, it is more subtle.) An object's mutability is determined by its type; for instance, numbers, strings and tuples are immutable, while dictionaries and lists are mutable.

Objects are never explicitly destroyed; however, when they become unreachable they may be garbage-collected. An implementation is allowed to postpone garbage collection or omit it altogether -- it is a matter of implementation quality how garbage collection is implemented, as long as no objects are collected that are still reachable. (Implementation note: the current implementation uses a reference-counting scheme which collects most objects as soon as they become unreachable, but never collects garbage containing circular references.)

Note that the use of the implementation's tracing or debugging facilities may keep objects alive that would normally be collectable. Also note that catching an exception with a `try...except'` statement may keep objects alive.

Some objects contain references to "external" resources such as open files or windows. It is understood that these resources are freed when the object is garbage-collected, but since garbage collection is not guaranteed to happen, such objects also provide an explicit way to release the external resource, usually a `close()` method. Programs are strongly recommended to explicitly close such objects. The `try...finally'` statement provides a convenient way to do this.

Some objects contain references to other objects; these are called *containers*. Examples of containers are tuples, lists and dictionaries. The references are part of a container's value. In most cases, when we talk about the value of a container, we imply the values, not the identities of the contained objects; however, when we talk about the mutability of a container, only the identities of the immediately contained objects are implied. So, if an immutable container (like a tuple) contains a reference to a mutable object, its value changes if that mutable object is changed.

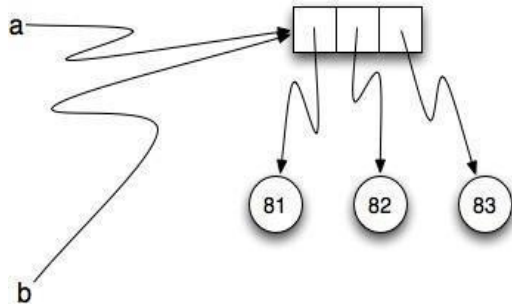
Aliasing

Since variables refer to objects, if we assign one variable to another, both variables refer to the same object:

```
a = [81, 82, 83]
b = a print(a is b)
```

output:
True

In this case, the reference diagram looks like this:



Because the same list has two different names, `a` and `b`, we say that it is **aliased**. Changes made with one alias affect the other. In the code example below, you can see that `a` and `b` refer to the same list after executing the assignment statement `b = a`.

```
1         a = [81, 82, 83]
2         b = [81, 82, 83]
4         print(a == b)
5         print(a is b)
7         b = a
8         print(a == b)
9         print(a is b)

        b[0] = 5
12        print(a)
```

Using Lists as Parameters

Functions which take lists as arguments and change them during execution are called **modifiers** and the changes they make are called **side effects**. Passing a list as an argument actually passes a reference to the list, not a copy of the list. Since lists are mutable, changes made to the elements referenced by the parameter change the same list that the argument is referencing. For example, the function below takes a list as an argument and multiplies each element in the list by 2:

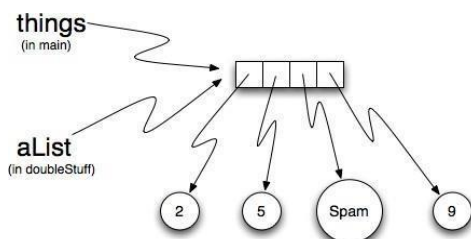
```
def doubleStuff(aList):
    """ Overwrite each element in aList with double its value. """
    for position in range(len(aList)): aList[position] = 2 *
        aList[position]
```

```
things = [2, 5, 9]
print(things)
doubleStuff(things)
print(things)
```

output:

```
[2,5,9]
[4, 10, 18]
```

The parameter `aList` and the variable `things` are aliases for the same object.



Since the list object is shared by two references, there is only one copy. If a function modifies the elements of a list parameter, the caller sees the change since the change is occurring to the original. This can be easily seen in codeLens. Note that after the call to `doubleStuff`, the formal parameter `aList` refers to the same object as the actual parameter `things`. There is only one copy of the list object itself.

UNIT-IV Chapter-1 Dictionaries

1.Dictionary in mapping:

Dictionary in Python is an unordered collection of data values, used to store data values like a map, which unlike other Data Types that hold only single value as an element, Dictionary holds **key:value** pair. Key value is provided in the dictionary to make it more optimized.

2.Dictionary as a Counter:

Suppose you are given a string and you want to count how many times each letter appears. There are several ways you could do it:

You could create 26 variables, one for each letter of the alphabet. Then you could traverse the string and, for each character, increment the corresponding counter, probably using a chained conditional.

You could create a list with 26 elements. Then you could convert each character to a number (using the built-in function `ord`), use the number as an index into the list, and increment the appropriate counter.

You could create a dictionary with characters as keys and counters as the corresponding values. The first time you see a character, you would add an item to the dictionary. After that you would increment the value of a existing item.

Each of these options performs the same computation, but each of them implements that computation in a different way.

An implementation is a way of performing a computation; some implementations are better than others. For example, an advantage of the dictionary implementation is that we don't have to know ahead of time which letters appear in the string and we only have to make room for the letters that do appear.

Here is what the code might look like:

```
word = 'brontosaurus'd = dict()for c in word:  if c not in d:  d[c] = 1  else:  d[c] = d[c] + 1print d
```

We are effectively computing a histogram, which is a statistical term for a set of counters (or frequencies).

The for loop traverses the string. Each time through the loop, if the character `c` is not in the dictionary, we create a new item with key `c` and the initial value 1 (since we have seen this letter once). If `c` is already in the dictionary we increment `d[c]`.

Here's the output of the program:

```
{'a': 1, 'b': 1, 'o': 2, 'n': 1, 's': 2, 'r': 2, 'u': 2, 't': 1}
```

The histogram indicates that the letters 'a' and 'b' appear once; 'o' appears twice, and so on.

Dictionaries have a method called `get` that takes a key and a default value. If the key appears in the dictionary, `get` returns the corresponding value; otherwise it returns the default value. For example:

```
>>> counts = { 'chuck': 1 , 'annie': 42, 'jan': 100}>>> print counts.get('jan', 0)100>>> print counts.get('tim', 0)0
```

We can use `get` to write our histogram loop more concisely. Because the `get` method automatically handles the case where a key is not in a dictionary, we can reduce four lines down to one and eliminate the `if` statement.

```
word = 'brontosaurus'd = dict()for c in word:  d[c] = d.get(c,0) + 1print d
```

The use of the `get` method to simplify this counting loop ends up being a very commonly used “idiom” in Python and we will use it many times the rest of the book. So you should take a moment and compare the loop using

the *if* statement and *in* operator with the loop using the get method. They do exactly the same thing, but one is more succinct.

3. Looping and Dictionary:

If you use a dictionary as the sequence in a for statement, it traverses the keys of the dictionary. This loop prints each key and the corresponding value:

```
counts = { 'chuck' : 1 , 'annie' : 42, 'jan': 100}for key in counts: print key, counts[key]
```

Here's what the output looks like:

```
jan 100chuck 1annie 42
```

Again, the keys are in no particular order.

We can use this pattern to implement the various loop idioms that we have described earlier. For example if we wanted to find all the entries in a dictionary with a value above ten, we could write the following code:

```
counts = { 'chuck' : 1 , 'annie' : 42, 'jan': 100}for key in counts: if counts[key] > 10 : print key, counts[key]
```

The *for* loop iterates through the *keys* of the dictionary, so we must use the index operator to retrieve the corresponding value for each key. Here's what the output looks like:

```
jan 100annie 42
```

We see only the entries with a value above 10.

If you want to print the keys in alphabetical order, you first make a list of the keys in the dictionary using the *keys* method available in dictionary objects, and then sort that list and loop through the sorted list, looking up each key printing out key/value pairs in sorted order as follows:

```
counts = { 'chuck' : 1 , 'annie' : 42, 'jan': 100}lst = counts.keys()print lstlst.sort()for key in lst: print key, counts[key]
```

Here's what the output looks like:

```
['jan', 'chuck', 'annie']annie 42chuck 1jan 100
```

First you see the list of keys in unsorted order that we get from the *keys* method.

Then we see the key/value pairs in order from the for loop.

4. Reverse dictionary lookup in Python

Doing a reverse dictionary lookup returns a list containing each key in the dictionary that maps to a specified value.

USE `dict.items()` TO DO A REVERSE DICTIONARY LOOKUP

Use the syntax for `key, value in dict.items()` to iterate over each key, value pair in the dictionary `dict`. At each iteration, if `value` is the lookup value, add `key` to an initially empty list.

```
print(a_dictionary)
```

```
O U T P U T
```

```
{'a': 1, 'b': 3, 'c': 1, 'd': 2}
```

```
lookup_value = 1
```

```
all_keys = []
```

```
for key, value in a_dictionary.items():
```

```
if (value == lookup_value):
```

```
all_keys.append(key)
```

```
print(all_keys)
```

```
O U T P U T
```

```
['a', 'c']
```

Use a dictionary comprehension for a more compact implementation. `all_keys`

```
= [key for key, value in a_dictionary.items() if value == lookup_value]
```

```
print(all_keys)
```

```
O U T P U T
```

```
['a', 'c']
```

5. Dictionaries and Lists:

Lists are just like the arrays, declared in other languages. Lists need not be homogeneous always which makes it a most powerful tool in Python. A single list may contain DataTypes like Integers, Strings, as well as Objects. Lists are mutable, and hence, they can be altered even after their creation.

Example:

```
# Python program to demonstrate
# Lists

# Creating a List with
# the use of multiple values
List=["Geeks", "For", "Geeks"]
print("List containing multiple values: ")
print(List[0])
print(List[2])
```

```
# Creating a Multi-Dimensional List
# (By Nesting a list inside a List)
List=[['Geeks', 'For'], ['Geeks']]
print("\nMulti-Dimensional List: ")
print(List)
```

Output:
List containing multiple values:
Geeks
Geeks

Multi-Dimensional List:

```
[['Geeks', 'For'], ['Geeks']]
```

Dictionary in Python on the other hand is an unordered collection of data values, used to store data values like a map, which unlike other Data Types that hold only single value as an element, Dictionary holds key:value pair. Key-value is provided in the dictionary to make it more optimized. Each key-value pair in a Dictionary is separated by a colon :, whereas each key is separated by a ‘comma’.

Example:

```
# Python program to demonstrate
# dictionary
# Creating a Dictionary
# with Integer Keys
Dict={1: 'Geeks', 2: 'For', 3: 'Geeks'}
print("Dictionary with the use of Integer Keys: ")
print(Dict)
```

```
# Creating a Dictionary
# with Mixed keys
Dict={'Name': 'Geeks', 1: [1, 2, 3, 4]}
print("\nDictionary with the use of Mixed Keys: ")
print(Dict)
```

Output:

Dictionary with the use of Integer Keys:
{1: 'Geeks', 2: 'For', 3: 'Geeks'}

Dictionary with the use of Mixed Keys:
{1: [1, 2, 3, 4], 'Name': 'Geeks'}

Difference between List and Dictionary:

LIST	DICTIONARY
List is a collection of index values pairs	Dictionary is a hashed structure of key and value pairs.

LIST	DICTIONARY
as that of array in c++.	
List is created by placing elements in [] seperated by commas “, “	Dictionary is created by placing elements in { } as “key”:”value”, each key value pair is seperated by commas “, ”
The indices of list are integers starting from 0.	The keys of dictionary can be of any data type.
The elements are accessed via indices.	The elements are accessed via key-values.
The order of the elements entered are maintained.	There is no guarantee for maintaining order.

6.MEMO:

memoize and *keyed-memoize* decorators.

`memo`: The classical *memoize* decorator. It keeps a cache `args -> result` so you don't continue to perform the same computations.

`keymemo(key)`: This decorator factory act as `memo` but it permits to specify a `key` function that takes the `args` of the decorated function and computes a `key` value to use as key in the cache dictionary. This way you can for example use a single value of a dictionary as key of the cache, or apply a function before passing something to the cache.

`instancememo`: The classical *memoize* decorator that can be applied to class functions. It keeps a cache `args -> result` so you don't continue to perform the same computations. The cache is kept in the class namespace.

`instancekeymemo(key)`: This decorator factory works like a combination of `instancememo` and `keymemo`, so it allows to specify a function that generate the cache key based on the function arguments and can be applied to class functions.

Usage

```
from memo import memo
```

```
@memo
```

```
deffibonacci(n):
```

```
    if n <= 2:
```

```
        return 1
```

```
    return fibonacci(n-1) + fibonacci(n-2)
```

```
from memo import keymemo
```

```
@keymemo(lambda tup: tup[0])
```

```
deffunction(tup):
```

```
    # build a cache based on the first value of a tuple
```

```
    ...
```

The package has been uploaded to [PyPI](#), so you can install it with pip:

```
pip install python-memo
```

7.Python Global Variables

In this tutorial, you'll learn about Python Global variables, Local variables, Nonlocal variables and where to use them.

Global Variables

In Python, a variable declared outside of the function or in global scope is known as a global variable. This means that a global variable can be accessed inside or outside of the function.

Let's see an example of how a global variable is created in Python.

Example 1: Create a Global Variable

```
x = "global"
```

```
deffoo():
```

```
    print("x inside:", x)
```

```
foo()
print("x outside:", x)
```

Chapter-2 Tuples

1. Tuples are lists that are immutable.

I like Al Sweigart's characterization of a tuple as being the "cousin" of the list. The **tuple** is so similar to the list that I am tempted to just skip covering it, especially since it's an object that other popular languages – such as Ruby, Java, and JavaScript – get by just fine without having. However, the tuple is an object that is frequently used in Python programming, so it's important to at least be able to recognize its usage, even if you don't use it much yourself.

Syntax for declaring a tuple

Like a list, a tuple is a collection of other objects. The main *visual* difference, in terms of syntax, is that instead of enclosing the values in **we use parentheses**, not square brackets, to enclose the values of a tuple:

List	Tuple
[1, 2, "hello"]	(1, 2, "hello")

Otherwise, the process of iterating through a tuple, and using **square bracket** notation to access or slice a tuple's contents is the same as it is for lists (and pretty much for every other Python **sequence** object, such as **range**...but we'll gloss over that detail for now).

Word of warning: if you're relatively new to programming and reading code, the use of **parentheses** as delimiters might seem like a potential syntactic clusterf—, as parentheses are already used in various other contexts, such as function calls. What differentiates a tuple declaration, e.g.

```
mytuple=("hello","world")
```

– from the parentheses-enclosed values of a function call, e.g.

```
print("hello","world")
```

Well, that's easy – the latter set of parentheses-enclosed objects immediately follows a function name, i.e. `print .`

The potential confusion from the similar notation isn't too terrible, in practice.

One strange thing you might come across is this:

```
>>>mytuple=("hello",)
```

```
>>>type(mytuple)
```

```
tuple
```

```
>>>len(mytuple)
```

```
1
```

Having a **trailing comma** is the only way to denote a tuple of length 1. *Without* that trailing comma, `mytuple` would be pointing to a plain string object that happens to be enclosed in parentheses:

```
>>>mytuple=("hello")
```

```
>>>type(mytuple)
```

```
str
```

2. Tuples are immutable

Besides the different kind of brackets used to delimit them, the main difference between a tuple and a list is that the tuple object is **immutable**. Once we've declared the contents of a tuple, we can't modify the contents of that tuple.

For example, here's how we modify the **0th** member of a **list**:

```
>>>mylist=[1,2,3]
>>>mylist[0]=999
print(mylist)
[999,2,3]
```

That will *not* work with a **tuple**:

```
>>>mytuple=(1,2,3)
>>>mytuple[0]=999
```

TypeError:'tuple'objectdoesnotsupportitemassignment

And while the **list** object has several methods for *adding* new members, the **tuple** has no such methods.

In other words, "**immutability**" == "never-changing".

Similarly, when a program alters the contents of a *mutable* object, it's often described as "*mutating*" that object.

3. Tuple Assignment

Python has a very powerful **tuple assignment** feature that allows a tuple of variables on the left of an assignment to be assigned values from a tuple on the right of the assignment.

```
(name, surname, birth_year, movie, movie_year, profession, birth_place) =julia
```

This does the equivalent of seven assignment statements, all on one easy line. One requirement is that the number of variables on the left must match the number of elements in the tuple.

Once in a while, it is useful to swap the values of two variables. With conventional assignment statements, we have to use a temporary variable. For example, to swap `a` and `b`:

```
temp=a
```

```
a=b
```

```
b=temp
```

Tuple assignment solves this problem neatly:

```
(a, b) = (b, a)
```

The left side is a tuple of variables; the right side is a tuple of values. Each value is assigned to its respective variable. All the expressions on the right side are evaluated before any of the assignments. This feature makes tuple assignment quite versatile.

Naturally, the number of variables on the left and the number of values on the right have to be the same.

```
>>>(a, b, c, d) = (1, 2, 3)
```

ValueError: need more than 3 values to unpack.

4. Tuples as Return Values

Functions can return tuples as return values. This is very useful — we often want to know some batsman's highest and lowest score, or we want to find the mean and the standard deviation, or we want to know the year, the month, and the day, or if we're doing some ecological modeling we may want to know the number of rabbits and the number of wolves on an island at a given time. In each case, a function (which can only return a single value), can create a single tuple holding multiple elements.

For example, we could write a function that returns both the area and the circumference of a circle of radius `r`.

```
def circleInfo(r):
```

```
    """ Return (circumference, area) of a circle of radius r """
```

```
    c = 2 * 3.14159 * r
```

```
    a = 3.14159 * r * r
```

```
    return (c, a)
```

```
print(circleInfo(10))
```

5. List and Tuple

The main difference between lists and tuples is the fact that lists are **mutable** whereas tuples are **immutable**.

What does that even mean, you say?

A mutable data type means that a python object of this type can be modified.

An immutable object can't.

Let's create a list and assign it to a variable.

```
>>> a = ["apples", "bananas", "oranges"]
```

Now let's see what happens when we try to modify the first item of the list.

Let's change "apples" to "berries".

```
>>>a[0]="berries"
```

```
>>> a
['berries','bananas','oranges']
Perfect! the first item of a has changed.
Now, what if we want to try the same thing with a tuple instead of a list? Let's see.
>>> a=("apples","bananas","oranges")
>>>a[0]="berries"
Traceback(most recent call last):
File"", line 1,in
TypeError:'tuple'object does not support item assignment
We get an error saying that a tuple object doesn't support item assignment.
The reason we get this error is because tuple objects, unlike lists, are immutable which means you can't modify a tuple object after it's created.
But you might be thinking, Karim, my man, I know you say you can't do assignments the way you wrote it but how about this, doesn't the following code modify a?
>>> a=("apples","bananas","oranges")
>>> a=("berries","bananas","oranges")
>>> a
('berries','bananas','oranges')
```

Fair question!

Let's see, are we actually modifying the first item in tuple a with the code above?

The answer is **No**, absolutely not.

6. Variable-length argument tuples:

To understand why, you first have to understand the difference between a variable and a python object.

Syntax

Syntax for a function with non-keyword variable arguments is this –

```
def functionname([formal_args,] *var_args_tuple ):
```

```
"function_docstring"
```

```
function_suite
```

```
return [expression]
```

An asterisk (*) is placed before the variable name that holds the values of all nonkeyword variable arguments.

This tuple remains empty if no additional arguments are specified during the function call.

Example

```
#!/usr/bin/python
```

```
# Function definition is here
```

```
def printinfo( arg1,*vartuple):
```

```
"This prints a variable passed arguments"
```

```
print"Output is: "
```

```
print arg1
```

```
for var in vartuple:
```

```
print var
```

```
return;
```

```
# Now you can call printinfo function
```

```
printinfo(10)
```

```
printinfo(70,60,50)
```

Output

When the above code is executed, it produces the following result –

```
Output is:
```

```
10
```

```
Output is:
```

```
70
```

```
60
```

```
50
```

7. Dictionaries and Tuples

Besides lists, Python has two additional data structures that can store multiple objects. These data structures are *dictionaries* and *tuples*. Tuples will be discussed first.

Tuples

Tuples are *immutable* lists. Elements of a list can be modified, but elements in a tuple can only be accessed, not modified. The name *tuple* does not mean that only two values can be stored in this data structure.

Tuples are defined in Python by enclosing elements in parenthesis () and separating elements with commas. The command below creates a tuple containing the numbers 3, 4, and 5.

```
>>>t_var = (3,4,5)
```

```
>>>t_var
```

```
(3, 4, 5)
```

Note how the elements of a list can be modified:

```
>>>l_var = [3,4,5] # a list
```

```
>>>l_var[0]= 8
```

```
>>>l_var
```

```
[8, 4, 5]
```

The elements of a tuple can not be modified. If you try to assign a new value to one of the elements in a tuple, an error is returned.

```
>>>t_var = (3,4,5) # a tuple
```

```
>>>t_var[0]= 8
```

```
>>>t_var
```

TypeError: 'tuple' object does not support item assignment

To create a tuple that just contains one numerical value, the number must be followed by a comma. Without a comma, the variable is defined as a number.

```
>>>num = (5)
```

```
>>> type(num)
```

```
int
```

When a comma is included after the number, the variable is defined as a tuple.

```
>>>t_var = (5,)
```

```
>>> type(t_var)
```

```
tuple
```

Dictionaries

Dictionaries are made up of key: value pairs. In Python, lists and tuples are organized and accessed based on position. Dictionaries in Python are organized and accessed using keys and values. The location of a pair of keys and values stored in a Python dictionary is irrelevant.

Dictionaries are defined in Python with curly braces { }. Commas separate the key-value pairs that make up the dictionary. Each key-value pair is related by a colon :.

Let's store the ages of two people in a dictionary. The two people are Gabby and Maelle. Gabby is 8 and Maelle is 5. Note the name Gabby is a string and the age 8 is an integer.

```
>>>age_dict = {"Gabby": 8 , "Maelle": 5 }
```

```
>>> type(age_dict)
```

```
dict
```

The values stored in a dictionary are called and assigned using the following syntax:

```
dict_name[key] = value
```

```
>>>age_dict = {"Gabby": 8 , "Maelle": 5 }
```

```
>>>age_dict["Gabby"]
```

```
8
```

We can add a new person to our age_dict with the following command:

```
>>>age_dict = {"Gabby": 8 , "Maelle": 5 }
```

```
>>>age_dict["Peter"]= 40
```

```
>>>age_dict
```

```
{'Gabby': 8, 'Maelle': 5, 'Peter': 40}
```

Dictionaries can be converted to lists by calling the .items(), .keys(), and .values() methods.

```
>>>age_dict = {"Gabby": 8 , "Maelle": 5 }
```

```
>>>whole_list = list(age_dict.items())
```

```
>>>whole_list
```

```
[('Gabby', 8), ('Maelle', 5)]
```

```
>>>name_list = list(age_dict.keys())
```

```
>>>name_list  
['Gabby', 'Maele']
```

```
>>>age_list = list(age_dict.values())
```

```
>>>age_list  
[8, 5]
```

Items can be removed from dictionaries by calling the .pop() method. The dictionary key (and that key's associated value) supplied to the .pop() method is removed from the dictionary.

```
>>>age_dict = {"Gabby": 8 , "Maele": 5}
```

```
>>>age_dict.pop("Gabby")
```

```
>>>age_dict  
{'Maele': 5}
```

8. Sequences of Sequences:

Some basic sequence type classes in python are, list, tuple, range. There are some additional sequence type objects, these are binary data and text string.

Some common operations for the sequence type object can work on both mutable and immutable sequences.

Some of the operations are as follows –

Sr.No.	Operation/Functions & Description
1	x in seq True, when x is found in the sequence seq, otherwise False
2	x not in seq False, when x is found in the sequence seq, otherwise True
3	x + y Concatenate two sequences x and y
4	x * n or n * x Add sequence x with itself n times
5	seq[i] ith item of the sequence.
6	seq[i:j] Slice sequence from index i to j
7	seq[i:j:k] Slice sequence from index i to j with step k
8	len(seq) Length or number of elements in the sequence
9	min(seq) Minimum element in the sequence
10	max(seq) Maximum element in the sequence
11	seq.index(x, i, j) Index of the first occurrence of x (in the index range i and j)
12	seq.count(x) Count total number of elements in the sequence

13	seq.append(x) Add x at the end of the sequence
14	seq.clear() Clear the contents of the sequence
15	seq.insert(i, x) Insert x at the position i
16	seq.pop([i]) Return the item at position i, and also remove it from sequence. Default is last element.
17	seq.remove(x) Remove first occurrence of item x
18	seq.reverse() Reverse the list

Example Code

```
myList1 =[10,20,30,40,50]
myList2 =[56,42,79,42,85,96,23]
```

```
if 30 in myList1:
    print('30 is present')
```

```
if 120 not in myList1:
    print('120 is not present')
```

```
print(myList1 + myList2)#Concatinate lists
print(myList1 *3)#Add myList1 three times with itself
print(max(myList2))
print(myList2.count(42))#42 has two times in the list
```

```
print(myList2[2:7])
print(myList2[2:7:2])
```

```
myList1.append(60)
print(myList1)
```

```
myList2.insert(5,17)
print(myList2)
```

```
myList2.pop(3)
print(myList2)
myList1.reverse()
print(myList1)
```

```
myList1.clear()
print(myList1)
```

Output

```
30 is present
120 is not present
[10, 20, 30, 40, 50, 56, 42, 79, 42, 85, 96, 23]
[10, 20, 30, 40, 50, 10, 20, 30, 40, 50, 10, 20, 30, 40, 50]
96
2
```

[79, 42, 85, 96, 23]
[79, 85, 23]
[10, 20, 30, 40, 50, 60]
[56, 42, 79, 42, 85, 17, 96, 23]
[56, 42, 79, 85, 17, 96, 23]
[60, 50, 40, 30, 20, 10]
[]

Chapter-3 Files

1. Persistence

During the course of using any software application, user provides some data to be processed. The data may be input, using a standard input device (keyboard) or other devices such as disk file, scanner, camera, network cable, WiFi connection, etc.

Data so received, is stored in computer's main memory (RAM) in the form of various data structures such as, variables and objects until the application is running. Thereafter, memory contents from RAM are erased.

However, more often than not, it is desired that the values of variables and/or objects be stored in such a manner, that it can be retrieved whenever required, instead of again inputting the same data.

The word 'persistence' means "the continuance of an effect after its cause is removed". The term data persistence means it continues to exist even after the application has ended. Thus, data stored in a non-volatile storage medium such as, a disk file is a persistent data storage.

In this tutorial, we will explore various built-in and third party Python modules to store and retrieve data to/from various formats such as text file, CSV, JSON and XML files as well as relational and non-relational databases.

Using Python's built-in File object, it is possible to write string data to a disk file and read from it. Python's standard library, provides modules to store and retrieve serialized data in various data structures such as JSON and XML.

Python's DB-API provides a standard way of interacting with relational databases. Other third party Python packages, present interfacing functionality with NOSQL databases such as MongoDB and Cassandra.

This tutorial also introduces, ZODB database which is a persistence API for Python objects. Microsoft Excel format is a very popular data file format. In this tutorial, we will learn how to handle .xlsx file through Python.

2. Reading and Writing to text files in Python

Python provides inbuilt functions for creating, writing and reading files. There are two types of files that can be handled in python, normal text files and binary files (written in binary language, 0s and 1s).

Text files: In this type of file, Each line of text is terminated with a special character called EOL (End of Line), which is the new line character ('\n') in python by default.

Binary files: In this type of file, there is no terminator for a line and the data is stored after converting it into machine understandable binary language.

In this article, we will be focusing on opening, closing, reading and writing data in a text file.

File Access Modes

Access modes govern the type of operations possible in the opened file. It refers to how the file will be used once its opened. These modes also define the location of the **File Handle** in the file. File handle is like a cursor, which defines from where the data has to be read or written in the file. There are 6 access modes in python.

Read Only ('r') : Open text file for reading. The handle is positioned at the beginning of the file. If the file does not exists, raises I/O error. This is also the default mode in which file is opened.

Read and Write ('r+') : Open the file for reading and writing. The handle is positioned at the beginning of the file. Raises I/O error if the file does not exist.

Write Only ('w') : Open the file for writing. For existing file, the data is truncated and over-written. The handle is positioned at the beginning of the file. Creates the file if the file does not exist.

Write and Read ('w+') : Open the file for reading and writing. For existing file, data is truncated and over-written. The handle is positioned at the beginning of the file.

Append Only ('a') : Open the file for writing. The file is created if it does not exist. The handle is positioned at the end of the file. The data being written will be inserted at the end, after the existing data.

Append and Read ('a+') : Open the file for reading and writing. The file is created if it does not exist. The handle is positioned at the end of the file. The data being written will be inserted at the end, after the existing data.

Opening a File

It is done using the open() function. No module is required to be imported for this function.

```
File_object = open(r"File_Name","Access_Mode")
```

The file should exist in the same directory as the python program file else, full address of the file should be written on place of filename.

Note: The **r** is placed before filename to prevent the characters in filename string to be treated as special character. For example, if there is `\temp` in the file address, then `\t` is treated as the tab character and error is raised of invalid address. The **r** makes the string raw, that is, it tells that the string is without any special characters. The **r** can be ignored if the file is in same directory and address is not being placed.

```
# Open function to open the file "MyFile1.txt"
```

```
# (same directory) in append mode and
```

```
file1 =open("MyFile.txt","a")
```

```
# store its reference in the variable file1
```

```
# and "MyFile2.txt" in D:\Text in file2
```

```
file2 =open(r"D:\Text\MyFile2.txt","w+")
```

Here, file1 is created as object for MyFile1 and file2 as object for MyFile2

Closing a file

close() function closes the file and frees the memory space acquired by that file. It is used at the time when the file is no longer needed or if it is to be opened in a different file mode.

```
File_object.close()
```

```
# Opening and Closing a file "MyFile.txt"
```

```
# for object name file1.
```

```
file1 =open("MyFile.txt","a")
```

```
file1.close()
```

Writing to a file

There are two ways to write in a file.

write() : Inserts the string str1 in a single line in the text file.

```
File_object.write(str1)
```

writelines() : For a list of string elements, each string is inserted in the text file.Used to insert multiple strings at a single time.

```
File_object.writelines(L) for L = [str1, str2, str3]
```

Reading from a file

There are three ways to read data from a text file.

read() : Returns the read bytes in form of a string. Reads n bytes, if no n specified, reads the entire file.

```
File_object.read([n])
```

readline() : Reads a line of the file and returns in form of a string.For specified n, reads at most n bytes.

However, does not reads more than one line, even if n exceeds the length of the line.

```
File_object.readline([n])
```

readlines() : Reads all the lines and return them as each line a string element in a list.

```
File_object.readlines()
```

Note: '\n' is treated as a special character of two bytes

```
filter_none
```

```
edit
```

```
play_arrow
```

```
brightness_4
# Program to show various ways to read and
# write data in a file.
file1 =open("myfile.txt","w")
L=["This is Delhi \n","This is Paris \n","This is London \n"]
```

```
# \n is placed to indicate EOL (End of Line)
file1.write("Hello \n")
file1.writelines(L)
file1.close() #to change file access modes
```

```
file1 =open("myfile.txt","r+")
```

```
print"Output of Read function is "
printfile1.read()
print
```

```
# seek(n) takes the file handle to the nth
# bite from the beginning.
file1.seek(0)
```

```
print"Output of Readline function is "
printfile1.readline()
print
```

```
file1.seek(0)
```

```
# To show difference between read and readline
print"Output of Read(9) function is "
printfile1.read(9)
print
```

```
file1.seek(0)
```

```
print"Output of Readline(9) function is "
printfile1.readline(9)
```

```
file1.seek(0)
```

```
# readlines function
print"Output of Readlines function is "
printfile1.readlines()
print
file1.close()
```

Output:

Output of Read function is

Hello

This is Delhi

This is Paris

This is London

Output of Readline function is

Hello

Output of Read(9) function is

Hello

Th

Output of Readline(9) function is
Hello

Output of Readlines function is
['Hello \n', 'This is Delhi \n', 'This is Paris \n', 'This is London \n']

Appending to a file

```
filter_none
edit
play_arrow
brightness_4
# Python program to illustrate
# Append vs write mode
file1 =open("myfile.txt","w")
L=["This is Delhi \n","This is Paris \n","This is London \n"]
file1.close()
```

```
# Append-adds at last
file1 =open("myfile.txt","a")#append mode
file1.write("Today \n")
file1.close()
```

```
file1 =open("myfile.txt","r")
print"Output of Readlines after appending"
printfile1.readlines()
print
file1.close()
```

```
# Write-Overwrites
file1 =open("myfile.txt","w")#write mode
file1.write("Tomorrow \n")
file1.close()
```

```
file1 =open("myfile.txt","r")
print"Output of Readlines after writing"
printfile1.readlines()
print
file1.close()
```

Output:
Output of Readlines after appending
['This is Delhi \n', 'This is Paris \n', 'This is London \n', 'Today \n']

Output of Readlines after writing
['Tomorrow \n']

Data Persistence and Exchange

Python provides several modules for storing data. There are basically two aspects to persistence: converting the in-memory object back and forth into a format for saving it, and working with the storage of the converted data. Serializing Objects

Python includes two modules capable of converting objects into a transmittable or storable format (*serializing*): **pickle** and **json**. It is most common to use **pickle**, since there is a fast C implementation and it is integrated with some of the other standard library modules that actually store the serialized data, such as **shelve**. Web-based applications may want to examine **json**, however, since it integrates better with some of the existing web service storage applications.

Storing Serialized Objects

Once the in-memory object is converted to a storable format, the next step is to decide how to store the data. A simple flat-file with serialized objects written one after the other works for data that does not need to be indexed in any way. But Python includes a collection of modules for storing key-value pairs in a simple database using one of the DBM format variants.

The simplest interface to take advantage of the DBM format is provided by **shelve**. Simply open the shelve file, and access it through a dictionary-like API. Objects saved to the shelve are automatically pickled and saved without any extra work on your part.

One drawback of shelve is that with the default interface you can't guarantee which DBM format will be used. That won't matter if your application doesn't need to share the database files between hosts with different libraries, but if that is needed you can use one of the classes in the module to ensure a specific format is selected (*Specific Shelf Types*).

If you're going to be passing a lot of data around via JSON anyway, using **json** and **anydbm** can provide another persistence mechanism. Since the DBM database keys and values must be strings, however, the objects won't be automatically re-created when you access the value in the database.

Relational Databases

The excellent **sqlite3** in-process relational database is available with most Python distributions. It stores its database in memory or in a local file, and all access is from within the same process, so there is no network lag. The compact nature of **sqlite3** makes it especially well suited for embedding in desktop applications or development versions of web apps.

All access to the database is through the Python DBI 2.0 API, by default, as no object relational mapper (ORM) is included. The most popular general purpose ORM is [SQLAlchemy](#), but others such as Django's native ORM layer also support SQLite. SQLAlchemy is easy to install and set up, but if your objects aren't very complicated and you are worried about overhead, you may want to use the DBI interface directly.

Data Exchange Through Standard Formats

Although not usually considered a true persistence format **csv**, or comma-separated-value, files can be an effective way to migrate data between applications. Most spreadsheet programs and databases support both export and import using CSV, so dumping data to a CSV file is frequently the simplest way to move data out of your application and into an analysis tool.

Python Exception Handling Using try, except and finally statement Python has many [built-in exceptions](#) that are raised when your program encounters an error (something in the program goes wrong).

When these exceptions occur, the Python interpreter stops the current process and passes it to the calling process until it is handled. If not handled, the program will crash.

For example, let us consider a program where we have a [function A](#) that calls function [B](#), which in turn calls function [C](#). If an exception occurs in function [C](#) but is not handled in [C](#), the exception passes to [B](#) and then to [A](#).

If never handled, an error message is displayed and our program comes to a sudden unexpected halt.

3. Formatting Operator in Python

One of Python's coolest features is the string format operator **%**. This operator is unique to strings and makes up for the pack of having functions from C's printf() family. Following is a simple example –

Example

```
#!/usr/bin/python
print "My name is %s and weight is %d kg!" % ('Zara', 21)
```

Output

When the above code is executed, it produces the following result –

My name is Zara and weight is 21 kg!

Here is the list of complete set of symbols which can be used along with **%** –

Sr.No	Format Symbol & Conversion
-------	----------------------------

Sr.No	Format Symbol & Conversion
1	%c character
2	%s string conversion via str() prior to formatting
3	%i signed decimal integer
4	%d signed decimal integer
5	%u unsigned decimal integer
6	%o octal integer
7	%x hexadecimal integer (lowercase letters)
8	%X hexadecimal integer (UPPERcase letters)
9	%e exponential notation (with lowercase 'e')
10	%E exponential notation (with UPPERcase 'E')
11	%f floating point real number
12	%g the shorter of %f and %e
13	%G the shorter of %f and %E

Other supported symbols and functionality are listed in the following table –

Sr.No	Symbol & Functionality
1	* argument specifies width or precision
2	- left justification
3	+ display the sign
4	<sp> leave a blank space before a positive number
5	# add the octal leading zero ('0') or hexadecimal leading '0x' or '0X', depending on whether

Sr.No	Symbol & Functionality
	'x' or 'X' were used.
6	0 pad from left with zeros (instead of spaces)
7	% '%%' leaves you with a single literal '%'
8	(var) mapping variable (dictionary arguments)
9	m.n. m is the minimum total width and n is the number of digits to display after the decimal point (if appl.)

4. Filenames and file paths in Python

Test your paths

```
def check_path(out_fc):
    """Check for a filegeodatabase and a filename"""
    msg = dedent(check_path._doc_)
    _punc_ = '!"#$%&\'()*+,-;<=>?@[]^~`{ '
    flotsam = " ".join([i for i in _punc_]) # " ... plus the `space`"
    fail = False
    if (".gdb" not in fc) or np.any([i in fc for i in flotsam]):
        fail = True
    pth = fc.replace("\\", "/").split("/")
    name = pth[-1]
    if (len(pth) == 1) or (name[-4:] == ".gdb"):
        fail = True
    if fail:
        tweet(msg)
        return (None, None)
    gdb = "/".join(pth[:-1])
    return gdb, name
pth = "C:\Users\dan_p\AppData\Local\ESRI\ArcGISPro"
File "<ipython-input-66-5b37dd76b72d>", line 1
pth = "C:\Users\dan_p\AppData\Local\ESRI\ArcGISPro"
^
```

SyntaxError: (unicode error) 'unicodeescape' codec can't decode bytes in position 2-3: truncated \UXXXXXXXX escape

the fix is still raw encoding

```
pth = r"C:\Users\dan_p\AppData\Local\ESRI\ArcGISPro"
```

```
pth
```

```
'C:\\Users\\dan_p\\AppData\\Local\\ESRI\\ArcGISPro'
```

5. Catching Exceptions in Python

In Python, exceptions can be handled using a try

The critical operation which can raise an exception is placed inside the `try` clause. The code that handles the exceptions is written in the `except` clause.

We can thus choose what operations to perform once we have caught the exception. Here is a simple example.

```
# import module sys to get the type of exception
import sys
```

```
randomList = ['a', 0, 2]
```

```
for entry in randomList:
```

```
try:
```

```
print("The entry is", entry)
```

```
    r = 1/int(entry)
```

```
break
```

```
except:
```

```
print("Oops!", sys.exc_info()[0], "occurred.")
```

```
print("Next entry.")
```

```
print()
```

```
print("The reciprocal of", entry, "is", r)
```

Run Code

Output

```
The entry is a
```

```
Oops! <class 'ValueError'> occurred.
```

```
Next entry.
```

```
The entry is 0
```

```
Oops! <class 'ZeroDivisionError'> occurred.
```

```
Next entry.
```

```
The entry is 2
```

```
The reciprocal of 2 is 0.5
```

In this program, we loop through the values of the `randomList` list. As previously mentioned, the portion that can cause an exception is placed inside the `try` block.

In this program, we loop through the values of the `randomList` list. As previously mentioned, the portion that can cause an exception is placed inside the `try` block.

If no exception occurs, the `except` block is skipped and normal flow continues (for last value). But if any exception occurs, it is caught by the `except` block (first and second values).

Here, we print the name of the exception using the `exc_info()` function inside `sys` module. We can see that `a` causes `ValueError` and `0` causes `ZeroDivisionError`.

6.Database

In previous guides, we have explained how to import data from Excel spreadsheets, tab-delimited files, and online APIs. As helpful as those resources are, if the data we need to handle is large in size or becomes too complex, a database (relational or otherwise) may be a better solution. Regardless of the flavor you choose, there are general principles and basic tools that we can use to query a database and manipulate the results using Python.

Prerequisites

To begin, we need to install the appropriate *connector* (also known as *driver*) for the database system that we are using. This utility comes in the form of a module that is at one's disposal either from the standard library (such as `sqlite3`) or a third-party package like `mysql-connector-python` and `psycopg2-binary` for MySQL / MariaDB and PostgreSQL, respectively. In any event, the [Python Package Index](#) is our go-to place to search for available adapters.

In this guide, we will use PostgreSQL, since it provides a function called `ROW_TO_JSON` out of the box. As its name suggests, this function returns each row in the result set as a JSON object. Since we have already learned how to work with JSON data, we will be able to manipulate the result of a query very easily.

If we use a different database system, we can iterate over the results and create a list of dictionaries where each element is a record in the result set.

That being said, we will need to install **psycopg2-binary**, preferably inside a [virtual environment](#) before we proceed:

```
1 pip install psycopg2-binary bash
```

Now let's examine the PostgreSQL database we will work with, which is called **nba**. Figs. 1 through 3 show the structure of the **coaches**, **players**, and **teams** tables.

coaches stores the following data, where **coach_id** acts as the primary key. Besides the coach's first and last names, there's also a **team_id** which is a foreign key that references the homonymous field in the **teams** table.

```
Table "public.coaches"
  Column |          Type          | Modifiers
-----+-----+-----
coach_id | integer                | not null
first_name | character varying(50) | not null
last_name  | character varying(50) | not null
team_id    | integer                | not null
Indexes:
    "Coaches_pkey" PRIMARY KEY, btree (coach_id)
Foreign-key constraints:
    "Teams_fkey" FOREIGN KEY (team_id) REFERENCES teams(team_id)
```

players, besides the **player_id** (primary key) and **team_id** (foreign key, which indicates the team he is currently playing for), also holds the first and last names, the jersey number, the height in meters, the weight in kilograms, and the country of origin.

```
Table "public.players"
  Column |          Type          | Modifiers
-----+-----+-----
player_id | integer                | not null
first_name | character varying(50) | not null
last_name  | character varying(50) | not null
team_id    | integer                | not null
jersey     | integer                | not null
height_meters | numeric                | not null
weight_kilograms | numeric                | not null
country    | character varying     | not null
Indexes:
    "Players_pkey" PRIMARY KEY, btree (player_id)
Foreign-key constraints:
    "Teams_fkey" FOREIGN KEY (team_id) REFERENCES teams(team_id)
```

Finally, **teams** are described by their name, conference, current conference rank, home wins and losses, and away wins and losses. Of course, it also has the **team_id** primary key that is referenced in the other two tables.

```
Table "public.teams"
  Column |          Type          | Modifiers
-----+-----+-----
team_id | integer                | not null
name     | character varying(50) | not null
city     | character varying(50) | not null
conference | character varying(50) | not null
conference_rank | integer                | not null
home_wins | integer                | not null
home_losses | integer                | not null
away_wins | integer                | not null
away_losses | integer                | not null
Indexes:
    "Teams_pkey" PRIMARY KEY, btree (team_id)
Referenced by:
    TABLE "games" CONSTRAINT "HTeam_fkey" FOREIGN KEY (home_team_id) REFERENCES teams(team_id)
    TABLE "coaches" CONSTRAINT "Teams_fkey" FOREIGN KEY (team_id) REFERENCES teams(team_id)
    TABLE "players" CONSTRAINT "Teams_fkey" FOREIGN KEY (team_id) REFERENCES teams(team_id)
    TABLE "games" CONSTRAINT "VTeam_fkey" FOREIGN KEY (visitor_team_id) REFERENCES teams(team_id)
```


The next step consists in writing a SQL query to retrieve the list of teams ordered by conference and rank, along with the number of players in each team and the name of its coach. And while we're at it, we can also add the number of home and away wins:

1
2
3
4
5
6
7
8
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14

```
SELECT
    t.name,
    t.city,
    t.conference,
    t.conference_rank,
    COUNT(p.player_id) AS number_of_players,
    CONCAT(c.first_name, ' ', c.last_name) AS coach,
    t.home_wins,
    t.away_wins
FROM    players p, teams t, coaches c
WHERE   p.team_id = t.team_id
AND     c.team_id = t.team_id
GROUP BY t.name, c.first_name, c.last_name, t.city, t.conference, t.conference_rank, t.home_wins,
t.away_wins
ORDER BY t.conference, t.conference_rank
```

sql

We will then wrap the query inside the ROW_TO_JSON function for our convenience and save it to a file named **query.sql** in the current directory:

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16

```
SELECT ROW_TO_JSON(team_info) FROM (
    SELECT
        t.name,
```

```

COUNT(p.player_id) AS number_of_players,
CONCAT(c.first_name, ' ', c.last_name) AS coach,
t.home_wins,
t.away_wins
FROM      players p, teams t, coaches c
WHERE     p.team_id = t.team_id
AND       c.team_id = t.team_id
GROUP BY  t.name, c.first_name, c.last_name, t.city, t.conference, t.conference_rank,
t.home_wins, t.away_wins
ORDER BY  t.conference, t.conference_rank
) AS team_info
sql

```

Fig. 4 shows the first records of the above query. Note that each row has the structure of a Python dictionary where the names of the fields returned by the query are the keys.

team_info
{"name": "Toronto Raptors", "city": "Toronto", "conference": "East", "conference_rank": 1, "number_of_players": 16, "coach": "Nick Nurse"}
{"name": "Milwaukee Bucks", "city": "Milwaukee", "conference": "East", "conference_rank": 2, "number_of_players": 18, "coach": "Mike Budenholzer"}
{"name": "Indiana Pacers", "city": "Indiana", "conference": "East", "conference_rank": 3, "number_of_players": 16, "coach": "Nate McMillan"}
{"name": "Boston Celtics", "city": "Boston", "conference": "East", "conference_rank": 4, "number_of_players": 16, "coach": "Brad Stevens"}
{"name": "Philadelphia 76ers", "city": "Philadelphia", "conference": "East", "conference_rank": 5, "number_of_players": 16, "coach": "Brett Brown"}
{"name": "Detroit Pistons", "city": "Detroit", "conference": "East", "conference_rank": 6, "number_of_players": 17, "coach": "Dwane Casey"}
{"name": "Charlotte Hornets", "city": "Charlotte", "conference": "East", "conference_rank": 7, "number_of_players": 16, "coach": "James Borrego"}

Last, but not least, a word of caution. To connect to a database, we need a username and a password. It is best practice to use environment variables instead of exposing them in plain sight as part of the connection string. This is particularly important if you push your code to a version control system that other people can access. In Unix-like environments, this can be done by appending the following two lines at the end of your shell's initialization file. To apply changes, you will need to log out and log back in or source the file in the current session.

```

1
2
export DB_USER="your_PostgreSQL_username_here_inside_quotes"
export DB_PASS="your_password_inside_quotes"
bash

```

In Windows, go to **Control Panel / System / Advanced system settings**. Select the **Advanced** tab and click on **Environment Variables** to add them:

We are now ready to start writing Python code!

Querying the Database and Manipulating Results

At the top of our program we will import the necessary modules and one function to handle errors:

```

1
2
3
import os
import psycopg2 as p
from psycopg2 import Error python

```

Next, we will load the contents of **query.sql** into **query** and instantiate the connection. You can also use environment variables for *host*, *port*, and *database* just like we did for user and password, although it is not strictly necessary to do so.

```

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```

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```
with open('query.sql') as sql:
    query = sql.read()

conn = p.connect(
    user = os.environ['DB_USER'],
    password = os.environ['DB_PASS'],
    host = 'localhost',
    port = '5432',
    database = 'nba'
)
```

python
Once we have successfully connected to the database, it is time to execute the query. To do so, a control structure associated with the connection and known as *cursor* is used. If everything went as expected, the variable called **result** contains a list of one-element tuples where each element is a dictionary.

1
2
3

```
cursor = conn.cursor()
cursor.execute(query)
result = cursor.fetchall()
```

python
At this point, we can iterate over **result** and manipulate its contents as desired. For example, we may insert them into a spreadsheet (as illustrated in Fig. 5), as we learned in [Importing Data from Microsoft Excel Files with Python](#), or use them to feed an HTML table via a web application.

	A	B	C	D	E	F	G	H
1	Name	City	Conference	Rank	Players	Coach	Home wins	Away wins
2	Toronto Raptors	Toronto	East	1	16	Nick Nurse	7	5
3	Milwaukee Bucks	Milwaukee	East	2	18	Mike Budenholzer	6	4
4	Indiana Pacers	Indiana	East	3	16	Nate McMillan	3	5
5	Boston Celtics	Boston	East	4	16	Brad Stevens	4	4
6	Philadelphia 76ers	Philadelphia	East	5	16	Brett Brown	7	2
7	Detroit Pistons	Detroit	East	6	17	Dwane Casey	3	4
8	Charlotte Hornets	Charlotte	East	7	16	James Borrego	4	3
9	Orlando Magic	Orlando	East	8	17	Steve Clifford	4	3
10	Miami Heat	Miami	East	9	16	Erik Spoelstra	2	2

To catch errors, if they occur, it is necessary to wrap our code inside a try-except block. And while we are at it, adding a finally sentence allows us to clean up the connection when we are done using it:

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64
65

try:

```
# Instantiate the connection
conn = p.connect(
    user = os.environ['DB_USER'],
```

```

password = os.environ['DB_PASS'],
host = 'localhost',
port = '5432',
database = 'nba'
)

# Create cursor, execute the query, and fetch results
cursor = conn.cursor()
cursor.execute(query)
result = cursor.fetchall()

# Create workbook and select active sheet
wb = Workbook()
ws = wb.active

# Rename active sheet
ws.title = 'Teams'

# Column headings
column_headings = [
    'Name',
    'City',
    'Conference',
    'Rank',
    'Players',
    'Coach',
    'Home wins',
    'Away wins'
]
ws.append(column_headings)

# Add players
for team in result:
    ws.append(list(team[0].values()))

# Get coordinates of last cell
last_cell = ws.cell(row = ws.max_row, column = ws.max_column).coordinate

# Create table
team_table = Table(displayName = 'TeamTable', ref = 'A1:{}'.format(last_cell))

# Add 'Table Style Medium 6' style
style = TableStyleInfo(name = 'TableStyleMedium6', showRowStripes = True)

# Apply style to table
team_table.tableStyleInfo = style

# Add table to spreadsheet
ws.add_table(team_table)

# Save spreadsheet
wb.save('teams.xlsx')

except p.Error as error:
    print('There was an error with the database operation: {}'.format(error))
except:
    print('There was an unexpected error of type {}'.format(sys.exc_info()[0]))
finally:

```

```
if conn:
    cursor.close()
    conn.close()
```

python

Both the script and the SQL file are available in [Github](#). Feel free to use and modify them as you need.

7. Understanding Python Pickling with example

Prerequisite: [Pickle Module](#)

Python pickle module is used for serializing and de-serializing a Python object structure. Any object in Python can be pickled so that it can be saved on disk. What pickle does is that it “serializes” the object first before writing it to file. Pickling is a way to convert a python object (list, dict, etc.) into a character stream. The idea is that this character stream contains all the information necessary to reconstruct the object in another python script.

```
# Python3 program to illustrate store
# efficiently using pickle module
# Module translates an in-memory Python object
# into a serialized byte stream—a string of
# bytes that can be written to any file-like object.

import pickle

def storeData():
    # initializing data to be stored in db
    Omkar = {'key': 'Omkar', 'name': 'Omkar Pathak',
            'age': 21, 'pay': 40000}
    Jagdish = {'key': 'Jagdish', 'name': 'Jagdish Pathak',
            'age': 50, 'pay': 50000}

    # database
    db = {}
    db['Omkar'] = Omkar
    db['Jagdish'] = Jagdish

    # Its important to use binary mode
    dbfile = open('examplePickle', 'ab')

    # source, destination
    pickle.dump(db, dbfile)
    dbfile.close()

def loadData():
    # for reading also binary mode is important
    dbfile = open('examplePickle', 'rb')
    db = pickle.load(dbfile)
    for keys in db:
        print(keys, '=>', db[keys])
    dbfile.close()

if __name__ == '__main__':
    storeData()
    loadData()
```

Output:

```
omkarpathak-Inspiron-3542:~/Documents/Python-Programs$ python P60_PickleModule.py
Omkar => {'age': 21, 'name': 'Omkar Pathak', 'key': 'Omkar', 'pay': 40000}
Jagdish => {'age': 50, 'name': 'Jagdish Pathak', 'key': 'Jagdish', 'pay': 50000}
```

8.Pipes in Python

Pipe



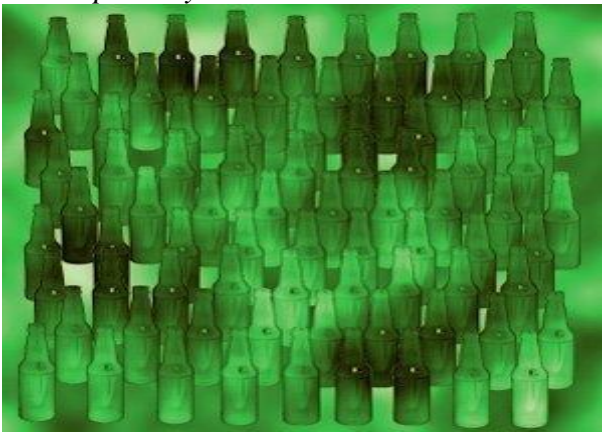
Unix or Linux without pipes is unthinkable, or at least, pipelines are a very important part of Unix and Linux applications. Small elements are put together by using pipes. Processes are chained together by their standard streams, i.e. the output of one process is used as the input of another process. To chain processes like this, so-called anonymous pipes are used. The concept of pipes and pipelines was introduced by Douglas McIlroy, one of the authors of the early command shells, after he noticed that much of the time they were processing the output of one program as the input to another. Ken Thompson added the concept of pipes to the UNIX operating system in 1973. Pipelines have later been ported to other operating systems like DOS, OS/2 and Microsoft Windows as well.

Generally there are two kinds of pipes:

- 1.anonymous pipes
- 2.named pipes

Anonymous pipes exist solely within processes and are usually used in combination with forks.

Beer Pipe in Python



"99 Bottles of Beer" is a traditional song in the United States and Canada. The song is derived from the English "Ten Green Bottles". The song consists of 100 verses, which are very similar. Just the number of bottles varies. Only one, i.e. the hundredth verse is slightly different. This song is often sung on long trips, because it is easy to memorize, especially when drunken, and it can take a long time to sing.

Here are the lyrics of this song:

Ninety-nine bottles of beer on the wall, Ninety-nine bottles of beer. Take one down, pass it around, Ninety-eight bottles of beer on the wall.

The next verse is the same starting with 98 bottles of beer. So the general rule is, each verse one bottle less, until there in none left. The song normally ends here. But we want to implement the Aleph-Null (i.e. the infinite) version of this song with an additional verse:

No more bottles of beer on the wall, no more bottles of beer. Go to the store and buy some more, Ninety-nine bottles of beer on the wall.

This song has been implemented in all conceivable computer languages like "Whitespace" or "Brainfuck". You find the collection at <http://99-bottles-of-beer.net>

We program the Aleph-Null variant of the song with a fork and a pipe:

```
import os

def child(pipeout):
    bottles = 99
    while True:
        bob = "bottles of beer"
        otw = "on the wall"
        take1 = "Take one down and pass it around"
        store = "Go to the store and buy some more"

        if bottles > 0:
            values = (bottles, bob, otw, bottles, bob, take1, bottles - 1, bob, otw)
            verse = "%2d %s %s,\n%2d %s.\n%s,\n%2d %s %s." % values
            os.write(pipeout, verse)
            bottles -= 1
        else:
            bottles = 99
            values = (bob, otw, bob, store, bottles, bob, otw)
            verse = "No more %s %s,\nno more %s.\n%s,\n%2d %s %s." % values
            os.write(pipeout, verse)

def parent():
    pipein, pipeout = os.pipe()
    if os.fork() == 0:
        child(pipeout)
    else:
        counter = 1
        while True:
            if counter % 100:
                verse = os.read(pipein, 117)
            else:
                verse = os.read(pipein, 128)
            print 'verse %d\n%s\n' % (counter, verse)
            counter += 1
```

parent()

The problem in the code above is that we or better the parent process have to know exactly how many bytes the child will send each time. For the first 99 verses it will be 117 Bytes (verse = os.read(pipein, 117)) and for the Aleph-Null verse it will be 128 bytes (verse = os.read(pipein, 128))

We fixed this in the following implementation, in which we read complete lines:

```
import os

def child(pipeout):
    bottles = 99
    while True:
        bob = "bottles of beer"
        otw = "on the wall"
        take1 = "Take one down and pass it around"
        store = "Go to the store and buy some more"

        if bottles > 0:
            values = (bottles, bob, otw, bottles, bob, take1, bottles - 1, bob, otw)
            verse = "%2d %s %s,\n%2d %s.\n%s,\n%2d %s %s.\n" % values
            os.write(pipeout, verse)
            bottles -= 1
```



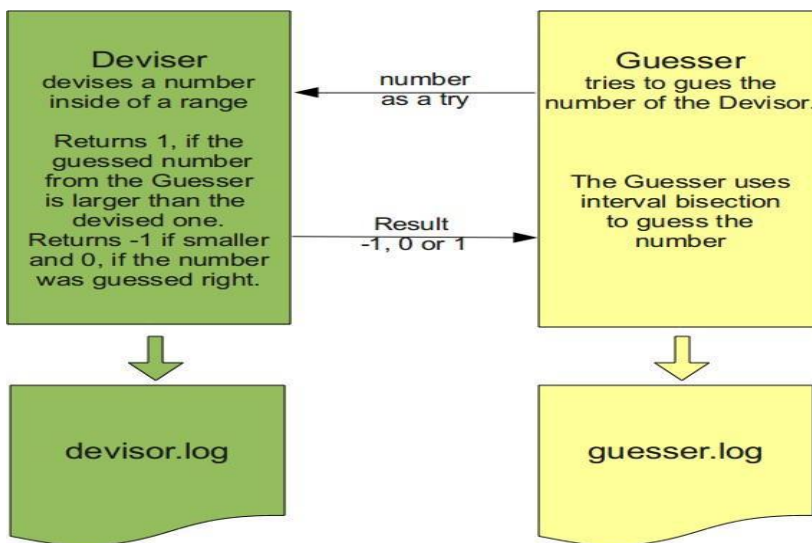
```

else:
    bottles = 99
    values = (bob, otw, bob, store, bottles, bob,otw)
    verse = "No more %s %s,\nno more %s.\n%s,\n%2d %s %s.\n" % values
    os.write(pipeout, verse)
def parent():
    pipein, pipeout = os.pipe()
    if os.fork() == 0:
        os.close(pipein)
        child(pipeout)
    else:
        os.close(pipeout)
        counter = 1
        pipein = os.fdopen(pipein)
        while True:
            print 'verse %d' % (counter)
            for i in range(4):
                verse = pipein.readline()[:-1]
                print '%s' % (verse)
            counter += 1
            print
parent()

```

Bidirectional Pipes

Now we come to something completely non-alcoholic. It's a simple guessing game, which small children often play. We want to implement this game with bidirectional Pipes. There is an explanation of this game in our tutorial in the chapter about [loops](#). The following diagram explains both the rules of the game and the way we implemented it:



The deviser, the one who devises the number, has to imagine a number between a range of 1 to n. The Guesser inputs his guess. The deviser informs the player, if this number is larger, smaller or equal to the secret number, i.e. the number which the deviser has randomly created. Both the deviser and the guesser write their results into log files, i.e. devisor.log and guesser.log respectively.

This is the complete implementation:
import os, sys, random

```

def deviser(max):
    fh = open("devisor.log", "w")
    to_be_guessed = int(max * random.random()) + 1

```

```

guess = 0
while guess != to_be_guessed:
    guess = int(raw_input())
    fh.write(str(guess) + " ")
    if guess > 0:
        if guess > to_be_guessed:
            print 1
        elif guess < to_be_guessed:
            print -1
        else:
            print 0
    sys.stdout.flush()
else:
    break
fh.close()

def guesser(max):
    fh = open("guesser.log", "w")
    bottom = 0
    top = max
    fuzzy = 10
    res = 1
    while res != 0:
        guess = (bottom + top) / 2
        print guess
        sys.stdout.flush()
        fh.write(str(guess) + " ")
        res = int(raw_input())
        if res == -1: # number is higher
            bottom = guess
        elif res == 1:
            top = guess
        elif res == 0:
            message = "Wanted number is %d" % guess
            fh.write(message)
        else: # this case shouldn't occur
            print "input not correct"
            fh.write("Something's wrong")

n = 100
stdin = sys.stdin.fileno() # usually 0
stdout = sys.stdout.fileno() # usually 1

parentStdin, childStdout = os.pipe()
childStdin, parentStdout = os.pipe()
pid = os.fork()
if pid:
    # parent process
    os.close(childStdout)
    os.close(childStdin)
    os.dup2(parentStdin, stdin)
    os.dup2(parentStdout, stdout)
    deviser(n)
else:
    # child process
    os.close(parentStdin)

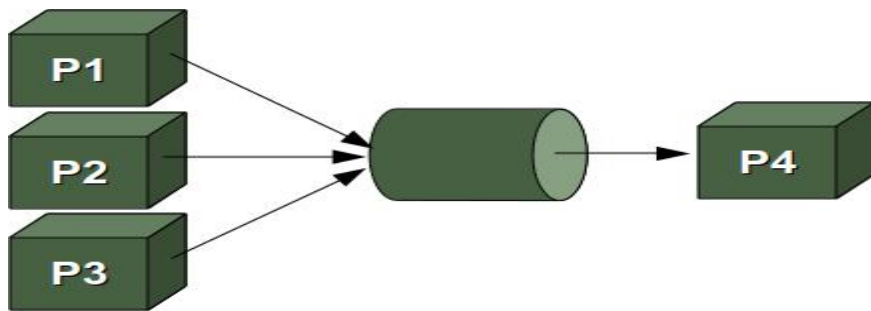
```

```

os.close(parentStdout)
os.dup2(childStdin, stdin)
os.dup2(childStdout, stdout)
guesser(n)

```

Named Pipes, Fifos



Under Unix as well as under Linux it's possible to create Pipes, which are implemented as files.

These Pipes are called "named pipes" or sometimes Fifos (First In First Out).

A process reads from and writes to such a pipe as if it were a regular file. Sometimes more than one process write to such a pipe but only one process reads from it.

The following example illustrates the case, in which one process (child process) writes to the pipe and another process (the parent process) reads from this pipe.

```

import os, time, sys
pipe_name = 'pipe_test'

def child( ):
    pipeout = os.open(pipe_name, os.O_WRONLY)
    counter = 0
    while True:
        time.sleep(1)
        os.write(pipeout, 'Number %03d\n' % counter)
        counter = (counter+1) % 5

def parent( ):
    pipein = open(pipe_name, 'r')
    while True:
        line = pipein.readline()[:-1]
        print 'Parent %d got "%s" at %s' % (os.getpid(), line, time.time( ))

if not os.path.exists(pipe_name):
    os.mkfifo(pipe_name)
pid = os.fork()
if pid != 0:
    parent()
else:
    child()

```

9.Modules

If you quit from the Python interpreter and enter it again, the definitions you have made (functions and variables) are lost. Therefore, if you want to write a somewhat longer program, you are better off using a text editor to prepare the input for the interpreter and running it with that file as input instead. This is known as creating a *script*. As your program gets longer, you may want to split it into several files for easier maintenance. You may

also want to use a handy function that you've written in several programs without copying its definition into each program.

To support this, Python has a way to put definitions in a file and use them in a script or in an interactive instance of the interpreter. Such a file is called a *module*; definitions from a module can be *imported* into other modules or into the *main* module (the collection of variables that you have access to in a script executed at the top level and in calculator mode).

A module is a file containing Python definitions and statements. The file name is the module name with the suffix `.py` appended. Within a module, the module's name (as a string) is available as the value of the global variable `__name__`. For instance, use your favorite text editor to create a file called `fibonacci.py` in the current directory with the following contents:

```
# Fibonacci numbers module
```

```
def fib(n): # write Fibonacci series up to n
    a, b = 0, 1
    while a < n:
        print(a, end=' ')
        a, b = b, a+b
    print()
```

```
def fib2(n): # return Fibonacci series up to n
    result = []
    a, b = 0, 1
    while a < n:
        result.append(a)
        a, b = b, a+b
    return result
```

Now enter the Python interpreter and import this module with the following command:

```
>>>
>>> import fibo
```

This does not enter the names of the functions defined in `fibo` directly in the current symbol table; it only enters the module name `fibo` there. Using the module name you can access the functions:

```
>>>
>>> fibo.fib(1000)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 987
>>> fibo.fib2(100)
[0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89]
>>> fibo.__name__
'fibo'
```

If you intend to use a function often you can assign it to a local name:

```
>>>
>>> fib = fibo.fib
>>> fib(500)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377
```

More on Modules

A module can contain executable statements as well as function definitions. These statements are intended to initialize the module. They are executed only the *first* time the module name is encountered in an import statement. [1](#) (They are also run if the file is executed as a script.)

Each module has its own private symbol table, which is used as the global symbol table by all functions defined in the module. Thus, the author of a module can use global variables in the module without worrying about accidental clashes with a user's global variables. On the other hand, if you know what you are doing you can touch a module's global variables with the same notation used to refer to its functions, `modname.itemname`.

Modules can import other modules. It is customary but not required to place all import statements at the beginning of a module (or script, for that matter). The imported module names are placed in the importing module's global symbol table.

There is a variant of the import statement that imports names from a module directly into the importing module's symbol table. For example:

```
>>>
>>> from fibo import fib, fib2
>>> fib(500)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377
```

This does not introduce the module name from which the imports are taken in the local symbol table (so in the example, fibo is not defined).

There is even a variant to import all names that a module defines:

```
>>>
>>> from fibo import *
>>> fib(500)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377
```

This imports all names except those beginning with an underscore (`_`). In most cases Python programmers do not use this facility since it introduces an unknown set of names into the interpreter, possibly hiding some things you have already defined.

Note that in general the practice of importing `*` from a module or package is frowned upon, since it often causes poorly readable code. However, it is okay to use it to save typing in interactive sessions.

If the module name is followed by `as`, then the name following `as` is bound directly to the imported module.

```
>>>
>>> import fibo as fib
>>> fib.fib(500)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377
```

This is effectively importing the module in the same way that `import fibo` will do, with the only difference of it being available as `fib`.

It can also be used when utilising `from` with similar effects:

```
>>>
>>> from fibo import fib as fibonacci
>>> fibonacci(500)
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377
```

Note

For efficiency reasons, each module is only imported once per interpreter session. Therefore, if you change your modules, you must restart the interpreter – or, if it's just one module you want to test interactively, use `importlib.reload()`, e.g. `import importlib; importlib.reload(modulename)`.

Executing modules as scripts

When you run a Python module with

```
python fibo.py <arguments>
```

the code in the module will be executed, just as if you imported it, but with the `__name__` set to `"_main_"`.

That means that by adding this code at the end of your module:

```
if __name__ == "_main_":
```

```
    import sys
```

```
    fib(int(sys.argv[1]))
```

you can make the file usable as a script as well as an importable module, because the code that parses the command line only runs if the module is executed as the “main” file:

```
$ python fibo.py 50
```

```
0 1 1 2 3 5 8 13 21 34
```

If the module is imported, the code is not run:

```
>>>
>>> import fibo
>>>
```

This is often used either to provide a convenient user interface to a module, or for testing purposes (running the module as a script executes a test suite).

The Module Search Path

When a module named `spam` is imported, the interpreter first searches for a built-in module with that name. If not found, it then searches for a file named `spam.py` in a list of directories given by the variable `sys.path`. `sys.path` is initialized from these locations:

The directory containing the input script (or the current directory when no file is specified).

`PYTHONPATH` (a list of directory names, with the same syntax as the shell variable `PATH`).

The installation-dependent default.

Note

On file systems which support symlinks, the directory containing the input script is calculated after the symlink is followed. In other words the directory containing the symlink is **not** added to the module search path.

After initialization, Python programs can modify `sys.path`. The directory containing the script being run is placed at the beginning of the search path, ahead of the standard library path. This means that scripts in that directory will be loaded instead of modules of the same name in the library directory. This is an error unless the replacement is intended. See section [Standard Modules](#) for more information.

“Compiled” Python files

To speed up loading modules, Python caches the compiled version of each module in the `_pycache_` directory under the name `module.version.pyc`, where the version encodes the format of the compiled file; it generally contains the Python version number. For example, in CPython release 3.3 the compiled version of `spam.py` would be cached as `_pycache_/spam.cpython-33.pyc`. This naming convention allows compiled modules from different releases and different versions of Python to coexist.

Python checks the modification date of the source against the compiled version to see if it's out of date and needs to be recompiled. This is a completely automatic process. Also, the compiled modules are platform-independent, so the same library can be shared among systems with different architectures.

Python does not check the cache in two circumstances. First, it always recompiles and does not store the result for the module that's loaded directly from the command line. Second, it does not check the cache if there is no source module. To support a non-source (compiled only) distribution, the compiled module must be in the source directory, and there must not be a source module.

Some tips for experts:

You can use the `-O` or `-OO` switches on the Python command to reduce the size of a compiled module. The `-O` switch removes assert statements, the `-OO` switch removes both assert statements and `__doc__` strings. Since some programs may rely on having these available, you should only use this option if you know what you're doing. “Optimized” modules have an `opt-` tag and are usually smaller. Future releases may change the effects of optimization.

A program doesn't run any faster when it is read from a `.pyc` file than when it is read from a `.py` file; the only thing that's faster about `.pyc` files is the speed with which they are loaded.

The module `compileall` can create `.pyc` files for all modules in a directory.

There is more detail on this process, including a flow chart of the decisions, in [PEP 3147](#).

Standard Modules

Python comes with a library of standard modules, described in a separate document, the Python Library Reference (“Library Reference” hereafter). Some modules are built into the interpreter; these provide access to operations that are not part of the core of the language but are nevertheless built in, either for efficiency or to provide access to operating system primitives such as system calls. The set of such modules is a configuration option which also depends on the underlying platform. For example, the `winreg` module is only provided on Windows systems. One particular module deserves some attention: `sys`, which is built into every Python interpreter. The variables `sys.ps1` and `sys.ps2` define the strings used as primary and secondary prompts:

```
>>>
>>> import sys
```

```
>>> sys.ps1
'>>>'
>>> sys.ps2
'...'
>>> sys.ps1 = 'C>'
C> print('Yuck!')
Yuck!
C>
```

These two variables are only defined if the interpreter is in interactive mode.

The variable `sys.path` is a list of strings that determines the interpreter's search path for modules. It is initialized to a default path taken from the environment variable `PYTHONPATH`, or from a built-in default if `PYTHONPATH` is not set. You can modify it using standard list operations:

```
>>>
>>> import sys
>>> sys.path.append('/ufs/guido/lib/python')
```

The `dir()` Function

The built-in function `dir()` is used to find out which names a module defines. It returns a sorted list of strings:

```
>>>
>>> import fibo, sys
>>> dir(fibo)
['_name_', 'fib', 'fib2']
>>> dir(sys)
['_breakpointhook_', '__displayhook__', '_doc_', '_excepthook_',
'_interactivehook_', '__loader__', '__name__', '__package__', '__spec__',
'_stderr_', '_stdin_', '_stdout_', '_unraisablehook_',
'_clear_type_cache', '_current_frames', '_debugmallocstats', '_framework',
'_getframe', '_git', '_home', '_xoptions', 'abiflags', 'addaudithook',
'api_version', 'argv', 'audit', 'base_exec_prefix', 'base_prefix',
'breakpointhook', 'builtin_module_names', 'byteorder', 'call_tracing',
'callstats', 'copyright', 'displayhook', 'dont_write_bytecode', 'exc_info',
'excepthook', 'exec_prefix', 'executable', 'exit', 'flags', 'float_info',
'float_repr_style', 'get_asyncgen_hooks', 'get_coroutine_origin_tracking_depth',
'getallocatedblocks', 'getdefaultencoding', 'getdlopenflags',
'getfilesystemcodeerrors', 'getfilesystemencoding', 'getprofile',
'getrecursionlimit', 'getrefcount', 'getsizeof', 'getswitchinterval',
'gettrace', 'hash_info', 'hexversion', 'implementation', 'int_info',
'intern', 'is_finalizing', 'last_traceback', 'last_type', 'last_value',
'maxsize', 'maxunicode', 'meta_path', 'modules', 'path', 'path_hooks',
'path_importer_cache', 'platform', 'prefix', 'ps1', 'ps2', 'pycache_prefix',
'set_asyncgen_hooks', 'set_coroutine_origin_tracking_depth', 'setdlopenflags',
'setprofile', 'setrecursionlimit', 'setswitchinterval', 'settrace', 'stderr',
'stdin', 'stdout', 'thread_info', 'unraisablehook', 'version', 'version_info',
'warnoptions']
```

Without arguments, `dir()` lists the names you have defined currently:

```
>>>
>>> a = [1, 2, 3, 4, 5]
>>> import fibo
>>> fib = fibo.fib
>>> dir()
['_builtins_', '_name_', 'a', 'fib', 'fibo', 'sys']
```

Note that it lists all types of names: variables, modules, functions, etc.

`dir()` does not list the names of built-in functions and variables. If you want a list of those, they are defined in the standard module `builtins`:

```
>>>
>>> import builtins
```

```
>>> dir(builtins)
['ArithmeticError', 'AssertionError', 'AttributeError', 'BaseException',
'BlockingIOError', 'BrokenPipeError', 'BufferError', 'BytesWarning',
'ChildProcessError', 'ConnectionAbortedError', 'ConnectionError',
'ConnectionRefusedError', 'ConnectionResetError', 'DeprecationWarning',
'EOFError', 'Ellipsis', 'EnvironmentError', 'Exception', 'False',
'FileExistsError', 'FileNotFoundError', 'FloatingPointError',
'FutureWarning', 'GeneratorExit', 'IOError', 'ImportError',
'ImportWarning', 'IndentationError', 'IndexError', 'InterruptedError',
'IsADirectoryError', 'KeyError', 'KeyboardInterrupt', 'LookupError',
'MemoryError', 'NameError', 'None', 'NotADirectoryError', 'NotImplemented',
'NotImplementedError', 'OSError', 'OverflowError',
'PendingDeprecationWarning', 'PermissionError', 'ProcessLookupError',
'ReferenceError', 'ResourceWarning', 'RuntimeError', 'RuntimeWarning',
'StopIteration', 'SyntaxError', 'SyntaxWarning', 'SystemError',
'SystemExit', 'TabError', 'TimeoutError', 'True', 'TypeError',
'UnboundLocalError', 'UnicodeDecodeError', 'UnicodeEncodeError',
'UnicodeError', 'UnicodeTranslateError', 'UnicodeWarning', 'UserWarning',
'ValueError', 'Warning', 'ZeroDivisionError', '_', '__build_class__',
'debug', 'doc', 'import', 'name', 'package', 'abs',
'all', 'any', 'ascii', 'bin', 'bool', 'bytearray', 'bytes', 'callable',
'chr', 'classmethod', 'compile', 'complex', 'copyright', 'credits',
'delattr', 'dict', 'dir', 'divmod', 'enumerate', 'eval', 'exec', 'exit',
'filter', 'float', 'format', 'frozenset', 'getattr', 'globals', 'hasattr',
'hash', 'help', 'hex', 'id', 'input', 'int', 'isinstance', 'issubclass',
'iter', 'len', 'license', 'list', 'locals', 'map', 'max', 'memoryview',
'min', 'next', 'object', 'oct', 'open', 'ord', 'pow', 'print', 'property',
'quit', 'range', 'repr', 'reversed', 'round', 'set', 'setattr', 'slice',
'sorted', 'staticmethod', 'str', 'sum', 'super', 'tuple', 'type', 'vars',
'zip']
```

Packages

Packages are a way of structuring Python’s module namespace by using “dotted module names”. For example, the module name `A.B` designates a submodule named `B` in a package named `A`. Just like the use of modules saves the authors of different modules from having to worry about each other’s global variable names, the use of dotted module names saves the authors of multi-module packages like NumPy or Pillow from having to worry about each other’s module names.

Suppose you want to design a collection of modules (a “package”) for the uniform handling of sound files and sound data. There are many different sound file formats (usually recognized by their extension, for example: `.wav`, `.aiff`, `.au`), so you may need to create and maintain a growing collection of modules for the conversion between the various file formats. There are also many different operations you might want to perform on sound data (such as mixing, adding echo, applying an equalizer function, creating an artificial stereo effect), so in addition you will be writing a never-ending stream of modules to perform these operations. Here’s a possible structure for your package (expressed in terms of a hierarchical filesystem):

```
sound/                Top-level package
__init__.py          Initialize the sound package
formats/             Subpackage for file format conversions
  __init__.py
  wavread.py
  wavwrite.py
  aiffread.py
  aiffwrite.py
  auread.py
  auwrite.py
  ...
effects/            Subpackage for sound effects
  __init__.py
```



```

echo.py
surround.py
reverse.py
...
filters/          Subpackage for filters
  __init__.py
equalizer.py
vocoder.py
karaoke.py
...

```

When importing the package, Python searches through the directories on `sys.path` looking for the package subdirectory.

The `__init__.py` files are required to make Python treat directories containing the file as packages. This prevents directories with a common name, such as `string`, unintentionally hiding valid modules that occur later on the module search path. In the simplest case, `__init__.py` can just be an empty file, but it can also execute initialization code for the package or set the `__all__` variable, described later.

Users of the package can import individual modules from the package, for example:

import sound.effects.echo

This loads the submodule `sound.effects.echo`. It must be referenced with its full name.

```
sound.effects.echo.echofilter(input, output, delay=0.7, atten=4)
```

An alternative way of importing the submodule is:

from sound.effects **import** echo

This also loads the submodule `echo`, and makes it available without its package prefix, so it can be used as follows:

```
echo.echofilter(input, output, delay=0.7, atten=4)
```

Yet another variation is to import the desired function or variable directly:

from sound.effects.echo **import** echofilter

Again, this loads the submodule `echo`, but this makes its function `echofilter()` directly available:

```
echofilter(input, output, delay=0.7, atten=4)
```

Note that when using `from package import item`, the `item` can be either a submodule (or subpackage) of the package, or some other name defined in the package, like a function, class or variable. The `import` statement first tests whether the `item` is defined in the package; if not, it assumes it is a module and attempts to load it. If it fails to find it, an `ImportError` exception is raised.

Contrarily, when using syntax like `import item.subitem.subsubitem`, each item except for the last must be a package; the last item can be a module or a package but can't be a class or function or variable defined in the previous item.

Importing * From a Package

Now what happens when the user writes `from sound.effects import *`? Ideally, one would hope that this somehow goes out to the filesystem, finds which submodules are present in the package, and imports them all. This could take a long time and importing sub-modules might have unwanted side-effects that should only happen when the sub-module is explicitly imported.

The only solution is for the package author to provide an explicit index of the package. The `import` statement uses the following convention: if a package's `__init__.py` code defines a list named `__all__`, it is taken to be the list of module names that should be imported when `from package import *` is encountered. It is up to the package author to keep this list up-to-date when a new version of the package is released. Package authors may also decide not to support it, if they don't see a use for importing `*` from their package. For example, the file `sound/effects/__init__.py` could contain the following code:

```
__all__ = ["echo", "surround", "reverse"]
```

This would mean that `from sound.effects import *` would import the three named submodules of the `sound` package.

If `__all__` is not defined, the statement `from sound.effects import *` does *not* import all submodules from the package `sound.effects` into the current namespace; it only ensures that the package `sound.effects` has been imported (possibly running any initialization code in `__init__.py`) and then imports whatever names are defined in the package. This includes any names defined (and submodules explicitly loaded) by `__init__.py`. It also includes any submodules of the package that were explicitly loaded by previous import statements. Consider this code:

```
import sound.effects.echo
import sound.effects.surround
from sound.effects import *
```

In this example, the `echo` and `surround` modules are imported in the current namespace because they are defined in the `sound.effects` package when the `from...import` statement is executed. (This also works when `__all__` is defined.)

Although certain modules are designed to export only names that follow certain patterns when you use `import *`, it is still considered bad practice in production code.

Remember, there is nothing wrong with using `from package import specific_submodule!` In fact, this is the recommended notation unless the importing module needs to use submodules with the same name from different packages.

Intra-package References

When packages are structured into subpackages (as with the `sound` package in the example), you can use absolute imports to refer to submodules of siblings packages. For example, if the module `sound.filters.vocoder` needs to use the `echo` module in the `sound.effects` package, it can use `from sound.effects import echo`.

You can also write relative imports, with the `from module import name` form of import statement. These imports use leading dots to indicate the current and parent packages involved in the relative import. From the `surround` module for example, you might use:

```
from . import echo
from .. import formats
from ..filters import equalizer
```

Note that relative imports are based on the name of the current module. Since the name of the main module is always `"__main__"`, modules intended for use as the main module of a Python application must always use absolute imports.

Packages in Multiple Directories

Packages support one more special attribute, `__path__`. This is initialized to be a list containing the name of the directory holding the package's `__init__.py` before the code in that file is executed. This variable can be modified; doing so affects future searches for modules and subpackages contained in the package.

While this feature is not often needed, it can be used to extend the set of modules found in a package.

Chapter-4 Classes and Objects

A class is a user-defined blueprint or prototype from which objects are created. Classes provide a means of bundling data and functionality together. Creating a new class creates a new type of object, allowing new instances

of that type to be made. Each class instance can have attributes attached to it for maintaining its state. Class instances can also have methods (defined by its class) for modifying its state.

To understand the need for creating a class let's consider an example, let's say you wanted to track the number of dogs which may have different attributes like breed, age. If a list is used, the first element could be the dog's breed while the second element could represent its age. Let's suppose there are 100 different dogs, then how would you know which element is supposed to be which? What if you wanted to add other properties to these dogs? This lacks organization and it's the exact need for classes.

Class creates a user-defined data structure, which holds its own data members and member functions, which can be accessed and used by creating an instance of that class. A class is like a blueprint for an object.

Some points on Python class:

Classes are created by keyword class.

Attributes are the variables that belong to class.

Attributes are always public and can be accessed using dot (.) operator. Eg.: Myclass.Myattribute

Class Definition Syntax:

```
class ClassName:  
    # Statement-1  
    .  
    .  
    .  
    # Statement-N
```

Defining a class –

```
# Python program to  
# demonstrate defining  
# a class
```

```
class Dog:  
    pass
```

In the above example, class keyword indicates that you are creating a class followed by the name of the class (Dog in this case).

Class Objects

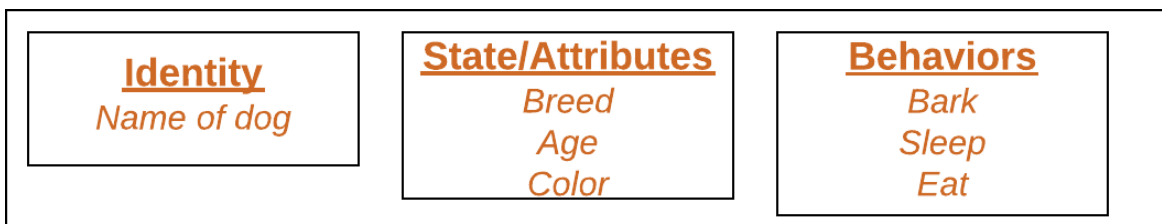
An Object is an instance of a Class. A class is like a blueprint while an instance is a copy of the class with *actual values*. It's not an idea anymore, it's an actual dog, like a dog of breed pug who's seven years old. You can have many dogs to create many different instances, but without the class as a guide, you would be lost, not knowing what information is required.

An object consists of :

State : It is represented by attributes of an object. It also reflects the properties of an object.

Behavior : It is represented by methods of an object. It also reflects the response of an object with other objects.

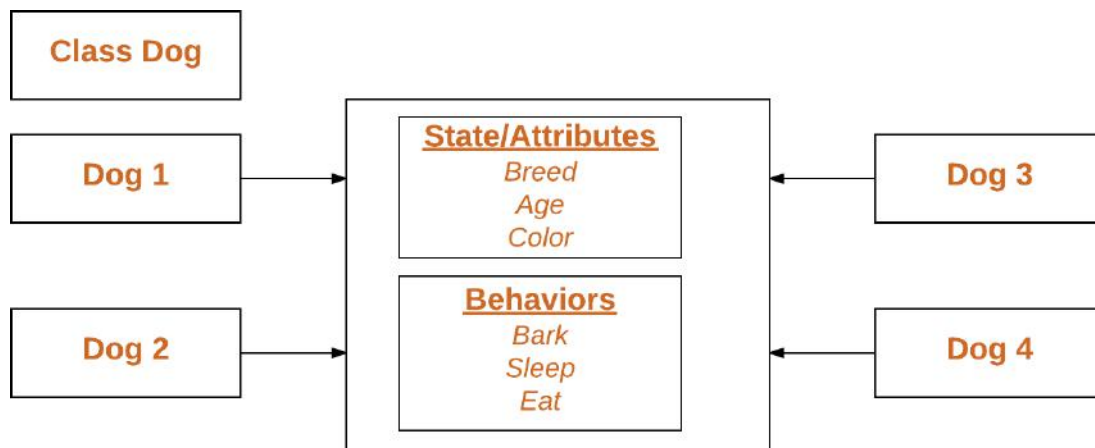
Identity : It gives a unique name to an object and enables one object to interact with other objects.



Declaring Objects (Also called instantiating a class)

When an object of a class is created, the class is said to be instantiated. All the instances share the attributes and the behavior of the class. But the values of those attributes, i.e. the state are unique for each object. A single class may have any number of instances.

Example:



Declaring an object –

```
# Python program to
# demonstrate instantiating
# a class
```

```
class Dog:
```

```
    # A simple class
    # attribute
    attr1 = "mamal"
    attr2 = "dog"

    # A sample method
    def fun(self):
        print("I'm a", self.attr1)
        print("I'm a", self.attr2)
```

```
# Driver code
# Object instantiation
Rodger = Dog()

# Accessing class attributes
# and method through objects
print(Rodger.attr1)
Rodger.fun()
```

```
Output:
mamal
I'm a mamal
I'm a dog
```

In the above example, an object is created which is basically a dog named Rodger. This class only has two class attributes that tell us that Rodger is a dog and a mammal.

The self Class methods must have an extra first parameter in method definition. We do not give a value for this parameter when we call the method, Python provides it. If we have a method which takes no arguments, then we still have to have one argument. This is similar to this pointer in C++ and this reference in Java. When we call a method of this object as myobject.method(arg1, arg2), this is automatically converted by Python into MyClass.method(myobject, arg1, arg2) – this is all the special self is about.

```
__init__ method
```

The `__init__` method is similar to constructors in C++ and Java. Constructors are used to initialize the object's state. Like methods, a constructor also contains a collection of statements (i.e. instructions) that are executed at

the time of Object creation. It is run as soon as an object of a class is instantiated. The method is useful to do any initialization you want to do with your object.

```
filter_none
edit
play_arrow
brightness_4
# A Sample class with init method
class Person:

    # init method or constructor
    def __init__(self, name):
        self.name = name

    # Sample Method
    def say_hi(self):
        print('Hello, my name is', self.name)
```

```
p = Person('Nikhil')
p.say_hi()
```

Output:

```
Hello, my name is Nikhil
```

Class and Instance Variables

Instance variables are for data unique to each instance and class variables are for attributes and methods shared by all instances of the class. Instance variables are variables whose value is assigned inside a constructor or method with self whereas class variables are variables whose value is assigned in the class.

Defining instance variable using constructor.

```
filter_none
edit
play_arrow
brightness_4
# Python program to show that the variables with a value
# assigned in the class declaration, are class variables and
# variables inside methods and constructors are instance
# variables.

# Class for Dog
class Dog:

    # Class Variable
    animal = 'dog'

    # The init method or constructor
    def __init__(self, breed, color):

        # Instance Variable
        self.breed = breed
        self.color = color

# Objects of Dog class
Rodger = Dog("Pug", "brown")
Buzo = Dog("Bulldog", "black")

print('Rodger details:')
print('Rodger is a', Rodger.animal)
print('Breed: ', Rodger.breed)
```

```

print('Color: ', Rodger.color)

print('\nBuzo details:')
print('Buzo is a', Buzo.animal)
print('Breed: ', Buzo.breed)
print('Color: ', Buzo.color)

# Class variables can be accessed using class
# name also
print("\nAccessing class variable using class name")
print(Dog.animal)

```

Output:
Rodger details:
Rodger is a dog
Breed: Pug
Color: brown

Buzo details:
Buzo is a dog
Breed: Bulldog
Color: black

```

Accessing class variable using class name
dog
Defining instance variable using the normal method.
filter_none
edit
play_arrow
brightness_4
# Python program to show that we can create
# instance variables inside methods

```

```

# Class for Dog
class Dog:

    # Class Variable
    animal = 'dog'

    # The init method or constructor
    def __init__(self, breed):

        # Instance Variable
        self.breed = breed

    # Adds an instance variable
    def setColor(self, color):
        self.color = color

    # Retrieves instance variable
    def getColor(self):
        return self.color

```

```

# Driver Code
Rodger = Dog("pug")
Rodger.setColor("brown")
print(Rodger.getColor())
Output:

```

brown
Attention geek! Strengthen your foundations with the Python Programming Foundation Course and learn the basics.
To begin with, your interview preparations Enhance your Data Structures concepts with the Python DS Course.

Attributes:

Python Class Attributes

My interviewer was wrong in that the above code *is* syntactically valid.

I too was wrong in that it isn't setting a "default value" for the instance attribute. Instead, it's defining `data` as a *class* attribute with value `[]`.

In my experience, Python class attributes are a topic that *many* people know *something* about, but few understand completely.

Python Class Variable vs. Instance Variable: What's the Difference?

A Python class attribute is an attribute of the class (circular, I know), rather than an attribute of an *instance* of a class.

Let's use a Python class example to illustrate the difference. Here, `class_var` is a class attribute, and `i_var` is an instance attribute:

```
class MyClass(object):  
    class_var = 1
```

```
    def __init__(self, i_var):  
        self.i_var = i_var
```

Note that all instances of the class have access to `class_var`, and that it can also be accessed as a property of the *class itself*:

```
foo = MyClass(2)  
bar = MyClass(3)
```

```
foo.class_var, foo.i_var
```

```
## 1, 2
```

```
bar.class_var, bar.i_var
```

```
## 1, 3
```

```
MyClass.class_var ## <— This is key
```

```
## 1
```

For Java or C++ programmers, the class attribute is similar—but not identical—to the static member. We'll see how they differ later.

Class vs. Instance Namespaces

To understand what's happening here, let's talk briefly about **Python namespaces**.

A [namespace](#) is a mapping from names to objects, with the property that there is zero relation between names in different namespaces. They're usually implemented as Python dictionaries, although this is abstracted away.

Depending on the context, you may need to access a namespace using dot syntax (e.g., `object.name_from_objects_namespace`) or as a local variable (e.g., `object_from_namespace`). As a concrete example:

```
class MyClass(object):  
    ## No need for dot syntax
```

```
class_var = 1
```

```
def __init__(self, i_var):
```

```
    self.i_var = i_var
```

```
## Need dot syntax as we've left scope of class namespace
```

```
MyClass.class_var
```

```
## 1
```

Python classes *and* instances of classes each have their own distinct namespaces represented by [pre-defined attributes](#) `MyClass.__dict__` and `instance_of_MyClass.__dict__`, respectively.

When you try to access an attribute from an instance of a class, it first looks at its *instance* namespace. If it finds the attribute, it returns the associated value. If not, it *then* looks in the *class* namespace and returns the attribute (if it's present, throwing an error otherwise). For example:

```
foo = MyClass(2)
```

```
## Finds i_var in foo's instance namespace
```

```
foo.i_var
```

```
## 2
```

```
## Doesn't find class_var in instance namespace...
```

```
## So look's in class namespace (MyClass._dict_)
```

```
foo.class_var
```

```
## 1
```

The instance namespace takes supremacy over the class namespace: if there is an attribute with the same name in both, the instance namespace will be checked first and its value returned. Here's a simplified version of the code ([source](#)) for attribute lookup:

```
def instlookup(inst, name):
```

```
    ## simplified algorithm...
```

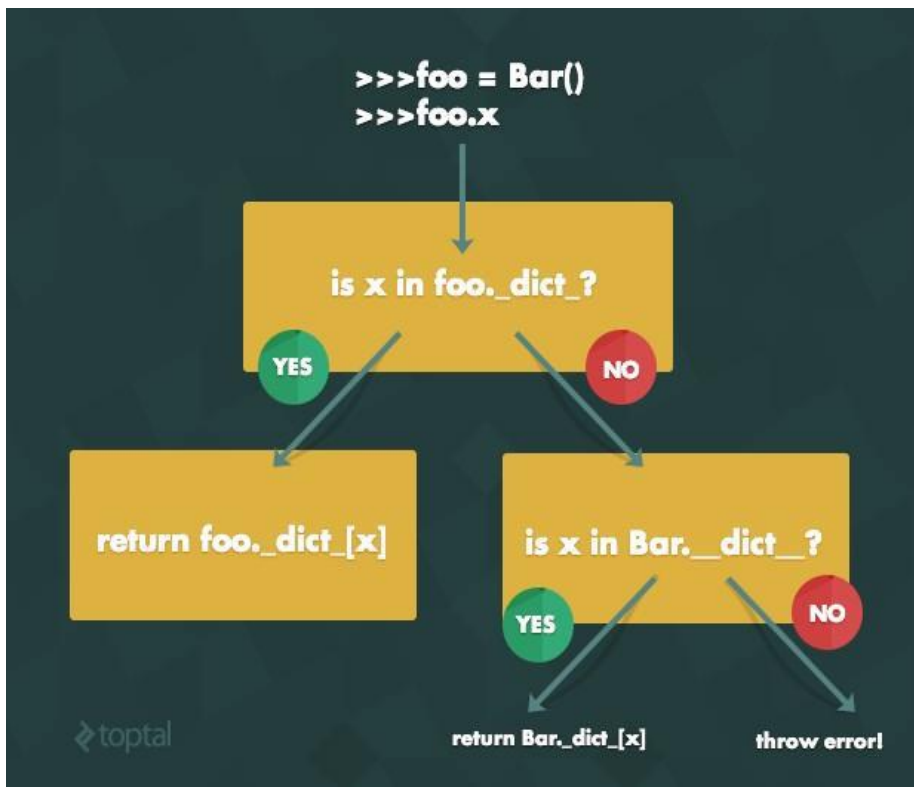
```
    if inst._dict_.has_key(name):
```

```
        return inst._dict_[name]
```

```
    else:
```

```
        return inst._class__._dict_[name]
```

And, in visual form:



How Class Attributes Handle Assignment

With this in mind, we can make sense of how Python class attributes handle assignment:

If a class attribute is set by accessing the class, it will override the value for *all* instances. For example:

```

foo = MyClass(2)
foo.class_var
## 1
MyClass.class_var = 2
foo.class_var
## 2
  
```

At the namespace level... we're setting `MyClass.__dict__['class_var'] = 2`. (Note: this [isn't the exact code](#) (which would be `setattr(MyClass, 'class_var', 2)`) as `__dict__` returns a [dictproxy](#), an immutable wrapper that prevents direct assignment, but it helps for demonstration's sake). Then, when we access `foo.class_var`, `class_var` has a new value in the class namespace and thus 2 is returned.

If a Python class variable is set by accessing an instance, it will override the value *only for that instance*. This essentially overrides the class variable and turns it into an instance variable available, intuitively, *only for that instance*. For example:

```

foo = MyClass(2)
foo.class_var
## 1
foo.class_var = 2
foo.class_var
## 2
MyClass.class_var
## 1
  
```

At the namespace level... we're adding the `class_var` attribute to `foo.__dict__`, so when we lookup `foo.class_var`, we return 2. Meanwhile, other instances of `MyClass` will *not* have `class_var` in their instance namespaces, so they continue to find `class_var` in `MyClass.__dict__` and thus return 1.

Mutability

Quiz question: What if your class attribute has a **mutable type**? You can manipulate (mutilate?) the class attribute by accessing it through a particular instance and, in turn, end up *manipulating the referenced object that all instances are accessing* (as pointed out by [Timothy Wiseman](#)).

This is best demonstrated by example. Let's go back to the `Service` I defined earlier and see how my use of a class variable could have led to problems down the road.

```
class Service(object):
```

```
    data = []
```

```
    def __init__(self, other_data):
```

```
        self.other_data = other_data
```

```
    ...
```

My goal was to have the empty list (`[]`) as the default value for `data`, and for each instance of `Service` to have *its own data* that would be altered over time on an instance-by-instance basis. But in this case, we get the following behavior (recall that `Service` takes some argument `other_data`, which is arbitrary in this example):

```
s1 = Service(['a', 'b'])
```

```
s2 = Service(['c', 'd'])
```

```
s1.data.append(1)
```

```
s1.data
```

```
## [1]
```

```
s2.data
```

```
## [1]
```

```
s2.data.append(2)
```

```
s1.data
```

```
## [1, 2]
```

```
s2.data
```

```
## [1, 2]
```

This is no good—altering the class variable via one instance alters it for all the others!

At the namespace level... all instances of `Service` are accessing and modifying the same list in `Service.__dict__` without making their own `data` attributes in their instance namespaces.

We could get around this using assignment; that is, instead of exploiting the list's mutability, we could assign our `Service` objects to have their own lists, as follows:

```
s1 = Service(['a', 'b'])
```

```
s2 = Service(['c', 'd'])
```

```
s1.data = [1]
```

```
s2.data = [2]
```

```
s1.data
```

```
## [1]
```

```
s2.data
```

```
## [2]
```

In this case, we're adding `s1._dict['data'] = [1]`, so the original `Service._dict['data']` remains unchanged.

Unfortunately, this requires that `Service` users have intimate knowledge of its variables, and is certainly prone to mistakes. In a sense, we'd be addressing the symptoms rather than the cause. We'd prefer something that was correct by construction.

My personal solution: if you're just using a class variable to assign a default value to a would-be Python instance variable, *don't use mutable values*. In this case, every instance of `Service` was going to override `Service.data` with its own instance attribute eventually, so using an empty list as the default led to a tiny bug that was easily overlooked. Instead of the above, we could've either: Stuck to instance attributes entirely, as demonstrated in the introduction.

Avoided using the empty list (a mutable value) as our "default":

```
class Service(object):
```

```
    data = None
```

```
    def __init__(self, other_data):
```

```
        self.other_data = other_data
```

```
    ...
```

Of course, we'd have to handle the `None` case appropriately, but that's a small price to pay.

So When Should you Use Python Class Attributes?

Class attributes are tricky, but let's look at a few cases when they would come in handy:

Storing constants. As class attributes can be accessed as attributes of the class itself, it's often nice to use them for storing Class-wide, Class-specific constants. For example:

```
class Circle(object):
```

```
    pi = 3.14159
```

```
    def __init__(self, radius):
```

```
        self.radius = radius
```

```
    def area(self):
```

```
        return Circle.pi * self.radius * self.radius
```

```
Circle.pi
```

```
## 3.14159
```

```
c = Circle(10)
```

```
c.pi
## 3.14159
c.area()
## 314.159
```

Defining default values. As a trivial example, we might create a bounded list (i.e., a list that can only hold a certain number of elements or fewer) and choose to have a default cap of 10 items:

```
class MyClass(object):
    limit = 10

    def __init__(self):
        self.data = []

    def item(self, i):
        return self.data[i]

    def add(self, e):
        if len(self.data) >= self.limit:
            raise Exception("Too many elements")
        self.data.append(e)
```

```
MyClass.limit
## 10
```

We could then create instances with their own specific limits, too, by assigning to the instance's `limit` attribute.

```
foo = MyClass()
foo.limit = 50
## foo can now hold 50 elements—other instances can hold 10
```

This only makes sense if you will want your typical instance of `MyClass` to hold just 10 elements or fewer—if you're giving all of your instances different limits, then `limit` should be an instance variable. (Remember, though: take care when using mutable values as your defaults.)

Tracking all data across all instances of a given class. This is sort of specific, but I could see a scenario in which you might want to access a piece of data related to every existing instance of a given class.

To make the scenario more concrete, let's say we have a `Person` class, and every person has a `name`. We want to keep track of all the names that have been used. One approach might be to [iterate over the garbage collector's list of objects](#), but it's simpler to use class variables.

Note that, in this case, `names` will only be accessed as a class variable, so the mutable default is acceptable.

```
class Person(object):
    all_names = []

    def __init__(self, name):
        self.name = name
        Person.all_names.append(name)
```

```
joe = Person('Joe')
bob = Person('Bob')
print Person.all_names
## ['Joe', 'Bob']
```

We could even use this design pattern to track all existing instances of a given class, rather than just some associated data.

```
class Person(object):
    all_people = []

    def __init__(self, name):
        self.name = name
        Person.all_people.append(self)
```

```
joe = Person('Joe')
bob = Person('Bob')
print Person.all_people
## [<_main_.Person object at 0x10e428c50>, <_main_.Person object at 0x10e428c90>]
```

Under-the-hood

Note: *If you're worrying about performance at this level, you might not want to be use Python in the first place, as the differences will be on the order of tenths of a millisecond—but it's still fun to poke around a bit, and helps for illustration's sake.*

Recall that a class's namespace is created and filled in at the time of the class's definition. That means that we do just one assignment—*ever*—for a given class variable, while instance variables must be assigned every time a new instance is created. Let's take an example.

```
def called_class():
    print "Class assignment"
    return 2
```

```
class Bar(object):
    y = called_class()
```

```
    def __init__(self, x):
        self.x = x
```

```
## "Class assignment"
```

```
def called_instance():
    print "Instance assignment"
    return 2
```

```
class Foo(object):
    def __init__(self, x):
```

```
self.y = called_instance()
```

```
self.x = x
```

```
Bar(1)
```

```
Bar(2)
```

```
Foo(1)
```

```
## "Instance assignment"
```

```
Foo(2)
```

```
## "Instance assignment"
```

We assign to `Bar.y` just once, but `instance_of_Foo.y` on every call to `__init__`.

As further evidence, let's use the [Python disassembler](#):

```
import dis
```

```
class Bar(object):
```

```
    y = 2
```

```
    def __init__(self, x):
```

```
        self.x = x
```

```
class Foo(object):
```

```
    def __init__(self, x):
```

```
        self.y = 2
```

```
        self.x = x
```

```
dis.dis(Bar)
```

```
## Disassembly of __init__:
```

```
## 7      0 LOAD_FAST      1 (x)
```

```
##      3 LOAD_FAST      0 (self)
```

```
##      6 STORE_ATTR     0 (x)
```

```
##      9 LOAD_CONST     0 (None)
```

```
##     12 RETURN_VALUE
```

```
dis.dis(Foo)
```

```
## Disassembly of __init__:
```

```
## 11     0 LOAD_CONST     1 (2)
```

```
##      3 LOAD_FAST      0 (self)
```

```
##      6 STORE_ATTR     0 (y)
```

```
##     12     9 LOAD_FAST      1 (x)
```

```
##     12    12 LOAD_FAST      0 (self)
```

##	15 STORE_ATTR	1 (x)
##	18 LOAD_CONST	0 (None)
##	21 RETURN_VALUE	

When we look at the byte code, it's again obvious that `Foo.__init__` has to do two assignments, while `Bar.__init__` does just one.

In practice, what does this gain really look like? I'll be the first to admit that timing tests are highly dependent on often uncontrollable factors and the differences between them are often hard to explain accurately.

However, I think these small snippets (run with the Python [timeit](#) module) help to illustrate the differences between class and instance variables, so I've included them anyway.

Note: I'm on a MacBook Pro with OS X 10.8.5 and Python 2.7.2.

Initialization

```
10000000 calls to `Bar(2)`: 4.940s
```

```
10000000 calls to `Foo(2)`: 6.043s
```

The initializations of `Bar` are faster by over a second, so the difference here does appear to be statistically significant.

So why is this the case? One *speculative* explanation: we do two assignments in `Foo.__init__`, but just one in `Bar.__init__`.

Assignment

```
10000000 calls to `Bar(2).y = 15`: 6.232s
```

```
10000000 calls to `Foo(2).y = 15`: 6.855s
```

```
10000000 `Bar` assignments: 6.232s - 4.940s = 1.292s
```

```
10000000 `Foo` assignments: 6.855s - 6.043s = 0.812s
```

Note: There's no way to re-run your setup code on each trial with [timeit](#), so we have to reinitialize our variable on our trial. The second line of times represents the above times with the previously calculated initialization times deducted.

From the above, it looks like `Foo` only takes about 60% as long as `Bar` to handle assignments.

Why is this the case? One *speculative* explanation: when we assign to `Bar(2).y`, we first look in the instance namespace (`Bar(2).__dict__[y]`), fail to find `y`, and then look in the class namespace (`Bar.__dict__[y]`), then making the proper assignment. When we assign to `Foo(2).y`, we do half as many lookups, as we immediately assign to the instance namespace (`Foo(2).__dict__[y]`).

In summary, though these performance gains won't matter in reality, these tests are interesting at the conceptual level. If anything, I hope these differences help illustrate the mechanical distinctions between class and instance variables.

Instances as Return Values

Functions and methods can return objects. This is actually nothing new since everything in Python is an object and we have been returning values for quite some time. The difference here is that we want to have the method create an object using the constructor and then return it as the value of the method.

Suppose you have a point object and wish to find the midpoint halfway between it and some other target point. We would like to write a method, call it `halfway` that takes another `Point` as a parameter and returns the `Point` that is halfway between the point and the target.

class `Point`:

```
def __init__(self, initX, initY):
    """ Create a new point at the given coordinates. """
    self.x = initX
    self.y = initY
```

```

def getX(self):
    return self.x

def getY(self):
    return self.y

def distanceFromOrigin(self):
    return ((self.x ** 2) + (self.y ** 2)) ** 0.5

def __str__(self):
    return "x=" + str(self.x) + ", y=" + str(self.y)

def halfway(self, target):
    mx = (self.x + target.x) / 2
    my = (self.y + target.y) / 2
    return Point(mx, my)

```

```

p = Point(3, 4)
q = Point(5, 12)
mid = p.halfway(q)

```

```

print(mid)
print(mid.getX())
print(mid.getY())

```

```

output:
x=4.0,
4.0
8.0

```

y=8.0

The resulting Point, mid, has an x value of 4 and a y value of 8. We can also use any other methods since mid is a Point object.

In the definition of the method halfway see how the requirement to always use dot notation with attributes disambiguates the meaning of the attributes x and y: We can always see whether the coordinates of Point self or target are being referred to.

Copying Mutable Objects by Reference

Let's see what happens if we give **two names** of the same object for a mutable data types.

```

Output:
2450343166664
2450343166664
True
[4, 5, 6, 7]

```

We can see that the variable names have the **same identity** meaning that they are referencing to the **same object** in computer memory. Reminder: the **is operator** compares the identity of two objects.

So, when we have changed the values of the second variable, the values of the first one are also changed. This happens only with the mutable objects. You can see how you can prevent this in [one](#) of my previous blog posts.

Copying Immutable Objects

Let's try to do a similar example with an immutable object. We can try to copy two strings and change the value in any of them.

```

text = "Python"
text2 = text
print(id(text))
print(id(text2))
print(text is text2)
print()

```



```
text += " is awesome"
print(id(text))
print(id(text2))
print(text is text2)
print()
```

```
print(text)
print(text2)
```

```
Output:
3063511450488
3063511450488
True
```

```
3063551623648
3063511450488
False
```

```
Python                is                awesome
Python
```

Mutable objects:

list, dict, set, byte array

A practical example to find out the mutability of object types

```
x = 10x = y
```

classes and functions:

Classes

Classes provide a means of bundling data and functionality together. Creating a new class creates a new *type* of object, allowing new *instances* of that type to be made. Each class instance can have attributes attached to it for maintaining its state. Class instances can also have methods (defined by its class) for modifying its state.

Compared with other programming languages, Python's class mechanism adds classes with a minimum of new syntax and semantics. It is a mixture of the class mechanisms found in C++ and Modula-3. Python classes provide all the standard features of Object Oriented Programming: the class inheritance mechanism allows multiple base classes, a derived class can override any methods of its base class or classes, and a method can call the method of a base class with the same name. Objects can contain arbitrary amounts and kinds of data. As is true for modules, classes partake of the dynamic nature of Python: they are created at runtime, and can be modified further after creation.

In C++ terminology, normally class members (including the data members) are *public* (except see below Private Variables), and all member functions are *virtual*. As in Modula-3, there are no shorthands for referencing the object's members from its methods: the method function is declared with an explicit first argument representing the object, which is provided implicitly by the call. As in Smalltalk, classes themselves are objects. This provides semantics for importing and renaming. Unlike C++ and Modula-3, built-in types can be used as base classes for extension by the user. Also, like in C++, most built-in operators with special syntax (arithmetic operators, subscripting etc.) can be redefined for class instances.

(Lacking universally accepted terminology to talk about classes, I will make occasional use of Smalltalk and C++ terms. I would use Modula-3 terms, since its object-oriented semantics are closer to those of Python than C++, but I expect that few readers have heard of it.)

A Word About Names and Objects

Objects have individuality, and multiple names (in multiple scopes) can be bound to the same object. This is known as aliasing in other languages. This is usually not appreciated on a first glance at Python, and can be safely ignored when dealing with immutable basic types (numbers, strings, tuples). However, aliasing has a possibly surprising effect on the semantics of Python code involving mutable objects such as lists, dictionaries, and most other types. This is usually used to the benefit of the program, since aliases behave like pointers in some respects. For example, passing an object is cheap since only a pointer is passed by the implementation; and

if a function modifies an object passed as an argument, the caller will see the change — this eliminates the need for two different argument passing mechanisms as in Pascal.

Python Scopes and Namespaces

Before introducing classes, I first have to tell you something about Python's scope rules. Class definitions play some neat tricks with namespaces, and you need to know how scopes and namespaces work to fully understand what's going on. Incidentally, knowledge about this subject is useful for any advanced Python programmer.

Let's begin with some definitions.

A *namespace* is a mapping from names to objects. Most namespaces are currently implemented as Python dictionaries, but that's normally not noticeable in any way (except for performance), and it may change in the future. Examples of namespaces are: the set of built-in names (containing functions such as `abs()`, and built-in exception names); the global names in a module; and the local names in a function invocation. In a sense the set of attributes of an object also form a namespace. The important thing to know about namespaces is that there is absolutely no relation between names in different namespaces; for instance, two different modules may both define a function `maximize` without confusion — users of the modules must prefix it with the module name.

By the way, I use the word *attribute* for any name following a dot — for example, in the expression `z.real`, `real` is an attribute of the object `z`. Strictly speaking, references to names in modules are attribute references: in the expression `modname.funcname`, `modname` is a module object and `funcname` is an attribute of it. In this case there happens to be a straightforward mapping between the module's attributes and the global names defined in the module: they share the same namespace!

Attributes may be read-only or writable. In the latter case, assignment to attributes is possible. Module attributes are writable: you can write `modname.the_answer = 42`. Writable attributes may also be deleted with the `del` statement. For example, `del modname.the_answer` will remove the attribute `the_answer` from the object named by `modname`.

Namespaces are created at different moments and have different lifetimes. The namespace containing the built-in names is created when the Python interpreter starts up, and is never deleted. The global namespace for a module is created when the module definition is read in; normally, module namespaces also last until the interpreter quits. The statements executed by the top-level invocation of the interpreter, either read from a script file or interactively, are considered part of a module called `_main_`, so they have their own global namespace. (The built-in names actually also live in a module; this is called `builtins`.)

The local namespace for a function is created when the function is called, and deleted when the function returns or raises an exception that is not handled within the function. (Actually, forgetting would be a better way to describe what actually happens.) Of course, recursive invocations each have their own local namespace.

A *scope* is a textual region of a Python program where a namespace is directly accessible. "Directly accessible" here means that an unqualified reference to a name attempts to find the name in the namespace.

Although scopes are determined statically, they are used dynamically. At any time during execution, there are 3 or 4 nested scopes whose namespaces are directly accessible:

- the innermost scope, which is searched first, contains the local names

- the scopes of any enclosing functions, which are searched starting with the nearest enclosing scope, contains non-local, but also non-global names

- the next-to-last scope contains the current module's global names

- the outermost scope (searched last) is the namespace containing built-in names

If a name is declared global, then all references and assignments go directly to the middle scope containing the module's global names. To rebind variables found outside of the innermost scope, the `nonlocal` statement can be used; if not declared `nonlocal`, those variables are read-only (an attempt to write to such a variable will simply create a *new* local variable in the innermost scope, leaving the identically named outer variable unchanged).

Usually, the local scope references the local names of the (textually) current function. Outside functions, the local scope references the same namespace as the global scope: the module's namespace. Class definitions place yet another namespace in the local scope.

It is important to realize that scopes are determined textually: the global scope of a function defined in a module is that module's namespace, no matter from where or by what alias the function is called. On the other hand, the actual search for names is done dynamically, at run time — however, the language definition is evolving towards

static name resolution, at “compile” time, so don’t rely on dynamic name resolution! (In fact, local variables are already determined statically.)

A special quirk of Python is that – if no global or nonlocal statement is in effect – assignments to names always go into the innermost scope. Assignments do not copy data — they just bind names to objects. The same is true for deletions: the statement `del x` removes the binding of `x` from the namespace referenced by the local scope. In fact, all operations that introduce new names use the local scope: in particular, import statements and function definitions bind the module or function name in the local scope.

The `global` statement can be used to indicate that particular variables live in the global scope and should be rebound there; the `nonlocal` statement indicates that particular variables live in an enclosing scope and should be rebound there.

Scopes and Namespaces Example

This is an example demonstrating how to reference the different scopes and namespaces, and how global and nonlocal affect variable binding:

```
def scope_test():
    def do_local():
        spam = "local spam"

    def do_nonlocal():
        nonlocal spam
        spam = "nonlocal spam"

    def do_global():
        global spam
        spam = "global spam"

    spam = "test spam"
    do_local()
    print("After local assignment:", spam)
    do_nonlocal()
    print("After nonlocal assignment:", spam)
    do_global()
    print("After global assignment:", spam)
```

```
scope_test()
print("In global scope:", spam)
```

The output of the example code is:

After local assignment: test spam

After nonlocal assignment: nonlocal spam

After global assignment: nonlocal spam

In global scope: global spam

Note how the *local* assignment (which is default) didn’t change *scope_test*’s binding of *spam*. The nonlocal assignment changed *scope_test*’s binding of *spam*, and the global assignment changed the module-level binding.

You can also see that there was no previous binding for *spam* before the global assignment.

A First Look at Classes

Classes introduce a little bit of new syntax, three new object types, and some new semantics.

Class Definition Syntax

The simplest form of class definition looks like this:

```
class ClassName:
    <statement-1>
    .
    .
    .
    <statement-N>
```

Class definitions, like function definitions (def statements) must be executed before they have any effect. (You could conceivably place a class definition in a branch of an if statement, or inside a function.)

In practice, the statements inside a class definition will usually be function definitions, but other statements are allowed, and sometimes useful — we'll come back to this later. The function definitions inside a class normally have a peculiar form of argument list, dictated by the calling conventions for methods — again, this is explained later.

When a class definition is entered, a new namespace is created, and used as the local scope — thus, all assignments to local variables go into this new namespace. In particular, function definitions bind the name of the new function here.

When a class definition is left normally (via the end), a *class object* is created. This is basically a wrapper around the contents of the namespace created by the class definition; we'll learn more about class objects in the next section. The original local scope (the one in effect just before the class definition was entered) is reinstated, and the class object is bound here to the class name given in the class definition header (ClassName in the example).

Class Objects

Class objects support two kinds of operations: attribute references and instantiation.

Attribute references use the standard syntax used for all attribute references in Python: `obj.name`. Valid attribute names are all the names that were in the class's namespace when the class object was created. So, if the class definition looked like this:

```
class MyClass:
    """A simple example class"""
    i = 12345
```

```
    def f(self):
        return 'hello world'
```

then `MyClass.i` and `MyClass.f` are valid attribute references, returning an integer and a function object, respectively. Class attributes can also be assigned to, so you can change the value of `MyClass.i` by assignment. `__doc__` is also a valid attribute, returning the docstring belonging to the class: "A simple example class".

Class *instantiation* uses function notation. Just pretend that the class object is a parameterless function that returns a new instance of the class. For example (assuming the above class):

```
x = MyClass()
creates a new instance of the class and assigns this object to the local variable x.
```

The instantiation operation ("calling" a class object) creates an empty object. Many classes like to create objects with instances customized to a specific initial state. Therefore a class may define a special method named `__init__()`, like this:

```
def __init__(self):
    self.data = []
```

When a class defines an `__init__()` method, class instantiation automatically invokes `__init__()` for the newly-created class instance. So in this example, a new, initialized instance can be obtained by:

```
x = MyClass()
```

Of course, the `__init__()` method may have arguments for greater flexibility. In that case, arguments given to the class instantiation operator are passed on to `__init__()`. For example,

```
>>>
>>> class Complex:
...     def __init__(self, realpart, imagpart):
...         self.r = realpart
...         self.i = imagpart
...
>>> x = Complex(3.0, -4.5)
>>> x.r, x.i
(3.0, -4.5)
```

Instance Objects

Now what can we do with instance objects? The only operations understood by instance objects are attribute references. There are two kinds of valid attribute names: data attributes and methods.

data attributes correspond to “instance variables” in Smalltalk, and to “data members” in C++. Data attributes need not be declared; like local variables, they spring into existence when they are first assigned to. For example, if `x` is the instance of `MyClass` created above, the following piece of code will print the value `16`, without leaving a trace:

```
x.counter = 1
while x.counter < 10:
    x.counter = x.counter * 2
print(x.counter)
del x.counter
```

The other kind of instance attribute reference is a *method*. A method is a function that “belongs to” an object. (In Python, the term method is not unique to class instances: other object types can have methods as well. For example, list objects have methods called `append`, `insert`, `remove`, `sort`, and so on. However, in the following discussion, we’ll use the term method exclusively to mean methods of class instance objects, unless explicitly stated otherwise.)

Valid method names of an instance object depend on its class. By definition, all attributes of a class that are function objects define corresponding methods of its instances. So in our example, `x.f` is a valid method reference, since `MyClass.f` is a function, but `x.i` is not, since `MyClass.i` is not. But `x.f` is not the same thing as `MyClass.f` — it is a *method object*, not a function object.

Method Objects

Usually, a method is called right after it is bound:

```
x.f()
```

In the `MyClass` example, this will return the string `'hello world'`. However, it is not necessary to call a method right away: `x.f` is a method object, and can be stored away and called at a later time. For example:

```
xf = x.f
while True:
    print(xf())
```

will continue to print `hello world` until the end of time.

What exactly happens when a method is called? You may have noticed that `x.f()` was called without an argument above, even though the function definition for `f()` specified an argument. What happened to the argument? Surely Python raises an exception when a function that requires an argument is called without any — even if the argument isn’t actually used...

Actually, you may have guessed the answer: the special thing about methods is that the instance object is passed as the first argument of the function. In our example, the call `x.f()` is exactly equivalent to `MyClass.f(x)`. In general, calling a method with a list of n arguments is equivalent to calling the corresponding function with an argument list that is created by inserting the method’s instance object before the first argument.

If you still don’t understand how methods work, a look at the implementation can perhaps clarify matters. When a non-data attribute of an instance is referenced, the instance’s class is searched. If the name denotes a valid class attribute that is a function object, a method object is created by packing (pointers to) the instance object and the function object just found together in an abstract object: this is the method object. When the method object is called with an argument list, a new argument list is constructed from the instance object and the argument list, and the function object is called with this new argument list.

Class and Instance Variables

Generally speaking, instance variables are for data unique to each instance and class variables are for attributes and methods shared by all instances of the class:

```
class Dog:
```

```
    kind = 'canine'      # class variable shared by all instances
```

```
def __init__(self, name):
    self.name = name    # instance variable unique to each instance
```

```
>>> d = Dog('Fido')
>>> e = Dog('Buddy')
>>> d.kind          # shared by all dogs
'canine'
>>> e.kind          # shared by all dogs
'canine'
>>> d.name          # unique to d
'Fido'
>>> e.name          # unique to e
'Buddy'
```

As discussed in A Word About Names and Objects, shared data can have possibly surprising effects with involving mutable objects such as lists and dictionaries. For example, the *tricks* list in the following code should not be used as a class variable because just a single list would be shared by all *Dog* instances:

class Dog:

```
    tricks = []          # mistaken use of a class variable
```

```
    def __init__(self, name):
        self.name = name
```

```
    def add_trick(self, trick):
        self.tricks.append(trick)
```

```
>>> d = Dog('Fido')
>>> e = Dog('Buddy')
>>> d.add_trick('roll over')
>>> e.add_trick('play dead')
>>> d.tricks          # unexpectedly shared by all dogs
['roll over', 'play dead']
```

Correct design of the class should use an instance variable instead:

class Dog:

```
    def __init__(self, name):
        self.name = name
        self.tricks = []    # creates a new empty list for each dog
```

```
    def add_trick(self, trick):
        self.tricks.append(trick)
```

```
>>> d = Dog('Fido')
>>> e = Dog('Buddy')
>>> d.add_trick('roll over')
>>> e.add_trick('play dead')
>>> d.tricks
['roll over']
>>> e.tricks
['play dead']
```

Random Remarks

If the same attribute name occurs in both an instance and in a class, then attribute lookup prioritizes the instance:

```
>>>
>>> class Warehouse:
    purpose = 'storage'
```

```

region = 'west'

>>> w1 = Warehouse()
>>> print(w1.purpose, w1.region)
storage west
>>> w2 = Warehouse()
>>> w2.region = 'east'
>>> print(w2.purpose, w2.region)
storage east

```

Data attributes may be referenced by methods as well as by ordinary users (“clients”) of an object. In other words, classes are not usable to implement pure abstract data types. In fact, nothing in Python makes it possible to enforce data hiding — it is all based upon convention. (On the other hand, the Python implementation, written in C, can completely hide implementation details and control access to an object if necessary; this can be used by extensions to Python written in C.)

Clients should use data attributes with care — clients may mess up invariants maintained by the methods by stamping on their data attributes. Note that clients may add data attributes of their own to an instance object without affecting the validity of the methods, as long as name conflicts are avoided — again, a naming convention can save a lot of headaches here.

There is no shorthand for referencing data attributes (or other methods!) from within methods. I find that this actually increases the readability of methods: there is no chance of confusing local variables and instance variables when glancing through a method.

Often, the first argument of a method is called `self`. This is nothing more than a convention: the name `self` has absolutely no special meaning to Python. Note, however, that by not following the convention your code may be less readable to other Python programmers, and it is also conceivable that a *class browser* program might be written that relies upon such a convention.

Any function object that is a class attribute defines a method for instances of that class. It is not necessary that the function definition is textually enclosed in the class definition: assigning a function object to a local variable in the class is also ok. For example:

Function defined outside the class

```

def f1(self, x, y):
    return min(x, x+y)

```

class C:

```

    f = f1

```

```

    def g(self):
        return 'hello world'

```

```

    h = g

```

Now `f`, `g` and `h` are all attributes of class `C` that refer to function objects, and consequently they are all methods of instances of `C` — `h` being exactly equivalent to `g`. Note that this practice usually only serves to confuse the reader of a program.

Methods may call other methods by using method attributes of the `self` argument:

class Bag:

```

    def __init__(self):
        self.data = []

```

```

    def add(self, x):
        self.data.append(x)

```

```

    def addtwice(self, x):
        self.add(x)
        self.add(x)

```

Methods may reference global names in the same way as ordinary functions. The global scope associated with a method is the module containing its definition. (A class is never used as a global scope.) While one rarely encounters a good reason for using global data in a method, there are many legitimate uses of the global scope: for one thing, functions and modules imported into the global scope can be used by methods, as well as functions and classes defined in it. Usually, the class containing the method is itself defined in this global scope, and in the next section we'll find some good reasons why a method would want to reference its own class. Each value is an object, and therefore has a *class* (also called its *type*). It is stored as `object.__class__`.

Inheritance

Of course, a language feature would not be worthy of the name “class” without supporting inheritance. The syntax for a derived class definition looks like this:

```
class DerivedClassName(BaseClassName):
```

```
<statement-1>
```

```
·  
·  
·
```

```
<statement-N>
```

The name `BaseClassName` must be defined in a scope containing the derived class definition. In place of a base class name, other arbitrary expressions are also allowed. This can be useful, for example, when the base class is defined in another module:

```
class DerivedClassName(modname.BaseClassName):
```

Execution of a derived class definition proceeds the same as for a base class. When the class object is constructed, the base class is remembered. This is used for resolving attribute references: if a requested attribute is not found in the class, the search proceeds to look in the base class. This rule is applied recursively if the base class itself is derived from some other class.

There's nothing special about instantiation of derived classes: `DerivedClassName()` creates a new instance of the class. Method references are resolved as follows: the corresponding class attribute is searched, descending down the chain of base classes if necessary, and the method reference is valid if this yields a function object.

Derived classes may override methods of their base classes. Because methods have no special privileges when calling other methods of the same object, a method of a base class that calls another method defined in the same base class may end up calling a method of a derived class that overrides it. (For C++ programmers: all methods in Python are effectively `virtual`.)

An overriding method in a derived class may in fact want to extend rather than simply replace the base class method of the same name. There is a simple way to call the base class method directly: just call `BaseClassName.methodname(self, arguments)`. This is occasionally useful to clients as well. (Note that this only works if the base class is accessible as `BaseClassName` in the global scope.)

Python has two built-in functions that work with inheritance:

Use `isinstance()` to check an instance's type: `isinstance(obj, int)` will be `True` only if `obj.__class__` is `int` or some class derived from `int`.

Use `issubclass()` to check class inheritance: `issubclass(bool, int)` is `True` since `bool` is a subclass of `int`. However, `issubclass(float, int)` is `False` since `float` is not a subclass of `int`.

Multiple Inheritance

Python supports a form of multiple inheritance as well. A class definition with multiple base classes looks like this:

```
class DerivedClassName(Base1, Base2, Base3):
```

```
<statement-1>
```

```
·  
·  
·
```

```
<statement-N>
```


For most purposes, in the simplest cases, you can think of the search for attributes inherited from a parent class as depth-first, left-to-right, not searching twice in the same class where there is an overlap in the hierarchy. Thus, if an attribute is not found in `DerivedClassName`, it is searched for in `Base1`, then (recursively) in the base classes of `Base1`, and if it was not found there, it was searched for in `Base2`, and so on.

In fact, it is slightly more complex than that; the method resolution order changes dynamically to support cooperative calls to `super()`. This approach is known in some other multiple-inheritance languages as call-next-method and is more powerful than the `super` call found in single-inheritance languages.

Dynamic ordering is necessary because all cases of multiple inheritance exhibit one or more diamond relationships (where at least one of the parent classes can be accessed through multiple paths from the bottommost class). For example, all classes inherit from `object`, so any case of multiple inheritance provides more than one path to reach `object`. To keep the base classes from being accessed more than once, the dynamic algorithm linearizes the search order in a way that preserves the left-to-right ordering specified in each class, that calls each parent only once, and that is monotonic (meaning that a class can be subclassed without affecting the precedence order of its parents). Taken together, these properties make it possible to design reliable and extensible classes with multiple inheritance.

Private Variables

“Private” instance variables that cannot be accessed except from inside an object don’t exist in Python. However, there is a convention that is followed by most Python code: a name prefixed with an underscore (e.g. `_spam`) should be treated as a non-public part of the API (whether it is a function, a method or a data member). It should be considered an implementation detail and subject to change without notice.

Since there is a valid use-case for class-private members (namely to avoid name clashes of names with names defined by subclasses), there is limited support for such a mechanism, called *name mangling*. Any identifier of the form `_spam` (at least two leading underscores, at most one trailing underscore) is textually replaced with `_classname_spam`, where `classname` is the current class name with leading underscore(s) stripped. This mangling is done without regard to the syntactic position of the identifier, as long as it occurs within the definition of a class.

Name mangling is helpful for letting subclasses override methods without breaking intraclass method calls. For example:

class Mapping:

```
def __init__(self, iterable):
    self.items_list = []
    self.__update(iterable)
```

```
def update(self, iterable):
    for item in iterable:
        self.items_list.append(item)
```

```
__update = update # private copy of original update() method
```

class MappingSubclass(Mapping):

```
def update(self, keys, values):
    # provides new signature for update()
    # but does not break __init__()
    for item in zip(keys, values):
        self.items_list.append(item)
```

The above example would work even if `MappingSubclass` were to introduce a `_update` identifier since it is replaced with `_Mapping__update` in the `Mapping` class and `_MappingSubclass_update` in the `MappingSubclass` class respectively.

Note that the mangling rules are designed mostly to avoid accidents; it still is possible to access or modify a variable that is considered private. This can even be useful in special circumstances, such as in the debugger.

Notice that code passed to `exec()` or `eval()` does not consider the classname of the invoking class to be the current class; this is similar to the effect of the `global` statement, the effect of which is likewise restricted to code that is byte-compiled together. The same restriction applies to `getattr()`, `setattr()` and `delattr()`, as well as when referencing `_dict_` directly.

Odds and Ends

Sometimes it is useful to have a data type similar to the Pascal “record” or C “struct”, bundling together a few named data items. An empty class definition will do nicely:

```
class Employee:
```

```
    pass
```

```
john = Employee() # Create an empty employee record
```

```
# Fill the fields of the record
```

```
john.name = 'John Doe'
```

```
john.dept = 'computer lab'
```

```
john.salary = 1000
```

A piece of Python code that expects a particular abstract data type can often be passed a class that emulates the methods of that data type instead. For instance, if you have a function that formats some data from a file object, you can define a class with methods `read()` and `readline()` that get the data from a string buffer instead, and pass it as an argument.

Instance method objects have attributes, too: `m.__self__` is the instance object with the method `m()`, and `m.__func__` is the function object corresponding to the method.

Iterators

By now you have probably noticed that most container objects can be looped over using a `for` statement:

```
for element in [1, 2, 3]:
```

```
    print(element)
```

```
for element in (1, 2, 3):
```

```
    print(element)
```

```
for key in {'one':1, 'two':2}:
```

```
    print(key)
```

```
for char in "123":
```

```
    print(char)
```

```
for line in open("myfile.txt"):
```

```
    print(line, end="")
```

This style of access is clear, concise, and convenient. The use of iterators pervades and unifies Python. Behind the scenes, the `for` statement calls `iter()` on the container object. The function returns an iterator object that defines the method `__next__()` which accesses elements in the container one at a time. When there are no more elements, `__next__()` raises a `StopIteration` exception which tells the `for` loop to terminate. You can call the `__next__()` method using the `next()` built-in function; this example shows how it all works:

```
>>>
```

```
>>> s = 'abc'
```

```
>>> it = iter(s)
```

```
>>> it
```

```
<iterator object at 0x00A1DB50>
```

```
>>> next(it)
```

```
'a'
```

```
>>> next(it)
```

```
'b'
```

```
>>> next(it)
```

```
'c'
```

```
>>> next(it)
```

```
Traceback (most recent call last):
```

```
File "<stdin>", line 1, in <module>
    next(it)
StopIteration
```

Having seen the mechanics behind the iterator protocol, it is easy to add iterator behavior to your classes. Define an `__iter__()` method which returns an object with a `__next__()` method. If the class defines `__next__()`, then `__iter__()` can just return `self`:

```
class Reverse:
    """Iterator for looping over a sequence backwards."""
    def init_(self, data):
        self.data = data
        self.index = len(data)

    def iter_(self):
        return self

    def next__(self):
        if self.index == 0:
            raise StopIteration
        self.index = self.index - 1
        return self.data[self.index]
```

```
>>>
>>> rev = Reverse('spam')
>>> iter(rev)
<_main_.Reverse object at 0x00A1DB50>
>>> for char in rev:
...     print(char)
...
m
a
p
s
```

Generators

Generators are a simple and powerful tool for creating iterators. They are written like regular functions but use the `yield` statement whenever they want to return data. Each time `next()` is called on it, the generator resumes where it left off (it remembers all the data values and which statement was last executed). An example shows that generators can be trivially easy to create:

```
def reverse(data):
    for index in range(len(data)-1, -1, -1):
        yield data[index]
```

```
>>>
>>> for char in reverse('golf'):
...     print(char)
...
f
l
o
g
```

Anything that can be done with generators can also be done with class-based iterators as described in the previous section. What makes generators so compact is that `__iter__()` and `__next__()` methods are created automatically.

Another key feature is that the local variables and execution state are automatically saved between calls. This made the function easier to write and much more clear than an approach using instance variables like `self.index` and `self.data`.

In addition to automatic method creation and saving program state, when generators terminate, they automatically raise `StopIteration`. In combination, these features make it easy to create iterators with no more effort than writing a regular function.

Generator Expressions

Some simple generators can be coded succinctly as expressions using a syntax similar to list comprehensions but with parentheses instead of square brackets. These expressions are designed for situations where the generator is used right away by an enclosing function. Generator expressions are more compact but less versatile than full generator definitions and tend to be more memory friendly than equivalent list comprehensions.

Examples:

```
>>>
>>> sum(i*i for i in range(10))          # sum of squares
285

>>> xvec = [10, 20, 30]
>>> yvec = [7, 5, 3]
>>> sum(x*y for x,y in zip(xvec, yvec))  # dot product
260

>>> unique_words = set(word for line in page for word in line.split())

>>> valedictorian = max((student.gpa, student.name) for student in graduates)

>>> data = 'golf'
>>> list(data[i] for i in range(len(data)-1, -1, -1))
['f', 'l', 'o', 'g']
```

Python - Functions

A function is a set of statements that take inputs, do some specific computation and produces output. The idea is to put some commonly or repeatedly done task together and make a function, so that instead of writing the same code again and again for different inputs, we can call the function.

Python provides built-in functions like `print()`, etc. but we can also create your own functions. These functions are called user-defined functions.

A simple Python function to check

whether x is even or odd

```
def evenOdd( x ):
    if (x % 2 == 0):
        print "even"
    else:
        print "odd"
```

Driver code

```
evenOdd(2)
```

```
evenOdd(3)
```

Output:

```
even
```

```
odd
```

Pass by Reference or pass by value

One important thing to note is, in Python every variable name is a reference. When we pass a variable to a function, a new reference to the object is created. Parameter passing in Python is same as reference passing in Java.

```
filter_none
edit
play_arrow
brightness_4
# Here x is a new reference to same list lst
def myFun(x):
    x[0] = 20

# Driver Code (Note that lst is modified
# after function call.
lst = [10, 11, 12, 13, 14, 15]
myFun(lst);
print(lst)
```

Output:

```
[20, 11, 12, 13, 14, 15]
```

When we pass a reference and change the received reference to something else, the connection between passed and received parameter is broken. For example, consider below program.

Chapter-4 Classes and Objects

1.Classes

We have already seen how we can use a dictionary to group related data together, and how we can use functions to create shortcuts for commonly used groups of statements. A function performs an action using some set of input parameters. Not all functions are applicable to all kinds of data. *Classes* are a way of grouping together related data *and* functions which act upon that data.

A class is a kind of data type, just like a string, integer or list. When we create an object of that data type, we call it an *instance* of a class.

As we have already mentioned, in some other languages some entities are objects and some are not. In Python, everything is an object – everything is an instance of some class. In earlier versions of Python a distinction was made between built-in types and user-defined classes, but these are now completely indistinguishable. Classes and types are themselves objects, and they are of type `type`. You can find out the type of any object using the `type` function:

```
type(any_object)
```

The data values which we store inside an object are called *attributes*, and the functions which are associated with the object are called *methods*. We have already used the methods of some built-in objects, like strings and lists. When we design our own objects, we have to decide how we are going to group things together, and what our objects are going to represent.

Sometimes we write objects which map very intuitively onto things in the real world. For example, if we are writing code to simulate chemical reactions, we might have `Atom` objects which we can combine to make

a `Molecule` object. However, it isn't always necessary, desirable or even possible to make all code objects perfectly analogous to their real-world counterparts.

Sometimes we may create objects which don't have any kind of real-world equivalent, just because it's useful to group certain functions together.

Defining and using a class

Here is an example of a simple custom class which stores information about a person:

```
import datetime # we will use this for date objects

class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

    def age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month, self.birthdate.day):
            age -= 1

        return age

person = Person(
    "Jane",
    "Doe",
    datetime.date(1992, 3, 12), # year, month, day
    "No. 12 Short Street, Greenville",
    "555 456 0987",
    "jane.doe@example.com"
)

print(person.name)
print(person.email)
print(person.age())
```

We start the class definition with the `class` keyword, followed by the class name and a colon. We would list any parent classes in between round brackets before the colon, but this class doesn't have any, so we can leave them out.

Inside the class body, we define two functions – these are our object's methods. The first is called `__init__`, which is a special method. When we call the class object, a new instance of the class is created, and the `__init__` method on this new object is immediately executed with all the parameters that we passed to the class object. The purpose of this method is thus to set up a new object using data that we have provided. The second method is a custom method which calculates the age of our person using the birthdate and the current date.

Note

`__init__` is sometimes called the object's *constructor*, because it is used similarly to the way that constructors are used in other languages, but that is not technically correct – it's better to call it the *initialiser*. There is a different method called `__new__` which is more analogous to a constructor, but it is hardly ever used.

You may have noticed that both of these method definitions have `self` as the first parameter, and we use this variable inside the method bodies – but we don't appear to pass this parameter in. This is because whenever we call a method on an object, *the object itself* is automatically passed in as the first parameter. This gives us a way to access the object's properties from inside the object's methods.

In some languages this parameter is *implicit* – that is, it is not visible in the function signature – and we access it with a special keyword. In Python it is explicitly exposed. It doesn't have to be called `self`, but this is a very strongly followed convention.

Now you should be able to see that our `__init__` function creates attributes on the object and sets them to the values we have passed in as parameters. We use the same names for the attributes and the parameters, but this is not compulsory.

The `age` function doesn't take any parameters except `self` – it only uses information stored in the object's attributes, and the current date (which it retrieves using the `datetime` module).

Note that the `birthdate` attribute is itself an object. The `date` class is defined in the `datetime` module, and we create a new instance of this class to use as the `birthdate` parameter when we create an instance of the `Person` class. We don't have to assign it to an intermediate variable before using it as a parameter to `Person`; we can just create it when we call `Person`, just like we create the string literals for the other parameters.

3. Instances as Return Values

Functions and methods can return objects. This is actually nothing new since everything in Python is an object and we have been returning values for quite some time. The difference here is that we want to have the method create an object using the constructor and then return it as the value of the method.

Suppose you have a point object and wish to find the midpoint halfway between it and some other target point. We would like to write a method, call it `halfway` that takes another `Point` as a parameter and returns the `Point` that is halfway between the point and the target.

RunLoadHistoryShow CodeLens

int:

```
def __init__(self, initX, initY):
    """ Create a new point at the given coordinates. """
    self.x = initX
    self.y = initY

    def getX(self):
        return self.x

    def getY(self):
        return self.y

    def distanceFromOrigin(self):
        return ((self.x ** 2) + (self.y ** 2)) ** 0.5

    def __str__(self):
        return "x=" + str(self.x) + ", y=" + str(self.y)

    def halfway(self, target):
```

```
mx = (self.x + target.x) / 2
my = (self.y + target.y) / 2
return Point(mx, my)
```

```
p = Point(3, 4)
q = Point(5, 12)
mid = p.halfway(q)
```

```
print(mid)
print(mid.getX())
print(mid.getY())
```

The resulting Point, `mid`, has an x value of 4 and a y value of 8. We can also use any other methods since `mid` is a Point object.

In the definition of the method `halfway` see how the requirement to always use dot notation with attributes disambiguates the meaning of the attributes `x` and `y`: We can always see whether the coordinates of Point `self` or `target` are being referred to.

Mutable vs Immutable Objects in Python

Every variable in python holds an instance of an object. There are two types of objects in python i.e. **Mutable** and **Immutable objects**. Whenever an object is instantiated, it is assigned a unique object id. The type of the object is defined at the runtime and it can't be changed afterwards. However, it's state can be changed if it is a mutable object.

To summarise the difference, mutable objects can change their state or contents and immutable objects can't change their state or content.

Immutable Objects : These are of in-built types like **int, float, bool, string, unicode, tuple**. In simple words, an immutable object can't be changed after it is created.

```
filter_none
```

```
edit
```

```
play_arrow
```

```
brightness_4
```

```
# Python code to test that
# tuples are immutable
```

```
tuple1 =(0, 1, 2, 3)
tuple1[0] =4
print(tuple1)
```

```
Error :
```

```
Traceback (most recent call last):
```

```
File "e0eaddff843a8695575daec34506f126.py", line 3, in
tuple1[0]=4
```

```
TypeError: 'tuple' object does not support item assignment
```

```
filter_none
```

```
edit
```

```
play_arrow
```

```
brightness_4
```

```
# Python code to test that
# strings are immutable
```

```
message ="Welcome to GeeksforGeeks"
message[0] ='p'
print(message)
```

```
Error :
```

```
Traceback (most recent call last):
```

```
File "/home/ff856d3c5411909530c4d328eeca165b.py", line 3, in
```



```
message[0] = 'p'  
TypeError: 'str' object does not support item assignment
```

Mutable Objects : These are of type [list, dict, set](#) . Custom classes are generally mutable.

```
# Python code to test that  
# lists are mutable  
color = ["red", "blue", "green"]  
print(color)
```

```
color[0] = "pink"  
color[-1] = "orange"  
print(color)
```

Output: ['red', 'blue', 'green']
['pink', 'blue', 'orange']

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

Create a class named MyClass, with a property named x:

```
class MyClass:  
    x = 5
```

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)
```

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)
```

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("Hellomynameis" +self.name)

p1=Person("John", 36)
p1.myfunc()

```

UNIT-V Chapter-1

Classes and Functions:

Python provides library to read, represent and reset the time information in many ways by using “time” module. Date, time and date time are an object in Python, so whenever we do any operation on them, we actually manipulate objects not strings or timestamps.

a.Time:

In this section we’re going to discuss the “time” module which allows us to handle various operations on time. The time module follows the “EPOCH” convention which refers to the point where the time starts. In Unix system “EPOCH” time started from 1 January, 12:00 am, 1970 to year 2038.

To determine the EPOCH time value on your system, just type below code -

```

>>>import time
>>>time.gmtime(0)

```

Output

```

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

```

Tick in python?

A tick refers to a time interval which is a floating-point number measured as units of seconds. Sometime we get time as Daylight Saving Time(DST), where the clock moves 1 hour forward during the summer time, and back again in the fall.

Most common functions in Python Time Module -

1.time.time() function

The time() is the main function of the time module. It measures the number of seconds since the epoch as a floating point value.

Syntax

```
time.time()
```

Program to demonstrate above function:

```

import time
print("Number of seconds elapsed since the epoch are : ", time.time())

```

Output

```
Number of seconds elapsed since the epoch are : 1553262407.0398576
```

We can use python time function to calculate the elapsed Wall-clock time between two points.

Below is the program to calculate Wall clock time:

```

import time
start =time.time()

```

```
print("Time elapsed on working...")
time.sleep(0.9)
end=time.time()
print("Time consumed in working: ",end- start)
```

Output

```
Time elapsed on working...
Time consumed in working: 0.9219651222229004
```

2. time.clock() function

The time.clock() function return the processor time. It is used for performance testing/benchmarking.

Syntax

```
time.clock()
```

The clock() function returns the right time taken by the program and it more accurate than its counterpart.

Let's write a program using above two time functions (discussed above) to differentiate:

```
import time
template = 'time()# {:0.2f}, clock()# {:0.2f}'
print(template.format(time.time(), time.clock()))
for i in range(5, 0, -1):
    print('---Sleeping for: ', i, 'sec.')
    time.sleep(i)
print(template.format(time.time(), time.clock()))
```

Output

```
time()# 1553263728.08, clock()# 0.00
---Sleeping for: 5 sec.
time()# 1553263733.14, clock()# 5.06
---Sleeping for: 4 sec.
time()# 1553263737.25, clock()# 9.17
---Sleeping for: 3 sec.
time()# 1553263740.30, clock()# 12.22
---Sleeping for: 2 sec.
time()# 1553263742.36, clock()# 14.28
---Sleeping for: 1 sec.
time()# 1553263743.42, clock()# 15.34
```

3. time.ctime() function

time.time() function takes the time in “seconds since the epoch” as input and translates into a human readable string value as per the local time. If no argument is passed, it returns the current time.

import time

```
print("The current local time is :", time.ctime())
newtime = time.time() + 60
print('60 secs from now :', time.ctime(newtime))
```

Output

```
The current local time is : Fri Mar 22 19:43:11 2019
60 secs from now : Fri Mar 22 19:44:11 2019
```

4. time.sleep() function

time.sleep() function halts the execution of the current thread for the specified number of seconds. Pass a floating point value as input to get more precise sleep time.

The sleep() function can be used in situation where we need to wait for a file to finish closing or let a database commit to happen.

import time

```
# using ctime() to display present time
print("Time starts from : ",end="")
print(time.ctime())
# using sleep() to suspend execution
print('Waiting for 5 sec.')
```

```
time.sleep(5)
# using ctime() to show present time
print("Time ends at : ",end="")
print(time.ctime())
```

Output

```
Time starts from : Fri Mar 22 20:00:00 2019
Waiting for 5 sec.
Time ends at : Fri Mar 22 20:00:05 2019
```

5. time.struct_time class

The time.struct_time is the only data structure present in the time module. It has a named tuple interface and is accessible via index or the attribute name.

Syntax

```
time.struct_time
```

This class is useful when you need to access the specific field of a date.

This class provides number of functions like localtime(), gmtime() and return the struct_time objects.

```
import time
```

```
print(' Current local time:', time.ctime())
```

```
t = time.localtime()
```

```
print('Day of month:', t.tm_mday)
```

```
print('Day of week :', t.tm_wday)
```

```
print('Day of year :', t.tm_yday)
```

Output

```
Current local time: Fri Mar 22 20:10:25 2019
Day of month: 22
Day of week : 4
Day of year : 81
```

6. time.strftime() function

This function takes a tuple or struct_time in the second argument and converts to a string as per the format specified in the first argument.

Syntax

```
time.strftime()
```

Below is the program to implement time.strftime() function -

```
import time
```

```
now = time.localtime(time.time())
```

```
print("Current date time is: ",time.asctime(now))
```

```
print(time.strftime("%y/%m/%d %H:%M", now))
```

```
print(time.strftime("%a %b %d", now))
```

```
print(time.strftime("%c", now))
```

```
print(time.strftime("%I %p", now))
```

```
print(time.strftime("%Y-%m-%d %H:%M:%S %Z", now))
```

Output

```
Current date time is: Fri Mar 22 20:13:43 2019
19/03/22 20:13
Fri Mar 22
Fri Mar 22 20:13:43 2019
08 PM
2019-03-22 20:13:43 India Standard Time
```

Check timezone in python

There are two time-properties which give you the timezone info -

1. time.timezone

It returns the offset of the local (non-DST) timezone in UTC format.

```
>>>time.timezone
```

-19800

2. `time.tzname` – It returns a tuple containing the local non-DST and DST time zones.

```
>>>time.tzname
('India Standard Time', 'India Daylight Time')
```

b.Pure Functions

A function is called [pure function](#) if it always returns the same result for same argument values and it has no side effects like modifying an argument (or global variable) or outputting something. The only result of calling a pure function is the return value. Examples of pure functions are `strlen()`, `pow()`, `sqrt()` etc. Examples of impure functions are `printf()`, `rand()`, `time()`, etc.

If a function is known as pure to compiler then [Loop optimization](#) and [subexpression elimination](#) can be applied to it. In GCC, we can mark functions as pure using the “pure” attribute.

```
__attribute__((pure)) return-type fun-name(arguments1, ...)
```

```
{
    /* function body */
}
```

Following is an example pure function that returns square of a passed integer.

```
__attribute__((pure)) intmy_square(intval)
```

```
{
    returnval*val;
}
```

Consider the below example

```
filter_none
edit
play_arrow
brightness_4
for(len = 0; len<strlen(str); ++len)
    printf("%c", toupper(str[len]));
```

If “`strlen()`” function is not marked as pure function then compiler will invoke the “`strlen()`” function with each iteration of the loop, and if function is marked as pure function then compiler knows that value of “`strlen()`” function will be same for each call, that’s why compiler optimizes the for loop and generates code like following.

```
intlen = strlen(str);
```

```
for(i = 0; i<len; ++i)
    printf("%c", toupper((str[i]));
```

Let us write our own pure function to calculate string length.

```
__attribute__((pure)) size_tmy_strlen(constchar*str)
```

```
{
    constchar*ptr = str;
    while(*ptr)
        ++ptr;

    return(ptr – str);
}
```

Marking function as pure says that the hypothetical function “`my_strlen()`” is safe to call fewer times than the program says.

c.Modifiers:

Python - public, private and protected

Classical object-oriented languages, such as C++ and Java, control the access to class resources by public, private and protected keywords. Private members of a class are denied access from the environment outside the class. They can be handled only from within the class.

Public members (generally methods declared in a class) are accessible from outside the class. The object of the same class is required to invoke a public method. This arrangement of private instance variables and public methods ensures the principle of data encapsulation.

Protected members of a class are accessible from within the class and are also available to its sub-classes. No other environment is permitted access to it. This enables specific resources of the parent class to be inherited by the child class.

Python doesn't have any mechanism that effectively restricts access to any instance variable or method. Python prescribes a convention of prefixing the name of the variable/method with single or double underscore to emulate the behaviour of protected and private access specifiers.

All members in a Python class are **public** by default. Any member can be accessed from outside the class environment.

Example: Public Attributes

```
Copy
class employee:
def __init__(self, name, sal):
    self.name=name
self.salary=sal
```

You can access employee class's attributes and also modify their values, as shown below.

```
>>> e1=employee("Kiran",10000)
>>> e1.salary
10000
>>> e1.salary=20000
>>> e1.salary
20000
```

Python's convention to make an instance variable **protected** is to add a prefix `_` (single underscore) to it. This effectively prevents it to be accessed, unless it is from within a sub-class.

Example: Protected Attributes

```
Copy
class employee:
def __init__(self, name, sal):
self._name=name # protected attribute
self._salary=sal# protected attribute
```

In fact, this doesn't prevent instance variables from accessing or modifying the instance. You can still perform the following operations:

```
>>> e1=employee("Swati", 10000)
>>> e1._salary
10000
```

```
>>> e1._salary=20000
```

```
>>> e1._salary
```

```
20000
```

Hence, the responsible programmer would refrain from accessing and modifying instance variables prefixed with `_` from outside its class.

Similarly, a double underscore `__` prefixed to a variable makes it **private**. It gives a strong suggestion not to touch it from outside the class. Any attempt to do so will result in an `AttributeError`:

Example: Private Attributes

Copy

```
class employee:
```

```
def __init__(self, name, sal):
```

```
self.__name=name # private attribute
```

```
self.__salary=sal# private attribute
```

```
>>> e1=employee("Bill",10000)
```

```
>>> e1._salary
```

```
AttributeError: 'employee' object has no attribute '_salary'
```

Python performs name mangling of private variables. Every member with double underscore will be changed to `__object.__class__variable`. If so required, it can still be accessed from outside the class, but the practice should be refrained.

```
>>> e1=employee("Bill",10000)
```

```
>>> e1.__employee_salary
```

```
10000
```

```
>>> e1.__employee_salary=20000
```

```
>>> e1.__employee_salary
```

```
20000
```

d.Prototyping Versus Planning:

The development plan I am demonstrating is called “prototype and patch.” For each function, I wrote a prototype that performed the basic calculation and then tested it, patching errors along the way.

This approach can be effective, especially if you don’t yet have a deep understanding of the problem. But incremental corrections can generate code that is unnecessarily complicated—since it deals with many special cases—and unreliable—since it is hard to know if you have found all the errors.

An alternative is planned development, in which high-level insight into the problem can make the programming much easier. In this case, the insight is that a Time object is really a three-digit number in base 60 (see <http://en.wikipedia.org/wiki/Sexagesimal>.)! The second attribute is the “ones column,” the minute attribute is the “sixties column,” and the hour attribute is the “thirty-six hundreds column.”

When we wrote `add_time` and `increment`, we were effectively doing addition in base 60, which is why we had to carry from one column to the next.

This observation suggests another approach to the whole problem—we can convert `Time` objects to integers and take advantage of the fact that the computer knows how to do integer arithmetic.

Here is a function that converts `Times` to integers:

```
def time_to_int(time):
    minutes = time.hour * 60 + time.minute
    seconds = minutes * 60 + time.second
    return seconds
```

And here is the function that converts integers to `Times` (recall that `divmod` divides the first argument by the second and returns the quotient and remainder as a tuple).

```
def int_to_time(seconds):
    time = Time()
    minutes, time.second = divmod(seconds, 60)
    time.hour, time.minute = divmod(minutes, 60)
    return time
```

You might have to think a bit, and run some tests, to convince yourself that these functions are correct. One way to test them is to check that `time_to_int(int_to_time(x)) == x` for many values of `x`. This is an example of a consistency check.

Once you are convinced they are correct, you can use them to rewrite `add_time`:

```
def add_time(t1, t2):
    seconds = time_to_int(t1) + time_to_int(t2)
    return int_to_time(seconds)
```

This version is shorter than the original, and easier to verify.

Chapter-2 Classes and Methods

1. Object oriented Features:

Major OOP (object-oriented programming) concepts in Python include Class, Object, Method, Inheritance, Polymorphism, Data Abstraction, and Encapsulation.

Classes and Objects:

Classes:

A class is a collection of objects or you can say it is a blueprint of objects defining the common attributes and behavior. Now the question arises, how do you do that?

Well, it logically groups the data in such a way that code reusability becomes easy. I can give you a real-life example- think of an office going 'employee' as a class and all the attributes related to it like 'emp_name', 'emp_age', 'emp_salary', 'emp_id' as the objects in [Python](#). Let us see from the coding perspective that how do you instantiate a class and an object.

Class is defined under a "Class" Keyword.

Example:

```
1 class class1(): // class 1 is the name of the class
```

Note: Python is not case-sensitive.

Objects:

Objects are an instance of a class. It is an entity that has state and behavior. In a nutshell, it is an instance of a class that can access the data.

Syntax: `obj = class1()`

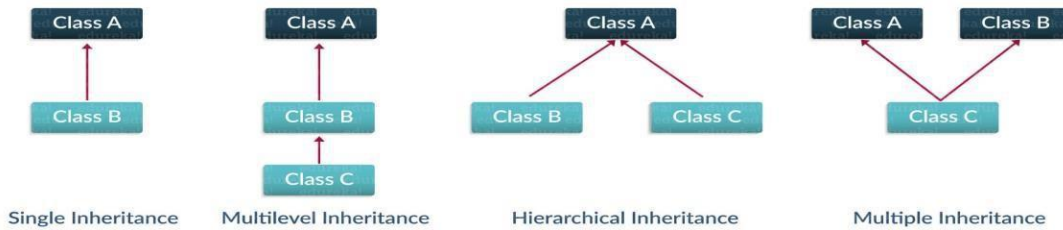
Here `obj` is the "object" of `class1`.

Inheritance:

Ever heard of this dialogue from relatives "you look exactly like your father/mother" the reason behind this is called '[inheritance](#)'. From the Programming aspect, It generally means "inheriting or transfer of characteristics from parent to child class without any modification". The new class is called the **derived/child** class and the one from which it is derived is called a **parent/base** class.

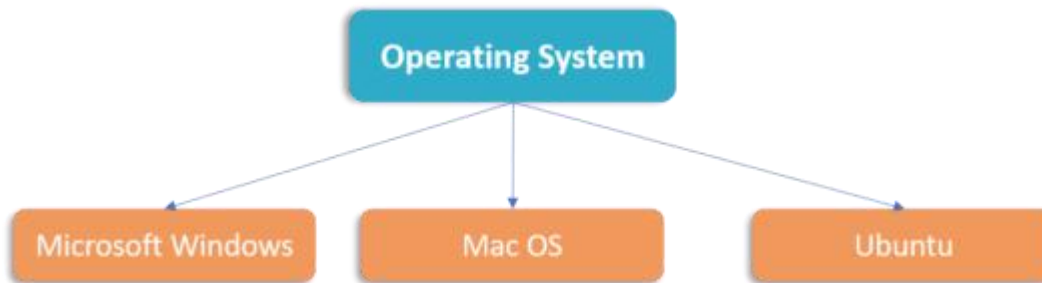
Types Of Inheritance

edureka!



Polymorphism:

You all must have used GPS for navigating the route, Isn't it amazing how many different routes you come across for the same destination depending on the traffic, from a programming point of view this is called 'polymorphism'. It is one such OOP methodology where one task can be performed in several different ways. To put it in simple words, *it is a property of an object which allows it to take multiple forms.*



Encapsulation:

In a raw form, encapsulation basically means binding up of data in a single class. Python does not have any private keyword, unlike [Java](#). A class shouldn't be directly accessed but be prefixed in an underscore.

Abstraction:

Suppose you booked a movie ticket from bookmyshow using net banking or any other process. You don't know the procedure of how the pin is generated or how the verification is done. This is called 'abstraction' from the programming aspect, it basically means you only show the implementation details of a particular process and hide the details from the user. It is used to simplify complex problems by modeling classes appropriate to the problem.

2. Print objects of a class in Python

An [Object](#) is an instance of a Class. A class is like a blueprint while an instance is a copy of the class with actual values. When an object of a class is created, the class is said to be instantiated. All the instances share the attributes and the behavior of the class. But the values of those attributes, i.e. the state are unique for each object. A single class may have any number of instances.

Refer to the below articles to get the idea about classes and objects in Python.

[Python Classes and Objects](#)

Printing objects give us information about the objects we are working with. In C++, we can do this by adding a friend ostream& operator << (ostream&, constFoobar&) method for the class. In Java, we use toString() method. In Python, this can be achieved by using __repr__ or __str__ methods. __repr__ is used if we need a detailed information for debugging while __str__ is used to print a string version for the users.

Example:

```
filter_none
edit
play_arrow
brightness_4
# Python program to demonstrate
# object printing
```

```
# Defining a class
```

```

class Test:
    def __init__(self, a, b):
        self.a = a
        self.b = b

    def __repr__(self):
        return "Test a:% s b:% s"%(self.a, self.b)

    def __str__(self):
        return "From str method of Test: a is % s, "\
            "b is % s"%(self.a, self.b)

# Driver Code
t = Test(1234, 5678)

# This calls __str__()
print(t)

# This calls __repr__()
print([t])

```

Python is an **object-oriented programming language**. What this means is we can solve a problem in Python by creating objects in our programs. In this guide, we will discuss OOPs terms such as **class, objects, methods** etc. along with the Object oriented programming features such as **inheritance, polymorphism, abstraction, encapsulation**.

Object

An object is an entity that has attributes and behaviour. For example, Ram is an object who has attributes such as height, weight, color etc. and has certain behaviours such as walking, talking, eating etc.

Class

A class is a blueprint for the objects. For example, Ram, Shyam, Steve, Rick are all objects so we can define a template (blueprint) class Human for these objects. The class can define the common attributes and behaviours of all the objects.

Methods

As we discussed above, an object has attributes and behaviours. These behaviours are called methods in programming.

Example of Class and Objects

In this example, we have two objects Ram and Steve that belong to the class Human

Object attributes: name, height, weight

Object behaviour: eating()

```

.
Source code
class Human:
# instance attributes
def __init__(self, name, height, weight):
self.name = name
self.height= height
self.weight= weight

# instance methods (behaviours)
def eating(self, food):
return "{} is eating {}".format(self.name, food)

```

```

# creating objects of class Human
ram = Human("Ram",6,60)

```

```
steve=Human("Steve",5.9,56)
```

```
# accessing object information
print("Height of {} is {}".format(ram.name,ram.height))
print("Weight of {} is {}".format(ram.name,ram.weight))
print(ram.eating("Pizza"))
print("Weight of {} is {}".format(steve.name,steve.height))
print("Weight of {} is {}".format(steve.name,steve.weight))
print(steve.eating("Big Kahuna Burger"))
```

Output:

```
Height of Ramis6
Weight of Ramis60
Ramis eating Pizza
Weight of Steveis5.9
Weight of Steveis56
Steveis eating BigKahunaBurger
```

From str method of Test: a is 1234, b is 5678

```
[Test a:1234 b:5678]
```

Important Points about Printing:

Python uses `__repr__` method if there is no `__str__` method.

Example:

```
classTest:
    def_init_(self, a, b):
        self.a =a
        self.b =b

    def_repr_(self):
        return"Test a:% s b:% s"%(self.a, self.b)
```

```
# Driver Code
t =Test(1234, 5678)
print(t)
```

Output:

```
Test a:1234 b:5678
```

If no `__repr__` method is defined then the default is used.

Example:

```
classTest:
    def_init_(self, a, b):
        self.a =a
        self.b =b
```

```
# Driver Code
t =Test(1234, 5678)
print(t)
```

Output:

```
<_main_.Test object at 0x7f9b5738c550>
```

3.INIT:

self :

self represents the instance of the class. By using the "self" keyword we can access the attributes and methods of the class in python.

__init__:

"init" is a reserved method in python classes. It is known as a constructor in object oriented concepts. This method called when an object is created from the class and it allow the class to initialize the attributes of a class.

How can we use "`__init__`" ?

Let's consider that you are creating a NFS game. for that we should have a car. Car can have attributes like "color", "company", "speed_limit" etc. and methods like "change_gear", "start", "accelarate", "move" etc.

```
classCar(object):
```

```
"""
```

```
    blueprint for car
```

```
"""
```

```
def __init__(self, model,color, company,speed_limit):
```

```
    self.color=color
```

```
    self.company= company
```

```
    self.speed_limit=speed_limit
```

```
    self.model= model
```

```
def start(self):
```

```
    print("started")
```

```
def stop(self):
```

```
    print("stopped")
```

```
defaccelarate(self):
```

```
    print("accelarating...")
```

```
    "accelarator functionality here"
```

```
defchange_gear(self,gear_type):
```

```
    print("gear changed")
```

```
    " gear related functionality here"
```

Lets try to create different types of cars

```
maruthi_suzuki=Car("ertiga","black","suzuki",60)
```

```
audi=Car("A6","red","audi",80)
```

We have created two different types of car objects with the same class. while creating the car object we passed arguments "**ertiga**", "**black**", "**suzuki**", **60** these arguments will pass to "**__init__**" method to initialize the object.

Here, the magic keyword "**self**" represents the instance of the class. It binds the attributes with the given arguments.

Usage of "self" in class to access the methods and attributes

Case: Find out the cost of a rectangular field with breadth(b=120), length(l=160). It costs x (2000) rupees per 1 square unit

```
classRectangle:
```

```
def __init__(self, length, breadth,unit_cost=0):
```

```
    self.length= length
```

```
    self.breadth= breadth
```

```
    self.unit_cost=unit_cost
```

```
defget_perimeter(self):
```

```
    return2*(self.length+self.breadth)
```

```
defget_area(self):
```

```
    returnself.length*self.breadth
```

```
defcalculate_cost(self):
```

```
    area =self.get_area()
```

```
    return area *self.unit_cost
```

```
# breadth = 120 cm, length = 160 cm, 1 cm^2 = Rs 2000
```

```
r =Rectangle(160,120,2000)
```

```
print("Area of Rectangle: %s cm^2"%(r.get_area()))
```

```
print("Cost of rectangular field: Rs. %s "%(r.calculate_cost()))
```

As we already discussed "*self*" represents the same object or instance of the class. If you see, inside the method "*get_area*" we have used "*self.length*" to get the value of the attribute "*length*". attribute "*length*" is bind to the object(instance of the class) at the time of object creation. "*self*" represents the object inside the class. "*self*" works just like "*r*" in the statement "*r = Rectangle(160, 120, 2000)*". If you see the method structure "*def get_area(self):* " we have used "*self*" as a parameter in the method because whenever we call the method the object (instance of class) automatically passes as a first argument along with other arguments of the method. If no other arguments are provided only "*self*" is passed to the method. That's the reason we use "*self*" to call the method inside the class ("*self.get_area()*"). we use object(instance of class) to call the method outside of the class definition ("*r.get_area()*"). "*r*" is the instance of the class, when we call method "*r.get_area()*" the instance "*r*" is passed as as first argument in the place of self.

```
r=Rectangle(160,120,2000)
```

Note:"*r*"is the representation of the object outside of the classand"*self*" is the representation of the object inside the class.

4. Python str ()

This method returns the [string](#) representation of the object. This method is called when `print()` or `str()` function is invoked on an object.

Advertisement: 0:13

This method must return the String object. If we don't implement `__str__()` function for a class, then built-in object implementation is used that actually calls `__repr__()` function.

Python `__repr__()`

Python `__repr__()` function returns the object representation. It could be any valid python expression such as [tuple](#), [dictionary](#), string etc.

This method is called when `repr()` function is invoked on the object, in that case, `__repr__()` function must return a String otherwise error will be thrown.

Python `__str__` and `__repr__` example

Both of these functions are used in debugging, let's see what happens if we don't define these functions for an object.

```
class Person:
```

```
    name = ""
    age = 0
```

```
def __init__(self, personName, personAge):
```

```
    self.name = personName
```

```
    self.age = personAge
```

```
p = Person('Pankaj', 34)
```

```
print(p.__str__())
```

```
print(p.__repr__())
```

Output:

```
<__main__.Person object at 0x10ff22470>
```

```
<__main__.Person object at 0x10ff22470>
```

5. Operator Overloading in Python

Operator Overloading means giving extended meaning beyond their predefined operational meaning. For example operator `+` is used to add two integers as well as join two strings and merge two lists. It is achievable because `+` operator is overloaded by int class and str class. You might have noticed that the same built-in operator or function shows different behavior for objects of different classes, this is called *Operator Overloading*.

```
filter_none
```

```
edit
```

```
play_arrow
```

```
brightness_4
```

```
# Python program to show use of
# + operator for different purposes.
```

```
print(1+2)

# concatenate two strings
print("Geeks"+"For")

# Product two numbers
print(3*4)

# Repeat the String
print("Geeks"*4)
```

Output:

```
3
GeeksFor
12
GeeksGeeksGeeksGeeks
```

How to overload the operators in Python?

Consider that we have two objects which are a physical representation of a class (user-defined data type) and we have to add two objects with binary '+' operator it throws an error, because compiler don't know how to add two objects. So we define a method for an operator and that process is called operator overloading. We can overload all existing operators but we can't create a new operator. To perform operator overloading, Python provides some special function or magic function that is automatically invoked when it is associated with that particular operator. For example, when we use + operator, the magic method `__add__` is automatically invoked in which the operation for + operator is defined.

Overloading binary + operator in Python :

When we use an operator on user defined data types then automatically a special function or magic function associated with that operator is invoked. Changing the behavior of operator is as simple as changing the behavior of method or function. You define methods in your class and operators work according to that behavior defined in methods. When we use + operator, the magic method `__add__` is automatically invoked in which the operation for + operator is defined. There by changing this magic method's code, we can give extra meaning to the + operator.

Code 1:

```
filter_none
edit
play_arrow
brightness_4
# Python Program illustrate how
# to overload an binary + operator

classA:
    def_init_(self, a):
        self.a =a

    # adding two objects
    def_add_(self, o):
        returnself.a +o.a
ob1 =A(1)
ob2 =A(2)
ob3 =A("Geeks")
ob4 =A("For")
```

```
print(ob1 +ob2)
print(ob3 +ob4)
```

Output :

```
3
GeeksFor
```

Code 2:

```
filter_none
edit
play_arrow
brightness_4
# Python Program to perform addition
# of two complex numbers using binary
# + operator overloading.
```

```
classcomplex:
    def_init_(self, a, b):
        self.a =a
        self.b =b

    # adding two objects
    def_add_(self, other):
        returnself.a +other.a, self.b +other.b

    def_str_(self):
        returnself.a, self.b
```

```
Ob1 =complex(1, 2)
Ob2 =complex(2, 3)
Ob3 =Ob1 +Ob2
print(Ob3)
```

Output :

```
(3, 5)
```

Overloading comparison operators in Python :

```
filter_none
edit
play_arrow
brightness_4
# Python program to overload
# a comparison operators
```

```
classA:
    def_init_(self, a):
        self.a =a
    def_gt_(self, other):
        if(self.a>other.a):
            returnTrue
        else:
            returnFalse
ob1 =A(2)
ob2 =A(3)
if(ob1>ob2):
    print("ob1 is greater than ob2")
else:
    print("ob2 is greater than ob1")
```

Output :

```
ob2 is greater than ob1
```

Overloading equality and less than operators :

OPERATOR	MAGIC METHOD
<	__lt__(self, other)
>	__gt__(self, other)
<=	__le__(self, other)
>=	__ge__(self, other)
==	__eq__(self, other)
!=	__ne__(self, other)

filter_none

edit

play_arrow

brightness_4

Python program to overload equality

and less than operators

classA:

def __init__(self, a):

self.a = a

def __lt__(self, other):

if(self.a < other.a):

return "ob1 is less than ob2"

else:

return "ob2 is less than ob1"

def __eq__(self, other):

if(self.a == other.a):

return "Both are equal"

else:

return "Not equal"

ob1 = A(2)

ob2 = A(3)

print(ob1 < ob2)

ob3 = A(4)

ob4 = A(4)

print(ob1 == ob2)

Output :

ob1 is less than ob2

Not equal

Python magic methods or special functions for operator overloading

Binary Operators:

OPERATOR	MAGIC METHOD
+	__add__(self, other)
-	__sub__(self, other)
*	__mul__(self, other)

/	__truediv__(self, other)
%	__mod__(self, other)
**	__pow__(self, other)

Unary Operators :

In the previous section we added two Time objects, but you also might want to add an integer to a Time object. The following is a version of `__add__` that checks the type of `other` and invokes either `add_time` or `increment`:
inside class Time:

```
def __add__(self, other):
    if isinstance(other, Time):
        return self.add_time(other)
    else:
        return self.increment(other)

def add_time(self, other):
    seconds = self.time_to_int() + other.time_to_int()
    return int_to_time(seconds)

def increment(self, seconds):
    seconds += self.time_to_int()
    return int_to_time(seconds)
```

The built-in function `isinstance` takes a value and a class object, and returns True if the value is an instance of the class.

If `other` is a Time object, `__add__` invokes `add_time`. Otherwise it assumes that the parameter is a number and invokes `increment`. This operation is called a **type-based dispatch** because it dispatches the computation to different methods based on the type of the arguments.

Here are examples that use the `+` operator with different types:

```
>>> start = Time(9, 45)
>>> duration = Time(1, 35)
>>> print start + duration
11:20:00
>>> print start + 1337
10:07:17
```

Unfortunately, this implementation of addition is not commutative. If the integer is the first operand, you get

```
>>> print 1337 + start
TypeError: unsupported operand type(s) for +: 'int' and 'instance'
```

The problem is, instead of asking the Time object to add an integer, Python is asking an integer to add a Time object, and it doesn't know how to do that. But there is a clever solution for this problem: the special method `__radd__`, which stands for “right-side add.” This method is invoked when a Time object appears on the right side of the `+` operator. Here's the definition:

```
# inside class Time:
def __radd__(self, other):
    return self.__add__(other)

And here's how it's used:
>>> print 1337 + start
10:07:17
```

7. Polymorphism in Python

What is Polymorphism?

The literal meaning of polymorphism is the condition of occurrence in different forms.

Polymorphism is a very important concept in programming. It refers to the use of a single type entity (method, operator or object) to represent different types in different scenarios.

Let's take an example:

Example 1: Polymorphism in addition operator

We know that the `+` operator is used extensively in Python programs. But, it does not have a single usage.

For integer data types, `+` operator is used to perform arithmetic addition operation.

```
num1 = 1
num2 = 2
print(num1+num2)
```

Run Code

Hence, the above program outputs `3`.

Similarly, for string data types, `+` operator is used to perform concatenation.

```
str1 = "Python"
str2 = "Programming"
print(str1+" "+str2)
```

Run Code

As a result, the above program outputs `Python Programming`.

Here, we can see that a single operator `+` has been used to carry out different operations for distinct data types.

This is one of the most simple occurrences of polymorphism in Python.

Function Polymorphism in Python

There are some functions in Python which are compatible to run with multiple data types.

One such function is the `len()` function. It can run with many data types in Python. Let's look at some example use cases of the function.

Example 2: Polymorphic `len()` function

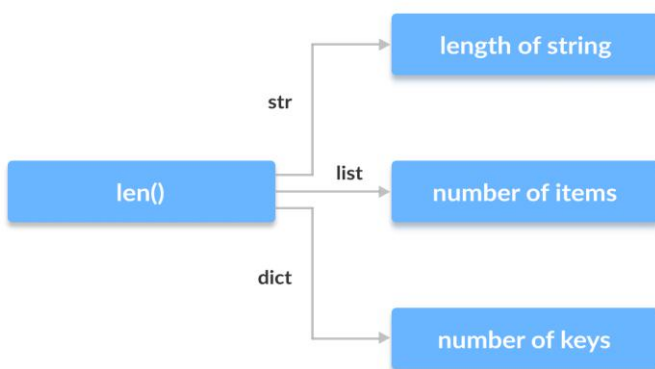
```
print(len("Programiz"))
print(len(["Python", "Java", "C"]))
print(len({"Name": "John", "Address": "Nepal"}))
```

Run Code

Output

```
9
3
2
```

Here, we can see that many data types such as string, list, tuple, set, and dictionary can work with the `len()` function. However, we can see that it returns specific information about specific data types.



Polymorphism in `len()` function in Python

Class Polymorphism in Python

Polymorphism is a very important concept in Object-Oriented Programming.

To learn more about OOP in Python,

We can use the concept of polymorphism while creating class methods as Python allows different classes to have methods with the same name.

We can then later generalize calling these methods by disregarding the object we are working with. Let's look at an example:

Example 3: Polymorphism in Class Methods

`classCat:`

```

def __init__(self, name, age):
    self.name = name
    self.age = age

def info(self):
    print(f"I am a cat. My name is {self.name}. I am {self.age} years old.")

def make_sound(self):
    print("Meow")

class Dog:
    def __init__(self, name, age):
        self.name = name
        self.age = age

    def info(self):
        print(f"I am a dog. My name is {self.name}. I am {self.age} years old.")

    def make_sound(self):
        print("Bark")

cat1 = Cat("Kitty", 2.5)
dog1 = Dog("Fluffy", 4)

for animal in (cat1, dog1):
    animal.make_sound()
    animal.info()
    animal.make_sound()

```

Run Code

Output

```

Meow
I am a cat. My name is Kitty. I am 2.5 years old.
Meow
Bark
I am a dog. My name is Fluffy. I am 4 years old.
Bark

```

Here, we have created two classes `Cat` and `Dog`. They share a similar structure and have the same method names `info()` and `make_sound()`. However, notice that we have not created a common superclass or linked the classes together in any way. Even then, we can pack these two different objects into a tuple and iterate through it using a common `animal` variable. It is possible due to polymorphism.

Polymorphism and Inheritance

Like in other programming languages, the child classes in Python also inherit methods and attributes from the parent class. We can redefine certain methods and attributes specifically to fit the child class, which is known as **Method Overriding**.

Polymorphism allows us to access these overridden methods and attributes that have the same name as the parent class.

Let's look at an example:

Example 4: Method Overriding
from math import pi

```
classShape:
def_init_(self, name):
    self.name = name
```

```
defarea(self):
pass
```

```
deffact(self):
return"I am a two-dimensional shape."
```

```
def_str_(self):
return self.name
```

```
classSquare(Shape):
def_init_(self, length):
    super()._init_("Square")
self.length = length
```

```
defarea(self):
returnself.length**2
```

```
deffact(self):
return"Squares have each angle equal to 90 degrees."
```

```
classCircle(Shape):
def_init_(self, radius):
    super()._init_("Circle")
self.radius = radius
```

```
defarea(self):
return pi*self.radius**2
```

```
a = Square(4)
b = Circle(7)
print(b)
print(b.fact())
print(a.fact())
print(b.area())
Run Code
```

Output

Circle

I am a two-dimensional shape.

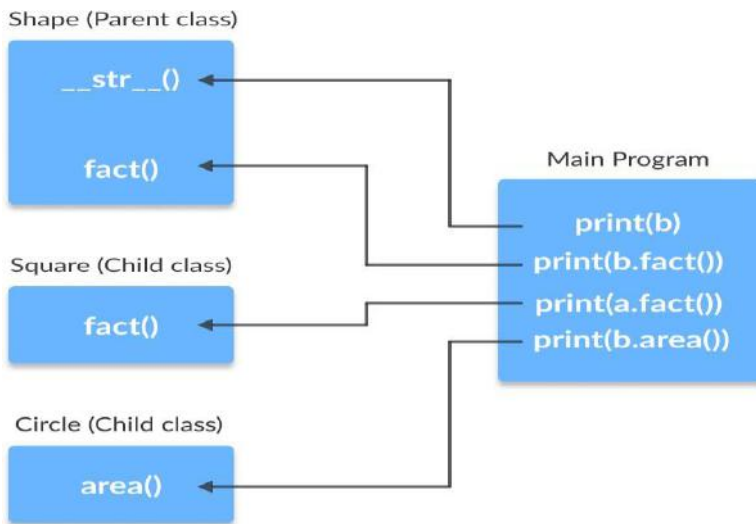
Squares have each angle equal to 90 degrees.

153.93804002589985

Here, we can see that the methods such as `_str_()`, which have not been overridden in the child classes, are used from the parent class.

Due to polymorphism, the Python interpreter automatically recognizes that the `fact()` method for object `a` (`Square` class) is overridden. So, it uses the one defined in the child class.

On the other hand, since the `fact()` method for object `b` isn't overridden, it is used from the Parent `Shape` class.



Polymorphism in parent and child classes in Python

8. Python-interface module

In object-oriented languages like Python, the interface is a collection of method signatures that should be provided by the implementing class. Implementing an interface is a way of writing an organized code and achieve abstraction.

The package **zope.interface** provides an implementation of “object interfaces” for Python. It is maintained by the Zope Toolkit project. The package exports two objects, ‘Interface’ and ‘Attribute’ directly. It also exports several helper methods. It aims to provide stricter semantics and better error messages than Python’s built-in abc module.

Declaring interface

In python, interface is defined using python class statements and is a subclass of **interface.Interface** which is the parent interface for all interfaces.

Syntax :

```
class IMyInterface(zope.interface.Interface):
    # methods and attributes
```

Example

```
filter_none
brightness_4
import zope.interface
class MyInterface(zope.interface.Interface):
    x = zope.interface.Attribute("foo")
    def method1(self, x):
        pass
    def method2(self):
        pass
```

```
print(type(MyInterface))
print(MyInterface._module_)
print(MyInterface._name_)
# get attribute
x = MyInterface['x']
print(x)
print(type(x))
```

Output :

```
<class zope.interface.interface.InterfaceClass>
__main__
MyInterface
<zope.interface.interface.Attribute object at 0x00000270A8C74358>
<class 'zope.interface.interface.Attribute'>
Implementing interface
```

Interface acts as a blueprint for designing classes, so interfaces are implemented using **implementer** decorator on class. If a class implements an interface, then the instances of the class provide the interface. Objects can provide interfaces directly, in addition to what their classes implement.

Syntax :

```
@zope.interface.implementer(*interfaces)
class Class_name:
    # methods
```

Example

```
filter_none
brightness_4
importzope.interface
```

```
classMyInterface(zope.interface.Interface):
    x =zope.interface.Attribute("foo")
    defmethod1(self, x):
        pass
    defmethod2(self):
        pass
```

```
@zope.interface.implementer(MyInterface)
classMyClass:
    defmethod1(self, x):
        returnx**2
    defmethod2(self):
        return"foo"
```

We declared that MyClass implements MyInterface. This means that instances of MyClass provide MyInterface. Methods

implementedBy(class) – returns a boolean value, True if class implements the interface else False

providedBy(object) – returns a boolean value, True if object provides the interface else False

providedBy(class) – returns False as class does not provide interface but implements it

list(zope.interface.implementedBy(class)) – returns the list of interfaces implemented by a class

list(zope.interface.providedBy(object)) – returns the list of interfaces provided by an object.

list(zope.interface.providedBy(class)) – returns empty list as class does not provide interface but implements it.

```
filter_none
brightness_4
importzope.interface
```

```
classMyInterface(zope.interface.Interface):
    x =zope.interface.Attribute('foo')
    defmethod1(self, x, y, z):
        pass
    defmethod2(self):
        pass
```

```
@zope.interface.implementer(MyInterface)
classMyClass:
    defmethod1(self, x):
        returnx**2
    defmethod2(self):
        return"foo"
obj =MyClass()
```

```
# ask an interface whether it
# is implemented by a class:
print(MyInterface.implementedBy(MyClass))
```

```
# MyClass does not provide
```

```

# MyInterface but implements it:
print(MyInterface.providedBy(MyClass))

# ask whether an interface
# is provided by an object:
print(MyInterface.providedBy(obj))

# ask what interfaces are
# implemented by a class:
print(list(zope.interface.implementedBy(MyClass)))

# ask what interfaces are
# provided by an object:
print(list(zope.interface.providedBy(obj)))

```

```

# class does not provide interface
print(list(zope.interface.providedBy(MyClass)))

```

Output :

```

True
False
True
[<InterfaceClass__main__.MyInterface>]
[<InterfaceClass__main__.MyInterface>]
[]

```

Interface Inheritance

Interfaces can extend other interfaces by listing the other interfaces as base interfaces.

Functions

extends(interface) – returns boolean value, whether one interface extends another.

isOrExtends(interface) – returns boolean value, whether interfaces are same or one extends another.

isEqualOrExtendedBy(interface) – returns boolean value, whether interfaces are same or one is extended by another.

filter_none

brightness_4

Import zope.interface

```

classBaseI(zope.interface.Interface):
    defm1(self, x):
        pass
    defm2(self):
        pass

```

```

classDerivedI(BaseI):
    defm3(self, x, y):
        pass

```

```

@zope.interface.implementer(DerivedI)

```

```

classcls:

```

```

    defm1(self, z):
        returnz**3
    defm2(self):
        return'foo'
    defm3(self, x, y):
        returnx ^ y

```

```

# Get base interfaces

```

```

print(DerivedI._bases_)

```

```

# Ask whether baseI extends

```

```

# DerivedI
print(BaseI.extends(DerivedI))

# Ask whether baseI is equal to
# or is extended by DerivedI
print(BaseI.isEqualOrExtendedBy(DerivedI))

# Ask whether baseI is equal to
# or extends DerivedI
print(BaseI.isOrExtends(DerivedI))

# Ask whether DerivedI is equal
# to or extends BaseI
print(DerivedI.isOrExtends(DerivedI))

```

Output :

```

(<InterfaceClass __main__.BaseI>, )
False
True
False
True

```

Type-based dispatch

In the previous section we added two Time objects, but you also might want to add an integer to a Time object. The following is a version of `__add__` that checks the type of `other` and invokes either `add_time` or `increment`:

```

# inside class Time:

def __add__(self, other):
    if isinstance(other, Time):
        return self.add_time(other)
    else:
        return self.increment(other)

def add_time(self, other):
    seconds = self.time_to_int() + other.time_to_int()
    return int_to_time(seconds)

def increment(self, seconds):
    seconds += self.time_to_int()
    return int_to_time(seconds)

```

The built-in function `isinstance` takes a value and a class object, and returns True if the value is an instance of the class.

If `other` is a Time object, `__add__` invokes `add_time`. Otherwise it assumes that the parameter is a number and invokes `increment`. This operation is called a type-based dispatch because it dispatches the computation to different methods based on the type of the arguments.

Here are examples that use the `+` operator with different types:

```

>>> start = Time(9, 45)>>> duration = Time(1, 35)>>> print start + duration
11:20:00>>> print start + 1337
10:07:17

```

Unfortunately, this implementation of addition is not commutative. If the integer is the first operand, you get

```

>>> print 1337 + start
TypeError: unsupported operand type(s) for +: 'int' and 'instance'

```

The problem is, instead of asking the Time object to add an integer, Python is asking an integer to add a Time object, and it doesn't know how to do that. But there is a clever solution for this problem: the special method `radd__`, which stands for “right-side add.” This method is invoked when a Time object appears on the right side of the `+` operator. Here's the definition:

```

# inside class Time:

def radd__(self, other):
    return self.__add__(other)

```


And here's how it's used:
>>> print 1337 + start10:07:17

Chapter-3 Inheritance

In this chapter we look at a larger example using object oriented programming and learn about the very useful OOP feature of [inheritance](#).

Composition

By now, you have seen several examples of composition. One of the first examples was using a method invocation as part of an expression. Another example is the nested structure of statements; you can put an if statement within a while loop, within another if statement, and so on.

Having seen this pattern, and having learned about lists and objects, you should not be surprised to learn that you can create lists of objects. You can also create objects that contain lists (as attributes); you can create lists that contain lists; you can create objects that contain objects; and so on.

In this chapter we will look at some examples of these combinations, using Card objects as an example.

1. Card objects

If you are not familiar with common playing cards, now would be a good time to get a deck, or else this chapter might not make much sense. There are fifty-two cards in a deck, each of which belongs to one of four suits and one of thirteen ranks. The suits are Spades, Hearts, Diamonds, and Clubs (in descending order in bridge). The ranks are Ace, 2, 3, 4, 5, 6, 7, 8, 9, 10, Jack, Queen, and King. Depending on the game that you are playing, the rank of Ace may be higher than King or lower than 2.

If we want to define a new object to represent a playing card, it is obvious what the attributes should be: rank and suit. It is not as obvious what type the attributes should be. One possibility is to use strings containing words like "Spade" for suits and "Queen" for ranks. One problem with this implementation is that it would not be easy to compare cards to see which had a higher rank or suit.

An alternative is to use integers to **encode** the ranks and suits. By encode, we do not mean what some people think, which is to encrypt or translate into a secret code. What a computer scientist means by encode is to define a mapping between a sequence of numbers and the items I want to represent. For example:

Spades-->3

Hearts-->2

Diamonds-->1

Clubs-->0

An obvious feature of this mapping is that the suits map to integers in order, so we can compare suits by comparing integers. The mapping for ranks is fairly obvious; each of the numerical ranks maps to the corresponding integer, and for face cards:

Jack-->11

Queen-->12

King-->13

The reason we are using mathematical notation for these mappings is that they are not part of the Python program. They are part of the program design, but they never appear explicitly in the code. The class definition for the Card type looks like this:

```
classCard:
```

```
    def __init__(self, suit=0, rank=0):
```

```
        self.suit=suit
```

```
        self.rank=rank
```

As usual, we provide an initialization method that takes an optional parameter for each attribute.

To create an object that represents the 3 of Clubs, use this command:

```
three_of_clubs=Card(0, 3)
```

The first argument, 0, represents the suit Clubs.

2. Class attributes and the `__str__` method

In order to print Card objects in a way that people can easily read, we want to map the integer codes onto words. A natural way to do that is with lists of strings. We assign these lists to **class attributes** at the top of the class definition:

```

classCard:
    SUITS= ('Clubs', 'Diamonds', 'Hearts', 'Spades')
    RANKS= ('narf', 'Ace', '2', '3', '4', '5', '6', '7',
            '8', '9', '10', 'Jack', 'Queen', 'King']

    def __init__(self, suit=0, rank=0):
        self.suit=suit
        self.rank=rank

    def __str__(self):
        """
        >>>print(Card(2, 11))
            Queen of Hearts
            """
        return'{0} of {1}'.format(Card.RANKS[self.rank],
            Card.SUITS[self.suit])

```

```

if __name__ == '__main__':

```

```

importdoctest
doctest.testmod()

```

Class attributes like Card.SUITS and Card.RANKS are defined outside of any method, and can be accessed from any of the methods in the class.

Inside `__str__`, we can use SUITS and RANKS to map the numerical values of suit and rank to strings. For example, the expression `Card.SUITS[self.suit]` means use the attribute `suit` from the object `self` as an index into the class attribute named SUITS, and select the appropriate string.

The reason for the "narf" in the first element in ranks is to act as a place keeper for the zero-eth element of the list, which will never be used. The only valid ranks are 1 to 13. This wasted item is not entirely necessary. We could have started at 0, as usual, but it is less confusing to encode 2 as 2, 3 as 3, and so on.

We have a doctest in the `__str__` method to confirm that `Card(2, 11)` will display as "Queen of Hearts".

3. Comparing cards

For primitive types, there are conditional operators (`<`, `>`, `==`, etc.) that compare values and determine when one is greater than, less than, or equal to another. For user-defined types, we can override the behavior of the built-in operators by providing a method named `__cmp__`. By convention, `__cmp__` takes two parameters, `self` and `other`, and returns 1 if the first object is greater, -1 if the second object is greater, and 0 if they are equal to each other.

Some types are completely ordered, which means that you can compare any two elements and tell which is bigger. For example, the integers and the floating-point numbers are completely ordered. Some sets are unordered, which means that there is no meaningful way to say that one element is bigger than another. For example, the fruits are unordered, which is why you cannot compare apples and oranges.

The set of playing cards is partially ordered, which means that sometimes you can compare cards and sometimes not. For example, you know that the 3 of Clubs is higher than the 2 of Clubs, and the 3 of Diamonds is higher than the 3 of Clubs. But which is better, the 3 of Clubs or the 2 of Diamonds? One has a higher rank, but the other has a higher suit.

In order to make cards comparable, you have to decide which is more important, rank or suit. To be honest, the choice is arbitrary. For the sake of choosing, we will say that suit is more important, because a new deck of cards comes sorted with all the Clubs together, followed by all the Diamonds, and so on.

With that decided, we can write `__cmp__`:

```

def __cmp__(self, other):
    # check the suits
    ifself.suit>other.suit: return1
    ifself.suit<other.suit: return-1
    # suits are the same... check ranks
    ifself.rank>other.rank: return1
    ifself.rank<other.rank: return-1
    # ranks are the same... it's a tie

```

return 0

In this ordering, Aces appear lower than Deuces (2s).

4. Decks:

Now that we have objects to represent Cards, the next logical step is to define a class to represent a Deck. Of course, a deck is made up of cards, so each Deck object will contain a list of cards as an attribute.

The following is a class definition for the Deck class. The initialization method creates the attribute cards and generates the standard set of fifty-two cards:

```
classDeck:
```

```
    def __init__(self):
```

```
        self.cards= []
```

```
    for suit in range(4):
```

```
        for rank in range(1, 14):
```

```
            self.cards.append(Card(suit, rank))
```

The easiest way to populate the deck is with a nested loop. The outer loop enumerates the suits from 0 to 3. The inner loop enumerates the ranks from 1 to 13. Since the outer loop iterates four times, and the inner loop iterates thirteen times, the total number of times the body is executed is fifty-two (thirteen times four). Each iteration creates a new instance of Card with the current suit and rank, and appends that card to the cards list.

The append method works on lists but not, of course, tuples.

5. Printing the deck

As usual, when we define a new type of object we want a method that prints the contents of an object. To print a Deck, we traverse the list and print each Card:

```
classDeck:
```

```
    ...
```

```
    def print_deck(self):
```

```
        for card in self.cards:
```

```
            print(card)
```

Here, and from now on, the ellipsis (...) indicates that we have omitted the other methods in the class.

As an alternative to print_deck, we could write a __str__ method for the Deck class. The advantage of __str__ is that it is more flexible. Rather than just printing the contents of the object, it generates a string representation that other parts of the program can manipulate before printing, or store for later use.

Here is a version of __str__ that returns a string representation of a Deck. To add a bit of pizzazz, it arranges the cards in a cascade where each card is indented one space more than the previous card:

```
classDeck:
```

```
    ...
```

```
    def __str__(self):
```

```
        s=""
```

```
        for i in range(len(self.cards)):
```

```
            s+=" "*i+str(self.cards[i])+"\n"
```

```
        return s
```

This example demonstrates several features. First, instead of traversing self.cards and assigning each card to a variable, we are using i as a loop variable and an index into the list of cards.

Second, we are using the string multiplication operator to indent each card by one more space than the last. The expression " " * i yields a number of spaces equal to the current value of i.

Third, instead of using the print function to print the cards, we use the str function. Passing an object as an argument to str is equivalent to invoking the __str__ method on the object.

Finally, we are using the variable s as an **accumulator**. Initially, s is the empty string. Each time through the loop, a new string is generated and concatenated with the old value of s to get the new value. When the loop ends, s contains the complete string representation of the Deck, which looks like this:

```
>>>deck=Deck()
```

```
>>>print(deck)
```

```
Ace of Clubs
```

```
 2 of Clubs
```

```
 3 of Clubs
```

```
 4 of Clubs
```

```
 5 of Clubs
```

```
 6 of Clubs
```

```
7 of Clubs
8 of Clubs
9 of Clubs
10 of Clubs
Jack of Clubs
Queen of Clubs
King of Clubs
Ace of Diamonds
```

And so on. Even though the result appears on 52 lines, it is one long string that contains newlines.

5. Shuffling the deck

If a deck is perfectly shuffled, then any card is equally likely to appear anywhere in the deck, and any location in the deck is equally likely to contain any card.

To shuffle the deck, we will use the `randrange` function from the `random` module. With two integer arguments, `a` and `b`, `randrange` chooses a random integer in the range $a \leq x < b$. Since the upper bound is strictly less than `b`, we can use the length of a list as the second parameter, and we are guaranteed to get a legal index. For example, this expression chooses the index of a random card in a deck:

```
random.randrange(0, len(self.cards))
```

An easy way to shuffle the deck is by traversing the cards and swapping each card with a randomly chosen one. It is possible that the card will be swapped with itself, but that is fine. In fact, if we precluded that possibility, the order of the cards would be less than entirely random:

classDeck:

```
...
defshuffle(self):
importrandom
num_cards=len(self.cards)
foriinrange(num_cards):
j=random.randrange(i, num_cards)
self.cards[i], self.cards[j] =self.cards[j], self.cards[i]
```

Rather than assume that there are fifty-two cards in the deck, we get the actual length of the list and store it in `num_cards`.

For each card in the deck, we choose a random card from among the cards that haven't been shuffled yet. Then we swap the current card (`i`) with the selected card (`j`). To swap the cards we use a tuple assignment:

```
self.cards[i], self.cards[j] =self.cards[j], self.cards[i].
```

Removing and dealing cards

Another method that would be useful for the `Deck` class is `remove`, which takes a card as a parameter, removes it, and returns `True` if the card was in the deck and `False` otherwise:

classDeck:

```
...
defremove(self, card):
ifcardinself.cards:
self.cards.remove(card)
returnTrue
else:
returnFalse
```

The `in` operator returns `True` if the first operand is in the second, which must be a list or a tuple. If the first operand is an object, Python uses the object's `__cmp__` method to determine equality with items in the list. Since the `__cmp__` in the `Card` class checks for deep equality, the `remove` method checks for deep equality.

To deal cards, we want to remove and return the top card. The list method `pop` provides a convenient way to do that:

classDeck:

```
...
defpop(self):
returnself.cards.pop()
```

Actually, `pop` removes the *last* card in the list, so we are in effect dealing from the bottom of the deck.

One more operation that we are likely to want is the boolean function `is_empty`, which returns true if the deck contains no cards:

classDeck:

...

```
def is_empty(self):
```

```
    return (len(self.cards) == 0)
```

Add:

To add a card, we can use the list method `append`:

#inside class Deck:

```
def add_card(self, card):
```

```
    self.cards.append(card)
```

7. Inheritance

The language feature most often associated with object-oriented programming is **inheritance**. Inheritance is the ability to define a new class that is a modified version of an existing class.

The primary advantage of this feature is that you can add new methods to a class without modifying the existing class. It is called inheritance because the new class inherits all of the methods of the existing class. Extending this metaphor, the existing class is sometimes called the **parent** class. The new class may be called the **child** class or sometimes subclass.

Inheritance is a powerful feature. Some programs that would be complicated without inheritance can be written concisely and simply with it. Also, inheritance can facilitate code reuse, since you can customize the behavior of parent classes without having to modify them. In some cases, the inheritance structure reflects the natural structure of the problem, which makes the program easier to understand.

On the other hand, inheritance can make programs difficult to read. When a method is invoked, it is sometimes not clear where to find its definition. The relevant code may be scattered among several modules. Also, many of the things that can be done using inheritance can be done as elegantly (or more so) without it. If the natural structure of the problem does not lend itself to inheritance, this style of programming can do more harm than good.

Inheritance in Python

Last Updated: 14-09-2020

Inheritance is the capability of one class to derive or inherit the properties from another class. The benefits of inheritance are:

It represents real-world relationships well.

It provides **reusability** of a code. We don't have to write the same code again and again. Also, it allows us to add more features to a class without modifying it.

It is transitive in nature, which means that if class B inherits from another class A, then all the subclasses of B would automatically inherit from class A.

Below is a simple example of inheritance in Python

Python

```
filter_none
```

```
edit
```

```
play_arrow
```

```
brightness_4
```

```
# A Python program to demonstrate inheritance
```

```
# Base or Super class. Note object in bracket.
```

```
# (Generally, object is made ancestor of all classes)
```

```
# In Python 3.x "class Person" is
```

```
# equivalent to "class Person(object)"
```

```
class Person(object):
```

```

# Constructor
def __init__(self, name):
    self.name = name

# To get name
def getName(self):
    return self.name

# To check if this person is an employee
def isEmployee(self):
    return False

# Inherited or Subclass (Note Person in bracket)
class Employee(Person):

    # Here we return true
    def isEmployee(self):
        return True

# Driver code
emp = Person("Geek1") # An Object of Person
print(emp.getName(), emp.isEmployee())

emp = Employee("Geek2") # An Object of Employee
print(emp.getName(), emp.isEmployee())

```

Output:

```

Geek1 False
Geek2 True

```

What is object class?

Like [Java Object class](#), in Python (from version 3.x), object is root of all classes. In Python 3.x, “class Test(object)” and “class Test” are same. In Python 2.x, “class Test(object)” creates a class with object as parent (called new style class) and “class Test” creates old style class (without object parent). Refer [this](#) for more details.

Subclassing (Calling constructor of parent class)

A child class needs to identify which class is its parent class. This can be done by mentioning the parent class name in the definition of the child class.

Eg: class **subclass_name** (**superclass_name**):

```

-
-

```

Python

filter_none

edit

play_arrow

brightness_4

Python code to demonstrate how parent constructors

are called.

parent class

class Person(object):

```

# __init__ is known as the constructor
def __init__(self, name, idnumber):
    self.name = name
    self.idnumber = idnumber
def display(self):
    print(self.name)
    print(self.idnumber)

# child class
class Employee( Person ):
    def __init__(self, name, idnumber, salary, post):
        self.salary = salary
        self.post = post

        # invoking the __init__ of the parent class
        Person.__init__(self, name, idnumber)

# creation of an object variable or an instance
a = Employee('Rahul', 886012, 200000, "Intern")

# calling a function of the class Person using its instance
a.display()
Output:
Rahul
886012

```

‘a’ is the instance created for the class Person. It invokes the `__init__()` of the referred class. You can see ‘object’ written in the declaration of the class Person. In Python, every class inherits from a built-in basic class called ‘object’. The constructor i.e. the ‘`__init__`’ function of a class is invoked when we create an object variable or an instance of the class.

The variables defined within `__init__()` are called as the instance variables or objects. Hence, ‘name’ and ‘idnumber’ are the objects of the class Person. Similarly, ‘salary’ and ‘post’ are the objects of the class Employee. Since the class Employee inherits from class Person, ‘name’ and ‘idnumber’ are also the objects of class Employee. If you forget to invoke the `__init__()` of the parent class then its instance variables would not be available to the child class.

The following code produces an error for the same reason.

```

Python
filter_none
edit
play_arrow
brightness_4
# Python program to demonstrate error if we
# forget to invoke __init__() of the parent.

class A:
    def __init__(self, n = 'Rahul'):
        self.name = n
class B(A):
    def __init__(self, roll):
        self.roll = roll

object = B(23)
print (object.name)

```

Output :

Traceback (most recent call last):

```
File "/home/de4570cca20263ac2c4149f435dba22c.py", line 12, in  
    print (object.name)
```

AttributeError: 'B' object has no attribute 'name'

Different forms of Inheritance:

1. Single inheritance: When a child class inherits from only one parent class, it is called single inheritance. We saw an example above.

2. Multiple inheritance: When a child class inherits from multiple parent classes, it is called multiple inheritance. Unlike Java and like C++, Python supports multiple inheritance. We specify all parent classes as a comma-separated list in the bracket.

```
Python  
filter_none  
edit  
play_arrow  
brightness_4  
# Python example to show the working of multiple  
# inheritance  
class Base1(object):  
    def __init__(self):  
        self.str1 = "Geek1"  
        print("Base1")  
  
class Base2(object):  
    def __init__(self):  
        self.str2 = "Geek2"  
        print("Base2")  
  
class Derived(Base1, Base2):  
    def __init__(self):  
  
        # Calling constructors of Base1  
        # and Base2 classes  
        Base1.__init__(self)  
        Base2.__init__(self)  
        print("Derived")  
  
    def printStrs(self):  
        print(self.str1, self.str2)
```

```
ob = Derived()  
ob.printStrs()
```

Output:

```
Base1  
Base2  
Derived  
Geek1 Geek2
```

3. Multilevel inheritance: When we have a child and grandchild relationship.

```
Python  
filter_none  
edit  
play_arrow  
brightness_4  
# A Python program to demonstrate inheritance
```



```
# Base or Super class. Note object in bracket.
# (Generally, object is made ancestor of all classes)
# In Python 3.x "class Person" is
# equivalent to "class Person(object)"
class Base(object):
```

```
    # Constructor
    def __init__(self, name):
        self.name = name
```

```
    # To get name
    def getName(self):
        return self.name
```

```
# Inherited or Sub class (Note Person in bracket)
class Child(Base):
```

```
    # Constructor
    def __init__(self, name, age):
        Base.__init__(self, name)
        self.age = age
```

```
    # To get name
    def getAge(self):
        return self.age
```

```
# Inherited or Sub class (Note Person in bracket)
class GrandChild(Child):
```

```
    # Constructor
    def __init__(self, name, age, address):
        Child.__init__(self, name, age)
        self.address = address
```

```
    # To get address
    def getAddress(self):
        return self.address
```

```
# Driver code
g = GrandChild("Geek1", 23, "Noida")
print(g.getName(), g.getAge(), g.getAddress())
```

Output:

Geek1 23 Noida

4. Hierarchical inheritance More than one derived classes are created from a single base.

5. Hybrid inheritance: This form combines more than one form of inheritance. Basically, it is a blend of more than one type of inheritance.

Private members of parent class
We don't always want the instance variables of the parent class to be inherited by the child class i.e. we can make some of the instance variables of the parent class private, which won't be available to the child class. We can make an instance variable by adding double underscores before its name. For example,

Python

```

filter_none
edit
play_arrow
brightness_4
# Python program to demonstrate private members
# of the parent class
class C(object):
    def __init__(self):
        self.c = 21

        # d is private instance variable
        self._d = 42
class D(C):
    def __init__(self):
        self.e = 84
        C.__init__(self)
object1 = D()

```

produces an error as d is private instance variable

```
print(object1.d)
```

Output :

```
File "/home/993bb61c3e76cda5bb67bd9ea05956a1.py", line 16, in
print (object1.d)
AttributeError: type object 'D' has no attribute 'd'
```

Since ‘d’ is made private by those underscores, it is not available to the child class ‘D’ and hence the error.

Attention geek! Strengthen your foundations with the [Python Programming Foundation](#) Course and learn the basics.

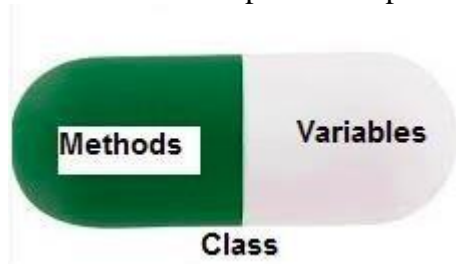
To begin with, your interview preparations Enhance your Data Structures concepts with the [Python DS](#) Course.

Encapsulation in Python

Encapsulation is one of the fundamental concepts in object-oriented programming (OOP). It describes the idea of wrapping data and the methods that work on data within one unit. This puts restrictions on accessing variables and methods directly and can prevent the accidental modification of data. To prevent accidental change, an object’s variable can only be changed by an object’s method. Those type of variables are known as **private**

variable.

A class is an example of encapsulation as it encapsulates all the data that is member functions, variables, etc.



Consider a real-life example of encapsulation, in a company, there are different sections like the accounts section, finance section, sales section etc. The finance section handles all the financial transactions and keeps records of all the data related to finance. Similarly, the sales section handles all the sales-related activities and keeps records of all the sales. Now there may arise a situation when for some reason an official from the finance section needs all the data about sales in a particular month. In this case, he is not allowed to directly access the data of the sales section. He will first have to contact some other officer in the sales section and then request him to give the particular data. This is what encapsulation is. Here the data of the sales section and the employees that can manipulate them are wrapped under a single name “sales section”. As using encapsulation also hides the data. In this example, the data of any of the sections like sales, finance or accounts are hidden from any other section.

Protected members

Protected members (in C++ and JAVA) are those members of the class which cannot be accessed outside the class but can be accessed from within the class and its subclasses. To accomplish this in Python, just follow **the convention** by prefixing the name of the member by a **single underscore “_”**.

Note: The `__init__` method is a constructor and runs as soon as an object of a class is instantiated.

```
# Python program to
# demonstrate protected members

# Creating a base class
classBase:
    def__init__(self):

        # Protected member
        self._a =2

# Creating a derived class
classDerived(Base):
    def__init__(self):

        # Calling constructor of
        # Base class
        Base.__init__(self)
        print("Calling protected member of base class: ")
        print(self._a)

obj1 =Derived()

obj2 =Base()

# Calling protected member
# Outside class will result in
# AttributeError
print(obj2.a)
```

Output:

Calling protected member of base class:

2

Traceback (most recent call last):

File `"/home/6fb1b95dfba0e198298f9dd02469eb4a.py"`, line 25, in

`print(obj1.a)`

AttributeError: 'Base' object has no attribute 'a'

Private members

Private members are similar to protected members, the difference is that the class members declared private should neither be accessed outside the class nor by any base class. In Python, there is no existence of **Private** instance variables that cannot be accessed except inside a class. However, to define a private member prefix the member name with double underscore “`__`”.

Note: Python’s private and protect member can be accessed outside the class through [python name mangling](#).

```
# Python program to
# demonstrate private members
```

```

# Creating a Base class
class Base:
    def __init__(self):
        self.a = "GeeksforGeeks"
        self.c = "GeeksforGeeks"

# Creating a derived class
class Derived(Base):
    def __init__(self):

        # Calling constructor of
        # Base class
        Base.__init__(self)
        print("Calling private member of base class: ")
        print(self._a)

# Driver code
obj1 = Base()
print(obj1.a)

# Uncommenting print(obj1.c) will
# raise an AttributeError

# Uncommenting obj2 = Derived() will
# also raise an AttributeError as
# private member of base class
# is called inside derived class

```

Output:

Traceback (most recent call last):

```

File "/home/ee6c98f658e288878c9c206332568d9a.py", line 24, in
    print(obj._c)
AttributeError: 'Test' object has no attribute '_c'

```

Traceback (most recent call last):

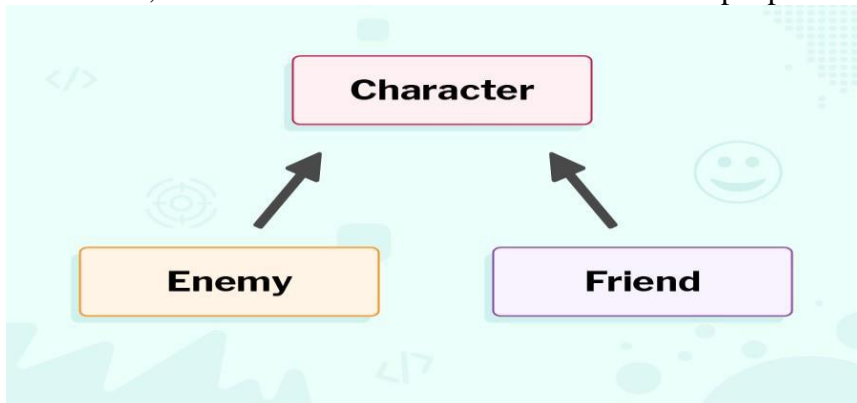
```

File "/home/abbc7bf34551e0ebfc889c55f079dbc7.py", line 26, in
    obj2 = Derived()
File "/home/abbc7bf34551e0ebfc889c55f079dbc7.py", line 18, in __init__
    print(self._c)

```

Class diagrams

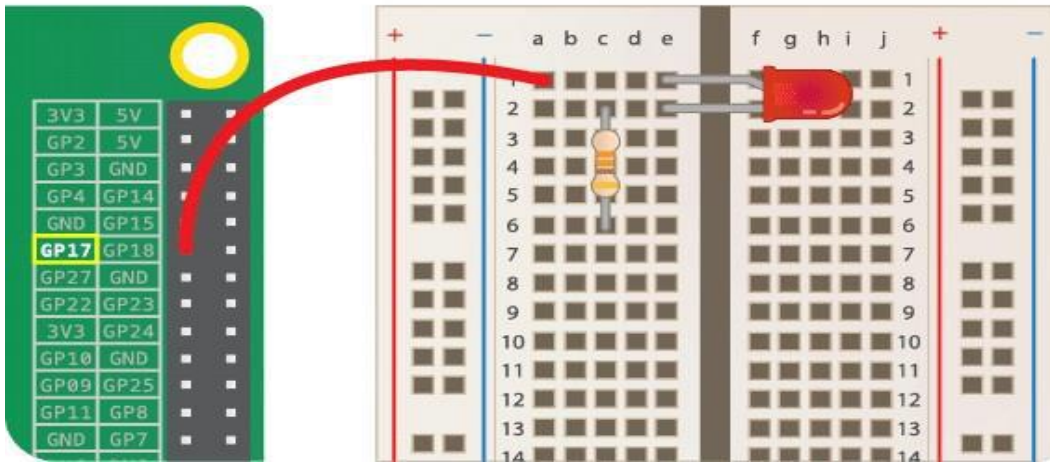
To represent inheritance between classes, you can use a class diagram showing which classes inherit from which other classes. This may make the terms ‘superclass’ and ‘subclass’ easier to remember, as super- indicates the class above, while sub- indicates the class below. Some people like to compare these diagrams to family trees.



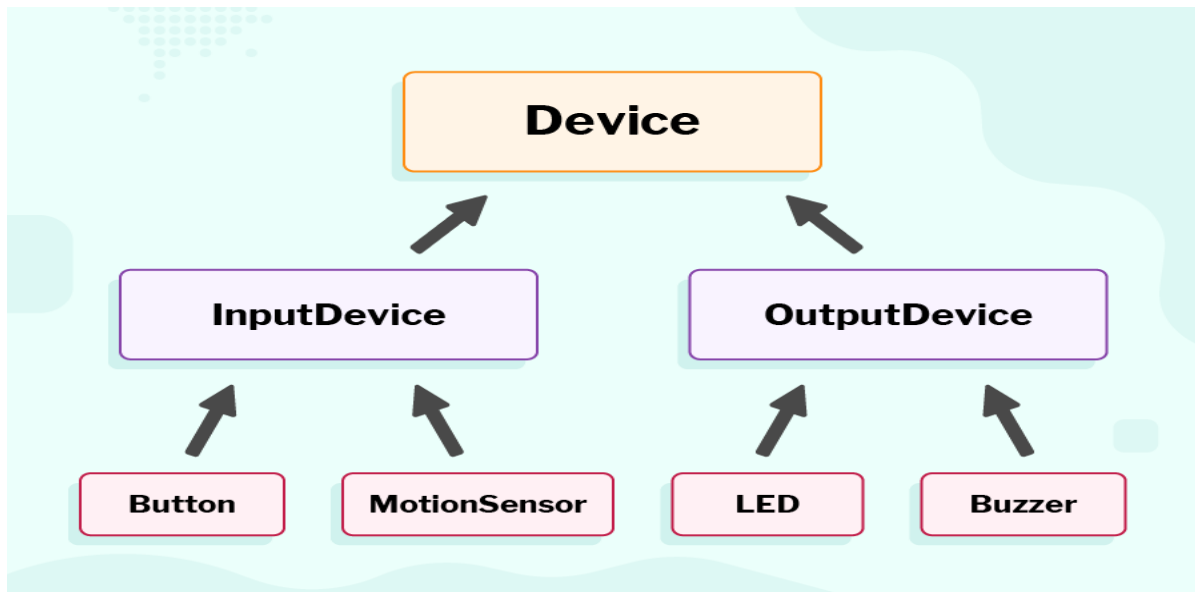
In the diagram, each class is represented by a rectangle. An arrow points towards the class from which something is inherited.

Looking at a class diagram can also help us to understand polymorphism. If a class inherits from another class, it can also be considered to be an object of that class. For example, Enemy inherits from Character, so Enemy is a Character.

In week one, you used the gpiozero library to create an LED object in code to represent a physical LED.



You can see in the diagram below that the class LED is a subclass of OutputDevice. This means that LED is an OutputDevice: it inherits the properties of a generic OutputDevice and adds some specialised methods of its own.



Buzzer is also a subclass of OutputDevice, but it has different functionality. If you look into the documentation, you will find that LED has a blink() method, whereas Buzzer has a beep() method. Both LED and Buzzer inherit the same on() and off() methods from OutputDevice.

The Goodies

One of my goals for this book has been to teach you as little Python as possible. When there were two ways to do something, I picked one and avoided mentioning the other. Or sometimes I put the second one into an exercise. Now I want to go back for some of the good bits that got left behind. Python provides a number of features that are not really necessary—you can write good code without them—but with them you can sometimes write code that’s more concise, readable or efficient, and sometimes all three.

1. Conditional expressions

Conditional statements are often used to choose one of two values; for example:

```
if x > 0:
    y = math.log(x)
else:
    y = float('nan')
```

This statement checks whether `x` is positive. If so, it computes `math.log`. If not, `math.log` would raise a `ValueError`. To avoid stopping the program, we generate a “NaN”, which is a special floating-point value that represents “Not a Number”.

We can write this statement more concisely using a **conditional expression**:

```
y = math.log(x) if x > 0 else float('nan')
```

You can almost read this line like English: “`y` gets `log-x` if `x` is greater than 0; otherwise it gets `NaN`”.

Recursive functions can sometimes be rewritten using conditional expressions. For example, here is a recursive version of factorial:

```
def factorial(n):
    if n == 0:
        return 1
    else:
        return n * factorial(n-1)
```

We can rewrite it like this:

```
def factorial(n):
    return 1 if n == 0 else n * factorial(n-1)
```

Another use of conditional expressions is handling optional arguments. For example, here is the `init` method from `GoodKangaroo`

```
def __init__(self, name, contents=None):
    self.name = name
    if contents == None:
        contents = []
self.pouch_contents = contents
```

We can rewrite this one like this:

```
def __init__(self, name, contents=None):
    self.name = name
self.pouch_contents = [] if contents == None else contents
```

In general, you can replace a conditional statement with a conditional expression if both branches contain simple expressions that are either returned or assigned to the same variable.

2. List comprehensions

In we saw the `map` and `filter` patterns. For example, this function takes a list of strings, maps the string method `capitalize` to the elements, and returns a new list of strings:

```
def capitalize_all(t):
    res = []
    for s in t:
        res.append(s.capitalize())
    return res
```

We can write this more concisely using a **list comprehension**:

```
def capitalize_all(t):
    return [s.capitalize() for s in t]
```

The bracket operators indicate that we are constructing a new list. The expression inside the brackets specifies the elements of the list, and the `for` clause indicates what sequence we are traversing.

The syntax of a list comprehension is a little awkward because the loop variable, `s` in this example, appears in the expression before we get to the definition.

List comprehensions can also be used for filtering. For example, this function selects only the elements of `t` that are upper case, and returns a new list:

```
def only_upper(t):
    res = []
    for s in t:
        if s.isupper():
            res.append(s)
    return res
```

We can rewrite it using a list comprehension

```
def only_upper(t):
    return [s for s in t if s.isupper()]
```

List comprehensions are concise and easy to read, at least for simple expressions. And they are usually faster than the equivalent for loops, sometimes much faster. So if you are mad at me for not mentioning them earlier, I understand.

But, in my defense, list comprehensions are harder to debug because you can't put a print statement inside the loop. I suggest that you use them only if the computation is simple enough that you are likely to get it right the first time. And for beginners that means never.

3. Generator expressions

Generator expressions are similar to list comprehensions, but with parentheses instead of square brackets:

```
>>> g = (x**2 for x in range(5))
>>> g
<generator object <genexpr> at 0x7f4c45a786c0>
```

The result is a generator object that knows how to iterate through a sequence of values. But unlike a list comprehension, it does not compute the values all at once; it waits to be asked. The built-in function `next` gets the next value from the generator:

```
>>> next(g)
0
>>> next(g)
1
```

When you get to the end of the sequence, `next` raises a `StopIteration` exception. You can also use a for loop to iterate through the values:

```
>>> for val in g:
...     print(val)
4
9
16
```

The generator object keeps track of where it is in the sequence, so the for loop picks up where `next` left off. Once the generator is exhausted, it continues to raise `StopIteration`:

```
>>> next(g)
StopIteration
```

Generator expressions are often used with functions like `sum`, `max`, and `min`:

```
>>> sum(x**2 for x in range(5))
30
```

4. any and all

Python provides a built-in function, `any`, that takes a sequence of boolean values and returns `True` if any of the values are `True`. It works on lists:

```
>>> any([False, False, True])
True
```

But it is often used with generator expressions:

```
>>> any(letter == 't' for letter in 'monty')
True
```

That example isn't very useful because it does the same thing as the `in` operator. But we could use `any` to rewrite some of the search functions we wrote in Section [9.3](#). For example, we could write `avoids` like this:

```
def avoids(word, forbidden):
    return not any(letter in forbidden for letter in word)
```

The function almost reads like English, "word avoids forbidden if there are not any forbidden letters in word."

Using any with a generator expression is efficient because it stops immediately if it finds a True value, so it doesn't have to evaluate the whole sequence.

Python provides another built-in function, all, that returns True if every element of the sequence is True. As an exercise, use all to re-write uses_all

5. Sets

I use dictionaries to find the words that appear in a document but not in a word list. The function I wrote takes d1, which contains the words from the document as keys, and d2, which contains the list of words. It returns a dictionary that contains the keys from d1 that are not in d2.

```
def subtract(d1, d2):
    res = dict()
    for key in d1:
        if key not in d2:
            res[key] = None
    return res
```

In all of these dictionaries, the values are None because we never use them. As a result, we waste some storage space.

Python provides another built-in type, called a set, that behaves like a collection of dictionary keys with no values. Adding elements to a set is fast; so is checking membership. And sets provide methods and operators to compute common set operations.

For example, set subtraction is available as a method called difference or as an operator, -. So we can rewrite subtract like this:

```
def subtract(d1, d2):
    return set(d1) - set(d2)
```

The result is a set instead of a dictionary, but for operations like iteration, the behavior is the same.

Some of the exercises in this book can be done concisely and efficiently with sets. For example, here is a solution to has_duplicates, that uses a dictionary:

```
def has_duplicates(t):
    d = {}
    for x in t:
        if x in d:
            return True
        d[x] = True
    return False
```

When an element appears for the first time, it is added to the dictionary. If the same element appears again, the function returns True.

Using sets, we can write the same function like this:

```
def has_duplicates(t):
    return len(set(t)) < len(t)
```

An element can only appear in a set once, so if an element in t appears more than once, the set will be smaller than t. If there are no duplicates, the set will be the same size as t.

For example, here's a version of uses_only with a loop:

```
def uses_only(word, available):
    for letter in word:
        if letter not in available:
            return False
    return True
```

uses_only checks whether all letters in word are in available. We can rewrite it like this:

```
def uses_only(word, available):
    return set(word) <= set(available)
```

The <= operator checks whether one set is a subset of another, including the possibility that they are equal, which is true if all the letters in word appear in available.

As an exercise, rewrite avoids using sets.

6. Counters

A Counter is like a set, except that if an element appears more than once, the Counter keeps track of how many times it appears. If you are familiar with the mathematical idea of a **multiset**, a Counter is a natural way to represent a multiset.

Counter is defined in a standard module called collections, so you have to import it. You can initialize a Counter with a string, list, or anything else that supports iteration:

```
>>> from collections import Counter
```

```
>>> count = Counter('parrot')
```

```
>>> count
```

```
Counter({'r': 2, 't': 1, 'o': 1, 'p': 1, 'a': 1})
```

Counters behave like dictionaries in many ways; they map from each key to the number of times it appears. As in dictionaries, the keys have to be hashable.

Unlike dictionaries, Counters don't raise an exception if you access an element that doesn't appear. Instead, they return 0:

```
>>> count['d']
```

```
0
```

We can use Counters to rewrite is_anagram :

```
def is_anagram(word1, word2):
```

```
    return Counter(word1) == Counter(word2)
```

If two words are anagrams, they contain the same letters with the same counts, so their Counters are equivalent.

Counters provide methods and operators to perform set-like operations, including addition, subtraction, union and intersection. And they provide an often-useful method, most_common, which returns a list of value-frequency pairs, sorted from most common to least:

```
>>> count = Counter('parrot')
```

```
>>> for val, freq in count.most_common(3):
```

```
...     print(val, freq)
```

```
r 2
```

```
p 1
```

```
a 1
```

7.defaultdict

The collections module also provides defaultdict, which is like a dictionary except that if you access a key that doesn't exist, it can generate a new value on the fly.

When you create a defaultdict, you provide a function that's used to create new values. A function used to create objects is sometimes called a **factory**. The built-in functions that create lists, sets, and other types can be used as factories:

```
>>> from collections import defaultdict
```

```
>>> d = defaultdict(list)
```

Notice that the argument is list, which is a class object, not list(), which is a new list. The function you provide doesn't get called unless you access a key that doesn't exist.

```
>>> t = d['new key']
```

```
>>> t
```

```
[]
```

The new list, which we're calling t, is also added to the dictionary. So if we modify t, the change appears in d:

```
>>>t.append('new value')
```

```
>>> d
```

```
defaultdict(<class 'list'>, {'new key': ['new value']})
```

If you are making a dictionary of lists, you can often write simpler code using defaultdict. In my solution to, which you can get from http://thinkpython2.com/code/anagram_sets.py, I make a dictionary that maps from a sorted string of letters to the list of words that can be spelled with those letters. For example, 'opst' maps to the list ['opts', 'post', 'pots', 'spot', 'stop', 'tops'].

Here's the original code:

```
def all_anagrams(filename):
```

```
    d = { }
```

```
    for line in open(filename):
```

```
        word = line.strip().lower()
```

```
        t = signature(word)
```

```
        if t not in d:
```

```
            d[t] = [word]
```

```

else:
    d[t].append(word)
return d

```

This can be simplified using `setdefault`, which you might have used in Exercise 2:

```

def all_anagrams(filename):
    d = {}
    for line in open(filename):
        word = line.strip().lower()
        t = signature(word)
    d.setdefault(t, []).append(word)
    return d

```

This solution has the drawback that it makes a new list every time, regardless of whether it is needed. For lists, that's no big deal, but if the factory function is complicated, it might be.

We can avoid this problem and simplify the code using a `defaultdict`:

```

def all_anagrams(filename):
    d = defaultdict(list)
    for line in open(filename):
        word = line.strip().lower()
        t = signature(word)
        d[t].append(word)
    return d

```

My solution to, which you can download from <http://thinkpython2.com/code/PokerHandSoln.py>, uses `setdefault` in the function `has_straightflush`. This solution has the drawback of creating a `Hand` object every time through the loop, whether it is needed or not. As an exercise, rewrite it using a `defaultdict`.

8. Named tuples

Many simple objects are basically collections of related values. For example, the `Point` object defined in contains two numbers, `x` and `y`. When you define a class like this, you usually start with an `init` method and a `str` method:

```
class Point:
```

```

    def __init__(self, x=0, y=0):
        self.x = x
        self.y = y

```

```

    def __str__(self):
        return '%g, %g' % (self.x, self.y)

```

This is a lot of code to convey a small amount of information. Python provides a more concise way to say the same thing:

```

from collections import namedtuple
Point = namedtuple('Point', ['x', 'y'])

```

The first argument is the name of the class you want to create. The second is a list of the attributes `Point` objects should have, as strings. The return value from `namedtuple` is a class object:

```

>>> Point
<class '_main_.Point'>

```

`Point` automatically provides methods like `__init__` and `__str__` so you don't have to write them.

To create a `Point` object, you use the `Point` class as a function:

```

>>> p = Point(1, 2)
>>> p
Point(x=1, y=2)

```

The `init` method assigns the arguments to attributes using the names you provided. The `str` method prints a representation of the `Point` object and its attributes.

You can access the elements of the named tuple by name:

```

>>> p.x, p.y
(1, 2)

```

But you can also treat a named tuple as a tuple:

```

>>> p[0], p[1]
(1, 2)

```

```

>>> x, y = p

```

```
>>> x, y
(1, 2)
```

Named tuples provide a quick way to define simple classes. The drawback is that simple classes don't always stay simple. You might decide later that you want to add methods to a named tuple. In that case, you could define a new class that inherits from the named tuple:

```
class Pointier(Point):
    # add more methods here
```

Or you could switch to a conventional class definition.

9. Gathering keyword args

we saw how to write a function that gathers its arguments into a tuple:

```
def printall(*args):
    print(args)
```

You can call this function with any number of positional arguments (that is, arguments that don't have keywords):

```
>>> printall(1, 2.0, '3')
(1, 2.0, '3')
```

But the * operator doesn't gather keyword arguments:

```
>>> printall(1, 2.0, third='3')
```

`TypeError: printall() got an unexpected keyword argument 'third'`

To gather keyword arguments, you can use the ** operator:

```
def printall(*args, **kwargs):
    print(args, kwargs)
```

You can call the keyword gathering parameter anything you want, but `kwargs` is a common choice. The result is a dictionary that maps keywords to values:

```
>>> printall(1, 2.0, third='3')
(1, 2.0) {'third': '3'}
```

If you have a dictionary of keywords and values, you can use the scatter operator, ** to call a function:

```
>>> d = dict(x=1, y=2)
>>> Point(**d)
Point(x=1, y=2)
```

Without the scatter operator, the function would treat `d` as a single positional argument, so it would assign `d` to `x` and complain because there's nothing to assign to `y`:

```
>>> d = dict(x=1, y=2)
>>> Point(d)
```

Traceback (most recent call last):

```
File "<stdin>", line 1, in <module>
```

```
TypeError: new_() missing 1 required positional argument: 'y'
```

When you are working with functions that have a large number of parameters, it is often useful to create and pass around dictionaries that specify frequently used options.