

PROGRAMMING AND PROBLEM SOLVING
WITH
PYTHON

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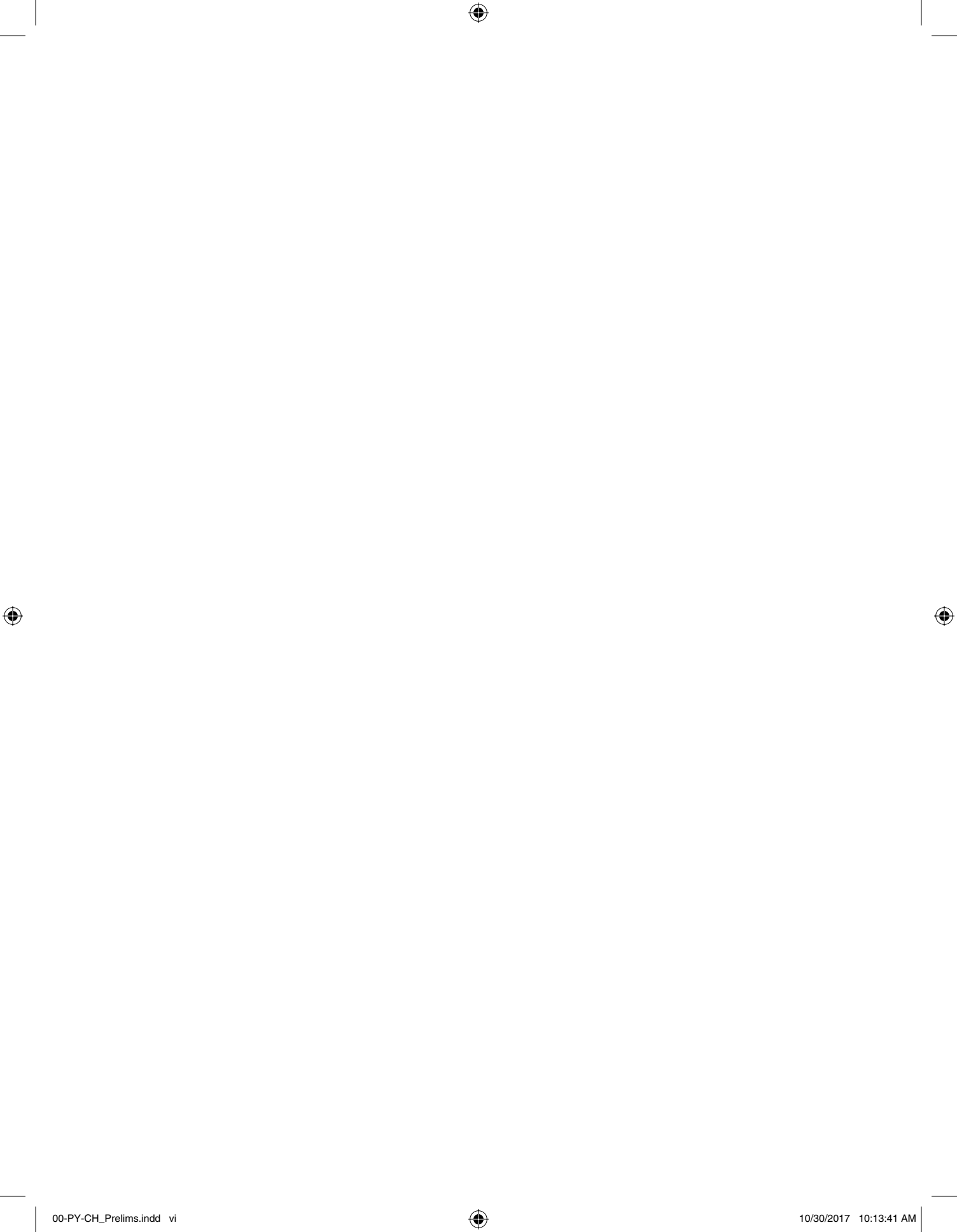
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Dedicated to

*Sow Surekha Ashok Kamthane
(Mother of Amit Ashok Kamthane)*



Preface

It gives us immense pleasure to bring the book '*Programming and Problem Solving with Python*'. The book is intended for the students in initial years of engineering and mathematics who can use this high-level programming language as an effective tool in mathematical problem solving. Python is used to develop applications of any stream and it is not restricted only to computer science.

We believe that anyone who has basic knowledge of computer and ability of logical thinking can learn programming. With this motivation, we have written this book in a lucid manner. Once you go through the book, you will know how simple the programming language is and at the same time you will learn the basics of python programming. You will feel motivated enough to develop applications using python.

Since this book has been written with consideration that reader has no prior knowledge of python programming, before going through all the chapters, reader should know what are the benefits of learning python programming. Following are some of the reasons why one should learn python language.

- Python language is simple and easy to learn. For example, it has simple syntax compared to other programming languages.
- Python is an object-oriented programming language. It is used to develop desktop, standalone and scripting applications.
- Python is also an example of free open source software. Due to its open nature one can write programs and can deploy on any of platform, i.e., (Windows, Linux, Ubuntu and Mac OS), without changing the original program.

Thus, due to the features enlisted above, python has become the most popular language and is widely used among programmers.

Use of Python in Engineering Domains

Computer Engineering

Python is used in computer engineering

- To develop web applications
- By data scientists to analyse large amount of data
- In automation testing

- To develop GUI-based applications, cryptography and network security and many more applications

Electronics and Telecommunication Engineering and Electrical Engineering

- Image processing applications can be developed by using python's 'scikit-image' library
- Widely used in developing embedded applications
- Develop IOT applications using Arduino and Raspberry pi

Python can also be used in **other engineering streams** such as mechanical, chemical, and bioinformatics to perform complex calculations by making use of numpy, scipy, and pandas library.

Thus, the end user of this book can be anyone who wants to learn basics of python programming. To learn the basics, the student can be of any stream/any engineering/Diploma/BCA/MCA background and interested to develop applications using python.

Organization of the Book

The book is organized into two parts. The first part covers fundamentals of computer programming while the second part covers topics related to object-oriented programming and some basic topics on data structures.

In the first part of the book, the readers will learn about basics of computer, basics of python programming, executing python programs on various operating systems (**Chapter 1**), data types used in python, assignments, formatting numbers and strings (**Chapter 2**) operators and expressions (**Chapter 3**), decision statements (**Chapter 4**), loop control statements (**Chapter 5**) and functions (**Chapter 6**).

In the second part, the readers will be introduced to creation of classes and objects. The concept of creating list and strings using classes are discussed in **Chapters 7 and 8**. Reader will also become aware of basic topics of data structures, i.e. searching and sorting (**Chapter 9**) since it is one of the most important concept and used in almost all real-world applications. Various concepts and features of object-oriented programming such as inheritance, accessibility, i.e. encapsulation have been covered in **Chapter 10**. **Chapter 11** comprises one of the major important data structures of python, i.e. tuples, sets and dictionaries in great detail whereas **Chapter 12** explains graphics creation using turtle. Finally, **Chapter 13** will help the readers to understand the need of file handling and develop real-time applications based on it. Thus, after going through the second part of the book, the readers will be in a position to create a software application by considering flexibility, and reusability.

Online Learning Centre

The text is supported by additional content which can be accessed from the weblink <http://www.mhhe.com/kamthane/python>. The weblink comprises

- Problems for practice
- Solutions Manual (for Instructors and Students)
- PPTs
- Useful web links for further reading

In the end, we would like to express gratitude to all our well-wishers and readers, whose unstinted support and encouragement has kept us going as a teacher and author of this book. Any suggestion regarding the improvement of the book will be highly appreciated.

ASHOK NAMDEV KAMTHANE

AMIT ASHOK KAMTHANE

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Visual Walkthrough

All chapters within the book have been structured into the following important pedagogical components:

- **Learning Outcomes** give a clear idea to the students and programmers on what they will learn in each chapter. After completion of chapter, they will be able to comprehend and apply all the objectives of the chapter.
- **Introduction** explains the basics of each topic and familiarizes the reader to the concept being dealt with.

PROGRAM 8.1 Write a program to create a list with elements 1,2,3,4 and 5. Display even elements of the list using list comprehension.

```
List1=[1,2,3,4,5]
print("Content of List1")
print(List1)
List1=[x for x in List1 if x%2==0]
print("Even elements from the List1")
print(List1)
```

Output

```
Content of List1
[1, 2, 3, 4, 5]
Even elements from the
[2, 4]
```

PROGRAM 13.3 Generate 50 random numbers within a range 500 to 1000 and write them to file **WriteNumRandom.txt**.

```
from random import randint          # Import Random Module
fpl = open("WriteNumRandom.txt", "w") # Open file in write mode
for x in range(51):                 # Iterates for 50 times
    x = randint(500,1000)             # Generate one random number
    x = str(x)                        # Convert Number to String
    fpl.write(x + " ")                # Write Number to Output file
fpl.close()                          # Finish Writing Close the file
```

Output File

```
WriteNumRandom.txt - C:\Python34\WriteNumRandom.txt (3.42)
File Edit Format Run Options Windows Help
504 955 584 643 933 602 857 883 820 515 714 763 509 926 560 879 785 634 587 985
```

Decision Statements

4

CHAPTER OUTLINE

4.1 Introduction	4.6 Boolean Expressions and Relational Operators
4.2 Boolean Type	4.7 Decision Making Statements
4.3 Boolean Operators	4.8 Conditional Expressions
4.4 Using Numbers with Boolean Operators	
4.5 Using String with Boolean Operators	

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Describe Boolean expressions and **bool** data type
- Perform operations on numbers and strings using **Boolean and Relational** operators (>, <=, <, >= and !=)
- Write a simple decision making statement and its implementation with **if** statement, two-way decision making statements and their implementation with **if else** statement, nested statements and their implementation with **if-elif-else** statements
- Explain and use **conditional expressions** to write programs
- Write non-sequential programs using Boolean expressions.

4.1 INTRODUCTION

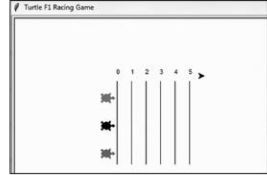
So far, we have seen programs that contain a sequence of instructions. These programs are executed by the compiler line by line, in the way the program line appears. The flow control in

- **Programs** are the highlighting feature of the chapters. Ample programs have been provided against each sub topic to effectively strengthen the learnt concepts.

- **Mini Project** consists of a problem statement that will compel the readers to think and make use of various concepts learnt to solve real-life problems through programming.

MINI PROJECT Turtle Racing Game

Create **three** different Turtles of colors **red, green and black**. Design one track for all of them to run over the track and win the competition. The track and the Turtle before the start of the completion should look as shown.



Turtle Racing Track

To solve this case study, the for loop and Turtle's inbuilt functions such as `penup()`, `pendown()`, `forward()`, `right()`, `goto()`, `color()`, `shape()`, `speed()`, and `left()` will be used.

Note: The `del` operator uses index to access the elements of a list. It gives a run time error if the index is out of range.

Example:

```
>>> del Lst[4]
```

Traceback (most recent call last):

```
File "<pyshell#37>", line 1, in <module>
del Lst[4]
IndexError: list assignment index out of range
```

- **Notes** have been inserted in each chapter to provide valuable insights based on programming concepts. Notes shall also act as precautionary statements for readers to solve programming problems effectively.

- A concise **Summary** has been listed at chapter-end to reiterate vital points and describes in short, the complex concepts covered within the chapter.
- **Key Terms** enlists important keywords and concepts covered within the chapter.
- Extensive **Review Questions** presented at the end of each chapter comprise Multiple Choice Questions, True False statements, Exercise Questions and Programming Assignments. This would help in analyzing the learnt information.

SUMMARY

- A function is a self-contained block of one or more statements that perform a special task when called.
- A function's definition in Python begins with the `def` keyword followed by the function's name, parameter and body.
- The function header may contain zero or more number of parameters.
- Parameters are the names that appear in a function's definition.
- Arguments are the values actually passed to a function when calling a function.
- Arguments to a function can be passed as positional or keyword arguments.
- The arguments must match the parameters in order, number and type as defined in the function.
- A variable must be created before it is used.
- Variables defined within the scope of a function are said to be local variables.
- Variables that are assigned outside of functions are said to be global variables.
- The `return` statement is used to return a value from a function.
- Functions in Python can return multiple values.
- Python also supports a recursive feature, i.e. a function can be called repetitively by itself.

KEY TERMS

- ⇒ **The `def` keyword:** Reserved word to define a function
- ⇒ **Positional arguments:** By default, parameters are assigned according to their position
- ⇒ **Keyword arguments:** Use syntax keyword = Value to call a function with keyword arguments
- ⇒ **Local and global scope of a variable:** Describes two different scopes of a variable
- ⇒ **The `return` keyword:** Used to return single or multiple values
- ⇒ **Lambda:** An anonymous function

REVIEW QUESTIONS

A. Multiple Choice Questions

1. A variable defined outside a function is referred to as
 - a. Local variable
 - b. Only variable
 - c. Global variable
 - d. None of the above
2. Which of the following function headers is correct?
 - a. `def Demo(P, Q = 10):`
 - b. `def Demo(P=10, Q = 20):`
 - c. `def Demo(P=10, Q)`
 - d. Both a and c
3. What will be the output of the following program?


```
x = 10
def f():
    x = x + 10
    print(x)
f()
```



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ASHOK NAMDEV KAMTHANE
AMIT ASHOK KAMTHANE



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Introduction to Computer and Python Programming

1

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LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Identify the functionalities of modern computer systems and various programming languages
- Explain the importance of Python and describe its need as a programming language
- Install Python in various operating systems and write and execute programs in Python

1.1 INTRODUCTION

Nowadays computers have become an integral part of human lives. They are used in diverse sectors to execute a range of everyday tasks such as reservation of tickets, payment of electricity bills, virtual transfer of money, forecasting the weather, diagnosis of diseases and so on. In short, each one of us—directly or indirectly—makes use of computers. So, before learning python programming language, this chapter explains the basics of computers and different types of programming

languages for ease of beginners and then introduces Python in detail, covering installation and execution of Python and Python programs.

1.2 WHAT IS A COMPUTER?

The word computer is derived from 'compute', which means 'to calculate'. A computer is an electronic device which accepts data from a user, processes the data for calculations specified by the user and generates an output. A computer performs these operations with speed and accuracy using certain hardware and software. Hardware is visible physical element of a computer and software consist of a written set of instructions used to control the hardware. Figure 1.1. shows the various components of a modern computer system.

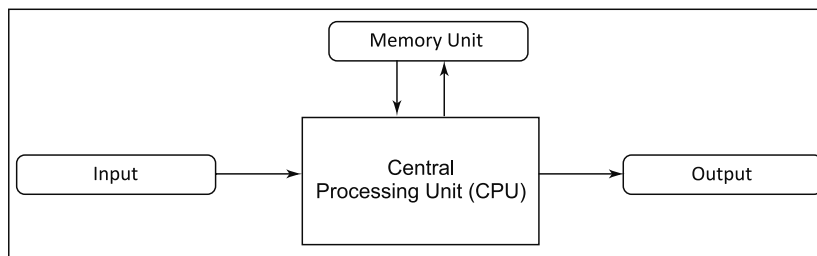


Figure 1.1 Block diagram of a modern computer system

The hardware of a computer system consists of three main components, viz. input/output (I/O) unit, central processing unit and memory unit.

1.2.1 Input/Output (I/O) Unit

Users interact with a computer using various I/O units. Inputs can be given to a computer using input devices, such as a keyboard. The input unit of a computer converts the data that it accepts from a user into a form that is understandable by it. As soon as the computer receives the input, it is processed and sent to its output device. Monitors, printers, etc., are examples of output devices of a computer.

1.2.2 Central Processing Unit (CPU)

The CPU is one of the most important parts of a computer. It handles processing of data and consists of an arithmetic logic unit (ALU) and a control unit. The ALU performs all operations on the input data and the control unit directs the computer memory and input and output devices response to the instructions received from a program.

1.2.3 Memory Unit

The function of the memory unit is to store programs and data. The unit is a compilation of numerous storage cells and each cell can store one bit of information. These cells are processed

in a group of fixed sizes of units called words and they never read or write as individual cells. A computer's memory system can be divided into the following three groups:

1. **Internal memory:** It refers to the set of registers confined to the CPU. These registers hold temporary results when a computation is in progress.
2. **Primary memory:** It is a storage area in which all the programs are executed. All programs and data must be stored in the primary memory for speedy execution.
3. **Secondary memory:** It is known as **external memory** or **storage memory**. Programs and data are stored here for the long term. Hard disk, floppy disk, CDs, DVDs and magnetic tapes are different forms of secondary memory.

1.3 OVERVIEW OF PROGRAMMING LANGUAGES

A computer program is a set of instructions, which performs a specific task when executed by a computer. Computer programs are commonly known as **software**. The instructions in a program tell a computer what to do and these instructions can be written in three types of programming languages described next.

1.3.1 Machine Language

A computer is an electronic machine which can understand any instruction written in binary form, i.e. using only 0s and 1s. A program written in 0s and 1s is called machine language. While a computer easily understands this language, it is difficult for humans to write an instruction in terms of 0's and 1's. Consider the following example.

Example

A series of numbers, such as 0011, 1000, 1010 is an instruction written in machine language. The instruction implies addition of a number stored at location 8 (1000) and another number stored at location 10 (1010) and storing the result at location 8 (1000). Here, the binary code 0011 stands for addition.

1.3.2 Assembly Language

From the above example, we know that it is difficult to write, read, communicate or change a program written in machine language for humans. Hence, the need to create another more convenient language arose. In assembly language, which was developed subsequently, machine operations are represented by mnemonic codes (such as ADD and MUL) and symbolic names that specify the memory address. Consider the following example.

Example

```
MOV X, 10
MOV Y, 20
ADD X, Y
```

Here the mnemonic MOV indicates an operation to store the value of variable X as 10. The mnemonic ADD implies addition of the contents of variable X, Y and finally storing the result in variable X itself.

Since computers cannot understand the assembly language, a program called **assembler** is used to translate assembly language programs into equivalent machine language programs.

1.3.3 High-level Language

High-level languages are much easier to write than low-level languages because programs written in these are similar to instructions written in the English language. Here 'high' does not imply that the language is complicated. It means that the language is more problem oriented. Generally, high-level languages are platform independent. This means that one can write a program in a high-level language and run it on different types of machines. Instructions written in high-level languages are called **statements**.

For example, a statement to calculate the square of a number can be written in a high-level language as

Square = number * number

There are many high-level languages and the selection of a language is based on the purpose it is expected to fulfill. A program written in a high-level language is called *source code* or *source program*. The process of executing programs written in high-level languages is given below.

- ◎ **STEP 1:** An **interpreter** or **compiler** is used to translate a program written in a high-level language into its equivalent machine code for execution.
- ◎ **STEP 2:** A **linker** is used to combine the object code and the code stored in libraries into machine language.
- ◎ **STEP 3:** Finally, the machine language code generated in Step 2 is executed.

Figure 1.2 depicts the steps on how to execute a program written in a high-level language.

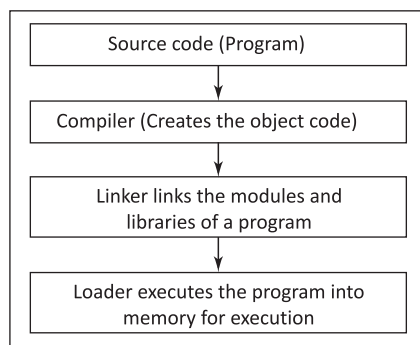


Figure 1.2 Steps to execute a high-level language program

The next section describes compiler, interpreter, linker and loader in detail.

Compiler

It is a software that translates a program written in a high-level language into machine language. This compiled program is called object code. The object code is an executable code which can run as a standalone code, i.e. it does not need the compiler to be present during execution. Every programming language, such as C, C++ and Java has its own compiler.

Interpreter

While a compiler converts the whole source code into an equivalent object code or machine code, the interpreter reads the source code line by line and converts it into object code (i.e. a code understandable to the machine).

Linker

It is a program that links different program modules and libraries to form a single executable program. A source code of a program is very large. It can consist of hundreds of lines of code. Before the execution of a program, all the modules of the program and the required libraries are linked together using a software called a **linker**. The compiled and linked program is called the **executable code**.

Loader

This software is used to load and relocate an executable program in the main memory during execution. The loader assigns a storage space to a program in the main memory for execution.

1.4 HISTORY OF PYTHON

Python was developed by Guido van Rossum at National Research Institute for Mathematics and Computer Science in Netherlands in 1990. Rossum wanted the name of his new language to be short, unique and mysterious. Inspired by *Monty Python's Flying Circus*, a BBC comedy series, he named the language Python.

Python became a popular programming language, widely used in both industry and academia because of its simple, concise and extensive support of libraries. It is a general purpose, interpreted and object-oriented programming language. Python source code is available under General Public License (GPL) and maintained by a core development team at the same institute.

1.4.1 Why Python?

COBOL, C#, C, C++ and Java are a few of the many programming languages available in information and technology today. One common question that beginners in programming often ask is, '*Why use Python when there are so many programming languages?*' While on one hand it may just be a matter of personal preference, there are some very well-known advantages of Python which make it a popular programming language. These are given below.

1. **Readability:** Developer's **readability** of code is one of the most crucial factors in programming. The longest part of any software's life cycle is its maintenance. Therefore, if a software has a highly readable code, then it is easier to maintain. Readability also helps a programmer to reuse the existing code with ease to maintain and update a software. Python offers more readability of code when compared to other programming languages.
2. **Portability:** Python is platform independent, i.e. its programs run on all platforms. The language is designed for portability.
3. **Vast support of libraries:** Python has a large collection of in-built functionalities known as standard *library functions*. Python also supports various third-party software like NumPy. **NumPy** is an extension, i.e. it provides support for large, multidimensional arrays and matrices.

4. **Software integration:** An important aspect of Python is that it can easily extend, communicate and integrate with several other languages. For example, Python code can easily invoke libraries of C and C++ programming languages. It can also be used to communicate with **Java** and **.net** components. Python can sometimes act as an intermediary or agent between two applications.
5. **Developer productivity:** Compared to other programming languages, Python is a dynamically typed language, which means there is no need to declare variables explicitly. Again, there are various other features of Python due to which the size of code written is typically smaller or half of the code written in some other languages, such as C, C++ or Java.

As the size of code is reduced quite a bit, there is less to type and debug. The amount of time needed to compile and execute is also very less as compared to other programming languages. Python programs run immediately, i.e. without taking much time to link and compile.

These benefits offered by Python make it the topmost choice for programmers to develop application software or projects with Python.

1.4.2 Installing Python in Windows

Python is available for almost all operating systems such as Windows, Mac, Linux/Unix, etc. The complete list of different versions of Python can be found at <http://www.Python.org/downloads>. Step-wise details for installing Python in Windows are given below.

- ① **STEP 1:** Open an Internet browser like Internet Browser, Mozilla Firefox or Chrome. Type <http://www.Python.org/> in the address bar and press Enter. Immediately, the following page will appear (Figure 1.3).

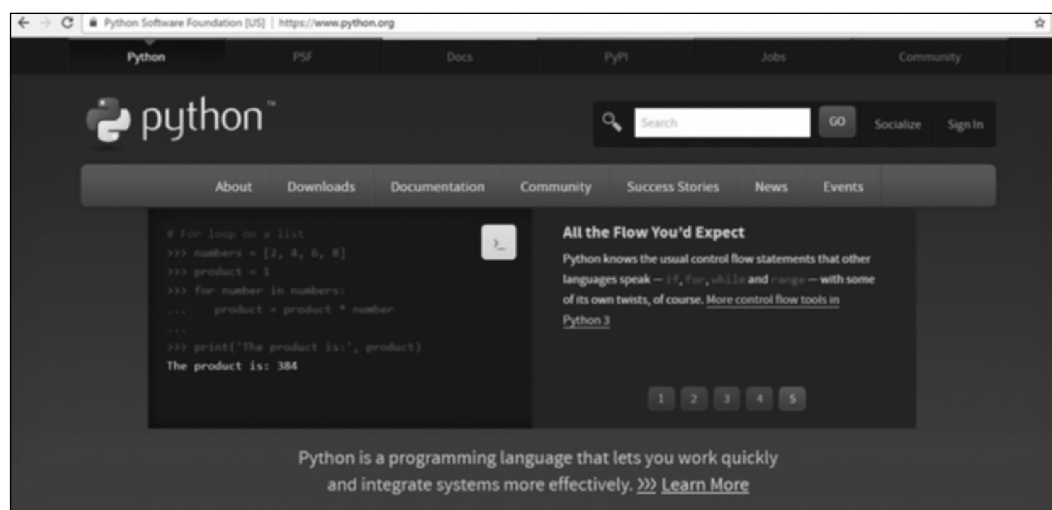


Figure 1.3 Python home page

- ② **STEP 2:** Click on Downloads and you will see the latest version of Python. Since all programs in this book are written and executed on **Python 3.4**, download **Python 3.4** version by clicking on **All Releases** under Downloads as shown in Figure 1.4.

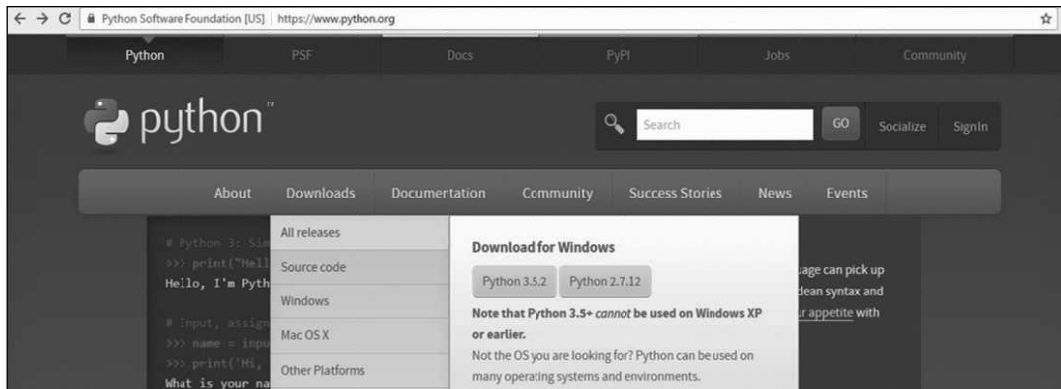


Figure 1.4 Python download page

- ◎ **STEP 3:** After clicking on All Releases under Downloads browse through the page to the bottom. You will see a list of Python releases as shown in Figure 1.5.

Looking for a specific release?
Python releases by version number:

Release version	Release date		Click for more
Python 3.4.5	2015-02-25	Download	Release Notes
Python 2.7.9	2014-12-10	Download	Release Notes
Python 3.4.2	2014-10-13	Download	Release Notes
Python 3.3.6	2014-10-12	Download	Release Notes
Python 3.2.6	2014-10-12	Download	Release Notes
Python 2.7.8	2014-07-02	Download	Release Notes
Python 2.7.7	2014-06-01	Download	Release Notes
Python 3.4.1	2014-05-19	Download	Release Notes

Figure 1.5 Python release versions

- ◎ **STEP 4:** Click on Python 3.4.2 and download it.
- ◎ **STEP 5:** Open the folder where you have downloaded the Python 3.4 version pack and double click on it to start the installation (Figure 1.6).

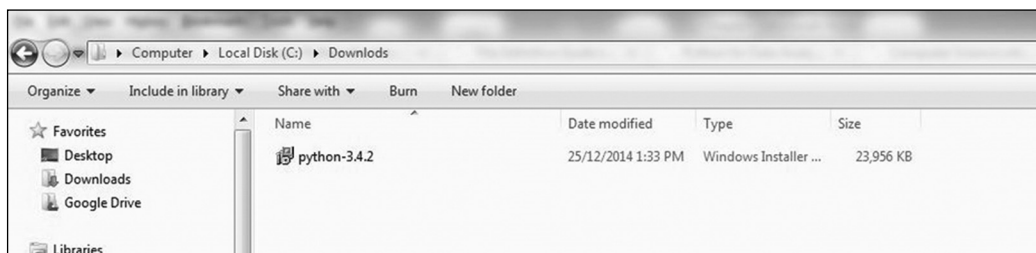


Figure 1.6 Python software

8 ..

- ◎ **STEP 6:** After clicking on it you will see the first window to set up Python 3.4.2 (Figure 1.7).



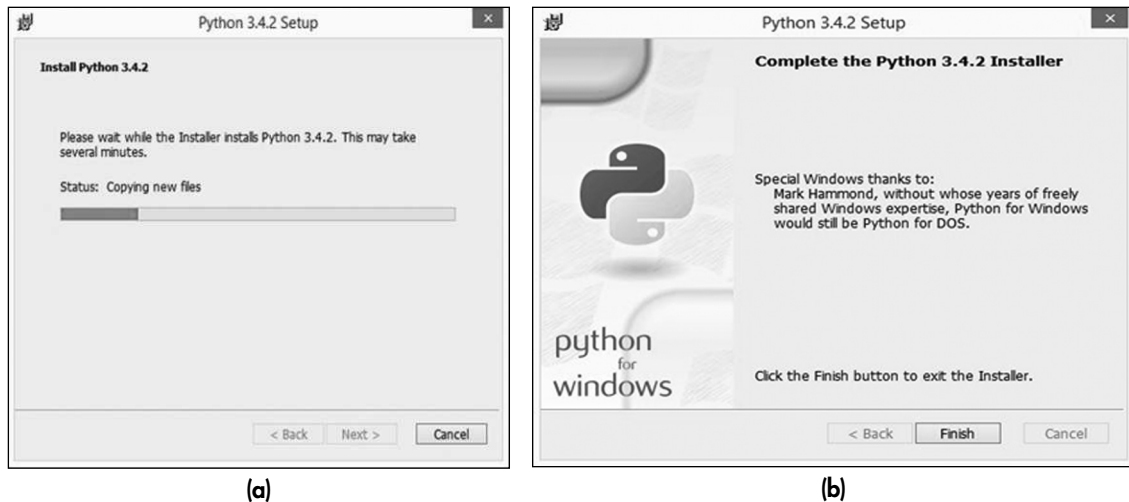
Figure 1.7 Python first setup window

- ◎ **STEP 7:** Click on Next and you will see a second window which tells you to specify the location where you want to install Python (Figure 1.8).



Figure 1.8 Python second setup window

By default, Python will be installed in C:\. Then click on Next to continue the installation. Just before completing the installation, it will show you the following two windows (Figures 1.9 a and b).



Figures 1.9 a and b Python final setup window

- ◎ **STEP 8:** Click on Finish to complete the installation.
- ◎ **STEP 9:** To check if Python is installed successfully just press windows key on Windows 7 or Windows 8 and then in the search bar type Python as shown in Figure 1.10.

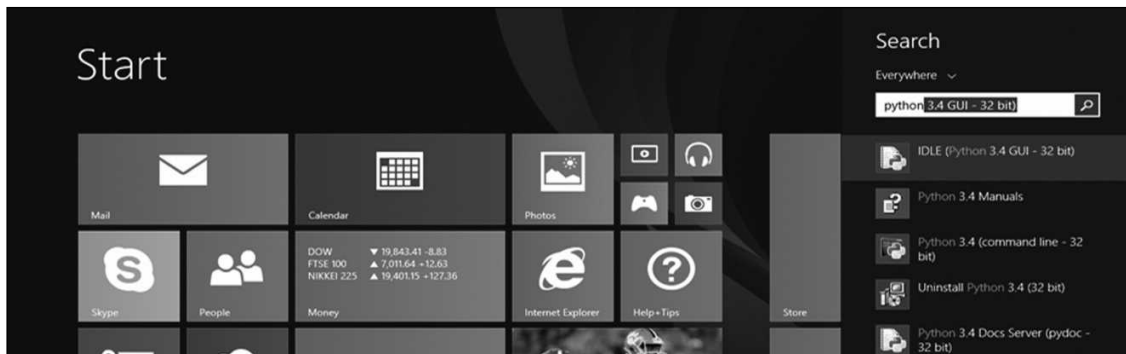


Figure 1.10 Windows 8 showing successful installation of Python

1.4.3 Starting Python in Different Execution Modes

After installing Python in Windows, you can start Python in two different modes, viz. Python (Command Line) and Python (IDLE).

Starting Python (Command Line)

Python is an interpreted language. You can directly write the code into the Python interpreter or you can write a sequence of instructions into a file and then run the file.

When you execute Python expressions or statements from the command line then you are in **interactive mode** or **interactive prompt**.

Steps for writing a Python command line in Windows 7 are given as follows:

- ◎ **STEP 1:** Press the Start button (Figure 1.11).



Figure 1.11

- ◎ **STEP 2:** Click on All programs and then **Python 3.4**. After clicking on **Python 3.4** you will see a list of options as shown in Figure 1.12.

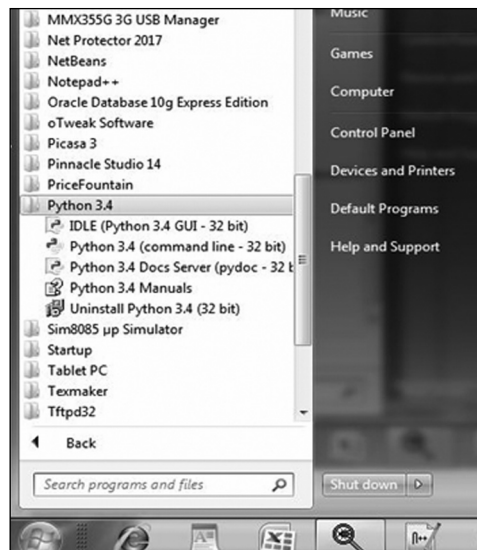


Figure 1.12

- ..
- ◎ **STEP 3:** In this list click on **Python (Command Line—32 bit)**. After clicking on it, you will see the Python **interactive prompt** in Python command line as shown in Figure 1.13.

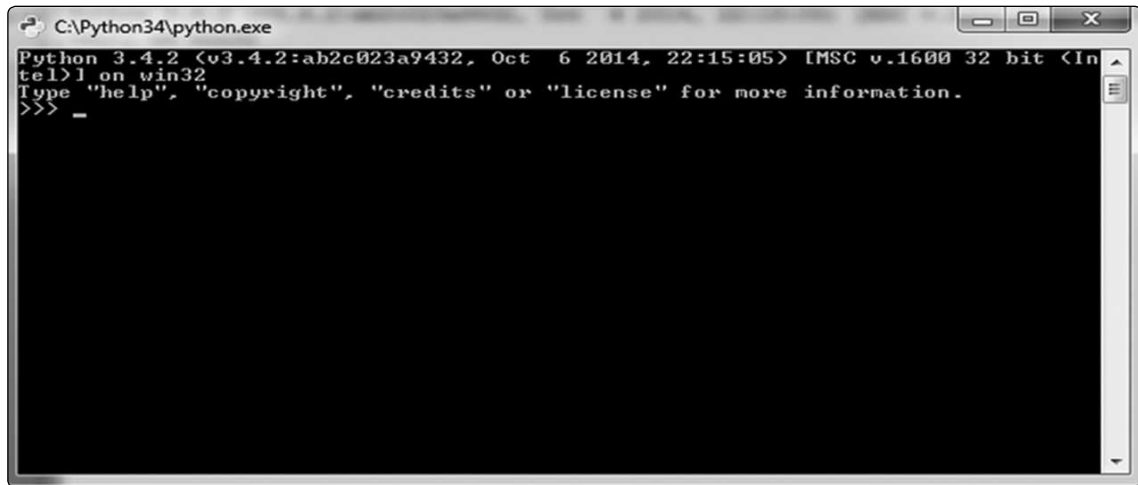


Figure 1.13 Python interactive mode as Python command line window

In Figure 1.13, the Python command prompt contains an opening message `>>>`, called **command prompt**. The cursor at the command prompt waits for you to enter a Python command. A complete command is called a **statement**. Simple commands executed in the interactive mode of Python command line are shown in Figure 1.14.

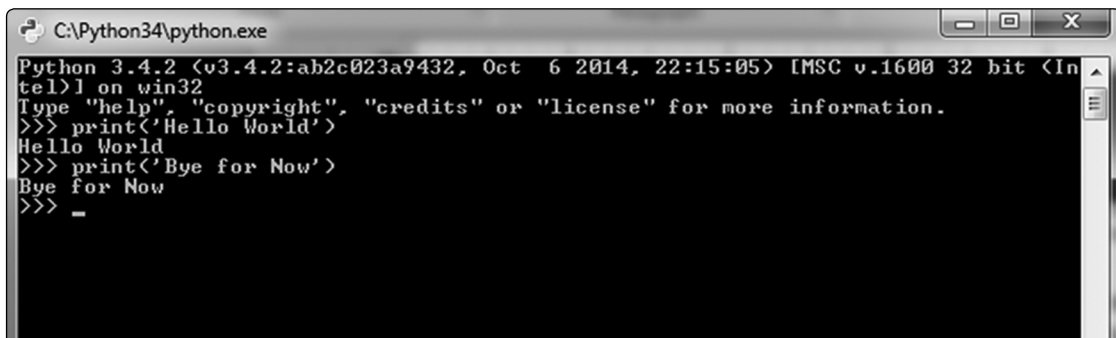


Figure 1.14 Simple commands executed in interactive mode of Python command prompt

We have written two simple commands or statements. The first statement, i.e. `print('Hello World')` when executed in the interactive mode of Python command prompt gives the output as the entered command, i.e. `'Hello World'` for this message. More details about print and its syntax are explained in Chapter 2.

Precautions to be taken while executing commands in the interactive mode of Python with command line are given as follows.

If you try to put an extra space between Python prompt, i.e. `>>>` and the command, then it will produce an error called **Indentation Error: Unexpected Indent**. A simple example to demonstrate this error is given below.

Example:

```
>>> print('Hello World')
File "<stdin>", line 1
  print('Hello World')
  ^
```

IndentationError: unexpected indent

Thus, due to an extra space between `>>>` and command, i.e. `print('Hello world')`, the Python interpreter raises an error.

To exit from the command line of **Python 3.4**, press **Ctrl+Z** followed by **Enter**.

Starting Python IDLE

Launching Python **IDLE** is another way to start executing Python statements or commands in the interactive mode of Python IDLE. It is a graphical integrated development environment for Python.

Python statements or commands which run in the interactive mode of Python IDLE are called **shell**. IDLE is downloaded by default while installing Python. Launching Python IDLE is the simplest way to open a Python shell. The steps to launch Python IDLE are similar to those used to start a Python command line and are detailed below.

- ◎ **STEP 1:** Press the Start button.
- ◎ **STEP 2:** Click on All Programs and then **Python 3.4**. After clicking on **Python 3.4** you will see a list of options as shown in Figure 1.15.

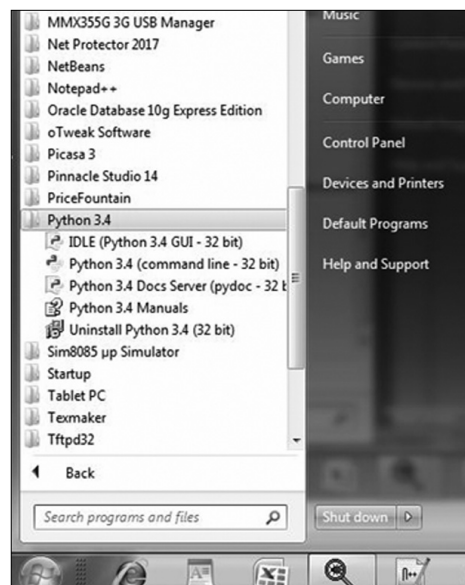


Figure 1.15

- ..
- ⊙ **STEP 3:** Click on **IDLE (Python 3.4 GUI—32 bit)** and you will see the Python **interactive prompt**, i.e. an **interactive shell** as shown in Figure 1.16.

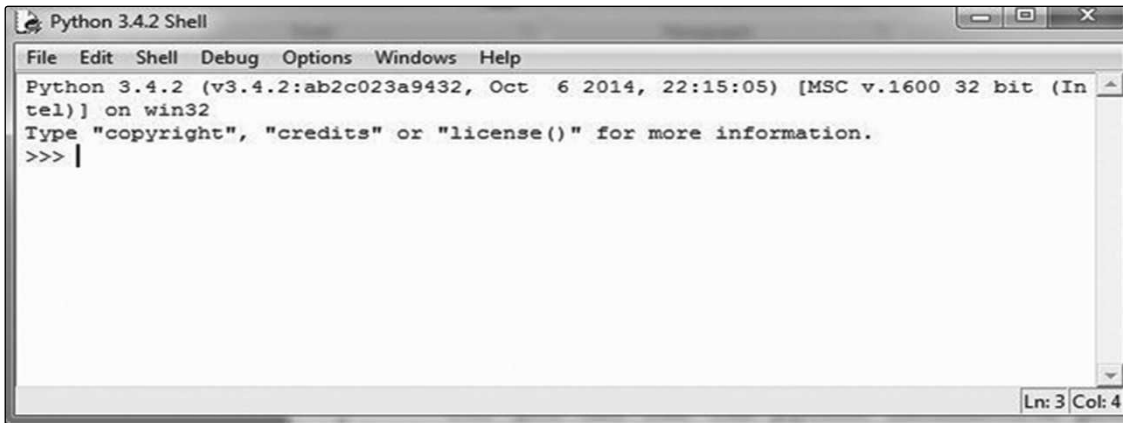


Figure 1.16 Python IDLE—Interactive shell

In Figure 1.16, a Python interactive shell prompt contains an opening message `>>>`, called '**shell prompt**'. The cursor at the shell prompt waits for you to enter a Python command. A complete command is called a **statement**. As soon as you write a command and press Enter, the **Python interpreter** will immediately display the result.

Figure 1.17 shows simple commands which are executed in the interactive mode, i.e. the interactive shell of Python IDLE.

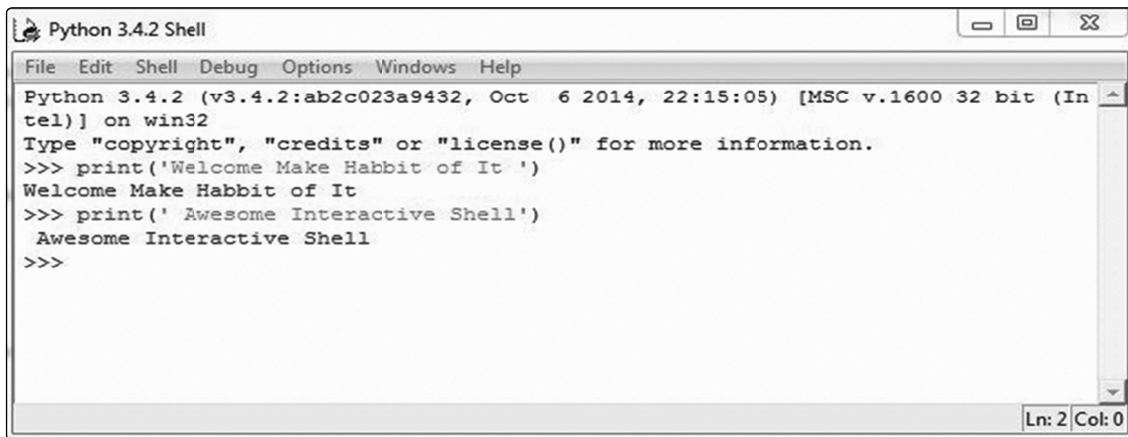


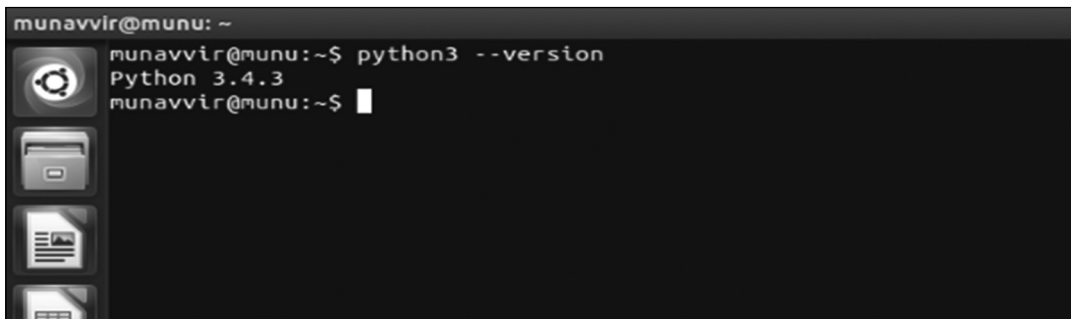
Figure 1.17 Running commands in Python IDLE's interactive shell

 **Note:** Hereafter all commands given as examples in the forthcoming chapters of this book are executed in Python 3.4 IDLE's interactive mode, i.e. the interactive shell prompt.

1.5 INSTALLING PYTHON IN UBUNTU

Python 2.7 and Python 3.4 are installed by default on Ubuntu 15.0. The following steps can be used to check their presence.

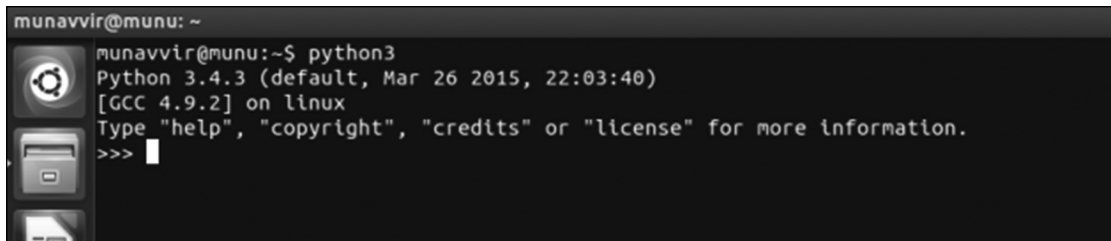
- ◎ **STEP 1:** Open Ubuntu 15.0.
- ◎ **STEP 2:** Press the Windows button on the keyboard and type 'terminal' or press the shortcut Ctrl+Alt+T to open the terminal.
- ◎ **STEP 3:** Once the terminal is open, type **Python3—version** to check if it is installed.



```
munavvir@munu: ~  
munavvir@munu:~$ python3 --version  
Python 3.4.3  
munavvir@munu:~$
```

Figure 1.18 Check default installation of Python

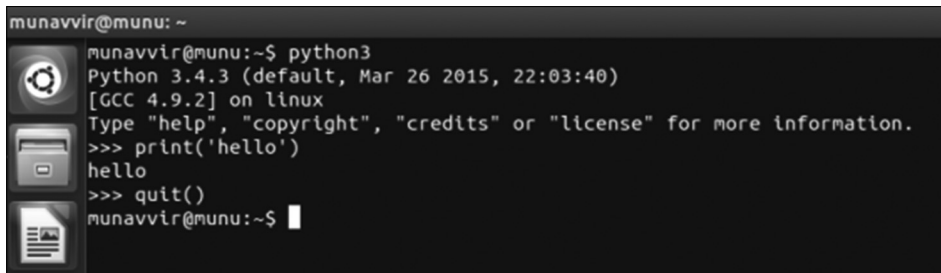
- ◎ **STEP 4:** From Figure 1.18 we can know that default Python3.X version has been installed successfully.
- ◎ **STEP 5:** To launch the **command line mode** or **interactive mode** of Python 3.X version in Ubuntu, type Python3 on the terminal.



```
munavvir@munu: ~  
munavvir@munu:~$ python3  
Python 3.4.3 (default, Mar 26 2015, 22:03:40)  
[GCC 4.9.2] on linux  
Type "help", "copyright", "credits" or "license" for more information.  
>>>
```

Figure 1.19 Ubuntu Python3 command line mode

From Figure 1.19 we can see the command line mode of Ubuntu has been started and the programmer is ready to give instructions to Python. The following figure (Figure 1.20) illustrates an example of printing 'hello' in the command line mode of Ubuntu.



```
munavvir@munu: ~
munavvir@munu:~$ python3
Python 3.4.3 (default, Mar 26 2015, 22:03:40)
[GCC 4.9.2] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> print('hello')
hello
>>> quit()
munavvir@munu:~$
```

Figure 1.20 Executing instructions of Python3 in Ubuntu command line mode

- ◎ **STEP 6:** A programmer can launch **Python IDLE mode** in Ubuntu in the same manner. To launch the IDLE mode of Python, type the command given below on the terminal.

Python -m idlelib



Note: If IDLE is not installed then the programmer can install it by typing the command given below on the terminal.

`sudo apt-get install idle3`

1.6 EXECUTING PYTHON PROGRAMS

The previous section explained the installation of Python3 in Windows and Ubuntu. This section describes how to execute Python programs in script mode on Windows. All the programs written in this book are written and executed on Windows. Once IDLE is launched in Ubuntu, a programmer can write programs in script mode in the same manner as done in Windows.

Running Python programs from a script file is known as running Python in **script mode**. You can write a sequence of instructions in one file and execute them. The steps required to write Python programs in Python IDLE's script mode are given as follows.

- ◎ **STEP 1:** In Python IDLE's - Shell window, click on **File** and then on **New File** or just click **CTRL+N** (Figure 1.21).

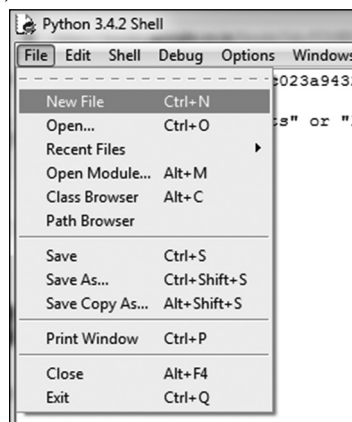


Figure 1.21 Python IDLE file menu bar

As soon as you click on New File, the window shown below will open (Figure 1.22).

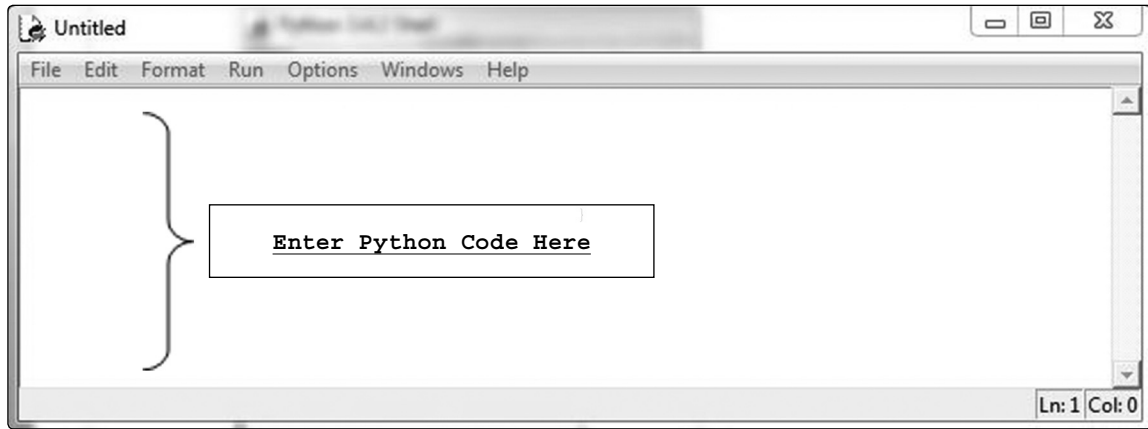


Figure 1.22 Python script mode

You can write a series of instructions in this window and then run it to view the output.

1.6.1 Writing the First Python Program in Script Mode

Use the following steps to create and run your first Python program.

◎ **STEP 1:** Writing Python code in script mode

Let us consider a simple program to print the messages “Hello Welcome to Python”, “Awesome Python!” and “Bye” on the console. The statements needed to print these are

```
print('Hello Welcome to Python')
print('Awesome Python!')
```

Once you write the above statements in Python script mode, they will look like as given in Figure 1.23.

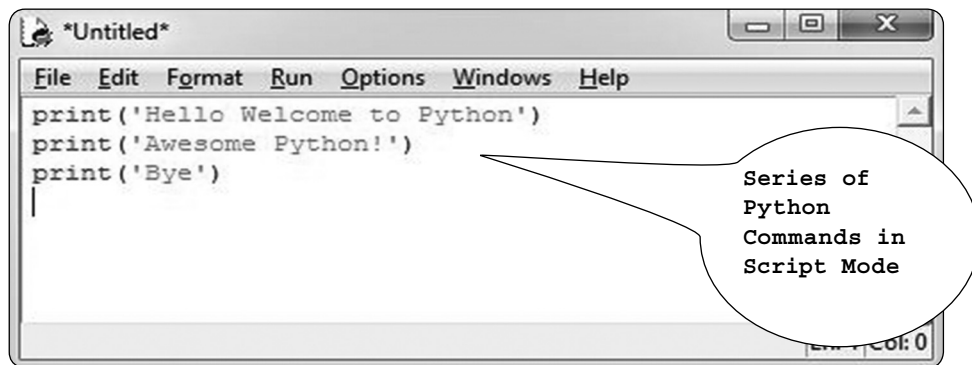


Figure 1.23 Writing program in Python script mode

- ..
- ⊙ **STEP 2:** Save the above code written in script mode by some name.

In Figure 1.23 we can see the name ***Untitled**. If you don't save the above code by some specific name, then by default the Python interpreter will save it using the name **Untitled.py**. In this name, **py** indicates that the code is written in Python. The ***** in front of **Untitled** indicates that the program has not been saved. To identify the purpose of a program, you should give it a proper name. Follow the steps given below to save the above program.

- ⊙ **STEP 1:** Click on File and then click on Save or press Ctrl+S. Then you will see the default installation folder (Python34) to save the file (Figure 1.24).

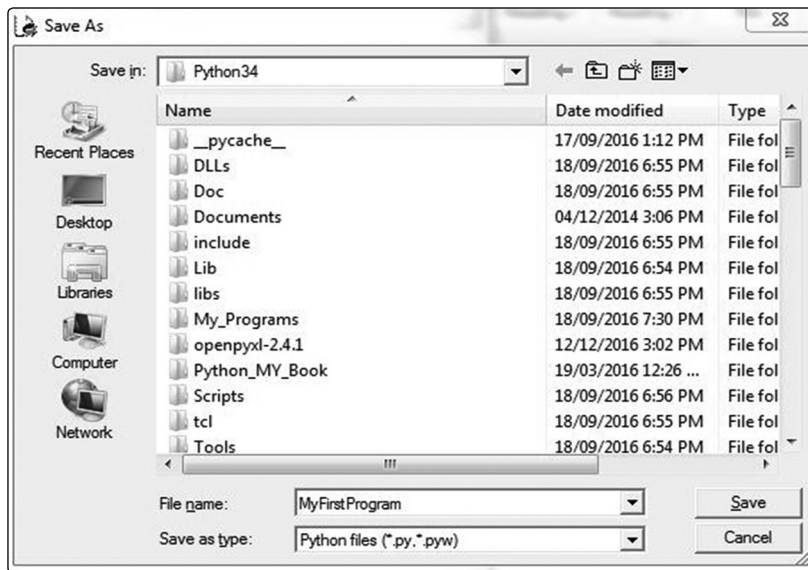


Figure 1.24 Saving a Python program

- ⊙ **STEP 2:** Write the name of your Python program. As it is your first Python program, you can save it as **MyFirstProgram**. Once you write the name of the file, click on Save. After the name is saved, it will get displayed on title bar of the Python script window as shown in Figure 1.25.



Figure 1.25 File name appearing on the title bar

- ◎ **STEP 3:** Executing a Python program: A Python program is executed only after it is saved with a specific file name. Thus, to run the above Python program, click on **Run** and then **Run Module** as shown in Figure 1.26. Alternatively, you can also press **Ctrl+F5** to run the program.

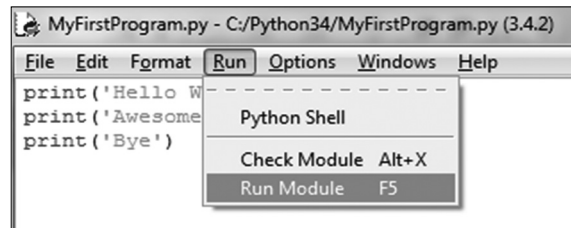


Figure 1.26 Executing a Python program

After clicking on **Run Module** you will see the output of the program if it is written correctly (Figure 1.27).

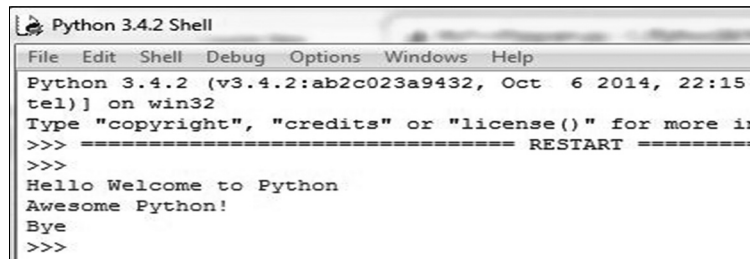


Figure 1.27 Output of a Python program in Python IDLE's interactive shell prompt



Note: Hereafter all the Python programs given as examples in the forthcoming chapters of this book are executed in Python 3.4 IDLE's script mode.

1.7 COMMENTING IN PYTHON

Comments in Python are preceded by a hash symbol (#) on a line and called a **line comment**. Three consecutive single quotation marks ''' are used to give multiple comments or comments on several lines at once and called **paragraph comment**.

When the Python interpreter sees #, it ignores all the text after # on the same line. Similarly, when it sees the triple quotation marks ''' it scans for the next ''' and ignores any text in between the triple quotation marks.

The following program demonstrates the use of comment statements in Python.

#Learn How to Comment in Python

```
print('I Learnt How to Comment in Python')
''' Amazing tool
in Python called Comment'''
print('Bye')
```


Output

```
I Learnt How to Comment in Python
Bye
```

Explanation As explained above, Python ignores all the text in a statement if it is preceded by the # symbol. When the above program is executed, it ignores all the text followed by the # symbol and triple quotation marks.

1.8 INTERNAL WORKING OF PYTHON

When a programmer tries to run a Python code as a script or instructions in an interactive manner in a Python shell, then Python performs various operations internally. All such internal operations can be broken down into a series of steps as shown in **Figure 1.28**.

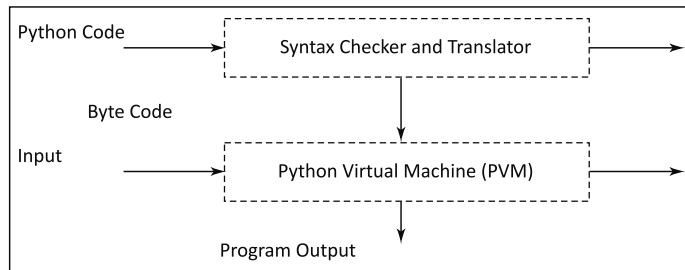


Figure 1.28 Internal working of Python

The Python interpreter performs the following steps to execute a Python program or run a set of instructions in interactive mode.

- ◎ **STEP 1:** The interpreter reads a Python code or instruction. Then it verifies that the instruction is well formatted, i.e. it checks the syntax of each line. If it encounters any error, it immediately halts the translation and shows an error message.
- ◎ **STEP 2:** If there is no error, i.e. if the Python instruction or code is well formatted then the interpreter translates it into its equivalent form in low level language called “**Byte Code**”. Thus, after successful execution of Python script or code, it is completely translated into byte code.
- ◎ **STEP 3:** Byte code is sent to the **Python Virtual Machine (PVM)**. Here again the byte code is executed on **PVM**. If an error occurs during this execution then the execution is halted with an error message.

1.9 PYTHON IMPLEMENTATIONS

The standard implementation of Python is usually called “**CPython**”. It is the default and widely used implementation of the Python programming language. It is written in C. Besides C, there are different implementation alternatives of Python, such as **Jython**, **IronPython**, **Stackless** and **Pypy**. All these Python implementations have specific purposes and roles. All of them make use of simple

Python language but execute programs in different ways. Different Python implementations are briefly explained ahead.

1.9.1 Jython

Originally, Jython was known as “JPython”. JPython takes Python programming language syntax and enables it to run on the Java platform. In short, it is used to run Python programs on Java platforms. More details about JPython can be found at <http://jPython.org>.

1.9.2 IronPython

IronPython is an open source implementation of Python for the .NET framework. It uses dynamic language runtime (DLR), which is a framework for writing dynamic languages for .net. A major use of **IronPython** is to embed .net applications. More details about IronPython can be found at <http://ironpythonPython.net>.

1.9.3 Stackless Python

It is a Python programming language interpreter. If you run a program on Stackless Python environment then the running program is split into multithreads. The best thing about multithreads in Stackless Python is the handling of multithreads, which are managed by the language interpreter itself and not by the operating system. More details about Stackless Python can be found at <http://www.stackless.com>.

1.9.4 PyPy

The **PyPy** is a reimplementation of Python in Python. In short, the Python interpreter is itself written in Python. It focuses on speed, efficiency and compatibility. It makes use of **Just-in-Time compiler (JIT)** to run the code more quickly as compared to running the same code in regular Python language. More details about **PyPy** Python can be found at <http://pypy.org>.

SUMMARY

- ♦ A computer is an electronic device which accepts data from a user, processes it for calculations specified by the user and generates an output.
- ♦ The hardware of a computer system consists of three main components, viz. **input/output (I/O) unit**, **central processing unit (CPU)** and **memory unit**.
- ♦ A program written in **1s** and **0s** is called machine language.
- ♦ In assembly languages, machine operations are represented by **mnemonic codes** such as ADD, MUL, etc. and symbolic names that specify the memory address.
- ♦ Programs written in high-level languages are similar to instructions written in English language.
- ♦ An **assembler** is used to translate an **assembly language program** into an equivalent **machine language program**.
- ♦ An **interpreter** or **compiler** is used to translate a program written in a high-level language into an equivalent machine code for execution.
- ♦ An **interpreter** reads the source code line by line and converts it into object code.

- ♦ A **compiler** is a software which translates an entire program written in a high-level language into machine language at one go.
- ♦ A **loader** is a software used to load and relocate the executable program in the main memory during execution.
- ♦ Python is a general purpose, interpreted and objects oriented programming language.
- ♦ You can enter Python statements interactively from the Python prompt `>>>`.
- ♦ Python source programs are case sensitive.
- ♦ The `#` symbol is used to comment a single line in Python.
- ♦ Triple single quotation `'''` marks are used to comment multiple lines in Python.
- ♦ Python programs can be executed on any operating system like Windows, Linux or Ubuntu.

KEY TERMS

- ⇒ **Assembly Language:** Machine operations are represented by mnemonic code
- ⇒ **Byte Code:** The Python interpreter translates Python codes/instructions into their equivalent low level language
- ⇒ **Central Processing Unit (CPU):** It consists of Arithmetic Logical Unit and Control Unit
- ⇒ **High-level Language:** Programs are written in a manner similar to writing instructions in English language
- ⇒ **Jython, IronPython, Stackless, PyPy:** Different implementation alternatives of Python
- ⇒ **Machine Language:** Instructions are written in binary form, i.e. 0s and 1s
- ⇒ **Python Virtual Machine (PVM):** Used to check if the object code contains errors

REVIEW QUESTIONS

A. Multiple Choice Questions

1. Which of the following memory is used to store temporary results in registers when the computation is in progress?
 - a. Primary Memory
 - b. Secondary Memory
 - c. Internal Memory
 - d. None of the above
2. Secondary memory is also called _____.
 - a. Storage Memory
 - b. External Memory
 - c. Only b
 - d. Both a and b
3. _____ is used to translate a program written in a high-level language into its equivalent machine code.
 - a. Compiler
 - b. Linker
 - c. Loader
 - d. Both a and b
4. _____ is used to relocate executable programs to the main memory during execution.
 - a. Linker
 - b. Compiler
 - c. Interpreter
 - d. Loader
5. What is the correct syntax for the print statement in Python 3.0?
 - a. `print()`
 - b. `print`
 - c. `print()`
 - d. None of the above

6. Which of the following symbols is used to make single line comments in Python?
- #
 - '
 - '''
 - &

B. True or False

- Python is not case sensitive.
- We can execute Python on Windows.
- We cannot comment on multiple lines in a Python program.
- An assembler is used to translate an assembly language program into its equivalent machine language program.
- Python is an interpreted language.

C. Exercise Questions

- Explain the classification of programming languages in brief.
- What is a compiler?
- What is an interpreter?
- Differentiate between a compiler and an interpreter.
- What is a linker?
- What is a loader?
- Explain the internal working of Python in brief.
- Describe the memory unit of a computer system in brief.

PROGRAMMING ASSIGNMENTS

- Write a program to display the statement given below in two different lines.
"I am using Python" and "It's my First Assignment"
- Write a program to display the statements given below.
ohhh!!!
What a Python language is!!!
It's Easy!Get Started
- Write a program to display the pattern given below.

```

      A
    A  A
  A    A
A      A

```

- Write a program to display the pattern given below.

```

00000
0  0
0  0
0  0
00000

```

Basics of Python Programming

2

CHAPTER OUTLINE

2.1 Introduction	2.7 Multiple Assignments
2.2 Python Character Set	2.8 Writing Simple Programs in Python
2.3 Token	2.9 The <code>input()</code> Function
2.4 Python Core Data Type	2.10 The <code>eval()</code> Function
2.5 The <code>print()</code> Function	2.11 Formatting Number and Strings
2.6 Assigning Value to a Variable	2.12 Python Inbuilt Functions

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Describe keywords, delimiters, literals, operators and identifiers supported by Python
- Read data from the console using input function
- Assign value or data to a variable and multiple values to multiple variables at a time
- Use `ord` function to obtain a numeric code for a given character value, `chr` function to convert numeric value to a character and `str` function to convert numbers to a string
- Format strings and numbers using the `format` function
- Identify and use various in-built math functions supported by Python

2.1 INTRODUCTION

Computer programming languages are designed to process different kinds of data, viz. numbers, characters and strings in the form of digits, alphabets, symbols etc. to get a meaningful output known as result or information. Thus, program written in any programming language consists of a set of instructions or statements which executes a specific task in a sequential form. Whereas all these instructions are written using specific words and symbols according to syntax rules or the grammar of a language. Hence, every programmer should know the rules, i.e. syntax supported by language for the proper execution of a program.

This chapter describes basics of python programming, i.e. syntax, data types, identifiers, tokens, and how to read values from the user using input function, etc.

2.2 PYTHON CHARACTER SET

Any program written in Python contains words or statements which follow a sequence of characters. When these characters are submitted to the Python interpreter, they are interpreted or uniquely identified in various contexts, such as characters, identifiers, names or constants. Python uses the following character set:

- **Letters:** Upper case and lower case letters
- **Digits:** 0,1,2,3,4,5,6,7,8,9
- **Special Symbols:** Underscore (_), (,), [,], {, }, +, -, *, &, ^, %, \$, #, !, Single quote('), Double quotes(""), Back slash(\), Colon(:), and Semi Colon (;)
- **White Spaces:** ('\\t\\n\\x0b\\x0c\\r'), Space, Tab.

2.3 TOKEN

A program in Python contains a sequence of instructions. Python breaks each statement into a sequence of lexical components known as **tokens**. Each token corresponds to a substring of a statement. Python contains various types of tokens. Figure 2.1 shows the list of tokens supported by Python.

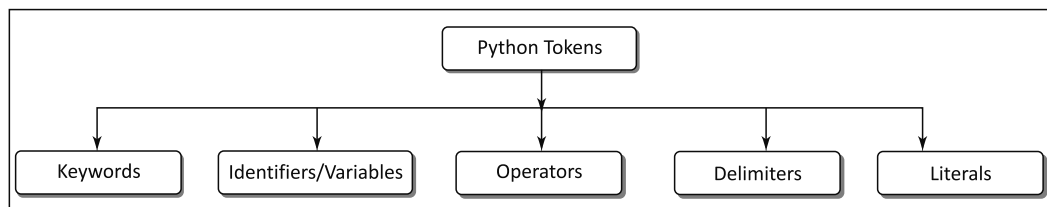


Figure 2.1 Tokens in Python

Details for all the tokens are given next.

2.3.1 Literal

Literals are numbers or strings or characters that appear directly in a program. A list of some literals in Python is as follows:

Example

```
78                #Integer Literal
21.98             #Floating Point Literal
'Q'               #Character Literal
"Hello"           #String Literal
```

Python also contains other literals, such as lists, tuple and dictionary. Details of all such literals are given in the forthcoming chapters.

Display Literals in Interactive Mode

Let us consider a simple example. Print the message “Hello World” as a string literal in Python interactive mode.

Example

```
>>> 'Hello World'
'Hello World'
```

As shown above, type **Hello World** in interactive mode and press enter. Immediately after pressing enter you will see the required message.

2.3.2 Value and Type on Literals

Programming languages contain data in terms of input and output and any kind of data can be presented in terms of **value**. Here **value** can be of any form like literals containing numbers, characters and strings.

You may have noticed that in the previous example we wrote ‘Hello World’ in single quotes. However, we don’t know the type of value in it. To know the exact type of any value, Python offers an in-built method called **type**.

The syntax to know the type of any value is **type (value)**

Example

```
>>> type('Hello World')
<class 'str'>
>>> type(123)
<class 'int'>
```

Thus, when the above examples are executed in Python interactive mode, return type of value is passed to the in-built function `type()`.

2.3.3 Keywords

Keywords are reserved words with fixed meanings assigned to them. Keywords cannot be used as identifiers or variables. Table 2.1. shows the complete list of keywords supported by Python.

Table 2.1 List of Python keywords for Python version 3.0

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

2.3.4 Operator

Python contains various operators, viz. arithmetic, relational, logical and bitwise operators, as shown in Table 2.2.

Table 2.2 Operators in Python

Operator Type	Operators
+ - * / // % **	Arithmetic Operator
== != < > <= >=	Relational Operator
and not or	Logical Operator
& ~ ^ << >>	Bitwise Operator

Details about Python operators like operators and expressions are given in Chapter 3.

2.3.5 Delimiter

Delimiters are symbols that perform a special role in Python like grouping, punctuation and assignment. Python uses the following symbols and symbol combinations as delimiters.

```
( ) [ ] { }
, : . ' = ;
+= -= *= /= //= %=
&= |= ^= >>= <<= **=
```

2.3.6 Identifier/Variable

Identifier is the name used to find a variable, function, class or other objects. All identifiers must obey the following rules.

An identifier:

- Is a sequence of characters that consists of letters, digits and underscore

- Can be of any length
- Starts with a letter which can be either lower or upper case
- Can start with an underscore '_'
- Cannot start with a digit
- Cannot be a keyword.

Some examples of valid identifiers are Name, Roll_NO, A1, _Address etc.

Python gives a **syntax error** if a programmer writes an invalid identifier. Some examples of invalid identifiers are First Name, 12Name, for, Salary@

If we type the invalid identifiers given above in Python interactive shell, it will show an error as these are invalid.

Example

```
>>> First Name
SyntaxError: invalid syntax
>>> 12Name
SyntaxError: invalid syntax
>>> for
SyntaxError: invalid syntax
```

2.4 PYTHON CORE DATA TYPE

All features in Python are associated with an **object**. It is one of the primitive elements of Python. Further, all kinds of objects are classified into **types**. One of the easiest types to work with is numbers, and the native data types supported by Python are string, integer, floating point numbers and complex numbers.

The following section details the basic data types supported by Python.

2.4.1 Integer

From simple Mathematics, we know that an integer is a combination of positive and negative numbers including (zero) 0. In a program, integer literals are written without commas and a leading minus sign to indicate a negative value. Following is an example of simple integer literals displayed in Python interactive mode.

Example

```
>>> 10
10
>>> 1220303
1220303
>>> -87
-87
```

Integer literals can be octal or hexadecimal in format. All the above examples are of decimal type integers. Decimal integers or literals are represented by a sequence of digits in which the first digit is non-zero. To represent an **octal**, **0o**, i.e. a zero and a lower or upper case letter **O** followed by a sequence of digits from **0 to 7** is used. An example of octal literals is given as follows.

Example

```
>>> 0o12
10
>>> 0o100
64
```



Note: In Python version 2.6 or earlier, octal literals were represented by the leading letter **O**, followed by a sequence of digits. In Python 3.0, octal literals have to be accompanied by a leading **0o**, i.e. a zero and a lower or upper case letter **O**.

In the previous section, we have learnt about representation of numbers as default **decimal (base 10)** notation and octal (**base 8**) notation. Similarly, numbers can also be represented as hexadecimal (**base 16**) notation using **0x** (zero and the letter X) followed by a sequence of digits. Simple examples of hexadecimal literals displayed in Python interactive mode are given as follows:

Example

```
>>> 0x20
32
>>> 0x33
51
```



Note: Integer in Python 2.6 (int and long)—In Python 2.6 there are two types of integers. One of 32 bits and another having unlimited precession. Python 2.6 automatically converts integers to long integers if the value of the integer overflows 32 bits.

Integers in Python 3.0 (Only int type)—In Python 3.0 the normal `int` and `long` integer have been merged. Hence, there is only one type called integer.

The int Function

The `int` function converts a string or a number into a whole number to integer. The `int` function removes everything after the decimal point. Consider the following example.

Example

```
>>> int(12.456)
12
```

The following example converts a string to an integer.

Example

```
>>> int('123')
123
```

2.4.2 Floating Point Number

The value of π (3.14) is an example of a real number in mathematics. It consists of a whole number, decimal point and fractional part. The length of real numbers has infinite precession, i.e. the digits in the fractional part can continue forever. Thus, Python uses floating point numbers to represent real numbers. A floating-point number can be written using a **decimal notation** or **scientific notation**. Some examples of floating point numbers displayed in Python interactive mode are given as follows:

Example

```
>>> 3.7e1
37.0
>>> 3.7
3.7
>>> 3.7*10
37.0
```

The above example shows the representation of floating point number **37.0** in both decimal and scientific manner. Scientific notations are very helpful because they help programmers to represent very large numbers. Table 2.3 shows decimal notations in scientific notation format.

Table 2.3 Example of floating point numbers

<i>Decimal Notation</i>	<i>Scientific Notation</i>	<i>Meaning</i>
2.34	2.34e0	$2.34 * 10^0$
23.4	2.34e1	$2.34 * 10^1$
234.0	2.34e2	$2.34 * 10^2$

The float Function

The **float** function converts a string into a floating-point number. A programmer can make use of float to convert string into float. Consider the following example.

Example

```
>>>float('10.23')
10.23
```

2.4.3 Complex Number

A complex number is a number that can be expressed in the form **a+bj**, where **a** and **b** are real numbers and **j** is an imaginary unit. Simple example of complex numbers displayed in Python interactive mode is given as follows:

Example

```
>>> 2+4j
(2+4j)
```

```

>>> type(2+4j)
<class 'complex'>
>>> 9j
9j
>>> type(9j)
<class 'complex'>

```

Here we have written a simple kind of complex number and using **type** we have checked the type of the number.

2.4.4 Boolean Type

The Boolean data type is represented in Python as type **bool**. It is a primitive data type having one of the two values, viz. **True** or **False**. Internally, the **True** value is represented as 1 and False as 0. In the following example check the type of **True** and **False** value in Python interactive mode.

```

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

```

The Boolean type is used to compare the two values. For example, when relational operators, such as **==**, **!=**, **<=**, **>=** are used in between two operands then it returns the value as **True** or **False**.

Example

```

>>> 5 == 4
False
>>> 5 == 5
True
>>> 4 < 6
True
>>> 6 > 3
True

```

2.4.5 String Type

A string literal or string in Python can be created using single, double and triple quotes. A simple example of type as string is given as follows:

Example

```

>>> D = 'Hello World'
>>> D
'Hello World'
>>> D="Good Bye"

```

```

..
>>> D
'Good Bye'
>>> Sentence
'Hello, How are you? Welcome to the world of Python Programming. It is just the
beginning. Let us move on to the next topic.'
>>> Sentence
'Hello, How are you? Welcome to the world of Python Programming. It is just the
beginning. Let us move on to the next topic.'

```

In the previous examples, we presented string literals in three different formats, viz. single quote, double quote and triple single quotes. The triple single quotes are used to write a multiline string.

The str Function

The `str` function is used to convert a number into a string. The following example illustrates the same.

```

>>> 12.5          #Floating Point Number
12.5
>>> type(12.5)
<class 'float'>
>>> str(12.5)     #Convert floating point number to string
'12.5'

```

The String Concatenation (+) Operator In both mathematics and programming, we make use of '+' operator to add two numbers. Similarly, '+' operator is used to concatenate two different strings. The following example illustrates the use of + operator on strings.

```

>>> "Woowow" + "Python Programming"
'WoowowPython Programming'      #Concatenates two different strings

```

2.5 THE `print()` FUNCTION

In Python, a function is a group of statements that are put together to perform a specific task. The task of `print` function is to display the contents on the screen. The syntax of `print` function is:

Syntax of `print()` function:

```
print(argument)
```

The argument of the `print` function can be a value of any type `int`, `str`, `float` etc. It can also be a value stored in a variable. Simple examples of `print()` function executed in interactive mode of Python are given as follows:

Example

Display messages using `print()`

```

>>> print('Hello Welcome to Python Programming')
Hello Welcome to Python Programming

```

```
>>> print(10000)
10000
>>> print("Display String Demo")
Display String Demo
```

Suppose you want to print a message with quotation marks in the output as

```
print("The flight attendant asked, "May I see your boarding pass?")
```

If you try to run the above statement as is, Python will show an error. For Python, the second quotation mark is the end of the string and hence it does not know what to do with the rest of the characters. To overcome this problem Python has a special notation to represent a special character. This special notation consists of a **backslash** (\) followed by a letter or a combination of digits and is called an **escape sequence**. Using **backslash**, the special characters within **print** can be written as shown below.

Example

```
>>> print("The flight attendant asked,\"May I see your boarding pass?\" ")
The flight attendant asked, "May I see your boarding pass?"
```

In the above example, we have used backslash before the quotation marks to display the quotation marks in the output.

Table 2.4 illustrates a list of escape sequences used in Python.

Table 2.4 Python escape sequences

Character Escape Sequence	Name
\'	Single Quote
\"	Double Quote
\n	Linefeed
\f	Formfeed
\r	Carriage return
\t	Tab
\\	Backslash
\b	Backspace



Note: The syntax of **print** function is different in Python 2.X. It is

print arguments

Python 2.X does not use an additional parenthesis. If you try to execute the print statement without parenthesis, unlike Python 3, it will raise a syntax error.

Example:

```
>>> print 'Hello World'
```

Syntax Error: Missing parentheses in call to 'print'

(Contd.)

Python programs are case sensitive. Python raises an error if a programmer tries to replace `print` by `Print`.

Example:

```
>>> Print('hi')
Traceback (most recent call last):
  File "<pyshell#3>", line 1, in <module>
    Print('hi')
NameError: name 'Print' is not defined
```

2.5.1 The `print()` Function with `end` Argument

Consider a simple program of a print statement.

PROGRAM 2.1 | Write a program to display the messages “Hello”, “World” and “Good Bye”. Each of the three messages should get displayed on a different line.

```
print('Hello')
print('World')
print('Good Bye')
```

Output

```
Hello
World
Good Bye
```

In the above program, we have displayed each message in a different line. In short, the `print` function automatically prints a **linefeed** (`\n`) to cause the output to advance to the next line. However, if you want to display the messages “Hello” “World” and “Good Bye” in one line without using a single `print` statement, then you can invoke the `print` function by passing a special argument named `end=' '`. The following program illustrates the use of the `end` argument within the `print` function.

PROGRAM 2.2 | Write a basic program to make use of the `end` key and display the messages “Hello” “World” and “Good Bye” in one line.

```
print(' Hello',end=' ')
print(' World',end=' ')
print(' Good Bye')
```

Output

```
Hello World Good Bye
```

2.6 ASSIGNING VALUE TO A VARIABLE

In Python, the equal sign (=) is used as the assignment operator. The statement for assigning a value to a variable is called an **assignment statement**. The syntax used to assign value to a variable or identifier is:

Variable = expression

In the above syntax, expression may contain information in terms of values, even some time expression may contain operands with operators which evaluates to a value.

Let us consider the following example of assigning and displaying the value of a variable in Python interactive mode.

Example

```
>>> Z = 1                                # Assign value 1 to variable Z
>>> Z                                    # Display value of Z
1
>>> radius = 5                          #Assign value 5 to the variable radius
>>> radius                              #Display value of variable radius
5
>>> R = radius + Z                       #Assign the addition of radius and Z to R
>>> R                                    #Display value of Variable R
6
>>> E = (5 + 10 * (10 + 5))             #Assign the value of the expression to E
>>> E
155
```

This example explains how a variable can be used to assign a value and how a variable can be used on both the sides of = operator. As given in the above example:

$R = \text{radius} + Z$

In the above assignment statement, the result of **radius+Z** is assigned to R. Initially the value assigned to Z is 1. Once Python executes the above statement, it adds the most recent value of Z and assigns the final value to a variable R.



Note: To assign a value to a variable, you must place the variable name to the left of the assignment operator. If you write in the following manner, Python will display an error.

```
>>> 10 = X
```

Syntax Error: can't assign to literal

In Mathematics, $E = (5 + 10 * (10 + 5))$, denotes an equation, but in Python $E = (5 + 10 * (10 + 5))$ is an assignment statement that evaluates the expression and assigns the result to E.

2.6.1 More on Assigning Values to Variables

Consider the following example where a value has been assigned to multiple variables.

Example

```

>>> P = Q = R = 100          #Assign 100 to P, Q and R
>>> P                        #Display value of Variable P
100
>>> Q                        #Display value of Variable Q
100
>>> R                        #Display Value of Variable R
100

```

In the above example, we have assigned value 100 to **P**, **Q** and **R**. The statement **P = Q = R = 100** is equivalent to

```

P = 100
Q = 100
R = 100

```

2.6.2 Scope of a Variable

Each variable has a scope. The scope of a variable is a part of the program where a variable can be referenced. More details on scope of variables are given in Chapter 6. Consider the following simple example and run it on Python interpreter.

```

>>> C = Count + 1
Traceback (most recent call last):
  File "<pyshell#9>", line 1, in <module>
    C = Count + 1
NameError: name 'Count' is not defined

```

In the above example, we have written a statement as **C = Count + 1**, but when Python tries to execute the above statement it raises an error, viz. **"Count is not defined"**. To fix the above error in Python the variable must be assigned some value before it is used in an expression. Thus, the correct version of the above code written in Python interactive mode is as given as follows:

```

>>> Count = 1
>>> C = Count + 1
>>> C
2

```



Note: A variable must be assigned a value before it can be used in an expression.

2.7 MULTIPLE ASSIGNMENTS

Python supports simultaneous assignment to multiple variables. The syntax of multiple assignments is

```
Var1, Var2, Var3, ..... = Exp1, Exp2, Exp3, ..... ExpN
```

In the above syntax, Python simultaneously evaluates all the expressions on the right and assigns them to a corresponding variable on the left.

Consider the following statements to swap the values of the two variables **P** and **Q**. The common approach to swap the contents of the two variables is shown as follows:

Example

```
>>> P = 20
>>> Q = 30
>>> Temp = P           #Save value of variable P into a variable Temp
>>> P = Q              #Assign value of Q to P
>>> Q = Temp           #Assign the value of Temp to Q
#After Swapping the value of P, and Q are as follows.
>>> P
30
>>>
>>> Q
20
```

In the above code, we have used the following statements to swap the values of the two variables **P** and **Q**.

```
Temp = P
P = Q
Q = Temp
```

However, by using the concept of multiple assignment, you can simplify the task of swapping two numbers.

```
>>> P, Q = Q, P      #Swap P with Q & Q with P
```

Thus, the entire code to swap two numbers using multiple assignment is as follows:

```
>>> P = 20           #Initial Values of P and Q
>>> Q = 30
>>> P
20
>>> Q
30
>>> P, Q = Q, P      #Swap values of P and Q
>>> P                #Display value of P
30
>>> Q                #Display Value of Q
20
```

2.8 WRITING SIMPLE PROGRAMS IN PYTHON

How can a simple program to calculate the area of a rectangle be written in Python?

We know that a program is written in a step-wise manner. Consider the initial steps given as follows:

- ◎ **STEP 1:** Design an algorithm for the given problem.

An algorithm describes how a problem is to be solved by listing all the actions that need to be taken. It also describes the order in which the series of actions need to be carried out. An algorithm helps a programmer to plan for the program before actually writing it in a programming language. Algorithms are written in simple English language along with some programming code.

- ◎ **STEP 2:** Translate an algorithm to programming instructions or code.

Let us now write an algorithm to calculate the area of a rectangle.

Algorithm to Calculate the Area of a Rectangle

- a. Get the length and breadth of the rectangle from the user.
- b. Use the relevant formula to calculate the area

$$\text{Area} = \text{Length} * \text{Breadth}$$

- c. Finally display the area of the rectangle.

This algorithm can be written as code as shown in program 2.3.

PROGRAM 2.3 | Write a program to calculate the area of a rectangle.

```
Length = 10
breadth = 20
print(' Length = ',length,' Breadth = ',breadth)
area = length * breadth
print(' Area of Rectangle is = ',area)
```

Output

```
Length = 10 Breadth = 20
Area of Rectangle is = 200
```

Explanation In the above program, two variables, viz. length and breadth are initialized with values 10 and 20, respectively. The statement **area = length x breadth** is used to compute the area of the rectangle.

Here the values of the variables are fixed. However, a user may want to calculate the area of different rectangles with different dimensions in future. In order to get the values according to the user's choice, a programmer must know how to read the input values from the console. This is described in the next section.

2.9 THE `input()` FUNCTION

The `input()` function is used to accept an input from a user. A programmer can ask a user to input a value by making use of `input()`.

`input()` function is used to assign a value to a variable.

Syntax

```
Variable_Name = input()
```

OR

```
Variable_Name = input('String')
```

2.9.1 Reading String from the Console

A simple program of `input()` function to read strings from the keyboard is given in Program 2.4.

PROGRAM 2.4 | Write a program to read strings from the keyboard.

```
Str1 = input('Enter String1:')
Str2 = input('Enter String2: ')
print(' String1 = ',Str1)
print(' String2 = ',Str2)
```

Output

```
Enter String1:Hello
Enter String2: Welcome to Python Programming
String1 = Hello
String2 = Welcome to Python Programming
```

Explanation The `input()` function is used to read the string from the user. The string values entered from the user are stored in two separate variables, viz. **Str1** and **Str2**. Finally all the values are printed by making use of `print()` function.

Let us also check what happens if by mistake the user enters digits instead of characters. Program 2.5 illustrates the same.

PROGRAM 2.5 | Write a program to enter digits instead of characters.

```
print(' Please Enter the Number:')
X = input()
print(' Entered Number is: ',X)
print(' Type of X is:')
print(type(X))
```

(Contd.)

Output

```
Please Enter the number:
60
Entered Number is: 60
Type of X is:
<class 'str'>
```

Explanation We know that Python executes statements sequentially. Hence, in the above program the first print statement is printed, i.e. 'Please Enter the Number.' But when it runs the second statement, i.e. `X = input()` the programming execution stops and waits for the user to type the text using the keyboard. The text that the user types is not committed until he/she presses Enter. Once the user enters some text from the keyboard, the value gets stored in an associated variable. Finally, the entered value is printed on the console. The last statement is used to check the type of value entered.



Note: The input function produces only string. Therefore, in the above program even if the user enters a numeric, i.e. integer value, Python returns the type of input value as string.

In the above program, how does a programmer read integer values using the input function?

Python has provided an alternative mechanism to convert existing string to int. A programmer can use `int` to convert a string of digits into an integer. Program 2.6 illustrates the use of `int` and `input` ().

PROGRAM 2.6 | Write a program to demonstrate the use of `int` and `input` function.

```
print(' Please Enter Number')
Num1 = input()                #Get input from user
print(' Num1 = ',Num1)        #Print value of Num1
print(type(Num1))             #Check type of Num1
print(' Converting type of Num1 to int ')
Num1 = int(Num1)              #Convert type of Num1 from str to int
print(Num1)                   #print the value of Num1
print(type(Num1))             #Check type of Num1
```

Output

```
Please Enter Number
12
Num1 = 12
<class 'str'>
Converting type of Num1 to int
12
<class 'int'>
```

Explanation The above program asks the user for input. The user has entered the input as 12 but it is of type str. By making use of int, i.e. the statement **Num1 = int(Num1)**, it converts the existing type to int.

We can minimise the number of lines in a program directly by making use of **int** before **input** function. A shorter version of the above program is given in Program 2.7.

PROGRAM 2.7 | Write a program to demonstrate the use of **int** before input.

```
Num1 = int(input(' Please Enter Number:'))
print(' Num1 = ',Num1) #Print the value of Num1
print(type(Num1)) #Check type of Num1
```

Output

```
Please Enter Number:
20
Num1 = 20
<class 'int'>
```

PROGRAM 2.8 | Write a program to read the length and breadth of a rectangle from a user and display the area of the rectangle.

```
print(' Enter Length of Rectangle:', end=' ')
Length = int(input()) #Read Length of Rectangle
print(' Enter Breadth of Rectangle:', end=' ')
Breadth = int(input()) #Read Breadth of Rectangle
Area = Length * Breadth #Compute Area of Rectangle
print('-----Details of Rectangle-----')
print(' Length = ',Length) #Display Length
print(' Breadth = ',Breadth) #Display Breadth
print(' Area of rectangle is :',Area)
```

Output

```
Enter Length of Rectangle: 10
Enter Breadth of Rectangle: 20
-----Details of Rectangle-----
Length = 10
Breadth = 20
Area of rectangle is: 200
```



Note: A programmer can make use of any type to convert the string into a specific type.

Example:

```
X = int(input())      #Convert it to int
X = float(input())    #Convert it to float
```

PROGRAM 2.9 | Write a program to add one integer and floating type number.

```
print('Enter integer number: ',end='')
Num1 = int(input()) # Read Num1
print('Enter Floating type number:',end='')
Num2 = float(input()) #Read Num2
print(' Number1 = ',Num1) #Print Num1
print(' Number2 = ',Num2) #Print Num2
sum = Num1 + Num2 #Calculate Sum
print(' sum = ',sum) #Display Sum
```

Output

```
Enter integer number: 2
Enter Floating type number:2.5
Number1 = 2
Number2 = 2.5
sum = 4.5
```



Note: Python 3 uses **input()** method to read the input from the user.

Python 2 uses **raw _input()** method to read the input from the user.

In subsequent programs in this chapter we are going to use **input()** method only as all programs are executed in Python 3.

2.10 THE **eval()** FUNCTION

The full form of **eval** function is to evaluate. It takes a string as parameter and returns it as if it is a Python expression. For example, if we try to run the statement **eval('print("Hello")')** in Python interactive mode, it will actually run the statement **print("Hello")**.

Example

```
>>> eval('print("Hello")')
Hello
```

The **eval** function takes a string and returns it in the type it is expected. The following example illustrates this concept.

Example

```
>>> X = eval('123')
>>> X
123
>>> print(type(X))
<class 'int'>
```

2.10.1 Apply eval() to input() Function

In the previous section we learnt about the `input()` function in detail. We know that the `input()` function returns every input by the user as string, including numbers. And this problem was solved by making use of `type` before `input()` function.

Example

```
X = int (input('Enter the Number'))
```

Once the above statement is executed, Python returns it into its respective type.

By making use of `eval()` function, we can avoid specifying a particular type in front of `input()` function. Thus, the above statement,

```
X = int (input('Enter the Number'))
```

can be written as:

```
X = eval(input('Enter the Number'))
```

With respect to the above statement, a programmer does not know what values a user can enter. He/she may enter a value of any type, i.e. int, float, string, complex etc. By making use of `eval`, Python automatically determines the type of value entered by the user. Program 2.10 demonstrates the use of `eval()`.

PROGRAM 2.10 | Write a program to display details entered by a user, i.e. name, age, gender and height.

```
Name = (input('Enter Name :'))
Age = eval(input('Enter Age :')) #eval() determine input type
Gender = (input('Enter gender:'))
Height = eval(input('Enter Height:')) #eval() determine input type
print(' User Details are as follows: ')
print(' Name: ',Name)
print(' Age: ',Age)
print(' Gender: ',Gender)
print(' Height ',Height)
```

Output

```
Enter Name: Donald Trump
```

(Contd.)


```

Enter Age: 60
Enter Gender: M
Enter Height:5.9
User details are as follows:
Name: Donald Trump
Age: 60
Gender: M
Height: 5.9

```

Explanation In the above program we have used `eval()` in front of `input()` function as:

```
Age = eval(input('Enter Age :'))
```

The above statement reads the input as a string and converts a string into a number. After the user enters a number and presses Enter, the number is read and assigned to a variable name.

2.11 FORMATTING NUMBER AND STRINGS

A formatting string helps make string look presentable to the user for printing. A programmer can make use of **format** function to return a formatted string. Consider the following example to calculate the area of a circle before using this function.

PROGRAM 2.11 | Write a program to calculate the area of a circle.

```

radius = int(input('Please Enter the Radius of Circle: '))
print(' Radius = ', radius)           #Print Radius
PI = 3.1428                           #Initialize value of PI
Area = PI * radius * radius           #Calculate Area
print(' Area of Circle is: ',Area)    #Print Area

```

Output

```

Please Enter the Radius of Circle: 4
Radius = 4
Area of Circle is: 50.2848

```

In the above program, the user entered the radius as 4. Thus, for a circle having radius 4, it has displayed the area as **50.2848**. To display only two digits after the decimal point, make use of **format()** function. The syntax of format function is

```
format(item, format-specifier)
```

item is the number or string and **format-specifier** is a string that specifies how the item is formatted. A simple example of **format()** function executed in Python interactive mode is given as follows:

Example

```
>>> x = 12.3897                                #Assign value to variable x
>>> print(x)                                    # print x
12.3897
>>> format(x,".2f")                            #Return formatted string
'12.39'
```

PROGRAM 2.12 | Make use of `format()` function and display the area of a circle.

```
radius = int(input('Please Enter the Radius of Circle: '))
print(' Radius = ', radius)
PI = 3.1428
Area = PI * radius * radius
print(' Area of Circle is: ',format(Area,'.2f'))
```

Output

```
Please Enter the Radius of Circle: 4
Radius = 4
Area of Circle is: 50.28
```

In the above program, the statement, `print('Area of Circle is: ',format(Area,'.2f'))` is used to display the area of the circle. Within format function, `Area` is an item and `'2f'` is the format specifier which tells the Python interpreter to display only two digits after the decimal point.

2.11.1 Formatting Floating Point Numbers

If the item is a float value, we can make use of specifiers to give the **width** and **precision**. We can use `format` function in the form **width.precisionf**. Precision specifies the number of digits after the decimal point and width specifies the width of the resultant string. In **width.precisionf** `'f'` is called conversion code. `'f'` indicates the formatting for floating point numbers. Examples of floating point numbers are

```
print(format(10.345,"10.2f"))
print(format(10,"10.2f"))
print(format(10.32245,"10.2f"))
```

displays the output as follows:

```
10.35
10.00
10.32
```

In above example, print statement uses `10.2f` as the format specifier. `10.2f` is explained in detail in **Fig. 2.2**.

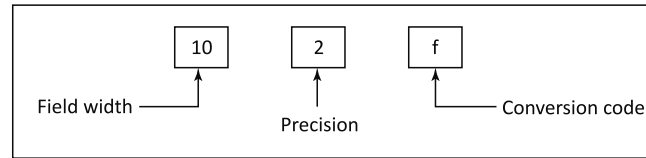


Figure 2.2 Format specifier details

The actual representation of the above output is:

10									
					1	0	.	3	5
					1	0	.	0	0
					1	0	.	3	2

The gray box denotes a blank space. The decimal point is also counted as 1.

2.11.2 Justifying Format

By default, the integer number is right justified. You can insert < in the format specifier to specify an item to be left justified. The following example illustrates the use of right and left justification.

Example

```
>>> print (format (10.234566, "10.2f")) #Right Justification Example
10.23
>>> print (format (10.234566, "<10.2f")) #Left Justification Example
10.23
```

The actual representation of the above output for left justification is:

1	0	.	2	3					
10									

2.11.3 Integer Formatting

In case of integer formatting, you can make use of conversion code **d** and **x**. **d** indicates that the integer is to be formatted, whereas **x** specifies that the integer is formatted into a hexadecimal integer. The following example illustrates integer formatting.

Example

```
>>> print (format (20, "10x")) #Integer formatted to Hexadecimal Integer
14
>>> print (format (20, "<10x"))
14
```

```
>>> print(format(1234,"10d"))    #Right Justification
1234
```

In the above example the statement **print(format(20,"10x"))** converts the number 20 into a hexadecimal, i.e. 14.

2.11.4 Formatting String

A programmer can make use of conversion code **s** to format a string with a specified width. However, by default, string is left justified. Following are some examples of string formatting.

Example

```
>>> print(format("Hello World!","25s")) #Left Justification Example
Hello World!
```

```
>>>print(format("HELLO WORLD!",">20s"))    #String Right Justification
      HELLO WORLD!
```

In the above example, the statement **(format("HELLO WORLD!",">20s"))** displays the output as:

									H	E	L	L	O		W	O	R	L	D	!
←										20 →										

In print function 20 specifies the string to be formatted with a width of 20. In the second print statement, ">" is used for right justification of the given string.

2.11.5 Formatting as a Percentage

The conversion code **%** is used to format a number as a percentage. The following example illustrates the same.

Example

```
>>> print(format(0.31456,"10.2%"))
31.46%
>>> print(format(3.1,"10.2%"))
310.00%
>>> print(format(1.765,"10.2%"))
176.50%
```

In the above example, the statement **print(format(0.31456,"10.2%"))**, contains the format specifier **10.2%**. It causes the number to be multiplied by 100. The **10.2%** denotes the integer to be formatted with a width of 10. In width, % is counted as one space.

2.11.6 Formatting Scientific Notation

While formatting floating point numbers we have used the conversion code **f**. However, if we want to format a given floating point number in scientific notation then the conversion code **e** will be used. An example of formatting floating point numbers is given as follows:

Example

```
>>> print(format(31.2345,"10.2e"))
      3.12e+01
>>> print(format(131.2345,"10.2e"))
      1.31e+02
```

Most frequently used specifiers are shown in Table 2.5.

Table 2.5 Frequently used specifiers

<i>Specifier</i>	<i>Format</i>
10.2f	Format floating point number with precision 2 and width 10.
<10.2f	Left Justify the floating point number.
>10.2f	Right Justify the formatted item.
10X	Format integer in hexadecimal with width 10
20s	Format String with width 20
10.2%	Format the number in decimal

2.12 PYTHON INBUILT FUNCTIONS

In the previous sections of this chapter we have learnt how to use the functions **print**, **eval**, **input** and **int**. We know that a function is a group of statements that performs a specific task. Apart from the above functions, Python supports various inbuilt functions as well. A list of all inbuilt functions supported by Python is given in **Table 2.6**. It provides the name of a function, its description and examples executed in Python interactive mode.

Table 2.6 Inbuilt functions in Python

<i>Function</i>	<i>Description</i>
abs(x)	Returns absolute value of x
Example	
<pre>>>> abs(-2) 2 >>> abs(4) 4</pre>	

(Contd.)

max(x1, x2, x3,.....,xN)	Returns largest value among X1, X2, X3, X4,... , XN
Example:	
<pre>>>> max(10,20,30,40) 40</pre>	
min(x1, x2, x3,.....,xN)	Returns minimum value among X1, X2, X3, X4,... , XN.
pow(X, Y)	Return the X^Y
Example:	
<pre>>>> pow(2,3) 8</pre>	
round(x)	Returns an integer nearest to the value of x.
Example:	
<pre>>>> round(10.34) 10 >>> round(10.89) 11</pre>	

Functions given in Table 2.6 are not enough to solve mathematical calculations. Thus, Python has an additional list of functions defined under Python's **math** module to solve problems related to mathematical calculations. List of functions under the **math** module is given in Table 2.7.

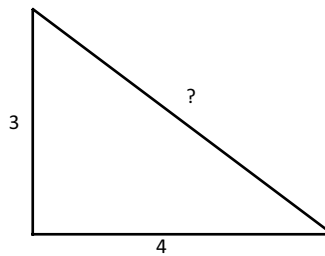
Table 2.7 Inbuilt mathematical functions in Python

Function	Example	Description
ceil(X)	<pre>>>> math.ceil(10.23) 11</pre>	Round X to nearest integer and returns that integer.
floor(X)	<pre>>>> math.floor(18.9) 18</pre>	Returns the largest value not greater than X
exp(X)	<pre>>>> math.exp(1) 2.718281828459045</pre>	Returns the exponential value for e^x
log(X)	<pre>>>> math.log(2.71828) 0.999999327347282</pre>	Returns the natural logarithmic of x (to base e)
log(x,base)	<pre>>>> math.log(8,2) 3.0</pre>	Returns the logarithmic of x to the given base
sqrt(X)	<pre>>>>math.sqrt(9) 3.0</pre>	Return the square root of x
Sin(X)	<pre>>>> math.sin(3.14159/2) 0.999999999991198</pre>	Return the sin of X, where X is the value in radians
asin(X)	<pre>>>> math.asin(1) 1.5707963267948966</pre>	Return the angle in radians for the inverse of sine
cos(X)	<pre>>>> math.cos(0) 1.0</pre>	Return the sin of X, where X is the value in radians
aCos(X)	<pre>>>> math.acos(1) 0.0</pre>	Return the angle in radians for the inverse of cosine

(Contd.)

tan(X)	>>> math.tan(3.14/4) 0.9992039901050427	Return the tangent of X, where X is the value in radians
degrees(X)	>>> math.degrees(1.57) 89.95437383553924	Convert angle X from radians to degrees
Radians(X)	>>> math. radians(89.99999) 1.5707961522619713	Convert angle x from degrees to radians

PROGRAM 2.13 | Write a program to calculate the hypotenuse of the right-angled triangle given as follows:



$$\begin{aligned}
 \text{Hypotenuse} &= \text{Square_Root} \{(\text{Base})^2 + (\text{Height})^2\} \\
 &= \text{Square_Root} \{(3)^2 + (4)^2\} \\
 &= 5
 \end{aligned}$$

```

import math #Import Math Module
Base = int(input('Enter the base of a right-angled triangle:'))
Height = int(input('Enter the height of a right-angled triangle:'))
print(' Triangle details are as follows: ')
print(' Base = ',Base)
print(' Height = ',Height)
Hypotenuse = math.sqrt(Base * Base + Height * Height )
print(' Hypotenuse = ',Hypotenuse)

```

Output

```

Enter the base of a right-angled triangle:3
Enter the height of a right-angled triangle:4
Triangle details are as follows:
Base = 3
Height = 4
Hypotenuse = 5.0

```

Explanation In the above program, the first line '**import math**' is used to include all in-built functions supported by Python under the math module. The **input** function is used to read the

base and height of the right-angled triangle. The statement **math.sqrt** is executed to find the square root of the number. Finally, print for the hypotenuse of the right-angled triangle is given.

2.12.1 The `ord` and `chr` Functions

As we know, a string is a sequence of characters. It can include both text and numbers. All these characters are stored in a computer as a sequence of 0s and 1s. Therefore, a process of mapping a character to its binary representation is called **character encoding**.

There are different ways to encode a character. The **encoding scheme** decides the manner in which characters are encoded. The American Standard Code for Information Interchangeable (**ASCII**) is one of the most popular encoding schemes. It is a 7-bit encoding scheme for representation of all lower and upper case letters, digits and punctuation marks. The ASCII uses numbers from 0 to 127 to represent all characters. Python uses the in-built function **ord(ch)** to return the ASCII value for a given character. The following example demonstrates the use of the in-built function `ord()`.

Example

```
>>> ord('A') #Returns ASCII value of Character 'A'
65
>>> ord('Z') #Returns ASCII Value of Character of 'Z'
90
>>> ord('a') #Returns ASCII Value of Character of 'a'
97
>>> ord('z') #Returns ASCII Value of Character of 'z'
122
```

The **chr(Code)** returns the character corresponding to its code, i.e. the ASCII value. The following example demonstrates the use of in-built function `chr()`.

Example

```
>>> chr(90)
'Z'
>>> chr(65)
'A'
>>> chr(97)
'a'
>>> chr(122)
'z'
```

PROGRAM 2.14 | Write a program to find the difference between the ASCII code of any lower case letter and its corresponding upper case letter.

```
Char1 = 'b'
Char2 = 'B'
print('Letter\tASCII Value')
```

(Contd.)


```

print(Char1, '\t', ord(Char1))
print(Char2, '\t', ord(Char2))
print(' Difference between ASCII value of two Letters:')
print(ord(Char1), '-', ord(Char2), '=', end=' ')
print(ord(Char1) - ord(Char2))

```

Output

```

Letter ASCII Value
b      98
B      66
Difference between ASCII value of two Letters:
98 - 66 = 32

```

Explanation In the above program, the letter 'b' is stored in variable **Char1** and the letter 'B' is stored in variable **Char2**. The **ord()** function is used to find the ASCII value of the letters. Finally, the statement **ord(Char1) - ord(Char2)** is used to find the difference between the ASCII values of the two letters **Char1** and **Char2**.

SUMMARY

- ♦ Python breaks each statement into a sequence of lexical components called tokens.
- ♦ Literals are numbers, strings or characters that appear directly in a program.
- ♦ Python offers an inbuilt method called **type** to know the exact type of any value.
- ♦ Keywords are reserved words.
- ♦ Keywords cannot be used as identifiers or variables.
- ♦ An identifier is a name used to identify a variable, function, class or other objects.
- ♦ Everything in Python is an object.
- ♦ The **int** function converts a string or a number into a whole number or integer.
- ♦ The float function converts a string into a floating-point number.
- ♦ The Boolean data type is represented in Python as of type **bool**.
- ♦ **print** function is used to display contents on the screen.
- ♦ **input()** function is used to accept input from the user.
- ♦ **format()** function can be used to return a formatted string.

KEY TERMS

- ⇒ **chr()**: Returns a character for a given ASCII value
- ⇒ **end()**: Used as argument with **print()** function
- ⇒ **format()**: Formats string and integer
- ⇒ **Identifier**: Name to identify a variable

- ⇒ **Inbuilt Math Functions:** `abs()`, `max()`, `round()`, `ceil()`, `log()`, `exp()`, `sqrt()`, `sin()`, `asin()`, `acos()`, `atan()`, `cos()`, `degrees()`, `radians()` and `floor()`.
- ⇒ **`input()`:** Used to accept data from the user
- ⇒ **`int()`:** Used to convert string or float into integer
- ⇒ **`ord()`:** Returns ASCII value of a character
- ⇒ **`print()`:** Prints contents on the screen
- ⇒ **`str()`:** Used to convert a number into string
- ⇒ **`type()`:** Used to know the exact type of any value
- ⇒ **Tokens:** Breaks each statement into a sequence of lexical components

REVIEW QUESTIONS

A. Multiple Choice Questions

- Which of the following is not a valid identifier?
 - `A_`
 - `_A`
 - `1a`
 - `_1`
- Which of the following is an invalid statement?
 - `w,X,Y,Z = 1,00,000,0000`
 - `WXYZ = 1,0,00,000`
 - `W X Y Z =10 10 11 10`
 - `W_X_Y = 1,100,1000`
- Which of the following is not a complex number?
 - `A = 1+2j`
 - `B = complex(1,2)`
 - `C = 2+2i`
 - None of the above
- What is the output of the following statement?


```
round(1.5)-round(-1.5)
```

 - 1
 - 2
 - 3
 - 4
- What is the output of the following statement?


```
print('{:,}'.format('100000'))
```

 - 1,00,000
 - 1,0,0,0,0,0
 - 10,00,00,0
 - Error
- Which type of error will occur on executing the following statement?


```
Name = MyName
```

 - Syntax Error
 - Name Error
 - Type Error
 - Value Error
- What is the output of following statement?


```
Sum = 10 + '10'
```

 - 1010
 - 20
 - TypeError
 - None of the above
- What will be printed if we write `print()` statement as


```
Print("Hello Python!")
```

 - Hello Python
 - Syntax Error
 - Name Error
 - Both a and b

9. Which of the following is a valid input() statement?
- | | |
|--|--|
| a. <code>x = input(Enter number:)</code> | b. <code>X = Input(Enter number:)</code> |
| c. <code>X = input('Enter number:')</code> | d. <code>X = Input('Enter Number:')</code> |
10. What will be the output of the following statement if the user has entered 20 as the value of x.
- ```
x = input('Enter Number:')
print(10+x)
```
- |         |          |
|---------|----------|
| a. 1010 | b. 20    |
| c. 30   | d. Error |

## B. True or False

- Python breaks each statement into a sequence of lexical components known as tokens.
- Keywords are tokens of Python.
- Operators are not a part of tokens.
- Python keywords do not have fixed meaning.
- Keywords can be used as identifiers or variables.
- Strings are part of literals.
- An identifier is a name used to identify a variable, function etc.
- Python classifies different kinds of objects into types.
- The float function converts a string into a whole integer number.
- The str function is used to convert a number into a string.

## C. Exercise Questions

- Which of the following identifiers are valid?  
Name, Roll\_No , Sr.No, Roll-No, break, elif, DoB
- What will be the output of the following statements if all of them are executed in Python interactive mode?

|                                   |                                  |
|-----------------------------------|----------------------------------|
| a. <code>abs(-2)</code>           | b. <code>min(102,220,130)</code> |
| c. <code>max(-1,-4,-10)</code>    | d. <code>max('A','B','Z')</code> |
| e. <code>max('a','B','Z')</code>  | f. <code>round(1.6)</code>       |
| g. <code>math.ceil(1.2)</code>    | h. <code>math.floor(1.8)</code>  |
| i. <code>math.log(16,2)</code>    | j. <code>math.exp(1)</code>      |
| k. <code>math.</code>             | l. <code>cos(math.pi)</code>     |
| m. <code>math.cos(math.pi)</code> |                                  |
- What will be the output of the following statements if all of them are executed in Python interactive mode?

|                          |                          |
|--------------------------|--------------------------|
| a. <code>ord('a')</code> | b. <code>ord('F')</code> |
| c. <code>ord('f')</code> | d. <code>chr(97)</code>  |
| e. <code>chr(100)</code> |                          |
- Identify the error in the following piece of code. Explain how you will fix it.

```
num1 = '10'
num2 = 20.65
sum = num1 + num2
```

```
print(sum)
```

5. State the output of following statements.
  - a. `print(format(16,'x'))`
  - b. `print(format(10,'x'))`
  - c. `print(format(10+10,'x'))`
  - d. `print(format(10+ord('a'),'x'))`
  - e. `print(format(20,'o'))`
  - f. `print(format(100,'b'))`
  - g. `print(format(10,'b'))`
6. State the output of the following statements.
  - a. `print(format('Hello','>2'))`
  - b. `print(format('Hello','<2'))`
  - c. `print(format('Hello','>4'))`
  - d. `print(format('Hello','>20'))`
7. State the output of the following statements.
  - a. `print(format(10,'>20'))`
  - b. `print(format('10','<20'))`
  - c. `print(format(10.76121421431,'.2f'))`
  - d. `print(format(10.76121421431,'f'))`
8. Explain the use of end keyword with a suitable example.
9. Explain character set supported by Python in detail.
10. How are complex numbers displayed in interactive mode? Give an example.
11. State the output of the following code.

```
num1 = '10'
num2 = '20'
sum = num1 + num2
print(sum)
```

## PROGRAMMING ASSIGNMENTS

1. Write a program to print 'F' to 'A' in five different lines.
2. Write a program to read and store the name of three different cities in three different variables and print all the contents of variables on the console.
3. Write a program to prompt the user to enter and display their personal details, such as name, address and mobile number.
4. By making use of five different print statements, write a program to print 'A' to 'F' in one single line.
5. Write a program to read an integer as string. Convert the string into integer and display the type of value before and after converting to int.
6. Write a program initialize the string "hello world" to a variable Str1 and convert the string into upper case.
7. Translate the following algorithm into Python code.
  - Step 1: Initialize variable named Pounds with value 10.
  - Step 2: Multiply Pounds by 0.45 and assign it to a variable Kilogram.
  - Step 3: Display the value of variable Pounds and Variable.
8. Write a program to read the radius of a circle and print the area of the circle.

# Operators and Expressions

## 3

### CHAPTER OUTLINE

|                                                                   |                                                                          |
|-------------------------------------------------------------------|--------------------------------------------------------------------------|
| 3.1 Introduction                                                  | 3.6 Translating Mathematical Formulae into Equivalent Python Expressions |
| 3.2 Operators and Expressions                                     | 3.7 Bitwise Operator                                                     |
| 3.3 Arithmetic Operators                                          | 3.8 The Compound Assignment Operator                                     |
| 3.4 Operator Precedence and Associativity                         |                                                                          |
| 3.5 Changing Precedence and Associativity of Arithmetic Operators |                                                                          |

### LEARNING OUTCOMES

*After completing this chapter, students will be able to:*

- Perform simple arithmetic operations
- Explain the difference between division and floor division operators
- Use unary, binary and bitwise operators, and perform multiplication and division operations using bitwise left and right shift operators
- Evaluate numeric expressions and translate mathematical formulae into expressions
- Recognise the importance of associativity and operator precedence in programming languages

### 3.1 INTRODUCTION

An operator indicates an operation to be performed on data to yield a result. In our day to day life, we use various kinds of operators to perform diverse data operations. Python supports different

operators which can be used to link variables and constants. These include arithmetic operators, Boolean operators, bitwise operators, relational operators and simple assignment and compound assignment operators.

Table 3.1 lists basic operators in Python with their symbolic representation

**Table 3.1** Types of operators

| Type of Operator                                    | Symbolic Representation |
|-----------------------------------------------------|-------------------------|
| Arithmetic Operators                                | +, -, /, //, *, %, %%   |
| Boolean Operators                                   | and, or, not            |
| Relational Operators                                | >, <, <=, >=, !=        |
| Bitwise Operators                                   | &,  , ^, >>, <<, ~      |
| Simple Assignment and Compound Assignment Operators | =, +=, *=, /=, %=, **=  |

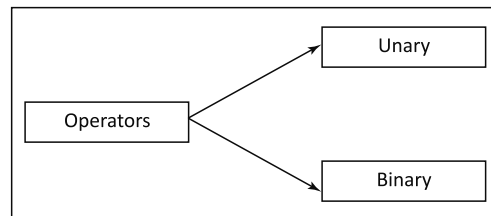
## 3.2 OPERATORS AND EXPRESSIONS

Most statements contain expressions. An expression in Python is a block of code that produces a result or value upon evaluation. A simple example of an expression is `6 + 3`. An expression can be broken down into operators and operands. Operators are symbols which help the user or command computer to perform mathematical or logical operations. In the expression `6 + 3`, the '+' acts as the operator. An operator requires data to operate and this data is called **operand**. In this example, `6` and `3` are the operands.

The following sections describe the various kinds of operators and their usage. The expressions given in the examples are executed in Python interactive mode.

## 3.3 ARITHMETIC OPERATORS

There are two types of arithmetic operators in Python, viz. binary and unary (as shown in Fig. 3.1).



**Figure 3.1** Types of arithmetic operators

### 3.3.1 Unary Operators

Unary arithmetic operators perform mathematical operations on one operand only. The '+' and '-' are two unary operators. The unary operator minus (-) produces the negation of its numeric

operand. The unary operator plus (+) returns the numeric operand without change. Table 3.2 gives the details of unary operators.

**Table 3.2** Unary operators

| Unary Operator | Example                                   | Description                                                                           |
|----------------|-------------------------------------------|---------------------------------------------------------------------------------------|
| +              | +X<br>(+X returns the same value, i.e. X) | Returns the same value that is provided as input                                      |
| -              | -X<br>(-x returns the negation of x)      | Negates the original value so that the positive value becomes negative and vice versa |

### Examples of Unary Operators

```
>>> x=-5 #Negates the value of X
>>> x
-5
>>> x=+6 #Returns the numeric operand, i.e. 6, without any change
>>> x
6
```

### Some More Complex Examples of Unary Operators

```
>>> +-5
-5
```

In the above expression `+-5`, the first '+' operator represents the unary plus operation and the second '-' operator represents the unary minus operation. The expression `+-5` is equivalent to `+(-(5))`, which is equal to -5.

```
>>> 1--3 #Equivalent to 1-(-3)
4
>>> 2---3 #Equivalent to 2-(-(-3))
-1
>>> 3+--2 #Equivalent to 3+(-(-2))
5
```

## 3.3.2 Binary Operators

Binary operators are operators which require two operands. They are written in **infix** form, i.e. the operator is written in between two operands.

### The Addition (+) Operator

The '+' operator in Python can be used with binary and unary form. If the addition operator is applied in between two operands, it returns the result as the arithmetic sum of the operands. Some examples of addition operators executed in Python interactive mode are given as follows:

**Example**

```
>>> 4+7 #Addition
11

>>>5+5 Addition
10
```

Table 3.3. explains the syntax and semantics of the addition operator in Python, using its three numeric types, viz. **int**, **float** and **complex**.

**Table 3.3** Addition operator

| <i>Syntax</i>               | <i>Example</i>      |
|-----------------------------|---------------------|
| (int, int)-> int            | 2+4 returns 6       |
| (float, float)->float       | 1.0+4.0 returns 5.0 |
| (int, float)->float         | 1+2.0 returns 3.0   |
| (float, int)->float         | 2.0+1 returns 3.0   |
| (complex, complex)->complex | 3j+2j returns 5j    |

**The Subtraction (-) Operator**

The '-' operator in Python can be used with binary and unary form. If the subtraction operator is applied in between two operands, the result is returned as the arithmetic difference of the operands. Some examples of subtraction operators executed in Python interactive mode are given as follows:

**Example**

```
>>> 7-4 #Subtraction
3

>>>5-2 #Subtraction
3
```

Table 3.4 explains the syntax and semantics of the subtraction operator in Python, using its three numeric types, viz. **int**, **float** and **complex**.

**Table 3.4** Subtraction operator

| <i>Syntax</i>               | <i>Example</i>      |
|-----------------------------|---------------------|
| (int, int)-> int            | 4-2 returns 2       |
| (float, float)->float       | 3.5-1.5 returns 2.0 |
| (int, float)->float         | 4-1.5 returns 2.5   |
| (float, int)->float         | 4.0-2 returns 2.0   |
| (complex, complex)->complex | 3j-2j returns 1j    |



**PROGRAM 3.1** | Read the cost and selling price of an object and write a program to find the profit earned by a seller (in rupees). The selling price is greater than the cost price.

```
SP=eval(input('Enter the Selling Price of an Object:'))
CP=eval(input('Enter the Cost Price of an Object:'))
print('-----')
print(' Selling Price = ',SP)
print(' Cost Price = ',CP)
print('-----')
Profit=SP - CP #Formula to Calculate Profit
print(' Profit Earned by Selling = ',Profit)
```

### Output

```
Enter the Selling Price of an Object: 45
Enter the Cost Price of an Object: 20

Selling Price = 45
Cost Price = 20

Profit Earned by Selling = 25
```

**Explanation** At the start of the program, the selling price and cost price of the object is read using eval. The statement, **Profit = SP - CP** is executed to calculate the profit earned by the seller.

### The Multiplication (\*) Operator

The '\*' operator in Python can be used only with binary form. If the multiplication operator is applied in between two operands, it returns the result as the arithmetic product of the operands. Some examples of multiplication operators executed in Python interactive mode are given as follows:

#### Example

```
>>> 7*4 #Multiplication
28
>>>5*2 #Multiplication
10
```

Table 3.5 explains the syntax and semantics of the multiplication operator in Python, using its three numeric types, viz. **int**, **float** and **complex**.

**Table 3.5** Multiplication operator

| <i>Syntax</i>               | <i>Example</i>      |
|-----------------------------|---------------------|
| (int, int)-> int            | 4*2 returns 8       |
| (float, float)->float       | 1.5*3.0 returns 4.5 |
| (int, float)->float         | 2*1.5 returns 3.0   |
| (float, int)->float         | 1.5* 5 returns 7.5  |
| (complex, complex)->complex | 2j*2j returns -4+0j |

**PROGRAM 3.2** | Write a program to calculate the square and cube of a number using \* operator.

```
num=eval(input('Enter the number:')) # Read Number
print('Number = ',num)
Square=num* num #Calculate Square
Cube = num * num * num #Calculate Cube
print('Square of a Number = ',num,' is ',Square)
print('Cube of a Number = ',num,' is ',Cube)
```

### Output

```
Enter the number: 5
Number = 5
Square of a Number = 5 is 25
Cube of a Number = 5 is 125
```

## The Division (/) Operator

The “/” operator in Python can be used only with binary form. If the division operator is applied in between two operands, it returns the result as the arithmetic quotient of the operands. Some examples of division operators executed in Python interactive mode are given as follows:

### Example

```
>>> 4/2 #Division
2.0

>>> 10/3
3.3333333333333335 #Division
```

Table 3.6 explains the syntax and semantics of the division operator in Python, using its three numeric types, viz. **int**, **float** and **complex**.

**Table 3.6** Division (/) operator

| Syntax                      | Example             |
|-----------------------------|---------------------|
| (int, int)-> float          | 25/5 returns 5.0    |
| (float, float)->float       | 0.6/2.0 returns 0.3 |
| (int, float)->float         | 4/0.2 returns 20.0  |
| (float, int)->float         | 1.5/2 returns 0.75  |
| (complex, complex)->complex | 6j/2j returns 3+0j  |



**Note:** When the division (/) operator is applied on two **int** operands, Python returns a **float** result.

**PROGRAM 3.3** | Write a program to calculate simple interest (SI). Read the principle, rate of interest and number of years from the user.

```
P=eval(input('Enter principle Amount in Rs = ')) #Read P
ROI=eval(input('Enter Rate of Interest = ')) #Read ROI
years=eval(input('Enter the Number of years = ')) #Read years
print(' Principle = ',P)
print(' Rate of Interest = ',ROI)
print(' Number of Years = ',years)
SI = P*ROI*Years/100 #Calculate SI
print('Simple Interest = ',SI)
```

### Output

```
Enter Principle Amount in Rs = 1000
Enter Rate of Interest = 8.5
Enter the Number of Years = 3
Principle = 1000
Rate of Interest = 8.5
Number of Years = 3
Simple Interest = 255.0
```

**PROGRAM 3.4** | Write a program to read a temperature in Celsius from the user and convert it into Fahrenheit.

```
Celsius =eval(input('Enter Degree is Celsius:')) #Read Celsius from User
print('Celsius = ', Celsius) #Print Celsius
Fahrenheit = (9 / 5) * Celsius + 32 # Convert Celsius to Fahrenheit
print(' Fahrenheit = ', Fahrenheit) # Print Fahrenheit
```

(Contd.)

**Output**

```
Enter Degree is Celsius: 23
Celsius = 23
Fahrenheit = 73.4
```



**Note:** Formula to convert Celsius into Fahrenheit is:  

$$\text{Fahrenheit} = (9/5) * \text{Celsius} + 32$$

**The Floor Division (//) Operator**

The ‘//’ operator in Python can be used only with binary form. If the floor division operator is applied in between two operands, it returns the result as the arithmetic quotient of the operands. Some examples of floor division operators executed in Python interactive mode are given as follows:

**Example**

```
>>> 4//2 # Floor Division
2
>>> 10//3
3 #Floor Division
```

Table 3.7 explains the syntax and semantics of the floor division operator in Python, using its numeric types, viz. **int** and **float**.

**Table 3.7** Floor division (//) operator

| <i>Syntax</i>         | <i>Example</i>        |
|-----------------------|-----------------------|
| (int, int)-> int      | 25//5 returns 5       |
| (float, float)->float | 10.5//5.0 returns 2.0 |
| (int, float)->float   | 11//2.5 returns 4.0   |
| (float, int)->float   | 4.0//3 returns 1.0    |



**Note:** a. From the above example, it is clear that when the floor division (//) operator is applied on two **int** operands, Python returns an **int** result.  
 b. In the second example 10.5//5.0, the result returned is 2.0. However, if 10.5/5.0 returns 2.1, it means the floor division operator has been applied on two float operands. Hence, it returns the result in float but ignores the decimal number after the decimal point.

**The Modulo (%) Operator**

When the second number divides the first number, the modulo operator returns the remainder. The % modulo operator is also known as the remainder operator. If the remainder of x divided by y is zero then we can say that x is divisible by y or x is a multiple of y.

Consider the following example.

$$\begin{array}{rcl}
 & 3 & \longleftarrow \text{Quotient} \\
 \text{Divisor} \longrightarrow 4 & \overline{) 14} & \longleftarrow \text{Dividend} \\
 & - 12 & \\
 & \hline
 & 2 & \longleftarrow \text{Remainder}
 \end{array}$$

In the above example, `14 % 4` returns 3 as the remainder. Thus, the left-side operand, i.e. 14 is the dividend and the right-side operand, i.e. 4 is the divisor. Some more examples of the modulo operator executed in Python interactive mode are given below.

### Example

```
>>> 10 % 4 # 10 is divided by 4 returns remainder as 2
2
>>> 13%5
3
```

Table 3.8 explains the syntax and semantics of the modulo (%) operator in Python, using its numeric types, viz. **int** and **float**.

**Table 3.8** Modulo (%) operator

| Syntax                | Example                |
|-----------------------|------------------------|
| (int, int)-> int      | 25%4 returns 1         |
| (float, float)->float | 2.5 % 1.2 returns 0.10 |
| (int, float)->float   | 13%2.0 returns 1.0     |
| (float, int)->float   | 1.5 % 2 returns 1.5    |



**Note:** Mathematically,  $X\%Y$  is equivalent to  $X - Y * (x//Y)$

**Example:** 14%5 returns 4  
 Therefore,  
 $14 \% 5 = 14 - 5*(14//5)$   
 $= 14 - 5* (2)$   
 $= 14 - 10$   
 $= 4$

**Use of % Modulo Operator in Programming** The modulo operator, i.e. the remainder operator is very useful in programming. It is used to check if a number is even or odd, i.e. if `number % 2` returns zero then it is an even number and if `number % 2 == 1` then it is an odd number.

**PROGRAM 3.5** | Write a program to read the weight of an object in grams and display its weight in kilograms and grams, respectively.

**Example**

**Input:** Enter the weight of the object in grams: 2,500

**Output:** Weight of the object (kilograms and grams): 2 kg and 500 g

**Note:** 1 kilogram = 1,000 grams

```
W1 = eval(input('Enter the Weight of Object in grams:')) #Input Weight
print(' Weight of Object = ',W1,' grams') # Print Weight
W2 = W1 // 1000 #Calculate No of kg
W3 = W1 % 1000 #Calculate No of g
print(' Weight of Object = ',W2,' kg and ',W3,' g')
```

**Output**

```
Enter the Weight of Object in g : 1250
Weight of Object = 1250 g
Weight of Object = 1 kg and 250 g
```

**PROGRAM 3.6** | Write a program to reverse a four-digit number using % and // operators.

```
Num=eval(input('Enter four-digit number: '))
print('Entered number is:',num)
r1=num%10
q1=num//10
r2=q1%10
q2=q1//10
r3=q2%10
q3=q2//10
r4=q3%10
print('Reverse of ',num,'is:',r1,r2,r3,r4)
```

**Output**

```
Enter four-digit number: 8763
Entered number is: 8763
Reverse of 8763 is: 3 6 7 8
```

**Explanation** In the above program, initially the number is read from the user. For instance, the number read through the user is **8763**. To reverse the contents of the number, initially the operation  $(8763 \% 10)$  gives a remainder 3. To display the second digit 6, the number has to be divided by 10. Hence,  $(8763 // 10)$  gives **876**. After obtaining the quotient as **876**, the modulus operation  $(876 \% 10)$  is performed again to obtain the digit **6**. This process is continued three times to obtain the reverse of the four-digit number entered by the user.

### The Exponent \*\* Operator

The `**` exponent operator is used to calculate the power or exponent of a number. To compute  $x^Y$  ( $x$  raised to  $Y$ ), the expression is written as  $X**Y$ . The exponent operator is also called **power operator**.

#### Example

```
>>> 4**2 #Calculate Square of a Number 4
16
>>> 2**3 #Calculate Cube of a Number 2
8
```

Table 3.9 explains the syntax and semantics of the exponent (`**`) operator in Python, using its numeric types, viz. **int** and **float**.

**Table 3.9** Exponent(`**`) operator

| Syntax                | Example              |
|-----------------------|----------------------|
| (int, int)-> int      | 2**4 returns 16      |
| (float, float)->float | 2.0**3.0 returns 8.0 |
| (int, float)->float   | 5**2.0 returns 25.0  |
| (float, int)->float   | 4.0 **3 returns 64.0 |

**PROGRAM 3.7** | Write a program to calculate the distance between two points. The formula for computing distance is

$$\sqrt{(X2 - X1)^2 + (Y2 - Y1)^2}$$

We can use  $Z^{0.5}$  to compute the square root of the expression  $\sqrt{Z}$ . The program below prompts the user to read the coordinates of the two points and compute the distance between them.

```
print('Point1')
X1 = eval(input('Enter X1 coordinate:')) #Read X1
Y1 = eval(input('Enter Y1 coordinate:')) #Read Y1
print('point2')
X2 = eval(input('Enter X2 coordinate: ')) #Read X2
Y2 = eval(input('Enter Y2 coordinate: ')) #Read Y2
L1=(X2-X1)**2 + (Y2-Y1)**2 #Computer inner expression
Distance = L1**0.5 #Compute Square root.
print('Distance between two point is as follows')
print('(' ,X1,Y1,')', '(' ,X2,Y2,')'=' , Distance)
```

#### Output

```
Point1
Enter X1 Coordinate :4
Enter Y1 Coordinate :6
```

(Contd.)

```

point2
Enter X2 Coordinate: 8
Enter Y2 Coordinate: 10
Distance between the two points is as follows
(4 6) (8 10) = 5.656854249492381

```

**PROGRAM 3.8** | Write a program to display the following table.

| X  | Y | X**Y   |
|----|---|--------|
| 10 | 2 | 100    |
| 10 | 3 | 1000   |
| 10 | 4 | 10000  |
| 10 | 5 | 100000 |

```

print('X \t Y \t X**Y')
print('10 \t 2 \t ',10**2)
print('10 \t 3 \t ',10**3)
print('10 \t 4 \t ',10**4)
print('10 \t 5 \t ',10**5)

```

#### Output

| X  | Y | X**Y   |
|----|---|--------|
| 10 | 2 | 100    |
| 10 | 3 | 1000   |
| 10 | 4 | 10000  |
| 10 | 5 | 100000 |

## 3.4 OPERATOR PRECEDENCE AND ASSOCIATIVITY

Operator precedence determines the order in which the Python interpreter evaluates the operators in an expression.

Consider the expression  $4+5*3$ .

Now, you may ask so how does Python know which operation to perform first? In the above example  $4+5*3$ , it is important to know whether  $4+5*3$  evaluates to 19 (where the multiplication is done first) or 27 (where the addition is done first).

The default order of precedence determines that multiplication is computed first so the result is 19. As an expression may contain a lot of operators, operations on the operands are carried out according to the priority, also called the precedence of the operator. The operator having higher priority is evaluated first.

Table 3.10 gives the list of operator precedence in the descending order. The operators on the top rows have higher precedence and the operators on the bottom rows have lower precedence. If a row contains multiple operators, it means all the operators are of equal priority or precedence.



**Table 3.10** Operator precedence

| Precedence | Operator                        | Name                                                      |
|------------|---------------------------------|-----------------------------------------------------------|
|            | **                              | Exponential                                               |
|            | +, -, ~                         | Plus, Minus, Bitwise not                                  |
|            | *, /, //, %                     | Multiplication, division, integer division, and remainder |
|            | +, -                            | Binary Addition, Subtraction                              |
|            | <<, >>                          | Left and Right Shift                                      |
|            | &                               | Bitwise AND                                               |
|            | ^                               | Bitwise XOR                                               |
|            |                                 | Bitwise OR                                                |
|            | <, <=, >, >=                    | Comparison                                                |
|            | ==, !=                          | Equality                                                  |
|            | =, %=, /=, //=, -=, +=, *=, **= | Assignment Operators                                      |
|            | is, is not                      | Identity Operators                                        |
|            | in, not in                      | Membership Operator                                       |
|            | Not                             | Boolean Not                                               |
|            | And                             | Boolean and                                               |
|            | Or                              | Boolean or                                                |

### 3.4.1 Example of Operator Precedence

Consider arithmetic operators  $*$ ,  $/$ ,  $//$  and  $\%$ , which have higher precedence as compared to operators  $+$  and  $-$ .

#### Example

$$4+5*3-10$$

As compared to  $+$  and  $*$  operators, the  $*$  operator has higher priority. Hence, the multiplication operation is performed first. Therefore, above expression becomes,

$$4+15-10$$

Now in above expression,  $+$  and  $-$  have the same priority. In such a situation, the leftmost operation is evaluated first. Hence, the above expression becomes

$$19 - 10$$

Consequently, subtraction is performed last and the final answer of the expression will be 9.

### 3.4.2 Associativity

When an expression contains operators with equal precedence then the associativity property decides which operation is to be performed first. Associativity implies the direction of execution and is of two types, viz. left to right and right to left.

- (i) **Left to Right:** In this type of expression, the evaluation is executed from the left to right.

$$4 + 6 - 3 + 2$$

In the above example, all operators have the same precedence. Therefore, associativity rule is followed (i.e. the direction of execution is from the left to right).

The evaluation of the expression  $4+6-3+2$  is equivalent to

$$\begin{aligned} &= ((4+6)-3)+2 \\ &= ((10)-3)+2 \\ &= (7)+2 \\ &= 9 \end{aligned}$$

- (ii) **Right to Left:** In this type of expression, the evaluation is executed from the right to left.

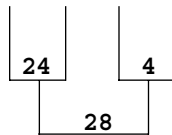
$$X = Y = Z = \text{Value}$$

In the above example, assignment operators are used. The value of  $Z$  is assigned to  $Y$  and then to  $X$ . Thus, the evaluation starts from the right.

### Example of Associativity

- (i) When operators of the same priority are found in an expression, precedence is given to the leftmost operator.

$$Z = 4 * 6 + 8 // 2$$



In the above expression  $*$  is evaluated first, even though  $*$  and  $//$  have the same priorities. The operator  $*$  occurs before  $//$  and hence the evaluation starts from the left. Therefore, the final answer for the above expression is 28.

The examples so far illustrated how Python uses associativity rules for evaluating expressions. Table 3.11 shows the precedence and associativity for arithmetic operators.

**Table 3.11** Associativity table for arithmetic operators

| Precedence | Operators | Associativity          |
|------------|-----------|------------------------|
| Highest    | ()        | Innermost to Outermost |
|            | **        | Highest                |
|            | *,/,//,%  | Left to Right          |
| Lowest     | + -       | Left to Right          |

## 3.5 CHANGING PRECEDENCE AND ASSOCIATIVITY OF ARITHMETIC OPERATORS

One can change the precedence and associativity of arithmetic operators by using  $()$ , i.e. the parentheses operator. The  $()$  operator has the highest precedence among all other arithmetic

operators. It can be used to force an expression to evaluate in any order. Parentheses operator () also makes an expression more readable.

Some examples of parentheses operator executed in Python interactive mode are given as follows:

### Example

```
>>> z=(5+6)*10
>>> z
110
```

### Explanation

In the above example, z is initialized with one expression  $(5+6)*10$ . The sub expression  $(5 + 6)$  is evaluated first, followed by the multiplication operation.

### Some More Complex Examples

```
>>> A= 100 / (2*5)
>>> A
10.0

>>> B= 4 + (5 * (4/2) + (4 + 3))
>>> B
21.0
```

**PROGRAM 3.9** | Write a program to find the area and perimeter of a rectangle using (), i.e. the parenthesis operator.

```
Length = eval(input('Enter the Length of Rectangle:'))
Breadth = eval(input('Enter the Breadth of Rectangle:'))
print('- - - - -')
print(' Length = ',Length)
print(' Breadth = ',Breadth)
print('- - - - -')
print(' Area = ', Length * Breadth)
print(' Perimeter = ',2 * (Length + Breadth))
```

### Output

```
Enter the Length of Rectangle: 10
Enter the Breadth of Rectangle: 20
- - - - -
Length = 10
Breadth = 20
- - - - -
Area = 200
Perimeter = 60
```

**Explanation** In the above program, the values of variables length and breadth of the rectangle are initially read from the user. Then using the multiplication \* operator, the area of the rectangle is computed. Finally, in order to compute the perimeter, the addition of length and breadth is performed and the result is multiplied by 2.



**Note:** Area of Rectangle = Length \* Breadth  
Perimeter of Rectangle = 2 \* (Length + Breadth)

### 3.6 TRANSLATING MATHEMATICAL FORMULAE INTO EQUIVALENT PYTHON EXPRESSIONS

Consider the following quadratic equation written in normal arithmetic manner.

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

The steps required to convert this quadratic equation into its equivalent Python expression are given as follows:

- ◎ **STEP 1:** The numerator and denominator are computed first to find the roots of the quadratic equation. Division between the numerator and denominator is performed as the last step. Hence, we can write the above expression as:

$$\text{Numerator/Denominator}$$

- ◎ **STEP 2:** The denominator is just 2a, so we can rewrite the formula as:

$$\text{Numerator}/((2 * a))$$

- ◎ **STEP 3:** Now we can split the numerator into two parts, i.e. left and right as follows:

$$(\text{Left} + \text{Right}) / ((2 * a))$$

- ◎ **STEP 4:** Substitute -b for left. There is no need to put parenthesis for -b because unary operator has higher precedence than binary addition. Hence, the above equation becomes:

$$(-b + \text{Right}) / ((2 * a))$$

- ◎ **STEP 5:** The right contains the expression inside the square root. Therefore, the above equation can be rewritten as:

$$(-b + \text{sqrt}(\text{expression})) / ((2 * a))$$

- ◎ **STEP 6:** But the expression inside the square root contains two parts left and right. Hence, the above equation is further rewritten as

$$(-b + \text{sqrt}(\text{left} + \text{right})) / ((2 * a))$$

- ◎ **STEP 7:** Now the left part contains the expression b\*\*2 and the right part contains the expression 4\*a\*c. There is no need to put parenthesis for b\*\*2 because the exponent operator has

higher precedence than the \* operator since the expression  $4*a*c$  is present on the right side. The above equation can be rewritten as

$$(-b + \sqrt{b^2 - 4*a*c}) / (2*a)$$

Thus, we have converted the mathematical expression into a Python expression. While converting an equation into a Python expression, one needs to only remember the rules of operator precedence and associativity.

**PROGRAM 3.10** | Write the following numeric expression in Python and evaluate it.

$$\frac{2+8P}{2} - \frac{(P-Q)(P+Q)}{2} + 4 * \frac{(P+Q)}{2}$$

Consider the value of variables P and Q as 4 and 2, respectively.

```
P = 4
Q = 2
Z = (2 + 8 * P) / 2 - ((P-Q)*(P+Q))/2 + 4 * ((P+Q)/2)
print('(2 + 8 * P) / 2 - ((P-Q)*(P+Q))/2 + 4 * ((P+Q)/2)')
print(' Where P = ',P,' and Q = ', Q)
print(' Answer of above expression = ',Z)
```

### Output

```
(2 + 8 * P) / 2 - ((P-Q)*(P+Q))/2 + 4 * ((P+Q)/2)
Where P = 4 and Q = 2
Answer of above expression = 23.0
```

**Explanation** In the above program, initially the equation

$$\frac{2+8P}{2} - \frac{(P-Q)(P+Q)}{2} + 4 * \frac{(P+Q)}{2}$$

is translated into a Python expression as

$$(2 + 8 * P) / 2 - ((P - Q) * (P + Q)) / 2 + 4 * ((P + Q) / 2).$$

Once the expression is converted into a Python expression, the values of P and Q are substituted by the Python interpreter and finally the expression is evaluated considering Python precedence and associativity rules.

## 3.7 BITWISE OPERATOR

Python has six bitwise operators for bitwise manipulation. The bitwise operator permits a programmer to access and manipulate individual bits within a piece of data. Table 3.12. shows various bitwise operators supported by Python.

**Table 3.12** Bitwise operators

| <i>Operator</i>       | <i>Meaning</i> |
|-----------------------|----------------|
| <code>&amp;</code>    | Bitwise AND    |
| <code> </code>        | Bitwise OR     |
| <code>^</code>        | Bitwise XOR    |
| <code>&gt;&gt;</code> | Right Shift    |
| <code>&lt;&lt;</code> | Left Shift     |
| <code>~</code>        | Bitwise NOT    |

### 3.7.1 The Bitwise AND (&) Operator

This operator performs **AND** operation on input bits of numbers. The Bitwise **AND** operator is represented as '&'. The '&' operator operates on two operands bit-by-bit. Table 3.13. explains the AND operator.

**Table 3.13** AND operator

| <i>Input</i> |   | <i>Output</i> |
|--------------|---|---------------|
| X            | Y | X & Y         |
| 0            | 0 | 0             |
| 0            | 1 | 0             |
| 1            | 0 | 0             |
| 1            | 1 | 1             |

We can conclude from this table that the output is obtained by multiplying the input bits.

#### Example of AND Operator

```
>>> 1 & 3
1 # The bitwise & operator on 1 and 3 returns 1
>>> 5 & 4
4 # The bitwise & operator on 5 and 4 returns 4
```

Working of the bitwise operator is given as follows:

|                                                           |   |   |   |   |         |
|-----------------------------------------------------------|---|---|---|---|---------|
| 1 and 3 are converted into their equivalent binary format |   |   |   |   |         |
|                                                           | 0 | 0 | 0 | 1 | (one)   |
| &                                                         |   |   |   |   |         |
|                                                           | 0 | 0 | 1 | 1 | (Three) |
| -----                                                     |   |   |   |   |         |
| Bitwise operation (0 & 0) (0 & 0) (0 & 1) (1 & 1)         |   |   |   |   |         |
| -----                                                     |   |   |   |   |         |
| Result                                                    | 0 | 0 | 0 | 1 | (One)   |
| Decimal equivalent of (0 0 0 1) = 1                       |   |   |   |   |         |
| Therefore, 1 & 3 = 1                                      |   |   |   |   |         |

**PROGRAM 3.11** | Write a program to read two numbers from the user. Display the result using bitwise & operator on the numbers.

```
num1 = int(input('Enter First Number: '))
num2 = int(input('Enter Second Number: '))
print(num1, ' & ', num2, ' = ', num1 & num2)
```

### Output

```
#Test Case 1
Enter First Number: 1
Enter Second Number: 3
 1 & 3 = 1

#Test Case 2
Enter First Number: 5
Enter Second Number: 6
 5 & 6 = 4
```

## 3.7.2 The Bitwise OR (|) Operator

This operator performs bitwise OR operation on the numbers. The bitwise OR operator is represented as '|'. It also operates on two operands and the two operands are compared bit-by-bit. Table 3.14 explains the '|' (OR) operator.

**Table 3.14** Bitwise OR operator

| Input |   | Output |
|-------|---|--------|
| X     | Y | X   Y  |
| 0     | 0 | 0      |
| 0     | 1 | 1      |
| 1     | 0 | 1      |
| 1     | 1 | 1      |

We can conclude from this table that the output is obtained by adding the input bits.

### Examples of Bitwise '|' (OR) Operator

```
>>> 3 | 5
7 # The bitwise | operator on 3 and 5 returns 7

>>> 1 | 5
5 # The bitwise | operator on 1 and 5 returns 5
```

Working of the bitwise OR ('|') operator is given as follows:

Working of expression 3 | 5 is as below.

Initially 3 and 5 are converted into their equivalent binary format

0011 (Three)

|

0101 (Five)

-----

Bitwise operation (0 | 0) (0 | 1) (1 | 0) (1 | 1)

-----

Result 0111 (seven)

Decimal Equivalent of (0 1 1 1) = 7

Therefore 3 | 5 = 7

**PROGRAM 3.12** | Write a program to read two numbers from the user. Display the result using bitwise | operator on the numbers.

```

num1 = int(input('Enter First Number: '))
num2 = int(input('Enter Second Number: '))
print(num1,' | ',num2,' = ', num1 | num2)

```

Output

#Test Case 1
Enter First Number: 3
Enter Second Number: 5
3 | 5 = 7

#Test Case 2
Enter First Number: 6
Enter Second Number: 1
6 | 1 = 7

### 3.7.3 The Bitwise XOR (^) Operator

This operator performs bitwise exclusive or XOR operation on the numbers. It is represented as '^'. The '^' operator also operates on two operands and these two operands are compared bit-by-bit. Table 3.15. explains the '^' (XOR) operator.



**Table 3.15** The Table for Bitwise XOR Operator

| Input |   | Output       |
|-------|---|--------------|
| X     | Y | $X \wedge Y$ |
| 0     | 0 | 0            |
| 0     | 1 | 1            |
| 1     | 0 | 1            |
| 1     | 1 | 0            |

We can conclude from this table that the output is logic one when one of the input bits is logic one.

### Examples of Bitwise XOR (^) Operator

```
>>> 3 ^ 5
6 # The bitwise ^ operator on 3 and 5 returns 6
>>> 1 ^ 5
4 # The bitwise ^ operator on 1 and 5 returns 4
```

Working of the bitwise XOR (^) operator is given as follows:

Working of expression  $3 \wedge 5$  is as below.

Initially 3 and 5 are converted into their equivalent binary format

|                                          |                |                |                |                |         |
|------------------------------------------|----------------|----------------|----------------|----------------|---------|
|                                          | 0              | 0              | 1              | 1              | (Three) |
| $\wedge$                                 |                |                |                |                |         |
|                                          | 0              | 1              | 0              | 1              | (Five)  |
| -----                                    |                |                |                |                |         |
| <b>Bitwise operation</b>                 | $(0 \wedge 0)$ | $(0 \wedge 1)$ | $(1 \wedge 0)$ | $(1 \wedge 1)$ |         |
| -----                                    |                |                |                |                |         |
| <b>Result</b>                            | 0              | 1              | 1              | 0              | (Six)   |
| Decimal Equivalent of $(0\ 1\ 1\ 0) = 6$ |                |                |                |                |         |
| Therefore $3 \wedge 5 = 6$               |                |                |                |                |         |

**PROGRAM 3.13** Write a program to read two numbers from the user. Operate bitwise ^ operator on them and display the result.

```
num1 = int(input('Enter First Number: '))
num2 = int(input('Enter Second Number: '))
print(num1, ' ^ ', num2, ' = ', num1 ^ num2)
```

### Output

```
#Test Case 1
Enter First Number: 3
```

(Contd.)

```

Enter Second Number: 5
3 ^ 5 = 6
#Test Case 2
Enter First Number: 1
Enter Second Number: 2
1 ^ 2 = 3

```

### 3.7.4 The Right Shift (>>) Operator

The right shift operator is represented as >>. It also needs two operands. It is used to shift bits to the right by  $n$  position. Working of the right shift operator (>>) is explained as follows:

#### Example

```

>>>4 >> 2 # The input data 4 is to be shifted by 2 bits towards the right side
1
>>>8>>2
2

```

#### Explanation

Consider the expression  $4 \gg 2$ .

Initially, the number 4 is converted into its corresponding binary format, i.e. 0 1 0 0

0 0 0 0 0 0 1 0 0      Binary 4 ←

8 7 6 5 4 3 2 1 0      Bit Index ←

The input data 4 is to be shifted by 2 bits towards the right side.

The answer in binary bits would be

0 0 0 0 0 0 0 0 1      Binary 1 ←

8 7 6 5 4 3 2 1 0      Bit Index ←



**Note:** Shifting the input number by  $N$  bits towards the right means the number is divided by  $2^S$ . In short, it means  $Y = N/2^S$ .

Where,

$N$  = The Number

$S$  = The Number of Bit Positions to Shift

Consider the above example  $4 \gg 2$ . Let us solve this using the above formula, i.e.  $y = N / 2^S$

$$= 4 / 2^2$$

$$= 4 / 4$$

$$= 1$$

Therefore,  $4 \gg 2$  returns 1 in Python interactive mode.

**PROGRAM 3.14** | Write a program to shift input data by 2 bits towards the right.

```
N = int(input('Enter Number: '))
S = int(input('Enter Number of Bits to be shift Right: '))
print(N, ' >> ', S, ' = ', N >> S)
```

### Output

```
Enter Number: 8
Enter Number of Bits to be shift Right: 2
8 >> 2 = 2
```

## 3.7.5 The Left Shift (<<) Operator

The left shift operator is represented as <<. It also needs two operands. It is used to shift bits to the left by N position. The working of the left shift operator is given as follows:

### Example

```
>>> 4 << 2 # The input data 4 is to be shifted by 2 bits towards the left side
16
```

```
>>> 8 << 2 # The input data 8 is to be shifted by 2 bits towards the left side
32
```

### Explanation

Consider the expression  $4 \ll 2$ .

Initially, the number 4 is converted into its corresponding binary format, i.e. 0 1 0 0

0 0 0 0 0 0 1 0 0      Binary 4 ←

8 7 6 5 4 3 2 1 0      Bit Index ←

The input data 4 is to be shifted by 2 bits towards the left side.

The answer in binary bits would be

0 0 0 0 1 0 0 0 0      Binary 16 ←

8 7 6 5 4 3 2 1 0      Bit Index ←



**Note:** Shifting the input number by N bits towards the left side means the number is multiplied by  $2^S$ . In short, it means  $Y = N * 2^S$ .

Where,

N = The Number

S = The Number of Bit Positions to Shift

Consider the above example  $4 \ll 2$ . Let us solve this using the above formula, i.e.

$$\begin{aligned} y &= N * 2^S \\ &= 4 * 2^2 \\ &= 4 * 4 \\ &= 16 \end{aligned}$$

Therefore,  $4 \ll 2$  returns 16 in Python interactive mode.

### PROGRAM 3.15 | Write a program to shift input data by four bits towards the left.

```
N = int(input('Enter Number: '))
S = int(input('Enter Number of Bits to be shift Left: '))
print(N, ' << ', S, ' = ', N << S)
```

#### Output

```
Enter Number: 4
Enter Number of Bits to be shift Left: 2
4 << 2 = 16
```

## 3.8 THE COMPOUND ASSIGNMENT OPERATOR

The operators  $+$ ,  $*$ ,  $//$ ,  $/$ ,  $\%$  and  $**$  are used with the assignment operator ( $=$ ) to form the compound or augmented assignment operator.

### Example

Consider the following example, where the value of a variable X is increased by 1.

$$X = X + 1$$

Python allows a programmer to combine the assignment and addition operator. Thus, the above statement  $X = X + 1$  can also be written as

$$X += 1$$

The  $+=$  operator is called the addition operator. A list of all other compound assignment operators is given in Table 3.16.

**Table 3.16** Compound assignment operators

| Operator         | Example            | Equivalent          | Explanation                                                                   |
|------------------|--------------------|---------------------|-------------------------------------------------------------------------------|
| <code>+=</code>  | <code>Z+=X</code>  | <code>Z=Z+X</code>  | Add the value of X to Z                                                       |
| <code>-=</code>  | <code>Z-=X</code>  | <code>Z=Z-X</code>  | Subtract X from Z                                                             |
| <code>*=</code>  | <code>Z*=X</code>  | <code>Z=Z*X</code>  | Multiplies the value of X, Y and stores the result in Z                       |
| <code>/=</code>  | <code>Z/=X</code>  | <code>Z=Z/X</code>  | Performs floating point division operation and stores the result in Z         |
| <code>//=</code> | <code>Z//=X</code> | <code>Z=Z//X</code> | Performs normal integer floor division and stores the result in Z             |
| <code>**=</code> | <code>Z**=X</code> | <code>Z=Z**X</code> | The value of variable X is raised to Z and the result is stored in variable Z |
| <code>%=</code>  | <code>Z%=X</code>  | <code>Z=Z%X</code>  | The Z modulo X operation is performed.                                        |

**PROGRAM 3.16** | Write a program using compound assignment operators to calculate the area of a circle.

```
radius = eval(input('Enter the Radius of Circle: ')) #Read Radius
print(' Radius = ',radius) #Display Radius
area = 3.14
radius **=2 #Radius = Radius ** 2
area*=radius #Area=Area*Radius
print(' Radius of Circle is = ',area) #Print area
```

### Output

```
Enter the Radius of Circle: 2
Radius = 2
Radius of Circle is = 12.56
```

Thus, to perform various operations in the above program we have to make use of compound assignment operators such as `**=`, and `*=`.

## MINI PROJECT Goods Service Tax (GST) Calculator

### What is GST?

Goods and services tax is a comprehensive tax levied on the manufacture, sale and consumption of goods and services at a national level. This tax has substituted all indirect taxes levied on goods and services earlier by the central and state governments in India.

### Problem Statement

We all buy various goods from a store. Along with the price of the goods we wish to buy, we also have to pay an additional tax, which is calculated as a specific percentage on the total price of the goods. This is called GST on the products.

### Model of GST Using an Example

The GST has two components, viz. one which is levied by the central government (referred to as central GST or **CGST**), and one levied by the state government (referred to as state GST or **SGST**). The **rates** for central GST and state GST are given as follows:

| Type of Tax | Tax Rate |
|-------------|----------|
| CGST        | @9%      |
| SGST        | @9%      |

### Example

Invoice of a product

| Particulars                   | GST on Particulars |
|-------------------------------|--------------------|
| Cost of Production            | 5,000              |
| Add: CGST @ 9%                | 450                |
| Add: SGST @ 9%                | 450                |
| <b>Total Cost of Product:</b> | <b>₹5,900</b>      |

### Formula to Calculate Total Cost

(CGST Tax Rate on product) + (SGST Tax Rate on product)



**Note:** Make use of proper operators to solve the above problem.

### Algorithm

- ☉ **STEP 1:** Read Cost of Production
- ☉ **STEP 2:** Input the CGST tax rate
- ☉ **STEP 3:** Input the SGST tax rate
- ☉ **STEP 4:** Calculate and print the total cost of the product.

### Program

```
CP = float(input('Enter the Cost of Product:'))
CGST = float(input('Enter tax % imposed by Centre, i.e. CGST:'))
SGST = float(input('Enter tax % imposed by State, i.e. SGST:'))
total = 0
Amount_CGST = ((CGST/100) * CP)
Amount_SGST = ((SGST/100) * CP)
total = CP + Amount_CGST + Amount_SGST
print('Total Cost of Product: Rs ',total)
```

(Contd.)

**Output**

```
Enter the Cost of Product: 5000
Enter tax % imposed by Centre, i.e. CGST: 9
Enter tax % imposed by State, i.e. SGST: 9
Total Cost of Product: Rs. 5900.0
```

In the above example, we have calculated final cost of the product based on the tax rate.

**SUMMARY**

- ◆ Python supports various operators such as Arithmetic, Boolean, Relational, Bitwise and compound Assignment Operator.
- ◆ Unary Operator perform operation on one operand only whereas Binary operator requires two operands.
- ◆ The Divison(\) operator applied on two operands returns a float value.
- ◆ Modulo (%) operator return s remainder when first number is divided by the second.
- ◆ Exponent (\*\*) operator calculates power of number.
- ◆ Operator precedence determines the order in which python evaluates the operators in an expression.
- ◆ Associativity gives direction of execution, i.e. **left to right** or **right to left**.

**KEY TERMS**

- ⇒ **Arithmetic Operators:** Binary and Unary Operators
- ⇒ **Bitwise Operators:** and (&), or (|), xor (^), left shift (<<) and right shift (>>)
- ⇒ **Augmented Assignment Operator:** Operators used with the assignment operator
- ⇒ **Operator Precedence:** Determines the order in which the Python interpreter evaluates an expression
- ⇒ **Associativity:** Determines which operation is to be performed first.

**REVIEW QUESTIONS****A. Multiple Choice Questions**

1. What will be the output of the following expression if it is executed in Python interactive mode?  
`16 % 3`
  - a. 5
  - b. 1
  - c. 0
  - d. -1
2. What will be the output of the following program?  

```
X=5
Y=5
print (X/Y)
```

- a. 1  
c. 0.1
- b. 1.0  
d. None of the above
3. What will be the output of the following statement?  

```
print(15 + 20 / 5 + 3 * 2 - 1)
```

a. 19.0  
c. 12.0
- b. 19  
d. 24.0
4. What will be the output of the following program?  

```
A=7
B=4
C=2
print(a//b/c)
```

a. 0.85  
c. 0.5
- b. 0  
d. 0.0
5. Which one of the following operators belongs to floor division?  
a. %  
c. //
- b. /  
d. None of the above
6. What will be the output of the following expression?  

```
4*1**2
```

a. 16  
c. 8
- b. 4  
d. 1
7. What will be the output of the following program?  

```
X=4.6
Y=15
Z=X//Y
print(Z)
```

a. 0  
c. 0.30
- b. 0.0  
d. None of the above
8. Operators with the same precedence are evaluated in which of the following orders?  
a. Left to Right  
c. Unpredictable
- b. Right to Left  
d. None of the above
9. What will be the output, if the input data 5 is shifted towards the left by 2 bits?  
a. 20  
c. 1
- b. 10  
d. 25
10. Which of the following have the highest precedence in an expression?  
a. Addition  
c. Exponent
- b. Multiplication  
d. parenthesis

## B. True or False

- Operators operate on operands.
- Binary operators operate on at least two operators.
- The '-' operator in Python can be used with binary and unary form.
- 4.5-1.5 returns 3.0.



5. The unary arithmetic operator performs mathematical operations on more than one operand.
6. The operator precedence determines the order in which the Python interpreter operates the operators in an expression.
7. Associativity implies the direction of execution of an expression.
8. Shifting the input number by N bits towards the left means the number is divided by  $2^N$ .
9. Shifting the input number by N bits towards the right means the number is divided by  $2^N$ .
10. The right shift operator is represented as `>>`.
11. The `()` operator has the highest precedence among all other arithmetic operators.

### C. Exercise Questions

1. State the results of the following expressions.

| Expression         | Results |
|--------------------|---------|
| <code>40/8</code>  |         |
| <code>40//8</code> |         |
| <code>50%5</code>  |         |
| <code>3%2</code>   |         |
| <code>3**3</code>  |         |

2. State the output of each of the following expression, if each expression is independent. Assume the value of X as 4.

| Expression          | Output |
|---------------------|--------|
| <code>X +=10</code> |        |
| <code>X -=4</code>  |        |
| <code>X *=6</code>  |        |
| <code>X **=2</code> |        |
| <code>X %=2</code>  |        |
| <code>X /=2</code>  |        |

3. Values assigned to different variables are

A = 10

B = 20

C = 40

D = 4

E = 5

Evaluate each of the following Python expression.

- (i)  $(A + B) * C$
- (ii)  $A + (B - E)$
- (iii)  $A * B / E$
- (iv)  $C / B // 5$
- (v)  $C + (A * E) / (B - A)$

4. Convert the following expressions into their shortest form.

| Expression      | Equivalent Expression |
|-----------------|-----------------------|
| Z = Z* 10 + 4   |                       |
| A = A % 20      |                       |
| B = B ** 10 + 2 |                       |
| C = C / 3       |                       |

5. Find the output of each expression given below if Python executes each expression separately.  
Initially the value of X = 4

| Expression | Output |
|------------|--------|
| X=X<<2     |        |
| X=X>>2     |        |
| X=x>>3     |        |
| X=X<<3     |        |

6. Determine the hierarchy of operations and evaluate the following expressions.

$X = 4/2*2+16/8+5$   
 $Y = 3*4/2+2/2+6-4+4/2$

7. Convert the following equations into their corresponding Python expressions.

(a)  $\frac{2XY}{C+10} - \frac{X}{4(Z+D)}$

(b)  $Z = \frac{10Y(ab+C)}{d} - 0.8 + 2b$   
 $(x+a)\left(\frac{1}{z}\right)$

8. The programmer has to find out the area of a rectangle but he/she has one constraint, viz. he/she has to take the value of the length and breadth of the rectangle from the user. The programmer has written the following program but he/she is unable to detect the bug in the program. Go through the following program to find the bug and then rewrite the whole program.

```
area=0
length = 0
breadth = 0
area= length * breadth
length=eval(input('Enter the Length of Rectangle:'))
breadth=eval(input('Enter the Breadth of Rectangle:'))
print('Area of Rectangle = ',area)
```

9. Evaluate the expression, (X + Y – abs(X – Y))/2, when  
X = 4 and Y = 6  
X = 5 and Y = 4

## PROGRAMMING ASSIGNMENTS

1. Write a program to read the marks of 5 subjects through the keyboard. Find out the aggregate and percentage of marks obtained by the student. Assume maximum marks that can be obtained by a student in each subject as 100.
2. Write a program to read a four-digit number through the keyboard and calculate the sum of its digits.
3. Write a program to read the distance between any two cities in kilometer (km) and print the distances in meters (m), centimeters (cm) and miles.

**Note:** 1 km = 1000 meter

1 km = 100000 centimeter

1 km = 0.6213 miles

4. Write a program to read the weight of an object in kilogram and print its weight in pound and tonne.

**Note:** 1 kg = 2.20 pound

1 kg = 0.001 tonne

5. Read a distance in meters and a time in seconds through the keyboard. Write a program to calculate the speed of a car in meter/second.

**Note:**  $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$

6. Write a program to read the radius of a sphere from the user and calculate the volume of the sphere.

**Note:** Volume of sphere =  $\frac{4}{3} \times 3.14 \times r^3$

7. An ATM contains Indian currency notes of 100, 500 and 1000. To withdraw cash from this ATM, the user has to enter the number of notes he/she wants of each currency, i.e. of 100, 500 and 1000. Write a program to calculate the total amount withdrawn by the person from the ATM in rupees.

# Decision Statements

## 4

### CHAPTER OUTLINE

|                                          |                                                  |
|------------------------------------------|--------------------------------------------------|
| 4.1 Introduction                         | 4.6 Boolean Expressions and Relational Operators |
| 4.2 Boolean Type                         | 4.7 Decision Making Statements                   |
| 4.3 Boolean Operators                    | 4.8 Conditional Expressions                      |
| 4.4 Using Numbers with Boolean Operators |                                                  |
| 4.5 Using String with Boolean Operators  |                                                  |

### LEARNING OUTCOMES

*After completing this chapter, students will be able to:*

- Describe Boolean expressions and **bool** data type
- Perform operations on numbers and strings using **Boolean** and **Relational** operators (>, <,>=, <= and !=)
- Write a simple decision making statement and its implementation with **if** statement, two-way decision making statements and their implementation with **if else** statement, nested statements and their implementation with **if** statements and multi-way decision making statements and their implementation with **if-elif-else** statements
- Explain and use **conditional expressions** to write programs
- Write non-sequential programs using Boolean expressions

## 4.1 INTRODUCTION

So far, we have seen programs that contain a sequence of instructions. These programs are executed by the compiler line by line, in the way the program line appears. The control flow in

such programs is sequential. Control flow refers to the order in which program statements are executed, i.e. when the execution of one statement is complete, the computer control passes to the next statement in the code. This process is similar to reading the text, figures and tables on a page of a book.

In monolithic programs, instructions are executed sequentially one by one in the order in which they come into sight in the program. Of course, this is a fundamental programming concept for beginners to develop simple programs. It is not advisable to have a sequential program writing style for solving every problem. Quite often, it is advantageous in a program to alter the sequence of the flow of statements depending upon the circumstances. In real-time applications, there are a number of situations where a programmer has to change the order of execution of statements based on certain conditions. Therefore, when a programmer desires the control flow to be non-sequential then he/she may use control structures or decision statements. Thus, decision making statements help a programmer in transferring the control from one statement to another in the program. In short, a **programmer decides which statement is to be executed based on a condition**. Decision making statements use conditions which are similar to **Boolean expressions**.

After reading this chapter, a programmer is expected to take up real life problems/applications and implement with Python programming containing conditional statements. Programmer may think the programming pattern for preparation of mark sheet, grade sheet, preparation of electricity bill for residential and commercial consumers, Railway tariff based on distances, simple calculations of interest on deposits for banking problems, etc. Of course, unlimited problems are existing in the nature for which a programmer is expected to give programming solution.

## 4.2 BOOLEAN TYPE

Python has a type called 'bool'. The bool has only two values, viz. **true** and **false**. The term, 'Boolean' comes from the name of the British mathematician, George Boole. In the 1840s, Boole showed that the classical rules of logic could be expressed in purely mathematical form using only two values, viz. true and false. The simplest Boolean expression in Python is True and False. In Python interactive shell, a programmer can check if the type of two values, viz. true and false belong to the type 'bool' in the following manner:

```
>>> True
True
>>> False
False
>>> type(True)
<class 'bool'> #The Value True belongs to the class type bool
>>> type(False)
<class 'bool'> #The Value False belongs to the class type bool
```



**Note:** There are only two Boolean values, **True** and **False**. Capitalisation of the first letter is important for these values and so **true** and **false** are not considered Boolean values in Python. As illustrated, the Python interpreter will show an error if a programmer checks the type of 'true' or 'false'.

(Contd.)

```
>>> type(true)
Traceback (most recent call last):
 File "<pyshell#10>", line 1, in <module>
 type(true)
NameError: name 'true' is not defined
```

## 4.3 BOOLEAN OPERATORS

The **and**, **or** and **not** are the only three basic Boolean operators. Boolean operators are also called **logical operators**. The not operator has the highest precedence, followed by **and** and then **or**.

### 4.3.1 The not Operator

The **not** operator is a unary operator. It is applied to just one value. The **not** operator takes a single operand and negates or inverts its Boolean value. If we apply the not operator on an expression having false value then it returns it as true. Similarly, if we apply the not operator on an expression having true value then it returns it as false.

#### Example

Use of the not operator on a simple Boolean expression in Python, i.e. true and false.

```
>>> True
True
>>> not True
False
>>> False
False
>>> not False
True
```

### 4.3.2 The and Operator

The **and** is a binary operator. The and operator takes two operands and performs left to right evaluation to determine whether both the operands are true. Thus, and of Boolean operand is **true** if and only if both operands are **true**. Table 4.1 explains the add operator.

**Table 4.1** The **and** operator

| X     | Y            | <i>X and Y</i> |
|-------|--------------|----------------|
| True  | <b>True</b>  | <b>True</b>    |
| True  | <b>False</b> | <b>False</b>   |
| False | <b>True</b>  | <b>False</b>   |
| False | <b>False</b> | <b>False</b>   |

**Example**

Evaluation of the **and** operator in Python interactive mode.

```
>>> True and True
True
>>> True and False
False
>>> False and True
False
>>> False and False
False
```

**4.3.3 The or Operator**

The **or** of two Boolean operands is true if at least one of the operands is true. Table 4.2 explains the **or** operator.

**Table 4.2** The **or** operator

| X     | Y     | X or Y |
|-------|-------|--------|
| True  | True  | True   |
| True  | False | True   |
| False | True  | True   |
| False | False | False  |

**Example**

Evaluation of the **or** operator in Python interactive mode.

```
>>> True or True
True
>>> True or False
True
>>> False or True
True
>>> False or False
False
```

**4.4 USING NUMBERS WITH BOOLEAN OPERATORS**

A programmer can use numbers with Boolean operators in Python. One such example is given as follows:

**Example**

```
>>> not 1
False
```

```

>>> 5
5
>>> not 5
False
>>> not 0
True
>>> not 0.0
True

```

**Explanation** Here, Python uses the Boolean operator **not** on the numbers and treats all numbers as **True**. Therefore, by writing **not 1**, Python substitutes 1 as **True** and evaluates **not True**, which returns **False**. Similarly, **not** is used before 5 and Python substitute **True** in place of 5 and it again evaluates the expression **not True**, which returns **False**. But in case of the numbers 0 and 0.0, Python treats them as **False**. Therefore, while evaluating **not 0**, it substitutes **False** in place of 0 and again evaluates the expression **not False**, which returns **True**.

## 4.5 USING STRING WITH BOOLEAN OPERATORS

Like numbers, a programmer can use strings with Boolean operators in Python. One such example is given as follows:

### Example

```

>>> not 'hello'
False
>>> not ''
True

```

**Explanation** Here, Python uses the Boolean operator **not** on string. The expression **not hello** returns **True** since Python treats all strings as **True**. Therefore, it substitutes **True** in place of 'hello' and again reevaluates the expression **not True**, which returns **False**. However, if it is an empty string, Python will treat it as **False**. Therefore, it substitutes **False** in place of an empty string "and reevaluates the expression **not False**, which in turn returns **True**.

## 4.6 BOOLEAN EXPRESSIONS AND RELATIONAL OPERATORS

A Boolean expression is an expression that is either true or false. The following example compares the value of two operands using the **==** operator and produces the result true if the values of both the operands are equal.

### Example

The **==** operator compares two values and produces a Boolean value.

```

>>> 2==2
True

```



```
..
>>> a=2
>>> b=2
>>> a==b
True
```



**Note:** The comparison operator `==` contains two equal signs. Whereas the assignment operator `=` contains only one equal sign.

From the above example, it is clear how we can compare two values or two operands. Thus, `==` is one of the Python **relational operators**. Other relational operators supported in Python are given in Table 4.3.

**Table 4.3** Relational operators

| Operator           | Meaning                  | Example              | Python Return Value |
|--------------------|--------------------------|----------------------|---------------------|
| <code>&gt;</code>  | Greater than             | <code>4&gt;1</code>  | True                |
| <code>&lt;</code>  | Less than                | <code>4&lt;9</code>  | True                |
| <code>&gt;=</code> | Greater than or equal to | <code>4&gt;=4</code> | True                |
| <code>&lt;=</code> | Less than or equal to    | <code>4&lt;=3</code> | True                |
| <code>!=</code>    | Not equal to             | <code>5!=4</code>    | True                |

**PROGRAM 4.1** Write a program to prompt a user to enter the values of the three different variables and display the output of the following expressions.

- `p>q>r`
- `p<q<r`
- `p<q` and `q<z`
- `p<q` or `q<z`

```
p,q,r=eval(input('Enter Three Numbers:'))
print(' p =',p,' q = ',q,' r = ',r)
print('(p > q > r) is ', p > q > r)
print('(p < q < r) is ', p < q < r)
print('(p < q) and (q < r) is ', (p < q) and (q < r))
print('(p < q) or (q < r) is ', (p < q) or (q < r))
```

### Output

```
Enter Three Numbers:1,2,3
p = 1 q = 2 r = 3
(p > q > r) is False
(p < q < r) is True
(p < q) and (q < r) is True
(p < q) or (q < r) is True
```



**Note:** An expression always returns a value and a statement does not return any value. A statement may include one or more than one expression.

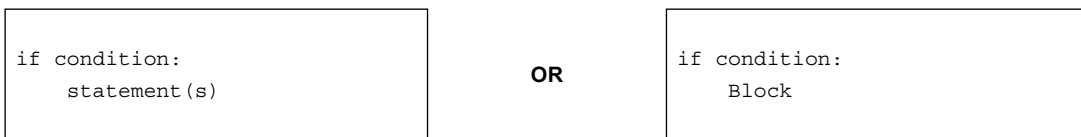
## 4.7 DECISION MAKING STATEMENTS

Python supports various decision-making statements. These are:

1. if statements
2. if-else statements
3. Nested if statements
4. Multi-way if-elif-else statements

### 4.7.1 The if Statements

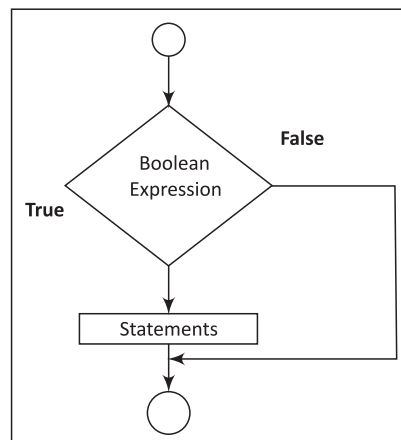
The **if** statement executes a statement if a condition is true. The syntax for if statement is shown in Figure 4.1.



**Figure 4.1** Syntax for **if** statement

#### *Details of the if Statement*

The keyword **if** begins the **if** statement. The condition is a Boolean expression which determines whether or not the body of **if** block will be executed. A colon (:) must always be followed by the condition. The block may contain one or more statements. The statement or statements are executed if and only if the condition within the **if** statement is true. The flow chart for **if** statement is given in Figure 4.2.



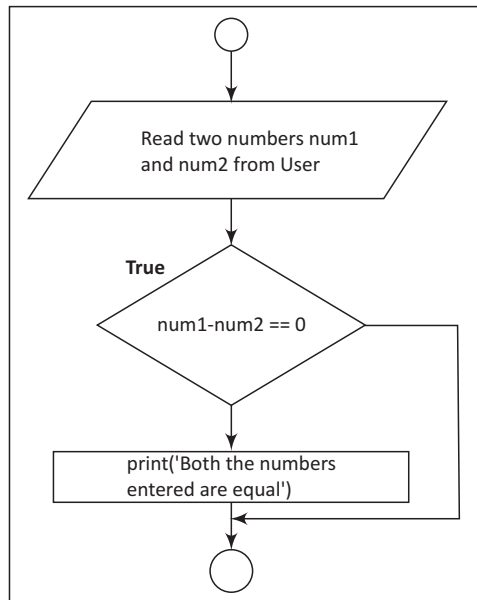
**Figure 4.2** Flowchart for **if** statement

**Points to Remember**

- (a) The statement(s) must be indented at least one space right of the **if** statement.
- (b) In case there is more than one statement after the **if** condition, then each statement must be indented using the same number of spaces to avoid indentation errors.

The statement(s) within the if block are executed if the Boolean expression evaluates to true.

**PROGRAM 4.2** | Write a program that prompts a user to enter two integer values. Print the message '**Equals**' if both the entered values are equal.

**Flow Chart**

```

num1=eval(input("Enter First Number: "))
num2=eval(input("Enter Second Number: "))
if num1-num2==0:
 print("Both the numbers entered are Equal")

```

**Output**

```

Enter First Number: 12
Enter Second Number: 12
Both the numbers entered are Equal

```

**Explanation** In the above program, the two numbers are provided by a user. The statement within the if block is executed if and only if the Boolean expression  $\text{num1} - \text{num2}$  evaluates to True.

**Precautions** Sometimes a program may contain only one statement within the if block. In this case a programmer can write the block of code in two different ways.

(a) Consider the code given as:

```
Number=eval(input("Enter the Number: "))
if Number>0:
 Number = Number * Number
```

This code can also be written as:

```
Number=eval(input("Enter the Number: "))
if Number>0: Number = Number * Number
```

(b) The above code **cannot** be written as:

```
Number=eval(input("Enter the Number: "))
if Number>0:
Number = Number * Number
```

The above code does not run and displays an error called **indentation error**. Thus, Python determines which statement makes a block using indentation.

**PROGRAM 4.3** | Write a program which prompts a user to enter the radius of a circle. If the radius is greater than zero then calculate and print the area and circumference of the circle.

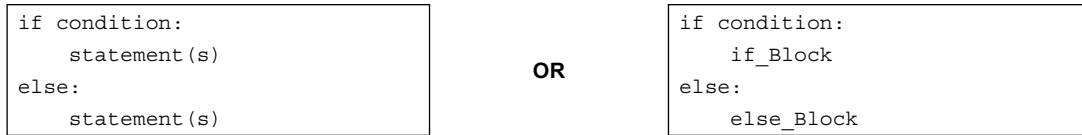
```
from math import pi
Radius=eval(input("Enter Radius of Circle: "))
if Radius>0:
 Area=Radius*Radius*pi
 print(" Area of Circle is = ",format(Area,".2f"))
 Circumference=2*pi*Radius
 print("Circumference of Circle is = ",format(Circumference,".2f"))
```

### Output

```
Enter Radius of Circle: 5
Area of Circle is = 78.54
Circumference of Circle is = 31.42
```

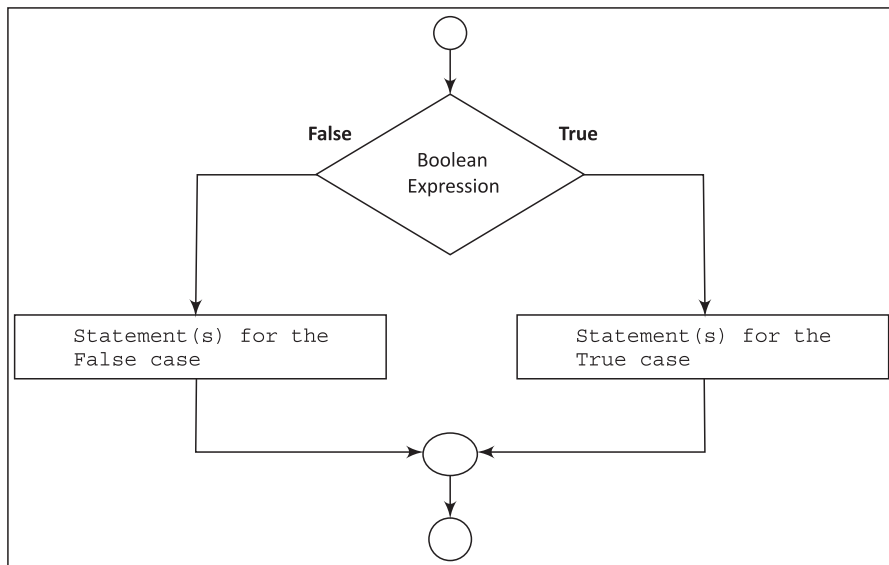
## 4.7.2 The if-else Statement

The execution of the if statement has been explained in the previous programs. We know, the if statement executes when the condition following if is true and it does nothing when the condition is false. The **if-else** statement takes care of a true as well a false condition. The syntax for **if-else** statement is given in Figure 4.3.

Figure 4.3 Syntax for **if-else** statement

### Details of if-else Statement

The **if-else** statement takes care of both true and false conditions. It has two blocks. One block is for **if** and it may contain one or more than one statements. The block is executed when the condition is true. The other block is for **else**. The **else** block may also have one or more than one statements. It is executed when the condition is false. A colon (:) must always be followed by the condition. The keyword **else** should also be followed by a colon (:). The flow chart for **if-else** statement is given in Figure 4.4.

Figure 4.4 Flow chart for **if-else** statement

**PROGRAM 4.4** | Write a program to prompt a user to enter two numbers. Find the greater number.

```

num1=int(input("Enter the First Number:"))
num2=int(input("Enter the Second Number:"))
if num1>num2:
 print(num1,"is greater than ",num2)
else:
 print(num2,"is greater than ",num1)

```

(Contd.)

**Output**

```
Enter the First Number:100
Enter the Second Number:43
100 is greater than 43
```

**Explanation** The above program prompts a user to read any two numbers. The two numbers entered are stored in variables num1 and num2, respectively. If the value of num1 is greater than num2 is checked using the **if** condition. If the value of num1 is greater then the message 'num1 is greater than num2' is displayed. Otherwise, the message 'num2 is greater than num1' is displayed.

**PROGRAM 4.5** | Write a program to calculate the salary of a medical representative considering the sales bonus and incentives offered to him are based on the total sales. If the sales exceed or equal to ₹1,00,000 follow the particulars of Column 1, else follow Column 2.

| Column 1                 | Column 2                |
|--------------------------|-------------------------|
| Basic = ₹4000            | Basic = ₹4000           |
| HRA = 20% of Basic       | HRA = 10% of Basic      |
| DA = 110 % of Basic      | DA = 110 % of Basic     |
| Conveyance = ₹500        | Conveyance = ₹500       |
| Incentive = 10% of Sales | Incentive = 4% of Sales |
| Bonus = ₹1000            | Bonus = ₹500            |

```
Sales=float(input('Enter Total Sales of the Month:'))
if Sales >= 100000:
 basic = 4000
 hra = 20 * basic/100
 da = 110 * basic/100
 incentive = Sales * 10/100
 bonus = 1000
 conveyance = 500
else:
 basic = 4000
 hra = 10 * basic/100
 da = 110 * basic/100
 incentive = Sales * 4/100
 bonus = 500
 conveyance = 500

salary= basic+hra+da+incentive+bonus+conveyance
print('Salary Receipt of Employee ')
```

(Contd.)

```

print(' Total Sales = ',Sales)
print(' Basic = ',basic)
print(' HRA = ',hra)
print(' DA = ',da)
print(' Incentive = ',incentive)
print(' Bonus = ',bonus)
print(' Conveyance = ',conveyance)
print(' Gross Salary = ',salary)

```

### Output

```

Enter Total Sales of the Month:100000
Salary Receipt of Employee
Total Sales = 100000.0
Basic = 4000
HRA = 800.0
DA = 4400.0
Incentive = 10000.0
Bonus = 1000
Conveyance = 500
Gross Salary = 20700.0

```

**Explanation** The program calculates the salary of a medical representative according to the total sale of products. The basic salary is the same but other allowances and incentives change according to the total sales. **If** the total sale is more than ₹1,00,000 the rate of allowances and incentive is calculated as per Column 1, **else** as per Column 2. The **if** condition checks the given figure of total sale. If the total sale is more than ₹1,00,000 the first block following the **if** statement is executed, otherwise the **else** block is executed.

### Points to Remember

- Indentation is very important in Python. The **else** keyword must properly line up with the **if** statement.
- If a programmer does not line up **if** and **else** in exactly the same columns then Python will not know that **if** and **else** will go together. Consequentially, it will show an indentation error.
- Both statements within the **if** block and **else** block must be indented and must be indented the same amount.

**PROGRAM 4.6** | Write a program to test whether a number is divisible by 5 and 10 or by 5 or 10.

```

num=int(input('Enter the number:'))
print('Entered Number is: ',num)

```

(Contd.)

```

if(num % 5 == 0 and num % 10==0):
 print(num,' is divisible by both 5 and 10')
if(num % 5 == 0 or num % 10 == 0):
 print(num,'is divisible by 5 or 10')
else:
 print(num,' is not divisible either by 5 or 10')

```

### Output

#### #Test Case 1:

```

Enter the number:45
Entered Number is: 45
45 is divisible by 5 or 10

```

#### #Test Case 2:

```

Enter the number:100
Entered Number is: 100
100 is divisible by both 5 and 10
100 is divisible by 5 or 10

```

**Explanation** In the above program, the number is read from the user. The Boolean expression `num % 5 == 0 and num % 10==0` checks whether the number is divisible by both 5 and 10. Again the Boolean expression `num % 5 == 0 or num % 10 == 0` is used to check if the number entered is divisible either by 5 or by 10.



**Note: Conditional or Short Circuit AND Operator:** If one of the operands of an AND operator is false, the expression is false. Consider two operands OP1 and OP2. When evaluating OP1 and OP2, Python first evaluates OP1 and if OP1 is **True** then Python evaluates the second operand OP2. Python improves the performance of the AND operator, i.e. if the operand OP1 is **False**, it does not evaluate the value of the second operand OP2. The AND operator is also referred to as **conditional or short circuit AND operator**.

**Conditional or Short Circuit OR Operator:** We have seen in Table 4.2 that even if one of the operands of an OR operator is **True**, the expression is **True**. Python improves the performance of the OR operator. Consider two operands OP1 and OP2 and the expression OP1 or OP2. While evaluating the expression OP1 or OP2, Python first evaluates OP1. If OP1 is **False**, it evaluates OP2. If OP1 is **True**, it does not evaluate OP2. The OR operator is also referred to as **conditional or short circuit OR operator**.

## 4.7.3 Nested if Statements

When a programmer writes one **if** statement inside another **if** statement then it is called a **nested if** statement. A general syntax for **nested if** statements is given as follows:

```

if Boolean-expression1:
 if Boolean-expression2:
 statement1

```



```

..
 else:
 statement2
else:
statement3

```

In the above syntax, if the Boolean-expression1 and Boolean-expression2 are correct then statement1 will execute. If the Boolean-expression1 is correct and Boolean-expression2 is incorrect then statement2 will execute. And if both Boolean-expression1 and Boolean-expression2 are incorrect then statement3 will execute.

A program to demonstrate the use of **nested if** statements is given as follows:

**PROGRAM 4.7** | Write a program to read three numbers from a user and check if the first number is greater or less than the other two numbers.

```

num1=int(input("Enter the number:"))
num2=int(input("Enter the number:"))
num3=int(input("Enter the number:"))
if num1>num2:
 if num2>num3:
 print(num1,"is greater than ",num2,"and ",num3)
else:
 print(num1," is less than ",num2,"and",num3)
print("End of Nested if")

```

### Output

```

Enter the number:12
Enter the number:34
Enter the number:56
12 is less than 34 and 56
End of Nested if

```

**Explanation** In the above program, three numbers—num1, num2 and num3—are provided from the user through a keyboard. Initially, the **if** condition with Boolean expression **num1>num2** is checked if it is true and the then other nested **if** condition with Boolean expression **num2>num3** is checked. If both the **if** conditions are true then the statements following the second if statement are executed.

## 4.7.4 Multi-way if-elif-else Statements

The syntax for **if-elif-else** statements is given as follows:

```

If Boolean-expression1:
 statement1
elif Boolean-expression2 :

```

```

 statement2
 elif Boolean-expression3 :
 statement3
- - - - - - - - - -
- - - - - - - - - -
elif Boolean-expression n :
 statement N
else :
 Statement (s)

```

In this kind of statements, the number of conditions, i.e. Boolean expressions are checked from top to bottom. When a true condition is found, the statement associated with it is executed and the rest of the conditional statements are skipped. If none of the conditions are found true then the last else statement is executed. If all other conditions are false and if the final else statement is not present then no action takes place.

**PROGRAM 4.8** | Write a program to prompt a user to read the marks of five different subjects. Calculate the total marks and percentage of the marks and display the message according to the range of percentage given in table.

| Percentage            | Message      |
|-----------------------|--------------|
| per >= 90             | Distinction  |
| per >= 80 && per < 90 | First Class  |
| per >= 70 && per < 80 | Second Class |
| per >= 60 && per < 70 | First Class  |
| per < 60              | Fail         |

```

Subject1=float(input("Enter the Marks of Data-Structure:"))
Subject2=float(input("Enter the Marks of Python:"))
Subject3=float(input("Enter the Marks of Java:"))
Subject4=float(input("Enter the Marks of C Programming:"))
Subject5=float(input("Enter the Marks of HTML:"))
sum=Subject1+Subject2+Subject3+Subject4+Subject5
per=sum/5
print("Total Marks Obtained", sum, "Out of 500")
print("Percentage = ",per)

if per>=90:
 print("Distinction")
else:
 if per>=80:
 print(" First Class")

```

(Contd.)

```

else:
 if per>=70:
 print("Second Class")
 else:
 if per>=60:
 print("Pass")
 else:
 print("Fail")

```

### Output

```

Enter the Marks of Data-Structure: 60
Enter the Marks of Python: 70
Enter the Marks of Java: 80
Enter the Marks of C Programming: 90
Enter the Marks of HTML: 95
Total Marks Obtained 385.0 out of 500
Percentage = 77.0
Second Class

```

**Explanation** In the above program, the marks of five subjects are entered through a keyboard. Their sum and average is calculated. The percentage obtained is stored in the variable 'per'. The obtained percentages are checked with different conditions using if-else blocks and the statements are executed according to the conditions.



**Note:** The above program consists of **if-else-if** statements. It can also be written in **if-elif-else** form as shown in Figure 4.5(b).

```

if per>=90:
 print("Distinction")
else:
 if per>=80:
 print(" First Class")
 else:
 if per>=70:
 print("Second Class")
 else:
 if per>=60:
 print("Pass")
 else:
 print("Fail")

```

(a)

Equivalent

```

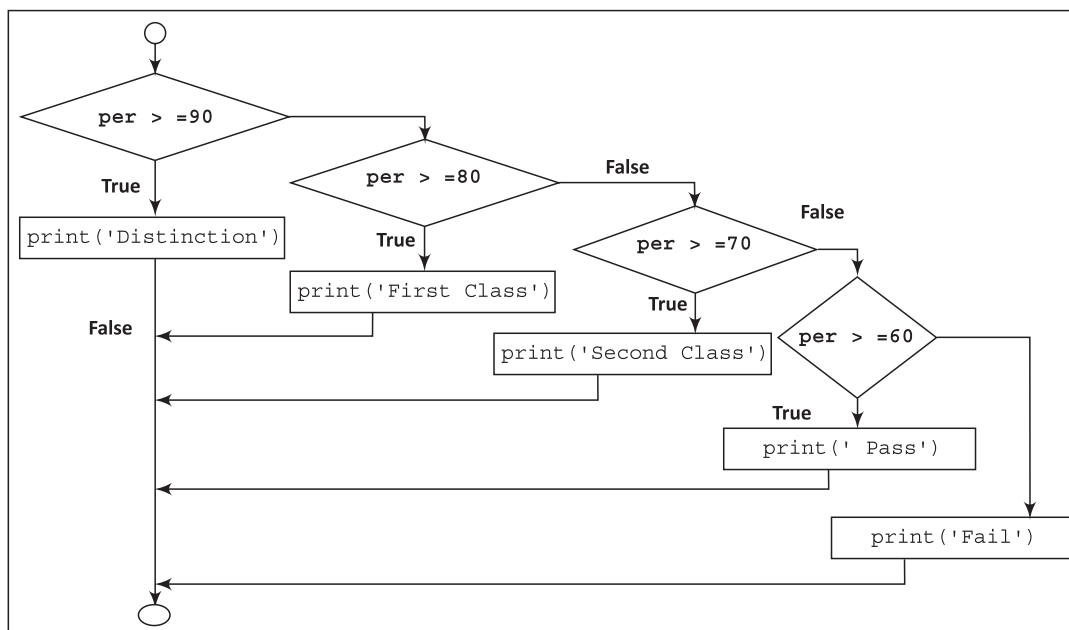
if per>=90:
 print("Distinction")
elif per>=80:
 print(" First Class")
elif per>=70:
 print("Second Class")
elif per>=60:
 print("Pass")
else:
 print("Fail")

```

(b)

**Figure 4.5** (a) if-else-if-else (b) if-elif-else

The flowchart for multi-way **if-else-if** statements for the above program is given in Figure 4.6.



**Figure 4.6** Flowchart for multi-way **if-else-if** statements

**PROGRAM 4.9** Write a program to prompt a user to enter a day of the week. If the entered day of the week is between 1 and 7 then display the respective name of the day.

```

Day=int(input("Enter the day of week:"))
if day==1:
 print(" Its Monday")
elif day==2:
 print("Its Tuesday")
elif day==3:
 print("Its Wednesday")
elif day==4:
 print("Its Thursday")
elif day==5:
 print("Its Friday")
elif day==6:
 print("Its Saturday")
elif day==7:
 print(" Its Sunday")
else:
 print("Sorry!!! Week contains only 7 days")

```

(Contd.)

**Output**

```
Enter the day of week: 7
Its Sunday
```

**PROGRAM 4.10** | Write a program that prompts a user to enter two different numbers. Perform basic arithmetic operations based on the choices.

```
num1=float(input("Enter the first number:"))
num2=float(input("Enter the Second number:"))

print("1) Addition ")
print("2) Subtraction ")
print("3) Multiplication ")
print("4) Division ")

choice = int(input("Please Enter the Choice:"))
if choice==1:
 print(" Addition of ",num1,"and",num2,"is:",num1+num2)
elif choice==2:
 print(" Subtraction of ",num1,"and",num2,"is:",num1-num2)
elif choice==3:
 print(" Multiplication of ",num1,"and",num2,"is:",num1*num2)
elif choice==4:
 print(" Division of ",num1,"and",num2,"is:",num1/num2)
else:
 print("Sorry!!! Invalid Choice")
```

**Output**

```
Enter the first number:15
Enter the Second number:10
1) Addition
2) Subtraction
3) Multiplication
4) Division
Please Enter the Choice:3
Multiplication of 15.0 and 10.0 is: 150.0
```

## 4.8 CONDITIONAL EXPRESSIONS

Consider the following piece of code.

```
if x%2==0:
 x = x*x
```

```
else:
```

```
 x = x*x*x
```

In the above code, initially,  $x$  is divided by 2. If  $x$  is divisible by 2 then the square of the number is assigned to variable  $x$ , else the cube of the number is assigned. To improve the performance of simple if-else statements, Python provides a conditional expression. Using this conditional expression, the code above can be rewritten as:

```
x=x*x if x % 2 == 0 else x*x*x
```

Therefore, the general form of conditional expression is:

```
Expression1 if condition else Expression2
```

Expression<sub>1</sub> is the value of the conditional expression if the condition is true.

Condition is a normal Boolean expression that generally appears in front of an if statement.

Expression<sub>2</sub> is the value of the conditional expression if the condition is false.

Consider the program without conditional expression given as follows:

**PROGRAM 4.11** | Write a program to find the smaller number among the two numbers.

```
num1=int(input('Enter two Numbers:'))
num2=int(input('Enter two Numbers:'))
if num1 < num2:
 min=num1
 print('min = ',min)
else:
 min=num2
 print('min = ',min)
```

### Output

```
Enter two Numbers: 20
Enter two Numbers: 30
min = 20
```

The same program can be written using conditional expression as follows:

```
num1=int(input('Enter two Numbers:'))
num2=int(input('Enter two Numbers:'))
min = print('min = ',num1) if num1 < num2 else print('min = ',num2)
```

### Output

```
Enter two Numbers: 45
Enter two Numbers: 60
min = 45
```



**Note:** Many programming languages, such as Java, C++ have a '?:', i.e. **ternary operator**. This is a conditional operator. The syntax for the '?:' ternary operator is:

**Boolean expression? if\_true\_return\_value1: if\_false\_return\_value2**

The ternary operator works like **if-else**. If the Boolean expression is true, it returns value1 and if the Boolean expression is false, it returns the second value.

Python does not have a ternary operator. It uses a **conditional expression**.

## MINI PROJECT Finding the Number of Days in a Month

This mini project will make use of programming features such as **if statement** and **elif statements**. It will help a programmer to know the number of days in a month.

**Hint:** If entered the month is 2 then read the corresponding year. To know the number of days in month 2 check if the entered year is a leap year. If leap then **num\_days = 29** or not leap then **num\_days = 28** for month 2, respectively.

**Leap year:** A leap year is divisible by 4 but not by 100 or divisible by 400.

### Algorithm

- ◎ **STEP 1:** Prompt the month from the user.
- ◎ **STEP 2:** Check if the entered month is 2, i.e. February. If so then go to **Step 3**, else go to **Step 4**.
- ◎ **STEP 3:** If the entered month is 2 then check if the year is a **leap** year. If it is a leap year then store **num\_days = 29**, else **num\_days = 28**.
- ◎ **STEP 4:** If the entered month is one of the following from the list (1, 3, 5, 7, 8, 12) then store **num\_days = 31**. Or if the entered month is from the list (4, 6, 9, 11) then store **num\_days = 29**. If the entered month is different from the range (1 to 12) then display message "Invalid Month".
- ◎ **STEP 5:** If the input is valid then display the message as "there are N number of days in the month M".

### Program

**#Number of Days in a Month**

```
print('Program will print number of days in a given month')
```

```
#init
```

```
flag = 1 # Assumes user enters valid input
```

```
#Get month from the user
```

```
month = (int(input('Enter the month(1-12):')))
```

(Contd.)

```

Check if entered month = 2 i.e. February
if month == 2:
 year = int(input('Enter year:'))

 if (year % 4 == 0) and (not(year % 100 == 0)) or (year % 400 == 0):
 num_days = 29
 else:
 num_days = 28
if entered month is one from (jan, march, may, july, august, october, or
december)
elif month in (1,3,5,7,8,10,12):
 num_days = 31
if entered month is one from (April, June, September November,)
elif month in (4, 6, 9, 11):
 num_days = 30
else:
 print('Please Enter Valid Month')
 flag = 0

#Finally print num_days
if flag == 1:
 print('There are ',num_days, 'days in', month,' month')

```

### Output (Case 1)

```

Program will print number of days in a given month
Enter the month(1-12):2
Enter year: 2020
There are 29 days in 2 month

```

### Output (Case 2)

```

Program will print number of days in a given month
Enter the month(1-12):4
There are 30 days in 4 month

```

Thus, the above case study helps the user to know the number of days for the entered year.

## SUMMARY

- ♦ A Boolean expression contains two values, viz. True and False.
- ♦ True and False are of type 'bool'.
- ♦ The and, or and not are the three basic Boolean operators.



- The not operator has highest precedence, followed by and and then or.
- A programmer can use strings with Boolean operators.
- The == operator compares two values and produces a Boolean value.
- Python supports various relational Operators such as >, <, >=, <= and !=.
- Applying relational operators on numbers and characters yields a Boolean value.
- Python Supports various decision statements, such as if, if-else and multi-way if-elif-else statements.
- Python does not have a ternary operator. It uses a a conditional expression instead.

## KEY TERMS

- ⇒ **Boolean Expressions:** An expression whose value is either **True** or **False**.
- ⇒ **Logical Operators:** Comprise the **and**, **or** and **not** operators.
- ⇒ **Relational Operators:** Comparison of two values with relational operators, such as <, <=, >, >=, != and == operators. One of the operators among them is used while comparing two operands.
- ⇒ **Conditional Expression:** Evaluates expression based on condition.
- ⇒ **Conditional or Short Circuit AND Operator:** Improves performance. Python avoids executing the second operand in case the first operand is false.
- ⇒ **Conditional or Short circuit OR Operator:** Improves performance. Python avoids executing the second operand in case the first operand is true.

## REVIEW QUESTIONS

### A. Multiple Choice Questions

1. What will be the output of following program after the execution of the following code?

```
x = 0
y = 0
if x > 0:
 y = y + 1
else:
 if x < 0 :
 y = y + 2
 else:
 y = y + 5
print(' Y =',y)
```

- a. 1
  - b. 0
  - c. 2
  - d. 5
2. What will be stored in num after the execution of the following code?
- ```
i=10
j=20
k=30
```

```

if j>k:
    if i > j:
        num = i
    else:
        num = j
else:
    if i > k:
        num = i
    else:
        num = k
print('Num = ',num)

```

- a. 10
 - b. 20
 - c. 30
 - d. None of the above
3. Which of the following Python logical expressions can determine whether x and y are greater than z?
 - a. $x \& y > z$
 - b. $(x > z) \& (y > z)$
 - c. $(y > z) \& (x > y)$
 - d. Both b and c
 - e. All of the above
4. Evaluate the following Python expression and tell the value in terms of true and false.
 - a. `i=5`
 - b. `i=5`
 - `j=10`
 - `k=15`
 - `print(k % i < k / i)`
 - `print(i == k / j)`
5. What will be the output of the following code fragment assuming num is 10?


```

num=10
if num == 20:
    print('Apple')
    print('Grapes')
print('No Output')

```

 - a. Apple
 - b. Grapes
 - c. Apple Grapes
 - d. No Output
6. What will be the output of the following program?


```

P=int(True)
q=int(False)
print('P = ',p)
print('q = ',q)

```

 - a. Error
 - b. `p=0 q=1`
 - c. `p=True q=False`
 - d. `p = 1 and q = 0`
7. Evaluate the following Boolean expressions. Consider the value of P, Q and R as 4, 5 and 6, respectively.
 - a. $P > 7$
 - b. $P < 7$ and $Q > 2$
 - c. $P == 1$
 - d. $P > 2 \ || \ Q > 6$

8. What will be the output of the following program if the value stored in variable num is 19?

```
if num % 2 == 1:
    print(num, ' is odd number')
print(num, ' is even number ')
```

9. Consider the two different blocks of codes a) and b) given as follows. State which of the following codes is better and why.

a.

```
weight = 10
if weight >= 55:
    print(' The person is eligible for Blood Donation ')
if weight < 55:
    print(' The person is not eligible for Blood Donation ')
```

b.

```
weight = 10
if weight >= 55:
    print(' The person is eligible for Blood Donation ')
else:
    print(' The person is not eligible for Blood Donation ')
```

10. What will be the output of the following program?

```
if ( 20 < 1) and (1 < -1):
    print("Hello")
elif (20 > 10) or False:
    print('Hii')
else:
    print('Bye')
```

- a. Hello
c. Bye

- b. Hii
d. Error

B. True or False

1. In monolithic programs, the instructions are executed sequentially one by one.
2. There are only three Boolean values.
3. The and, or and not are only three basic Boolean operators.
4. The not operator is a binary operator.
5. In Python, a programmer cannot use numbers along with Boolean operators.
6. A Python programmer can use strings with Boolean operators.
7. The if statement executes a statement if the condition is true.
8. The == operator compares two values and produces a Boolean value.
9. With if-elif-else statements, the number of Boolean expressions is checked from top to bottom. When a true condition is found, the statement associated with it is executed.
10. Integer equivalent of True is 0.

C. Exercise Questions

- Write the following statement in terms of if-else statement in Python.
 - If temperature is greater than 50 then temperature is hot, otherwise temperature is cold.
 - If age is greater than 18 then fare is \$400, otherwise fare is \$200.
- Write the Boolean expressions for the following statements.
 - If age is greater than 5 and less than 10.
 - If age is less than 3 and greater than 70, display the message “No Air Fare”.
- What are Boolean operators? Explain each operator.
- Is it necessary to change the flow control in a program?
- What are the different ways in which the flow control can be changed in Python?
- List few Boolean expressions with relational operators.
- Give the syntax for if_else statement.
- Illustrate the nested if statements with a suitable example.
- What is a conditional expression?
- Draw and explain multi-way if-elif-else statements.

PROGRAMMING ASSIGNMENTS

- Write a program to prompt (input) year and check if it is a leap year.
- Write a program to calculate an Internet browsing bill. Use the conditions specified as follows:
 - 1 Hour – ₹20
 - ½ Hour – ₹10
 - Unlimited hours in a day – ₹100
 The owner should enter the number of hours spent on browsing.
- Write nested if statements to print the appropriate message depending on the value of the variables temperature and humidity as given as follows. Assume that the temperature can only be warm and cold and the humidity can only be dry and humid.

<i>if temperature is</i>	<i>if humidity is</i>	<i>Print this activity</i>
Warm	Dry	Play Basketball
Warm	Humid	Play Tennis
Cold	Dry	Play Cricket
Cold	Humid	Swim

- Write a program to calculate the square of only those numbers whose least significant digit is 5.

Example: Enter the number: 25
Square: 25*25 = 625
- Consider a college cricket club in which a student can enroll only if he/she is less than 18 and greater than 15 years old. Write a program using the not operator.

Loop Control Statements

5

CHAPTER OUTLINE

5.1 Introduction	5.5 Nested Loops
5.2 The while Loop	5.6 The break Statement
5.3 The range() Function	5.7 The continue Statement
5.4 The for Loop	

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Write programs using **for** and **while** loop to repeat a sequence of instructions
- Write a program and perform a task until a condition is satisfied
- Use **loops** to traverse the sequence of characters in string or traverse the sequence of integers
- Apply the syntax and working of **range()** function
- Control the execution of programs using **break** or **continue** statement

5.1 INTRODUCTION

In our day-to-day life, we perform certain tasks repeatedly. It can be tedious to perform such tasks using pen and paper. For instance, teaching multiplication tables to multiple classes can become easier if the teacher uses a simple computer program with loop instructions instead of pen and paper.

Let us try to understand the concept of control statements in this context. Suppose a programmer wants to display the message, “I Love Python” 50 times. It would be tedious for him/her to write the statement 50 times on a computer screen or even on paper. This task can become very easy, quick and accurate if the programmer completes it using loop instructions in a computer programming language. Almost all computer programming languages facilitate the use of control loop statements to repeatedly execute a block of code until a condition is satisfied.

Consider the example to print the statement, “I Love Python” 50 times. Assume that the programmer doesn’t know the concept of control statements and writes the code in the following manner.

Example

```
print("I Love Python")
print("I Love Python")
print("I Love Python")
.
.
.
.
.
print('I Love Python')
```

} print "I Love Python" for 50 times

In the above example, the print statement is written for displaying the message 50 times. This can be done more easily using loop in Python. Loops are used to repeat the same code multiple times. Python provides two types of loop statements, viz. **while** and **for** loops. The **while** loop is a **condition controlled** loop. It is controlled by true or false conditions. The **for** loop is a **count controlled** loop which repeats for a specific number of times.

After understanding the concept of loop, a programmer can take up any challenging application in which statements/actions are to be repeated several times.

5.2 THE while LOOP

The **while** loop is a loop control statement in Python and frequently used in programming for repeated execution of statement(s) in a loop. It executes a sequence of statements repeatedly as long as a condition remains true. The syntax for while loop is given as follows:

```
while test-condition:
    #Loop Body
    statement(s)
```

5.2.1 Details of while Loop

The reserved keyword **while** begins with the **while** statement. The test condition is a Boolean expression. The colon (:) must follow the test condition, i.e. the **while** statement be terminated with a colon (:). The statement(s) within the while loop will be executed till the condition is true, i.e. the condition is evaluated and if the condition is true then the body of the loop is executed. When the

condition is false, the execution will be completed out of the loop or in other words, the control goes out of the loop. The flowchart in Fig. 5.2 shows the execution of the while loop.

5.2.2 Flowchart for while Loop

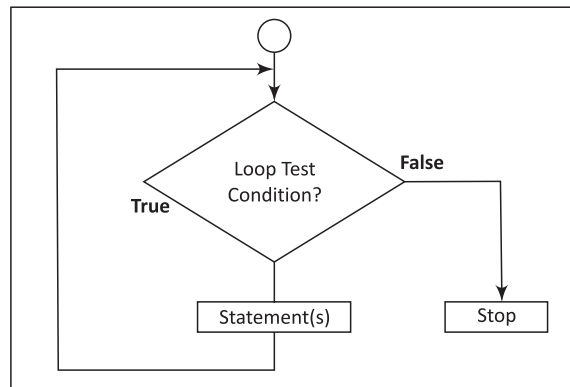


Figure 5.1 Flowchart of while loop

PROGRAM 5.1 | Write a program to print the numbers from one to five using the while loop.

```

count=0 #initialize the counter
while count<=5:                                # Test condition
    print("Count = ",count)                     # print the value of count
    count=count+1                               # Increment the value of count by 1
  
```

Output

```

Count = 0
Count = 1
Count = 2
Count = 3
Count = 4
Count = 5
  
```

Explanation In the above program, initially the value of a variable **count** is initialised to 0. The loop checks whether the value of the count is less than 5 (**count<=5**). If the condition is **true**, it executes the part of the loop that contains the statements to be repeated in order to display the value of **count** and it increments the value of **count** by 1. It repeatedly executes the statements within the loop until **count<=5**. The loop terminates when the value of **count** reaches 6.



Note: Precaution is to be taken while writing statements within the while loop.

Consider the program as shown in Figure 5.2.

<pre>count=0 while count<=5: print("Count = ",count) count=count+1</pre>	<pre>count=0 while count<=5: print("Count = ",count) count=count+1</pre>
(a) Good Code	(b) Bad Code


Figure 5.2 Precautions regarding the while loop

In Figure 5.2 (a) the value of count is initially set to 0. Then it increments to 2, 3, 4 and 5. When the value of count becomes 6, the condition **count<=5** is false and the loop exits.

Consider the Figure 5.2 (b) where the loop is mistakenly written as:

```
count=0
while count<=5:
    print("Count = ",count)
count=count+1
```

The above code is called **bad code** because the entire loop body must be indented inside the loop. Since the statement **count=count+1** is not in the loop body, the loop executes for infinite number of times. And because the value of count is always 0, the condition **count <=5** is always true.



Note: All statements within the while block must be indented with the same number of spaces.

PROGRAM 5.2 | Write a program to add 10 consecutive numbers starting from 1 using the while loop.

```
count=0  #initialize the counter
sum=0    #initialize sum to zero
while count<=10:
    sum= sum +count
    count=count+1
1
print("Sum of First 10 Numbers = ",sum)
```

Output

Sum of First 10 Numbers = 55

PROGRAM 5.3 | Write a program to find the sum of the digits of a given number.

For example, if a user enters 123. The program should return (3+2+1), i.e. 6 as the sum of all the digits in a number.

```
num=int(input("Please Enter the number:"))#Read Number from User
x=num                                     #Assign value of num to x
```

(Contd.)


```

sum=0
rem=0
while num>0:
    rem=num % 10
    num=num // 10
    sum=sum + rem
print("Sum of the digits of an entered number ",x," is = ",sum)

```

Output

```

Please Enter the number: 12345
Sum of the digits of an entered number 12345 is = 15

```

Explanation The integer number is read from the user through the keyboard and it is stored in variable `num`. Initially, the value of `sum` and `rem` are initialised to 0. Unless and until the value of `num>0` the statements within the loop continue to be executed. The modulus operator, i.e. `num%10` and the division operator, i.e. `num//10` are used frequently to obtain the sum of the numbers entered.

5.2.3 Some More Programs on while Loop

PROGRAM 5.4 | Write a program to display the reverse of the number entered.

For example, if a user enters 12345. The program should return (54321), i.e. the reverse of the number entered.

```

num =int(input("Please Enter the number: "))
x=num
rev=0
while num>0:
    rem=num % 10
    num=num // 10
    rev=rev*10+rem
print("Reverse of a entered number ",x," is = ",rev)

```

Output

```

Please Enter the number: 8759
Reverse of a entered number 8759 is = 9578

```

PROGRAM 5.5 | Write a program to print the sum of the numbers from 1 to 20 (1 and 20 are included) that are divisible by 5 using the while loop.

```

count=1
sum=0

```

(Contd.)

```

while count<=20:
    if count%5 == 0:
        sum=sum+count
        count=count+1
print("The Sum of Numbers from 1 to 20 divisible by 5 is: ",sum)

```

Output

The Sum of Numbers from 1 to 20 divisible by 5 is: 50

PROGRAM 5.6 | Write a program using the while loop to print the factorial of a number.

Factorial of 6 = $6*5*4*3*2*1 = 720$

```

Num=int(input("Enter the number:"))
fact=1
ans=1
while fact<=num:
    ans=ans*fact
    fact=fact+1
print("Factorial of",num," is: ",ans)

```

Output

Enter the number:6
Factorial of 6 is: 720



Note: The factorial of a number is defined as the product of all the numbers from 1 to n.

PROGRAM 5.7 | Write a program to check whether the number entered is an Armstrong number or not.

$153 = 1^3 + 5^3 + 3^3 = 153$

```

num=int(input("Please enter the number: "))
sum=0
x=num
while num>0:
    d=num%10
    num=num // 10
    sum=sum+ (d*d*d)

```

(Contd.)

```

if (x==sum):
    print("The number ", x ,"is Armstrong Number")
else:
    print(" The number ", x ,"is not Armstrong Number")

```

Output

```

Please enter the number: 153
The number 153 is Armstrong Number

```



Note: An Armstrong number is a number which is equal to the sum of the cube of its digits.

5.3 THE `range()` FUNCTION

There is a inbuilt function in Python called **`range()`**, which is used to generate a list of integers. The range function has one, two or three parameters. The last two parameters in **`range()`** are optional.

The general form of the range function is:

```
range(begin, end, step)
```

The 'begin' is the first beginning number in the sequence at which the list starts.

The 'end' is the limit, i.e. the last number in the sequence.

The 'step' is the difference between each number in the sequence.

5.3.1 Examples of `range()` Function

Example 1

Create a list of integers from 1 to 5.

```

>>> list(range(1,6))
[1,2,3,4,5]

```

`range(1,6)` function is used in the above example. It generates a list of integers starting from 1 to 5. Note that the second number, i.e. 6 is not included in the elements of this list. By default, the difference between the two successive numbers is one.



Note: The above range (1,6) is equivalent to `range(6)`. The output of both the range functions will be the same.

Example 2

Create a list of integers from 1 to 20 with a difference of 2 between two successive integers.

```

>>> list(range(1,20,2))
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19]

```

`range(1,20,2)` function is used in the above example. It generates a list of integers starting from 1 with a difference of two between two successive integers up to 20.

Table 5.1 shows different examples of the **range()** function with relevant outputs.

Table 5.1 Examples of `range()` function

Example of Range Function	Output
<code>range(5)</code>	[0, 1, 2, 3, 4]
<code>range(1,5)</code>	[1, 2, 3, 4]
<code>range(1,10,2)</code>	[1, 3, 5, 7, 9]
<code>range(5,0,-1)</code>	[5, 4, 3, 2, 1]
<code>range(5,0,-2)</code>	[5, 3, 1]
<code>range (-4,4)</code>	[-4, -3, -2, -1, 0, 1, 2, 3]
<code>range (-4,4,2)</code>	[-4, -2, 0, 2]
<code>range(0,1)</code>	[0]
<code>range(1,1)</code>	Empty
<code>range(0)</code>	Empty

5.4 THE for LOOP

The **for** loops in Python are slightly different from the **for** loops in other programming languages. The Python for loop iterates through a sequence of objects, i.e. it iterates through each value in a sequence, where the sequence of object holds multiple items of data stored one after another.

In the forthcoming chapters, we will study various sequence type objects of Python, such as string, list and tuples. The syntax of for loop is given as follows:

```
for var in sequence:
    statement(s)
    .....
    .....
    .....
```

5.4.1 Details of for Loop

The **for** loop is a Python statement which repeats a group of statements for a specified number of times. As described in the syntax, the keywords **for** and **in** are essential keywords to iterate the sequence of values. The variable **var** takes on each consecutive value in the sequence and the statements in the body of the loop are executed once for each value. A simple example of for loop is:

```
for var in range(m,n):
    print var
```

As discussed in Section 5.3, the function **range(m, n)** returns the sequence of integers starting from m, m+1, m+2, m+3..... n-1.

PROGRAM 5.8 | Use for loop to print numbers from 1 to 5.

```
for i in range(1,6):
    print(i)
print("End of The Program")
```

Output

```
1
2
3
4
5
End of The Program
```

Explanation In the above program, the sequence of numbers from 1 to 5 is printed. These numbers are generated using the inbuilt **range()** function. The expression **range(1, 6)** creates an object known as an iterable. This allows the for loop to assign the values 1, 2, 3, 4 and 5 to the iteration variable *i*. During the first iteration of the loop, the value of *i* is 1 within the block. During the second iteration, the value of *i* is 2 and so on.

PROGRAM 5.9 | Display capital letters from A to Z.

```
print(" The Capital Letters A to Z are as follows:")
for i in range(65,91,1):
    print(chr(i),end=" ")
```

Output

```
The Capital Letters A to Z are as follows:
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
```

Explanation The **range()** function contains three different parameters, viz. (**begin, end, step_size**). As in the above program, the range function contains the values 65, 90 and 1. It indicates to print the characters whose ASCII value starts from 65 and ends at 90. Therefore, the statement **print(chr(i),end=" ")** is used to print equivalent character value of ASCII value.

5.4.2 Some More Programs on for Loop**PROGRAM 5.10** | Use for loop to print numbers from 1 to 10 in the reverse order.

```
print("Numbers from 1 to 10 in Reverse Order: ")
for i in range(10,0,-1):
    print(i,end=" ")
print("\n End of Program")
```

(Contd.)

Output

```
Numbers from 1 to 10 in Reverse Order:
10 9 8 7 6 5 4 3 2 1
End of Program
```

PROGRAM 5.11 | Write a program to print squares of the first five numbers.

```
for i in range(1,6):
    square=i*i
    print("Square of ",i," is: ",square)
print("End of Program")
```

Output

```
Square of 1 is:  1
Square of 2 is:  4
Square of 3 is:  9
Square of 4 is:  16
Square of 5 is:  25
End of Program
```

PROGRAM 5.12 | Write a program to print even numbers from 0 to 10 and find their sum.

```
sum=0
print("Even numbers from 0 to 10 are as follows")
for i in range(0,11,1):
    if i%2==0:
        print(i)
        sum=sum+i
print("Sum of Even numbers from 0 to 10 is = ",sum)
```

Output

```
Even numbers from 0 to 10 are as follows
0
2
4
6
8
10
Sum of Even numbers from 0 to 10 is = 30
```

PROGRAM 5.13 | Write a program to calculate the sum of numbers from 1 to 20 which are not divisible 2, 3 or 5.

```
Sum=0
print("Numbers from 1 to 20 which are not divisible by 2,3,or 5")
for i in range(1,20):
    if i%2==0 or i%3==0 or i%5==0:
        print("")
    else:
        print(i)
        sum=sum+i
print("Sum of Even numbers from 1 to 10 is = ",sum)
```

Output

```
Numbers from 1 to 20 which are not divisible by 2, 3, and 5
1
7
11
13
17
19
Sum of Even numbers from 1 to 10 is = 68
```

PROGRAM 5.14 | Write a program that prompts a user to enter four numbers and find the greatest number among the four numbers entered.

```
Num1=int(input("Enter the first Number:"))
num2=int(input("Enter the first Number:"))
num3=int(input("Enter the first Number:"))
num4=int(input("Enter the first Number:"))
sum=num1+num2+num3+num4
print("The sum of Entered 5 Numbers is = ",sum)
for i in range(sum):
    if i==num1 or i==num2 or i==num3 or i==num4:
        Large=i
print(" Largest Number  = ",Large)
print("End of Program")
```

Output

```
Enter the first Number: 4
Enter the first Number: 3
Enter the first Number: 12
```

(Contd.)

```
Enter the first Number: 2
The sum of Entered 5 Numbers is = 21
Largest Number = 12
End of Program
```

PROGRAM 5.15 | Write a program to generate a triangular number.

If the number entered is 5, its triangular number would be $(1+2+3+4+5) = 15$.

```
Num=int(input("Please enter the Number: "))
Triangular_Num=0
for i in range(Num,0,-1):
    Triangular_Num=Triangular_Num+i
print(" Triangular Number of ",Num," is = ",Triangular_Num)
```

Output

```
Please enter the Number: 10
Triangular Number of 10 is = 55
```



Note: A triangular number is nothing but the summation of 1 to the given number.

PROGRAM 5.16 | Write a program to print Fibonacci series up to 8.

First_Number = 0

Second_Number = 1

Fibonacci Series = 0 1 1 2 3 5 8 13 21 34 55

```
First_Number=int(input("Please enter First Number:"))
Second_Number=int(input("Please enter First Number:"))
Limit=int(input(" Number of Fibonacci Numbers to be Print:  "))
print(First_Number,end=" ")
print(Second_Number,end=" ")
for i in range(Limit+1):
    sum=First_Number+Second_Number
    First_Number=Second_Number
    Second_Number=sum
    print(sum,end=" ")
```

(Contd.)

Output

```
Please enter First Number:0
Please enter First Number:1
Number of Fibonacci Numbers to be Print: 8
0 1 1 2 3 5 8 13 21 34 55
```

5.5 NESTED LOOPS

The **for** and **while** loop statements can be nested in the same manner in which the if statements are nested. Loops within the loops or when one loop is inserted completely within another loop, then it is called **nested loop**.

PROGRAM 5.17 | Write a program to demonstrate the use of the nested for loop.

```
for i in range(1,4,1):          #Outer Loop
    for j in range(1,4,1):      #Inner Loop
        print("i = ",i," j = ",j," i + j =",i + j)
print("End of Program")
```

Output

```
i = 1 j = 1 i + j = 2
i = 1 j = 2 i + j = 3
i = 1 j = 3 i + j = 4
i = 2 j = 1 i + j = 3
i = 2 j = 2 i + j = 4
i = 2 j = 3 i + j = 5
i = 3 j = 1 i + j = 4
i = 3 j = 2 i + j = 5
i = 3 j = 3 i + j = 6
End of Program
```

Explanation In the above program, we have used two loops. One is the outer loop and the other is the inner loop. The inner loop 'j' terminates when the value of j exceeds 3. Whereas, outer loop 'i' terminates when the value of i exceeds 3.

PROGRAM 5.18 | Write a program to display multiplication tables from 1 to 5.

```
Print("Multiplication Table from 1 to 5 ")
for i in range(1,11,1):          #Outer Loop
    for j in range(1,6,1):        #Inner Loop
```

(Contd.)

```

        print(format(i * j,"4d"),end=" ")
    print()
print("End of Program")

```

Output

Multiplication Table from 1 to 5

1	2	3	4	5
2	4	6	8	10
3	6	9	12	15
4	8	12	16	20
5	10	15	20	25
6	12	18	24	30
7	14	21	28	35
8	16	24	32	40
9	18	27	36	45
10	20	30	40	50

End of Program

Explanation The program contains two for loops. The 'j' for loop is the innermost for loop and the 'i' for loop is the outermost for loop. The outermost loop 'i' executes for 10 times. For each value of 'i', the innermost loop 'j' executes 5 times. At the same time for each value of 'i', the product $i*j$ is carried out. To align the numbers properly, the program formats the product of $i*j$ using `format(i*j,"4d")`. The digit `4d` within `format()` specifies a decimal integer format with width 4.

5.5.1 Some More Programs on Nested Loops

PROGRAM 5.19 | Write a program to display the pattern of stars given as follows:

```

*   *   *   *   *
*   *   *   *
*   *   *
*   *
*

```

```

print(" Star Pattern Display")
num=7
x=num
for i in range(1,6,1):
    num=num-1;
    for j in range(1,num,1):
        print(" * ",end=" ")
    x=num-1

```

(Contd.)

```
print()
print("End of Program")
```

Output

```
Star Pattern Display
*  *  *  *  *
*  *  *  *
*  *  *
*  *
*
End of Program
```

PROGRAM 5.20 | Write a program to display the pattern of stars given as follows:

```
*
*  *
*  *  *
*  *  *  *
*  *  *  *  *
```

```
print(" Star Pattern Display")
num=1
x=num
for i in range(1,6,1):
    num=num+1;
    for j in range(1,num,1):
        print(" * ",end=" ")
        x=num+1
    print()
print("End of Program")
```

Output

```
Star Pattern Display
*
*  *
*  *  *
*  *  *  *
*  *  *  *  *
End of Program
```

PROGRAM 5.21 | Write a program to display the pattern of numbers given as follows:

```
1
1 2
```

```
1 2 3
1 2 3 4
1 2 3 4 5
```

```
print(" Number Pattern Display")
num=1
x=num
for i in range(1,6,1):
    num=num+1;
    for j in range(1,num,1):
        print(j, end=" ")
        x=num+1
    print()
print("End of Program")
```

Output

```
Number Pattern Display
1
1 2
1 2 3
1 2 3 4
1 2 3 4 5
End of Program
```

PROGRAM 5.22 | Write a program to display the pattern of numbers given as follows:

```
1
1 2
1 2 3
1 2 3 4
1 2 3
1 2
1
```

```
print(" Number Pattern Display")
num=1
x=num
for i in range(1,5,1):
    num=num+1;
    for j in range(1,num,1):
        print(j, end=" ")
        x=num+1
    print()
```

(Contd.)

```

num=5
x=num
for i in range(1,5,1):
    num=num-1;
    for j in range(1,num,1):
        print(j, end=" ")
        x=num-1
    print()

```

Output

Number Pattern Display

```

1
1 2
1 2 3
1 2 3 4
1 2 3
1 2
1

```

5.6 THE break STATEMENT

The keyword **break** allows a programmer to terminate a loop. When the break statement is encountered inside a loop, the loop is immediately terminated and the program control automatically goes to the first statement following the loop. The flowchart for break is shown in Figure 5.3.

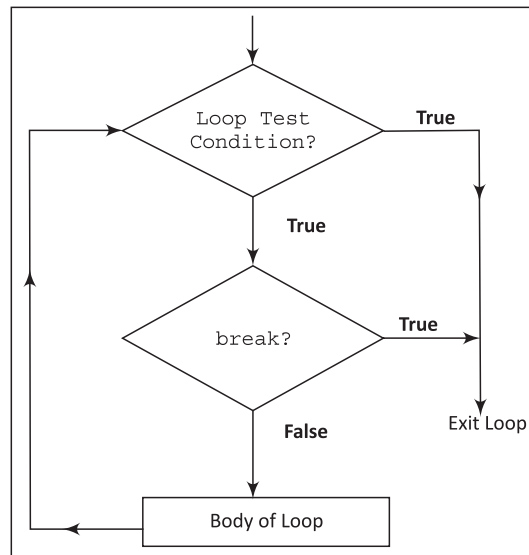


Figure 5.3 Flowchart for **break** statement

The working of break in while and for loop is shown as follows:

Working of break in while loop:

```

while test-Boolean-expression:
    body of while
    if condition:
        break
    body of while
→ statement(s)

```

Working of break in for loop:

```

for var in sequence:
    body of for
    if condition:
        break
    body of for
→ statement(s)

```

PROGRAM 5.23 | Write a program to demonstrate the use of the break statement.

```

print("The Numbers from 1 to 10 are as follows:")
for i in range(1,100,1):
    if(i==11):
        break
    else:
        print(i, end=" ")

```

Output

```

The Numbers from 1 to 10 are as follows:
1 2 3 4 5 6 7 8 9 10

```

Explanation The above program prints the numbers from 0 to 10 on the screen. The loop terminates because 'break' causes immediate exit from the loop.

PROGRAM 5.24 | Check if the number entered is prime or not.

```

num=int(input("Enter the Number:"))
x=num
for i in range(2,num):
    if num%i==0: #Check if entered number is divisible by i
        flag=0
        break
    else:

```

(Contd.)

```

        flag=1
if(flag==1):
    print(num," is Prime ")
else:
    print(num," is not prime ")

```

Output

#Test case 1:

Enter the Number:23

23 is Prime

#Test case 2:

Enter the Number:12

12 is not prime

Explanation The number is read from the user through the keyboard. A prime number should be divisible by 1 and itself. Therefore, the variable 'i' is iterated from 2 to one less than the number entered. Each value of 'i' is used to check if 'i' can divide the number entered.

5.7 THE continue STATEMENT

The **continue** statement is exactly opposite of the **break** statement. When **continue** is encountered within a loop, the remaining statements within the body are skipped but the loop condition is checked to see if the loop should continue or exit. Flowchart for continue statements is shown in Figure 5.4.

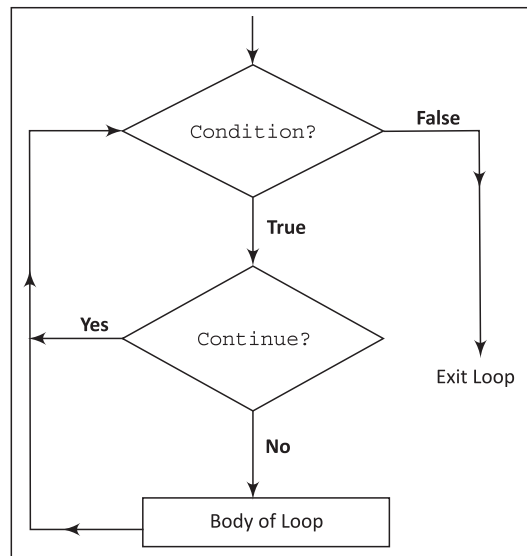


Figure 5.4 Flowchart for **continue** statement

The working of **continue** in while loop is shown as follows:

```
→ while test-boolean-expression:
    body of while
    if condition:
        continue
    body of while
    statement(s)
```

Alternatively, the working of **continue** in for loop is shown as follows:

```
→ for var in sequence:
    body of for
    if condition:
        continue
    body of for
    statement(s)
```

The difference between **break** and **continue** is given in Table 5.2.

Table 5.2 Difference between **break** and **continue** functions

<i>Break</i>	<i>Continue</i>
Exits from current block or loop.	Skips the current iteration and also skips the remaining statements within the body.
Control passes to the next statement.	Control passes at the beginning of the loop.
Terminates the loop.	Never terminates the loop.

PROGRAM 5.25 | Demonstrate the use of **continue** keyword.

```
for i in range(1,11,1):
    if i == 5:
        continue
    print(i, end=" ")
```

Output

```
1 2 3 4 6 7 8 9 10
```

Explanation In each iteration in the above program, the value of the variable ‘i’ is checked. If the value of ‘i’ is 5 then continue statement is executed and the statements following the continue statement are skipped.

PROGRAM 5.26 | Read the string “Hello World” from the user. Make use of **continue** keyword and remove space.


```

str1=str(input("Please Enter the String: "))
print(" Entered String is : ", str1)
print(" After Removing Spaces, the String becomes:")
for i in str1:
    if i==" ":
        continue
    print(i, end=" ")

```

Output

```

Please Enter the String: Hello World
Entered String is :  Hello World
After Removing Spaces, the String becomes:
HelloWorld

```

Explanation The string str1 is read from the user. Each character of entered string is iterated through the variable 'i'. The statement **if i == " "** is used to check if the entered string contains any space. If it contains space, the **continue** statement is executed and the rest of the statements following the **continue** statement are skipped. Finally, we obtain the string without spaces.

MINI PROJECT

Generate Prime Numbers using Charles Babbage Function

Charles Babbage discovered the first calculating machine to print prime numbers for a given equation. This mini project will make use of **if**, **if-else**, **if-elif** and **for** loop concepts of programming.

Let us consider the formula used by Charles Babbage:

$$T = X^2 + X + 41$$

The above formula generates a sequence of values for T , which happen to be prime numbers. Thus, calculate the sequence of prime numbers T for the values of x starting from 0 to 5. The following table contains prime numbers generated by the Charles Babbage function.

Table 5.3 Evaluation of Charles Babbage function

D2	D1	$T = X^2 + X + 41$	(Value of X)
		41	0
2	2	43	1
2	4	47	2
2	6	53	3
2	8	61	4
2	10	71	5

In Table 5.3, we have calculated prime numbers for all the values of x , i.e. from 0 to 5 using the Charles Babbage function. The $D1$ is the first difference column and D^2 is the second difference column.

Program Statement

Write a program to generate prime number using the Charles Babbage formula, ($T = X^2 + X + 41$). The output should be as shown in Table 5.3

Algorithm

- ⊙ **STEP 1:** Since we want 5 values of x, i.e. from 0 to 5. Iterate x as i 5 times.
- ⊙ **STEP 2:** For each value of i, assign the value to x.
- ⊙ **STEP 3:** Calculate the value of T for the value of x
- ⊙ **STEP 4:** If the value of i is equal to 0 then print the values of T and i.
- ⊙ **STEP 5:** If the value of i is greater than 0 and less than 2 then print the values of D, T and i. Else go to Step 6
- ⊙ **STEP 6:** Print value of D2, D, T and i.

Program

```
##### x2 + x + 41 = T #####
##### Charles Babbage Function #####
##### for second order #####
x = 0;
print('{ }\t{ }\t{ }\t{ }'.format('D2','D1','T','X'))
print('-----')
for i in range(0,5):
    x = i
    T = (x*x) + x + 41
    if(i == 0):
        print('\t\t{ }\t{ }'.format(T,i))
    elif( i > 0 and i < 2):
        a = ((x-1)*(x-1) + (x-1) + 41)
        print('\t{ }\t{ }\t{ }'.format(T - (a),T,i))
    else:
        a = ((x-1)*(x-1) + (x-1) + 41)
        b = ((x-2)*(x-2) + (x-2) + 41)
        c = (T - a) - (a - b)
        print('{ }\t{ }\t{ }\t{ }'.format(c,(T - a),T,i))
```

Thus, the above program generates all the prime numbers for all the values of x, i.e. from 0 to 5 for the given equation $T = x^2 + x + 41$. The `format()` method is used to print data in a well-formatted manner.

SUMMARY

- ♦ Loop is the process of executing a set of statements for fixed number of times.
- ♦ Iteration refers to one time execution of a statements within a loop.
- ♦ Python supports two types of loop control statements, i.e. for loop and while loop.
- ♦ While loop is condition controlled loop.
- ♦ for loop is count controlled loop and it execute statements within the body of loop for fixed number of times.
- ♦ The break and continue keywords can be in the loops.
- ♦ The break statement exits from the current block or loop and control passes to the next statement.
- ♦ The continue statement skips the current iteration and also skips the remaining statements within the body of a loop.

KEY TERMS

- ⇒ **while Loop:** Condition controlled loop
- ⇒ **for Loop:** Count controlled loop
- ⇒ **range():** Generates a list of integers
- ⇒ **nested Loop:** Loop within a loop
- ⇒ **break Statement:** The break statement within a loop helps a programmer to terminate the loop immediately
- ⇒ **continue Statement:** Skips the current iteration and also skips the remaining statement within the body.

REVIEW QUESTIONS

A. Multiple Choice Questions

1. How many times will a loop with header for count in range(5): execute statements in its body?
 - a. 5 times
 - b. 4 times
 - c. 6 times
 - d. 3 times
2. What will be the output of the following program?


```
count = 35
for x in range(0,10):
    count = count - 1
    if x == 2:
        break
print(count)
```

 - a. 35
 - b. 32
 - c. 35, 34, 33
 - d. 34, 33, 32

3. What will be the output of the following program?

```
Z = 1
while Z < 5:
    if Z % 7 == 0:
        break
    Z = Z + 2
print(Z)
```

- | | |
|------|------|
| a. 5 | b. 3 |
| c. 4 | d. 2 |

4. What will be the output of the following program?

```
My_str = "I LOVE PYTHON"
count = 0
for char in my_str:
    if char == "O":
        continue
    else:
        count = count + 1
print(count)
```

- | | |
|-------|-------|
| a. 10 | b. 9 |
| c. 11 | d. 12 |

5. What will be the output of the following program?

```
my_str = "I LOVE PYTHON"
count = 0
for char in my_str:
    count = count + 1
    if char == "E":
        break
print(count)
```

- | | |
|-------|-------|
| a. 11 | b. 13 |
| c. 10 | d. 12 |

6. What will be the output of the following program?

```
i = 1
for x in range(1,4):
    for y in range(1,3):
        i = i + (i * 1)
print(i)
```

- | | |
|-------|-------|
| a. 32 | b. 62 |
| c. 63 | d. 64 |

7. What will be the output of the following program?

```
count = 0
for x in range (1,3):
    for y in range (4,6):
        count = count + (x * y)
print (count)
```

- | | |
|-------|-------|
| a. 32 | b. 27 |
| c. 57 | d. 64 |

8. What will be the output of the following program?

```
i = 0
for x in range (1,3):
    j = 0
    for y in range (-2,0):
        j = j + y
        i = i + j
print (i)
```

- | | |
|-------|----------------------|
| a. 10 | b. -10 |
| c. 0 | d. None of the above |

9. By default, while is:

- | | |
|--------------------------------|---------------------------|
| a. Condition control statement | b. Loop control statement |
| c. Both a and b | d. None of the above |

10. What will be the output of the following program?

```
Count = 0
num = 10
while num > 8:
    for y in range(1,5):
        count = count + 1
    num = num - 1
print(count)
```

- | | |
|-------|-------|
| a. 10 | b. 8 |
| c. 12 | d. 11 |

B. True or False

- Python facilitates the use of control statements to change the flow of execution of programs.
- The while loop is not a keyword supported by Python.
- A loop cannot repeatedly execute a block of statements for a specified number of times.
- A loop cannot be nested.
- The continue statement is a keyword.
- The break statement is used to terminate from the loop.
- The break statement is not a keyword.
- The while statement is terminated by a semicolon (;).

9. The meaning of while(1) implies it is true.
10. Indentation does not play a major role for the statements within the body of a loop.

C. Exercise Questions

1. Give the syntax for control statements supported by Python.
2. Explain the working of the while loop with a flowchart.
3. What happens if we create a loop that never ends?
4. What is meant by nested loops?
5. Find the bugs in the following programs.

```
a. count = 0
   s=0
   while count<10:
       s += count
       count=count+1
       print(s)
```

```
b. count=0
   for i in range(10,0,-1)
       print(i)
```

6. Is it possible to nest the while loop within for loops?
7. When is the break statement used?
8. When is the continue statement used?
9. Convert the following for loop into while loop.

```
for i in range(50,0,-2):
    print(i,end=' ')
```

10. Answer the following questions.

- a. How many times will the following loop execute and what will be its output for both the programs, a and b?

```
sum=0
for i in range(20,0,-2):
    sum=sum+i
    print(i)
    if i==14:
        continue
print(sum)
```

(a)

```
sum=0
for i in range(20,0,-2):
    sum=sum+i
    print(i)
    if i==14:
        break
print(sum)
```

(b)

11. Convert the following while loop into for loop

```
i=0
s=0
while i<=50:
    if i%7==0:
        s = s+i
        i = i+7
print(s)
```

PROGRAMMING ASSIGNMENTS

1. Write a program that asks for input n and prints a sequence of powers of 5 from 5^0 to 5^n in separate lines.

Note: The input number n should be positive.

Example:

Input: $N=4$

Output: 1

5

25

125

625

2. Write a program to display the following table.

<i>Kilogram</i>	<i>Gram</i>
1	1000
2	2000
3	3000

Note: 1 kilogram = 1000 grams

3. Write a program to display the numbers of a series 1, 4, 9, 16, 25, ..., n by using **for** loop.
 4. Write a program using the while loop, which prints the sum of every fifth number from 0 to 500 (including both 0 and 500).
 5. Write a program using the while loop to read the positive integer and count the number of decimal digits in a positive integer.
 6. Write a program to read the password from a user. If the user types the correct password, i.e. "Python" then display the message, "Welcome to Python Programming".
- Note:** Only three attempts are allowed to enter the right password.
7. Write programs for the following series using the while loop.

a. $x + x^2/2! + x^3/3! + \dots + x^n$

b. $1 + x + x^2 + x^3 + \dots + x^n$

8. Consider a scenario where a son eats five chocolates every day. The price of each chocolate is different. His father pays the bill to the chocolate vendor at the end of every week. Develop a program that can generate the bills for the chocolates and send to the father. Also state which loop will be used to solve this problem.

6

Functions

CHAPTER OUTLINE

6.1 Introduction	6.5 The Local and Global Scope of a Variable
6.2 Syntax and Basics of a Function	6.6 The <code>return</code> Statement
6.3 Use of a Function	6.7 Recursive Functions
6.4 Parameters and Arguments in a Function	6.8 The Lambda Function

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Describe the necessity and importance of functions in programming languages
- Invoke functions with actual parameters and write a program by invoking a function using keyword or positional arguments
- Use local and global scope of a variable appropriately
- Define recursive function and its implementation with programs
- Write functions that return multiple values with programs

6.1 INTRODUCTION

It is difficult to prepare and maintain a large-scale program and the identification of the flow of data subsequently gets harder to understand. The best way to create a programming application is to divide a big program into small modules and repeatedly call these modules.

With the help of functions, an entire program can be divided into small independent modules (each small module is called a function). This improves the code's readability as well as the flow of execution as small modules can be managed easily.

6.2 SYNTAX AND BASICS OF A FUNCTION

A function is a self-contained block of one or more statements that performs a special task when called. The syntax for function is given as follows:

```
def name_of_function(Parameters): ← Function Header
    statement1
    statement2
    statement3
    .....
    .....
    statementN                      ← Function Body
```

The syntax for the Python function contains a **header** and **body**. The function header begins with the 'def' keyword. The def keyword signifies the beginning of the function's definition. The name of the function is followed by the def keyword. The function header may contain zero or more number of parameters. These parameters are called **formal parameters**. If a function contains more than one parameter then all the parameters are separated by commas. A function's body is a block of statements. The statements within the function's body define the actions that the function needs to perform.

A simple example for creating a function is explained in the following program.

PROGRAM 6.1 | Write a program to create a function having a name, display. Print the message, "Welcome to Python Programming" inside the function.

```
def Display():
    print("Welcome to Python Programming ")
Display()                #call function
```

Output

```
Welcome to Python Programming
```

Explanation In the above program, a function having the name **display()** is created. This function takes no parameters. The body of the function contains only one statement. Finally, function **display()** is called to print the message "Welcome to Python Programming" within the block of the function.

PROGRAM 6.2 | Write a program to prompt the name of a user and print the welcome message, "Dear Name_of_user Welcome to Python Programming!!!"

```
def print_msg():
    str1=input("Please Enter Your Name:")
    print("Dear ",str1," Welcome  to Python Programming ")
print_msg() #call function
```

Output

```
Please Enter Your Name: Virat
Dear Virat  Welcome  to Python Programming
```

Explanation The function named `print _ msg()` is created. Initially, the function `print _ msg()` is called and the control of the program passes to the called function `print _ msg()`. The function reads the name of the user by making use of the `input` reserved keyword and finally the welcome message is printed.

6.3 USE OF A FUNCTION

A programmer wants to find the sum of numbers starting from 1 to 25, 50 to 75 and 90 to 100. Without functions, he/she will write the code in the following manner.

PROGRAM 6.3 | Write a program to add the sum of digits from 1 to 25, 50 to 76 and 90 to 101 using three different for loops.

```
sum=0
for i in range(1,26):
    sum=sum+i
print('Sum of integers from 1 to 25 is:',sum)

sum=0
for i in range(50,76):
    sum=sum+i
print('Sum of integer from 50 to 76 is:',sum)

sum=0
for i in range(90,101):
    sum=sum+i
print('Sum of integer from 90 to 100 is:',sum)
```

Output

```
Sum of integers from 1 to 25 is: 325
Sum of integer from 50 to 76 is: 1625
Sum of integer from 90 to 100 is: 1045
```

The programmer has created the above code. Observe that the code to compute the sum of numbers is conventional. However, there is a slight difference in the range of numbers, i.e. starting integers and ending integers. Here, all the three for loops contain a different range, i.e. from 1 to 26, 50 to 76 and 90 to 101. Thus, by observing the above code, we can say that it would be better if we could simply write the common code once and then use it repeatedly. A programmer can accomplish this by defining function and using it repeatedly. The code above can be simplified and written using functions as shown in Program 6.4.

PROGRAM 6.4 | Write a program to illustrate the use of functions.

```
def sum(x,y):
    s=0;
    for i in range(x,y+1):
        s=s+i
    print('Sum of integers from ',x,' to ',y,' is ',s)
sum(1,25)
sum(50,75)
sum(90,100)
```

Explanation The function named sum is created with two parameters 'x' and 'y'. Initially, the function invokes the first function call, i.e. **sum(1, 25)** to compute the sum of numbers from 1 to 25. After computing the sum of numbers from 1 to 25 the control passes to the next function call, i.e. **sum(50, 75)**. After computing the sum of integers from 50 to 75, the third function is finally called, i.e. **sum(90,100)**.

Thus, a programmer can effectively make use of functions to write this program.

- If a programmer wants to perform a task repetitively, then it is not necessary to re-write the particular block of the program repeatedly. A particular block of statements can be shifted in a user-defined function. The function defined can be then called any number of times to perform a task.
- Large programs can be reduced to smaller ones using functions. It is easy to debug, i.e. find out the errors in it and hence, it also increases readability.

6.4 PARAMETERS AND ARGUMENTS IN A FUNCTION

Parameters are used to give inputs to a function. They are specified with a pair of parenthesis in the function's definition. When a programmer calls a function, the values are also passed to the function.

While parameters are defined by names that appear in the function's definition, arguments are values actually passed to a function when calling it. Thus, parameters define what types of arguments a function can accept.

Let us consider the example of passing parameters to a function given as follows and use it to differentiate between argument and parameter.

Example

```
def printMax(num1,num2):
    Statemen1
    Statemen2
    .....
    .....
    StatementN
```

} #Define a Function

printMax(10,20) ← Call a function (Invoke)

In the above example, `printMax(num1, num2)` has two parameters, viz. **num1** and **num2**. The parameters **num1** and **num2** are also called formal parameters. A function is invoked by calling the name of the function, i.e. `printMax(10,20)`, where 10, 20 are the actual parameters. Actual parameters are also called arguments. **num1** and **num2** are the parameters of a function. Program 6.5 demonstrates the use of parameters and arguments in a function.

PROGRAM 6.5 | Write a program to find the maximum of two numbers.

```
def printMax(num1,num2): #Function Definition
    print(" num1 = ",num1)
    print(" num2 = ",num2)

    if num1>num2:
        print("The Number ",num1," is Greater than ",num2)
    elif num2>num1:
        print("The Number ",num2," is Greater than ",num1)
    else:
        print(" Both Numbers ",num1," and ",num2," are equal")
printMax(20,10) #call to function printMax
```

Output

```
num1 = 20
num2 = 10
The Number 20 is Greater than 10
```

Explanation In the above program we have defined a function `printMax()`. The function contains two parameters, viz. **num1** and **num2**. The function `printMax()` is called by passing the values as arguments to the function. The statement `printMax(10, 20)` causes the value of 10 and 20 to be assigned to parameters **num1** and **num2**, respectively. Finally, based on the values of **num1** and **num2** within the function, greatest of the two numbers is calculated and displayed.

PROGRAM 6.6 | Write a program to find the maximum of two numbers.

```
def calc_factorial(num):
    fact=1
    print(" Entered Number is: ",num)
    for i in range(1,num+1):
        fact=fact*i
    print("Factorial of Number ",num," is  = ",fact)
number=int(input("Enter the Number:"))
calc_factorial(number)
```

Output

```
Enter the Number:5
Entered Number is:  5
Factorial of Number 5  is  =  120
```

6.4.1 Positional Arguments

Consider the question—If there are more than one parameters, how does Python know which argument in the call statement has to be assigned to which parameter?

The answer is quite simple. The parameters are assigned by default according to their position, i.e. the first argument in the call statement is assigned to the first parameter listed in the function definition. Similarly, the second argument in the call statement is assigned to the second parameter listed in the function's definition and so on.

Consider a simple example to demonstrate the use of positional arguments.

Example

```
def Display(Name,age):
    print("Name = ",Name,"age = ",age)
Display("John",25)
Display(40,"Sachin")
```

In the above example, the evaluation of statement **Display("John",25)** prints the result as Name = John and age = 25. However, the statement **Display(40,"Sachin")** has a different meaning. It passes 40 to name and Sachin to age. It means the first argument binds to the first parameter and the second argument binds to the second parameter. This style of matching up arguments and parameter is called **positional argument style** or **positional parameter style**.

In the above example, the function definition **Display(Name, age)** contains two parameters. Thus, the call is made to function **Display()** by passing exactly two parameters.

What will be the output of the following program?

```
def Display(Name,age):
    print("Name = ",Name,"age = ",age)
Display("John")
```

Output

Prints the error message

```
Traceback (most recent call last):
File "C:\Python34\keyword_1.py", line 3, in <module>
Display("John")TypeError: Display() missing 1 required positional
argument: 'age'
```

Explanation In the above program, there is no output due to an error. The third line of the program contains the statement `Display("John")`, i.e. the statement has made a call to function `Display(name, age)`. As the function call contains lesser number of arguments as compared to the function definition, Python will report a missing argument error.



Note: Python will show an error when an incorrect number of arguments are passed to the function call. The arguments must match the parameters in order, number and type as defined in the function.

6.4.2 Keyword Arguments

An alternative to positional argument is keyword argument. If a programmer knows the parameter name used within the function then he/she can explicitly use the parameter name while calling the function. A programmer can pass a keyword argument to a function by using its corresponding parameter name rather than its position. This can be done by simply typing **Parameter_name = value** in the function call.

Syntax to call a function using keyword argument is:

```
Name_of_Function(pos_args, keyword1=value, keyword2=value2.....)
```

PROGRAM 6.7 | Write a simple program on keyword argument.

```
def Display(Name,age):
    print("Name = ",Name,"age = ",age)
Display(age=25,Name="John") #Call function using keyword
                           arguments
```

Output

```
Name = John age = 25
```

Explanation Thus, in the above program, the statement `Display(age=25,Name="John")` passes the value 25 to the parameter 'age' and 'John' to the parameter 'Name'. It means arguments can appear in any order using keyword arguments.

Precautions for Using Keyword Arguments

1. A positional argument cannot follow a keyword argument.

Example: Consider the function definition,

```
def Display(num1,num2):
```

Thus, a programmer can invoke the above `Display()` function as:

```
Display(40,num2=10)
```

But, he/she cannot invoke the function as:

```
Display(num2=10,40)
```

because the positional argument **40** appears after the keyword argument **num2=10**.

2. A programmer cannot duplicate an argument by specifying it as both, a positional argument and a keyword argument.

Example: Consider the function definition,

```
def Display(num1,num2):
```

Thus, a programmer cannot invoke the above `Display()` function as

```
Display(40,num1=40) #Error
```

because he/she has specified multiple values for parameter `num1`.

6.4.3 Parameter with Default Values

Parameters within a function's definition can have default values. We can provide default value to a parameter by using the assignment (=) operator.

PROGRAM 6.8 | Write a program to illustrate the use of default values in a function's definition.

```
def greet(name,msg="Welcome to Python!!"):
    print(" Hello ",name,msg)
greet("Sachin")
```

Output

```
Hello Sachin Welcome to Python!!
```

In the above example, the function `greet()` has the parameter **name**. The parameter **name** does not have any default value and is mandatory during a function call. On the other hand, the parameter **msg** has a default value as **"Welcome to Python!!"**. Hence, it is optional during

a function call. If a value is provided, it will overwrite the default value. Here are some valid function calls to this function.

#Test case 1

```
>>> greet("Amit")
```

Output

```
Hello Amit Welcome to Python!!
```

#Test case 2

```
>>> greet("Bill Gates","How are You?")
```

Output

```
Hello Bill Gates How are You?
```

The above example has two test cases. In the first test case, only one argument is passed to the function **greet()** during the function call. And the second parameter is not passed. In such a case, Python uses the default value of a parameter specified during function definition. But in case of test case 2, both the parameters **greet("Bill Gates","How are You?")** are passed during the function call. In such a situation, the new argument value overwrites the default parameter value.



Note: During a function's definition, any number of parameters in a function can have default values. But once we have a default value to a parameter, all the parameters to its right must also have default values. For example, if we define a function's definition as:

```
def greet(msg="Welcome to Python!!", name):    #Error
```

Python will give the error as:

Syntax Error: Non-default argument follows default argument

PROGRAM 6.9 | Write a program to calculate the area of a circle using the formula:

$$\text{Area of Circle} = \pi \times (r)^2$$

Declare the default parameter value of pi as 3.14 and radius as 1.

```
def area_circle(pi=3.14,radius=1):
    area=pi*radius*radius
    print("radius=",radius)
    print(" The area of Circle  = ",area)
area_circle()
area_circle(radius=5)
```

Output

```
radius= 1
```

(Contd.)


```

The area of Circle = 3.14
radius= 5
The area of Circle = 78.5

```

What will be the output of the following program?

```

def disp_values(a,b=10,c=20):
    print(" a = ",a," b = ",b,"c= ",c)
disp_values(15)
disp_values(50,b=30)
disp_values(c=80,a=25,b=35)

```

Output

```

a = 15 b = 10 c= 20
a = 50 b = 30 c= 20
a = 25 b = 35 c= 80

```

Explanation In the above program, the function named **disp_values** has one parameter without a default argument value, followed by two parameters with default argument values.

During the first function call **disp_values(15)**, parameter a gets the value 15 and parameters b and c get the default values 10 and 20, respectively.

During the function call **disp_values(50,b=30)**, parameter a gets the value 50, parameter b gets the value 30, i.e. the value of b is overwritten and parameter c gets the default value 20.

During the function call **disp_values(c=80,a=25,b=35)**, the default values of parameters b and c are replaced by the new values 35 and 80, respectively.

6.5 THE LOCAL AND GLOBAL SCOPE OF A VARIABLE

Variables and parameters that are initialised within a function including parameters, are said to exist in that function's local scope. Variables that exist in local scope are called **local variables**. Variables that are assigned outside functions are said to exist in global scope. Therefore, variables that exist in global scope are called **global variables**.

PROGRAM 6.10 | Write a program to show local scope vs global scope.

```

p = 20          #global variable p
def Demo():
    q = 10      #Local variable q
    print('The value of Local variable q:',q)
    #Access global variable p within this function
    print('The value of Global Variable p:',p)
Demo()

```

(Contd.)

```
#Access global variable p outside the function Demo()
print('The value of global variable p:',p)
```

Output

```
The value of Local variable q: 10
The value of Global Variable p: 20
The value of global variable p: 20
```

Explanation In the above example, we have created one **local variable 'q'** and one **global variable 'p'**. As global variables are created outside all functions and are accessible to all functions in their scope, in the above example as well the global variable **'p'** is accessed from the function **Demo()** and it is also accessed outside the function.

Local Variables Cannot be Used in Global Scope

PROGRAM 6.11 | Write a program to access a local variable outside a function.

```
def Demo():
    q = 10          #Local variable q
    print('The value of Local variable q:',q)
Demo()
#Access local variable q outside the function Demo()
print('The value of local variable q:',q)    #Error
```

Output

```
The value of Local variable q: 10
Traceback (most recent call last):
  File "C:/Python34/loc1.py", line 6, in <module>
    print('The value of local variable q:',q)    #Error
NameError: name 'q' is not defined
```

Explanation The local variable **'q'** is defined within the function **Demo()**. The variable **'q'** is accessed from the function **Demo()**. The scope of a local variable lies within the block of the function, i.e. it starts from its creation and continues up to the end of the function. Therefore, any attempt to access the variable from outside of the function causes an error.



Note: Accessing a local variable outside the scope will cause an error.

6.5.1 Reading Global Variables from a Local Scope

Consider the following program where global variables are read from a local scope.

PROGRAM 6.12 | Write a program where global variables are read from a local scope.

```
def Demo():
    print(S)
S='I Love Python'
Demo()
```

Output

```
I Love Python
```

Explanation Before calling the function **Demo()**, the variable 's' is defined as a string, "I Love Python". However, the body of the function **Demo()** contains only one statement **print(s)** statement. As there is no local variable 's' defined within the function **Demo()**, the **print(s)** statement uses the value from the global variable. Hence, the output of the above program will be 'I Love Python'.

6.5.2 Local and Global Variables with the Same Name

What will be the output of the above program if we change the value of 's' inside the function **Demo()**? Will it affect the value of the global variable? Program 6.13 demonstrates the change in value 's' within the function **Demo()**.

PROGRAM 6.13 | Write a program to change the value 's' within the function.

```
def Demo():
    S='I Love Programming'
    print(S)
S='I Love Python'
Demo()
print(S)
```

Output

```
I Love Programming
I Love Python
```

Explanation As we know, the scope of a local variable lies within the block of a function. Initially, the value of 's' is assigned as 'I Love Python'. But after calling the function **Demo()**, the value of 's' is changed to 'I Love Programming'. Therefore, the print statement within the function **Demo()** will print the value of the local variable 's', i.e. 'I Love Programming'. Whereas the print statement after the **Demo()** statement, will print the old value of the variable 's', i.e. 'I Love Python'.

6.5.3 The Global Statement

Consider a situation where a programmer needs to modify the value of a global variable within a function. In such a situation, he/she has to make use of the **global** statement. The following program demonstrates the use of the **global** statement.

PROGRAM 6.14 | Write a program without using the global statement.

```
a = 20
def Display():
    a = 30
    print(' The value of a in function:',a)
Display()
print('The value of an outside function:',a)
```

Output

```
The value of a in function: 30
The value of an outside function: 20
```

Explanation In the above program, we have assigned the value of an outside function as 20. By chance, a programmer uses the same name, i.e. 'a' inside the function. But in this case the variable 'a' within the function is local to the function. Therefore, any changes to the value associated with the name inside the function will change the value of the local variable itself and not the value of the global variable 'a'.

PROGRAM 6.15 | Write a program using the global statement.

```
a = 20
def Display():
    global a
    a = 30
    print(' The value of a in function:',a)
Display()
print('The value of an outside function:',a)
```

Output

```
The value of a in function: 30
The value of an outside function: 30
```

Explanation The program demonstrates the use of the **global** keyword. The **global** keyword has been used before the name of the variable to change the value of the local variable. Since the value of the global variable is changed within the function, the value of 'a' outside the function will be the most recent value of 'a'.

6.6 THE **return** STATEMENT

The **return** statement is used to **return a value from the function**. It is also used to return from a function, i.e. break out of the function.

PROGRAM 6.16 | Write a program to return the minimum of two numbers.

```
def minimum(a,b):
    if a<b:
        return a
    elif b<a:
        return b
    else:
        return "Both the numbers are equal"
print(minimum(100,85))
```

Output

8 is minimum

Explanation The minimum function returns the minimum of the two numbers supplied as parameters to a function minimum. It uses simple if..elif..else statement to find the minimum value and then returns that value.

PROGRAM 6.17 | Write a function calc_Distance(x1, y1, x2, y2) to calculate the distance between two points represented by Point1(x1, y1) and Point2 (x2, y2). The formula for calculating distance is:

$$\text{Distance} = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

```
import math
def calc_Distance (x1, y1, x2, y2):
    print(" x1 = ",x1)
    print(" x2 = ",x2)
    print(" y1 = ",y1)
    print(" y2 = ",y2)
    dx=x2-x1
    dx=math.pow(dx,2)
    dy=y2-y1
    dy=math.pow(dy,2)
    z = math.pow((dx + dy), 0.5)
    return z
print("Distance = ",(format(calc_Distance(4,4,2,2),".2f")))
```

Output

```
x1 = 4
x2 = 2
y1 = 4
y2 = 2
Distance = 2.83
```

PROGRAM 6.18 For a quadratic equation in the form of ax^2+bx+c , the discriminant D , is $b^2 - 4ac$. Write a function to compute the discriminant D , that returns the following output depending on the discriminant D .

if $D > 0$: The Equation has two Real Roots

if $D = 0$: The Equation has one Real Root

if $D < 0$: The Equation has two Complex Roots

```
def quad_D(a,b,c):
    d=b*b-4*a*c
    print("a = ",a)
    print("a = ",b)
    print("a = ",c)
    print("D = ",d)
    if d>0:
        return "The Equation has two Real Roots"
    elif d<0:
        return "The Equation has two Complex Roots"
    else:
        return "The Equation has one Real Root"
print(quad_D(1,2,5))
```

Output

```
a = 1
a = 2
a = 3
D = -8
The Equation has two Complex Roots
```



Note: The return statement without a value is equivalent to return 'None'. Where, 'None' is a special type in Python that represents nothingness.

PROGRAM 6.19 Write a program to pass the radius of a circle as a parameter to a function **area_of_circle()**. Return the value **none** if the value of the radius is negative or return the area of the circle.

```
def area_of_Circle(radius):
    if radius<0:
        print(" Try Again, Radius of circle cannot be Negative ")
        return
    else:
        print("Radius = ",radius)
```

(Contd.)

```

    return 3.1459*radius**radius
print("Area of Circle =",area_of_Circle(2))

```

Output

```

Radius = 2
Area of Circle = 12.5836

```

Explanation In the above program, the user has to pass the radius of the circle as a parameter to the function `area_of_circle()`. If the radius of the circle is positive then it calculates and returns the area of the circle. Whereas, if the entered radius of the circle is negative, it returns a none value, i.e. it returns nothing.

What will be the output of the above program?

```

def calc_abs(x):
    if x<0:
        return -x
    elif x>0:
        return x
print(calc_abs(0))

```

Output

```

None

```

Explanation The above piece of code is incorrect because when the user has passed the value 0 as a parameter to the function `calc_abs()`, the value of `x` happened to be 0. Then neither condition is true and the function ends without executing any return statement. In such a situation, the function returns a special value called **None**.

6.6.1 Returning Multiple Values

It is possible to return multiple values in Python.

PROGRAM 6.20 | Write a function `calc_arith_op(num1, num2)` to calculate and return at once the result of arithmetic operations such as addition and subtraction.

```

def calc_arith_op(num1, num2):
    return num1+num2, num1-num2    #Return multiple values
print(" ",calc_arith_op(10,20))

```

Output

```

(30, -10)

```

Explanation In the above program, two parameters, viz. num1 and num2 are passed to a function `calc_arith_op()`. Within the body of the function, the **single return** statement computes the addition and subtraction of the two numbers. Finally, the single return statement returns the result of both the arithmetic operations, viz. addition and subtraction.

6.6.2 Assign Returned Multiple Values to Variable(s)

It is also possible for a function to perform certain operations, return multiple values and assign the returned multiple values to a multiple variable.

PROGRAM 6.21 | Write a program to return multiple values from a function.

```
def compute(num1):
    print("Number = ", num1)
    return num1*num1, num1*num1*num1
square, cube = compute(4)
print("Square = ", square, "Cube = ", cube)
```

Output

```
Number = 4
Square = 16 Cube = 64
```

Explanation The number is passed to the function `compute()`. The return statement calculates the square and cube of a passed number. After computation, it returns both the values simultaneously. The returned square of a number is assigned to a variable `square` and the returned cube of a number is assigned to a variable `cube`.

6.7 RECURSIVE FUNCTIONS

So far, we have seen that it is legal for one function to call another function. In programming, there might be a situation where a function needs to invoke itself. Python also supports the recursive feature, which means that a function is repetitively called by itself. Thus, a function is said to be recursive **if a statement within the body of the function calls itself**.

Let us consider a simple example of recursion. Suppose we want to calculate the factorial value of an integer. We know that the factorial of a number is the product of all the integers between 1 and that number, i.e. $n!$ is defined as $n * (n-1)!$.

Consider the following example.

Formula to calculate the factorial of a number $(n)! = n * (n-1)!$

$$\begin{aligned}
 5! &= 5 * (4!) \\
 &= 5 * 4 * (3!) \\
 &= 5 * 4 * 3 * (2!) \\
 &= 5 * 4 * 3 * 2 * (1) \\
 &= 120
 \end{aligned}$$

PROGRAM 6.22 | Calculate the factorial of a number using recursion.

```
def factorial(n):
    if n==0:
        return 1
    return n*factorial(n-1)
print(factorial(5))
```

Output

120

Explanation In the above program, `factorial()` is a recursive function. The number is passed to function `factorial()`. When the function `factorial` is executed, it is repeatedly invoked by itself. Every time a function is invoked, the value of 'n' is reduced by one and multiplication is carried out. The recursion function produces the number 5, 4, 3, 2 and 1. The multiplication of these numbers is carried out and returned. Finally, the print statement prints the factorial of the number.

PROGRAM 6.23 | Write a recursive function which computes the n^{th} Fibonacci number. Fibonacci numbers are defined as:

```
Fib(0)= 1,
Fib(1)= 1
Fib(n)= Fib(n-1)+Fib(n-2).
```

Write this as a Python code and then find the 8th Fibonacci number.

```
def fib(n):
    if n==0:
        return 1
    if n==1:
        return 1
    return fib(n-1)+fib(n-2)
print(" The Value of 8th Fibonacci number = ",fib(8))
```

Output

The Value of 8th Fibonacci number = 34

6.8 THE LAMBDA FUNCTION

Lambda functions are named after the Greek letter λ (lambda). These are also known as **anonymous functions**. Such kind of functions are not bound to a name. They only have a code to execute that which is associated with them. The basic syntax for a lambda function is:

Name = lambda(variables): Code

Let us consider a simple example which calculates the cube of a number using simple concepts of a function.

```
>>> def func(x):
    return x*x*x
```

```
>>> print(func(3))
27
```

Without the lambda function Now we will calculate the cube of a number using the lambda function.

```
>>> cube = lambda x: x*x*x      #Define lambda function
>>> print(cube(2))             #Call lambda function
8
```

Using the lambda function Thus, in the above example, both the functions **func()** and **cube()** do exactly the same thing. The statement **cube = lambda x: x*x*x** creates a **lambda** function called **cube**, which takes a single argument and returns the cube of a number.



Note: (a) A lambda function does not contain a return statement.
(b) It contains a single expression as a body and not a block of statements as a body.

MINI PROJECT

Calculation of Compound Interest and Yearly Analysis of Interest and Principal Amount

This mini project will use programming features, such as **decision**, **control statements** and **functions** to calculate the interest deposited for a principal amount for some period of time 'n' at some interest 'r'.

Explanation and Calculation of Compound Interest

Compound interest is the addition of interest to the initial principal amount and also to the accumulated interest over preceding periods of a deposit or loan.

Compound interest is different from simple interest. In simple interest, there is no interest on interest. Simply interest is added to the principal amount.

The formula to calculate annual compound interest including principal amount is

$$CI = P * \left(1 + \frac{r}{t}\right)^n - P$$

where,

P = Principal investment amount

r = Annual interest rate

n = Number of years the money is invested

t = Number of times the interest is compounded per year

The formula to calculate interest if it is compounded once per year is

$$I = P * (1 + r)^n \text{----- } \{A\}$$

Thus, 'I' gives future values of an investment or loan which is compound interest plus the principal. So, we are going to use formula 'A'.

Example

Let principal (P) amount = ₹10,000

Rate (R) of interest = 5

Number of Years = 7

Value of compound interest per year (t) = 1

We will use the above formula 'A' to calculate the interest accumulated each year.

Year	Starting Balance	Interest	Ending Balance
1	10000.00	500.00	10500.00
2	10500.00	525.00	11025.00
3	11025.00	551.25	11576.25
4	11576.25	578.81	12155.06
5	12155.06	607.75	12762.82
6	12762.82	638.14	13400.96
7	13400.96	670.05	14071.00

Algorithm to Calculate Compound Interest

- ◎ **STEP 1:** Read the principal amount, rate of interest and number of years the amount is to be deposited. (Assuming interest is compounded once per year).
- ◎ **STEP 2:** Pass the principal, rate of interest and the number of years to the function named **Calculate_Compound_Interest()**.
- ◎ **STEP 3:** Iterate **for loop** for 'n' number of times to calculate interest generated per year by using the formula for compound interest as discussed above.
- ◎ **STEP 4:** Display the final compound interest.

PROGRAM STATEMENT | Write a program to calculate compound interest for principal amount as ₹10,000, at rate of interest as 5% and number of years the amount is deposited as 7 years.

```
def Calculate_Compound_Interest(p,n,r):
    print('StartBalance\t','\tInterest\t','Ending Balance')
    total = 0
```

(Contd.)

```

x= r/100
tot = 0
for i in range(1,n+1):
    z_new = p*(1 + x) **i - p
    z_old = p*(1 + x)**(i-1) - p
    tot = tot + (z_new - z_old)
    if(i == 1):
        print('{0:.2f}\t'.format(p),end='')
        print('\t{0:.2f}\t'.format(z_new - z_old),end='')
        print('\t\t{0:.2f}\t'.format(z_new+p))
    else:
        print('{0:.2f}\t'.format(p+z_old),end='')
        print('\t{0:.2f}\t'.format(z_new - z_old ),end='')
        print('\t\t{0:.2f}\t'.format(z_new+p))
    print('Total Interest Deposited:Rs{0:.2f}'.format(tot))
p = int(input('Enter the Principal amount:'))
r = int(input('Enter the rate of interest:'))
n = int(input('Enter number of year:'))
Calculate_Compound_Interest(p,n,r)

```

Output

```

Enter the Principal amount:10000
Enter the rate of interest:5
Enter number of year:7

```

Start Balance	Interest	Ending Balance
10000.00	500.00	10500.00
10500.00	525.00	11025.00
11025.00	551.25	11576.25
11576.25	578.81	12155.06
12155.06	607.75	12762.82
12762.82	638.14	13400.96
13400.96	670.05	14071.00

```
Total Interest Deposited: Rs 4071.00
```

In the above program, initially principal amount, rate of interest and number of years are read from the user. The same values are passed as a parameter to the function **Calculate_Compound_Interest()**. The for loop is iterated for **n** number of times to calculate the annual interest generated per year. The difference between **Z_new** and **Z_old** in above program gives the interest generated per year. At last, the compound interest is displayed.

SUMMARY

- ♦ A function is a self-contained block of one or more statements that perform a special task when called.
- ♦ A function's definition in Python begins with the `def` keyword followed by the function's name, parameter and body.
- ♦ The function header may contain zero or more number of parameters.
- ♦ Parameters are the names that appear in a function's definition.
- ♦ Arguments are the values actually passed to a function while calling a function.
- ♦ Arguments to a function can be passed as positional or keyword arguments.
- ♦ The arguments must match the parameters in order, number and type as defined in the function.
- ♦ A variable must be created before it is used.
- ♦ Variables defined within the scope of a function are said to be local variables.
- ♦ Variables that are assigned outside of functions are said to be global variables.
- ♦ The `return` statement is used to return a value from a function.
- ♦ Functions in Python can return multiple values.
- ♦ Python also supports a recursive feature, i.e. a function can be called repetitively by itself.

KEY TERMS

- ⇒ **The `def` Keyword:** Reserved word to define a function
- ⇒ **Positional Arguments:** By default, parameters are assigned according to their position
- ⇒ **Keyword Arguments:** Use syntax `keyword = Value` to call a function with keyword arguments
- ⇒ **Local and Global Scope of a Variable:** Describes two different scopes of a variable
- ⇒ **The `Return` Keyword:** Used to return single or multiple values
- ⇒ **Lambda:** An anonymous function

REVIEW QUESTIONS

A. Multiple Choice Questions

1. A variable defined outside a function is referred to as
 - a. Local variable
 - b. Only variable
 - c. Global variable
 - d. None of the above
2. Which of the following function headers is correct?
 - a. `def Demo(P, Q = 10):`
 - b. `def Demo(P=10, Q = 20):`
 - c. `def Demo(P=10, Q)`
 - d. Both a and c
3. What will be the output of the following program?


```
x = 10
def f():
    x = x + 10
    print(x)
f()
```

- a. 20
- b. 10
- c. Error: Local variable X referenced before assignment
- d. None of the above

4. What will be the output of the following program?

```
def Func_A(P = 10, Q = 20):
    P = P + Q
    Q = Q + 1
    print(P, Q)
Func_A(Q = 20, P = 10)
```

- a. Error: P and Q are not defined.
- b. 20 10
- c. 10 20
- d. 30 21

5. What will be the output of the following program?

```
Def test():
    x=10
# Main Program #
x = 11
test()
print(x)
```

- a. 10
- b. 11
- c. Garbage value
- d. None of the above

6. If a function does not return any value, then by default which type of value is returned by the function?

- a. int
- b. double
- c. str
- d. None

7. What will be the output of the following program?

```
def test():
    global x
    x='A'
# Main Program #
x = 'Z'
test()
print(x)
```

- a. Z
- b. A
- c. Garbage value
- d. None of the above

8. What will be the output of following program?

```
def test(x):
    x = 200
# Main Program #
x = 100
test(x)
print(x)
```



```
# Main Program #
Num2, Num1 = perform_multiplication(5,4)
print(Num1, Num2)
```

- | | |
|----------|----------|
| a. 5, 4 | b. 5, 20 |
| c. 20, 5 | d. 4, 5 |

13. What will be the output of the following program?

```
def Display(Designation, Salary):
    print("Designation = ", Designation, "Salary = ", Salary)
Display("Manager", 25000)
Display(300000, 'Programmer')
```

- Error: Type Mismatch
- Manger 25000
300000 Programmer
- 300000 Programmer
Manger 25000
- None of the above

B. True or False

- A function divides a program in small independent modules.
- The syntax of Python function contains a header and body.
- The function header begins with the definition keyword.
- Parameters are used to give inputs to a function.
- Parameters are specified with a pair of parenthesis in the function's definition.
- In a function, parameters are defined by the names that appear in the function's definition.
- Arguments are values actually passed to a function when calling it.
- The return statement is used to return a value from a function.
- A function invoking itself is called a recursive function.
- A function is said to be recursive if a statement within the body of the function calls itself.

C. Exercise Questions

- What are the advantages of functions?
- What does a function do?
- Write the definition of a function.
- Write the syntax for a function.
- Differentiate between user-defined and library-defined functions.
- How does a function work? Explain how arguments are passed and results are returned?
- What are arguments? How are arguments passed to a function?
- What is the use of a return statement?
- Is it possible to return multiple values from a function?
- What are local and global variables?

PROGRAMMING ASSIGNMENTS

1. Write a function **eval_Quadratic_Equa(a, b, c, x)** which returns the value of any quadratic equation of form
 $ax^2 + bx + c$
2. Write a function **calc_exp(base, exp)** which computes the exponent of any number, i.e. **base^{exp}**. The function should take two values as base, which can be float or integer. Exp will be an integer greater than 0.
3. Write a function **Calc_GCD_Recurr(a, b)** which calculates the GCD recursively of two numbers. The function should take two positive integers and should return one integer as GCD.

Note: The greatest common divisor (GCD) of two positive integers is the largest integer that divides each of them without a remainder.

Example:

`gcd(12, 2) = 2`

`gcd(6, 12) = 6`

`gcd(9, 12) = 3`

4. Write a function **reverse_number()** to return the reverse of the number entered.

Example:

Reverse_number(1234) displays **4321**

5. A four-digit integer is entered through the keyboard. Write a function to calculate the sum of the four-digit number both without recursion and using recursion.
6. A positive integer is entered through the keyboard. Write a function **factors(num)** to obtain the factors of the given numbers.
7. Write a program to define function **dec_bin(num)** to convert the existing decimal number into its equivalent binary number.

Strings

7

CHAPTER OUTLINE

7.1 Introduction	7.5 Traversing String with for and while Loop
7.2 The str class	7.6 Immutable Strings
7.3 Basic Inbuilt Python Functions for String	7.7 The String Operators
7.4 The index[] Operator	7.8 String Operations

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Create and use string in programming
- Write programs to access characters within a string using index operators, including accessing characters via negative index
- Use str[start : end] slicing operator to get a substring from larger strings
- Use various inbuilt functions of strings, such as len(), min() and max() functions
- Apply inbuilt operators on strings +, * and compare two different strings using >, >=, <, <=, ==, != operators
- Use various methods of strings such as capitalise(), upper(), lower(), swapcase(), and replace() to convert string from one form to another
- Search substrings from a given string using various methods of string such as find(), rfind(), endswith(), startswith()
- Format strings by using ljust(), rjust(), centre(), format() functions

7.1 INTRODUCTION

Characters are building blocks of Python. A program is composed of a sequence of characters. When a sequence of characters is grouped together, a meaningful string is created. Thus, a string is a sequence of characters treated as a single unit.

In many languages, strings are treated as arrays of characters but in Python a string is an object of the **str** class. This string class has many constructors.

The next section describes constructors and how to access strings.

7.2 THE str CLASS

Strings are objects of the **str** class. We can create a string using the constructor of **str** class as:

```
S1=str() #Creates an Empty string Object
S2=str("Hello") #Creates a String Object for Hello
```

An alternative way to create a string object is by assigning a string value to a variable.

Example

```
S1 = "" # Creates a Empty String
S2= "Hello" # Equivalent to S2=str("Hello")
```

All the characters of a string can be accessed at one time using the index operator. This has been explained in Section 7.4.

7.3 BASIC INBUILT PYTHON FUNCTIONS FOR STRING

Python has several basic inbuilt functions that can be used with strings. A programmer can make use of **min()** and **max()** functions to return the largest and smallest character in a string. We can also use **len()** function to return the number of characters in a string.

The following example illustrates the use of the basic function on strings.

```
>>> a = "PYTHON"
>>> len(a) #Return length i.e. number of characters in string a
6
>>> min(a) #Return smallest character present in a string
'H'
>>> max(a) #Return largest character present in a string
'Y'
```

7.4 THE index[] OPERATOR

As a string is a sequence of characters, the characters in a string can be accessed one at a time through the index operator. The characters in a string are **zero based**, i.e. the first character of the string is stored at the 0th position and the last character of the string is stored at a position one less than that of the length of the string. Figure 7.1 illustrates how a string can be stored.

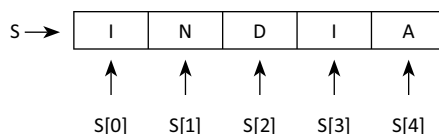


Figure 7.1 Accessing characters in a string using the index operator

Example

```
>>> S1="Python"
>>>S1[0] #Access the first element of the string.
'p'
>>>S1[5] #Access the last element of the String.
'n'
```



Note: Consider a string of length 'n', i.e. the valid indices for such string are from 0 to n-1. If you try to access the index greater than n-1, Python will raise a 'string index out of range' error. The following example illustrates the same.

```
>>> a='IIT'
>>> a[3]
Traceback (most recent call last):
  File "<pyshell#1>", line 1, in <module>
    a[3]
IndexError: string index out of range
```

7.4.1 Accessing Characters via Negative Index

The negative index accesses characters from the end of a string by counting in backward direction. The **index** of the last character of any non-empty string is always **-1**, as shown in Figure 7.2.

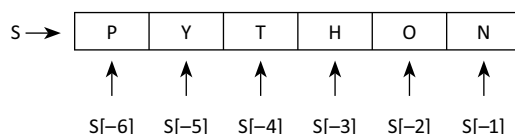


Figure 7.2 Accessing characters in a string using negative index

Example

```
>>> S="PYTHON"
>>> S[-1] #Access the last character of a String 'S'
'N'
>>> S[-2]
'O'
>>> S[-3]
'H'
>>> S[-4]
```

```

..
'T'
>>> S[-5]
'Y'
>>> S[-6] #Access the First character of a String 'S'
'P'

```



Note:

$$S[-n] == S[\text{Length_of}(S) - n]$$

Example:

```

S="IIT-Bombay"
>>> S[-3]
>>> 'b'

```

Explanation

$S[-3] == S[\text{Len}(S) - 3] = S[10 - 3] = S[7]$.

Thus, $S[-3] == S[7]$ prints the character stored at index 7 counting in a forward direction or we can say it prints the character stored at index -3 counting in backward direction from the string S.

7.5 TRAVERSING STRING WITH for AND while LOOP

A programmer can use the for loop to traverse all characters in a string. For example, the following code displays all the characters of a string.

PROGRAM 7.1 | Write a program to traverse all the elements of a string using the for loop.

```

S="India"
for ch in S:
    print(ch,end=" ")

```

Output

India

Explanation The string 'India' is assigned to the variable S. The for loop is used to print all the characters of a string S. The statement '**for ch in S:**' can read as 'for each character **ch** in **S** print **ch**'.

PROGRAM 7.2 | Write a program to traverse every second character of a string using the for loop.

```

S="ILOVEPYTHONPROGRAMMING"
for ch in range(0,len(S),2): #Traverse each Second character
    print(S[ch],end=" ")

```

Output

I O E Y H N R G A M N

7.5.1 Traversing with a while Loop

A programmer can also use the while loop to traverse all the elements of a string. The following example illustrates the use of the while loop to traverse all the characters within a string using the while loop.

PROGRAM 7.3 | Write a program to traverse all the elements of a string using the while loop.

```
S="India"
index=0
while index<len(S):
    print(S[index],end=" ")
    index=index+1
```

Output

India

Explanation The while loop traverses a string and displays each character. The condition `index<len(S)` is checked in each iteration. When the value of an index is equal to the length of the string, the condition is false and the body of loop is not executed. The last character accessed is one less than that of the length of the string.

7.6 IMMUTABLE STRINGS

Character sequences fall into two categories, i.e. mutable and immutable. Mutable means changeable and immutable means unchangeable. Hence, strings are immutable sequences of characters.

Consider the following example. Let's see what happens if we try to change the contents of the string.

Example

```
Str1="I Love Python"
Str1[0]="U"
print(Str1)
```

ERROR:

TypeError: 'str' object does not support item assignment

Explanation

In the above example, we have assigned the string "I Love Python" to Str1. The `index []` operator is used to change the contents of the string. Finally, it shows an error because the strings are **immutable**, which means one cannot change the existing string.



Note: If you want to change the existing string, the best way is to create a new string that is a variation of the original string.

```
Str1="I Love Python"
Str2="U"+Str1[1:]
print(Str2)
```

Output

```
U Love Python
```

Consider the following two similar strings. "Hello" is assigned to two different variables as:

```
Str1="Hello"
Str2="Hello"
```

In the above example both the variables, str1 and str2 have the same content. Thus, Python uses one object for each string which has the same content as shown in Figure 7.3. str1 and str2 refers to the same string object, whereas str1 and str2 have the same ID number.

```
>>>str1="Hello"
>>>str2="Hello"
>>>id(Str1)
53255968
>>>id(Str2)
53255968
```

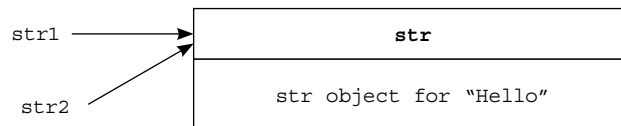


Figure 7.3 String with the same contents share the similar id

7.7 THE STRING OPERATORS

String contains the slicing operator and the slicing with step size parameter is used to obtain the subset of a string. It also has basic concatenation '+', 'in' and repetition '*' operators. The next section describes string operators in more detail.

7.7.1 The String Slicing Operator [start: end]

The slicing operator returns a subset of a string called **slice** by specifying two indices, viz. **start** and **end**. The syntax used to return a subset of a string is:

```
Name_of_Variable_of_a_String[Start_Index: End_Index]
```

Example

```
>>> S="IIT-BOMBAY"
>>> S[4:10] #Returns a Subset of a String
'BOMBAY'
```

The S[4:10] returns a subset of a string starting from start index, i.e. 4 to one index less than that of end parameter of slicing operation, i.e. $10 - 1 = 9$.

7.7.2 String Slicing with Step Size

In the above section, we learnt how to select a portion of a string. But how does a programmer select every second character from a string?

This can be done using **step size**. In slicing, the first two parameters are **start index** and **end index**. We need to add a third parameter as **step size** to select the characters from a string with step size.

Syntax

Name_of_Variable_of_a_String[Start_Index:End_Index:Step_Size]

Example

```
>>>S="IIT-BOMBAY"
>>> S[0:len(S):2]
>>>'ITBMA'
```

Explanation

Initially we have assigned a string "IIT-Bombay" to S. The statement **S[0:len(S):2]** indicates us to select the portion of a string which starts at index 0 and ends at index 10, i.e. the length of the string "IIT-BOMBAY". The step size is 2. It means that we first extract a slice or a portion of the string which starts with the index 0, ends with the index 10 and selects every other second character from the string S.

Some More Complex Examples of String Slicing

```
>>> S="IIT-MADRAS"
>>> S[:]#Prints the entire String
'IIT-MADRAS'

>>> S[::-1]
'SARDAM-TII'#Display the String in Reverse Order

>>>S="IIT-MADRAS"
>>> S[-1:0:-1]#Access the characters of a string from index -1
>>>'SARDAM-TI'
>>>S="IIT-MADRAS"
>>> S[-1:0:-1]#Access the characters of a string from index -1
>>>'SARDAM-TI'
```



```
>>> S[:-1]
#start with the character stored at index 0 & exclude the last character stored
at index -1.
'IIT-MADRA'
```

7.7.3 The String +, * and in Operators

1. **The + Operator:** The concatenation operator '+' is used to join two strings.

Example:

```
>>> S1="IIT "          #The String "IIT" assigned to S1
>>> S2="Delhi"#The String "Delhi" assigned to S1
>>> S1+S2
'IIT Delhi'
```

2. **The * Operator:** The multiplication (*) operator is used to concatenate the same string multiple times. It is also called **repetition operator**.

Example:

```
>>> S1="Hello"
>>> S2=3*S1#Print the String "Hello" three times
>>> S2
'HelloHelloHello'
```

Note: S2=3*S1 and S2=S1*3 gives same output

3. **The in and not in Operator:** Both Operators **in** and **not in** are used to check whether a string is present in another string.

Example:

```
>>> S1="Information Technology"
#Check if the string "Technology" is present in S1
>>> "Technology" in S1
True
#Check if the string "Technology" is present in S1
>>> "Engineering" in S1
False
>>> S1="Information Technology"
# Check if the string "Hello" is not present in S1
>> "Hello" not in S1
True
```

PROGRAM 7.4 | Write a program to print all the letters from word1 that also appear in word2.

Example: Word1 = USA North America
word2= USA South America

```
#Print the letter that appear in word1 &also appears in word2
```

Output

```
USA orth America
```

Solution

```
word1="USA North America"
word2="USA South America"
print("word1=",word1)
print("word2=",word2)
print("The words that appear in word1 also appears in word2")
for letter in word1:
    if letter in word2:
        print(letter,end=" ")
```

Output

```
word1= USA North America
word2= USA South America
The words that appear in word1 also appears in word2
USA orth America
```

Explanation

In the above program, the string "USA North America" is assigned to word1 and the string "USA South America" is assigned to the String word2. In the for loop, each letter of word1 is compared with all the letters of word2. If a letter of word1 appears in word2 then the particular letter is printed. A programmer can read the above for loop as **for each letter in the first word, if it appears in the second word then print that letter.**

7.8 STRING OPERATIONS

The str class provides different basic methods to perform various operations on a string. It helps to calculate the **length of a string**, to retrieve the individual characters from the given string and to compare and concatenate the two different strings.

7.8.1 String Comparison

Operators such as ==,<,>,<=,>= and != are used to compare the strings. Python compares strings by comparing their corresponding characters.

Example

```
>>> S1="abcd"
>>> S2="ABCD"
>>> S1>S2
True
```

Explanation

The string 'abcd' is assigned to the string S1 and the String 'ABCD' is assigned to S2. The statement S1 > S2 returns True because Python compares the numeric value of each character. In the above example, the numeric value, i.e. ASCII value of 'a' is 97 and ASCII numeric value of 'A' is 65. It means 97 > 65. Thus, it returns True. However, character by character comparison goes on till the end of the string.

Some More Examples of String Comparison

```
>>> S1="abc"
>>> S2="abc"
>>> S1==S2
True
>>> S1="ABC"
>>> S2="DEF"
>>> S1>S2
False

>>> S1="AAA"
>>> S2="AAB"
>>> S2>S1
True

>>> S1="ABCD"
>>> S2="abcd".upper()
>>> S2
'ABCD'
>>> S1>S2
False
>>> S1>=S2
True
```

7.8.2 The String .format() Method()

In Python 2 and 3, programmers can include %s inside a string and follow it with a list of values for each %.

Example

```
>>> "My Name is %s and I am from %s"%( "JHON", "USA")
'My Name is JHON and I am from USA'
```

In the above example, we have seen how to format a string using % (modulus) operator. However, for more complex formatting, Python 3 has added a new string method called **format()** method. Instead of % we can use {0}, {1} and so on. The syntax for format() method is:

```
template.format(P0,P1,.....,k0=V0,K1=V1...}
```

whereas the arguments to the `.format()` method are of two types. It consists of zero or more positional arguments P_i followed by zero or more keyword arguments of the form, $K_i=V_i$.

Example

```
>>> '{} plus {} equals {}'.format(4,5,'Nine')
'4 plus 5 equals Nine'
```

Explanation

The `format()` method is called on the string literal with arguments 4,5 and 'nine'. The empty {} are replaced with the arguments in order. The first {} curly bracket is replaced with the first argument and so on. By default, the index of the first argument in format always start from **zero**. One can also give a position of arguments inside the curly brackets. The following example illustrates the use of index as argument inside the curly bracket.

Example

```
>>> "My Name is {0} and I am from {1}".format("Milinda","USA")
'My Name is Milinda and I am from USA'
```

Explanation

The `format()` method contains various arguments. In the above example, the `format()` method has two arguments, viz. "Milinda" and "USA". The index of the first argument of the `format()` method always starts from 0. Therefore, {0} replaces the 0th argument of the format. Similarly {1} replaces the first argument of the format.

Keyword Argument and *format()* Method

We can also insert text within curly braces along with numeric indexes. However, this text has to match keyword arguments passed to the `format()` method.

Example

```
>>> "I am {0} years old.I Love to work on {PC} Laptop".format(25,PC="APPLE")
'I am 25 years old.I Love to work on APPLE Laptop'
```

7.8.3 The `split()` Method

The `split()` method returns a list of all the words in a string. It is used to break up a string into smaller strings.

Example

Consider the following example where names of different programming languages such as C, C++, Java and Python is assigned to a variable `Str1`. Applying **split()** method on `str1` returns the **list** of programming languages.

```
>>> Str1="C C++ JAVA Python"#Assigns names of Programming languages to Str1
>>> Str1.split()
['C,C++,JAVA,Python']
```

PROGRAM 7.5 | Consider a input string that has a list of names of various multinational companies, such as TCS, INFOSYS, MICROSOFT, YAHOO and GOOGLE. Use split method and display the name of each company in a different line.

```
TOP_10_Company="TCS,INFOSYS,GOOGLE,MICROSOFT,YAHOO"
Company=TOP_10_Company.split(",")
print(Company)
for c in Company:
    print(end=" ")
    print(c)
```

Output

```
['TCS', 'INFOSYS', 'GOOGLE', 'MICROSOFT', 'YAHOO']
TCS
INFOSYS
GOOGLE
MICROSOFT
YAHOO
```



Note: The `split()` method can be called without arguments. If it is called without a delimiter, then by default the space will act as a delimiter.

7.8.4 Testing String

A string may contain digits, alphabets or a combination of both of these. Thus, various methods are available to test if the entered string is a digit or alphabet or is alphanumeric. Methods to test the characters in a string are given in Table 7.1.

Table 7.1 The str class methods for testing its characters

Methods of str Class for Testing its Character	Meaning
bool isalnum() Example: <pre>>>>S="Python Programming" >>>S.isalnum() False >>> S="Python" >>>S.isalnum() True >>> P="1Jhon" >>>P.isalnum() True</pre>	Returns True if characters in the string are alphanumeric and there is at least one character.

(Contd.)

bool isalpha() Example: <pre>>>> S="Programming" >>>S.isalpha() True >>> S="1Programming" >>>S.isalpha() False</pre>	Returns True if the characters in the string are alphabetic and there is at least one character.
bool isdigit() Example: <pre>>>> Str1="1234" >>> Str1.isdigit() True >>> Str2="123Go" >>> Str2.isdigit() False</pre>	Returns True if the characters in the string contain only digits.
bool islower() Example: <pre>>>> S="hello" >>>S.islower() True</pre>	Returns True if all the characters in the string are in lowercase.
bool isupper() Example: <pre>>>> S="HELLO" >>>S.isupper () True</pre>	Returns True if all the characters in the string are in uppercase.
bool isspace() Example: <pre>>>> S=" " >>>S.isspace() True >>> Str1="Hello Welcome to Programming World" >>> Str1.isspace () False</pre>	Returns true if the string contains only white space characters.

7.8.5 Searching Substring in a String

Table 7.2 contains methods provided by the str class to search the substring in a given string.

Table 7.2 Methods to search a substring in a given string

<i>Methods of str Class for Searching the Substring in a Given String</i>	<i>Meaning</i>
bool endswith(str Str1) Example: <pre>>>> S="Python Programming" >>>S.endswith("Programming") True</pre>	Returns true if the string ends with the substring Str1.
bool startswith(str Str1) Example: <pre>>>> S="Python Programming" >>>S.startswith("Python") True</pre>	Returns true if the string starts with the substring Str1.
int find(str Str1) Example: <pre>>>> Str1="Python Programming" >>> Str1.find("Prog") 7#Returns the index from where the string "Prog" begins >>> Str1.find("Java") -1#Returns -1 if the string "Java" is not found in the string str1</pre>	Returns the lowest index where the string Str1 starts in this string or returns -1 if the string Str1 is not found in this string.
int rfind(str Str1) Example: <pre>>>> Str1="Python Programming" >>> Str1.rfind("o") 9#Returns the index of last occurrence of string "o" in Str1</pre>	Returns the highest index where the string Str1 starts in this string or returns -1 if the string Str1 is not found in this string.
int count(str S1) Example: <pre>>>> Str1="Good Morning" >>> Str1.count("o") 3</pre>	Returns the number of occurrences of this substring.

7.8.6 Methods to Convert a String into Another String

A string may be present in lower case or upper case. The string in lower case can be converted into upper case and vice versa using various methods of the str class. Table 7.3 contains various methods to convert a string from one form to another.

Table 7.3 Methods to convert string from one form to another

<i>Methods of Str Class to Convert a String from One Form to Another</i>	<i>Meaning</i>
str capitalize() Example: <pre>>>> Str1="hello" >>> Str1.capitalize () 'Hello' #Convert first alphabet of String Str1 to uppercase</pre>	Returns a copy of the string with only the first character capitalised.
str lower() Example: <pre>>>> Str1="INDIA" >>> Str1.lower () 'india'</pre>	Returns a copy of the string with all the letters converted into lower case.
str upper() Example: <pre>>>> Str1="iitbombay" >>> Str1.upper() 'IITBOMBAY'</pre>	Returns a copy of the string with all the letters converted into upper case.
str title() Example: <pre>>>> Str1="welcome to the world of programming" >>> Str1.title() 'Welcome To The World Of Programming'</pre>	Returns a copy of the string with the first letter capitalised in each word of the string.
str swapcase() Example: <pre>>>> Str1="InCreDible India" >>> Str1.swapcase () 'iNCRedIBLE iNDIA'</pre>	Returns a copy of the string which converts upper case characters into lower case characters and lower case characters into upper case characters.
str replace (str old, str new [,count]) Example: <pre>>>> S1="I have brought two chocolates, two cookies and two cakes" #Replace the old string i.e "two" by new string i.e. "three". >>> S2=S1.replace("two","three") #Replace all occurrences of old string "two" by "three" >>> S2 'I have brought three chocolates, three cookies and three cakes'</pre>	Returns a new string that replaces all the occurrences of the old string with a new string. The third parameter, i.e. the count is optional. It tells the number of old occurrences of the string to be replaced with new occurrences of the string.

(Contd.)

Q. Replace two chocolates and two cookies by three chocolates and three cookies.

```
>>> S1="I have brought two chocolates, two cookies
and two cakes"
>>> S1.replace("two","three",2)
#Replace only first 2 occurrences of old string
"two" by "three"
'I have brought three chocolates, three cookies and
two cakes'
```

7.8.7 Stripping Unwanted Characters from a String

A common problem when parsing text is leftover characters at the beginning or end of a string. Python provides various methods to remove white space characters from the beginning, end or both the ends of a string.



Note: Characters such as " ", \f, \r, and \n are called white space characters.

Methods to strip leading and trailing white space characters are given in Table 7.4.

Table 7.4 Methods to strip leading and trailing white space characters

Methods of str Class for Stripping White Space Characters	Meaning
str lstrip() Example: <pre>>>> Scentence1=" Hey Cool!!." >>> Scentence1#Display Scentence1 ' Hey Cool!!.'#Before Stripping left white space >>> Scentence1.lstrip()#Remove left white space characters 'Hey Cool!!.'#After Stripping left white space characters</pre> Example: <pre>>>>Bad_Sentence="\t\tHey Cool!!." >>>Bad_Sentence#print Bad_Sentence before removing whitespace '\t\tHey Cool!!.' >>>Bad_Sentence.lstrip()#Print Bad_Sentence after removing 'Hey Cool!!.'</pre>	Returns a string with the leading white space characters removed.
str rstrip() Example: <pre>>>> Scentence1="Welcome!!!\n\n\ " >>> Scentence1.rstrip()#Remove trailing white space character 'Welcome!!!\n\n\''#After Removing white space character</pre>	Returns a string with the trailing white space characters removed.

(Contd.)

```

str strip()
Example:
>>> Str1=" Hey,How are you!!!\t\t\t "
>>> Str1#Print string str1 before stripping
' Hey,How are you!!!\t\t\t '
>>> Str1.strip()#Print after Stripping
'Hey,How are you!!!'
Example:
>>> s1="@Cost Prize of Apple Laptop is at Rs = 20 Dollars $$$$"
>>> s1#Before removing unwanted characters @ and $
'@Cost Prize of Apple Laptop is at Rs = 20 Dollars $$$$'
>>> s1.strip('@$')
'Cost Prize of Apple Laptop is at Rs = 20 Dollars '#After Removing

```

Returns a string with the leading and trailing white space characters removed.



Note: Stripping does not apply to any text in the middle of a string. It only strips the white space characters from the beginning and end of a string.

Example

```

>>> S1="Python Programming"
>>> S1#Print S1 before stripping
'Python Programming'
>>> S1.strip()
'Python Programming'#Print S1 after stripping

```

In the above example, there are multiple spaces between the two string "Python" and "Programming". Even though after applying `strip()` method on `S1`, The string `S1` remain unchanged. The white space characters are not removed from the string `S1`.

7.8.8 Formatting String

Table 7.5 Methods to format a string

<i>Methods of str Class for Formatting Characters</i>	<i>Meaning</i>
str center(int width) Example >>> S1="APPLE MACOS" #Place the string S1 in the center of a string with 11 characters >>> S1.center(15) 'APPLE MACOS'	Returns a copy of the string centered in a field of the given width.

(Contd.)

```
str ljust(int width)
```

Example:

```
>>> S1="APPLE MACOS"
```

#Place the string S1 at the left of a string with 15 characters.

```
>>> S1.ljust(15)
```

```
'APPLE MACOS'
```

Returns a string left justified in a field of the given width.

```
str rjust(int width)
```

Example:

```
>>> S1="APPLE MACOS"
```

#Place the string S1 at the right of a string with 15 characters.

```
>>> S1.rjust(15)
```

```
'APPLE MACOS'
```

Returns a string right justified in a field of the given width.

7.8.9 Some Programs on String

PROGRAM 7.6 Write the function countB(word) which takes a word as the argument and returns the number of 'b' in that word.

```
def countB(word):
    print(word)
    count = 0
    for b in word:
        if (b == 'b'):
            count = count + 1
    return count
print(" Number of 'b' = ",countB("abbbabbbaaa"))
```

Output

```
abbbabbbaaa
```

```
Number of 'b' = 5
```

PROGRAM 7.7 Write the function count_Letter(word, letter) which takes a word and a letter as arguments and returns the number of occurrences of that letter in the word.

```
def count_Letter(word,letter):
    print("Word = ",word)
    print("Letter to count = ",letter)
    print("Number of occurrences of '",letter,"' is =",end="")
    count = 0
    for i in word:
```

(Contd.)

```

    if (i == letter):
        count = count + 1
    return count
x=count_Letter('INIDA','I')
print(x)

```

Output

```

Word = INIDA
Letter to count = I
Number of occurrences of ` I ` is =2

```

PROGRAM 7.8 | Write the function `modify_Case(word)` which changes the case of all the letters in a word and returns the new word.

```

def modify_Case(word):
    print("Original String = ",word)
    print("After Swapping String = ",end="")
    return word.swapcase()
print(modify_Case("hi Python is intresting, isn't it ? "))

```

Output

```

Original String = hi Python is intresting, isn't it ?
After Swapping String = HI PYTHON IS INTRESTING, ISN'T IT ?

```

PROGRAM 7.9 | A string contains a sequence of characters. Elements within a string can be accessed using an index which starts from 0. Write the function `getChar(word, pos)` which takes a word and a number as arguments and returns the character at that position.

```

def getChar(word,pos):
    print("Word = ",word)
    print("Character at Position ",pos," = ",end="")
    counter = 0
    for i in word:
        counter = counter + 1
        if (counter == pos):
            return i
print(getChar("Addicted to Python ",3))

```

Output

```

Word = Addicted to Python
Character at Position 3 = i

```

PROGRAM 7.10 | Write a function `Eliminate_Letter(word, letter)` which takes a word and a letter as arguments and removes all the occurrences of that particular letter from the word. The function will return the remaining letters in the word.

```
def Eliminate_Letter(word,Letter):
    print("String = ",word)
    print("After Removing Letter : ",Letter)
    print("String = ",end="")
    newstr = ''
    newstr = word.replace(Letter,"")
    return newstr

#Sample test
x = Eliminate_Letter(' PYTHON PROGRAMMING','P')
print(x)
```

Output

```
String =   PYTHON PROGRAMMING
After Removing Letter:  P
String = PYTHON ROGRAMMING
```

PROGRAM 7.11 | Write the function `countVowels(word)` which takes a word as an argument and returns the vowels ('a', 'e', 'i', 'o', 'u') in that word.

```
def countVowels(word):
    print(" Word = ",word)
    word = word.lower()
    return {v:word.count(v) for v in 'aeiou'}
print(countVowels("I Love Python Programming"))
```

Output

```
Word =  I Love Python Programming
{'u': 0, 'i': 2, 'o': 3, 'e': 1, 'a': 1}
```

PROGRAM 7.12 | Write the function `UpperCaseVowels(word)` which returns the word with all the vowels capitalised.

```
def UpperCaseVowels(word):
    new= ''
    print("string = ",word)
    print(" After Capitalizing Vowels")
    print("String = ",end="")
    for i in word:
```

(Contd.)

```

        if(i == 'a' or i == 'e' or i == 'i' or i == 'o' or i == 'u' ):
            new = new + i.upper()
        else:
            new = new + i
    return new
#Sample run
x = UpperCaseVowels('aehsdfiou')
print(x)

```

Output

```

string = aehsdfiou
After Capitalizing Vowels
String = AEhsdfIOU

```

PROGRAM 7.13 Write the function `replacevowels(word)` which removes all the vowels ('a', 'e', 'i', 'o', 'u') in a word and returns the remaining letters in the word.

```

def removeVowels(word):
    new = ''
    print("String =",word)
    print("String After Removing Vowels =",end="")
    for i in word:
        if(i!= 'a' and i!= 'e' and i!= 'i' and i!= 'o' and i!= 'u'):
            new = new + i
    return new
#Sample run
x = removeVowels('abceiodeuf')
print(x)

```

Output

```

String = abceiodeuf
String After Removing Vowels =bcdf

```

PROGRAM 7.14 Write the function `isReverse(word1, word2)` which takes two words as arguments and returns True if the second word is the reverse of the first word.

```

def isReverse(word1,word2):
    print("First Word = ",word1)
    print("Second Word = ",word2)
    if(word1 == word2[::-1]):
        return True

```

(Contd.)

```

else:
    return False
x = isReverse('Hello','olleH')
print(x)print(x)

```

Output

```

First Word = Hello
Second Word = olleH
True

```

PROGRAM 7.15 Write a function `mirrorText(word1, word2)` which takes two words as arguments and returns a new word in the following order: `word1word2word2word1`.

```

def mirrorText(word1, word2):
    print("String1 = ",word1)
    print("String2 = ",word2)
    print("Mirror String = ",end="")
    return word1+word2+word2+word1
x = mirrorText('PYTHON','STRONG')
print(x)

```

Output

```

String1 = PYTHON
String2 = STRONG
Mirror String = PYTHONSTRONGSTRONGPYTHON

```

MINI PROJECT**Conversion of HexDecimal Number into its Equivalent Binary Number**

Table 7.6. contains conversion of a hexadecimal number into its equivalent binary number.

Table 7.6 Hexadecimal into equivalent binary form

<i>Hexadecimal Number</i>	<i>Equivalent Binary Number</i>	<i>Equivalent Decimal Number</i>
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6

(Contd.)

7	0111	7
8	1000	8
9	1001	9
'A'	1010	10
'B'	1011	11
'C'	1100	12
'D'	1101	13
'E'	1110	14
'F'	1111	15

Program Statement

Write a program to convert a hexadecimal number entered as a string into its equivalent binary format.

Note: Use `ord()` to obtain the ASCII value of a character.

Sample Input

Please Enter Hexadecimal Number: 12FD

Output

Equivalent Binary Number is
0001 0010 1111 1101

Algorithm

- ☉ **STEP 1:** Read the hexadecimal number as string from the user.
- ☉ **STEP 2:** Pass 'h', i.e. the number as string to function named 'hex_to_bin(h)'
- ☉ **STEP 3:** Inside function `hex_to_bin(h)`, traverse each character of string 'h'.
Check if the character inside the string contains values in between 'A' and 'F'. Then add 10 to the difference between ASCII values, i.e. $(\text{ord}(\text{'ch'}) - \text{ord}(\text{'A'})) + 10$ and pass the obtained sum 'X' as string to function `dec_bin(X)`.
- ☉ **STEP 4:** Calculate the equivalent binary number of x and print the same.

```
def dec_bin(x):    #Decimal to Binary
    k=[]
    n=x
    while (n>0):
        a=int(float(n%2))
        k.append(a)
```

(Contd.)


```

        n=(n-a)/2
    k.append(0)
    string=""
    for j in k[::-1]:
        string=string+str(j)
    if len(string)>4:
        print(string[1:],end=' ')
    elif len(string)>3:
        print(string,end=' ')
    elif len(string)>2:
        print('0'+string,end=' ')
    else:
        print('00'+string,end=' ')

def hex_to_bin(h): #Hexadecimal Number 'h' passed to function
    print('',end='')
    for ch in range(len(h)):
        ch = h[ch]
        if 'A' <= ch <='F':
            dn = 10 + (ord(ch)-ord('A'))
            dec_bin(dn)
        else:
            dn = (ord(ch)-ord('0'))
            dec_bin(dn)

n=input('Please Enter Hexadecimal Number:')
print('Equivalent Binary Number is as follows:')
hex_to_bin(n)

```

Output

```

Please Enter Hexadecimal Number:12FD
Equivalent Binary Number is as follows:
0001 0010 1111 1101

```

In the above program, initially the number as string is read from the user and passed to the function **hex_to_bin()**. The function traverses all the characters. For each character it converts into its equivalent decimal form 'X', the equivalent decimal number 'X' is passed to the function **dec_bin(X)**, to calculate the binary of a number. Thus, finally we obtain an equivalent binary number for a given hexadecimal number.

SUMMARY

- ♦ String is the object of the str class.
- ♦ String object is immutable.
- ♦ The `index[]` operator is used to access individual characters in a string.
- ♦ You can use the for loop and the while loop to traverse the contents of a string.
- ♦ Various string methods can be used to manipulate strings and perform various operations such as conversion of lower to uppercase, reversal, concatenation, comparison, search and replacement of string elements.

KEY TERMS

- ⇒ **The `index[]` Operator:** Access character
- ⇒ **The `+`, `*` and `in` Operator:** Concatenate, repetition, check characters in a string
- ⇒ **Slicing `str[start: end]` Operation:** Obtain substring
- ⇒ **Comparison Operators:** `==`, `!=`, `>`, `<=`
- ⇒ **Immutable Strings:** Cannot change the existing string
- ⇒ **The `split()` Method:** Returns a list of words
- ⇒ **The `format()` Method:** Format string, i.e. left justify, right justify or center
- ⇒ **Testing String:** Check if the string contains digits, numbers or alphanumeric characters.

REVIEW QUESTIONS

A. Multiple Choice Questions

1. What will be the output of the following program?

```
S1="Welcome to JAVA Programming"
S2=S1.replace("JAVA","Python")
print(S1)
print(S2)
```

- a. Welcome to JAVA Programming
 - b. Welcome to Python Programming
 - c. Welcome to Java Python Programming
 - d. None of the above
2. What will be the output of the following program?

```
Str1 = "Hello"
Str2=Str1[:-1]
print(Str2)
```

- a. olle
 - b. Hello
 - c. el
 - d. Hell
3. What will be the output of the following program?

```
Str1= "The Sum of {0:b} and {1:b} is {2:b}".format(2,2,4)
print(Str1)
```

- a. The Sum of 10 and 10 is 0100 b. The Sum of 2 and 2 is 100
c. The Sum of 10 and 10 is 100 d. The Sum of 2 and 2 is 4
4. What will be the output of the following program?
- ```
Str1="ABBCCDEEBBFFERBBJJUIBB"
print(Str1.count("BB"),end=' ')
print(Str1.count("BB",1),end=' ')
print(Str1.count("BB",2),end=' ')
print(Str1.count("BB",3),end=' ')
```
- a. 4 4 3 3                      b. 4 3 4 3  
c. 3 4 3 4                      d. 4 4 4 3
5. What will be the output of the following program?
- ```
Str1="Python Programming"
Str1[0]="J"
print(Str1)
```
- a. Jython Programming b. Jython
c. Jython Jrogramming d. Error
6. What will be the output of the following program?
- ```
S="Programming"
for char in S:
 print(char, end=" ")
```
- a. Programming                      b. P r o g r a m m i n g  
c. Error                      d. None of the above
7. What will be the output of the following program?
- ```
S="ILOVEWORLD"
for ch in range(0,len(S),3):
    print(S[ch],end=" ")
```
- a. I V O D b. I O W L
c. I V W L d. I L O V
8. What will be the output of the following program?
- ```
def countbc(word):
 print(word)
 count = 0
 for bc in word:
 if (bc == 'bc'):
 count = count + 1
 return count
print(" Number of 'bc' = ",countbc("abcbabcaaa"))
```
- a. 0                      b. 10  
c. 2                      d. 1
9. How would you print 'UK' for the given list?
- ```
Countries = ['India', 'USA', 'UK']
```

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5. Write a procedure to traverse every third character of a string.
6. How can all the elements of a string be traversed using the while loop?
7. What is meant by immutable strings?
8. What is the use of the slicing operator?
9. How is a subset of a string obtained?
10. How is step size in a string used?
11. List the comparison operators in a string. Create a table indicating comparison operators and their meaning.
12. What is the use of the format () method?
13. How can a string be broken?
14. Explain the various methods to test if the strings entered contain digits or alphabets or alphanumerics.
15. What do you mean by formatting a character?

PROGRAMMING ASSIGNMENTS

1. Write a program to read string and display 'Total number of uppercase and lowercase letters'.
2. Write the function Echo_Word(word) which takes a word as the argument and returns a word that repeats itself based on the number of letters in the word.
3. Write the function Reverse_Word(word) which returns the word in the reverse order.
4. Write the function startEndVowels(word) which returns True if the word starts and ends with vowels.
5. Write the function getVowels(word) which takes a word as an argument and returns the vowels ('a', 'e', 'i', 'o', 'u') in that word.
6. Write a program to read a string containing binary digits and convert it into its equivalent decimal integer.

Lists

8

CHAPTER OUTLINE

8.1 Introduction	8.8 The List Operator
8.2 Creating Lists	8.9 List Comprehensions
8.3 Accessing the Elements of a List	8.10 List Methods
8.4 Negative List Indices	8.11 List and Strings
8.5 List Slicing [Start: end]	8.12 Splitting a String in List
8.6 List Slicing with Step Size	8.13 Passing List to a Function
8.7 Python Inbuilt Functions for Lists	8.14 Returning List from a Function

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Explain the necessity and importance of 'list' in programming languages
- Create a list of different and mixed types
- Write programs to access the elements of a list using the positive index operator and the negative index operator
- Explain list slicing with different features and programs
- Use various operators, such as +, * and in operators on lists
- Create a new list from an existing list, learn to pass a list to a function and write programs to return lists from a function

8.1 INTRODUCTION

We may need to store variables of the same data type on many occasions. For example, currency notes used in daily life in India are of denominations ₹5, 10, 20, 100, 500 and 2000. If a programmer wishes to display all the six currency notes then by regular programming methods he/she may print them by reading all the currency notes with six different variables. Through a list, however, a programmer can use a single variable to store all the elements of the same or different data type and even print them. Similarly, miscellaneous lists to display top 100 countries in the world, students qualifying GRE exams, buying groceries etc. can be created.

In Python, a list is a sequence of values called **items** or **elements**. The elements can be of any type. The structure of a list is similar to the structure of a string.

8.2 CREATING LISTS

The List class defines lists. A programmer can use a list's constructor to create a list. Consider the following example.

Example: Create a list using the constructor of the list class

- a. Create an empty list.

```
L1 = list();
```

- b. Create a list with any three integer elements, such as 10, 20 and 30.

```
L2 = list([10,20,30])
```

- c. Create a list with three string elements, such as "Apple", "Banana" and "Grapes".

```
L3 = list(["Apple","Banana","Grapes"])
```

- d. Create a list using inbuilt range() function.

```
L4 = list(range(0,6)) # create a list with elements from 0 to 5
```

- e. Create a list with inbuilt characters X, Y and Z.

```
L5=list("xyz")
```

Example: Creating a list without using the constructor of the list class

- a. Create a list with any three integer elements, such as 10, 20 and 30.

```
L1=[10,20,30]
```

- b. Create a list with three string elements, such as "Apple", "Banana" and "Grapes".

```
L2 = ["Apple", "Banana", "Grapes"]
```



Note: A list can contain the elements of mixed type.

Example:

```
L3=list(["Jhon","Male",25,5.8])
```

The above example creates a list L3, which is of mixed type, i.e. it contains elements of different types, such as string, float and integer.

8.3 ACCESSING THE ELEMENTS OF A LIST

The elements of a list are unidentifiable by their positions. Hence, the **index** `[]` operator is used to access them. The syntax is:

```
Name_of_Variable_of_a_List[index]
```

Example

```
>>> L1=( [10,20,30,40,50])  #Create a List with 5 Different Elements
>>> L1                      #print the complete List
[10, 20, 30, 40, 50]
>>> L1[0]                   # Print the first element of the List
10
```

Explanation The above example L1 creates a list of five elements

```
L1 = [10,20,30,40,50]
```

where L1 is the reference variable of the list.

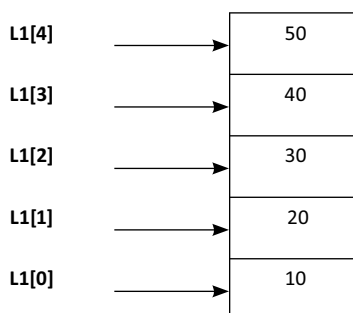


Figure 8.1 The list has five elements with index from 0 to 4



Note: A list retains its original order. Therefore, a list is an ordered set of elements enclosed in square brackets separated by commas. The index of a non-empty list always starts from zero.

8.4 NEGATIVE LIST INDICES

The negative index accesses the elements from the end of a list counting in backward direction. The **index** of the last element of any non-empty list is always **-1**, as shown in Figure 8.2.

List1 =	10	20	30	40	50	60
	-6	-5	-4	-3	-2	-1

Figure 8.2 List with negative index

Accessing the elements of a list using a negative index.

Example

```
>>> List1=[10,20,30,40,50,60]#Create a List
>>> List1[-1]                #Access Last element of a List
60
>>>List1[-2]                 #Access the second last element of List
50
>>> List1[-3]                #Access the Third last element of List
40
>>>List1[-6]                 #Access the first Element of the List
10
```

**Note:**

`List[-n] == List[Length_of(List)-n]`

Example:

```
>>>List1=[10,20,30,40,50,60]
>>>List1[-3]
40
```

Explanation:

`List1[-3]==List1[Len(List1)-3]=List1[6-3]=List1[3]` .

Thus, `List1[-3]==List1[3]` prints the element stored at index 3 counting in a forward direction from the list or we can say it prints the element stored at index -3 counting in a backward direction from the list.

8.5 LIST SLICING [START: END]

The slicing operator returns a subset of a list called **slice** by specifying two indices, i.e. **start** and **end**. The syntax is:

`Name_of_Variable_of_a_List[Start_Index: End_Index]`

Example

```
>>> L1=( [10,20,30,40,50] )   #Create a List with 5 Different Elements
>>> L1[1:4]
20,30,40
```

The `L1[1:4]` returns the subset of the list starting from index the start index 1 to one index less than that of the end index, i.e. $4-1 = 3$.

Example

```
>>> L1=( [10,20,30,40,50] )   #Create a List with 5 Different Elements
>>> L1[2:5]
[30, 40, 50]
```

The above example L1 creates a list of five elements. The index operator `L1[2:5]` returns all the elements stored between the index 2 and one less than the end index, i.e. $5-1 = 4$.

8.6 LIST SLICING WITH STEP SIZE

So far, we learnt how to select a portion of a list. In this section, we will explore how to select every second or third element of a list using **step size**. In slicing, the first two parameters are **start index** and **end index**. Thus, we need to add a third parameter as **step size** to select a list with step size. To be able to do this we use the syntax:

```
List_Name[Start_Index:End_Index:Step_Size]
```

Example

```
>>> MyList1 = ["Hello", 1, "Monkey", 2, "Dog", 3, "Donkey"]
>>> New_List1 = MyList1[0:6:2]
print(New_List1)
['Hello', 'Monkey', 'Dog']
```

Explanation Initially we created a list named **MyList1** with five elements. The statement **MyList1[0:6:2]** indicates the programmer to select the portion of a list which starts at index 0 and ends at index 6 with the step size as 2. It means we first extract a section or slice of the list which starts at the index 0 and ends at the index 6 and then selects every other second element.

Example

```
>>> List1 = ["Python", 450, "C", 300, "C++", 670]
>>> List1[0:6:3]    #Start from Zero and Select every Third Element
['Python', 300]    #Output
```

8.6.1 Some More Complex Examples of List Slicing

```
>>> List1 = [1, 2, 3, 4] #List With Four Elements

>>> MyList1[:2]    #Access first two elements of the List.
[1, 2]

>>> MyList1[::-1]  #Display List in Reverse Order
[4, 3, 2, 1]

#Start index with -1 and End Index with 0 and step Size with -1
>>> MyList1[-1:0:-1]
[4, 3, 2]
```

8.7 PYTHON INBUILT FUNCTIONS FOR LISTS

Python has various inbuilt functions that can be used with lists. Some of these are listed in Table 8.1.

Table 8.1 Inbuilt functions that can be used with lists

<i>Inbuilt Functions</i>	<i>Meaning</i>
Len()	Returns the number of elements in a list.
Max()	Returns the element with the greatest value.
Min()	Returns the element with the lowest value.
Sum()	Returns the sum of all the elements.
random.shuffle()	Shuffles the elements randomly.

Example

#Creates a List to store the names of Colors and return size of list.

```
>>> List1=["Red","Orange","Pink","Green"]
>>> List1
['Red', 'Orange', 'Pink', 'Green']
>>> len(List1)      #Returns the Size of List
4
```

#Create a List, find the Greatest and Minimum value from the list.

```
>>> List2=[10,20,30,50,60]
>>> List2
[10, 20, 30, 50, 60]
>>> max(List2)      #Returns the greatest element from the list.
60
>>> min(List2)      #Returns the minimum element from the list.
10
```

#Create a List, and Shuffle the elements in random manner.

#Test Case 1

```
>>>import random
>>> random.shuffle(List2)
>>> List2
[30, 10, 20, 50, 60]
>>> List2
[30, 10, 20, 50, 60]
```

#Test Case2

```
>>> random.shuffle(List2)
>>> List2
[20, 10, 30, 50, 60]
```

#Create a List, and find the sum of all the elements of a List.

```
>>> List2=[10,20,30,50,60]
>>> List2
[10, 20, 30, 50, 60]
>>> sum(List2)    # Returns the sum of all the elements
170
```

8.8 THE LIST OPERATOR

1. The + Operator: The concatenation operator is used to join two lists.

Example

```
>>> a=[1,2,3]           #Create a list with three elements 1,2, and 3
>>> a                   #Prints the list
[1, 2, 3]
>>> b=[4,5,6]           #Create a list with three elements 4,5, and 6
>>> b                   #print the list
[4, 5, 6]
>>> a+b                 #Concatenate the list a and b
[1, 2, 3, 4, 5, 6]
```

2. The * Operator: The multiplication operator is used to replicate the elements of a list.

Example

```
>>> List1=[10,20]
>>> List1
[10, 20]
>>> List2=[20,30]
>>> List2
[20, 30]
>>> List3=2*List1       #Print each element of a List1 twice.
>>> List3
[10, 20, 10, 20]
```

3. The in Operator: The in operator used to determine whether an element is in a list. It returns True if the element is present and False if the element is absent in the list.

Example

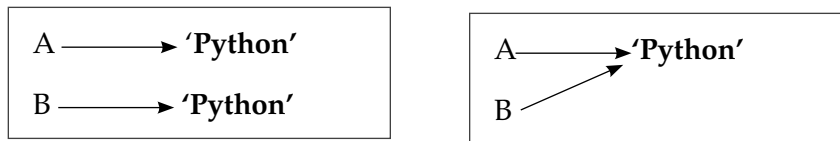
```
>>> List1= [10,20]
>>> List1
[10, 20]
>>> 40 in List1         #To Check if 40 is present in List1
False
>>> 10 in List1         #To Check if 10 is present in List1
True
```

4. The **is** Operator: Let us execute the following two statements:

```
A='Python'
```

```
B='Python'
```

We know that both A and B refer to a string but we don't know whether they refer to the same string or not. Two possible situations are:



In the first case, A and B refer to two different objects that have the same values. In second case, they refer to the same object. To understand whether two variables refer to the same object, a programmer can use the '**is**' operator.

Example

```
>>> A='Microsoft'
>>> B='Microsoft'
>>> A is B #Check if two variable refer to the same Object
True
```

From the above example, it is clear that Python created only one string object and both A and B refer to the same object. However, when we create two lists with the same elements, Python creates two different objects as well.

Example

```
>>> A=['A','B','C']
>>> B=['A','B','C']
>>> A is B #Check if two lists refer to the same Object
False
```

Explanation In the above example, the two lists A and B contain exactly the same number of elements. The **is** operator is used to check if both the variables A and B refer to the same object, but it returns False. It means that even if the two lists are the same, Python creates two different objects. State diagram for the above example is given in Figure 8.3.

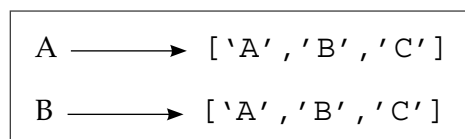


Figure 8.3 Effect of **is** operator on a list

It is important to note that in the above example, we can say that the two lists are **equivalent** because they have the same elements. We cannot say that both the lists are **identical** because they don't refer to the same object.

**Note:**

1. In case of strings, if both the variables contain the same values then both the variables refer to the same object.
2. In case of a list, if two variables contain the list with the same number of elements then both the variables refer to two different objects.
3. If two objects are **identical** then they are also **equivalent**.
4. If two objects are **equivalent** then it is not necessary that they will also be **identical**.

5. **The del Operator:** The del operator stands for Delete. The del operator is used to remove the elements from a list. To delete the element of a list, the elements of the list are accessed using their index position and the del operator is placed before them.

Example

```
Lst=[10,20,30,40,50,60,70]
>>> del Lst[2]      #Removes 3rd element from the List
>>> Lst
[10, 20, 40, 50, 60, 70]

Lst=[10,20,30,40,50,60,70]
>>> del Lst[-1]
>>> Lst              #Removes last element from the List
[10, 20, 30, 40, 50, 60]

>>> Lst=[10,20,30,40,50,60,70]
>>> del Lst[2:5]     #Removes element from index position 2 to 4
>>> Lst
[10, 20, 60, 70]

>>> Lst=[10,20,30,40,50,60,70]
>>> del Lst[:]      #Removes all the element from the List
>>> Lst
[]
```



Note: The del operator uses index to access the elements of a list. It gives a run time error if the index is out of range.

Example:

```
>>> del Lst[4]

Traceback (most recent call last):

  File "<pyshell#37>", line 1, in <module>
    del Lst[4]

IndexError: list assignment index out of range
```

8.9 LIST COMPREHENSIONS

List comprehension is used to create a new list from existing sequences. It is a tool for transforming a given list into another list.

Example: Without list comprehension

Create a list to store five different numbers such as 10, 20, 30, 40 and 50. Using the for loop, add number 5 to the existing elements of the list.

```
>>> List1= [10, 20, 30, 40, 50]
>>> List1
[10, 20, 30, 40, 50]
>>> for i in range(0,len(List1)):
    List1[i]=List1[i]+5    #Add 5 to each element of List1
>>> List1                #print the List1 After Performing
[15, 25, 35, 45, 55]
```

The above code is workable but **not** the **optimal code** or the best way to write a code in Python. Using list comprehension, we can replace the loop with a single expression that produces the same result.

The syntax of list comprehension is based on set builder notation in mathematics. Set builder notation is a mathematical notation for describing a set by stating the property that its members should satisfy. The syntax is

```
[<expression> for <element> in <sequence> if <conditional>]
```

The syntax is designed to read as “Compute the expression for each element in the sequence, if the conditional is true”.

Example: Using list comprehension

```
>>> List1= [10, 20, 30, 40, 50]
>>> List1
[10, 20, 30, 40, 50]

>>>for i in range(0,len(List1)):
    List1[i]=List1[i]+10

>>>List1
[20, 30, 40, 50, 60]
```

Without List Comprehension

```
>>> List1= [10,20,30,40,50]
>>> List1= [x+10 for x in List1]
>>> List1
[20, 30, 40, 50, 60]
```

Using List Comprehension

In the above example, the output for both without list comprehension and using list comprehension is the same. The use of list comprehension requires **lesser code** and also runs faster. With reference to the above example we can say that list comprehension contains:

- a. An input sequence

- b. A variable referencing the input sequence
- c. An optional expression
- d. An output expression or output variable

Example

```
List1= [20, 30, 40, 50, 60]
List1= [ x+10 for x in List1]
```

Output [20, 30, 40, 50, 60]

PROGRAM 8.1 | Write a program to create a list with elements 1,2,3,4 and 5. Display even elements of the list using list comprehension.

```
List1=[1,2,3,4,5]
print("Content of List1")
print(List1)
List1=[x for x in List1 if x%2==0]
print("Even elements from the List1")
print(List1)
```

Output

```
Content of List1
[1, 2, 3, 4, 5]
Even elements from the List1
[2, 4]
```

Explanation The List1 contains element 1,2,3,4 and 5. The statement `List1=[x for x in List1 if x%2==0]` consists of an output variable `x` and an input sequence `List1` and an expression `x%2==0`.

8.9.1 Some More Examples of List Comprehension

PROGRAM 8.2 | Consider the following mathematical expressions

```
A = {x : x in {0.....9}}
B = {x : x in {0.....9}}
C = {X : x in A and even}
```


Write a program to create a list '**A**' to generate squares of a number (from 1 to 10), list '**B**' to generate cubes of a number (from 1 to 10) and list '**C**' with those elements that are even and present in list '**A**'.

```
print("List A = ",end=" ")
A=[x**2 for x in range(11)] #Computes Square of a number X
print(A)
B=[x**3 for x in range(11)] # Computes Cube of a number X
print("List B = ",end=" ")
print(B)
print("Only Even Numbers from List A = ",end=" ")
C=[x for x in A if x%2==0]
print(C)
```

Output

```
List A = [0, 1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
List B = [0, 1, 8, 27, 64, 125, 216, 343, 512, 729, 1000]
Only Even Numbers from List A = [0, 4, 16, 36, 64, 100]
```

PROGRAM 8.3 | Consider a list with five different Celsius values. Convert all the Celsius values into Fahrenheit.

```
print("All the elements with Celsius Value:")
print("Celsius= ",end="")
Celsius=[10,20,31.3,40,39.2] #List with Celsius Value
print(Celsius)
print(" Celsius to Fahrenheit Conversion ")
print("Fahrenheit = ",end="")
Fahrenheit=[ ((float(9)/5)*x + 32) for x in Celsius]
print(Fahrenheit)
```

Output

```
All the elements with Celsius Value:
Celsius= [10, 20, 31.3, 40, 39.2]
 Celsius to Fahrenheit Conversion
Fahrenheit = [50.0, 68.0, 88.34, 104.0, 102.56]
```



Note: Formula to convert Celsius values into Fahrenheit.

Fahrenheit = $(9/5) * \text{Celsius} + 32$

PROGRAM 8.4 | Consider the list with mixed type of elements, such as `L1 = [1,'x',4,5.6,'z', 9, 'a', 0, 4]`. Create another list using list comprehension which consists of only the integer element present within the list `L1`.

```
print("List With Mixed Elements")
L1 = [1,'x' ,4,5.6,'z' , 9, 'a', 0, 4]
print(L1)
print("List With only Integer Elements:")
L2 = [ e for e in L1 if type(e) == int]
print(L2)
```

Output

```
List With Mixed Elements
[1, 'x', 4, 5.6, 'z', 9, 'a', 0, 4]
List With only Integer Elements:
[1, 4, 9, 0, 4]
```

8.10 LIST METHODS

Once a list is created, we can use the methods of the list class to manipulate the list. Table 8.2 contains the methods of the list class along with examples.

Table 8.2 Methods of list along with example

<i>Methods of List</i>	<i>Meaning</i>
None append(object x) Example: <pre>>>> List1=['X','Y','Z'] >>> List1 ['X', 'Y', 'Z'] >>> List1.append('A') #Append element 'A' to the end of the List1 >>> List1 ['X', 'Y', 'Z', 'A']</pre> <p>Note: Append method is equivalent to doing: <pre>List1[len(List1):]=[Element_Name]</pre></p> Example: <pre>>>>List1=["Red","Blue","Pink"] >>> List1 ['Red', 'Blue', 'Pink'] >>> List1[len(List1):]=['Yellow'] >>> List1 ['Red', 'Blue', 'Pink', 'Yellow']</pre>	<p>Adds an element x to the end of the list. None is the return type of method appended.</p>

(Contd.)

None clear()

Example:

```
>>> List1=["Red", "Blue", "Pink"]
>>> List1
['Red', 'Blue', 'Pink']
>>> List1.clear() # Removes all the element of List
>>> List1        # Returns Empty List after
removing all elements
[]
```

Removes all the items from the list.

int count(object x)

Example:

```
>>> List1=['A','B','C','A','B','Z']
>>> List1
['A', 'B', 'C', 'A', 'B', 'Z']
#Count the number of times the element 'A' has
appeared in the list
>>> List1.count('A')
2      # Thus, 'A' has appeared 2 times in List1
```

Returns the number of times the element x appears in the list.

List copy()

Example:

```
>>> List1=["Red","Blue","Pink"]
>>> List1
['Red', 'Blue', 'Pink']
>>> List2=List1.copy() # Copy the contents of List1
to List2
>>> List2
['Red', 'Blue', 'Pink']
```

This method returns a shallow copy of the list.

Note: Copy() Method is equivalent to doing

```
List2=List1[:] # Copies the content of List1 to List2
```

Example:

```
>>> List1=["Red","Blue","Pink"]
>>> List2=List1[:]
>>> List2
['Red', 'Blue', 'Pink']
```

None extend(list L2)

Example:

```
>>> List1= [1,2,3]
>>> List2= [4,5,6]
>>> List1
[1, 2, 3]
```

Appends all the elements of list L2 to the list.

(Contd.)

```
>>> List2
[4, 5, 6]
>>> List1.extend(List2)  #Appends all the elements
of List2 to List1
>>> List1
[1, 2, 3, 4, 5, 6]
```

int index(object x)

Example:

```
>>> List1=['A','B','C','B','D','A']
>>> List1
['A', 'B', 'C', 'B', 'D', 'A']
```

#Returns the index of first occurrence of element 'B' from the list1

```
>>> List1.index('B')
```

```
1      #Returns the index of element B
```

Returns the index of the first occurrence of the element *x* from the list.

None insert(int index, Object X)

Example:

```
>>> Lis1=[10,20,30,40,60]
```

```
>>> Lis1
```

```
[10, 20, 30, 40, 60]
```

```
>>> Lis1.insert(4,50)  #Insert Element 50 at index 4
```

```
>>> Lis1
```

```
[10, 20, 30, 40, 50, 60]
```

Insert the element at a given index.

Note: The index of the first element of a list is always zero.

Object pop(i)

Example:

```
>>> Lis1=[10,20,30,40,60]
```

```
>>> Lis1
```

```
[10, 20, 30, 40, 60]
```

```
>>> Lis1.pop(1)  # Remove the element which is at
index 1.
```

```
20
```

```
>>> Lis1      # Display List after removing the
element from index 1.
```

```
[10, 30, 40, 60]
```

```
>>> Lis1.pop() # Remove the last element from the
list
```

```
60
```

```
>>> Lis1
```

```
[10, 30, 40]  #Display the list after removing last
element
```

Removes the element from the given position. Also, it returns the removed element.

Note: The parameter *i* is optional. If it is not specified then it removes the last element from the list.

(Contd.)

None remove(object x)

Removes the first occurrence of element x from the list.

Example:

```
>>> List1=['A','B','C','B','D','E']
>>> List1
['A', 'B', 'C', 'B', 'D', 'E']
>>> List1.remove('B') #Removes the first occurrence
of element B
>>> List1
['A', 'C', 'B', 'D', 'E']
```

None reverse()

Reverses the element of the list.

Example:

```
>>> List1=['A','B','C','B','D','E']
>>> List1
['A', 'B', 'C', 'B', 'D', 'E']
>>> List1.reverse() # Reverse all the elements of
the list.
>>> List1
['E', 'D', 'B', 'C', 'B', 'A']
```

None sort()

Sort the elements of list.

Example:

```
>>> List1=['G','F','A','C','B']
>>> List1
['G', 'F', 'A', 'C', 'B']    #Unsorted List
>>> List1.sort()
>>> List1
['A', 'B', 'C', 'F', 'G']    #Sorted List
```

Q. What will be the output of the following program?

```
my_list = ['two', 5, ['one', 2]]
print(len(my_list))
```

Output

3

Explanation ['one',2] is one element so the overall length is 3.

Q. What will be the output of the following program?

```
Mixed_List=['pet' , 'dog' ,5, 'cat', 'good','dog']
Mixed_List.count('dog')
```

Output

2

Explanation It returns the number of occurrence of “dog” in the list.

Q. What will be the output of the following program?

```
Mylist=['Red',3]
Mylist.extend('Green')
print(Mylist)
```

Output

```
['Red', 3, 'G', 'r', 'e', 'e', 'n']
```

Explanation Extend the list by adding each character to it.

Q. What will be the output of the following program?

```
Mylist=[3,'Roses',2,'Chocolate ']
Mylist.remove(3)
Mylist
```

Output

```
['Roses', 2, 'Chocolate']
```

Explanation Remove the item from the list whose value is 3.

8.11 LIST AND STRINGS

A String is a sequence of characters and list is sequence of values, but a list of characters is not the same as string. To convert from string to a list of character, you can use list.

Example: Convert String to list of Characters

```
>>> p='Python'
>>> p
'Python'
>>> L=list(p)
>>> L
['p', 'y', 't', 'h', 'o', 'n']
```

8.12 SPLITTING A STRING IN LIST

In the above example, we have used the inbuilt function list. The `list()` function breaks a string into individual letters. In this section, we will explore how to split a string into words.

The **str** class contains the **split** method and is used to split a string into words.

Example

```
>>> A="Wow!!! I Love Python Programming" #A Complete String
>>> B=A.split() # Split a String into Words
>>> B #Print the contents of B
['Wow!!!', 'I', 'Love', 'Python', 'Programming']
```

Explanation In the above example, we have initialised string to A as “Wow!!! I Love Python Programming”. In the next line, the statement, B = A.split() is used to split “Wow!!! I Love Python Programming” into the list ['Wow!!!', 'I', 'Love', 'Python', 'Programming'].



Note: In the above program, we have used the following two lines to split string into words:

```
>>> A="Wow!!! I Love Python Programming"
>>> B=A.split()
```

We can also write the split method as

```
>>> A="Wow!!! I Love Python Programming".split()
```

It is fine to split a string without a delimiter. But what if the string contains the delimiter? A string containing a delimiter can be split into words by removing the delimiter. It is also possible to remove the delimiter from the string and convert the entire string into a list of words. In order to remove the delimiter, the **split()** method has a parameter called **split(delimiter)**. The parameter **delimiter** specifies the character to be removed from the string. The following example illustrates the use of a delimiter inside the **split()** method.

Example

```
>>> P="My-Data-of-Birth-03-June-1991" # String with Delimiter '-'
>>> P # Print the Entire String
'My-Data-of-Birth-03-June-1991'
>>> P.split('-') #Remove the delimiter '-' using split method.
['My', 'Data', 'of', 'Birth', '03', 'June', '1991']
```

8.13 PASSING LIST TO A FUNCTION

As list is a mutable object. A programmer can pass a list to a function and can perform various operations on it. We can change the contents of a list after passing it to a function. Since a list is an object, passing a list to a function is just like passing an object to a function.

Consider the following example to print the contents of a list after the list is passed to a function.

PROGRAM 8.5 | Create a list of 5 elements. Pass the list to a function and print the contents of the list inside the function.

```
def Print_List(Lst):
    for num in Lst:
```

(Contd.)

```

        print(num,end=" ")
Lst=[10,20,30,40,100]
Print_List(Lst)    # Invoke Function by Passing List as Parameter

```

Output

```
10 20 30 40 100
```

PROGRAM 8.6 | Create a list of five elements. Pass the list to a function and compute the average of five numbers.

```

def Calculate_Avg(Lst):
    print('Lst= ',Lst)
    print(' Sum = ',sum(Lst))
    avg=sum(Lst)/len(Lst)
    print(' Average = ',avg)
Lst=[10,20,30,40,3]
Calculate_Avg(Lst)

```

Output

```

Lst= [10, 20, 30, 40, 3]
Sum = 103
Average = 20.6

```

PROGRAM 8.7 | Write a function Split_List(Lst,n), where list Lst is split into two parts and the length of the first part is given as n.

```

Lst = [1,2,3,4,5,6]
Split_List(Lst,2)
Lst1=[1,2]
Lst2=[3,4,5,6]

```

```

def Split_List(Lst,n) :
    list1 = Lst[:n]
    list2 = Lst[n:]
    print('First List with ',n,' elements')
    print(list1)
    print('Second List with ',len(Lst)-n,' elements ')
    print(list2)
#Sample test:
Lst = [100,22,32,43,51,64]
print('List Lst Before Splitting')

```

(Contd.)


```
print(Lst)
Split_List(Lst,4)
```

Output

```
List Lst Before Splitting
[100, 22, 32, 43, 51, 64]
First List with 4 elements
[100, 22, 32, 43]
Second List with 2 elements
[51, 64]
```

8.14 RETURNING LIST FROM A FUNCTION

We can pass a list while invoking a function. Similarly, a function can return a list. When a function returns a list, the list's reference value is returned.

Consider the following example to pass a list to a function. After passing, reverse the elements of the list and return the list.

PROGRAM 8.8 | Write a program to pass a list to function

```
def Reverse_List(Lst):
    print('List Before Reversing = ',Lst)
    Lst.reverse()    # The reverse() to reverse the contents of list
    return Lst       # Return List
Lst=[10,20,30,40,3]
print('List after Reversing = ',Reverse_List(Lst))
```

Output

```
List Before Reversing = [10, 20, 30, 40, 3]
List after Reversing = [3, 40, 30, 20, 10]
```

PROGRAM 8.9 | Write a function that accepts a positive integer k and returns a list that contains the first five multiples of k.

The first five multiples of 3 are 3, 6, 9, 12, and 15.

```
def list_of_multiples(k):
    my_list=[]
    for i in range(1,6):
        res=k*i
        my_list.append(res)
```

(Contd.)

```

    return my_list
print(list_of_multiples(3))

```

Output

```
[3, 6, 9, 12, 15]
```

Some More Programs on List

PROGRAM 8.10 | Write a function that accepts two positive integers, viz. a and b and returns a list of all the even numbers between a and b (including a and not including b).

Even numbers between 10 and 20.

```
[10,12,14,16,18]
```

```

def list_of_even_numbers(start, end):
    output_list = []
    for number in range(start, end):
        # check if the number is even
        if number % 2 == 0:
            # if true put the numbers in the output list
            output_list.append(number)
    return output_list
print(list_of_even_numbers(10, 20))

```

Output

```
[10, 12, 14, 16, 18]
```

PROGRAM 8.11 | Write a function is_Lst_Palindrome(Lst) to check whether a list is palindrome. It should return True if Lst is palindrome and False if Lst is not palindrome.



Note: List is palindrome if it contains the same elements in forward direction & reverse direction.

Lst = [1,2,3,2,1] #Should return true

Lst = [1,2,3] #Should return false.

```

def is_Lst_Palindrome(Lst):
    r = Lst[::-1]
    for i in range(0, (len(Lst) + 1)//2):
        if r[i] != Lst[i]:
            return False
    return True

```

(Contd.)

```

#Sample test
Lst = [1,2,3,2,1]
x = is_Lst_Palindrome(Lst)
print(Lst," ( is palindrome): ",x)
Lst1 = [1,2,3,4]
x = is_Lst_Palindrome(Lst1)
print(Lst1," (is palindrome): ",x)

```

Output

```

[1, 2, 3, 2, 1] ( is palindrome):  True
[1, 2, 3, 4] (is palindrome):  False

```

PROGRAM 8.12 | Write a function `check_duplicate(Lst)` which returns `True` if a list `Lst` contains duplicate elements. It should return `False`, if all the elements in the list `Lst` are unique.

```

Lst = [4,6,2,1,6,7,4]
# Should return true as 4 and 6 appears more than once.
Lst = [1,2,3,12,4]
# Should return false as all the elements appears only once.

```

```

def check_duplicate(Lst) :
    dup_Lst = []
    for i in Lst:
        if i not in dup_Lst:
            dup_Lst.append(i)
        else:
            return True
    return False

#Sample test:
Lst = [4,6,2,1,6,7,4]
print(Lst)
x = check_duplicate(Lst)
print(x)
Lst1 = [1,2,3,12,4]
print(Lst1)
x = check_duplicate(Lst1)
print(x)

```

Output

```

[4, 6, 2, 1, 6, 7, 4]
True          # Returns true since 4 and 6 is repeated twice

```

(Contd.)

```
[1, 2, 3, 12, 4]
False
#Returns false since no element from above list is repeated twice
```

PROGRAM 8.13 | Write a program that prompts a user to enter the element of a list and add the element to a list. Write a function **maximum(Lst)** and **minimum(Lst)** to find the maximum and minimum number from the list.

```
Lst = [ 12,34,45,77]
```

#Should return 12 as Minimum and 77 as Maximum.

```
lst = []
for i in range(0,4):
    x = input('Enter element to add to the list:')
    x = int(x)
    lst.append(x)
print('Elements of List are as follows:')
print(lst)
def maximum(lst):
    myMax = lst[0]
    for num in lst:
        if myMax < num:
            myMax = num
    return myMax

def minimum(lst):
    myMin = lst[0]
    for num in lst:
        if myMin > num:
            myMin = num
    return myMin

#Sample test
y = maximum(lst)
print('Maximum Element from List = ',y)
y = minimum(lst)
print('Minimum Element from the List = ',y)
```

Output

```
Enter element to add to the list:665
Enter element to add to the list:234
```

(Contd.)

```

Enter element to add to the list:213
Enter element to add to the list:908
Elements of List are as follows:
[665, 234, 213, 908]
Maximum Element from List = 908
Minimum Element from the List = 213

```

PROGRAM 8.14 Write a function **Assign_grade(Lst)** which reads the marks of a student from a list and assigns a grade based on the following conditions:

```

if Marks >=90 then grade A
if Marks >=80 && <90 then grade B
if Marks >65 && < 80 then grade C
if Marks >=40 && <=65 then grade D
if Marks <40 then grade F

```

Consider the List of Marks of a 5 Student in English Subject.

```
Lst=[78,90,34,56,89]
```

#Should return

```

Student 1 Marks 78 grade C
Student 2 Marks 90 grade A
Student 3 Marks 34 grade F
Student 4 Marks 56 grade D
Student 5 Marks 89 grade B

```

```

def Assign_grade(Lst):
    for Marks in Lst:
        if Marks >= 90:
            print('Student',Lst.index(Marks) + 1,'Marks =',Marks,' grade A')
        elif Marks >=80 and Marks<90:
            print('Student',Lst.index(Marks)+ 1,'Marks =',Marks,' grade B')
        elif Marks >65 and Marks< 80:
            print('Student',Lst.index(Marks)+ 1,'Marks =',Marks,' grade C')
        elif Marks >=40 and Marks<=65:
            print('Student',Lst.index(Marks)+ 1,'Marks =',Marks,' grade D')
        else:
            print('Student',Lst.index(Marks)+ 1,'Marks =',Marks,' grade F')
#Sample test
Lst=[78,90,34,56,89]

```

(Contd.)

```
print('Marks of 5 Student = ',Lst)
Assign_grade(Lst)
```

Output

```
Marks of 5 Student = [78, 90, 34, 56, 89]
Student 1 Marks = 78 grade C
Student 2 Marks = 90 grade A
Student 3 Marks = 34 grade F
Student 4 Marks = 56 grade D
Student 5 Marks = 89 grade B
```

PROGRAM 8.15 | Write a function `check_duplicate(Lst)` which returns True if a list `Lst` contains duplicate elements. It should return False if all the elements in the list `Lst` are unique.

```
Lst = [4,6,2,1,6,7,4]
```

```
# Should return true as 4 and 6 appears more than once.
```

```
Lst = [1,2,3,12,4]
```

```
# Should return false as all the elements appears only once.
```

```
def check_duplicate(Lst) :
    dup_Lst = []
    for i in Lst:
        if i not in dup_Lst:
            dup_Lst.append(i)
        else:
            return True
    return False
```

#Sample test:

```
Lst = [4,6,2,1,6,7,4]
print(Lst)
x = check_duplicate(Lst)
print(x)
Lst1 = [1,2,3,12,4]
print(Lst1)
x = check_duplicate(Lst1)
print(x)
```

(Contd.)

Output

```
[4, 6, 2, 1, 6, 7, 4]
True          # Returns true since 4 and 6 is repeated twice
[1, 2, 3, 12, 4]
False #Returns false since no element from above list is repeated twice
```

PROGRAM 8.16 | Write a function `print_reverse(Lst)` to reverse the elements of a list.



Note: Reverse the contents of a list without using the `reverse()` method of a list and without using slicing.

```
Lst=[12,23,4,5]
# Should reverse the contents of list as follows
Lst=[5,4,23,12]
```

```
def print_reverse(Lst):
    print('List Before Reversing')
    print(Lst)
    lst = []
    count = 1
    for i in range(0, len(Lst)):
        lst.append(Lst[len(Lst)-count])
        count += 1
    lst = str(lst)
    lst = ''.join(lst)
    return lst
#Sample test:
Lst=[12,23,4,5,1,9]
x = print_reverse(Lst)
print('List After Reversing')
print(x)
```

Output

```
List Before Reversing
[12, 23, 4, 5, 1, 9]
List After Reversing
[9, 1, 5, 4, 23, 12]
```

PROGRAM 8.17 | Write a function that accepts two positive integers `a` and `b` (`a` is smaller than `b`) and returns a list that contains all the odd numbers between `a` and `b` (including `a` and including `b` if applicable) in descending order.

Odd numbers between 10 and 20 should create the list and print the list in descending order as follows

[19, 17, 15, 13, 11]

```
def list_of_odd_numbers(start, end):
    output_list = []
    for number in range(start, end+1):
        # check if the number is odd
        if number % 2 == 1:
            # if true put the numbers in the output list
            output_list.append(number)
            # Sort the List
            output_list.sort()
            # Reverse the list to display elements in descending order
            output_list.reverse()
    return output_list
print(list_of_odd_numbers(10, 20))
```

Output

[19, 17, 15, 13, 11]

PROGRAM 8.18 | Write a program to return prime numbers from a list.

```
List1=[3,17,9,2,4,8,97,43,39]
print('List1= ',List1)
lst = []
print('Prime Numbers from the List are as Follows:')
for a in List1 :
    prime = True
    for i in range(2, a):
        if (a%i == 0):
            prime = False
            break
    if prime:
        lst.append(a)
print(lst)
```

Output

```
List1= [3, 17, 9, 2, 4, 8, 97, 43, 39]
Prime Numbers from the List are as Follows:
[3, 17, 2, 97, 43]
```


SUMMARY

- A list is a sequence of zero or more elements.
- The element within a list can be of any data type.
- List is a mutable kind of data structure.
- A list can be initialised in different ways, viz. with and without using constructor lists.
- The index operator is used to access the elements of a list.
- The negative index accesses elements from the end of a list by counting in backward direction.
- The slicing operator and the list slicing with step size operator return a subset of a list.
- Various inbuilt functions can be used with lists.
- The for loop can be used to traverse the elements of a list.
- List comprehension can be used to create a new list from existing sequences. It is a tool for transforming a given list into another list.
- Methods such as copy, reverse and sort can be used to copy, reverse and sort the elements of a list.
- Methods such as append(), extend(), insert() are used to insert the elements within the list whereas methods such as pop(), and remove() are used to remove the contents from the list
- Proficiency in a list is impossible unless the unanswered problems are taken up for solving.

KEY TERMS

- ⇒ **The index[] Operator:** Accesses elements of a list
- ⇒ **List Slicing:** Returns a subset of a list
- ⇒ **List Comprehensions:** Creates a new list from an existing list
- ⇒ **The split() Method:** Splits a string into words
- ⇒ **The List Inbuilt Method:** min(), max(), shuffle(), len() and sum()

REVIEW QUESTIONS

A. Multiple Choice Questions

- Given: List1 = ['a','b','c','d'].
What will be the output of the following statement?
List1 = [x for x in List1 if ord(x) > 97]
print(List1)
 - ['a','b','c']
 - ['b','c','d']
 - ['a','b','c','d']
 - None of the above
- Consider the list, L = ['a','b','c','d','e','f','g','h','i','j']. Which one of the following outputs is correct?
 - >>> L[0:3]
['a', 'c', 'f', 'i']
 - >>> L[0:-1]
['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i']
 - >>> L[0:2]
 - None of the above

['a', 'b', 'c']

3. Consider the list L1 containing the elements L1= [1, 2, 3].

What will be the output of the following statement?

```
L1 = L1 + [4, 5, 6]
```

- a. L1=[1,2,3,5,7,9]
 - b. L1=[4,5,6]
 - c. L1=[5,7,9]
 - d. L1=[1,2,3,4,5,6]
4. What will be the output of the following statement?
- ```
List1 = [[n, n + 1, n + 2] for n in range(0, 3)]
```
- a. [0, 1, 2]
  - b. [[0, 1, 2],[0,1,2],[0,1,2]]
  - c. [[0, 1, 2],[1, 2, 3],[2, 3, 4]]
  - d. [[0, 1, 2],[2, 3, 4],[4, 5, 6]]
5. What will be the output of the following statement?

```
>>> string = 'DONALD TRUMPH'
>>> k = [print(i) for i in string if i not in "aeiou"]
>>> print(k)
```

- a. DONALD TRUMPH
  - b. DNLD TRMPH
  - c. DNLD
  - d. None of the above
6. What will be the output of the following program?

```
def func1(L):
 L[0]='A'
 L1=[1,2,3]
 func1(L1)
 print(L1)
```

- a. [1,2,3]
  - b. [1,'A',2]
  - c. ['A',1,2]
  - d. ['A','1','2']
7. What will be the output of the following statement?
- ```
>>> L1=['A', 'B', 3, 4, 5]
>>> L1[::-1]
>>> print(L1)
```
- a. [5,4,3,'B','A']
 - b. ['A','B',3,4,5]
 - c. ['A',3,5]
 - d. [5,3,'A']
8. How will a new element be added to the empty list L1?
- a. L1.append(10)
 - b. L1.add(10)
 - c. L1.appendLast(10)
 - d. L1.addLast(10)
9. What will be the output of the following program?

```
list1=[10,30]
list2 = list1
list1[0] = 40
print(list2)
```

- a. 10, 30
- b. 40, 30
- c. 10, 40
- d. 30, 40

10. List1 = ['A','B','C'] and List2 = ['B','A','C']

Is List1 == List2?

- a. Yes
- b. No

- c. Cannot predict
- d. None of the above

B. True or False

1. The `list()` is used to create an empty list.
2. The `range()` is used for creating a list with elements from 0 to 5.
3. A list can be created without using a constructor.
4. The elements of a list are not identified by their positions.
5. The negative index accesses elements from the start of a list.
6. List1[-1] accesses the first element of a list.
7. List1[2:5] returns all the elements stored between the index 2 and the one less than the end index, i.e. 5-1 = 4.
8. It is possible to access the elements of a list only in sequence.
9. The `len()` returns a number of elements in a list.
10. The `sum()` returns the sum of all the elements in a list.
11. It is impossible to shuffle elements randomly in a list.
12. The concatenation operator '+' is used to join two lists.
13. The multiplication operator '*' is used to replicate the elements in a list.
14. The `del` operator is used to remove a specific element from a list.
15. Odd elements of a list can be displayed using list comprehension.
16. One can insert an element at a given index.
17. The `pop(1)` removes an element from a list which is at index 1.
18. The `pop()` removes the last element from a list.
19. A string is a sequence of characters.
20. A programmer can pass a list to a function and perform various operations.

C. Exercise Questions

1. How is a list created?
2. Explain the different ways to create a list with suitable examples.
3. What is meant by slicing operation?
4. What is the benefit of step size in a list?
5. Explain the supporting inbuilt functions used to create lists.
6. List and clarify the operators supporting lists.
7. What is the use of the 'is' operator in Python?
8. Which operator is used to delete elements from a list?
9. What application is used for list comprehension?
10. What facilitates counting of similar elements in a list?
11. How are elements of a list reversed?
12. How is a string converted into characters?
13. How is an empty list and list with five integers, i.e. 10, 15, 30, 50 and 40 created?

14. Given: List1 = ['a','b','c','d','e'] and List2= [1, 2, 3]. What is the return value of each of the following statements?
- | | |
|------------|----------------|
| a. ice | b. List1+List2 |
| c. List2*2 | d. 2*List2 |
15. Given: List1 = [100,200,400,500]. What is the return value of the following statements?
- | | |
|--------------------------------------|---------------------|
| a. min(List1) | b. max(List1) |
| c. sum(List1) | d.) List.count(400) |
| e. List1.count(100)+List1.count(200) | |
16. Given: List1 = [12, 23, 45, 23]. What is the return value of the following statements?
- | | |
|--------------------------|--------------------|
| a. List1*List1.count(23) | b. List1+List1[:] |
| c. List1+List1[-1:] | d. List1+List1[::] |
| e. List1+List1[::-1] | |
17. Given: List Lst = [10,23,5,56,78,90]. Evaluate the following expressions.
- | | |
|--------------|--------------|
| a. Lst[:] | b. Lst[0:4] |
| c. Lst[:-1] | d. Lst[-1:] |
| e. Lst[-1] | f. Lst[::-1] |
| g. Lst[:-1:] | h. Lst[:-2:] |
18. Given: List1= [12, 45, 7, 89, 90]. What is the return value of the following statements?
- | | |
|---------------------|-----------------|
| a. List1.reverse() | b. List1.sort() |
| c. List1.append(10) | d. List.pop(2) |
| e. List1.clear() | |
19. What is the error in the following program?
- ```
List1=['a','b','c','d']
List2=[]+List1
List1[1]='f'
print(List1*List2)
print(List2)
```
20. Write a program to pass a list to a function and return it in the reverse order.

## PROGRAMMING ASSIGNMENTS

1. Write the function Replicate\_n\_times(Lst,n) to replicate the elements of a list n times, i.e. to replicate the elements of a list for a given number of times.

**Example:**

```
Lst = [1, 2, 3, 4]
Replicate_n_time(Lst,2)
Lst = [1,1,2,2,3,3,4,4]
```

2. Write a program to count the occurrences of each element within a list.

**Example:**

```
Lst = [1, 23, 0, 9, 0 ,23]
1 occurs 1 time
```

(Contd.)

## PROGRAMMING ASSIGNMENTS (Contd.)

```
23 occurs 2 times
0 occurs 2 times
9 occurs 1 times
```

3. Write the function `remove_negative(Lst)` to remove the negative elements and return the positive elements from a list.

**Example:**

```
Lst = [-1, 0, 2, -4, 12]
#Should return list with positive elements
Lst = [0, 2, 12]
```

4. Write a program to duplicate all the elements of a list.

**Example:**

```
Lst=[1,2,3]
#Should return
Lst=[1,1,2,2,3,3]
```

5. Write a program to check if an element of a list is a prime number. If it is prime, return True or else return False.

**Example:**

```
List1=[3,17,9,2,4,8]
#Should display
Lsit1=[True, True, False, False, False, False]
```

6. Write the function `remove_first_last(list)` to remove the first and last element from a list.

**Example:**

```
List1=[10,20,30,40,50]
removeFirstAndLast(Lis1)
#should return
[20, 30, 40]
```

7. Write a function `Extract_Even(List)` to return all even numbers from a list.

**Example:**

```
List1=[1,2,3,4,5,6]
Extract_Even(List1)
#should return
[2,4,6]
```

# List Processing: Searching and Sorting

## 9

### CHAPTER OUTLINE

|                          |                             |
|--------------------------|-----------------------------|
| 9.1 Introduction         | 9.3 Introduction to Sorting |
| 9.2 Searching Techniques |                             |

### LEARNING OUTCOMES

*After completing this chapter, students will be able to:*

- Develop applications based on different searching and sorting techniques
- Explain the importance of information retrieval
- Perform program implementation on linear/sequential search method and analysis of sequential search method
- Search an element from a list using binary search
- Sort the elements of a list using different sorting techniques, such as bubble sort, selection sort, quick sort, insertion and merge sort

## 9.1 INTRODUCTION

Numerous applications are available today to search and sort objects or items. For example, many a times, official files or list of meritorious students based on marks are stored alphabetically and sorted in a descending order. Thereby, making it easier to search for a specific item from the sorted list. A common and time-consuming task is retrieval of information from large data sets, which requires extensive research. A computer can easily manage this task. It can store everything from a small collection of personal data, phonebook information, photo catalogue to more detailed

financial records, information of employees, medical records, etc. Computers are widely used to search information, music, movies, readings etc. A computer rearranges the searched information to make it easier for a user to sort what he/she needs. For example, sorting a list of contacts by name or sorting a list of movies in an alphabetical order or arranging a list of files in increasing order of size etc. To be able to perform all such activities, two fundamental operations, viz. **searching** and **sorting** are needed.

## 9.2 SEARCHING TECHNIQUES

Searching is a technique of quickly finding a specific item from a given list of items, such as a number in a telephone directory. Each record has one or more fields such as name, address and number. Among the existing fields, the field used to distinguish records is called the **key**. Imagine a situation where you are trying to find the number of a friend. If you try to locate the record corresponding to the name of your friend, the 'name' will act as the key. Sometimes there can be various mobile numbers allotted to the same name. Therefore, the selection of the key plays a major role in defining the search algorithm. If the key is unique, the records are also identified uniquely. For example, mobile number can be used as the key to search for the mobile number of a specific person. If the search results in locating the desired record then the search is said to be successful, else the search is said to be unsuccessful. Depending on way the information is stored for searching a particular record, search techniques are categorised as:

- (a) Linear or sequential search
- (b) Binary search

These search techniques are explained in detail in this chapter.

### 9.2.1 Linear/Sequential Search

In linear search, elements are examined sequentially starting from the first element. Element to be searched, i.e. the (**key element**), is compared sequentially with each element in a list. The search process terminates when the element to be searched, i.e. the key element, matches with the element present in the list or the list is exhausted without a match being found in it. If the element to be searched is found within the list, the linear search returns the index of the matching element. If the element is not found, the search returns -1.

**PROGRAM 9.1** | Write a program to search an element from a list.

```
def Linear_Search(My_List, key):
 for i in range(len(My_List)):
 if(My_List[i]==key):
 #print(key,"is found at index",i)
 return i
 break
 return -1
My_List=[12,23,45,67,89]
```

(Contd.)

```

print("Contents of List are as follows:")
print(My_List)
key=(int(input("Enter the number to be searched:")))
L1=Linear_Search(My_List,key)
if(L1!=-1):
 print(key ," is found at position",L1+1)
else:
 print(key," is not present in the List")

```

### Output

#### #Test Case 1

```

Contents of List are as follows:
[12, 23, 45, 67, 89]
Enter the number to be searched:23
23 is found at position 2

```

#### #Test Case 2

```

Contents of List are as follows:
[12, 23, 45, 67, 89]
Enter the number to be searched:65
65 is not present in the List

```

**Explanation** In the above program, we have defined the function called **Linear\_Search()**. The list and element to be searched, i.e. the key, is passed to the function. The comparison starts from the first element of the list. The comparison goes on sequentially till the key element matches the element present within the list or the list is exhausted without a match being found.

### Unordered List—Analysis of Sequential Search

Table 9.1 shows that the analysis has been made with respect to the unordered list, i.e. if the content of the list is not in any order, either ascending or descending.

**Table 9.1** Sequential search analysis in an unordered list

| Case                               | Best Case | Worst Case | Average Case |
|------------------------------------|-----------|------------|--------------|
| Element is present in the list     | 1         | N          | N/2          |
| Element is not present in the list | N         | N          | N            |

### Sorted List—Analysis of Sequential Search

Expected number of comparisons required for an unsuccessful search can be reduced if the list is sorted.



**Example**

```

List1[] = 10 15 20 25 50 60 70 80
 ↑
Element to be searched = 30
 Search should terminate here.

```

Assuming the elements are stored in an ascending order, the search should terminate as soon as the value of the element in the list is greater than value of the element (key) to be searched or the key (element to be searched) is found (Table 9.2).

**Table 9.2** Sequential search analysis on a sorted list

|                                           | <i>Best Case</i> | <i>Worst Case</i> | <i>Average Case</i> |
|-------------------------------------------|------------------|-------------------|---------------------|
| <b>Element is present in the list</b>     | 1                | N                 | N/2                 |
| <b>Element is not present in the list</b> | 1                | N                 | N/2                 |

**9.2.2 The Binary Search**

In the previous section, we learnt linear search algorithm. Linear search is convenient for a small list. What happens if the size of a list is large? Let us consider the size of the list is 1 Million ( $2^{20}$ ). So, if we want to search using a sequential search algorithm then in the worst case we require  $2^{20}$  comparisons. This means that a sequential search algorithm is not suitable for a large list. Thus, we require more efficient algorithms. In this section, we will explore how binary search is a simple and efficient algorithm.

For binary search, the elements in a list must be in a sorted order. Let us consider the list is in ascending order. The binary search compares the element to be searched, i.e. the key element with the element in the middle of the list. The binary search algorithm is based on the following three conditions:

1. If the key is less than the list's middle element then a programmer has to search only in the first half of the list.
2. If the key is greater than the list's middle element then a programmer has to search only in the second half of the list.
3. If the element to be found, i.e. the key element is equal to the middle element in the list then the search ends.
4. If the element to be found is not present within the list then it returns None or -1 which indicates the element to be searched is not present in the list.

**Example of Binary Search**

Consider the sorted list of 10 integers given below.

10 18 19 20 25 28 48 55 62 70

Element to be searched = 48

### Iteration 1

| Index           | 0     | 1  | 2  | 3  | 4     | 5  | 6  | 7  | 8      | 9  |
|-----------------|-------|----|----|----|-------|----|----|----|--------|----|
| Element of List | 10    | 18 | 19 | 20 | 25    | 28 | 48 | 55 | 62     | 70 |
|                 | ↑     |    |    |    | ↑     |    |    |    |        | ↑  |
|                 | Low=0 |    |    |    | Mid=4 |    |    |    | High=9 |    |

$$\begin{aligned}\text{Mid} &= (\text{Low} + \text{High})/2 \\ &= (0 + 9)/2 \\ &= 4\end{aligned}$$

Now we will compare the middle element which is 25 with the element that we want to search, i.e. 48.

Since  $48 > 25$ ,

we will eliminate the first half of the list and we will search again in the second half of the list.

Now,

**Low** =  $\text{Mid} + 1 = 4 + 1 = 5$  #Change the Position of Low

**High** = 9 # High will remain as earlier.

### Iteration 2

| Index           | 0  | 1  | 2  | 3  | 4  | 5     | 6  | 7     | 8  | 9      |
|-----------------|----|----|----|----|----|-------|----|-------|----|--------|
| Element of List | 10 | 18 | 19 | 20 | 25 | 28    | 48 | 55    | 62 | 70     |
|                 |    |    |    |    |    | ↑     |    | ↑     |    | ↑      |
|                 |    |    |    |    |    | Low=5 |    | Mid=7 |    | High=9 |

$$\begin{aligned}\text{Mid} &= (\text{Low} + \text{High})/2 \\ &= (5 + 9)/2 \\ &= 7\end{aligned}$$

Now we will compare the middle element which is 55 with element we want to search, i.e. 48.

Since  $48 < 55$ ,

we will search the element in the left half of the list.

Now,

**Low** = 5 #It will remain as it is.

**High** =  $\text{Mid} - 1 = 7 - 1 = 6$  #Change the Position of High

**Iteration 3**

|                        |          |          |          |          |          |          |          |          |          |          |
|------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>Index</b>           | <b>0</b> | <b>1</b> | <b>2</b> | <b>3</b> | <b>4</b> | <b>5</b> | <b>6</b> | <b>7</b> | <b>8</b> | <b>9</b> |
| <b>Element of List</b> | 10       | 18       | 19       | 20       | 25       | 28       | 48       | 55       | 62       | 70       |

  
**Low=5 High=6**  
**Mid=5**

$$\text{Mid} = (\text{Low} + \text{High}) / 2$$

$$= (5 + 6) / 2$$

$$= 5$$

Now we will compare the middle element which is **28** with the element we want to search, i.e. 48.

Since **28 < 48**,

we will search the element in the right portion of the mid of the list.


Now,

**Low** = mid+1 = 6 #Change the Position of Low

**High** = 6 #High will remain as it is.

**Iteration 4**

|                        |          |          |          |          |          |          |          |          |          |          |
|------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>Index</b>           | <b>0</b> | <b>1</b> | <b>2</b> | <b>3</b> | <b>4</b> | <b>5</b> | <b>6</b> | <b>7</b> | <b>8</b> | <b>9</b> |
| <b>Element of List</b> | 10       | 18       | 19       | 20       | 25       | 28       | 48       | 55       | 62       | 70       |

  
**Low=6 High= Mid=6**

$$\text{Mid} = (\text{Low} + \text{High}) / 2$$

$$= 6$$

Now we will compare the middle element which is 48 with the element we want to search, i.e. 48.

Since 48=48, the number is found at index position 6.

**PROGRAM 9.2** | Write a program for binary search.

```
def Binary_Search(MyList, key):
 low=0
 high=len(MyList)-1
 while low<=high:
```

(Contd.)

```

mid=(low+high)//2 #Find the middle index
if MyList[mid]==key: #If key matches the mid index element
 return mid #If so return index
elif key>MyList[mid]: # else if key is greater
 low=mid+1
else:
 high=mid-1
return -1 #If no match return -1
MyList=[10,20,30,34,56,78,89,90]
print(MyList)
key=(eval(input("Enter the number to Search:")))
x=Binary_Search(MyList,key)
if(x==-1):
 print(key,"is not present in the list")
else:
 print(" The Element ",key," is found at position ",x+1)

```

### Output

#### #Test Case1

```

[10, 20, 30, 34, 56, 78, 89, 90]
Enter the number to Search: 20
The Element 20 is found at position 2

```

#### #Test Case 2

```

[10, 20, 30, 34, 56, 78, 89, 90]
Enter the number to Search: 43
43 is not present in the list

```

**Explanation** In the above program, we have defined the list with the elements [10 20 30 34 56 78 89 90]. The number to be searched is prompted from the user. The list and the number to be searched both are passed as parameters to the function. In each iteration, the value of low, middle and high is calculated. The element to be searched, i.e. the key element is compared with the middle element. Then depending on the condition, i.e. the value of the key element and the element found at the mid position, the values of low and high are changed.

### **Searching a List of Words from a Dictionary is Similar to Binary Search**

The binary search algorithm works in a manner similar to searching a word from a dictionary. Let us assume we want to search for a word starting with a particular letter, say 'L'. Next, we open the dictionary. If the page we have opened contains the word starting with 'L' then we have found what we are looking for. But if the page we have opened contains words starting from 'G' then we have to search again. So far, to find our word starting from 'L' we will not search the left

(Contd.)

part of the dictionary anymore, i.e. words starting from A to G. Hence, we will eliminate this part without looking anymore.

Next, we will search the remaining right side of the dictionary, i.e. from H to Z. As before, we will open any page from H to Z and check the words appearing on that page. If the opened page contains words starting from L, our search is successful. If not, we check the words appearing on the page and if they start with a letter which comes after 'L' in the alphabetical order then we eliminate this second part and continue searching in the remaining part.

We will repeat this process in the remaining part, i.e. open a page check again. As the process is repeated, the size of the dictionary to be searched keeps reducing by about half each time until the word is not found on the current page.

### 9.3 INTRODUCTION TO SORTING

Consider a situation where a user wants to pick up a book from a library but finds that the books are stacked in no particular order. In this situation, it will be very difficult to find any book quickly or easily. However, if the books were placed in some order, say alphabetically, then a desired title could be found with little effort. As in this case, sorting is used in various applications in general to retrieve information efficiently.

Sorting means rearranging the elements of a list, so that they are organised in some relevant order. The order can be either ascending or descending. Consider a list L1, in which the elements are arranged in an ascending order in a way that  $L1[0] < L1[1] < \dots < L1[N]$ .

#### Example

If a list is declared and initialised as:

$$L1 = [9, 3, 4, 2, 1]$$

The sorted list in an ascending order can be:

$$L1 = [1, 2, 3, 4, 9]$$

Form the above example, it is clear that sorting is a process of converting an unordered set of elements into an ordered set.

#### 9.3.1 Types of Sorting

Sorting algorithms are divided into two main categories, viz.

1. Internal sorting
2. External sorting

If all the records to be sorted are kept internally in the main memory then they can be sorted using internal sort. However, if a large number of records are to be sorted and kept in secondary storage then they have to be sorted using external sort.

1. **Internal sorting algorithms:** Any sorting algorithm which uses the **main memory** exclusively during sorting is called an **internal sort algorithm**. It takes advantage of the random access nature of the main memory. Internal sorting is faster than external sorting.

2. **External sorting algorithms:** External sorting is carried on **secondary storage**. Therefore, any sorting algorithm which uses external memory, such as tape or disk during sorting is called **external sort algorithm**. It is carried out if the number of elements to be stored is too large to fit in the main memory. Transfer of data between secondary and main memory is best done by moving blocks of contiguous elements.

The various sorting algorithms are Bubble sort, Selection sort, Insertion sort, Quick sort and Merge sort. Details of implementation of all these sorting algorithms are given ahead in this chapter.

### 9.3.2 Bubble Sort

Bubble sort is the simplest and oldest sorting algorithm. Bubble sort sorts a list of elements by repeatedly moving the largest element to the highest index position of the list. The consecutive adjacent pair of elements in both the lists is compared with each other. If the element at lower index is greater than the element at higher index then the two elements are interchanged so that the element with the smaller value is placed before the one with a higher value. The algorithm repeats this process till the list of unsorted elements is exhausted. This entire procedure of sorting is called bubble sort. The algorithm derives its name as bubble sort because the smaller elements bubble to the top of the list.

#### Example of Bubble Sort

Consider the elements within a list as:

L1 = [30, 50, 45, 20, 90, 78]

Sort the list using bubble sort.

#### Solution

##### Iteration 1

|    |    |    |    |    |    |                                                                                                                                         |
|----|----|----|----|----|----|-----------------------------------------------------------------------------------------------------------------------------------------|
| 30 | 40 | 45 | 20 | 90 | 78 | No Exchange                                                                                                                             |
| 30 | 40 | 45 | 20 | 90 | 78 | No Exchange                                                                                                                             |
| 30 | 40 | 45 | 20 | 90 | 78 | Exchange                                                                                                                                |
| 30 | 40 | 20 | 45 | 90 | 78 | No Exchange                                                                                                                             |
| 30 | 40 | 20 | 45 | 90 | 78 | Exchange                                                                                                                                |
| 30 | 40 | 20 | 45 | 78 | 90 | Output of bubble sort after the first iteration. But still the output is not in a sorted order. Repeat the above steps for iteration 2. |

**Iteration 2**

Apply bubble sort to the output of the first iteration.

|    |    |    |    |    |    |                                                                                                                                             |
|----|----|----|----|----|----|---------------------------------------------------------------------------------------------------------------------------------------------|
| 30 | 40 | 20 | 45 | 78 | 90 | No Exchange                                                                                                                                 |
| 30 | 40 | 20 | 45 | 78 | 90 | Exchange                                                                                                                                    |
| 30 | 20 | 40 | 45 | 78 | 90 | No Exchange                                                                                                                                 |
| 30 | 20 | 40 | 45 | 78 | 90 | No Exchange                                                                                                                                 |
| 30 | 20 | 40 | 45 | 78 | 90 | Output of bubble sort after the second iteration.<br>But still the output is not in a sorted order. Repeat the above steps for iteration 3. |

**Iteration 3**

Apply bubble sort to the output of the second iteration.

|    |    |    |    |    |    |             |
|----|----|----|----|----|----|-------------|
| 30 | 20 | 40 | 45 | 78 | 90 | Exchange    |
| 20 | 30 | 40 | 45 | 78 | 90 | No Exchange |
| 20 | 30 | 40 | 45 | 78 | 90 | No Exchange |
| 20 | 30 | 40 | 45 | 78 | 90 | No Exchange |
| 20 | 30 | 40 | 45 | 78 | 90 | No Exchange |

Thus, in third iteration itself we have obtained a sorted list of elements in an ascending order.

**Working of Bubble Sort**

In the above example, the working of bubble sort can be generalised as:

1. In each iteration, the first element of the list, i.e.  $L[1]$  is compared with the second element of the list, i.e.  $L[2]$  then  $L[2]$  is compared with  $L[3]$ ,  $L[3]$  is compared with  $L[4]$  and so on. Finally,  $L[N-1]$  is compared with  $L[N]$ . This process is continued till we obtain the list in a sorted order.
2. In the second iteration,  $L[1]$  is compared with  $L[2]$ ,  $L[2]$  is compared with  $L[3]$  and so on. Finally,  $L[N-2]$  is compared with  $L[N-1]$ . The iteration 2 just requires  $N-2$  comparisons. Therefore, at the end of the second iteration, the second biggest element is placed at the second highest index position of the list.
3. Similarly, the above process is continued for the subsequent iterations. Therefore, in the last iteration we obtain all the elements within the list in a sorted order.

**PROGRAM 9.3** | Write a program to implement bubble sort.

```
def Bubble_Sort(MyList):
 for i in range(len(MyList)-1,0,-1):
 for j in range(i):
 if MyList[j]>MyList[j+1]:
 temp, MyList[j]=MyList[j], MyList[j+1]
 MyList[j+1] = temp
MyList = [30, 50, 45,1,6,3,20, 90, 78]
print('Elements of List Before Sorting: ', MyList)
Bubble_Sort(MyList)
print('Elements of List After Sorting: ',end='')
print(MyList)
```

**Output**

```
Elements of List Before Sorting: [30, 50, 45, 1, 6, 3, 20, 90, 78]
Elements of List After Sorting: [1, 3, 6, 20, 30, 45, 50, 78, 90]
```

**Explanation** In the above program, the unsorted list is declared and initialised. The same list is passed as an argument to the function bubble sort. The list slicing operation is used to iterate through the loop. Each element is compared with its adjacent element and interchanged if the first element is greater than the second. Swapping of elements is done using Python's simultaneous assignment as shown.

```
if MyList[j]>MyList[j+1]:
 temp,MyList[j]= MyList[j],MyList[j+1]
 MyList[j+1] = temp
```

Therefore, the above code is used to swap two elements. The above code is equivalent to the code below. Thus, a programmer should make use of the code above since it reduces the number of code lines.

```
if MyList[j]>MyList[j+1]:
 temp = MyList[j]
 MyList[j]= MyList[j+1]
 MyList[j+1] = temp
```

**9.3.3 Selection Sort**

Consider a list of 10 elements list[0], list[1],.....list[N-1]. First you will search for the position of the smallest element from list[0] to list[N-1] and then interchange the smallest element with list[0]. Now you will search for the position of the second smallest element from list[1] to list[n-1] and then interchange that smallest element with list[1]. This process continues till the end and finally we obtain the sorted list. The whole process of selection sort will be as shown.



**Iteration 1**

1. Search the smallest element from list[0] to list[N-1].
2. Interchange list[0] with the smallest element.

Result: list[0] is sorted.

**Iteration 2**

1. Search the smallest element from list[1] to list[N-1].
2. Interchange list[1] with the smallest element.

Result: list[0],list[1] is sorted.

**Iteration N-1**

1. Search the smallest element from list[N-1] to list[N-1].
2. Interchange list[N-1] with the smallest element.

Result: list[0].....list[N-1].

**Example of Selection Sort**

Consider the unsorted list of 8 elements as

[74, 34, 42, 13, 87, 24, 64, 57]

**Operation**

Select **13** as the smallest element and swap it with 74 as the first element within the list.

74 34 42 13 87 24 64 57

Select **24** as the smallest element and swap it with 34 in the remaining list.

13 34 42 74 87 24 64 57

Select **34** as the smallest element and swap it with 42 in the remaining list.

13 24 42 74 87 34 64 57

Select **42** as the smallest element and swap it with 74 in the remaining list.

13 24 34 74 87 42 64 57

Select **57** as the smallest element and swap it with **87**.

13 24 34 42 87 74 64 57

Select **64** as the smallest element and swap it with **74** in the remaining list.

13 24 34 42 57 74 64 87

**Final Sorted List**

13 24 34 42 57 74 64 87



**Note:** Selection sort repeatedly selects the smallest element and swaps it with the first element in the remaining list.

#### PROGRAM 9.4 | Write a program for selection sort.

```
def Selection_Sort(MyList):
 #i - Outer Loop
 #j - Innner Loop
 #k - Index of the smallest Element
 for i in range(len(MyList)-1):
 k=i #i th element is assumed to be smallest
 for j in range(i+1,len(MyList)):
 if (MyList[j]<MyList[k]):
 k=j
 if (k!=i):
 temp=MyList[i]
 MyList[i]=MyList[k]
 MyList[k]=temp
MyList=[12,34,2,7,45,90,89,9,1]
print('Elements before Sorting')
print(MyList)
Selection_Sort(MyList)
print('Elements After Sorting')
print(MyList)
```

#### Output

```
Elements before Sorting
[12, 34, 2, 7, 45, 90, 89, 9, 1]
Elements After Sorting
[1, 2, 7, 9, 12, 34, 45, 89, 90]
```

### 9.3.4 Insertion Sort

Insertion sort is based on the principle of inserting an element in its correct place in a previously sorted list. It always maintains a sorted sublist in the lower portion of the list. Each new element is inserted back into the previous sub list. Thus, insertion sort sorts a list of elements repeatedly by inserting a new element into a sorted sublist until the whole list is sorted. An example of insertion sort is given below.

#### Example

Consider the unsorted list as

**MyList** = [15,0,11,19,12,16,14]

Initially, the sorted sublist contains the first element in the list, i.e. 15

|    |   |    |    |    |    |    |
|----|---|----|----|----|----|----|
| 15 | 0 | 11 | 19 | 12 | 16 | 14 |
|----|---|----|----|----|----|----|



**Note:** The shaded gray color represents the ordered sublist.

- ◎ **STEP 1:** Initially, the sorted sublist contains the first element in the list, i.e. 15. Now insert the next element from the list, i.e. 0 into the sublist.

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 15 | 11 | 19 | 12 | 16 | 14 |
|---|----|----|----|----|----|----|

- ◎ **STEP 2:** The sorted sublist is [0, 15]. Insert 11 into the sublist.

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 11 | 15 | 19 | 12 | 16 | 14 |
|---|----|----|----|----|----|----|

- ◎ **STEP 3:** The sorted sublist is [0,11,15]. Insert 19 into the sublist.

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 11 | 15 | 19 | 12 | 16 | 14 |
|---|----|----|----|----|----|----|

- ◎ **STEP 4:** The sorted sublist is [0,11,15,19]. Insert 12 into the sublist.

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 11 | 12 | 15 | 19 | 16 | 14 |
|---|----|----|----|----|----|----|

- ◎ **STEP 5:** The sorted sublist is [0,11,12,15,19]. Insert 16 into the sublist.

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 11 | 12 | 15 | 16 | 19 | 14 |
|---|----|----|----|----|----|----|

- ◎ **STEP 6:** The sorted sublist is [0,11,12,15,16,19]. Insert 14, into the sublist.

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 11 | 12 | 15 | 16 | 19 | 14 |
|---|----|----|----|----|----|----|

- ◎ **STEP 7:** The sorted sublist is [0,11,12,14,16,19].

|   |    |    |    |    |    |    |
|---|----|----|----|----|----|----|
| 0 | 11 | 12 | 14 | 15 | 16 | 19 |
|---|----|----|----|----|----|----|

Finally, we obtain the sorted list of elements in Step 7.

**PROGRAM 9.5** | Write a program to implement insertion sort.

```
def Insertion_Sort(MyList):
 for i in range(1,len(MyList)):
 CurrentElement=MyList[i]
 k=i-1
 while k>=0 and MyList[k]>CurrentElement:
 MyList[k+1]=MyList[k]
 k=k-1

 MyList[k+1]=CurrentElement
MyList=[12,23,5,2,21,1,4]
print('Elements before Sorting')
print(MyList)
Insertion_Sort(MyList)
print('Elements After Sorting')
print(MyList)
```

**Output**

```
Elements before Sorting
[12, 23, 5, 2, 21, 1, 4]
Elements After Sorting
[1, 2, 4, 5, 12, 21, 23]
```

**9.3.5 Quick Sort**

Quick sort is one of the fastest internal sorting algorithms. It is based on the following three main strategies:

1. **Split or Partition:** Select a random element called **pivot** from the sequence of elements to be sorted. Suppose the selected element is X, where X is any number. Now split (divide) the list into the two small lists, viz. Y and Z such that:
  - All the elements of the first part Y are less than the selected element pivot.
  - All the elements of the second part Z are greater than the selected element pivot.
2. **Sort** the sub-arrays.
3. **Merge** (join/concatenate) the sorted sub-array.

The split divides the lists into two smaller sublists. When these sublists are ultimately sorted recursively using quick sort these sublists are called **conquered**. Therefore, the quick sort algorithm is also so called the **divide and conquer algorithm**.

Suppose there are N elements as a[0], a[1], a[2],.....a[N-1]. The steps for using the quick sort algorithm are given below.

- ◎ **STEP 1:** Select any element as the **pivot**. For example, select the element stored at the first position in a list as the pivot element. Although there are many ways to choose the

pivot element, we will use the first item from the list. It helps to split a list into two parts.

Pivot = a[First] //Select Pivot Element

where the value of First is 0.

- ◎ **STEP 2:** Initialize the two pointers i and j.

i = First+1 (The first (low) index of a list)

j = Last (The last (upper) index of a list)

- ◎ **STEP 3:** Now increase the value of i until we locate an element that is greater than the pivot element.

while i<=j and a[i] <= Pivot

i++

- ◎ **STEP 4:** Decrease the value of j until we find a value less than the pivot element.

while i<=j and a[j]>=Pivot

j--

- ◎ **STEP 5:** If i<j interchange i a[i] and a[j].

- ◎ **STEP 6:** Repeat Steps 2 to 4 until i>j.

- ◎ **STEP 7:** Interchange the selected data element pivot and a[j].

### Example

Consider the elements of a list as 50, 30, 10, 90, 80, 20, 40 and 60.

- ◎ **STEP 1:** Select the pivot element.

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |

From the above Step 1 it is clear that we have selected the first element as the **pivot value**, i.e. 50.

- ◎ **STEP 2:** Initialize the two pointers i and j.

The goal of selecting the pivot element is to place the elements less than the pivot towards the left and the elements greater than the pivot towards the right.

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |

↑  
i

↓  
j

30 < 50. Therefore, move the pointer i towards the right.

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

Again  $10 < 50$ . Therefore, move the pointer i towards the right.

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

But now the element  $90 > 50$ . Therefore, don't move the pointer i. Now move the pointer j towards the left if  $a[j] \geq \text{Pivot}$ .

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

The value of  $a[j]$  is 60. As  $a[j] \geq 50$ , decrease the pointer j by 1.

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

As  $A[j]$  is not greater than the pivot, i.e. 50. Therefore, don't move the pointer j towards the left.

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
| 50 | 30 | 10 | 90 | 80 | 20 | 40 | 60 |

↑  
i

↑  
j

Now we have got the value of i and j, i.e. the index values are 3 and 6, respectively. As  $i < j$ , `swap(a[i], a[j])`.

After swapping  $a[i]$  and  $a[j]$ , the content of the list becomes

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 80 | 20 | 90 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

As  $40 < 50$  (pivot), increase the value of i by 1. Now  $80 > \text{pivot}$ , i.e. (50), hence stop moving i towards the right and start moving j towards the left.

Now continue moving left and right until i crosses j.

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 80 | 20 | 90 | 60 |
|----|----|----|----|----|----|----|----|

↑  
i

↑  
j

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 80 | 20 | 90 | 60 |

$\uparrow$        $\uparrow$   
*i*      *j*

$i < j$ , swap( $a[i]$ ,  $a[j]$ ) after swapping the contents of list are as follows.

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 20 | 80 | 90 | 60 |

$\uparrow$        $\uparrow$   
*i*      *j*

The value of  $a[j]$  is 90. As  $a[j] \geq 50$ , decrease the pointer  $j$  by 1. The new value of  $a[j]$  is 20 and  $A[j]$  is not greater than pivot, i.e. 50. Hence, don't move the pointer  $j$  towards the left. Thus, we have found the final value of  $i$  and  $j$ .

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 20 | 80 | 90 | 60 |

$\uparrow$   
*i, j*

After, swapping we have to move the pointer  $i$  towards the left and  $j$  towards the right.

Now  $20 < 50$  (pivot), so increase the value of  $i$  by 1 towards the right.

The new index value of  $i$  is 5. As  $80 > 50$  stop moving  $i$  towards the right and find the index value of  $j$ .

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 20 | 80 | 90 | 60 |

$\uparrow$   
*i, j*

| 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----|----|----|----|----|----|----|----|
| 50 | 30 | 10 | 40 | 20 | 80 | 90 | 60 |

$\uparrow$        $\uparrow$   
*j*      *i*

As  $A[j]$ , i.e. 80 is greater than pivot, i.e. 50, move the pointer  $j$  towards the left.

From the above condition, it is clear that  $i$  crosses  $j$ . Thus, we stop at the point where the value of  $j$  becomes less than  $i$ . Therefore, the position of  $j$  is now the **split point**, i.e. the partition point.

As  $j < i$

**Swap(pivot,  $a[j]$ )**

After swapping,

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| 20 | 30 | 10 | 40 | 50 | 80 | 90 | 60 |
|----|----|----|----|----|----|----|----|

All the elements are less than pivot.

All the elements are greater than pivot.

From the above example, it is clear that 50 is placed in its proper position. Elements less than 50 are placed towards the left and those greater than 50 are placed towards the right. Now apply the same method recursively for the two sublists, viz. **Y(20, 30, 10, 40)** and **Z(80, 90, 60)**.

**PROGRAM 9.6** | Write a Python program to sort elements of a list using **quick sort**.

```

def quickSort(MyList):
 """ Sorts an array or list using the recursive quick sort algorithm. """
 print('Elements of List are as follows')
 print(MyList)
 n = len(MyList)
 Rec_Quick_Sort(MyList, 0, n-1)

def Rec_Quick_Sort(MyList, first, last):
 """ The recursive implementation. """
 if first < last:
 pos = Partition(MyList, first, last)
 """ Split the List into two sublists Left and Right. """
 Rec_Quick_Sort(MyList, first, pos - 1)
 Rec_Quick_Sort(MyList, pos + 1, last)

def Partition(MyList, first, last):
 """ Partitions the sublists or subarrays using the first key as the pivot.
 """

 pivot = MyList[first] #Select the Pivot element

 # Find the pivot position and move the elements around the pivot.
 i = first + 1
 j = last
 while i < j :

 # Find the first key larger than the pivot.
 while i <= j and MyList[i] <= pivot :
 i = i + 1

 #Find the key from the list that is smaller than or equal to the pivot.
 while j >= i and pivot <= MyList[j] :
 j = j - 1

 # Swap the two keys if we have not completed this partition.
 if i < j :
 temp= MyList[i]
 MyList[i] = MyList[j]
 MyList[j] = temp

```

(Contd.)



```

 # Put the pivot in the proper position.
 #Swap pivot with MyList[j]
 temp=MyList[first]
 MyList[first] = MyList[j]
 MyList[j] = temp

 # Return the index position to partition into left and right
 return j

MyList=[50, 30, 10, 90, 80, 20, 40, 60];
quickSort(MyList)
print('Elements of List after Sorting Using Quick Sort')
print(MyList)

```

**Output**

```

Elements of List are as follows
[50, 30, 10, 90, 80, 20, 40, 60]
Elements of List after Sorting Using Quick Sort
[10, 20, 40, 30, 50, 60, 80, 90]

```

**9.3.6 Merge Sort**

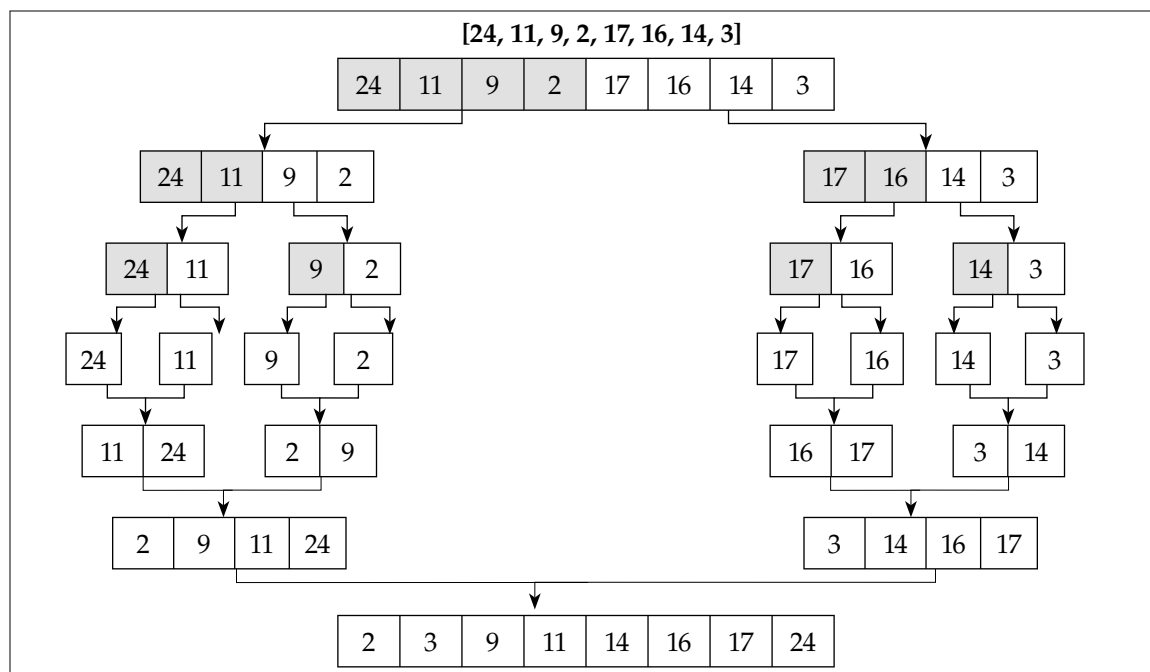
As discussed in the previous sections all sorting algorithms are mainly used for internal sorting where the data to be sorted fits in the main memory. When the data to be sorted resides in a file or on a disk and does not fit in the available memory, the merge sort method is used. Merge sort is a well-known and efficient method for external sorting.

Like quick sort, merge sort is also based on three main strategies:

- (a) Split the list into two sub lists (**Split or Divide**): Split implies partitioning the  $n$  elements of a list into two sublists, where each sublist contains  $n/2$  elements.
- (b) Sort sublists (**Conquer**): Sorting two sub-arrays recursively using merge sort.
- (c) Merge the sorted sublists (**Combine**): Combine implies merging two sorted sublists, each of size  $n/2$ , to produce a sorted list of  $n$  elements.

**Example of Merge Sort**

Consider the following elements within a list.



**Figure 9.1** Example of merge sort

The list in Figure 9.1 has 8 elements. The index of the first element is  $i=0$  and the index of the last element is  $j=7$ . In order to divide the above list around the middle element, the index of the middle element is found, i.e.  $\text{mid}=(i+j)/2$ .

Therefore,  $i = 0$  and  $j = 7$

$$\text{Mid} = (i + j) / 2 = (0+7)/2 = 3.$$

Merge sort is applied recursively to the left part of the list from  $i = 0$  to  $j = 3$ . After sorting of the left half of the list, the right half of the list is sorted from  $i= 4$  to  $j = 7$  recursively using merge sort. After sorting the left half of the list from  $i = 0$  to  $j = 3$  and right half of the list from  $i=4$  to  $j=7$ , the two lists are merged to produce a single sorted list.

### Merging Operation in Merge Sort

A fundamental operation in the merge sort algorithm is merging of two sorted lists. The merging algorithm takes two sorted lists  $a[]$  and  $b[]$ , i.e. (left and right list) as the input and the third list  $c[]$  as the output list. Each element of a list, i.e. (**LeftList**)  $a[i]$  is compared with the elements of the (**RightList**)  $b[j]$ . The smaller element among  $a[i]$  and  $b[j]$  is copied to the output list  $c[k]$ . When either of the input list is exhausted, the remainder of the other list is copied to the output list  $c$ .

In the above example, we obtained two sorted sublists, viz.  $a[]$  as the left list and  $b[]$  as the right list, as shown.

Left List a[]

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

↑  
i=0

Right List b[]

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

↑  
j=0

Output List

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

↑  
k=0

◎ **STEP 1:**

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

↑  
i=0

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

↑  
j=0

|   |  |  |  |  |  |  |  |
|---|--|--|--|--|--|--|--|
| 2 |  |  |  |  |  |  |  |
|---|--|--|--|--|--|--|--|

↑  
k=0

◎ **STEP 2:**

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

↑  
i=1

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

↑  
j=0

|   |   |  |  |  |  |  |  |
|---|---|--|--|--|--|--|--|
| 2 | 3 |  |  |  |  |  |  |
|---|---|--|--|--|--|--|--|

↑  
k=1

◎ **STEP 3:**

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

↑  
i=1

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

↑  
j=1

|   |   |   |  |  |  |  |  |
|---|---|---|--|--|--|--|--|
| 2 | 3 | 9 |  |  |  |  |  |
|---|---|---|--|--|--|--|--|

↑  
k=2

◎ **STEP 4:**

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

↑  
i=2

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

↑  
j=1

|   |   |   |    |  |  |  |  |
|---|---|---|----|--|--|--|--|
| 2 | 3 | 9 | 11 |  |  |  |  |
|---|---|---|----|--|--|--|--|

↑  
k=3

◎ **STEP 5:**

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

↑  
i=3

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

↑  
j=1

|   |   |   |    |    |  |  |  |
|---|---|---|----|----|--|--|--|
| 2 | 3 | 9 | 11 | 14 |  |  |  |
|---|---|---|----|----|--|--|--|

↑  
k=4

◎ **STEP 6:**

|   |   |    |    |
|---|---|----|----|
| 2 | 9 | 11 | 24 |
|---|---|----|----|

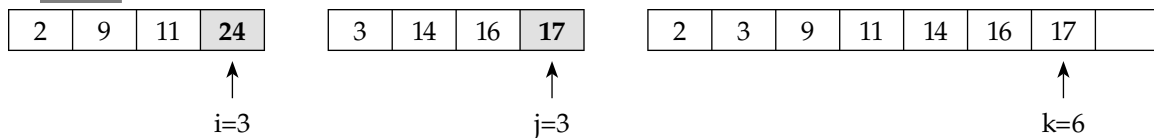
↑  
i=3

|   |    |    |    |
|---|----|----|----|
| 3 | 14 | 16 | 17 |
|---|----|----|----|

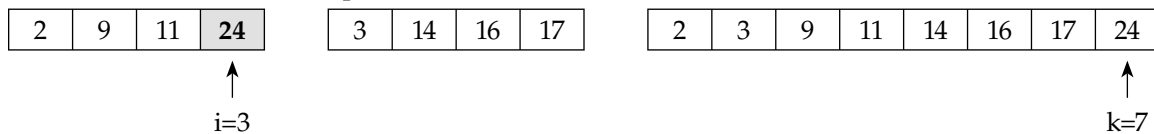
↑  
j=2

|   |   |   |    |    |    |  |  |
|---|---|---|----|----|----|--|--|
| 2 | 3 | 9 | 11 | 14 | 16 |  |  |
|---|---|---|----|----|----|--|--|

↑  
k=5

◎ **STEP 7:**

◎ **STEP 8:** In Step 7, the list b[] is exhausted. Therefore, the remaining elements of the list a[] are added to the output list.



Finally, in Step 8, all the elements of the list are sorted.

### PROGRAM 9.7 | Write a program to implement merge sort.

```
def mergeSort(MyList):
 if len(MyList)>1:
 mid = len(MyList)//2
 leftList = MyList[:mid]
 rightList = MyList[mid:]
 '''Merge sort to the left part of the list from 0 to mid-1.'''
 mergeSort(leftList)
 '''Merge sort to the right part of the list from mid to len(List)'''
 mergeSort(rightList)
 i=0
 j=0
 k=0
 ''' Merge Two Sorted List i.e. LeftList and RightList'''
 while i < len(leftList) and j < len(rightList):
 if leftList[i] < rightList[j]:
 MyList[k]=leftList[i]
 i=i+1
 else:
 MyList[k]=rightList[j]
 j=j+1
 k=k+1

 while i < len(leftList):
 MyList[k]=leftList[i]
```

(Contd.)

```

 i=i+1
 k=k+1

 while j < len(rightList):
 MyList[k]=rightList[j]
 j=j+1
 k=k+1

MyList = [54,26,93,17,77,31,44,55,20]
print('List Before Sorting',MyList)
mergeSort(MyList)
print('List After Sorting',MyList,end='')

```

**Output**

```

List Before Sorting [24, 11, 9, 2, 17, 16, 14, 3]
List After Sorting [2, 3, 9, 11, 14, 16, 17, 24]

```

**Explanation** In the above program, initially the list of elements are declared. The list is passed as argument to the function **mergeSort()**. If the list contains more than one element then the index of the middle element is calculated and the existing list is divided into two parts. Once the merge sort function is invoked on the left and right part of the list, the rest of the code is responsible for merging the two smaller sorted lists into a larger sorted list.

While merging the two sorted lists, the elements of the left list are compared with the elements of the right list. The elements with smaller values are placed in the output list. The process continues till we obtain the sorted list.

## MINI PROJECT **Sorting Based on the Length of Each Element**

This mini project will use programming features, such as **lists**, **functions** and **sorting algorithms** to sort the sequence of elements from a list based on some conditions.

**PROBLEM STATEMENT** | Sort list according to the length of the elements. Assume that the elements within the list are of type integers.

**Input**

Elements of a list (before sorting) based on the length of the element are

```
[23, 10, 4566, 344, 123, 121]
```

**Output**

Elements of a list (after sorting) based on the length of the elements are

```
[23, 10, 344, 123, 121, 4566]
```

### Algorithm

- ◎ **STEP 1:** Define the list with n number of elements of your choice.
- ◎ **STEP 2:** Pass the list to the function **Bubble\_Sort()**
- ◎ **STEP 3:** Calculate the length of each element by calling **calc()** function.
- ◎ **STEP 4:** In each iteration, compare the length of each element with the length of the neighbouring element and swap the elements accordingly.
- ◎ **STEP 5:** Print the sorted list according to the length of each element.

### Program

```
def calc(n): #Function to Calculate length of an element
 c = 0
 while n > 0:
 n = n//10
 c = c + 1
 return c #return length of an element

def Bubble_Sort(MyList):
 for i in range(len(MyList)-1,0,-1):
 for j in range(i):
 if calc(MyList[j]) > calc(MyList[j+1]):
 temp,MyList[j]=MyList[j],MyList[j+1]
 MyList[j+1] = temp
MyList = [23,10,4566,344,123,121]
print('List before sorting based on length of each element:')
print(MyList)
Bubble_Sort(MyList)
print('List after Sorting based on length of each element:')
print(MyList)
```

### Output

```
List before sorting based on length of each element:
[23, 10, 4566, 344, 123, 121]
List after Sorting based on length of each element:
[23, 10, 344, 123, 121, 4566]
```

Thus, this program will help a user to sort the elements of a list based on the length of each element.

## SUMMARY

- ♦ Binary search is faster than linear search. However, data within a list must be in a sorted order while using binary search to search the elements within a list.
- ♦ Sorting is a method which rearranges the elements of a list, so that they are kept in some relevant order. The order can be either ascending or descending.

## KEY TERMS

- ⇒ **Linear Search:** Searches sequentially
- ⇒ **Binary Search:** Divides a sorted list in two parts until an element is found
- ⇒ **Bubble Sort:** Adjacent elements of a list are compared frequently
- ⇒ **Selection Sort:** Selects the smallest element and swaps it with the first element in the remaining list
- ⇒ **Insertion Sort:** Inserts a new element into a previously sorted list
- ⇒ **Quick Sort:** Sorting of elements within the list is based on selection of a pivot element

## REVIEW QUESTIONS

## A. Multiple Choice Questions

1. Which sorting algorithm selects the smallest element from a list and interchanges it with the first position?
  - a. Insertion sort
  - b. Selection sort
  - c. Bubble sort
  - d. Quick sort
2. Insertion sort is based on which principle?
  - a. Inserting an element at the correct place in a previously unsorted list.
  - b. Inserting an element at the correct place in a previously sorted list.
  - c. Cannot predict
  - d. None of the above
3. Quick sort is also known as:
  - a. Merge sort
  - b. Partition and exchange sort
  - c. Shell sort
  - d. None of the above
4. Which sorting algorithm is of divide and conquer type?
  - a. Bubble sort
  - b. Insertion sort
  - c. Selection sort
  - d. Quick sort
5. The worst case while searching an element in linear search is \_\_\_\_\_.
  - a. Element is present in the middle of the list
  - b. Element is present at the last
  - c. Element is not present in the list at all
  - d. Element is present at the first position

6. A pivot element to partition unsorted list is used in:
  - a. Selection sort
  - b. Merge sort
  - c. Insertion sort
  - d. Quick sort
7. Which strategy is used by merge sort?
  - a. Divide and conquer
  - b. Divide
  - c. Greedy approach
  - d. None of the above
8. If a list is sorted or nearly in a sorted order then which algorithm gives a better performance?
  - a. Selection sort
  - b. Insertion sort
  - c. Quick sort
  - d. Merge sort
9. Which search algorithm requires the list to be in a sorted order?
  - a. Linear search
  - b. Binary search
  - c. Both a and b
  - d. None of the above
10. The best case while searching an element in a binary search is \_\_\_\_\_.
  - a. Element found at first position
  - b. Element found at last position
  - c. Element found at middle position
  - d. None of the above

## B. True or False

1. In linear search, the elements are examined sequentially starting from the first element.
2. In binary search, the elements in a list must be in a sorted order.
3. Any sort algorithm that uses the main memory exclusively during sorting is called an internal sort algorithm.
4. Binary search algorithm compares an element to be searched with the last element of a list in each iteration.
5. Internal sorting is slower than external sorting.
6. Insertion sort is based on the principle of inserting the elements at their correct place in a previously sorted list.
7. Insertion sort always maintains a sorted sublist in the lower portion of a list.
8. Quick sort divides a list into two smaller sublists.
9. In selection sort, the smallest element from an array is obtained and placed at the last position of the array.
10. Internal memory is used for external sort algorithm.

## C. Exercise Questions

1. Write the steps to implement the binary search method.
2. Sort the following list in the ascending order using selection sort: 55, 58, 90, 33, 42, 89, 59, 71.
3. Explain sequential searching and give its time analysis.
4. What is sorting and searching? List the different types of searching and sorting techniques.



## PROGRAMMING ASSIGNMENTS

1. Write a Python program to implement bubble sort.
2. Write a Python program to implement quick sort.
3. Sort recursive elements using selection sort.
4. Write a Python program to find the desired element in a list using binary search.
5. Write a Python program to implement merge sort.

# Object-Oriented Programming: Class, Objects and Inheritance

## 10

### CHAPTER OUTLINE

|       |                                                  |       |                                                        |
|-------|--------------------------------------------------|-------|--------------------------------------------------------|
| 10.1  | Introduction                                     | 10.12 | Operator Overloading                                   |
| 10.2  | Defining Classes                                 | 10.13 | Inheritance                                            |
| 10.3  | The Self-parameter and Adding Methods to a Class | 10.14 | Types of Inheritance                                   |
| 10.4  | Display Class Attributes and Methods             | 10.15 | The Object Class                                       |
| 10.5  | Special Class Attributes                         | 10.16 | Inheritance in Detail                                  |
| 10.6  | Accessibility                                    | 10.17 | Subclass Accessing Attributes of Parent Class          |
| 10.7  | The <code>__init__</code> Method (Constructor)   | 10.18 | Multilevel Inheritance in Detail                       |
| 10.8  | Passing an Object as Parameter to a Method       | 10.19 | Multiple Inheritance in Detail                         |
| 10.9  | <code>__del__()</code> (Destructor Method)       | 10.20 | Using <code>Super()</code>                             |
| 10.10 | Class Membership Tests                           | 10.21 | Method Overriding                                      |
| 10.11 | Method Overloading in Python                     | 10.22 | Precaution: Overriding Methods in Multiple Inheritance |

### LEARNING OUTCOMES

*After completing this chapter, students will be able to:*

- Explain the necessity and importance of object-oriented features in programming
- Describe attributes and methods for a given object
- Access attributes and member functions, i.e. methods of a class using the dot operator
- Reference an object using the self-parameter
- Overload inbuilt functions using special methods
- Learn to create super and sub classes using the concept of inheritance
- Learn different types of inheritance and make use of them effectively in programming

## 10.1 INTRODUCTION

Python is an object-oriented language. Object-oriented languages help a programmer to reduce the complexity of programs by reusing existing modules or functions. The concept of object-oriented programming language is based on **class**. We know that class is another name for **type** in Python. It means a programmer can create objects of their own class.

So far, we have learnt various inbuilt classes, such as **int**, **str**, **bool**, **float** and **list**. Since all of these are inbuilt classes, Python defines how these classes look and behave. Overall, in any object-oriented language, the class defines how an object of its type looks and behaves. For example, we know how an integer looks. Its 'behavior' will be the operations one can perform on it.

## 10.2 DEFINING CLASSES

As discussed above, class is another name for type in Python. A class may contain data in the form of **fields**. Fields are also called **attributes** and coded in the form of **procedures** known as **methods**. Finally, a programmer has to create an object of its own class, where the object represents an entity which can be easily identified. For example, person, vehicle, fan, book etc. represent real objects. Each object has a unique identity, state and behaviour. The state of the object is also called **property** or **attribute**. For example, a circular object has a data field radius which is a property that characterises a circle. The syntax to define a class in Python is given as follows:

```
Class Class_Name:
 Initializer
 attributes
 methods()
 Statement(s)
```

### PROGRAM 10.1 | Write a simple class program.

```
class Demo:
 pass
D1=Demo() #Instance or Object of the class Demo
print(D1)
```

#### Output

```
<__main__.Demo object at 0x029B3150>
```

**Explanation** In the above example, we have created a new class called **Demo** using the **class** statement. The class is followed by an indented block of statement which forms the body of the class. In the above program, we have an empty block which is indicated using the **pass** statement. The object/instance of this class is created using the name of the class followed by a pair of parentheses. The print statement is used to verify the type of variable D1. Therefore, the print statement tells us

that there is an instance of the Demo class in the `__main__` module. The output of the print statement is `<__main__.Demo object at 0x029B3150>`. It tells us the address of the computer's memory where the object D1 is stored. The value of the address varies from one machine to another. Python stores an object wherever it finds the space. We can say the return value of `print(D1)` is a reference to a Demo class, which we have assigned to D1. Creation of a new object is called **instantiation** and the object is an **instance** of the class.



**Note:** In the above program, we have created an object/instance of the class as:

```
D1=Demo()
```

Creating objects in Python is equivalent to the following code in Java, C++

```
Demo D1 = new Demo();
```

Therefore, there is no **new** keyword in Python as in Java and C++.

**PROGRAM 10.2** Write a program to create a simple class and print the message, "Welcome to Object-oriented Programming" and print the address of the instance of the class.

```
class MyFirstProgram:
 print(' Welcome to Object-oriented Programming')
C=MyFirstProgram() #Instance of class.
print(C)
```

### Output

```
Welcome to Object-oriented Programming
<__main__.MyFirstProgram object at 0x028B6C90>
```

**Explanation** Name of the class is **MyFirstProgram**. The instance, i.e. 'C' of the class is created. Inside the class, the print statement is used to display the welcome message. Additionally, the last print statement is used to display the address of the computer's memory where the object 'C' is stored.

## 10.2.1 Adding Attributes to a Class

In Program 10.1, we have created a simple class named **Demo**. The class Demo does not contain any data and it does not do anything. What can a programmer do to assign an attribute to a given object? The programs ahead explain how to add an attribute to an existing class.

Let us consider a simple class called **Rectangle** which defines two instance variables **length** and **breadth**. Currently, the class Rectangle does not contain any method.

Class Rectangle:

```
length=0; #Attribute length
breadth=0; #Attribute breadth
```

From above example, it is important to remember that a class declaration only creates a template, i.e. it does not create an actual object. Hence, the above code also does not create any object of type

**Rectangle.** To create a **Rectangle** object we will use the following statement.

```
R1 = Rectangle () # Instance of Class
```

After execution of the above statement R1 will be the instance of the class Rectangle. Each time we create an instance of class, we are creating an object that contains its own copy of each instance variable or attribute defined by that class. Thus, every Rectangle object will contain its copies of instance variables, length and breadth.

## 10.2.2 Accessing Attributes of a Class

The syntax used to access the attributes of a class is:

```
<object>.<attribute>
```

**PROGRAM 10.3** | Write a program to access the attributes of a class.

```
class Rectangle:
 length=0; #Attribute length
 breadth=0; #Attribute breadth
R1 = Rectangle () #Instance of a class
print (R1.length) #Access attribute length
print (R1.breadth) #Access attribute breadth
```

### Output

```
0
0
```

**Explanation** The class Rectangle is created as shown above. The class contains two attributes, viz. length and breadth. Initially the values of both the attributes are assigned to zero. R1 is the instance of the class. The object R1 and dot operators are used together to print the value of the attributes of a class.

## 10.2.3 Assigning Value to an Attribute

The syntax used to assign a value to an attribute of an object is

```
<object>.<attribute> = <Value>
```

The value can be anything like a Python primitive, an inbuilt data type, another object etc. It can even be a function or another class.

### Example

```
R1.length=20;
R1.breadth=30;
```

**PROGRAM 10.4** Write a program to calculate the area of a rectangle by assigning the value to the attributes of a rectangle, i.e. length and breadth.

```
class Rectangle:
 length=0; #Attribute length
 breadth=0; #Attribute breadth
R1 = Rectangle () #Instance of a class
print('Initial values of Attribute')
print('Length = ',R1.length) #Access attribute length
print('Breadth = ',R1.breadth) #Access attribute breadth
print('Area of Rectangle = ',R1.length * R1.breadth)
R1.length = 20 #Assign value to attribute length
R1.breadth = 30 #Assign value to attribute breadth
print('After reassigning the value of attributes')
print('Length = ',R1.length)
print('Breadth = ',R1.breadth)
print('Area of Rectangle is ',R1.length * R1.breadth)
```

### Output

```
Initial values of Attribute
Length = 0
Breadth = 0
Area of Rectangle = 0
After reassigning the value of attributes
Length = 20
Breadth = 30
Area of Rectangle is 600
```

## 10.3 THE SELF-PARAMETER AND ADDING METHODS TO A CLASS

### 10.3.1 Adding Methods to a Class

As discussed at the beginning of this chapter, a class usually consists of **instance variables** and **instance methods**. The syntax to add methods in a class is

```
class Class_Name:
 instance variable; #instance variable with initialisation
def mthod_name(Self,parameter_list):#Paramter List is Optional
 block_of_statements
```

### 10.3.2 The Self-parameter

To add methods to an existing class, the first parameter for each method should be **self**. There is only one difference between class methods and ordinary functions. The self-parameter is used

in the implementation of the method, but it is not used when the method is called. Therefore, the self-parameter references the object itself. Program 10.5 illustrates the self-parameter and addition of methods to an existing class.


**PROGRAM 10.5** Write a program to create a method `Display_Message()` in a class having the name `MethodDemo` and display the message, "Welcome to Python Programming".

```
class MethodDemo:
 def Display_Message(self):
 print('Welcome to Python Programming')
ob1 = MethodDemo() #Instance of a class
ob1.Display_Message() #Calling Method
```

### Output

```
Welcome to Python Programming
```

**Explanation** In the above program, the `Display_Message()` method takes no parameters but still the method has the self-parameter in the function definition. Therefore, the self-parameter refers to the current object itself. Finally, the method is called and the message is displayed.

-  **Note:** 1. The first parameter for each method inside a class should be defined by the name 'self'.  
2. The variable 'self' refers to the object itself. Therefore, for convention it is given the name self.  
3. The self in Python is equivalent to the 'this' pointer in C++ and 'this' reference in Java.

### Important Note

4. Although a programmer can give any name to the parameter self but it is strongly recommended that he/she uses the name 'self'. There are many advantages to using a standard name self, such as any reader of the program will be able to immediately recognise it.

## 10.3.3 Defining Self-parameter and Other Parameters in a Class Method

Program 10.6 explains defining of self and parameters for methods of the existing class.

**PROGRAM 10.6** Write a program to create a class named `Circle`. Pass the parameter radius to the method named `Calc_Area()` and calculate the area of the circle.

```
import math
class Circle:
 def Calc_Area(self, radius):
 print('radius = ', radius)
 return math.pi*radius**2
ob1 = Circle()
print('Area of circle is ', ob1.Calc_Area(5))
```

(Contd.)

**Output**

```
radius = 5
Area of circle is 78.53981633974483
```

**Explanation** The class with name Circle is created as shown above. The extra parameter radius is passed to a method defined inside the class `Calc_Area()`. The instance `ob1` of a class is created and used to call the method of the existing class. Even though the method `Calc_Area()` contains two parameters, viz. `self` and `radius`, only one parameter should be passed, viz. the radius of the circle while calling the method.

**PROGRAM 10.7** | Write a program to calculate the area of a rectangle. Pass the length and breadth of the rectangle to the method named `Calc_Rect_Area()`.

```
class Rectangle:
 def Calc_Area_Rect(self,length,breadth):
 print('length = ',length)
 print('breadth = ',breadth)
 return length*breadth
ob1 = Rectangle()
print('Area of Rectangle is ',ob1.Calc_Area_Rect(5,4))
```

**Output**

```
length = 5
breadth = 4
Area of rectangle is 20
```

### 10.3.4 The Self-parameter with Instance Variable

As discussed above, the `self` work as a reference to the current object whose method is invoked. The `self` can also be used to refer any **attribute/member variable** or **instance variable** of the current object from within the instance method. The `self` is used to handle variables.

We cannot create two instance variables/local variables with the same name. However, it is legal to create one instance variable and one local variable or method parameter with the same name. But in this scenario, the local variable tends to hide the value of the instance variable. Program 10.8 illustrates this concept of variable hiding.

**PROGRAM 10.8** | Write a program for variable hiding.

```
class Prac:
 x=5 # attribute x
 def disp(self, x):
```

(Contd.)



```

x=30
print(' The value of local variable x is ',x)
print(' The value of instance variable x is ',x)
ob=Prac()
ob.disp(50)

```

**Output**

```

The value of local variable x is 30
The value of instance variable x is 30

```

**Explanation** The instance variable `x` is initialised with the value 5. Similarly, the method `disp()` has a local variable named `x` and it is initialised with the value 30. Object `ob` is instantiated and the method `disp()` is invoked. Thereafter, it displays both the values of `x` as 30.

Thus, in the above program we have seen the value of the instance variable is hidden by the local variable. If a programmer does not want to hide the value of an instance variable, he/she needs to use **self** with the name of the instance variable. Program 10.9 demonstrates the use of **self** with an instance variable to solve the problem of variable hiding.

**PROGRAM 10.9** | Write a program to demonstrate the use of **self** with an instance variable to solve the problem of variable hiding.

```

class Prac:
 x=5
 def disp(self, x):
 x=30
 print(' The value of local variable x is',x)
 print(' The value of instance variable x is ',self.x)
ob=Prac()
ob.disp(50)

```

**Output**

```

The value of local variable x is 30
The value of instance variable x is 5

```

**Explanation** The **self** is used to differentiate between an instance and local variable. Here `x` displays the value of the local variable and `self.x` displays the value of the instance variable.

### 10.3.5 The Self-parameter with Method

The **self** is also used within methods to call another method from the same class.

**PROGRAM 10.10** | Write a program to create two methods, i.e. **Method\_A()** and **Method\_B()**. Call **Method\_A()** from **Method\_B()** using **self**.

```

class Self_Demo:
 def Method_A(self):
 print('In Method A')
 print('wow got a called from A!!!')
 def Method_B(self):
 print('In Method B calling Method A')
 self.Method_A() #Calling Method_A
Q=Self_Demo()
Q.Method_B() #calling Method_B

```

### Output

```

In Method B calling Method A
In Method A
wow got a called from A!!!

```

## 10.4 DISPLAY CLASS ATTRIBUTES AND METHODS

There are two ways to determine the attributes in a class. One way is by using the inbuilt function `dir()`. The syntax used to display `dir()` attributes is:

```

dir(name_of_class) or
dir(Instance_of_class)

```

Program 10.11 explains how to display the attributes present in a given class.

### PROGRAM 10.11 | Write a program to display the attributes present in a given class

```

class DisplayDemo:
 Name = ''; #Attribute
 Age = ''; #Attribute
 def read(self):
 Name=input('Enter Name of student: ')
 print('Name = ',Name)
 Age=input('Enter Age of the Student:')
 print('Age = ',Age)
D1 = DisplayDemo()
D1.read()

#Display attributes using dir() on the interactive mode
>>>(dir(DisplayDemo))
['Age', 'Name', '__class__', '__delattr__', '__dict__', '__dir__', '__doc__',
 '__eq__', '__format__', '__ge__', '__getattr__', '__gt__', '__hash__',
 '__init__', '__le__', '__lt__', '__module__', '__ne__', '__new__', '__
reduce__', '__reduce_ex__', '__repr__', '__setattr__', '__sizeof__', '__
str__', '__subclasshook__', '__weakref__', 'read']

```

**Explanation** When `dir()` method is executed in interactive mode, the `dir()` function returns a sorted list of attributes and methods belonging to an object. The function returns the existing attributes and methods belonging to the class, including any special methods.

An alternate way to display the attributes of a class is by using a special class attribute `__dict__`. The syntax to display the attributes and methods of an existing class using `__dict__` is

`Class_Name.__dict__`



**Note:** The dict contains two underscores i.e. two underscores before the word dict and two underscores afterwards.

**PROGRAM 10.12** | Write a program executing `__dict__` method on Program 10.11.

```
class DisplayDemo:
 Name = ''; #Attribute
 Age = ''; #Attribute
 def read(self):
 Name=input('Enter Name of student: ')
 print('Name = ',Name)
 Age=input('Enter Age of the Student:')
 print('Age = ',Age)

D1 = DisplayDemo()
D1.read()

#Display attributes using __dict__
>>> DisplayDemo.__dict__
mappingproxy({'read': <function DisplayDemo.read at 0x02E7C978>, '__weakref__': <attribute '__weakref__' of 'DisplayDemo' objects>, '__doc__': None, '__dict__': <attribute '__dict__' of 'DisplayDemo' objects>, '__module__': '__main__', 'Name': '', 'Age': ''})
```

**Explanation** The special class attribute `__dict__` returns the details of the class containing methods and attributes. The output of the above function returns the address of the method `read`, i.e. `{'read': <function DisplayDemo.read at 0x02E7C978>}`. It also displays the attributes of the class `DisplayDemo`, viz. `Name` and `Age`.

## 10.5 SPECIAL CLASS ATTRIBUTES

Consider a simple program of a class given as follows:

```
class Demol:
 pass
D1=Demol()
```

(Contd.)

```
>>>dir(D1)
['_class_', '_delattr_', '_dict_', '_dir_', '_doc_', '_eq_', '_format_', '_ge_', '_getattr_', '_gt_', '_hash_', '_init_', '_le_', '_lt_', '_module_', '_ne_', '_new_', '_reduce_', '_reduce_ex_', '_repr_', '_setattr_', '_sizeof_', '_str_', '_subclasshook_', '_weakref_']
```

In this program, we executed the `dir()` method on the class **Demo1**. The **Demo1** is a simple class. It neither contains any methods nor any attributes. However, by default it contains a list of special methods sorted in an ascending order as output of `dir()`.



**Note:** For any class C, Table 10.1 gives a list of all the special attributes.

**Table 10.1** Special attributes of a class

| Attribute    | Meaning                        |
|--------------|--------------------------------|
| C.__class__  | String name of class           |
| C.__doc__    | Documentation string for class |
| C.__dict__   | Attributes of class            |
| C.__module__ | Module where class is defined  |

## 10.6 ACCESSIBILITY

In Python, there are no keywords like **public**, **protected** or **private**. All attributes and methods are public by default.

There is one way to define private in Python. The syntax to define private attribute and methods is

```
__Attribute
__Methods_Name()
```

To make an attribute and a method private, we need to add two underscores, i.e. “\_\_” in front of the attribute and the method’s name. It helps in hiding these when accessed out of class.

**PROGRAM 10.13** | Write a program to illustrate the use of private.

```
class Person:
 def __init__(self):
 self.Name = 'Bill Gates' #Public attribute
 self.__BankAccNo =10101 #Private attribute

 def Display(self):
```

(Contd.)

```

 print(' Name = ',self.Name)
 print('Bank Account Number = ',self.__BankAccNo)

P = Person()
#Access public attribute outside class
print(' Name = ',P.Name)
P.Display()
#Try to access private variable outside class but fails
print(' Salary = ',P.__BankAccNo)
P.Displaay()

```

**Output**

```

Name = Bill Gates
Name = Bill Gates
Bank Account Number = 10101
Traceback (most recent call last): #Error
 File "C:/Python34/PrivateDemo.py", line 13, in <module>
 print(' Salary = ',P.__BankAccNo)
AttributeError: 'Person' object has no attribute '__BankAccNo'

```

**Explanation** In the above program, we have defined public and private attributes. The private variable can be accessed within the function. We have created an instance of class **Person**, i.e. **P** to access the attributes defined within the class.

However, it fails and shows an error when instance of class try to access private attributes defined inside the class & are accessed from outside the class.



**Note:** Python hides a private name by changing its name to `_ClassName__AttrName`. This technique is termed as "mangling".

## 10.7 THE `__init__` METHOD (CONSTRUCTOR)

There are many inbuilt methods in Python. Each method has its own significance. The importance of the `__init__` method is explained ahead.

The `__init__` method is known as an initialiser. It is a special method that is used to initialise the instance variable of an object. This method runs as soon as an object of a class is instantiated. The syntax of adding `__init__` method to a class is given as follows:

```

class Class_Name:
 def __init__(self): #__init__ method


```

Note that `__init__` needs to be preceded and followed by two underscores. Also `__init__` method must have `self` as the first argument. As `self` refers to the object itself, it refers to the object that invokes the method. The `self`-parameter within the `__init__` method automatically sets the reference for the object just created. The `__init__` method can also have positional and/or keyword arguments.

**PROGRAM 10.14** | Write a simple program using the `__init__` method.

```
class Circle:
 def __init__(self, pi):
 self.pi = pi
 def calc_area(self, radius):
 return self.pi*radius**2
C1=Circle(3.14)
print(' The area of Circle is ', C1.calc_area(5))
```

#### Output

```
The area of Circle is 78.5
```

**Explanation** In the above program we have created a class named `Circle`. The class contains two different methods, viz. one is `__init__` method and another `calc_area()` to calculate the area of a circle. Notice that in the above program we do not explicitly call the `__init__` method. We have created an instance of the class `Circle`, i.e. `C1`. While creating the instance of the class we have passed the arguments following the class name to initialise the instance variable of an object.

### 10.7.1 Attributes and `__init__` Method

Programmers can initialise the value of a member variable or attribute by making use of the `__init__` method. Program 10.15 demonstrates the use of the `__init__` method to initialise the attributes with some values.

**PROGRAM 10.15** | Write a program to initialise the value of the attributes by making use of the `__init__` method.

```
class Circle:
 pi = 0; #Attribute pi
 radius = 0 #Attribute radius
 def __init__(self):
 self.pi = 3.14
 self.radius = 5
 def calc_area(self):
 print('Radius = ', self.radius)
 return self.pi*self.radius**2
C1=Circle()
print(' The area of Circle is ', C1.calc_area())
```

**Explanation** Initially the attributes of the class Circle, i.e. pi and radius are initialised to Zero. With the help of the init method the value of the instance variable pi and radius are reinitialised to 3.14 and 5. These values are initialised upon the creation of the instance of class, i.e. C1. Finally, the area of the circle is calculated by calling the method calc\_area().

## 10.7.2 More Programs on \_\_init\_\_ Method

**PROGRAM 10.16** | Write a program to calculate the volume of a box.

```
class Box:
 width = 0; #Member Variables
 height = 0;
 depth = 0;
 volume = 0;
 def __init__(self):
 self.width = 5
 self.height = 5
 self.depth = 5
 def calc_vol(self):
 print('Width = ',self.width)
 print('Height = ',self.height)
 print('depth = ',self.depth)
 return self.width * self.height * self.depth
B1=Box()
print(' The Volume of Cube is ',B1.calc_vol())
```

### Output

```
Width = 5
Height = 5
Depth = 5
The Volume of Cube is 125
```

**Explanation** The member variable of class Box is initialised to zero. Thereafter, all the member variables, viz. width, height and depth are reinitialised to the value 5 by instantiating the object B1 and using the init method.

## 10.8 PASSING AN OBJECT AS PARAMETER TO A METHOD

So far, we have learnt about passing any kind of parameter of any type to methods.

We can also pass objects as parameter to a method. This is explained in Program 10.17.

**PROGRAM 10.17** | Write a program to pass an object as parameter to a method.

```

class Test:
 a = 0
 b = 0
 def __init__(self, x , y):
 self.a = x
 self.b = y
 def equals(self, obj):
 if(obj.a == self.a and obj.b == self.b):
 return True
 else:
 return False
Obj1 = Test(10,20)
Obj2 = Test(10,20)
Obj3 = Test(12,90)
print(' Obj1 == Obj2 ',Obj1.equals(Obj2))
print(' Obj1 == Obj3 ',Obj1.equals(Obj3))

```

**Output**

```

Obj1 == Obj2 True
Obj1 == Obj3 False

```

**Explanation** In the above program, the **equals()** method inside the class named **Test** compares two objects for equality and returns a result. It compares the invoking object with one that is passed as parameter to the method.

**ob1.equals (ob2)**

As shown above, the invoking object is ob1 and the object being passed to the equals method is ob2. If the values of ob1 and ob2 contain the same value then the method returns **True**, else it returns **False**.

**PROGRAM 10.18** | Write a program to calculate the area of a rectangle by passing an object as parameter to method.

```

class Rectangle:
 length = 0
 breadth = 0
 def __init__(self, l , w):
 self.length = l
 self.breadth = w
 def Calc_Area(self, obj):

```

(Contd.)



```

 print(' Length = ',obj.length)
 print(' Breadth = ',obj.breadth)
 return obj.length * obj.breadth
Obj1 = Rectangle(10,20)
print('The area of Rectangle is ', Obj1.Calc_Area(Obj1))

```

**Output**

```

Length = 10
Breadth = 20
The area of Rectangle is 200

```

**Explanation** The object **Obj1** of class **Rectangle** is instantiated. With the help of **init** method, the default values of length and rectangle are initialised to 100 and 200. The **Obj1** itself is passed as parameter to the method **Calc\_area()** and finally the area of the rectangle is computed.

## 10.9 \_\_del\_\_() (DESTRUCTOR METHOD)

Like other object-oriented programming languages, Python also has a destructor. The method **\_\_del\_\_** denotes the destructor and the syntax to define destructor is.

```

def __del__(self)
 block

```

Python invokes the destructor method when the instance is about to be destroyed. It is invoked one per instance. The **self** refers to the instance on which the **\_\_del\_\_()** method is invoked. In other words, Python manages garbage collection of objects by reference counting. This function is executed only if all the references to an instance object have been removed. Program 10.19 illustrates the use of the **\_\_del\_\_** method.

**PROGRAM 10.19** | Write a program to illustrate the use of the **\_\_del\_\_** method.

```

class Destructor_Demo:
 def __init__(self): #Constructor
 print('Welcome')
 def __del__(self): #Destructor
 print('Destructor Executed Successfully')
Ob1=Destructor_Demo() #Instantiation
Ob2 = Ob1
Ob3 = Ob1 #Object Ob2 and Ob3 refers to same object
print(' Id of Ob1 = ',id(Ob1))
print(' Id of Ob2 = ',id(Ob2))
print(' Id of Ob3 = ',id(Ob3))

```

(Contd.)

```
del Ob2 #Remove reference Ob2
del Ob1 #Remove reference Ob1
del Ob3 #Remove reference Ob3
```

### Output

```
Welcome
Id of Ob1 = 47364272
Id of Ob2 = 47364272
Id of Ob3 = 47364272
Destructor Executed Successfully
```

**Explanation** In the above example, we have used constructor `__init__` and destructor `__del__` functions. Initially we have instantiated the object **Ob1** and then assigned aliases **Ob2** and **Ob3** to it. The inbuilt function **id()** is used to confirm that all the three aliases reference to the same object. Finally, all the aliases are removed using the `del` statement.

The destructor `__del__` is not invoked unless all the aliases are deleted.  
The destructor is called exactly once.

```
#Program to demonstrate the above concept
class Destructor_Demo:
 def __init__(self):
 print('Welcome')
 def __del__(self):
 print('Destructor Executed Successfully')
Ob1=Destructor_Demo()
Ob2 = Ob1
Ob3 = Ob1
print(' Id of Ob1 = ',id(Ob1))
print(' Id of Ob2 = ',id(Ob2))
print(' Id of Ob3 = ',id(Ob3))
del Ob1
del Ob2
```

### Output

```
Welcome
Id of Ob1 = 48347312
Id of Ob2 = 48347312
Id of Ob3 = 48347312
```

#From the above program it is clear that the destructor `__del__` is not invoked until all the references to the instance of class are removed. Thus, in order to invoke `__del__`, the reference count has to be decreased to zero.

## 10.10 CLASS MEMBERSHIP TESTS

When we create an instance of a class, the **type** of that instance is the class itself. The inbuilt function **isinstance(obj,Class\_Name)** is used to check for membership in a class. The function returns **True** if an object **obj** belongs to the class **Class\_Name**. Program 10.20 demonstrates the use of the **isinstance()** function.

**PROGRAM 10.20** | Write a program to demonstrate the use of the **isinstance()** method.

```
class A:
 pass
class B:
 pass
class C:
 pass
Ob1=A() #Instance of Class A
Ob2=B() #Instance of Class B
Ob3=C() #Instance of Class C
#Lets make use of isinstance method to check the type.
>>> isinstance(Ob1,A)
True
>>> isinstance(Ob1,B)
False
>>> isinstance(Ob2,B)
True
>>> isinstance(Ob2,C)
False
>>> isinstance(Ob3,B)
False
>>> isinstance(Ob3,C)
True
```

## 10.11 METHOD OVERLOADING IN PYTHON

Most object-oriented programming languages contain the concept of method overloading. It simply refers to having multiple methods with the same name which accept different sets of arguments. Let us consider the code below to understand method overloading.

```
class OverloadDemo:
 def add(self,a,b):
 print(a+b)
 def add(self,a,b,c):
 print(a+b+c)
P = OverloadDemo()
P.add(10,20)
```

If we try to run the code above, it will not execute and show the following error.

```
Traceback (most recent call last):
 File "C:/Python34/Overload_Demo.py", line 7, in <module>
 P.add(10,20)
TypeError: add() missing 1 required positional argument: 'c'
```

This is because Python understands the last definition of the method **add(self, a, b ,c)** which takes only three arguments apart from self. Therefore, while calling the **add()** method it is forced to pass three arguments. In other words, it forgets the previous definition of method **add()**.



**Note:** C++ and Java support method overloading. Both the languages allow more than one methods with same name and different signature. The type of method argument defines the signature. In case of overloading, the signature determines which method is actually being invoked. However, Python does not allow method overloading based on **type** as it is not strongly **typed** language.

The above program on method overloading can be solved by using the inbuilt function **isinstanceof**.

#### PROGRAM 10.21 | Write a program on method overloading.

```
class Demo:
 result = 0
 def add(self,instanceOf=None, *args):
 if isinstance == 'int':
 self.result = 0
 if isinstance == 'str':
 self.result = ''
 for i in args:
 self.result = self.result + i
 return self.result
D1=Demo()
print(D1.add('int', 10,20,30))
print(D1.add('str', ' I ', ' Love ', ' Python ', ' Programming '))
```

#### Output

```
60
I Love Python Programming
```

**Explanation** The instance of class Demo named D1 is created. The method **add()** is called twice. The first and second call to **add()** methods are:

#### #First Call

```
D1.add('int', 10,20,30))
```

..

#Second Call

D1.add('str', ' I ', ' Love ', ' Python ', ' Programming ')

The **instanceof** method checks the type of the first parameter being passed to the `add()` method. It stores the value of **result** process based upon **type**.

**PROGRAM 10.22** | Write a program to display a greeting message. Create a class named **MethodOverloading**. Define the function `greeting()` having one parameter **Name**.

**Input:** `obj.greeting()`**Output:** Welcome**Input:** `obj.greeting('Donald Trump')`**Output:** Welcome Donald Trump

```
class methodOverloading :
 def greeting(self, name=None):
 if name is not None:
 print("Welcome " + name)
 else:
 print("Welcome")

Create an object referencing by variable obj
obj = methodOverloading()

call the method greeting without parameter
obj.greeting()

call the method with parameter
obj.greeting('Donald Trump')
```

In Python, method overloading is a technique to define a method in such way that there are more than one ways to call it. This is different from other programming languages.

## 10.12 OPERATOR OVERLOADING

The idea of operator overloading is not new. It has been used in various object-oriented programming languages, such as C++ and Java. It is one of the best features of a programming language since it makes it possible for a programmer to interact with objects in a natural way. It is the ability to define a data type which provides its own definition of operators. A programmer can overload almost every operator, such as arithmetic, comparison, indexing and slicing, and the number of inbuilt functions, such as length, hashing and type conversion. Overloading operators and inbuilt functions makes user defined types to behave exactly like built-in types.

## 10.12.1 Special Methods

To support operator overloading, Python associates a special method with each inbuilt function and operator. Corresponding to the special method, Python internally converts an expression into a call to perform a certain operation. For example, if a programmer wants to perform a sum of two operands then he/she writes `x + y`. When Python observes the `+` operator, it converts the expression `x + y` to call a special method `__add__`. Thus, to overload the `+` operator, he/she needs to include the implementation of the special method `__add__`.

The details for special methods for arithmetic operations are explained ahead.

## 10.12.2 Special Methods for Arithmetic Operations

Python supports various arithmetic operations, such as addition, subtraction, multiplication and division. It associates a special method with each arithmetic operator. A programmer can overload any arithmetic operation by implementing the corresponding special method. A list of arithmetic operators with their corresponding special method is given in **Table 10.2**.

**Table 10.2** Special methods for operator overloading

| Operation           | Special Method                         | Description                                         |
|---------------------|----------------------------------------|-----------------------------------------------------|
| <code>X + Y</code>  | <code>__add__(self, Other)</code>      | Add X and Y                                         |
| <code>X - Y</code>  | <code>__sub__(Self, Other)</code>      | Subtract Y from X                                   |
| <code>X * Y</code>  | <code>__mul__(self, Other)</code>      | Product of X and Y                                  |
| <code>X / Y</code>  | <code>__truediv__(self, Other)</code>  | Y divides X and it shows the quotient as its output |
| <code>X // Y</code> | <code>__floordiv__(self, Other)</code> | Floored quotient of X and Y                         |
| <code>X % Y</code>  | <code>__mod__(self, Other)</code>      | X mod Y gives a remainder when dividing X by Y      |
| <code>-X</code>     | <code>__neg__(self)</code>             | Arithmetic negation of X                            |

Program 10.23 illustrates operator overloading for adding two objects.

**PROGRAM 10.23** | Write a program to overload the `+` Operator and perform the addition of two objects.

```
class OprOverloadingDemo:
 def __init__(self,X):
 self.X = X

 def __add__(self,other):
 print(' The value of Ob1 =',self.X)
 print(' The value of Ob2 =',other.X)
 print(' The Addition of two objects is:',end='')
 return ((self.X+other.X))
Ob1 = OprOverloadingDemo(20)
Ob2 = OprOverloadingDemo(30)
```

(Contd.)

```
Ob3 = Ob1 + Ob2
print(Ob3)
```

**Output**

```
The value of Ob1 = 20
The value of Ob2 = 30
The Addition of two objects is: 50
```

**Explanation** In the above example, we have applied the + operation on two instances, Ob1 and Ob2. When we sum these two objects, the representation is as follows:

**Ob3 = Ob1 + Ob2**

As the above statement contains the + operator, Python automatically invokes the `__add__` method. In the `__add__` method, the first parameter is the object on which the method is invoked and the second parameter is **other**, which is used to distinguish from **self**.



**Note:** It is the responsibility of Python to call a method based on the types of operand of the operator involved while adding two objects.

**Example:** If a programmer writes `Ob1 + Ob2`, it will call the `int` class `__add__` method if `ob1` is an integer. It will call `float` types `__add__` method if `ob1` is float. This is because object on the left side of the + operator corresponds to the object on the right side.

Writing `Ob1 + Ob2` is equivalent to `Ob1.__add__(Ob2)`

### 10.12.3 Special Methods for Comparing Types

Comparison is not strictly done on numbers. It can be made on various types, such as list, string and even on dictionaries.

If you are creating your own class, it makes sense to compare your objects to other objects. Similar to the arithmetic operators' above, a programmer can overload any of the following comparison operators. We can use the following special methods to implement comparisons.

**Table 10.3** Special methods for comparison operators

| Operation              | Special Method                   | Description                    |
|------------------------|----------------------------------|--------------------------------|
| <code>X == Y</code>    | <code>__eq__(self, other)</code> | is X equal to Y?               |
| <code>X &lt; Y</code>  | <code>__lt__(self, other)</code> | is X less than Y?              |
| <code>X &lt;= Y</code> | <code>__le__(self, other)</code> | is X less than or equal to Y?  |
| <code>X &gt; Y</code>  | <code>__gt__(self, other)</code> | is X greater than Y?           |
| <code>X &gt;= Y</code> | <code>__ge__(self, other)</code> | is greater than or equal to Y? |

Program 10.24 demonstrates operator overloading for comparing two objects.

**PROGRAM 10.24** | Write a program to use special methods and compare two objects.

```

class CmpOprDemo:
 def __init__(self,X):
 self.X = X

 def __lt__(self,other):
 print(' The value of Ob1 =',self.X)
 print(' The value of Ob2 =',other.X)
 print(' Ob1 < Ob2 :',end='')
 return self.X < other.X

 def __gt__(self,other):
 print(' Ob1 > Ob2 :',end='')
 return self.X > other.X

 def __le__(self,other):
 print(' Ob1 <= Ob2 :',end='')
 return self.X <= other.X

Ob1 = CmpOprDemo(20)
Ob2 = CmpOprDemo(30)
print(Ob1 < Ob2)
print(Ob1 > Ob2)
print(Ob1 <= Ob2)

```

**Output**

```

The value of Ob1 = 20
The value of Ob2 = 30
Ob1 < Ob2 :True
Ob1 > Ob2 :False
Ob1 <= Ob2 :True

```

**Explanation** In the above example, we have applied <, > and <= operator on two instances, Ob1 and Ob2. Therefore, when we need to check if one object is less than other it appears as

**Ob1 < Ob2**

As the above statement contains the < operator, Python automatically invokes the `__lt__` method. Whenever Python observes > and <= operators, it invokes `__gt__` and `__ge__` methods.

**10.12.4 Reference Equality and Object Equality**

Consider the following example which gives more details about equality operators in Python.



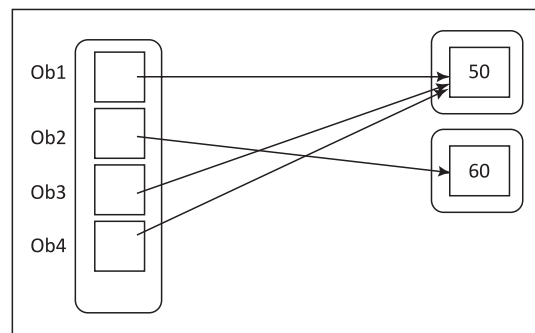
**Example**

```

>>> Ob1 = 50
>>> Ob2 = 60
>>> Ob3 = Ob1
>>> id(Ob1)
1533264672
>>> id(Ob2)
1533264832
>>> Ob1 is Ob2
False
>>> Ob3 is Ob1
True
>>> Ob4 = 50
>>> Ob1 == Ob4
>>> True

```

The above example can be illustrated as shown in Figure 10.1.



**Figure 10.1** Variable referencing objects

In Figure 10.1, objects are referenced by variables, viz. Ob1, Ob2, Ob3 and Ob4. From the figure, Ob1, Ob3 and Ob4 refer to the same object but Ob2 refer to other object. Programmer can make use of following two ways to check the equality of objects.

1. **Reference equality:** If two references are equal and refer to the same object then it is said to be a case of **reference equality**. The inbuilt **id()** function gives the memory address of the object, i.e. identity of the object. The **is** and **is not** operator test whether the two variables refer to the same object. The implementation of statement i.e. Ob1 is Ob2 checks whether id of Ob1, i.e. **id(Ob1)** and **id(Ob2)** are the same. If they are same, it returns True. In the above example as Ob1 and Ob2 reside at different memory locations, the statement **Ob1 is Ob2** returns False.
2. **Object equality:** When two references hold two different/same objects and if the values of the two objects are equal then it is said to be object equality. Thus, in the above example, **Ob1==Ob3** and **Ob1== Ob4** return True since both of them refer to the object with the same value.

## 10.12.5 Special Methods for Overloading Inbuilt Functions

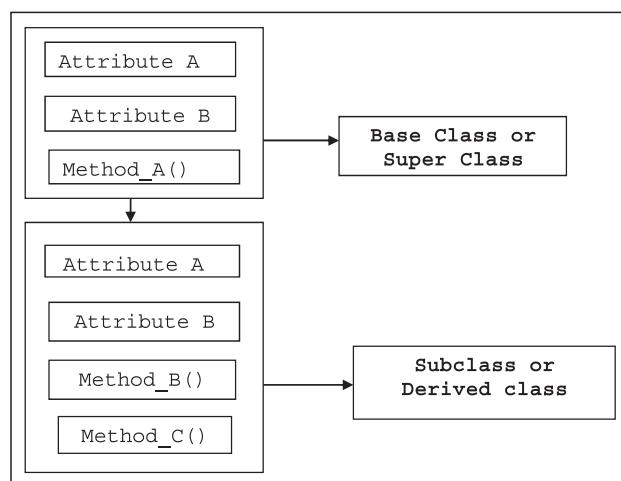
Like operators, we can also overload inbuilt functions. Several inbuilt functions can be overloaded in a manner similar to overloading normal operators in Python. Table 10.4 contains some common inbuilt functions.

**Table 10.4** Special methods for inbuilt functions

| <i>Operation</i> | <i>Special Method</i>        | <i>Description</i>                   |
|------------------|------------------------------|--------------------------------------|
| abs(x)           | <code>__abs__(Self)</code>   | Absolute value of x                  |
| float(x)         | <code>__float__(self)</code> | Float equivalent of x                |
| str(x)           | <code>__str__(self)</code>   | String representation of x           |
| iter(x)          | <code>__itr__(self)</code>   | Iterator of x                        |
| hash(x)          | <code>__hash__(self)</code>  | Generates an integer hash code for x |
| len(x)           | <code>__len__(self)</code>   | Length of x                          |

## 10.13 INHERITANCE

Inheritance is one of the most useful and essential characteristics of object-oriented programming. The existing classes are the main components of inheritance. New classes are created from the existing ones. The properties of the existing classes are simply extended to the new classes. A new class created using an existing one is called a **derived class or subclass** and the existing class is called a **base class or super class**. An example of inheritance is shown in Figure 10.2. The relationship between base and derived class is known as **kind of relationship**. A programmer can define new attributes, i.e. (member variables) and functions in a derived class.



**Figure 10.2** Simple example of inheritance

The procedure of creating a new class from one or more existing classes is called **inheritance**.

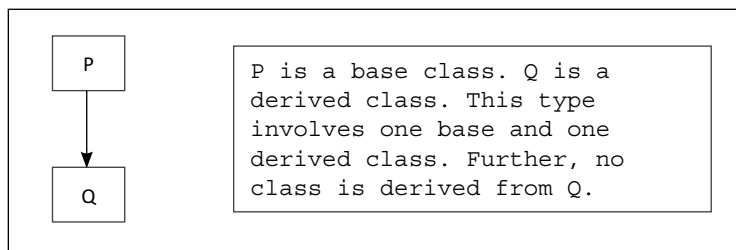
## 10.14 TYPES OF INHERITANCE

We have covered simple examples of inheritance using one base class and one derived class. The process of inheritance can be simple or complex according to the following:

1. **Number of base classes:** A programmer can use one or more base classes to derive a single class.
2. **Nested derivation:** The derived class can be used as the base class and a new class can be derived from it. This is possible at any extent.

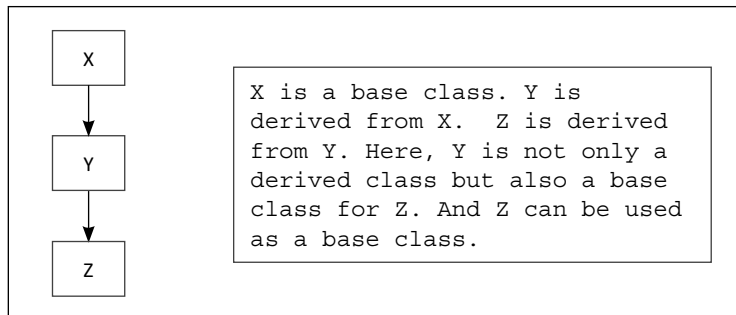
Inheritance can be classified as: (i) single inheritance, (ii) multilevel inheritance and (iii) multiple inheritance. Each of these has been described in detail as follows:

- (i) **Single inheritance:** Only one base class is used for deriving a new class. The derived class is not used as the base class.



**Figure 10.3** Single inheritance

- (ii) **Multilevel inheritance:** When a class is derived from another derived class, the derived class acts as the base class. This is known as multilevel inheritance.



**Figure 10.4** Multilevel inheritance

- (iii) **Multiple inheritance:** When two or more base classes are used for deriving a new class, it is called multiple Inheritance.

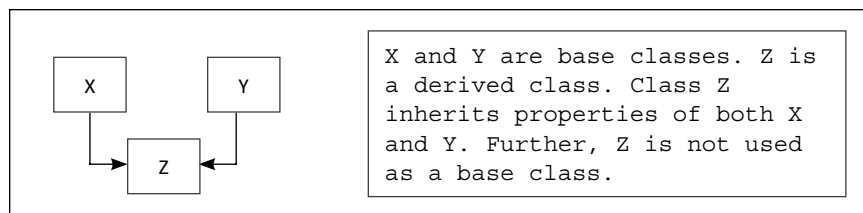


Figure 10.5 Multiple inheritance

## 10.15 THE OBJECT CLASS

Every class in Python is derived from the **object** class. The **object** class is defined in the Python library. Consider the following example of class.

### Example

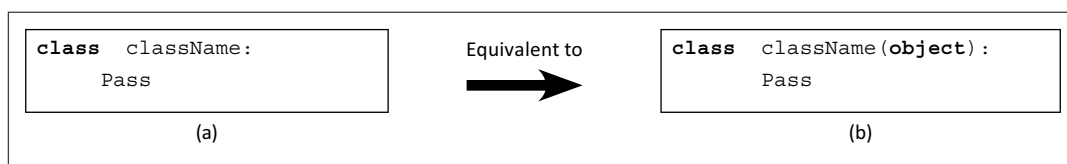


Figure 10.6 The simple class example

Figure 10.6 describes classes in Python. If no inheritance is specified when a class is defined then by default the class is derived from its super class **object**.

## 10.16 INHERITANCE IN DETAIL

Inheritance is a powerful feature of object-oriented programming. It helps creating a new class with little or no modifications on the existing class. The new class called subclass or derived class, inherits the features of its base class. The syntax to define inheritance (i.e. to inherit a single base class) in Python is:

```

Class Derived_Class_Name(Single_Base_Class_Name):
 Body_of_Derived_Class

```

The syntax to inherit multiple base classes is:

```

Class Derived_Class_Name(Comma_Seperated_Base_Class_Names):
 Body_of_Derived_Class

```

Program 10.25 demonstrates the concept of single inheritance.

**PROGRAM 10.25** | Write a simple program on inheritance.

```
class A:
 print('Hello I am in Base Class')
class B(A):
 print('Wow!! Great ! I am Derived class')
ob2 = A() #Instance of class B
```

**Output**

```
Hello I am in Base Class
Wow!! Great! I am Derived class
```

**Explanation** In the above program, we have created the parent class, i.e. (base class) **class A** and child class **class B(A)**: (also called the derived class). The 'A' inside the brackets indicates that class B inherits the properties of its base class A. The instance of the derived class, i.e. the instance ob2 is invoked to execute the functionality of the derived class.

**PROGRAM 10.26** | Write program to create a base class with **Point**. Define the method **Set\_Cordinate(X, Y)**. Define the new class **New\_Point**, which inherits the **Point** class. Also add draw() method inside the subclass.

```
Class Point: #Base Class
 def Set_Cordinates(self,X, Y):
 self.X = X
 self.Y = Y

class New_Point(Point): #Derived Class
 def draw(self):
 print(' Locate Point X = ',self.X,' On X axis')
 print(' Locate Point Y = ',self.Y,' On Y axis')

P = New_Point() #Instance of Derived Class
P.Set_Cordinates(10,20)
P.draw()
```

**Output**

```
Locate Point X = 10 On X axis
Locate Point Y = 20 On Y axis
```

**Explanation** The instance of the derived class **P** is created. It is used to initialise the two member variables, **X** and **Y**. **Set\_Cordinates()** method is used to initialise the values of **X** and **Y**. The instance, **P** can access this method since it has been inherited from the parent class. Finally, the **draw()** method is called to draw the point. Thus, the child class **New\_Point** has access to all the attributes and methods defined in its parent class.

## 10.17 SUBCLASS ACCESSING ATTRIBUTES OF PARENT CLASS

Consider Program 10.27 where attributes of the parent class are inherited by its child class.

**PROGRAM 10.27** | Write a program to inherit attributes of the parent class to a child class.

```
class A: # Base Class
 i = 0
 j = 0
 def Showij(self):
 print('i = ',self.i,' j = ',self.j)
class B(A): #Class B inherits attributes and methods of class A
 k = 0
 def Showijk(self):
 print(' i = ',self.i,' j = ',self.j,' k = ',self.k)
 def sum(self):
 print(' i + j + k = ', self.i + self.j + self.k)

Ob1 = A() #Instance of Base class
Ob2 = B() #Instance of Child class
Ob1.i = 100
Ob1.j = 200
print(' Contents of Obj1 ')
Ob1.Showij()
Ob2.i = 100
Ob2.j = 200
Ob2.k = 300
print(' Contents of Obj2 ')
Ob2.Showij() #Sub class Calling method of Base Class
Ob2.Showijk()
print(' Sum of i, j and k in Ob2')
Ob2.sum()
```

### Output

```
Contents of Obj1
i = 100 j = 200
```

(Contd.)

```

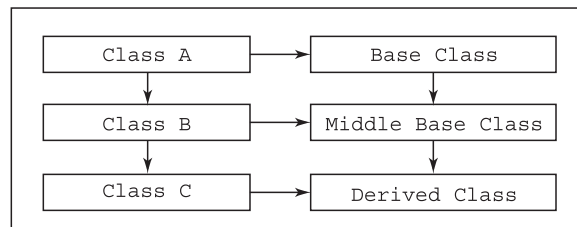
Contents of Obj2
i = 100 j = 200
i = 100 j = 200 k = 300
Sum of i, j and k in Obj2
i + j + k = 600

```

**Explanation** In the above example, the subclass **B** includes all the attributes of its base class **A**. This is why **Obj2** can access **i**, **j** and call method **showij()**.

## 10.18 MULTILEVEL INHERITANCE IN DETAIL

The procedure of deriving a class from a derived class is called multilevel inheritance.



**Figure 10.7** Multilevel inheritance

**PROGRAM 10.28** Write a simple program to demonstrate the concept of multilevel inheritance.

```

class A: #Base Class
 name = ' '
 age = 0

class B(A): #Derived Class inheriting Base Class A
 height = ' '

class C(B): #Derived Class inheriting his Base Class B
 weight = ' '

 def Read(self):
 print('Please Enter the Following Values')
 self.name=input('Enter Name:')
 self.age = (int(input('Enter Age:'))
 self.height = (input('Enter Height:'))
 self.weight = (int(input('Enter Weight:')))

 def Display(self):

```

(Contd.)

```

print('Entered Values are as follows')
print(' Name = ',self.name)
print(' Age = ',self.age)
print(' Height = ',self.height)
print(' Weight = ',self.weight)

```

```

B1 = C() #Instance of Class C
B1.Read() #Invoke Method Read
B1.Display() #Invoke Method Display

```

### Output

```

Please Enter the Following Values
Enter Name: Amit
Enter Age:25
Enter Height:5,7'
Enter Weight:60

```

```

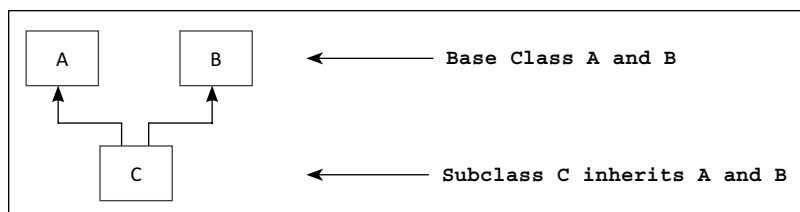
Entered Values are as follows
Name = Amit
Age = 25
Height = 5,7'
Weight = 60

```

**Explanation** In the above program **class A, B and C** are declared. The member variables of all these classes are initialised with the default value as zero. Class B is derived from class A. Class C is derived from class B. Thus, class B acts as the derived class as well as the base class for class C. The method `read()` reads data through the keyboard and the method `Display()` displays data on the screen. Both the functions are invoked using the object **B1** of **class C**.

## 10.19 MULTIPLE INHERITANCE IN DETAIL

When two or more base classes are used for derivation of a new class, it is called multiple inheritance. Let us create a two base classes A, B and one child class C. The child class C inherits the classes A and B.



**Figure 10.8** Example of multiple inheritance



**PROGRAM 10.29** | Write a simple program to demonstrate multiple inheritance.

```

class A: #Base Class A
 a = 0

class B: #Other Base Class B
 b = 0

class C(A,B): #Inherit A and B to create New Class C
 c = 0

 def Read(self):
 self.a = (int(input('Enter the Value of a:')))
 self.b = (int(input('Enter the value of b:')))
 self.c = (int(input('Enter the value of c:')))

 def display(self):
 print(' a = ',self.a)
 print(' b = ',self.b)
 print(' c = ',self.c)

Ob1 = C() #Instance of Child Class
Ob1.Read()
Ob1.display()

```

**Output**

```

Enter the Value of a:10
Enter the value of b:20
Enter the value of c:30
a = 10
b = 20
c = 30

```

**Explanation** In the above program we have created two base classes A and B. Class C is created, which inherits the properties of classes A and B. The statement **class C(A, B)** is used to inherit the properties of classes A and B. Finally, the instance of subclass C is used to call method read and display.

**10.19.1 More Practical Examples on Inheritance**

We have created the parent class **Box**. The constructor **\_\_init\_\_** is used to initialise all the attributes of the class Box. Similarly, the subclass named **ChildBox** is created. The extra attribute named weight is added to the child class, i.e. weight. Thus, all the attributes of the base class along with

the attributes of the child class are initialised in the constructor of the child class by making use of the `__init__` method.

**PROGRAM 10.30** | Write a program to calculate the volume of Box using the `init()` method.

```

Class Box:
 width = 0
 height = 0
 depth = 0
 def __init__(self,W,H,D):
 self.width = W
 self.height = H
 self.depth = D
 def volume(self):
 return self.width * self.height * self.depth

class ChildBox(Box):
 weight = 0
 def __init__(self,W,H,D,WT):
 self.width = W
 self.height = H
 self.depth = D
 self.weight = WT
 def volume(self):
 return self.width * self.height * self.depth

B1 = ChildBox(10,20,30,150)
B2 = ChildBox(5,4,2,100)
vol = B1.volume()
print(' ----- Characteristics of Box1 ----- ')
print(' Width = ',B1.width)
print(' height = ',B1.height)
print(' depth = ',B1.depth)
print(' Weight = ',B1.weight)
print(' Volume of Box1 = ',vol)
print(' ----- Characteristics of Box2----- ')
print(' Width = ',B2.width)
print(' height = ',B2.height)
print(' depth = ',B2.depth)
print(' Weight = ',B2.weight)
vol = B2.volume()
print(' Volume of Box2 = ',vol)

```

(Contd.)

**Output**

```

----- Characteristics of Box1 -----
Width = 10
height = 20
depth = 30
Weight = 150
Volume of Box1 = 6000
----- Characteristics of Box2-----
Width = 5
height = 4
depth = 2
Weight = 100
Volume of Box2 = 40

```

**10.20 USING super()**

Consider the following program.

**PROGRAM 10.31**

```

class Demo:
 a = 0
 b = 0
 c = 0
 def __init__(self,A,B,C):
 self.a = A
 self.b = B
 self.c = C
 def display(self):
 print(self.a,self.b,self.c)

class NewDemo(Demo):
 d = 0
 def __init__(self,A,B,C,D):
 self.a = A
 self.b = B
 self.c = C
 self.d = D

 def display(self):
 print(self.a,self.b,self.c,self.d)

```

(Contd.)

```

B1 = Demo(100,200,300)
print(' Contents of Base Class')
B1.display ()
D1=NewDemo(10,20,30,40)
print(' Contents of Derived Class')
D1.display()

```

### Output

```

Contents of Base Class
100 200 300
Contents of Derived Class
10 20 30 40

```

In the above program, the classes derived from the base class **Demo** were not implemented efficiently or robustly. For example, the derived class **NewDemo** explicitly initialises the value of **A**, **B** and **C**, fields of the **Base class**. The same duplication of code is found while initialising the same fields in the base class **Demo**, which is inefficient. This implies that a subclass must be granted access to the members of a super class.

Therefore, whenever a subclass needs to refer to its immediate super class, a programmer can do so by using **super**. The **super** is used to call the constructor, i.e. the `__init__` method of the super class.

### 10.20.1 Super to Call Super Class Constructor

Any subclass can call the constructor, i.e. the `__init__` method defined by its super class by making use of **super**. The syntax to call the constructor of a super class in Python 3.X is:

```
super().__init__(Parameters_of_Super_class_Constructor)
```

The syntax to call the super class constructor from its base class in Python 2.X is:

```
super(Derived_Class_Name,self).__init__(Parameters_of_Super_class_Constructor)
```

Consider the above program and use **super** to avoid duplication of code.

**PROGRAM 10.32** | Use **super()** and call the constructor of the base class.

```

class Demo:
 a = 0
 b = 0
 c = 0

```

(Contd.)

```

def __init__(self,A,B,C):
 self.a = A
 self.b = B
 self.c = C

def display(self):
 print(self.a,self.b,self.c)

class NewDemo(Demo):
 d = 0
 def __init__(self,A,B,C,D):
 self.d = D
 super().__init__(A,B,C) #Super to call Super class
 # __init__ method

 def display(self):
 print(self.a,self.b,self.c,self.d)

B1 = Demo(100,200,300)
print(' Contents of Base Class')
B1.display ()
D1=NewDemo(10,20,30,40)
print(' Contents of Derieved Class')
D1.display()

```

**Output**

```

Contents of Base Class
100 200 300
Contents of Derived Class
10 20 30 40

```

**Explanation** The derived class `NewDemo()` calls the `super()` with arguments `a`, `b` and `c`. This causes the constructor `__init__` of the base class, i.e. `Demo` to be called. This initialises the values of `a`, `b` and `c`. The `NewDemo()` class no longer initialises these values itself.

## 10.21 METHOD OVERRIDING

In class hierarchy, when a method in a sub class has the same name and same header as that of a super class then the method in the sub class is said to override the method in the super class. When an overridden method is called, it always invokes the method defined by its subclass. The same method defined by the super class is hidden. Consider the following example to demonstrate the concept of method overriding.

**PROGRAM 10.33** | Write a program to show method overriding.

```

class A: #Base Class
 i = 0
 def display(self):
 print(' I am in Super Class')

class B(A): #Derived Class
 i = 0
 def display(self): #Overridden Method
 print(' I am in Sub Class')

D1 = B()
D1.display()

```

**Explanation** In the above program when **display()** method is invoked on an instance of B, the method **display()** defined within B is invoked. Therefore, the method **display()** overrides the method **display()** defined in the base class A.

Programmer can make use of **super** to access the overridden methods. The syntax to call the overridden method that is defined in super class is

**super().method\_name**

The above same program 10.33 is given below except, the overridden method defined in super class is accessed by using **super()**.

```

class A: #Base Class
 i = 0
 def display(self):
 print(' I am in Super Class')

class B(A): #Super Class
 i = 0
 def display(self): #Overridden Method
 print(' I am in Sub Class')
 super().display() #Call Display method of Base class

D1 = B() #Instance of sub class
D1.display()

```

**Output:**

```

I am in Sub Class
I am in Super Class

```

From this program we have learnt how to call overridden methods using super.

## 10.22 PRECAUTION: OVERRIDING METHODS IN MULTIPLE INHERITANCE

As discussed before, in multiple inheritance there is at least one class which inherits the properties from two or more classes. Sometimes multiple inheritance can be so complex that some programming languages put restrictions on it.

Consider Program 10.34 on multiple inheritance where method named `display()` has been overridden.

**PROGRAM 10.34** | Program to override `Display()` method in multiple inheritance.

```
class A(object):
 def Display(self):
 print(" I am in A")

class B(A):
 def Display(self):
 print(" I am in B")
 A.Display(self) # call the parent class method too

class C(A):
 def Display(self):
 print(" I am in C")
 A.Display(self)

class D(B, C):
 def Display(self):
 print(" I am in D")
 B.Display(self)
 C.Display(self)

Ob = D()
Ob.Display()
```

### Output

```
I am in D
I am in B
I am in A
I am in C
I am in A
```

The problem with the above method is that **A.Display** method has been called twice. If we have a complex tree of multiple inheritance then it is very difficult to solve this problem by hand. We have to keep track of which super classes have already been called and avoid calling them a second time.

Therefore, to solve the above problem, we can make use of **super**. Consider the same program with some modifications.

```
class A(object):
 def Display(self):
 print(" I am in A")

class B(A):
 def Display(self):
 print(" I am in B")
 super().Display() # call the parent class method too

class C(A):
 def Display(self):
 print(" I am in C")
 super().Display()

class D(B, C):
 def Display(self):
 print(" I am in D")
 super().Display()

Ob = D()
Ob.Display()
```

### Output

```
I am in D
I am in B
I am in C
I am in A
```

Therefore, by using **super**, the method inside multiple inheritance hierarchy gets exactly called once and in the right order.

## MINI PROJECT Arithmetic Operations on Complex Numbers

This mini project will make use of various concepts of object-oriented programming such as **constructor**, **self-parameter**, creating **instance** of class and **overloading** of inbuilt functions.



### Explanation of Complex Numbers

Complex numbers can be written in the form  $a + bi$  where  $a$  and  $b$  are real numbers and  $i$  is the unit imaginary number, i.e.  $\sqrt{-1}$ . The values of  $a$  and  $b$  can be zero. Complex numbers contain two parts, viz. **real** and **imaginary**.

Valid examples of complex numbers are

$$2 + 6i, 1 - i, 4 + 0i$$

### Addition of Two Complex Numbers

Consider two complex numbers  $(a + bi)$  and  $(c + di)$ . In case of addition, add the real parts and then add the imaginary parts.

$$\begin{aligned}(a + bi) + (c + di) &= (a + c) + (b + d)i \\ (2 + 1i) + (5 + 6i) &= (2 + 5) + (1 + 6)i = (7 + 7i)\end{aligned}$$

### Subtraction of Two Complex Numbers

Consider two complex numbers  $(a + bi)$  and  $(c + di)$ . In case of subtraction, subtract the real parts and then subtract the imaginary parts.

$$\begin{aligned}(a + bi) - (c + di) &= (a - c) + (b - d)i \\ (2 + 1i) - (5 + 6i) &= (2 - 5) + (1 - 6)i = (-3 - 5i)\end{aligned}$$

### Multiplication of Two Complex Numbers

Consider two complex numbers  $(a + bi)$  and  $(c + di)$ . Multiplication of two such complex numbers is:

$$\begin{aligned}(a + bi) * (c + di) &= (ac - bd) + (ad + bc)i \\ (2 + 1i) * (5 + 6i) &= (2*5 - 1*6) + ((2*6)i + (1*5)i) \\ &= 4 + 17i\end{aligned}$$

**PROBLEM STATEMENT** | Write a program to perform the following operations on complex numbers.

- (a) Addition
- (b) Subtraction
- (c) Multiplication
- (d) Check if two complex numbers are equal or not
- (e) Check if  $C1 \geq C2$
- (f) Check if  $C1 \leq C2$



**Note:** Make use of the following inbuilt methods to implement the above functions.

`__add__` method to overload `+` Operator  
`__sub__` method to overload `-` Operator  
`__mul__` method to overload `*` operator  
`__le__` method to overload `<` operator  
`__ge__` method to overload `>` operator

## Algorithm

- ◎ **STEP 1:** Create a class named **Complex**.
- ◎ **STEP 2:** Create the constructor of the class **Complex** using the **init** method. The constructor will have two parameters, viz. one each to store the real and the imaginary part.
- ◎ **STEP 3:** Create such other methods for add, sub, mul to perform addition, subtraction and multiplication, respectively. Define all the functionalities of these operations by making use of inbuilt functions.
- ◎ **STEP 4:** Also define the inbuilt methods to check if two complex numbers are equal or if the first complex number is greater than the second.
- ◎ **STEP 5:** Create two **instances** of **Complex** class **C1** and **C2** to declare two complex numbers.
- ◎ **STEP 6:** Use these two instances to perform all the operations.

## Solution

```
class Complex(object):
 def __init__(self, real, imag=0.0):
 self.real = real
 self.imag = imag

 def print_Complex_Number(self):
 print('(' , self.real, ' , ' , self.imag, ')')

 def __add__(self, other):
 return Complex(self.real + other.real,
 self.imag + other.imag)

 def __sub__(self, other):
 return Complex(self.real - other.real,
 self.imag - other.imag)

 def __mul__(self, other):
 return Complex(self.real* other.real
```

(Contd.)

```
 - self.imag * other.imag,
 self.imag* other.real +
 self.real * other.imag)

def __eq__(self,other):
 return self.real == other.real and
 self.imag == other.imag

def __le__(self,other):
 return self.real < other.real and self.imag < other.imag

def __ge__(self,other):
 return self.real > other.real and self.imag > other.imag

C1 = Complex(2, 1)
print('First Complex Number is as Follows:')
C1.print_Complex_Number()

C2 = Complex(5, 6)
print('Second Complex Number is as Follows:')
C2.print_Complex_Number()

print('Addition of two complex Number is as follows:')
C3 = C1 + C2
C3.print_Complex_Number()

print('Subtraction of two Complex Number is as follows:')
C4 = C1 - C2
C4.print_Complex_Number()

print('Multiplication of two Complex Number is as follows:')
C5 = C1 * C2
C5.print_Complex_Number()

print('Compare Two Complex Numbers:')
print((C1 == C2)) #Returns true if equal
 #Returns false if not

print('Checking if C1 is Greater than C2:')
```

(Contd.)

```
print(C1 >= C2)

print('Checking if C1 is Less than C2:')
print(C1 <= C2)
```

### Output

```
First Complex Number is as Follows:
(2 , 1)
Second Complex Number is as Follows:
(5 , 6)
Addition of two complex Number is as follows:
(7 , 7)
Subtraction of two Complex Number is as follows:
(-3 , -5)
Multiplication of two Complex Number is as follows:
(4 , 17)
Compare Two Complex Numbers:
False
Checking if C1 is Greater than C2:
False
Checking if C1 is Less than C2:
True
```

Thus, in the above program we have effectively used inbuilt methods to overload various operators, such as +, -, \*, >=, <= and == operators.

## SUMMARY

- The **class** is fundamental building block of python's object-oriented programming.
- **Attributes** and **methods** can be added inside the class definition.
- **Instantiation** refers to creation of new object.
- **Self** parameter is used to distinguish between normal method defined outside the class and the method defined within the class.
- The **\_\_init\_\_** method is similar to the constructor of other programming language.
- The **\_\_del\_\_** i.e. destructor method is invoked when instance is about to be destroyed.
- Operator and method overloading have been discussed in brief in this chapter.
- The concept of inheritance is used to extend the properties of base class to its child class.

## KEY TERMS

- ⇒ **class:** Type in Python
- ⇒ **object:** Instance of class

- ⇒ **dot (.) Operator:** Access methods and attributes of a class
- ⇒ **Instantiation:** Process of creating new objects
- ⇒ **Self-parameter:** References the object itself
- ⇒ **Accessibility:** Prevents access
- ⇒ **\_\_init\_\_:** Initialiser (Constructor)
- ⇒ **\_\_del\_\_:** Destructor
- ⇒ **Operator Overloading:** Associates a special method for each operator
- ⇒ **Inheritance:** Creates a new class from an existing class
- ⇒ **Single, Multiple, Multilevel:** Types of inheritance
- ⇒ **super Keyword:** Used for method overriding

## REVIEW QUESTIONS

### A. Multiple Choice Questions

- What is the relation between object and class?
  - A class is an instance of an object
  - An object is an instance of an object
  - An object is an attribute of a class
  - None of the above
- Which method should be used to create default values in a class constructor?
  - \_\_doc\_\_
  - \_\_new\_\_
  - \_\_init\_\_
  - \_\_del\_\_
- Instantiation is a process of:
  - Destroying an object
  - Initialising an object with a default value
  - Creating a new object with a default value
  - None of the above
- What method is called when an object is created?
  - Self
  - obj.self
  - init
  - \_\_int\_\_
- We have an object instance obj and want to call its method calc\_area(). Which is the correct way of calling the function calc\_area()?
  - obj.calc\_area(self)
  - calc\_area.obj()
  - obj.calc\_area()
  - calc\_area.obj(self)
- Method overriding is \_\_\_\_\_.
  - A method with different name,
  - A method in a subclass which has the same name and same header as that of the super class
  - Both a and b
  - None of the above
- What is used to create an object?
  - Constructor
  - Class
  - Method
  - None of the above
- Which of the following statements are true?
  - Objects of the same type have the same id.
  - Each object has a unique id.
  - Both a and b
  - None of the above

9. \_\_\_\_\_ represents an entity in the real world which can be distinctly identified?
- Object
  - Class
  - Method
  - None of the above
10. Analyze the code given below to find the reason behind the error in the program.

```
class A:
 def __init__(self):
 self.P = 10
 self.__Q = 20

 def getY(self):
 return self.__Q

a = A()
print(a.__Q)
```

- Q is private and cannot be access outside of the class.
  - P is private and cannot be access outside of the class.
  - Both a and b
  - None of the above
11. Analyze the code given below to find the reason behind the error in the program.

```
class Base:
 def __init__(self, X):
 self.X = X
 def print(self):
 print(self.X)
```

```
Ob1 = Base()
Ob1.print()
```

- The class Base does not have a constructor.
  - X is not defined in print.
  - The constructor is invoked without arguments.
  - None of the above
12. What will be the output of the following program?

```
class A:
 def __init__(self, s):
 self.s = s
 def display():
 print(s)

a = A("Welcome")
a.display()
```

- Welcome
- Error: The self is missing in method display()
- Cannot access method display()
- None of the above

13. Which statement is correct about self?
- Self refers to the previous object.
  - Self refers to the next object.
  - Self refers to the current object.
  - None of the above
14. Which method runs as soon as an object of a class is instantiated?
- `__init__`
  - `__del__`
  - `self`
  - None of the above
15. Which of the following is not a type of inheritance?
- Single
  - Multilevel
  - Distributive
  - Multiple
16. Look at the following definition of class and determine the type of inheritance the class is using.
- ```
class A:
    Pass
class B:
    Pass
class C(A , B):
    Pass
```
- Single
 - Multilevel
 - Multiple
 - None of the above
17. Which method is used to display the attributes of a class?
- `__init__`
 - `__dict__`
 - `__del__`
 - None of the above
18. The `__del__` is executed only if all_____.
- The references to a current instance object have been removed
 - The references to a previous object have been removed
 - The references to an instance object have been removed
 - None of the above
19. Suppose B is a subclass of A. Which syntax will be used to invoke the `__init__` method defined in class A from class B?
- `super()`
 - `super().__init__(self)`
 - `super().__init__()`
 - None of the above
20. If Ob1 is an instance of class A. Which statement can be used to check whether the object Ob1 is an instance of class A?
- `Ob1.isinstance(A)`
 - `A.isinstance(Ob1)`
 - `isinstance(Ob1, A)`
 - `isinstance(A, Ob1)`

B. True or False

- Python does not permit re-use of an existing module or function.
- Indentation is not important in Python.
- A class is followed by an indented block of statements which forms the body of the class.
- In order to add methods to an existing class, the first parameter for each method should be self.
- The `directory()` function is used to see the attributes of a class.
- The `dir()` function returns a sorted list of attributes and methods belonging to an object.
- All attributes and methods in Python are public by default.

8. The `__init__` method is a special method which is used to initialise instance variable of an object.
9. We can pass an object as parameter to a method.
10. The properties of existing classes are simply extended to new classes.
11. New classes are not created from existing ones using inheritance.
12. In single inheritance, two base classes are used for the derivation of a new class.
13. When two or more base classes are used for derivation of a new class, it is called multiple inheritance.
14. Inheritance inherits features of its base class.
15. The syntax used to assign a value to an attribute on an object is `<object>.<attribute> = <Value>`

C. Exercise Questions

1. What is a class?
2. State the syntax to define a class.
3. How are attributes added to a class?
4. State the syntax to add methods in a class.
5. What is self-parameter? List its uses.
6. List the applications of special class attributes.
7. What is meant by inheritance?
8. List the different types of inheritances.
9. Explain multiple inheritance with an example.
10. What can be done with overriding a method?
11. State the syntax to override a method.
12. Complete the code given below and then perform the following tasks on the coordinate class.
 - a. Instantiate two different objects **P1** and **P2**.
 - b. Display the coordinates of P1 and P2.
 - c. Add an `__eq__` method that returns True if coordinates P1 and P2 refer to the same point in a plane.

```
class Coordinate(object):
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def getX(self):
        return self.x

    def getY(self):
        return self.y
```

13. Consider the code and answer the following questions.

```
class A(object):
    def __init__(self, Name, Gender):
        self.Name = Name
        self.Gender = Gender
```



```

def execute(self):
    print(self.Name)

class B(A):
    def __init__(self):
        A.__init__(self, 'John', 'Male')

class C(A):
    def __init__(self):
        A.__init__(self, 'Anushka', 'Female')

class D(A):
    print(A)

Ob1 = B()
Ob1.execute()

```

- Identify the parent classes present in the above code.
- Identify the child classes present in the above code.
- What will be the output of the above code?

PROGRAMMING ASSIGNMENTS

- Write a program to create a class named **Demo**. Define two methods **Get_String()** and **Print_String()**. Accept the string from user and print the string in upper case.
- Write a program to create a class **Circle**. Perform the following operations on it.
 - Define the attribute **radius**.
 - Define the constructor with one argument containing radius.
 - Define the method named **get_radius()** which returns the radius of the circle.
 - Define the method named **calc_area()** which returns the area of the circle.
- Write a program to create the class **Point**. Perform the following operations on it.
 - Initialise X and Y coordinates of the point.
 - Print the coordinates by defining the method **'Display()'**.
 - Define the method **Translate(X, Y)** to move the point X units in X direction and Y units in Y direction.
- Write a program to implement single inheritance.
 - Create the parent class **Circle**. Initialise the constructor with the radius of the circle.
 - Define the method **get_radius()** and **calc_area()** to know the radius and area of the circle.

(Contd.)

PROGRAMMING ASSIGNMENTS (Contd.)

- c. Create the child class named **Cylinder**. Initialise the value of the height within the constructor and call the constructor of the parent class to initialise the radius of the cylinder.
- d. Finally, define the method **Calc_area()** in the class **Cylinder** to calculate the area of the cylinder.

Note: Area of Cylinder = $2 * \pi * \text{radius} * \text{height}$

- 5. Write a program to implement the concept of multiple inheritance.
 - a. Create the parent class **Shape**. Initialise the constructor with **Shape**.
 - b. Create another class named **Rectangle** which inherits the properties of the parent class **Shape**. Define the attributes length and breadth in the Rectangle class. Initialise the length and breadth inside the constructor of the Rectangle class. Also call the constructor of the parent class to initialise the **color** of the Rectangle. Define the method **calc_area()** to return the area of the rectangle.
 - c. Create another class named **Triangle** which inherits the properties of the parent class **Shape**. Define the attributes **base** and **height** in the **Triangle** class. Initialise the base and height inside the constructor of the **Triangle** class. Also call the constructor of the parent class to initialise the **color** of the **Triangle**. Define the method **calc_area()** to return the area of the **Triangle**.
 - d. Also create the method **Tring_Details()** in the **Triangle** class and **Rect_Details()** in the **Rectangle** Class to return complete details about the rectangle and triangle.
 - e. Finally, create the instance of the **Rectangle** and **Triangle** classes to return the area of the Rectangle and Triangle.

Tuples, Sets and Dictionaries

11

CHAPTER OUTLINE

11.1 Introduction to Tuples

11.3 Dictionaries

11.2 Sets

LEARNING OUTCOMES

After completing this chapter, students will be able to:

- Create tuples, sets and dictionaries and explain their necessity and importance in programming
- Pass variable length arguments to tuples and use inbuilt functions such as `len`, `min`, `max` and `sum`, and other functions such as `zip()` and `sort()` on tuples
- Perform different operations on sets such as union, intersection, difference and symmetric difference
- Create dictionaries and add, retrieve, modify and delete the values of dictionaries
- Traverse the contents of sets, tuples and dictionaries using the for loop function

11.1 INTRODUCTION

Tuples work exactly like lists. A tuple contains a sequence of items of many types. The elements of tuples are fixed. Once a tuple has been created, we cannot add or delete elements, or even shuffle their order. Hence, tuples are immutable. This means that once created, they cannot be changed. Since tuples are immutable, their length is also fixed. A new tuple must be created to grow or shrink an earlier one.

11.1.1 Creating Tuples

A tuple is an inbuilt data type in Python. In order to create a tuple, the elements of tuples are enclosed in parenthesis instead of square brackets. All the elements of a tuple are separated by commas.

Example: Defining a tuple

```
T1 = ()      #Create an empty tuple
T2 = (12,34,56,90)  #Create a tuple with 4 elements
T3 = ('a','b','c','d','e') #Create a tuple of 5 characters
T4 = 'a','b','c','d','e'  #Create a tuple without parenthesis
```



Note: #To create a tuple of a single element, it should be followed by a comma.

```
>>> T1=(4,)
```

```
>>> type(T1)
```

```
<class 'tuple'>
```

Is it possible to create a tuple of a single element without a comma?

```
>>> T1=(4)
```

```
>>> type(T1)
```

```
<class 'int'>
```

Point to Remember

A single value in parenthesis is not a tuple.

11.1.2 The tuple() Function

In the above section, we learnt how to create a tuple. For example, an empty tuple is created by using empty parenthesis.

```
>>>t1=()      # Create Empty tuple
>>> t1        # Print Empty tuple
()
>>> type(t1)   #Check the type of t1
<class 'tuple'>
```

An alternate way of creating a tuple is by using the `tuple()` function.

Example

```
>>> t1=tuple()  # Create Empty tuple using tuple() function
>>> t1          # Print tuple t1
()
```

If the argument to a `tuple()` function is a sequence, i.e. string, list or a tuple then the result is a tuple with the elements of the sequence.

Example

```
>>> t1=tuple("TENNIS") #Tuple function with string as argument
>>> t1
('T', 'E', 'N', 'N', 'I', 'S')
```

11.1.3 Inbuilt Functions for Tuples

Python provides various inbuilt functions that can be used with tuples. Some of these are shown in Table 11.1.

Table 11.1 Inbuilt functions that can be used with tuples

<i>Inbuilt Functions</i>	<i>Meaning</i>
<code>len()</code>	Returns the number of elements in a tuple
<code>max()</code>	Returns the element with the greatest value
<code>min()</code>	Returns the element with the smallest value
<code>sum()</code>	Returns the sum of all the elements of a tuple
<code>index(x)</code>	Returns the index of element x
<code>count(x)</code>	Returns the number of occurrences of element x

Example

```
>>> t1=("APPLE")
>>> len(t1) #Return the length of tuple t1
5
>>> max(t1) #Return Element from tuple with Maximum Value
'P'
>>> min(t1) #Return Element from tuple with Minimum Value
'A'
>>> t1.index('A')
0
>>> t1.count('P')
2
```

11.1.4 Indexing and Slicing

Since tuples are like lists, the indexing and slicing of tuples is also similar to that of lists. The `index []` operator is used to access the elements of a tuple.

Example

t[0]	t[1]	t[2]	t[3]	t[4]	t[5]	← Positive Index
P	Y	T	H	O	N	
t[-6]	t[-5]	t[-4]	t[-3]	t[-2]	t[-1]	← Negative Index

```

>>> t=('P','Y','T','H','O','N')      #Create Tuple
>>> t                                  #Print Tuple
>>> ('P', 'Y', 'T', 'H', 'O', 'N')
>>> t[0]
'P'
>>> t[5]
'N'
>>> t[-1]
'N'
>>> t[-6]
'P'

```

Tuple Slicing Example

```

>>> t=('P','Y','T','H','O','N')      #Create Tuple
>>> t                                  #Print Tuple
>>> ('P', 'Y', 'T', 'H', 'O', 'N')
>>> t[0:] #Print the contents of tuple t starting from index 0
('P', 'Y', 'T', 'H', 'O', 'N')
>>> t[0:3] #Print the contents of tuple t starting from 0 to 2
('P', 'Y', 'T')

```



Note: More details of slicing can be found in Chapter 8: Lists.

11.1.5 Operations on Tuples

Tuples don't support all methods supported by lists. A tuple supports the usual sequence operations supported by a list.

1. **The + Operator:** The concatenation + operator is used to join two tuples.

```

>>> (1,2)+(3,4)      #The concatenation operator
(1, 2, 3, 4)

```

2. **The * Operator:** The multiplication operator is used to replicate the elements of a tuple.

```

>>> (1,2)*3          #The Repetition Operator
(1, 2, 1, 2, 1, 2)

```

11.1.6 Passing Variable Length Arguments to Tuples

We can pass variable number of parameters to a function. An argument which begins with the * in function definition gathers all arguments into a tuple.

PROGRAM 11.1 | Write a program to create a function `create _ tup()` which accepts a variable number of arguments and prints all of them.

```

def create_tup(*args):
    print(args)

```

(Contd.)

Output

Run the above program in interactive mode of Python.

```
>>> create_tup(1,2,3,4)
(1, 2, 3, 4)
>>> create_tup('a','b')
('a', 'b')
```

The inbuilt **sum()** function takes two parameters to add the elements within it.

How can we create a function that takes variable arguments and adds all the elements present in it?

The following program creates the function **sum_all()** which accepts a variable number of arguments and displays the sum of all the arguments.

PROGRAM 11.2 | Create function **sum_all()** to accept a variable number of arguments and display the sum of all the elements present in it.

```
def sum_all(*args):
    t=()
    s=0
    for i in args:
        s=s+i
    print(s)
```

Output

#Running the above program in Python interactive mode.

```
>>>sum_all(10,20,30,40) #Function sum_all with variable arguments
100

>>> sum_all(1,2,3)
6
```

11.1.7 Lists and Tuples

A tuple can also be created from a list. This is illustrated in the following example.

Example

```
>>> List1=[1,2,3,4]      #Create List
>>> print(List1)         #Print List1
[1, 2, 3, 4]
>>> type(List1)          #Print the type of variable List1
<class 'list'>
>>> t1=tuple(List1)      #Convert List to tuple
>>> t1                   #print t1
```

```
(1, 2, 3, 4)
>>> type(t1) #Check type of t1 after converting List to Tuple
<class 'tuple'>
```

11.1.8 Sort Tuples

If a programmer wants to sort a tuple, he/she can use the inbuilt `sort()` method. A tuple does not contain any method named `sort`. Therefore, to sort a tuple, a programmer will have to first convert a tuple into a list. After conversion, he/she can use `sort()` method for lists and then again convert the sorted list into a tuple.

```
>>> t1=(7,2,1,8) #Create Tuple t1
>>> t1           #Print t1
(7, 2, 1, 8)
>>> L1=list(t1)  #Convert Tuple t1 to List
>>> L1           #Print L1
[7, 2, 1, 8]
>>> L1.sort()    #Sort List
>>> t2=tuple(L1) #Convert Sorted List to Tuple
>>> t2           #Print sorted tuple
(1, 2, 7, 8)
```

11.1.9 Traverse Tuples from a List

A tuple assignment can be used in the for loop to traverse a list of tuples.

PROGRAM 11.3 | Write a program to traverse tuples from a list.

```
T=[(1, "Amit"), (2,"Divya"), (3,"Sameer")]
for no, name in t:
    print(no, name)
```

Output

```
1 Amit
2 Divya
3 Sameer
```

11.1.10 The `zip()` Function

The `zip()` is an inbuilt function in Python. It takes items in sequence from a number of collections to make a list of tuples, where each tuple contains one item from each collection. The function is often used to group items from a list which has the same index.

Example

```
>>> A1=[1,2,3]
```



```

..
>>> A2="XYZ"
>>> list(zip(A1,A2))           #Zip List A1 and A2
[(1, 'X'), (2, 'Y'), (3, 'Z')]

```

Explanation

The result of `list(zip(A1,A2))` is a list of tuples where each tuple contains an index wise element from each list as a pair.

Example

```

>>> L1=['Laptop', 'Desktop', 'Mobile']           #Create List1
>>> L2=[40000,30000,15000]                       #Create List2
>>> L3=tuple((list(zip(L1,L2)))) #Group item from List 1 and 2
>>> L3 #print L3
(('Laptop', 40000), ('Desktop', 30000), ('Mobile', 15000))

```



Note: If the sequences are not of the same length then the result of `zip()` has the length of the shorter sequence.

Example:

```

>>> a="abcd"           #Sequence of length 4
>>> b=[1,2,3]          #Sequence of length 3
>>> list(zip(a,b)) #Zip() on a and b returns list of tuples
[('a', 1), ('b', 2), ('c', 3)]

```

PROGRAM 11.4 | Consider two lists, viz. List L1 and L2 . Here, L1 contains a list of colors and L2 contains their color code as:

```

L1=['Black','White','Gray']
L2=[255,0,100]

```

Display the contents as:

```

('Black',255)
('white',0)
('Gray',100)

```

```

L1=['Black','White','Gray'] #Create List L1
L2=[255,0,100]              #Create List L2
for Color,Code in zip(L1,L2): # Use of zip in for loop
    print((Color,Code))

```

Output

```

('Black', 255)
('White', 0)
('Gray', 100)

```

11.1.11 The Inverse zip(*) Function

The * operator is used within the zip() function. The * operator unpacks a sequence into positional arguments. A simple example of the * operator on positional arguments is given as follows:

PROGRAM 11.5 | Demonstrate the use of the * operator on positional arguments.

```
def print_all(Country, Capital):
    print(Country)
    print(Capital)
```

Output

```
>>> args=("INDIA","DELHI")
>>> print_all(*args)
INDIA
DELHI
```

Explanation In the above program, the function print _ all() is created. When *args are assed to the function print_all, its values are *unpacked* into the function's positional arguments arg1 to Country and Capital to arg2.

The function zip(*) also performs the same operation, i.e. unpacks a sequence into positional arguments.

PROGRAM 11.6 | Demonstrate the use of the zip(*) function.

```
X=[("APPLE",50000),("DELL",30000)] #List of tuples
Laptop,Prize=zip(*X) # Unpacking Values
print(Laptop)
print(Prize)
```

Output

```
('APPLE', 'DELL')
(50000, 30000)
```

Explanation In the above program, initially the list is created. List x contains a sequence of tuples. The function zip(*) is used to unpack the values of x.

11.1.12 More Examples on zip(*) Function

#Transpose of a matrix

```
>>> Matrix=[(1,2),(3,4),(5,6)]
```

```

..
>>> Matrix
[(1, 2), (3, 4), (5, 6)]
>>> x=zip(*Matrix)
>>> tuple(x)
((1, 3, 5), (2, 4, 6))

```

11.1.13 More Programs on Tuples

PROGRAM 11.7 | Consider an example of a tuple as T = (1, 3, 2, 4, 6, 5). Write a program to store numbers present at odd index into a new tuple.

```

def oddTuples(aTup):    #Function with tuple as an argument
    rTup = ()           #Initially the output tuple rTup is empty
    index = 0
    while index < len(aTup):
        rTup += (aTup[index],)
        index += 2      #index increased by 2
    return rTup
t=(1, 3, 2, 4, 6, 5)
print(oddTuples(t))

```

Output

```
(1, 2, 6)
```

Explanation In the above program, initially a tuple 't' is created. This tuple 't' is passed as a parameter to a function. The while loop iterates till the length of the tuple. In each iteration, the number stored at an odd index is accessed and stored into the output tuple 'rTup'.

11.2 SETS

A set is an unordered collection of unique elements without duplicates. A set is mutable. Hence, we can easily add or remove elements from a set. The set data structure in Python is used to support mathematical set operations.

11.2.1 Creating Sets

A programmer can create a set by enclosing the elements inside a pair of curly brackets {}. The elements within a set can be separated using commas. We can also create a set using the inbuilt `set()` function, or from an existing list or tuple.

Examples

```

>>>S1 =set()    # Creates an empty Set
>>>S1           # Print Set S1

```

```

set()
>>> type(S1)    # Check type of S1
<class 'set'>

>>> S1={10,20,30,40}    # Create set of 4 elements
>>> S1                  # Print Set S1
{40, 10, 20, 30}

>>> S2=[1,2,3,2,5]      # Create List
>>> S2                  # Print List
[1, 2, 3, 2, 5]
>>> S3=set(S2)          # Convert List S2 to Set
>>> S3                  #Print S3 (Removes duplicate from the List)
{1, 2, 3, 5}

>>> S4=(1,2,3,4)        # Create Tuple
>>> S5=set(S4)          # Convert Tuple to Set
>>> S5                  # Print S5
{1, 2, 3, 4}

```

11.2.2 The Set in and not in Operator

The **in** operator is used to check if an element is in a set. The **in** operator returns True if the element is present in the list. The **not in** operator returns True if the said element is not present in the set.

Example

```

>>> S1={1,2,3}
>>> 3 in S1                # Check if 3 is in S1
True
>>> 4 not in S1            # Check if 4 is not in the S1
True

```

11.2.3 The Python Set Class

Python contains a **set** class. The most commonly used methods within the **set** class (with examples) are listed in Table 11.2.

Table 11.2 Methods of set class

Function	Meaning
s.add(x) Example: <pre>>>> s1={1,2,19,90} # Create set of 4 elements >>> s1.add(100) # Add 100 to the existing list s1 >>> s1 # Print s1 {1, 90, 19, 2, 100}</pre>	Adds the element x to an existing set s .
s.clear() Example: <pre>>>> s1={1,2,3,4} #Create set of 4 elements >>> s1.clear() #Remove all the elements from the set s1 >>> s1 #Print s1 set()</pre>	Removes the entire element from an existing set.
S.remove(x) Example: <pre>>>> s1={1,2,3,4} >>> s1.remove(2) #Remove element 2 from Set s1 >>> S1 {1, 3, 4}</pre> <p>Note: The <code>discard()</code> function is similar to remove function.</p>	Removes the item x from a set.
s1.issubset(s2) Example: <pre>>>> s1={1,2,3,4} >>> s2={1,2,3,4,5} >>> s1.issubset(s2) # Check if all the elements of s1 are in s2. True</pre>	If every element in $s1$ is also in $s2$ then set $s1$ is a subset of $s2$. The <code>issubset()</code> is used to check whether $s1$ is a subset of $s2$.
s2.issuperset(s1) Example: <pre>>>> s1={1,2,3} >>> s2={1,2,3,4} >>> s2.issuperset(s1) True</pre>	Let $s1$ and $s2$ be two sets. If $s1$ is a subset of $s2$ and the set $s1$ is not equal to $s2$ then the set $s2$ is called a superset of A .

11.2.4 Set Operations

In mathematics or everyday applications we often use various set operations, such as `union()`, `intersection()`, `difference()` and `symmetric_difference()`. All these methods are part of the set class.

The `union()` Method

The union of two sets A and B is a set of elements which are in A, in B or in both A and B. We can use the **union** method or the `|` operator to perform this operation.

Example

```
>>> S1={1,2,3,4}
>>> S2={2,4,5,6}
>>> S1.union(S2)
{1, 2, 3, 4, 5, 6}

>>>S1 | S2
{1, 2, 3, 4, 5, 6}
```



Note: Sets cannot have duplicate elements. So, the union of sets {1,2,3,4} and {2,4,5,6} is {1,2,3,4,5,6}.

The `intersection()` Method

The intersection of two sets A and B is a set which contains all the elements of A that also belong to B. In short, intersection is a set which contains elements that appear in both sets. We can use intersection methods or the `&` operator to perform this operation.

Example

```
>>> S1={1,2,3,4}
>>> S2={3,4,5,6}
>>> S1.intersection(S2)
{3, 4}
>>> S1 & S2
{3, 4}
```

The `difference()` Method

The difference between two sets A and B is a set which contains the elements in set A but not in set B. We can use the **difference** method or the `-` operator to perform the difference operation.

Example

```
>>> A={1,2,3,4}
>>> B={3,4,5,6}
>>> A.difference(B)
{1, 2}
```

..

```
>>>>> A-B
{1, 2}
```

The symmetric_difference()

The symmetric difference is a set which contains elements from the either set but not in both sets. We can use `symmetric_difference` method or the `^` (exclusive) operator to perform this operation.

Example

```
>>> S1={1,2,3,4}
>>> S2={3,4,5,6}
>>> S1.symmetric_difference(S2)
{1, 2, 5, 6}
>>> S1^S2
{1, 2, 5, 6}
```

11.3 DICTIONARIES

11.3.1 Need of Dictionaries

In the previous chapter, we learnt about a Python data structure called **list**. Lists organise their elements by position and this kind of structuring is useful when we want to locate elements in a specific order, i.e. locate either first, last element or visit each element in a sequence.

There may be situation where a programmer is not so much interested in the position of the item or element in the structure but in association of that element with some other element in the structure.

For example, to look up Amit's phone number we are just interested in his number from the phonebook and don't care much where the number is located in the phonebook. It means the name of the person is associated with his phone number.

11.3.2 Basics of Dictionaries

In Python, a dictionary is a collection that stores values along with keys. The sequence of such key and value pairs is separated by commas. These pairs are sometimes called **entries or items**. All entries are enclosed in curly brackets `{` and `}`. A colon separates a key and its value. Sometimes, items within dictionaries are also called associative arrays because they associate a key with a value.

Simple examples of dictionaries are given as follows:

```
Phonebook - {"Amit": "918624986968", "Amol": "919766962920"}
```

```
Country Code Information - {"India": "+91", "USA": "+1", "Singapore": "+65"}
```

The structure of a dictionary is shown in Figure 11.1a. The above phonebook example is illustrated in Figure 11.1b.

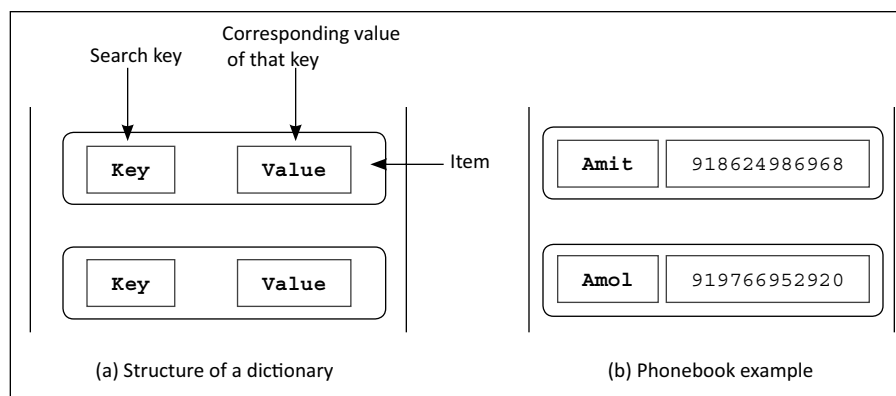


Figure 11.1 a and b Dictionary—structure and example

Keys are like an index operator in a dictionary. A key can be of any type. Therefore, a dictionary maps a set of objects, i.e. keys to another set of objects, i.e. values. It is a mapping of unique keys to values, i.e. each key is mapped to one value. Also, dictionaries do not contain any duplicate keys.

11.3.3 Creating a Dictionary

We can create a dictionary by enclosing the items inside a pair of curly brackets `{}`. One way to start a dictionary is to create an empty dictionary first and then add items to it.

Creating an Empty Dictionary

Example

```
>>> D1 = {}          # Create Empty Dictionary
>>> D1               # Print Empty Dictionary
{}
>>> type(D1)         # Check the type of D1
<class 'dict'>
```



Note: Python uses curly brackets for sets and dictionaries. Therefore, to create an empty dictionary, we use `{}` and to create an empty set, we use the function `set()`.

Creating a Dictionary with Two Items

To create a dictionary of two items, the items should be in the form of **key:value** and separated by commas.

Example: Creating a dictionary of two items

```
>>> P={"Amit":"918624986968", "Amol":"919766962920"}
>>> P      #Display P
{'Amit': '918624986968', 'Amol': '919766962920'}
```


Creating Dictionaries in Four Different Ways

Example

#Way 1:

```
>>> D1 = {'Name': 'Sachin', 'Age': 40}
>>> D1
{'Name': 'Sachin', 'Age': 40}
```

#Way 2:

```
>>> D2 = {}
>>> D2['Name'] = 'Sachin'
>>> D2['Age'] = 40
>>> D2
{'Name': 'Sachin', 'Age': 40}
```

#Way 3:

```
>>> D3 = dict(Name='Sachin', Age=40)
>>> D3
{'Name': 'Sachin', 'Age': 40}
```

#Way 4:

```
>>> dict([('name', 'Sachin'), ('age', 40)])
{'age': 40, 'name': 'Sachin'}
```

Explanation

In the above example, we have created dictionaries in four different ways. We can select the first way if we know all the contents of a dictionary in advance. The second way, if we want to add one field at a time. The third way requires all keys to string. The fourth way is good if we want to build keys and values at runtime.

11.3.4 Adding and Replacing Values

To add a new item to a dictionary, we can use the subscript[] operator. The syntax to add and an item to a dictionary is:

```
Dictionary_Name[key] = value
```

Example

```
P["Jhon"] = "913456789087"
```

In the above example, the name of the dictionary is P. We are adding the phone number of "Jhon" into our phonebook. The "Jhon" will act as the key and the phone number of Jhon will be its value.

#Running the above example in Python interactive mode

#Create Dictionary of Phonebook

```
P={"Amit":"918624986968", "Amol":"919766962920"}
>>> P      #Display P
{'Amit': '918624986968', 'Amol': '919766962920'}
```

#Add another element to the existing Dictionary of Phone Book P

```
>>> P["Jhon"]="913456789087"  #Add New element
>>> P
{'Jhon': '913456789087', 'Amit': '918624986968', 'Amol': '919766962920'}
```



Note: If a key is already present in a list then it replaces the old value for the said key with the new value.

Example

```
P={"Amit":"918624986968", "Amol":"919766962920"}
>>> P      #Display P
{'Amit': '918624986968', 'Amol': '919766962920'}

>>> P["Amit"]="921029087865"  #Replace the Old value by New
>>> P      #Print After Replacing
{'Amit': '921029087865', 'Amol': '919766962920'}
```

11.3.5 Retrieving Values

The subscript[] can also be used to obtain the value associated with a key. The syntax is:

Dictinoary_Name[Key] **#Retrieve the value associated with the key.**

Example

```
P={"Amit":"918624986968", "Amol":"919766962920"}
>>> P      #Display P
{'Amit': '918624986968', 'Amol': '919766962920'}

>>> P["Amol"] #Display the value associated with the key "Amol"
'919766962920'
```



Note: If a key is not in a dictionary, Python raises an error.

Example

```
>>>P={"Amit":"918624986968", "Amol":"919766962920"}
>>> P["Sachin"]
```

```
Traceback (most recent call last):
  File "<pyshell#48>", line 1, in <module>
    P["Sachin"]
KeyError: 'Sachin'
```

11.3.6 Formatting Dictionaries

The % operator is used to substitute values from a dictionary, into a string by a name.

Example

```
>>> D={}
>>> D["Laptop"]="MAC"
>>> D["Count"]=10
>>> D          #Print Dictionary D
{'Laptop': 'MAC', 'Count': 10}
>>> P="I want %(Count)d %(Laptop)s Laptops"%D
>>> P
'I want 10 MAC Laptops'
```

Explanation

In the above program, initially a dictionary is created containing two keys, viz. 'Laptop' and 'Count'. In the statement, "I want %(Count)d %(Laptop)s Laptops"%D." The characters 'd' and 's' for integer and string.

11.3.7 Deleting Items

We can delete any entry from a dictionary. The **del** operator is used to remove a key and its associated value. If a key is in a dictionary then it is removed otherwise Python raises an error. The syntax used to remove an element from a dictionary is

```
del dictionary_name[key]
```

Example

```
>>> P={"Amit": "918624986968", "Amit": "919766962920"}
>>> del P["Amit"]    #delete key "Amit"
>>> P                #Print after deleting
{'Amit': '919766962920'}
```

11.3.8 Comparing Two Dictionaries

The == operator is used to test if two dictionaries contain the same items. Also, the != operator returns True if the items within dictionaries are not the same.

Example

```
>>> A={"I":"India","A":"America"}
>>> A
{'I': 'India', 'A': 'America'}
>>> B={"I":"Italy","A":"America"}
>>> B
{'I': 'Italy', 'A': 'America'}
>>> A==B
False
>>> A!=B
True
```

11.3.9 The Methods of Dictionary Class

Python contains dict class for dictionaries. To see the complete documentation for dictionaries we can run `help(dict)` in Python interactive mode. Table 11.3 contains the methods of the dictionary class along with suitable examples.

Table 11.3 Some commonly used dictionary operations

<i>Methods of dict Class</i>	<i>What it does?</i>
keys() Example: <pre>>>> ASCII_CODE={"A":65,"B":66,"C":67,"D":68} >>> ASCII_CODE #Print Dictionary named ASCII_CODE {'D': 68, 'B': 66, 'A': 65, 'C': 67} >>> ASCII_CODE.keys() #Return all keys dict_keys(['D', 'B', 'A', 'C'])</pre>	Returns a sequence of keys.
Values() Example: <pre>>>> ASCII_CODE={"A":65,"B":66,"C":67,"D":68} >>> ASCII_CODE.values() #Return Values dict_values([68, 66, 65, 67])</pre>	Returns a sequence of values.
items() Examples: <pre>>>>ASCII_CODE={"A":65,"B":66,"C":67,"D":68} >>>ASCII_CODE.items() dict_items([('D', 68), ('B', 66), ('A', 65), ('C', 67)])</pre>	Returns a sequence of tuples.
clear() Example: <pre>>>>ASCII_CODE={"A":65,"B":66,"C":67,"D":68} >>> ASCII_CODE.clear() # Delete all entries >>> ASCII_CODE # Print after {}</pre>	Deletes all entries.

(Contd.)

<pre>get(key)</pre> <p>Example:</p> <pre>>>> Temperature={"Mumbai":35,"Delhi":40,"Chennai":54} >>> Temperature.get("Mumbai") 35</pre>	Returns the value for a key.
<pre>pop(key)</pre> <p>Example:</p> <pre>>>> Temperature.pop("Mumbai") 35 >>> Temperature #Print after removing key "Mumbai". {'Delhi': 40, 'Chennai': 54}</pre>	Removes a key and returns the value if the key exists.
<pre>clear()</pre> <p>Example:</p> <pre>>>> Temperature={"Mumabai":35,"Delhi":40,"Chennai":54} >>> Temperature.clear() >>> Temperature</pre>	Removes all the keys.

11.3.10 Traversing Dictionaries

The for loop is used to traverse all the keys and values of a dictionary. A variable of the for loop is bound to each key in an unspecified order. It means it retrieves the key and its value in any order. The following program shows the traversing elements of a dictionary.

PROGRAM 11.8 | Write a program to traverse the elements of a dictionary.

```
Grades={"Tammana":"A","Pranav":"B","Sumit":"C"}
for key in Grades:
    print(key," :",str(Grades[key]))
```

Output

```
Tammana: A
Sumit: C
Pranav: B
```



Note: Write the above program in Python shell and then execute it in Python interpreter. The latter will display all items in a different order.

PROGRAM 11.9 | Write a program to assign grades to students and display all the grades using keys() and get() method of a dictionary.

```
Grades={"Tamana":"A","Pranav":"B","Summit":"C"}
for key in Grades.keys():
```

(Contd.)

```
print(key, '', Grades.get(key, 0))
```

Output

```
Summit C
Pranav B
Tamana A
```

Explanation Grades of students are assigned to the dictionary Grades. As discussed in Table 11.3, the `keys()` method is used in for loop to return the sequence of keys. All returned keys are stored in a variable `key`. Finally, `get()` method is used to return values associated with the particular key.

11.3.11 Nested Dictionaries

A dictionary within a dictionary is called a nested dictionary. To understand this, let us make a dictionary of Indian cricket players with some information about them. The key for this dictionary will consist of the cricketers' names. The value will include information such as the runs scored in test and ODI matches.

```
>>> Players={"Virat Kohli" : { "ODI": 7212 ,"Test":3245},
             "Sachin Tendulkar" : { "ODI": 18426 ,"Test":15921}}

>>> Players['Virat Kohli']['ODI'] # Display run scored by Kohli in ODI
7212

>>> Players['Virat Kohli']['Test']#Display run scored by Kohli in Test
3245

>>> Players['Sachin Tendulkar']['Test']
15921

>>> Players['Sachin Tendulkar']['ODI']
18426
```

11.3.12 Traversing Nested Dictionaries

We used the for loop to traverse simple dictionaries. It can also be used to traverse nested dictionaries. Let us write the above example and use the for loop to go through the keys of the dictionaries.

```
Players={"Virat Kohli" : { "ODI": 7212 ,"Test":3245},
        "Sachin Tendulkar" : { "ODI": 18426 ,"Test":15921}}
#Way 1
for Player_Name, Player_Details in Players.items():
```

(Contd.)

```

print("", Player_Name)
print("", Player_Details)
#Way 2
for Player_Name, Player_Details in Players.items():
    print(" Player: ", Player_Name)
    print(" Run Scored in ODI:\t", Player_Details["ODI"])
    print(" Run Scored in Test:\t", Player_Details["Test"])

```

Output

```

Sachin Tendulkar
{'Test': 15921, 'ODI': 18426}
Virat Kohli
{'Test': 3245, 'ODI': 7212}

Player: Sachin Tendulkar
Run Scored in ODI:      18426
Run Scored in Test: 15921

Player: Virat Kohli
Run Scored in ODI:      7212
Run Scored in Test: 3245

```

Explanation The above program shows the two different ways to print the details of the dictionaries. The first way contains the code:

```

for Player_Name, Player_Details in Players.items():
    print("", Player_Name)
    print("", Player_Details)

```

In the above code, `Player_Name` stores the keys, i.e. the name of the player from the outer dictionary and the variable `Player_Details` stores the value associated with the key, i.e. `Player_Name`.

However, the second way is used to access specific information about a player. The code for the second way is:

```

for Player_Name, Player_Details in Players.items():
    print(" Player: ", Player_Name)
    print(" Run Scored in ODI:\t", Player_Details["ODI"])
    print(" Run Scored in Test:\t", Player_Details["Test"])

```

In the for loop we have used `Player_Name` which displays the name of the player as key of the dictionary. To access specific details of that player, key the index `[]` operator is used.

The above program code is much shorter and easier to maintain, but even this code will not keep up with our dictionary. If we add more information to our dictionary, we will have to update our print statements later.

Let us minimise the above piece of code and put a second for loop inside the first for loop in order to run through all the information about each player.

```
Players={"Virat Kohli" : { "ODI": 7212 ,"Test":3245},
        "Sachin Tendulkar" : {"ODI": 18426 ,"Test":15921}}
for Player_Name, Player_Details in Players.items():
    print(" ",Player_Name)
    for key in Player_Details:
        print(key,':',str(Player_Details[key]))
```

Output

```
Sachin Tendulkar
Test : 15921
ODI : 18426
    Virat Kohli
Test : 3245
ODI : 7212
```

Explanation The first loop gives us all the keys in the main dictionary which consist of the name of each player. Each of these names can be used to unlock the dictionary for each player. The inner loop goes through the dictionary for that individual player and pulls out all the keys in that player's dictionary. The inner for loop prints the key, which tells us the kind of information we are about to see and the value for that key.

11.3.13 Simple Programs on Dictionary

PROGRAM 11.10 Write a function histogram that takes string as parameter and generates a frequency of characters contained in it.

```
S = "APPLE"
```

The program should create a dictionary

```
D = {'A': 2, 'E': 1, 'P': 2, 'L': 1}
```

```
def Histogram(S):
    D=dict() #Initially Create Empty Dictionary
    for C in S:
        if C not in D:
            D[C] = 1
        else:
            D[C]=D[C]+1
```

(Contd.)


```

    return D
H=Histogram("AAPPLE")
print(H)

```

Output

```
{ 'A': 2, 'E': 1, 'P': 2, 'L': 1 }
```

Explanation In the above program, we created a function Histogram(S). A string S is passed as a parameter to the function. Initially, an empty dictionary is created. The for loop is used to traverse the string. While traversing, each character is stored in C. If the character C is not in the dictionary then we inserted a new item into the dictionary with key C and initial value as 1. If C is already in the dictionary then we incremented D[C].

PROGRAM 11.11 | Write a program to count the frequency of characters using the `get()` method.

```

def Histogram(S):
    D =dict()
    for C in S:
        if C not in D:
            D[C] = 1
        else:
            D[C]=D.get(C,0)+1

    return D
H=Histogram("AAPPLE")
print(H)

```

Output

```
{ 'P': 2, 'L': 1, 'A': 2, 'E': 1 }
```

PROGRAM 11.12 | Write a program to print and store squares of numbers into a dictionary.

```

def Sq_of_numbers(n):
    d=dict() #Creates A Empty Dictionary
    for i in range(1,n+1): # Iterates from 1 to N
        if i not in d:
            d[i]=i*i #Store the Square of a Number i into dictionary
    return d
print('Squares of Number:')

```

(Contd.)

```
Z=Sq_of_numbers(5)
print(Z)
```

Output

```
Squares of Number:
{1: 1, 2: 4, 3: 9, 4: 16, 5: 25}
```

PROGRAM 11.13 | Write a program to pass a list to a function. Calculate the total number of positive and negative numbers from the list and then display the count in terms of dictionary.

Input: L=[1,-2,-3,4]

Output: {'Neg': 2, 'Pos': 2}

```
def abc(L):
    D={}                                #Empty Dictionary
    D["Pos"]=0
    D["Neg"]=0
    for x in L:
        if x>0:
            D["Pos"]+=1
        else:
            D["Neg"]+=1
    print(D)
L=[1,-2,-3,4]
abc(L)
```

Output

```
{ 'Pos' : 2, 'Neg' : 2 }
```

Explanation In the above program, an empty dictionary D is created. Initially two keys are added to the dictionary, viz. Pos and Neg with count 0 as their respective value. The list L is passed to the function abc(). If the number is positive or negative, the count is increased accordingly.

PROGRAM 11.14 | Write a program to convert an octal number into binary.

Input: (543)₈

Output: (101100011)

```
def Convert_Oct_Bin(Number,Table):
    binary=''
    for digit in Number:
```

(Contd.)

```

        binary = binary + Table[digit]
    return binary

octToBinaryTable={'0':'000', '1':'001', '2':'010',
                  '3':'011', '4':'100', '5':'101',
                  '6':'110', '7':'111'}
```

Output

```

#Sample Input 1:
>>> Convert_Oct_Bin("553",octToBinaryTable)
'101101011'

#Sample Input 2:
>>> Convert_Oct_Bin("127",octToBinaryTable)
'001010111'
```

Explanation In the above program we created the function `Convert_oct_Bin()`. It accepts two parameters. The first parameter is the octal number as a string which we want to convert into binary and the second parameter is the dictionary which contains the decimal number and its equivalent binary number.

The above algorithm visits each digit of the octal number, selects the corresponding three bits which represent that digit in binary and add these bits to the result string binary.

11.3.14 Polynomials as Dictionaries

As we learnt in previous chapters, Python has two data types, viz. mutable and immutable. Python objects that cannot change their contents are known as immutable data types. The immutable data types consist of str and tuple. List and dictionaries can change their contents so they are called mutable objects. The keys in a dictionary are not restricted to be strings. Any immutable Python object can be used as a key. However, a common type of key used in a dictionary is of type integers.

Let us consider the following example of how dictionaries with integers as keys represent a polynomial.

Example of Polynomial

$$P(Y) = -2 + Y^2 + 3Y^6$$

The above example is a polynomial of a single variable, i.e. y . The above polynomial consists of three terms, viz. (-2) , (Y^2) and $(3Y^6)$. All the terms can be viewed as set of power and coefficient terms. The first term, i.e. (-2) contains power of y as 0 and coefficient as -2. Similarly, the term two (Y^2) contains the power of y as 2 and coefficient as 1. And the last term $(3Y^6)$ contains the power of y as 6 and coefficient as 3. A dictionary can be used to map a power to a coefficient.

Representing above Polynomial using Dictionaries

$$P = \{0:-2, 2:1, 6:3\}$$

The above polynomial can also be represented as a list. But we have to fill in all zero coefficients too since the index must match power. Therefore, representing the above polynomial as list is

$$P(Y) = -2 + Y^2 + 3Y^6$$

$$P = [-2, 0, 1, 0, 0, 0, 3]$$

After representing the said polynomial in terms of list, we can compare the representation of the polynomial in terms of dictionary and list. The advantage of a dictionary is that the user has to store only the non-zero coefficient. For the polynomial $1+x^{50}$, the dictionary holds only two elements, while the list holds 51 elements.

PROGRAM 11.15 | Write a program to evaluate a polynomial of one variable, i.e. x if the value of x is 2.

$$P(X) = -2+X^2+3X^3$$

$$P(2) = 26$$

```
def Eval_Poly(P,X):
    sum = 0
    for Power in P:
        sum = sum + P[Power]*X**Power
    print('The Value of Polynomial after Evaluation:',sum)
P={0:-2, 2:1, 3:3}
Eval_Poly(P,2)
```

Output

The Value of Polynomial after Evaluation: 26

Explanation The function Eval _ Poly() is created. The polynomial P is represented in the form of a dictionary. The argument to the function is a dictionary of polynomial P. Where P[Power] holds the coefficient associated with the term X**Power.

MINI PROJECT Orange Cap Calculator

The orange cap is an annual cricket award presented to the leading run scorer in a cricket series.

Example

Consider an ongoing test cricket series. Following are the names of the players and their scores in the test1 and 2. Calculate the highest number of runs scored by an individual cricketer in both the tests.

```

orange = {
    'test1': {'Dhoni': 74, 'Kohli': 150},
    'test2': {'Dhoni': 29, 'Pujara': 42}
}

```

From the above example we can analyse the runs scored by each player in both tests as

$$\text{Dhoni} = 74 + 29 = 103$$

$$\text{Kohli} = 150 + 0 = 150$$

$$\text{Pujara} = 0 + 42 = 42$$

Thus, Kohli scored the most runs in both the test matches and he will be awarded the orange cap for this tournament.

Program Statement

Define a Python function 'orangecap(d)' which reads a dictionary 'd' of the following form and identifies the player with the highest total score. The function should return a pair (playername, topscore), where playername is the name of the player with the highest score and topscore is the total runs scored by the player.

Input

```

orange = {
    'test1': {'Dhoni': 74, 'Kohli': 150},
    'test2': {'Dhoni': 29, 'Pujara': 42}
}

```

Output

```

('Kohli', 150)

```

Algorithm

- ◎ **STEP 1:** Create a dictionary 'd' consisting of overall score details of test1 and test2.
- ◎ **STEP 2:** Pass the dictionary 'd' to the Orangecap() function.
- ◎ **STEP 3:** Use the for loop to traverse the contents of dictionaries and nested dictionaries.
- ◎ **STEP 4:** In each iteration for each player store the runs scored by each player.
- ◎ **STEP 5:** Display information about a player with name and maximum runs in all the matches.

Program

```

def orangecap(d):
    total = {}
    for k in d.keys():
        for n in d[k].keys():
            if n in total.keys():
                total[n] = total[n] + d[k][n]
            else:

```

(Contd.)

```

        total[n] = d[k][n]
    print('Total Run Scored by Each Player in 2 Tests: ')
    print(total)

    print('Player With Highest Score')
    maxtotal = -1
    for n in total.keys():
        if total[n] > maxtotal:
            maxname = n
            maxtotal = total[n]

    return(maxname, maxtotal)
d=orangecap({'test1':{'Dhoni':74, 'Kohli':150}, 'test2':{'Dhoni':29,
'Pujara':42}})
print(d)

```

Output

```

Total Run Scored by Each Player
{'Dhoni': 103, 'Pujara': 42, 'Kohli': 150}
Player With Highest Score
('Kohli', 150)

```

SUMMARY

- A tuple contains a sequence of items of any type.
- The elements of tuples are fixed.
- Tuples are immutable.
- A tuple can also be created from a list.
- The elements of tuples are enclosed in parenthesis instead of square brackets.
- Tuples don't not contain any method named sort.
- A set is an unordered collection of elements without duplicates.
- Sets are mutable.
- Different mathematical operations such as union, intersection, difference and symmetric difference can be performed on sets.
- A dictionary is a collection which stores values along with keys.
- A for loop is used to traverse all keys and values of a dictionary.
- The in and not in can be used to check if a key is present in a dictionary.

KEY TERMS

- ⇒ **Tuple:** Sequence of elements of any type
- ⇒ **Set:** Unordered collection of elements without duplicates

- ⇒ **Dictionary:** Collection of key and value pair
- ⇒ **Immutable:** Python objects which can't be changed
- ⇒ **Nested Dictionary:** A dictionary within a dictionary
- ⇒ **zip() Function:** Inbuilt Python function used to make a list of tuples
- ⇒ **zip(*) Function:** Zip inverse
- ⇒ **set Functions:** union(), intersection(), difference() and symmetric_difference()

REVIEW QUESTIONS

A. Multiple Choice Questions

1. What will be the output of the following code?

```
def main():
    Average_Rainfall={}
    Average_Rainfall['Mumbai']=765
    Average_Rainfall['Chennai']=850
    print(Average_Rainfall)
main()
```

- | | |
|------------------------------------|------------------------------------|
| a. ['Mumbai': 765, 'Chennai': 850] | b. {'Mumbai': 765, 'Chennai': 850} |
| c. ('Mumbai': 765, 'Chennai': 850) | d. None of the above |

2. What will be the output of the following code?

```
init_tuple=()
print(init_tuple.__len__())
```

- | | |
|---------|----------|
| a. 1 | b. 0 |
| c. NULL | d. Empty |

3. What will be the output of the following code?

```
t = (1, 2, 3, 4)
t[2] = 10
print(t)
```

- | | |
|-------------|--------------|
| a. 1,2,10,4 | b. 1,10,2,4 |
| c. Error | d. 1,10,10,4 |

4. What will be the output of the following code?

```
a = ((1,2),)*7
print(len(a[3:6]))
```

- | | |
|------|----------|
| a. 2 | b. 3 |
| c. 4 | d. Error |

5. What will be the output of the following program?

```
my_dict={}
my_dict[(1, 2, 3)] = 12
my_dict[(4,5)] = 2
```

```
print(my_dict)
```

- a. {12,12,12,2,2}
 - b. Error
 - c. {(4, 5): 2, (1, 2, 3): 12}
 - d. {(1, 2, 3): 12 ,(4, 5): 2}
6. What will be the output of the following code?
- ```
jersey = {'sachin':10,'Virat':18}
jersey[10]
```
- a. Sachin
  - b. Virat
  - c. Error
  - d. None of the above
7. What will be the output after the execution of the following statements?
- ```
capital = {'India':'Delhi','SriLanka':'Colombo'}
capital=list(capital.values)
```
- a. Delhi
 - b. ['Delhi','Colombo']
 - c. ['Colombo']
 - d. Error
8. Which dictionary has been created correctly?
- a. d={1:['+91','India'],2:['+65','USA']}
 - b. d={'India':1,['USA']:2}
 - c. d={'India':1,('USA'):2}
 - d. d={1:"INDIA",2:"USA"}
 - e. d={"Payal":1,"Rutuja":2}
- a. Only d
 - b. Only b
 - c. a, b c
 - d. a, c, d and e
9. Which set has been created correctly?
- a. S1={1,2,3,4}
 - b. S2={(1,2),(23,45)}
 - c. S2=[1,2],[23,45]}
- a. All a, b and c
 - b. Only c
 - c. Both a and b
 - d. Both b and c
10. What will be the output of the following code?
- ```
Fruits = ('Banana','Grapes','Mango','WaterMelon')
print(max(fruits))
print(min(fruits))
```
- a. WaterMelon, Mango
  - b. WaterMelon, Banana
  - c. WaterMelon, Grapes
  - d. Banana, WaterMelon

## B. True or False

1. A tuple contains non-sequential items of any type.
2. The elements of tuples are fixed.
3. Elements can be added after a tuple has been created.
4. A tuple is an inbuilt data type in Python.
5. In order to create a tuple, the elements of tuples are enclosed in parenthesis instead of square brackets.



6. The elements of tuples are not separated by commas.
7. Indexing and slicing of tuples is similar to that of lists.
8. The index [] operator is used to access the elements of a tuple.
9. The zip() function takes items in a sequence from a number of collections to make a list of tuples.
10. The \* operator unpacks a sequence into positional arguments.
11. A dictionary within a dictionary is called a nested dictionary.
12. A for loop can be used to traverse nested dictionaries.
13. Python objects which cannot change their contents are known as mutable data types.
14. Immutable data types consist of int, float, complex, str and tuple.
15. List and dictionaries can change their contents, so they are called immutable.
16. A dictionary holds only two elements for the polynomial  $1+x^{50}$ .

### C. Exercise Questions

1. What is meant by a tuple and how is it created?
2. What are the functions of tuples?
3. Compare tuples and lists.
4. How is a single element using a tuple created?
5. List the inbuilt functions supported by tuples.
6. How is indexing and slicing of tuples done?
7. Which operator is used to access the elements in a tuple?
8. Can a programmer pass a variable to a function? If yes, how?
9. Consider the example of a tuple as follows:

```
x = (11, 12, (13, 'Sachin', 14), 'Hii')
```

- |             |              |
|-------------|--------------|
| a. x[0]     | b. x[2]      |
| c. x[-1]    | d. x[2][2]   |
| e. x[2][-1] | f. x[-1][-1] |
| g. x[-1][2] | h. x[0:1]    |
| i. x[0:-1]  | j. len(x)    |
| k. 2 in x   | l. 3 in x    |
| m. x[0] = 8 |              |

Write the output for the expression

10. What is the function of zip()?
11. What is the role of the \* operator within the zip() function?
12. Describe the basics of dictionaries.
13. A dictionary named 'Grades' is created as

```
Grades = {"Sahil":90,"Abhijeet":65}
```

What do the following statements do?

- |                            |                           |
|----------------------------|---------------------------|
| a. print(Grades.keys())    | b. print(Grades.values()) |
| c. print(len(Grades))      | d. Grades["Kuruss"]=99    |
| e. Grades["Abhijeet"] += 5 | f. del Grades["Abhijeet"] |
| g. print(Grades.items())   |                           |

14. What will be the output of the following code?

```
Set1 = {10, 20, 30, 40}
```

- |                                     |                              |
|-------------------------------------|------------------------------|
| a. S1.issubset({10,20,30,40,50,60}) | b. S1.issuperset({20,30,40}) |
| c. print(10 in S1)                  | d. print(101 in S1)          |
| e. print(len(S1))                   | f. print(max(S1))            |
| g. print(sum(s1))                   |                              |

15. Show the output of the following code.

```
S1 = { 'A' , 'B' , 'C' }
```

```
S2 = { 'C' , 'D' , 'E' }
```

- |                              |                                       |
|------------------------------|---------------------------------------|
| a. print(S1.union(S2))       | b. print(S1.intersection(S2))         |
| c. print(S1.difference (S2)) | d. print(S1.symmetric_difference(S2)) |
| e. print(S1 ^ S2)            | f. print( S1   S2)                    |
| g. print(S1 & S2)            |                                       |

16. What will be the output of the following code?

```
T = (10, 34, 22, 87, 90)
```

- |                  |                  |
|------------------|------------------|
| a. print(t)      | b. t[0]          |
| c. print(t[0:4]) | d. print(t[:-1]) |

17. How can all keys and values of a dictionary be traversed?

18. How are nested dictionaries created?

19. How can a polynomial be represented using dictionaries?

## PROGRAMMING ASSIGNMENTS

1. Write a function which takes a tuple as a parameter and returns a new tuple as the output, where every other element of the input tuple is copied, starting from the first one.

```
T = ('Hello', 'Are', 'You', 'Loving', 'Python?')
```

```
Output_Tuple = ('Hello', 'You', 'Python?')
```

2. Write a function called `how_many`, which returns the sum of the number of values associated with a dictionary.

```
T= animals = {'L': ['Lion'], 'D': ['Donkey'], 'E': ['Elephant']}
```

```
>>>print(how_many(animals))
```

```
3
```

3. Write a function 'biggest' which takes a dictionary as a parameter and returns the key corresponding to the entry with the largest number of values associated with it.

```
>>>animals = {'L': ['Lion'], 'D': ['Donkey', 'Deer'], 'E': ['Elephant']}
```

```
>>>biggest(animals)
```

```
>>>d #Since d contains two values
```

4. Write a function `Count_Each_vowel` which accepts string from a user. The function should return a dictionary which contains the count of each vowel.

```
>>> Count_Each_vowel("HELLO")
```

```
>>>{'H':1, 'E':1, 'L':2 , 'O':2}
```

# Graphics Programming: Drawing with Turtle Graphics

## 12

### CHAPTER OUTLINE

|                                                            |                                            |
|------------------------------------------------------------|--------------------------------------------|
| 12.1 Introduction                                          | 12.6 Drawing with Colors                   |
| 12.2 Getting Started with the Turtle Module                | 12.7 Drawing Basic Shapes using Iterations |
| 12.3 Moving the Turtle in any Direction                    | 12.8 Changing Color Dynamically using List |
| 12.4 Moving Turtle to Any Location                         | 12.9 Turtles to Create Bar Charts          |
| 12.5 The color, bgcolor, circle and Speed Method of Turtle |                                            |

### LEARNING OUTCOMES

*After completing this chapter, students will be able to:*

- Create simple graphics using the Turtle module
- Draw different geometric figures, such as lines, circles, rectangles, squares and polygons using the Turtle
- Draw basic shapes using iterations
- Draw simple charts

### 12.1 INTRODUCTION

A simple way to start learning graphics programming is to use the inbuilt **Turtle** module in Python. The Turtle module is a graphics package for drawing lines, circles and various other shapes, including text. In short, the **Turtle** is a **cursor** on the screen to draw graphics related things. Importing the Turtle module helps a programmer to access all graphics functions in Python.

## 12.2 GETTING STARTED WITH THE TURTLE MODULE

To start, a programmer can use **interactive mode (command line)** or **script mode** of Python. The steps required to start graphics programming using the Turtle module in interactive mode of Python are given as follows:

- ◎ **STEP 1:** Launch Python by pressing the start button in Windows and writing Python in the search box. Click on Python IDLE to start the interactive mode. The following window will then appear (Figure 12.1).

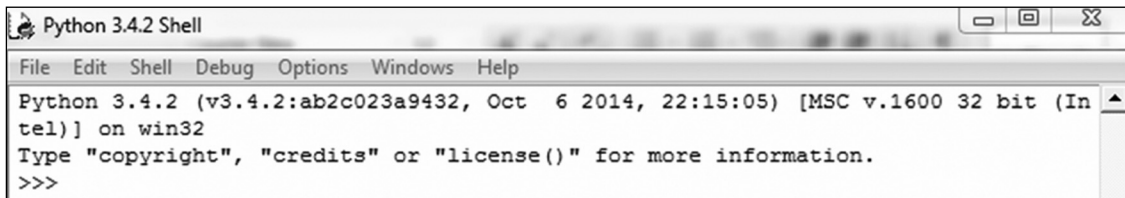


Figure 12.1

- ◎ **STEP 2:** At the Python's statement prompt >>> type the following command to import the Turtle module.  

```
>>> import Turtle #import Turtle module
```
- ◎ **STEP 3:** Type the following command to show the current location and direction of the Turtle.  

```
>>> Turtle.showTurtle()
```

After the execution of the above statement, Python's Turtle graphics window will be displayed as shown in Figure 12.2.

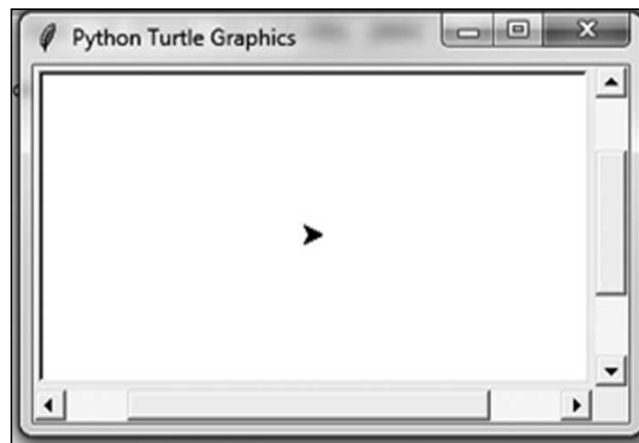


Figure 12.2 Python's Turtle Graphics Window

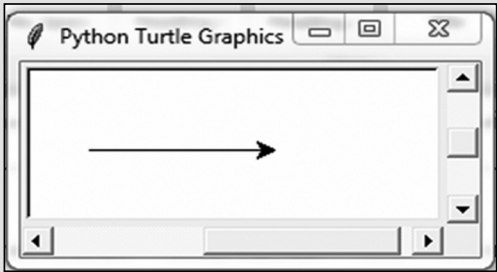
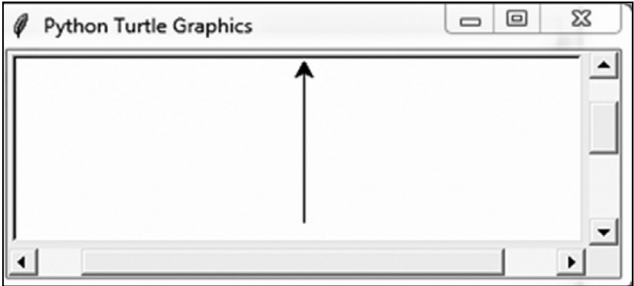
The Turtle is like a **pen**. The arrowhead indicates the current position and direction of the pen. Initially, the **Turtle** is positioned at the center of the window.

### 12.3 MOVING THE TURTLE IN ANY DIRECTION

As discussed above, the Turtle is an object which is created when we import the Turtle module. As soon as the object is created its position is set at **(0, 0)**, i.e. at the center of the Turtle graphics window. Also by default its direction is set to go straight to the right.

The imported Turtle module uses a pen to draw shapes. It can be used to move and draw lines in any direction. Python contains methods for **moving the pen, setting the pen's size, lifting and putting the pen down**. By default, the pen is down, i.e. it draws a line from the current position to the new position. Table 12.1 shows a list of methods to move the Turtle in specified directions.

**Table 12.1** Turtle methods related to directions

| Method                                                                                                                                       | Meaning                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Turtle.forward(P)</b><br>Example:<br><pre>&gt;&gt;&gt; import Turtle &gt;&gt;&gt; Turtle.forward(100)</pre>                               | Moves the Turtle P pixels in the direction of its current heading.<br><b>Output:</b><br>                                                                                                                                                                                                                  |
| <b>Turtle.left(angle)</b><br>Example:<br><pre>&gt;&gt;&gt; import Turtle &gt;&gt;&gt; Turtle.left(90) &gt;&gt;&gt; Turtle.forward(100)</pre> | Rotates the Turtle left by the specified angle.<br><b>Output:</b><br><br><b>Explanation:</b> Initially the Turtle is placed at the centre by default. The command <b>Turtle.left(90)</b> changes the direction of the Turtle to the left by 90 degrees. Finally, the arrowhead moves 100 pixels forward. |

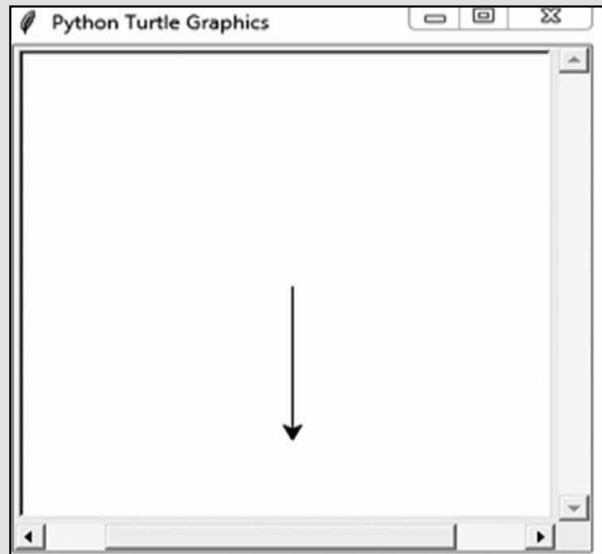
(Contd.)

**right(P)**

Rotates the Turtle in place a degree clockwise.

**Example:****Output:**

```
>>> import Turtle
>>> Turtle.right(90)
>>> Turtle.forward(100)
```



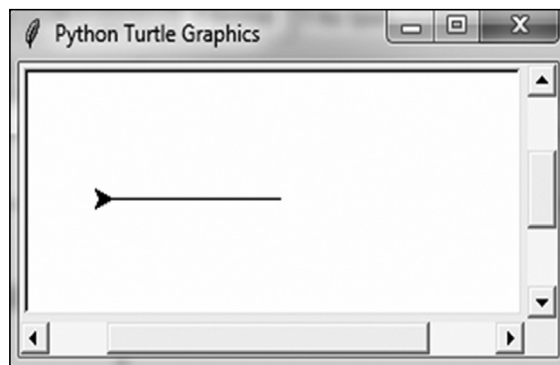
**Explanation:** Initially the Turtle is placed at the centre by default. The command **Turtle.right(90)** changes the direction of the Turtle to the right by 90 degrees. Finally, the arrowhead moves 100 pixels forward.

**backward(P)**

Moves the Turtle P pixels in a direction opposite to its current heading.

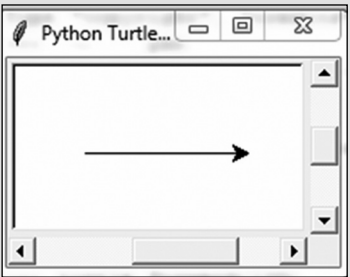

**Example:****Output:**

```
>>> import Turtle
>>> Turtle.backward(100)
```



In Table 12.1, we used various methods to move the Turtle from one position to the other. As discussed above, the Turtle draws a line from one position to the other with the help of the pen. Table 12.2 illustrates various methods related to the state of a pen.

**Table 12.2** Methods related to the state of a pen

| Method                                                                                                                                                   | Meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>Turtle.pendown()</code><br><b>Example:</b><br><pre>&gt;&gt;&gt; import Turtle &gt;&gt;&gt; Turtle.pendown() &gt;&gt;&gt; Turtle.forward(100)</pre> | <p>Pulls the pen down. Draws when it moves from one place to the other.</p> <p><b>Output:</b></p>  <p><b>Explanation:</b> In the above example, the method <b>Turtle.pendown()</b> draws different shapes when it moves from one place to the other.</p>                                                                                                                                                                                                                                                                                 |
| <code>Turtle.penup()</code><br><b>Example:</b><br><pre>&gt;&gt;&gt; import Turtle &gt;&gt;&gt; Turtle.penup() &gt;&gt;&gt; Turtle.forward(100)</pre>     | <p>Pulls the pen up. In this state, it just moves from one place to the other without drawing anything.</p> <p><b>Output:</b></p>  <p><b>Explanation:</b> The import Turtle method places the pen at the center of the circle. The <b>Turtle.penup()</b> doesn't allow a programmer to draw things, it just moves from one place to the other. When the statement <code>Turtle.forward(100)</code> is executed immediately after the <code>penup()</code> statement, it moves 100 pixels forward without drawing any line or shape.</p> |

(Contd.)

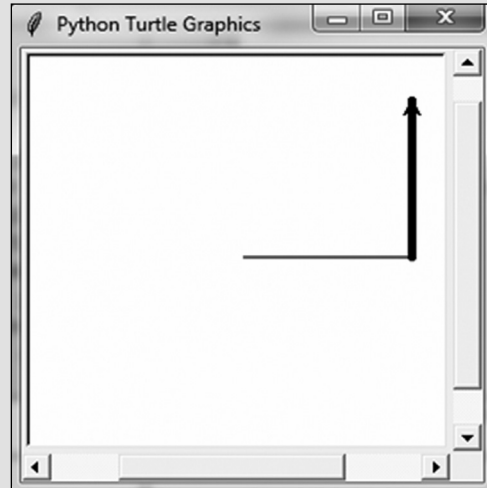
```
Turtle.pensize(width)
```

Sets the line thickness to the specified width.

**Example:**

**Output:**

```
>>> import Turtle
>>> Turtle.forward(100)
>>> Turtle.pensize(5)
>>> Turtle.pensize(5)
>>> Turtle.left(90)
>>> Turtle.forward(100)
```

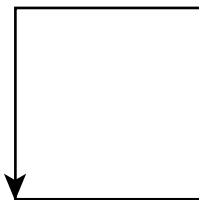


**Explanation:** In the above code, initially the line is drawn 100 pixels ahead in the forward direction. The statement **Turtle.pensize(5)** increases the thickness to draw the figure from here onwards.

### 12.3.1 Programs to Draw Different Shapes

The following programs make use of methods discussed above to draw different shapes.

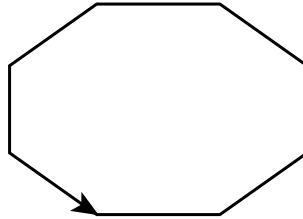
**PROGRAM 12.1** | Write a program to draw the square shown as follows using Python's Turtle module.



```
import Turtle #import Turtle module
Turtle.forward(100) #Move Turtle in forward direction
Turtle.left(90) #Change the direction of Turtle to left by 90 degree
Turtle.forward(100)
Turtle.left(90)
Turtle.forward(100)
Turtle.left(90)
Turtle.forward(100)
```



**PROGRAM 12.2** | Write a program to display the polygon shown as follows:

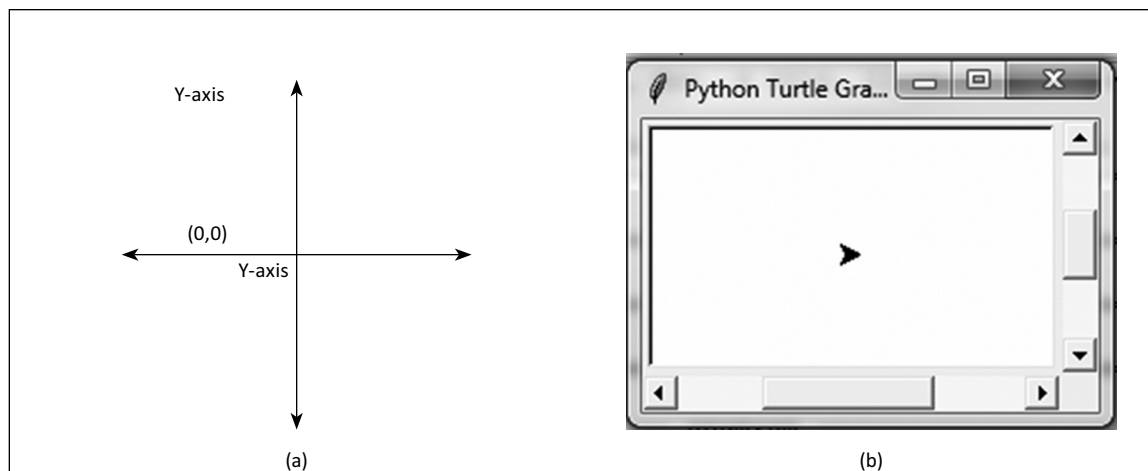


```
import Turtle #import Turtle module
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
Turtle.left(45)
Turtle.forward(50)
```

## 12.4 MOVING TURTLE TO ANY LOCATION

When a programmer tries to run Python's Turtle graphics program by default, the Turtle's arrowhead (**Cursor** or **Pen**) is at the center of the graphics window at coordinate(0, 0) as shown in Figure 12.3.

```
>>> import Turtle #import Turtle module
>>> Turtle.showTurtle ()
```



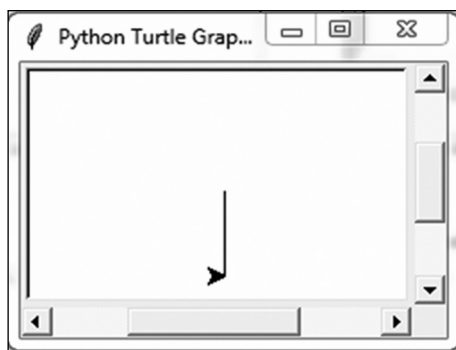
**Figure 12.3** (a) Representation of coordinate system (b) Centre of Turtle graphics at (0, 0)

The method **goto(x, y)** is used to move the Turtle at specified points (x, y). The following example illustrates the use of **goto(X, Y)** method.

### Example

```
>>> import Turtle
>>> Turtle.showTurtle ()
>>> Turtle.goto(0, -50)
```

### Output



**Figure 12.4**

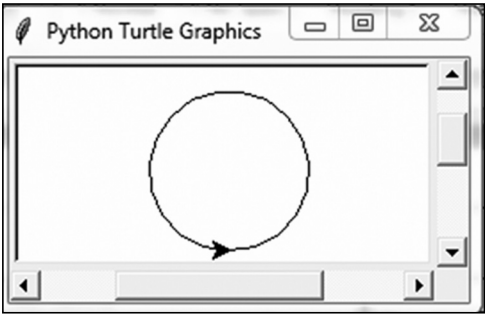
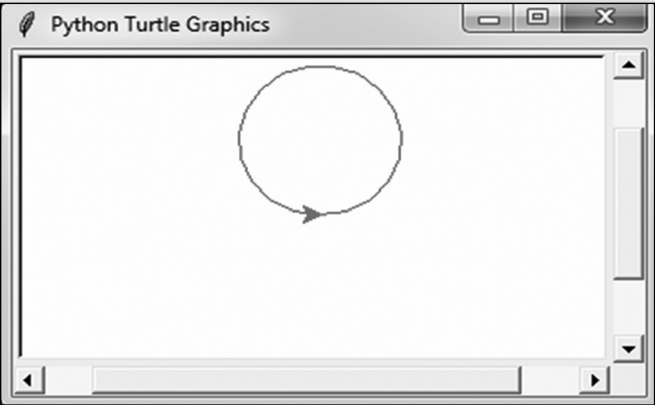
### Explanation

In the above example, the statement **goto(0,-50)** will move towards coordinate (0, -50).

12.5 THE COLOR, BGCOLOR, CIRCLE AND SPEED METHOD OF TURTLE

Table 12.3 gives more details about color, bgcolor, circle and speed method of the Turtle.

Table 12.3 Turtle methods related to color and speed of the Turtle

| Method                                                                                                                                                                                          | Meaning                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>Turtle.speed(integer _ paramter)</code>                                                                                                                                                   | The drawing speed of the Turtle must be in the range int 1 (slowest) to 10 (fastest) or 0 (instantaneous).                                                                                                                                                                                                                                                                                                                                                                           |
| <code>Turtle.circle(radius, extent=None)</code><br><b>Example:</b><br><code>&gt;&gt;&gt; import Turtle</code><br><code>&gt;&gt;&gt; Turtle.circle (45)</code>                                   | <div>Draws a circle with the given radius. The center is radius units left of the Turtle. The extent determines which part of the circle is drawn. If it is not given, the entire circle is drawn.</div> <div><b>Output:</b></div> <div></div> <div><b>Explanation:</b> The statement <code>Turtle.circle (45)</code> is used to draw a circle of radius 45 in an anti-clockwise direction.</div> |
| <code>Turtle.color(*args)</code><br><b>Example:</b><br><code>&gt;&gt;&gt; import Turtle</code><br><code>&gt;&gt;&gt; Turtle.color("red")</code><br><code>&gt;&gt;&gt; Turtle.circle (45)</code> | <div>The color method is used to draw colorful animations.</div> <div><b>Output:</b></div> <div></div> <div><b>Explanation:</b> The above statement draws a circle in red color.</div>                                                                                                                                                                                                           |

(Contd.)

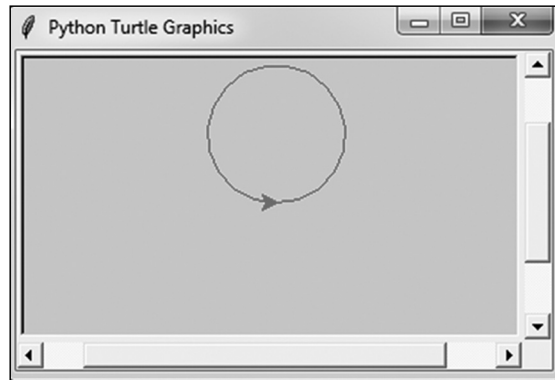
Turtle.bgcolor(\*arg)

Returns the background color of the Turtle screen.

**Example:**

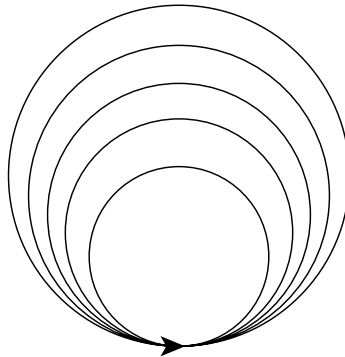
**Output:**

```
>>> import Turtle
>>> Turtle.color("red")
>>> Turtle.
bgcolor("pink")
```



**Explanation:** Changes the background color of the Turtle graphics window to pink.

**PROGRAM 12.3** | Write a program to display the circles shown. You can consider any radius.



```
import Turtle
Turtle.circle (45)
Turtle.circle (55)
Turtle.circle (65)
Turtle.circle (75)
Turtle.circle (85)
```

**Explanation** In the above program, the 5 circles are drawn with different radius, viz. 45, 55, 65, 75 and 85, respectively.

## 12.6 DRAWING WITH COLORS

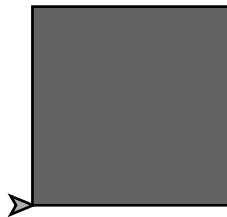
A Turtle object contains methods for setting a color. In the above section, we have learnt how to draw different shapes. Table 12.4 lists methods to draw different shapes with different colors.

**Table 12.4** More methods of Turtle related to color

| Method                                                                         | Meaning                                                                           |
|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <code>Turtle.color(c)</code>                                                   | Sets the pen's color                                                              |
| <code>Turtle.fillcolor(C)</code>                                               | Sets the pen's fill color to 'C'                                                  |
| <code>Turtle.begin_fill()</code>                                               | Calls this method before filling a shape                                          |
| <code>Turtle.end_fill()</code>                                                 | Fills the shape drawn before the last call to <b>begin_fill</b>                   |
| <code>Turtle.filling()</code>                                                  | Returns the fill state. True is filling, False if not filling.                    |
| <code>Turtle.clear()</code>                                                    | Clears the window. The state and position of window is not affected.              |
| <code>Turtle.reset()</code>                                                    | Clears the window and resets the state and position to its original default value |
| <code>Turtle.screensize()</code>                                               | Sets the width and height of the canvas                                           |
| <code>Turtle.showTurtle()</code>                                               | Makes the Turtle visible                                                          |
| <code>Turtle.hideTurtle()</code>                                               | Makes the Turtle invisible                                                        |
| <code>Turtle.write(msg, move, align, font=fontname, fontsize, fonttype)</code> | Writes a message on the Turtle graphics window                                    |

Program 12.4 demonstrates the use of **begin\_fill()** and **end\_fill()** method to fill a shape.

**PROGRAM 12.4** | Write a program to draw a color filled square box as shown.



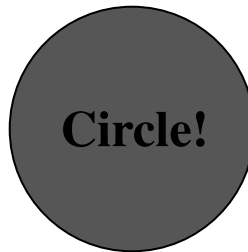
```
import Turtle
Turtle.fillcolor ("gray") #Fill gray color inside the square
Turtle.begin_fill ()
Turtle.forward(100)
Turtle.left(90)
```

(Contd.)

```
Turtle.forward(100)
Turtle.left(90)
Turtle.forward(100)
Turtle.left(90)
Turtle.forward(100)
Turtle.left(90)
Turtle.end_fill()
```

**PROGRAM 12.5** | Write a program to create a circle with specifications as:

- (a) Fill circle with gray color
- (b) Display the text message "Circle!" inside the circle.



```
import Turtle
Turtle.pendown()
Turtle.fillcolor ("gray")
Turtle.begin_fill()
Turtle.circle(70)
Turtle.end_fill()
Turtle.penup()
Turtle.goto(-25,50)
Turtle.hideturtle ()
Turtle.write('Circle!', font = ('Times New Roman', 20, 'bold'))
```

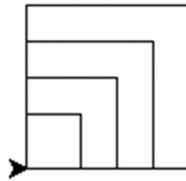
## 12.7 DRAWING BASIC SHAPES USING ITERATIONS

As shown in Program 12.4, a programmer needs to write the following six sentences to draw a simple square:

```
Turtle.forward(100)
Turtle.left(90)
Turtle.forward(100)
Turtle.left(90)
Turtle.forward(100)
Turtle.left(90)
```

However, if a programmer wants to display four different squares then it would be very cumbersome to type the above code repeatedly. Such kind of iterations can be accomplished using the **for** loop. Thus, to create four different squares, we need to create a function **square ()** and then draw the square using the for loop. Function takes one argument which is the side of a square. The following program demonstrates the use of the for loop to display multiple squares.

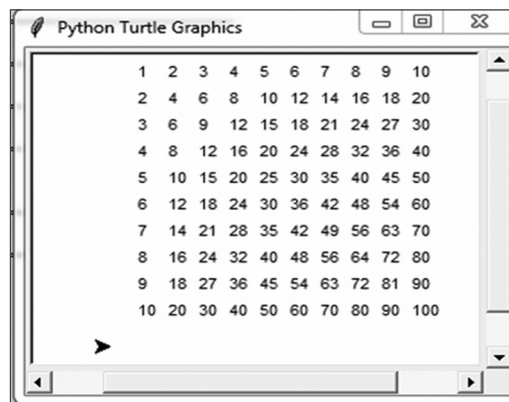
**PROGRAM 12.6** | Create a function to draw four different squares using the for loop as shown.



```
import Turtle
def square(side):
 for i in range(4):
 Turtle.forward(side)
 Turtle.left(90)

square(20)
square(30)
square(40)
square(50)
```

**PROGRAM 12.7** | Write a program to display the multiplication table from 1 to 10 in the Turtle graphics window as shown.



```
import Turtle as t
t.penup()
```

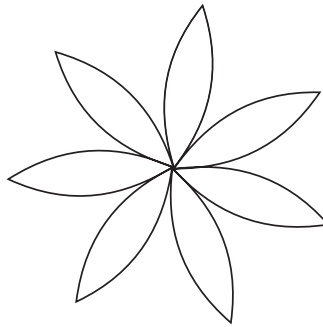
(Contd.)

```

x = -100
y = 100
t.goto(x,y) #Move pen at location x and y
t.penup()
for i in range(1,11,1): # value of i varies from 1 to 10
 y = y - 20
 for j in range(1,11,1): # Value of j varies from 1 to 10
 t.penup()
 t.speed(1)
 t.forward(20)
 t.write(i*j)
 t.goto(x, y)

```

**PROGRAM 12.8** | Write a program to draw the petals of the flower shown as follows using the circle method.



```

import Turtle as t
def petal(t, r, angle):
 """Use the Turtle (t) to draw a petal using two arcs
 with the radius (r) and angle.
 """
 for i in range(2):
 t.circle(r,angle)
 t.left(180-angle)

def flower(t, n, r, angle):
 """Use the Turtle (t) to draw a flower with (n) petals,
 each with the radius (r) and angle.
 """
 for i in range(n):
 petal(t, r, angle)
 t.left(360.0/n)

flower(t, 7, 80.0, 60.0)

```



## 12.8 CHANGING COLOR DYNAMICALLY USING LIST

As we have studied in the previous chapter, a list is a sequence of values called **items** or **elements**, where the elements can be of any type. Similarly, we can define the various colors inside a list using the syntax:

```
List_Name = ["First_Color_Name", "Second_Color_Name",
```

### Example

```
C = ["blue", "RED", "Pink"]
```

Program 12.9 demonstrates the use of **list** and **for** loop to change a color dynamically.

**PROGRAM 12.9** | Write a program to draw and fill circles with different colors.

```
import Turtle as t
C = ["blue", "RED", "Pink"]
for i in range(3):
 t.fillcolor (C[i])
 t.begin_fill()
 t.circle(70)
 t.end_fill()
```

**Explanation** In the above program, all the names of colors are defined inside the list **C**. The **for** loop is used to iterate all the elements of the list. The statement **t.fillcolor (C[i])** is used to fill color inside the circle.

## 12.9 TURTLES TO CREATE BAR CHARTS

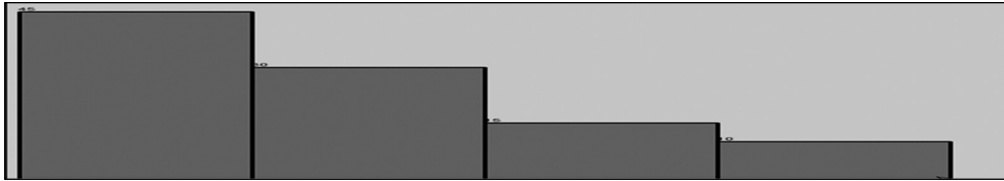
Turtles can be used to create bar charts. Bar charts can be created using various inbuilt methods discussed in the previous section of this chapter. A method such as **write ()** can be used to display the text on the canvas at a particular location. Other methods such as **begin \_ fill()** and **end \_ fill()** can be used to fill a shape with a specific color. Thus, by using various methods, we can draw bar charts in Python.

Table 12.5 shows statistics for the most downloaded browser by users in 2016–2017.

**Table 12.5** Sample data to draw a chart

| <i>Web Browser</i> | <i>Percentage</i> |
|--------------------|-------------------|
| Mozilla Firefox    | 45%               |
| Google Chrome      | 30%               |
| Internet Explorer  | 15%               |
| Others             | 10%               |

Corresponding to the percentage given in Table 12.5, we will draw a simple rectangle of the given height with fixed width. The bar chart for Table 12.5 will be:



**PROGRAM 12.10** | Write a program to draw a bar chart using Turtle for the sample data given in Table 12.5.

```
import Turtle
def Draw_Bar_Chart(t, height):
 t.begin_fill() # start filling this shape
 t.left(90)
 t.forward(height)
 t.write(str(height))
 t.right(90)
 t.forward(40)
 t.right(90)
 t.forward(height)
 t.left(90)
 t.end_fill() # stop filling this shape

Mozilla_Firefox = 45
Chrome = 30
IE = 15
Others = 10
S = [Mozilla_Firefox, Chrome, IE, Others] # Sample Data
maxheight = max(S)
num_ofBars = len(S)
border = 10
w = Turtle.Screen() # Setting up attributes of Window
w.setworldcoordinates(0,0,40*num_ofBars + border, maxheight + border)
w.bgcolor("pink")
T1 = Turtle.Turtle()
T1.color("#000000")
T1.fillcolor("#DB148E")
T1.pensize(3)
for a in S:
 Draw_Bar_Chart(T1,a)
```

**Explanation** In the above program, we have created a function named **Draw\_Bar\_Chart()**. Initially, the sample statistics data of a browser is given in list **S**. The function **setworldcoordinates()** is used to set the coordinates. The actual syntax and its details are:

**setworldcoordinates(LLX, LLY, URX, URY)**

where,

**LLX** - A number which indicates X coordinate of the lower left corner of the canvas.

**LLY** - A number which indicates Y coordinate of the lower left corner of the canvas.

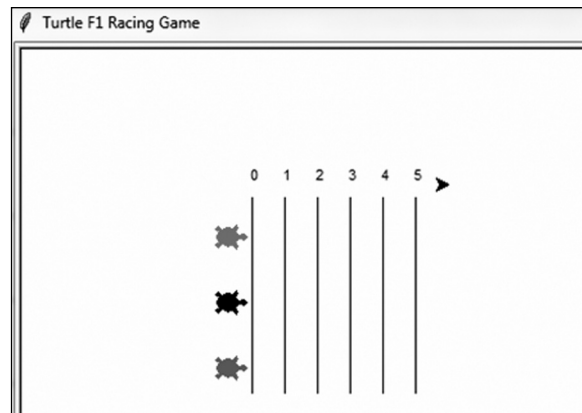
**URX** - A number which indicates X coordinate of the upper right corner of the canvas.

**URY** - A number which indicates X coordinate of the upper right corner of the canvas.

Thus, `setworldcoordinates()` sets the coordinates position to draw the chart.

## MINI PROJECT Turtle Racing Game

Create **three** different Turtles of colors **red**, **green** and **black**. Design one track for all of them to run over the track and win the competition. The track and the Turtle before the start of the completion should look as shown.



Turtle Racing Track

To solve this case study, the for loop and Turtle's inbuilt functions such as `penup()`, `pendown()`, `forward()`, `right()`, `goto()`, `color()`, `shape()`, `speed()`, and `left()` will be used.

### Algorithm

- ◎ **STEP 1:** Design the track.
- ◎ **STEP 2:** Place all the Turtles at the appropriate position to start the race.
- ◎ **STEP 3:** Use the for loop to run over the track and a random number to move the Turtle forward by x pixels.
- ◎ **STEP 4:** End.

### Part 1: Design the track.

- (a) First place the Turtles at the starting position position(x,y).

```
goto(-240,240)
```

- (b) To draw the lines vertically, change the direction of the Turtle facing towards the right.

```
penup()
right(90)
```

- (c) Move the Turtle 10 pixels ahead.

```
forward(10)
```

- (d) Now move the Turtle forward by 150 pixels.

```
pendown()
forward(150)
```

Thus, up to this step we have successfully created the starting line of the track. To draw the second line, move backwards by 160 pixels.

```
backward(160)
```

Now, the Turtle has come to its starting position in the first line but is facing up. Therefore, to draw the second line, change the direction towards the left by 90 degrees and forward by some 'y' distance.

```
left(90)
forward(Y)
```

Repeat all the above steps to draw the remaining lines.

The code to create track is given as follows:

```
from Turtle import*
title('Turtle F1 Racing Game')
speed(10)
penup()
goto(-240,240) #Initial Position of track
z=0
y=25

for x in range(6): #Iterate to draw six lines
 write(x) #Mark distance at the top of line
 right(90) #change direction facing downwards
 forward(10) #Move 10 steps ahead
 pendown() #Open Pen to draw
 forward(150) #Move 150 Steps ahead
 penup() #Close pen
 backward(160) #Move 160 steps backward
 left(90) #Change direction towards left
 forward(y) #Move by y distance
```

**Part II:** Write the code to create the three Turtles and place them at the proper position before the start of the first line.

```
t1 = Turtle() #create Turtle object t1
t1.penup() #pen up to place Turtle at x y position
```

```

..
t1.goto(X,Y)
t1.color('color_name') #Change the color of Turtle
t1.shape('Turtle') #Give proper shape to it

```

Repeat the above steps three times to create three Turtles.

Code to create three Turtles and place them at the proper position before the start of the first line is given as follows:

```

t1 = Turtle() #First Turtle - Red Colored
t1.penup()
t1.goto(-260,200)
t1.color('red')
t1.shape('Turtle')

t2 = Turtle() #Second Turtle - Black Colored
t2.penup()
t2.goto(-260,150)
t2.color('Black')
t2.shape('Turtle')

t3 = Turtle() #Third Turtle - Green Colored
t3.penup()
t3.goto(-260,100)
t3.color('Green')
t3.shape('Turtle')

```

### Part III: Moving the Turtles randomly.

Use randint from the random module to move a Turtle by x position randomly.

```
Turtleobject.forward(randint(1,5))
```

Perform the above steps for all the three Turtles.

Code to move the Turtles is given as follows:

```

from random import*
for t in range(50):
 t1.forward(randint(1,5))
 t2.forward(randint(1,5))
 t3.forward(randint(1,5))

```

**Solution**

Merging all codes, viz. part I, II and III, we get

```
from Turtle import*
from random import*
title('Turtle F1 Racing Game')
speed(10)
penup()
goto(-240,240)
z=0
y=25

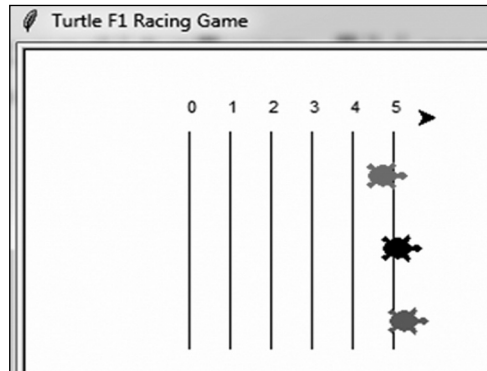
for x in range(6):
 write(x)
 right(90)
 forward(10)
 pendown()
 forward(150)
 penup()
 backward(160)
 left(90)
 forward(y)

t1 = Turtle()
t1.penup()
t1.goto(-260,200)
t1.color('red')
t1.shape('Turtle')

t2 = Turtle()
t2.penup()
t2.goto(-260,150)
t2.color('Black')
t2.shape('Turtle')

t3 = Turtle()
t3.penup()
t3.goto(-260,100)
t3.color('Green')
t3.shape('Turtle')

for t in range(50):
 t1.forward(randint(1,5))
 t2.forward(randint(1,5))
 t3.forward(randint(1,5))
```

**Output****SUMMARY**

- ◆ Turtle is Python's inbuilt graphics module for drawing various shapes such as lines, circle etc.
- ◆ The Turtle is like a pen.
- ◆ Initially the Turtle is positioned at the center of the window.
- ◆ Various methods such as `forward()` and `backward()` are used to move the Turtle forward and backward by x pixels.
- ◆ The Turtle `left(angle)` and `right(angle)` is used to rotate the Turtle left or right by some angle.
- ◆ The Turtle `goto(x, y)` method is used to move the Turtle to specified points(x, y).

**KEY TERMS**

- ⇒ **`turtle()`**: Graphics package to draw objects
- ⇒ **`forward()`, `left()`, `right()` and `backward()`**: Direction to move the Turtle in the given direction
- ⇒ **`penup()` and `pendown()`**: Draw depends on the status of the pen
- ⇒ **`color()`, `fillcolor()`, `end_fill()`, `begin_fill()`**: Methods to color Turtle objects
- ⇒ **`setworldcoordinates()`**: Coordinate the position to draw objects
- ⇒ **`goto(x, y)`**: Move the Turtle at location x,y.

**REVIEW QUESTIONS****A. Multiple Choice Questions**

1. Which instruction is used to set the pen size to 10 pixels?
  - a. `Turtle.size(10)`
  - b. `Turtle.pensize(10)`
  - c. `Turtle.setsize(10)`
  - d. All of them

2. Which instruction is used to set the position of the Turtle at 0,0?
  - a. Turtle.set(0,0)
  - b. Turtle.xy(0,0)
  - c. Turtle.goto(0,0)
  - d. Turtle.moveto(0,0)
3. Which instruction related to the pen is used to draw an object while it is moving?
  - a. pendown()
  - b. Pendown()
  - c. penDown()
  - d. PenDown()
4. Which instruction will help us draw a circle with radius 10?
  - a. Turtle.drawcircle(10)
  - b. Turtle.circledraw(10)
  - c. Turtle.c(10)
  - d. Turtle.circle(10)
5. Which inbuilt function is used change the speed of the Turtle?
  - a. Turtle.move(x)
  - b. Turtle.speed(x)
  - c. Both a and b
  - d. None of the above
6. Which instruction is used to show the current location and direction of the Turtle object?
  - a. Turtle.show()
  - b. Turtle.showdirection()
  - c. Turtle.shoedirloc()
  - d. Turtle.showTurtle()
7. Which instruction prevents the Turtle from drawing objects?
  - a. penUp()
  - b. penup()
  - c. PenUp()
  - d. PenuP()
8. Which instruction hides the Turtle?
  - a. Turtle.hide()
  - b. Turtle.noTurtle()
  - c. Turtle.invisble()
  - d. Turtle.hideall()

## B. True or False

1. Interactive mode (command Line) cannot used for graphics programming in Python.
2. The turtle is an object created when module turtle is imported.
3. The imported turtle module uses pen to draw shapes.
4. The turtle is used to move and draw lines in only forward and backward direction on the screen.
5. By default the position using Turtle pen is down side.
6. It is not possible to draw complicated figures using turtle.
7. Slowest speed range for drawing a figure using a turtle is -1.
8. Maximum speed range for drawing a figure using a turtle is 0.
9. A turtle object contains methods for setting color.
10. We can't fill up the circular figure with a color.

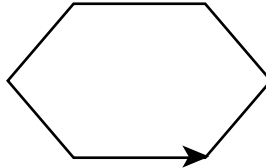
## C. Exercise Questions

1. What is Turtle and how is it used to draw objects?
2. Explain the various inbuilt methods to change the direction of the Turtle.
3. Explain how different shapes can be drawn using iterations.
4. Explain the steps required to create bar charts.
5. How can **penup()** and **pendown()** functions be used effectively?



## PROGRAMMING ASSIGNMENTS

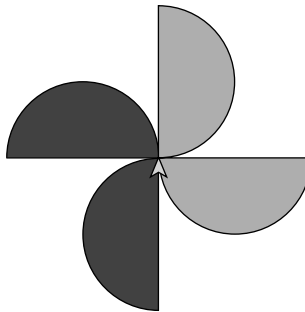
1. Write a program to display the hexagon given as follows:



2. Write a program to display the logo of BMW as given as follows:



3. Write a program to draw the figure given as follows:



4. Write a program to display the patterns of stars in the Turtle graphics window as shown.

```
*
* *
* * *
* * * *
* * * * *
```

# File Handling

## 13

### CHAPTER OUTLINE

|                                       |                                                                 |
|---------------------------------------|-----------------------------------------------------------------|
| 13.1 Introduction                     | 13.5 Binary Files                                               |
| 13.2 Need of File Handling            | 13.6 Accessing and Manipulating Files and Directories on a Disk |
| 13.3 Text Input and Output            |                                                                 |
| 13.4 The <code>seek()</code> Function |                                                                 |

### LEARNING OUTCOMES

*After completing this chapter, students will be able to:*

- Explain the need and importance of file handling
- Open a file and perform different operations on files, such as reading and writing
- Read the contents of a file using the `read`, `readline` and `readline` methods
- Read and write text and numerical data from and to a file, and append data to an existing file
- Access files and directories through various inbuilt functions
- Remove new line characters and other white spaces using the `split()` function

### 13.1 INTRODUCTION

A file is a collection of records. A record is a group of related data items. These data items may contain information related to students, employees, customers, etc. In other words, a file is a collection of numbers, symbols and text and can be considered a **stream of characters**.

## 13.2 NEED OF FILE HANDLING

Often the output screen of a laptop or monitor is not enough to display all the data. This usually happens when the data is large and only a limited amount can be displayed on the screen and stored in the memory. Computer memory is volatile, so even if a user tries to store the data in the memory, its contents would be lost once a program is terminated. If the user needs the same data again, either it has to be entered through a keyboard or regenerated programmatically. Obviously, both these operations are tedious. Therefore, to permanently store the data created in a program, a user needs to save it in a **File** on a disk or some other device. The data stored in a file is used to retrieve the user's information either in part or whole.

Various operations carried out on a file are

- (a) Creating a file
- (b) Opening a file
- (c) Reading from a file
- (d) Writing to a file
- (e) Closing a file

All these operations are discussed in detail in this chapter.

## 13.3 TEXT INPUT AND OUTPUT

To read data from a file or to write data to a file, a user needs to use the **open** function to first create a file object.

### 13.3.1 Opening a File

A file needs to open before we can perform read and write operations on it. To open a file, a user needs to first create a file object which is associated with a physical file. While opening a file, a user has to specify the name of the file and its mode of operation. The syntax to open a file is:

```
file object = open(File_Name, [Access_Mode], [Buffering])
```

The above syntax to open a file returns the object for file name. The mode operation used in the syntax above is a string value which indicates how a file is going to be opened. Table 13.1 describes the various modes used to open a file. The third parameter within the open function is an optional parameter, which controls the buffering of a file. If this parameter is set to 1, line buffering is performed while accessing the file. If the buffering value is set to 0 then no buffering takes place. If we specify the buffering value as an integer greater than 1 then the buffering action is performed with the indicated buffer size.

**Table 13.1** Different modes to open a file

| Mode | Description                                                                         |
|------|-------------------------------------------------------------------------------------|
| R    | Opens a file for reading                                                            |
| W    | Opens a new file for writing. If a file already exists, its contents are destroyed. |

(Contd.)

|    |                                                          |
|----|----------------------------------------------------------|
| A  | Opens a file for appending data from the end of the file |
| Wb | Opens a file for writing binary data                     |
| Rb | Opens a file for reading binary data                     |

### Example

```
F1 = open ("Demo.txt","r") #Open File from Current Directory
F2 = open("c:\Hello.txt","r")
```

The above example opens a file named Hello.txt located at C: in read mode.

### 13.3.2 Writing Text to a File

The open function creates a file object. It is an instance of `_io.TextIOWrapper` class. This class contains the methods for reading and writing data. Table 13.2 lists the methods defined in the `_io.TextIOWrapper` class.

**Table 13.2** Methods for reading and writing data

| <code>_io.TextIOWrapper</code>      | Meaning                                                                                                                       |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <code>str readline()</code>         | Returns the next line of a file as a string                                                                                   |
| <code>list readlines()</code>       | Returns a list containing all the lines in a file                                                                             |
| <code>str read([int number])</code> | Returns a specified number of characters from a file. If the argument is omitted then the entire content of the file is read. |
| <code>Write (str s)</code>          | Writes strings to a file                                                                                                      |
| <code>close()</code>                | Closes a file                                                                                                                 |

Once a file is opened, the write method is used to write a string to a file. Program 13.1 demonstrates the use of write method to write content to a file Demo1.txt.

#### PROGRAM 13.1 | Write a program to write the sentences given below the file **Demo1.txt**.

Hello, How are You?  
Welcome to The chapter File Handling.  
Enjoy the session.

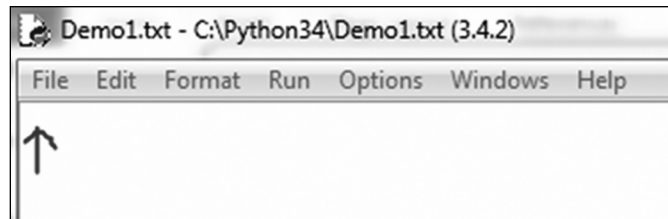
```
def main():
 obj1 = open("Demo1.txt","w") #Opens file in Write mode
 obj1.write(" Hello, How are You ? \n")
 obj1.write(" Welcome to The chapter File Handling. \n ")
 obj1.write(" Enjoy the session. \n ")
main() # Call to main function
```

**Explanation** In the above program, initially the file **Demo1.txt** is opened in ‘w’ mode, i.e. **write mode**. If the file **Demo1.txt** does not exist, the **open** function creates a new file. If the file already exists, the contents of the file will be over written with new data.

When a file is opened for reading or writing, a special pointer called **file pointer** is positioned internally in the file. Reading and writing operation within the file starts from the pointer's location. When a file is opened, the file pointer is set at the beginning of the file. The file pointer moves forward as soon as we start reading from the file or write the data to the file.

The step-wise execution and position of the file pointer is updated in the following manner by the Python interpreter.

Initially, a call is made to the **main()** function. The statement **obj1 = open("Demo1.txt","w")** opens **Demo1.txt** in write mode. The file is created and initially the file pointer is at the starting of the file as shown in Figure 13.1.

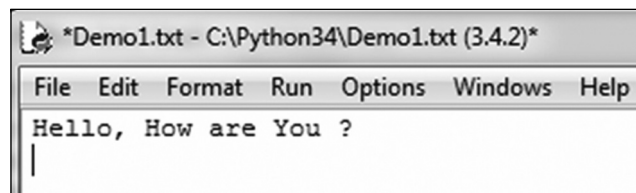


**Figure 13.1** Initial position of the file pointer

The following statement within the program invokes the write method on the file object to write strings into the file.

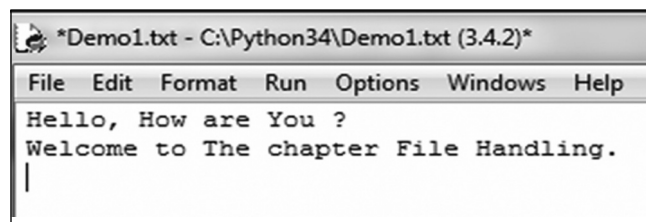
```
obj1.write(" Hello, How are You ? \n")
```

After successful execution of the above statement, the file pointer is located as shown in Figure 13.2.



**Figure 13.2**

After successful execution of a second statement, i.e. **obj1.write("Welcome to The chapter File Handling. \n ")**, the file pointer is located as shown in Figure 13.3.



**Figure 13.3**

Finally, after the execution of the third statement, i.e. `obj1.write(" Enjoy the session.\n")`, the contents of the file are updated as shown in Figure 13.4.

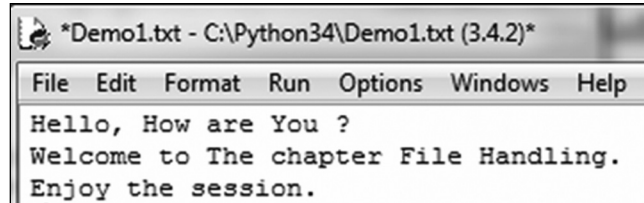


Figure 13.4



**Note:** When `print(str)` function is invoked, the function automatically inserts new line character. But when write function is invoked, we have to explicitly write the new line character to the file.

### 13.3.3 Closing a File

When we have finished reading or writing from a file, we need to properly close it. Since an open file consumes system resources (depending on the mode of the file), closing it will free resources tied to it. This is done using the `close()` method. The syntax to close a file is:

```
Fileobject.close()
```

#### Example

```
fp1 = open('Demo1.txt', 'w')
fp1.close()
```

### 13.3.4 Writing Numbers to a File

In the above program, we have seen that the `write(str s)` method is used to write a string to a file. However, if we try to write numbers to a file, the Python interpreter shows an error. The following program uses the write method to show the error generated by the Python interpreter upon execution.

```
def main():
 obj1 = open("Demo1.txt", "w") #Open file in Write mode
 for x in range(1,20):
 obj1.write(x) #Write number X to a file
 obj1.close()
main()
```

#### #Error

```
Traceback (most recent call last):
 File "C:\Python34\Demo1.py", line 6, in <module>
 main()
 File "C:\Python34\Demo1.py", line 4, in main
```

```

..
 obj1.write(x)
TypeError: must be str, not int

```

The **write ()** method expects a string as an argument. Therefore, if we want to write other data types, such as integers or floating point numbers then the numbers must be first converted into strings before writing them to an output file. In order to read the numbers correctly, we need to separate them using special characters, such as " " (**space**) or '\n' (**new line**). Program 13.2 uses **str** method to convert numbers into strings and write numbers to an output file.

### PROGRAM 13.2 | Write numbers from 1 to 20 to the output file **WriteNumbers.txt**.

```

def main():
 obj1 = open("WriteNumbers.txt","w") #Open File in Write mode
 for x in range(1,21): # Iterates from 1 to 20
 x=str(x) # Convert Number to String
 obj1.write(x) # Write Number to a output file
 obj1.write(" ") # Space to separate Numbers
 obj1.close() # Close File
main() # Call to main function

```

**Explanation** The program opens a **WriteNumbers.txt** file in **w** mode, i.e. write mode. The for loop iterates 20 times to write numbers from 1 to 20 to the file. The numbers are converted into strings using the **str** method before being written to the file.

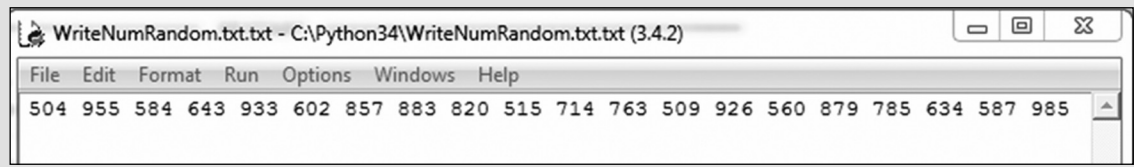
### PROGRAM 13.3 | Generate 50 random numbers within a range 500 to 1000 and write them to file **WriteNumRandom.txt**.

```

from random import randint # Import Random Module
fp1 = open("WriteNumRandom.txt","w") # Open file in write mode
for x in range(51): #Iterates for 50 times
 x = randint(500,1000) #Generate one random number
 x = str(x) #Convert Number to String
 fp1.write(x + " ") #Write Number to Output file
fp1.close() #Finish Writing Close the file

```

#### Output File



**Explanation** The above program generates 50 random integers within range (500 to 1000) and writes them to a text file WriteNumRandom.txt. The **randint** module is imported from **random** to generate random numbers.

### 13.3.5 Reading Text from a File

Once a file is opened using the **open** () function, its content is loaded into the memory. The pointer points to the very first character of the file. To read the content of the file, we open the file in 'r' (read) mode. The following code is used to open the file **ReadDemo1.txt**.

```
>>> fp1 = open("ReadDemo1.txt", "r")
```

There are several ways to read the content of a file. The two common approaches are:

- Use **read()** method to read all the data from a file and return as one complete string.
- Use **readlines()** method to read all data and return as a list of strings.

The following program demonstrates the use of the **read()** method to read the content of the file **ReadDemo1.txt**. The content of the file is as shown in Figure 13.5.

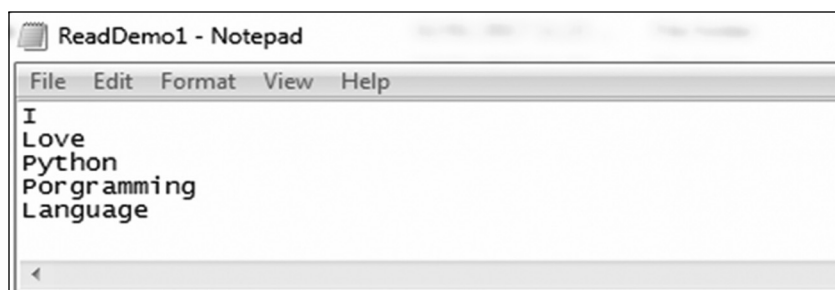


Figure 13.5

**PROGRAM 13.4** | Write a program to read the content of the file ReadDemo1.txt using the **read()** method.

```
fp = open("ReadDemo1.txt", "r") #Open file in read mode
text = fp.read() # Read Whole File exactly once
print(text) #Print the contents of file
```

#### Output

```
I
Love
Python
Programming
Language
```

**Explanation** Initially the file ReadDemo1.txt is opened in read mode. The content of the file is read using the **read()** method. It reads all the content of the file exactly once and returns all the data as a single string.



Alternatively, a programmer can write the for loop to read one line of a file at a time, process it and continue reading the next line until it reaches the end of the file.

```
fp = open("ReadDemo1.txt", "r")
for line in fp:
 print(line)
```

### Output

```
I
Love
Python
programming
Language
```

**Explanation** In the above program, the for loop views the file object as a sequence of lines of text. In each iteration of the for loop, the loop variable **line** is bound to the next line from the sequences of lines present in the text file. Note the output of above program. The **print()** statement prints one extra new line. This is because each line of the input file retains its new line character.

## 13.3.6 Reading Numbers from a File

Syntax used to open a file in read mode is

```
fp1 = open ("numbers.txt", "r");
```

The content of the file **numbers.txt** is as shown in Figure 13.6.

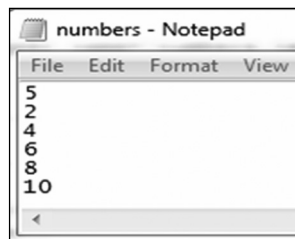


Figure 13.6

The first line of file **number.txt** contains a single integer '**n**', indicating the total number of values appearing in the file. Immediate to the next of the first line we have '**n**' lines with one number on each line. Thus, by making use of **read()** method, all the content of the file is read at once and returned as string. The following program reads the content of the file **numbers.txt** in '**r**' mode.

**PROGRAM 13.5** | Write a program to read the content of the file 'numbers.txt'.

```

fp1 = open("numbers.txt","r") #open file in read mode
num = fp1.read() #return entire contents of file as string
print(num) #print the contents of file stored in num
print(type(num)) # Check the type of num

```

**Output**

```

5
2
4
6
8
10
<class 'str'>

```

In the above program we use the **read()** method. It returns all the input content of the file as a single string. Assume that our goal is to add all the numbers present in a file except for the first one, which indicates the total numbers present in the file.

In order to add the numbers present in the file **numbers.txt**, the **readline()** function is used to read the content of the whole line. Program 13.6 illustrates the use of the **readline()** method.

**PROGRAM 13.6** | Write a program to add the content of a file numbers.txt and display the sum of all the numbers present in the file.

```

fp1 = open("numbers.txt","r")
num = int(fp1.readline())
print(num)
sum = 0
print('The ', num, ' numbers present in the file are as follows:')
for i in range(num):
 num1 = int(fp1.readline())
 print(num1)
 sum = sum + num1
print('Sum of all the numbers (except first):')
print(sum)

```

**Output**

```

5
The 5 numbers present in the file are as follows:
2
4

```

(Contd.)

```

6
8
10
Sum of all the numbers (except first):
30

```

**Explanation** In the above program, initially we have opened a file **numbers.txt** in read mode. The **num = int(fp1.readline())** statement instructs Python to read an entire line from a designated file. Since this is the first line after the file was opened, it will read the first line of the file. As **readline()** function returns string, using **(int)** function, the string is converted to int. This step is repeated to read the remaining lines from the file.

### 13.3.7 Reading Multiple Items on one Line

In the above program, we were able to read only one item per line. Many text files contain multiple items in a single line. The method **split()** for strings allows us to read more than one piece of information in a line. The **split()** returns all the items in a list. In short, it splits a string into separate items and all the items are separated by spaces or tabs.

The following example written in Python IDLE interpreter gives more details about the **split()** method.

```

>>> str = 'I am Loving The Concepts of File Handling'
>>> str.split()
['I', 'am', 'Loving', 'The', 'Concepts', 'of', 'File', 'Handling']
#
>>> for i in range(len(str)):
 print(str[i])

I
am
Loving
The
Concepts
of
File
Handling

```

**Explanation** The above example simply splits the string and stores the content to a list. Finally, the **for** loop is used to access and display each item of the list.

Let us look at a program which reads more than one piece of information in a line. Consider the problem of calculating the total and percentage marks obtained by students, stored in a file **Grades.txt**.

The content of **Grades.txt** file is as shown in Figure 13.7.

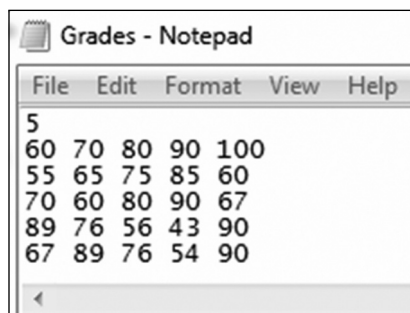


Figure 13.7

The first line of the input file **Grades.txt** has a single positive integer 'n' which represents the number of students in a class. The following 'n' lines next to the first line contain five positive integers in between 0 and 100, which represent the marks obtained by the students in five different subjects.

**PROGRAM 13.7** | Write a program to read the contents of a file **Grades.txt** and calculate the total marks and percentage obtained by a student.

```
fp1 = open("Grades.txt","r") #Open file in read mode
n = int(fp1.readline()) #Read first line of file
print('Total Number of Students: ',n)
for i in range(n):
 print('Student #',i+1,':', end = ' ')
 allgrades = (fp1.readline()).split()
 print(allgrades)
 sum = 0
 for j in range(len(allgrades)):
 sum = sum + int(allgrades[j])
 per = float((sum/500)*100)
 print('Total = ',sum, ' \nPercentage = ',per)
 print('\n')
```

### Output

```
Total Number of Students: 5
Student # 1 : ['60', '70', '80', '90', '100']
Total = 400
Percentage = 80.0
```

(Contd.)

```

Student # 2 : ['55', '65', '75', '85', '60']
Total = 340
Percentage = 68.0

Student # 3 : ['70', '60', '80', '90', '67']
Total = 367
Percentage = 73.4

Student # 4 : ['89', '76', '56', '43', '90']
Total = 354
Percentage = 70.8

Student # 5 : ['67', '89', '76', '54', '90']
Total = 376
Percentage = 75.2

```

**Explanation** Initially, the file **Grades.txt** is opened in read mode. The statement **n = int(fp1.readline())** reads the first line of the file. It returns the details about number of students present in the file. The **for** loop is used to go through each student. For each student, the marks obtained for five different subjects are stored in a **list**. Since **list** stores strings, each item of the list is converted into **int** to carry out the desired calculations.

**PROGRAM 13.8** | Write a function **Find\_Largest()** which accepts a file name as parameter and reports the longest line in the file.

The content of **Demo1.txt** file is as shown in Figure 13.8.

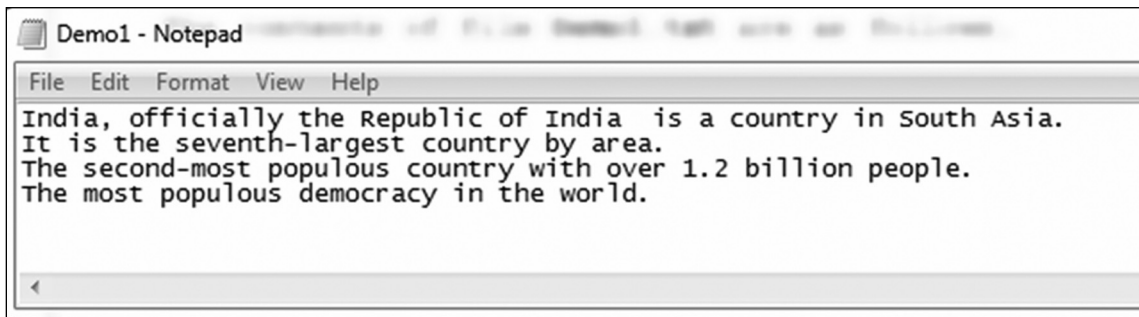


Figure 13.8

```
def Find_Largest(fp1):
 fp1 = open('Demo1.txt','r') #Open File in read Mode
 long = " " #Assume Longest Line = 0
 L = 0
 count = 0
 for line in fp1:
 count= count + 1
 print(' Line No: ',count)
 print(line)
 print(' Number of Character = ',len(line))
 print('-----')
 if(len(line) > len(long)):
 long = line
 L = line
 print(L, 'is the Longest Line with', len(long),'characters')
fp = open('Demo1.txt','r')
Find_Largest(fp)
```

### Output

```
Line No: 1
India, officially the Republic of India is a country in South Asia.

Number of Character = 70

Line No: 2
It is the seventh-largest country by area.

Number of Character = 43

Line No: 3
The second-most populous country with over 1.2 billion people.

Number of Character = 64

Line No: 4
The most populous democracy in the world.
Number of Character = 42

India, officially the Republic of India is a country in South Asia.
is the Longest Line with 70 characters
```

**Explanation** The file **Demo1.txt** is opened in read mode. Initially, we have assumed the length of the longest line is 0 characters. The for loop is used to traverse all the lines of the file **Demo1.txt**. While traversing, the length of each line is measured and compared with the previous longest length of a line present in the file. Finally, the line with the longest length is stored in the variable 'long'.

**PROGRAM 13.9** Write a program to copy lines which start with an uppercase letter only from the input file **Demo1.txt** and ignore the lines which start with a lowercase letter. The output file **Demo2.txt** should contain only those lines from the file **Demo1.txt** which start with an uppercase letter.

The content of **Demo1.txt** and **Demo2.txt** is as shown below. Initially, **Demo2.txt** is an empty file (Figure 13.9).

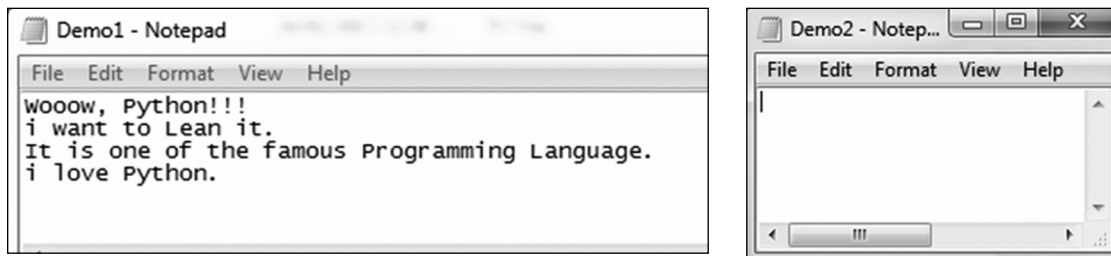
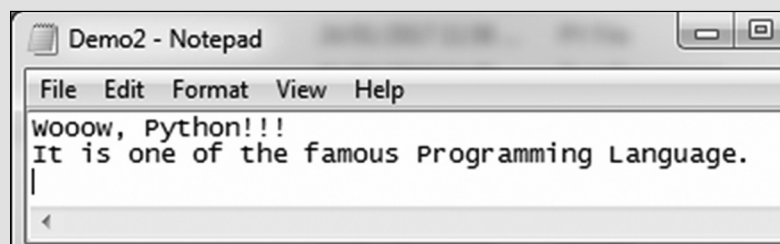


Figure 13.9

```
IP_File = open('Demo1.txt','r')
Out_File = open('Demo2.txt','w')
for line in IP_File:
 if line[0] not in 'abcdefghijklmnopqrstuvwxyz':
 Out_File.write(line)
Out_File.close()
```

### Output



**Explanation** The file Demo1.txt is opened in read mode. The **for** loop is used to go through all the lines present in it. Initially, the file Demo2.txt is an empty file. The statement **if line[0] not in 'abcdefghijklmnopqrstuvwxyz':** is used to check if a line starts with an uppercase letter. If the condition is satisfied, the corresponding line is copied to the file **Demo2.txt**.

### 13.3.8 Appending Data

The append '**a**' mode of a file is used to append data to the end of an existing file. The following program demonstrates the use of append mode.

**PROGRAM 13.10** | Write a program to append extra lines to a file name **appendDemo.txt**.

The content of **appendDemo.txt** file is as shown in Figure 13.10.

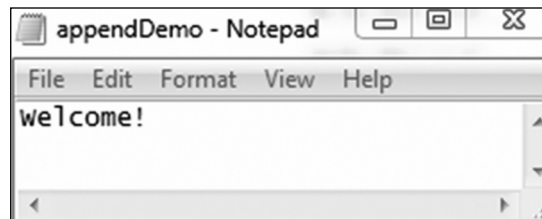
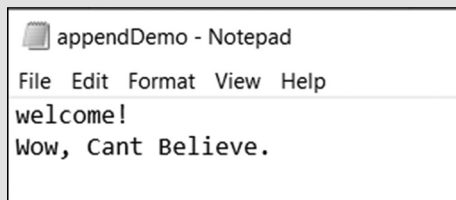


Figure 13.10

```
fp1=open('appendDemo.txt','a') # Open file in append file
fp1.write('\nWow, Cant Believe.')# Append contents to a file
fp1.close() #Close file
```

#### Output



## 13.4 THE seek() FUNCTION

So far, we have learnt that data is stored and subsequently read from a file in which it is stored. When a file is opened, we can imagine an imaginary pointer positioned at the beginning of the file. What about reading the content of files from random positions? Python provides an inbuilt function called **seek()** for moving the pointer explicitly to any position in a file.

Thus, the **seek()** method is used to set the file pointer to a specific position in a file. The syntax for **seek()** function is:



```
..
File_object.seek(offset, whence)
....
```

where **offset** indicates the number of bytes to be moved from the current position of the pointer and **whence** indicates the point of reference from where the bytes are to be moved from. The value of whence can be determined from Table 13.3.

**Table 13.3** Seek file pointer

| Value | Meaning                                                                                                                                                                                                   |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | The position is relative to the start of the file, i.e. it sets the pointer at the beginning of the file. This is a default setting if we don't supply '0' as the second argument to the seek() function. |
| 1     | The position is relative to the current position.                                                                                                                                                         |
| 2     | The position is relative to the end of the file.                                                                                                                                                          |

### Examples

```
#Create Seek_Demo1.txt file in write mode
>>> fp1= open('Seek_Demo1.txt','w+')
#Write some data to the file
>>> fp1.write('Oh!God!SaveEarth!')
17 #returns number of characters written in a file
#By default second argument of seek function is zero
>>> fp1.seek(3)
2
>>> fp1.readline()
'God!SaveEarth!'
```

### Explanation

In the above example the file Seek\_Demo.txt contains 17 characters. The statement **fp1.seek(3)** tells Python to read the content of the file from the third position.



**Note:** The statement **fp1.seek(3)** does not contain a second argument. Thus, by default, it is set to zero. The first argument cannot be negative if we don't supply a second argument.

**PROGRAM 13.11** | Write a program to perform the following operation using **seek()** and basic file operations.

- Open file weekdays.txt in write mode.
- Write weekdays from Monday to Friday in a file weekdays.txt.
- Use **seek()** to read the content of the file.
- Set the pointer to the end of the file and append two remaining weekdays, i.e. Saturday and Sunday to the existing file weekdays.txt.
- Read and print all content of the file.

```
fp1 = open('weekdays.txt', 'w+') #Open file in w+ mode
fp1.write('Monday\n') #Write to file
fp1.write('Tuesday\n')
fp1.write('Wednesday\n')
fp1.write('Thursday\n')
fp1.write('Friday\n')
fp1.seek(0) #Set file pointer to start of the file
#t = fp1.read() #Read file from current file pointer till end
fp1.seek(0,2) #Move file pointer at the end of file
fp1.write('Saturday\n') #Write at the end of file
fp1.write('Sunday')
fp1.seek(0)
t = fp1.read()
print(t)
```

### Output

```
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
```

**Explanation** In the above program, initially we have opened a file and written the content to the file. The statement `fp1.seek(0)` is used to reposition the pointer to the starting point of the file and read the whole content at once. Similarly, `seek(0, 2)` points to the end of the file and the remaining content is written to the file.

## 13.5 BINARY FILES

Binary files can be handled in a manner similar to that used for text files. Access mode `'r'` is required to open normal text files. In order to open binary files, we should include `'b'`, i.e. `'rb'` to read binary files and `'wb'` to write binary files.

Binary files don't have text in them. They might have pictures, music or some other kind of data. There are no new lines in binary files, which means we cannot use `readline()` and `readlines()` on them.

### 13.5.1 Reading Binary Files

Many proprietary applications use binary file formats. This type of file format begins with a specific series of bytes to identify the file type. For example, the first one byte in a jpg image is always **b'\xff\xd8'**, i.e. it indicates the type of the file. Similarly, **\xff\xd9** indicates the end of a file.

The following example shows how we can read the content of a jpeg file.

#### Example

```
>>> fp1 = open('C:\\Users\\shree\\Desktop\\demo.jpg', 'rb')
>>> fp1.read()
b'\xff\xd8\xff\xe0\x00\x10JFIF\x00\x01\x01\x01\x00~\x00~\x00\x00 \xff\xdb\x00C\x00\x02\x01....., \xff\xd9'
```

## 13.6 ACCESSING AND MANIPULATING FILES AND DIRECTORIES ON A DISK

Python supports various inbuilt functions for accessing and manipulating files and directories. Most file manipulation functions live in the **os** module and associated module are called **os.path**. The **os** provides basic file handling functions and the **os.path** handles operations on paths and filenames. Table 13.4 contains a list of inbuilt functions related to files and directories provided by Python.

**Table 13.3** Inbuilt functions to access files and directories

| Module and Function                                                                                                                                                                       | Description                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| <b>os.getcwd()</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; import os          # import os module &gt;&gt;&gt; os.getcwd()        # Returns Current Working Directory 'C:\\Python34'</pre> | Returns the path of the current working directory.                    |
| <b>os.chdir(newdir)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.chdir('C:\\Python34\\Lib') &gt;&gt;&gt; os.getcwd() 'C:\\Python34\\Lib'</pre>                                          | Changes the current working directory.                                |
| <b>os.path.isfile(fname)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.path.isfile('Demo1.py') True # Returns true since the file is present on the said path</pre>                      | Returns True if a file exists on the said path or else returns False. |

(Contd.)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <b>os.path.isdir(DirName)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.path.isdir('C:\\Python34') True</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                | Returns True if the said directory exists or else returns False.                                             |
| <b>os.mkdir(DirName)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.mkdir('Prac') &gt;&gt;&gt; os.chdir('C:\\Python34\\Prac')</pre>                                                                                                                                                                                                                                                                                                                                                                                                           | Creates a new directory in the said path or else by default it creates one in the current working directory. |
| <b>os.listdir(path)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.listdir('c:\\Python34\\Practice') ['apps.py', 'CDemo.py', 'ColorDemo.py', 'cprime.py']</pre>                                                                                                                                                                                                                                                                                                                                                                               | Lists the names of files and directories in the said path.                                                   |
| <b>os.rename(old, name)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.getcwd() #Get path of Current Working Directory 'C:\\Python34\\Prac' &gt;&gt;&gt; os.chdir('c:\\Python34\\Practice') #Change Path &gt;&gt;&gt; os.listdir() #List Names of Files and Directories ['apps.py', 'CDemo.py', 'ColorDemo.py', 'cprime.py'] &gt;&gt;&gt; os.rename('apps.py', 'MyApps.py') #Rename file 'MyApps.py' &gt;&gt;&gt; os.getcwd() 'c:\\Python34\\Practice' &gt;&gt;&gt; os.listdir() ['CDemo.py', 'ColorDemo.py', 'cprime.py', 'MyApps.py']</pre> | Renames the old file name to a new file name.                                                                |
| <b>os.path.getsize(path)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; import os &gt;&gt;&gt; os.path.getsize('Demo1.py') 173</pre>                                                                                                                                                                                                                                                                                                                                                                                                             | Return the size, in bytes for the said path.                                                                 |
| <b>os.path.exists (path)</b><br><b>Example:</b><br><pre>&gt;&gt;&gt; os.path.exists('Demo1.py') True</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                    | Returns True if the path exists otherwise returns False.                                                     |

## MINI PROJECT

### Extracting Data from a File and Performing Some Basic Mathematical Operations on It

Let us assume an individual spends 'x' amount (in **three** digits) on 'Y' item each month. The amount spent each month is stored in a file **Expenses.txt** in the format **MonthNo:X\n**. Create an application using file handling to calculate the total amount spent on 'Y' item in the last six months.

**Example**

Consider the Expenses.txt file given below. The information contained within the file is:

Month1 : 100  
 Month2 : 200  
 Month3 : 079  
 Month4 : 090  
 Month5 : 097  
 Month6 : 100  
 Total expense in the last six months: 566

**Algorithm**

- ◎ **STEP 1:** Open file Expenses.txt in w+ mode.
- ◎ **STEP 2:** Insert all the entries for the last six months in the said format.
- ◎ **STEP 3:** Reset the file pointer to the initial position.
- ◎ **STEP 4:** Iterate file. For each iteration, search for ':' and store the content after ':' in the variable 'exp'.
- ◎ **STEP 5:** Compute the sum of all the expenses for last six months and display the total expense.

**Program**

```
fp1=open('Expenses.txt','w+') #Open file in write mode
fp1.write('Month1:100\n')
fp1.write('Month2:200\n')
fp1.write('Month3:079\n')
fp1.write('Month4:090\n')
fp1.write('Month5:097\n')
fp1.write('Month6:100\n')
print('Contents of File Expenses.txt are as follows:')
fp1.seek(0) #Reposition pointer to the start of file
print(fp1.read()) #Read entire file at once
fp1.seek(0) #Again reposition pointer to the start of file
txt = fp1.readlines()#Read contents of file line wise
count = 0
sum = 0
for ch in txt:
 fp1.seek(7+count)
```

(Contd.)

```
exp = fp1.readline().strip('\n')
sum = sum + int(exp)
count += 12
print('Expenses of last six month:',sum)
```

### Output

Contents of File Expenses.txt are as follows:

Month1:100

Month2:200

Month3:079

Month4:090

Month5:097

Month6:100

Expenses of last six month: 666

## SUMMARY

- ♦ Read, write and append are the basics modes of a file.
- ♦ A file is opened in 'wb' mode for writing binary content to the file.
- ♦ A file is opened in 'rb' mode for reading binary content of the file.
- ♦ The open function is an instance of `_io.TextIOWrapper` class.
- ♦ The write (str s) method is used to write a string to a file.
- ♦ The method `readlines()` returns a list containing all the lines in a file.
- ♦ The `read()` method is used to read all the data from a file.
- ♦ The `read()` method returns all the data as one complete string.
- ♦ The `os` module and `os.path` handle various operations related to the file name and path.

## KEY TERMS

- ⇒ **open():** Used to open a specified file
- ⇒ **Mode:** R (read), W (write), A (Append), Wb (write binary data) and Rb(read binary data) are different modes to open a file
- ⇒ **write():** Method to write text and numbers to a file
- ⇒ **read, readline and readlines():** Various methods to read the content of a file
- ⇒ **split():** Reads more than one piece of information in a line and returns all the items in a list
- ⇒ **os.path():** Handles operations related to files and directories
- ⇒ **seek():** Places the file pointer at specific locations

## REVIEW QUESTIONS

## A. Multiple Choice Questions

- Opening a file in read mode performs which operation?
  - Creates a new file
  - Reads consecutive characters from a file
  - Reads all the content of a file
  - None of the above
- If we have to open a file **abc.txt** using the statement  

```
Fp1 = open('abc.txt', 'r')
```

 which statement will read the file into memory?
  - Fp2 = open(Fp1)
  - FP1.Open.read(Fp1)
  - Fp1.read()
  - None of the above
- The inbuilt method **readlines()** is used to:
  - Read an entire file as a string
  - Read one line at a time
  - Read each line in a file as an item in a list
  - None of the above
- If the statement **Fp1 = open('demo.txt','r')** is used to open a file demo.txt in read mode then which statement will be used to read 5 string characters from a file into memory?
  - Ch = fp1.read[:10]
  - Ch = fp.read(6)
  - Ch = fp.read(5)
  - All of the above
- The **close()** method is used to conserve memory because:
  - It closes all unused memory created by Python
  - It deletes all the text related to a file
  - It compresses a file
  - It removes the reference created by files **open()** function
- If we have to open a file to read its content using the statement  

```
Convert_Demo = open('Story.txt', 'r')
```

 which is a valid statement to convert each character of the first line of a file into uppercase?
  - print(Convert\_Demo[0].upper())
  - print(Convert\_Demo.upper())
  - print(Convert\_Demo.readline().upper())
  - All of the above
- If content of a file **cities.txt** is:
 

```
&Delhi&Chennai&
&Mumabi&Kolkata&Madras&
&Pune&Nagpur&Aurangabad&
```

What will be the output of the following code?

```
fp1 = open("cities.txt", "r")
name = fp1.readline().strip('&\n')
```

```
while name:
 if name.startswith("M"):
 print(name)
```

```

else:
 pass
name = fp1.readline().strip('&\n')

```

- |                            |                           |
|----------------------------|---------------------------|
| a. &Mumbai&Kolkata&Madras& | b. Mumabi&Kolkata&Madras  |
| c. Mumabi Kolkata&Madras   | d. &Mumabi Kolkata Madras |
8. What is the use of 'a' mode in file handling?
 

|           |          |
|-----------|----------|
| a. Read   | b. Write |
| c. Append | d. Alias |
  9. Which statement is used to move the pointer in a file to the beginning of the first character?
 

|              |             |
|--------------|-------------|
| a. .seek(-1) | b. .seek(1) |
| c. .seek(0)  | d. .seek(2) |
  10. Which statement is used to move the pointer in a file to the end of the file?
 

|              |             |
|--------------|-------------|
| a. .seek(-1) | b. .seek(1) |
| c. .seek(0)  | d. .seek(2) |

## B. True or False

1. 'w+' mode opens a file for write plus read.
2. The statement seek(5,1) is used to move the pointer 5 characters past the current position.
3. A file once opened in read mode cannot be used to write.
4. The .listread() statement is used to read each line of a file as an item in a list.
5. The readline() is used to read a line as string.
6. The readline() method can be used to read the content of each line in a binary file.
7. Binary files contain \n.

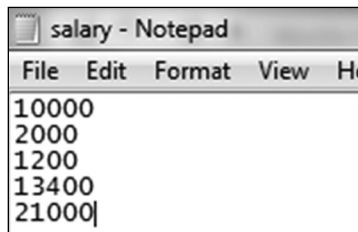
## C. Exercise Questions

1. Define a file and its advantages.
2. How are files opened and what operations can be done on them?
3. State the syntax to open, write text and close a file.
4. How is data appended to an existing file?
5. What are the applications of the seek() function?
6. State the syntax for seek() function.
7. Enlist the inbuilt functions supported by Python.
8. What is a binary file? List its applications.
9. Explain any five inbuilt file functions.
10. Using an example, write the procedure to read numbers from a file.

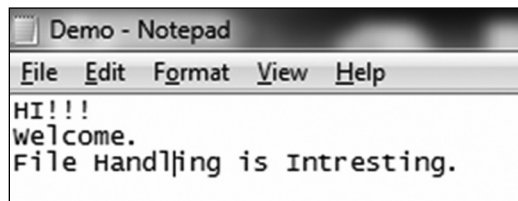


## PROGRAMMING ASSIGNMENTS

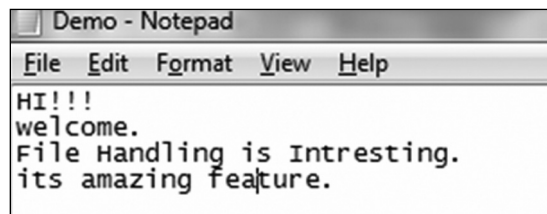
1. Write a program to add the contents of a file **salary.txt** and display the sum of salaries of all employees present in the file. The content of file **salary.txt** is



2. Write a function **Find\_Samllest()** which accepts the file name as parameter and reports the smallest line in the file. The content of file **Demo.txt** is



3. Write a program to copy lines which start with a lowercase letter only from the input file **Demo.txt** and ignore the lines which start with an uppercase letter. The output file **Demo2.txt** should contain only those lines from the file **Demo.txt** which start with a lowercase letter.



4. Write a program to copy the content of one file to another.
5. Write a program to read the content of a Python file and display all the lines without comments.

# Project for Creating a Phone Book Directory

## APPENDIX

### I

## INTRODUCTION

Many of us may have searched for a phone number from a phone book directory sometime. This phone book directory is also known as **telephone book** or **phone book** or **telephone directory**. Subscribers in a telephone directory are listed alphabetically.

The main objective of the project below is to create a telephone directory which can help users search for a mobile or phone number of a subscriber.

## OBJECTIVE

- (a) Store names and phone numbers of subscribers in a text file.
- (b) A user should be able to search the name and phone number of a subscriber in the telephone directory.

## PRE-REQUISITE

Before starting this project, a programmer should know the following concepts of Python:

1. Decision statements
2. Loops
3. Functions
4. Strings
5. Lists
6. Searching and sorting using lists
7. File handling

**Solution**

- (a) Write the function **Add \_ Details()** to add a new entry, i.e. add a new name and phone number of a subscriber.

```
def Add_Details():
 entry=[]
 name=input('Please Enter the Name: ')
 ph_no=input('Please Enter Phone Number: ')
 entry.append(name)
 entry.append(ph_no)
 return entry
```

In the above example, initially an empty list entry is created. The name and phone number of a subscriber are prompted from the user and appended to the empty list named Entry. The function **Add \_ Details()** can be called whenever we want to add a new subscriber's name and contact details to the existing telephone directory.

- (b) Write a function **bub \_ Sort()** to sort the contents of the telephone directory in the ascending order.

After adding the names and phone numbers of subscribers to a list from **Add \_ Details()** function, it may happen that the list may contain unsorted data. Hence, before inserting data into the telephone directory, make sure that the content of the list is in a sorted order. Therefore, the **bub \_ sort(dirList)** function must be placed immediately after the **Add \_ Details()** function.

```
def bub_sort(dirList):
 length = len(dirList) - 1
 unsorted = True
 while unsorted:
 unsorted = False
 for element in range(0,length):
 if dirList[element] > dirList[element + 1]:
 temp = dirList[element + 1]
 dirList[element + 1] = dirList[element]
 dirList[element] = temp
 #print(dirList)
 unsorted = True
```

Thus, in the above function, the normal bubble sort is used to sort the elements of the list in the ascending order.

- (c) Write the function **Save \_ Data \_ To \_ File()** to save the newly added subscribers to the telephone directory.

The function **bub\_sort()** helps to sort the contents of the list in the ascending order. Once the list is sorted, write the sorted contents of the list to a file named **Phone\_Directory.txt**. The function **Save\_Data\_To\_File()** contains the appropriate code to write the content of the list to the said file. The **Save\_Data\_To\_File()** function should be placed just below the **bub\_sort(dirList)** function.

```
def Save_Data_To_File(dirlist):
 f=open('Phone_Directory.txt','w') #directory.txt is the name for the new
 file to be saved
 for n in dirlist:
 f.write(n[0]) # writes the name
 f.write(',') # writes a comma
 f.write(n[1]) # writes the number
 f.write('\n') # writes a new line
 f.close()
```

The file **Phone\_Directory.txt** is opened in **write** mode to write the content of the list to a file.

(d) Write the **Display()** function to print all the names and phone numbers of all the subscribers.

```
def Display():
 if(os.path.isfile('Phone_Directory.txt')== 0):
 print('Sorry you Dont have any Contacts in your Phone Address Book.')
 print('Please Create it!!!!')

 elif(os.stat('Phone_Directory.txt').st_size==0):
 print('Address Book is empty')
 else:
 f=open('Phone_Directory.txt','r')
 text = f.read()
 print(text)
 f.close()
```

The display function is used to know all the details, such as name, phone number of all the subscribers. Initially, the **os.path.isfile('Phone\_Directory.txt')** is used to check if a file exists at the current location. The **os.stat('Phone\_Directory.txt').st\_size==0** function is used know if a file is empty or it contains any information. Finally, if a file exists and contains some data then it is opened in read mode.

Assume we have read the file and it contains names and corresponding phone numbers of thousands of subscribers. If we want to search for a phone number of a particular subscriber then it is not possible to manually read each line to find it. Thus, to make our application more useful write the **Search()** function after the **Display()** function.

(e) Write the **Search()** function to find the phone number of a particular subscriber.

```

def Search():
 name = input('Enter the Name:')
 f=open('Phone_Directory.txt','r')
 result = []
 for line in f:
 if name in line:
 found = True
 break
 else:
 found = False
 if(found == True):
 print('The Name of Person Exist in Directory:')
 print(line.replace(',',''))
 else:
 print('The Name Doesnot Exist in Directory')

```

In the search function, the file is opened in read mode. Initially the name of the subscriber is read from the user. The for loop is used to read all the lines in the file. It searches for the name of the subscriber in each line. If the name of the subscriber exists then the corresponding phone number is displayed. If it searches till end of the file and does not find a match in any line then it means the name of the subscriber does not exist in the phone directory.

After writing all the above basic functions, create one more function named **get \_ choice()**. The content of this function is given as follows:

```

def get_choice():
 print('1)\tAdd New Phone Number to a List of Phone Book Directory:')no
 print('2)\tSort Names in Ascending Order')
 print('3)\tSave all Phone Numbers to a File')
 print('4)\tPrint all Phone Book Directory on the Console')
 print('5)\tSearch Phone Number from Phone Directory')
 print('6)\tPlease Write 6 to exit from the menu:')
 ch=input('Please Enter the Choice:')
 return(ch)

```

The above function is used to get the subscriber from the user. The requested choice is returned to the main part of the program to perform a particular task. The content of the main part of a program should be written as

```

#main program
if(os.path.isfile('Phone_Directory.txt')== 0):
 print('Sorry you Dont have any Contacts in your Phone Address
Book.')
```

```

 print('Please Create it!!!!')
 directory = []
else:
 print('Already Your Phone Book has Some Contacts')
 print(' You can See it!!!!')
 directory = []
 f=open('Phone_Directory.txt','r')
 for line in f:
 if line.endswith('\n'):
 line = line[:-1]
 directory.append(line.strip().split(','))

 f.close()
#directory = []
c = True
while c:
 ch=get_choice()

 if ch == '1':
 e = Add_Details()
 directory.append(e)

 if ch == '2':
 bub_sort(directory)
 print('Contents of Phone Book Sorted Successfully!!!!')
```

```

 if ch == '3':
 Save_Data_To_File(directory)
 print('Data Saved to Phone Book Successfully!!!!')
```

```

 if ch == '4':
 Display()

 if ch == '5':
 Search()

 if ch == '6':
 print('Thanks a Lot for using Our Application')
 c = False

```

In the main part, first we check if any contact exists in the phone directory. If it does contain some contact then the existing contacts are copied to the list named **directory**. Lastly, the new contacts are appended to the existing ones.

If we combine all the above steps, the overall program on the phone book directory project will be as shown below.

```
import os
#-----#
def Add_Details():
 entry=[]
 name=input('Please Enter the Name: ')
 ph_no=input('Please Enter Phone Number: ')
 entry.append(name) #Append name to the list entrtty
 entry.append(ph_no) #Append ph_no to the list entrtty
 return entry
#-----#
def bub_sort(dirList):

 length = len(dirList) - 1
 unsorted = True

 while unsorted:
 unsorted = False
 for element in range(0,length):
 if dirList[element] > dirList[element + 1]:
 temp = dirList[element + 1]
 dirList[element + 1] = dirList[element]
 dirList[element] = temp
 #print(dirList)
 unsorted = True
#-----#
def Save_Data_To_File(dirlist):
 f=open('Phone_Directory.txt','w')
 for n in dirlist:
 f.write(n[0]) # writes the name
 f.write(',') # writes a comma
 f.write(n[1]) # writes the number
 f.write('\n') # writes a new line
 f.close()
#-----#
def Display():
 if(os.path.isfile('Phone_Directory.txt')== 0):
```

(Contd.)

```

 print('Sorry you Dont have any Contacts in your Phone Address Book.')
 print('Please Create it!!!!')

 elif(os.stat('Phone_Directory.txt').st_size==0):
#Check if File Contains data or not
 print('Address Book is empty')
 else:
 f=open('Phone_Directory.txt','r')
 text = f.read()
 print(text)
 f.close()

#-----#
def Search():
 name = input('Enter the Name:')
 f=open('Phone_Directory.txt','r')
 result = []
 for line in f:
 if name in line:
 found = True
 break
 else:
 found = False

 if(found == True):
 print('The Name of Person Exist in Directory:')
 print(line.replace(',',''))

 else:
 print('The Name Doesnot Exist in Directory')

#-----#
def get_choice():
 print('1)\tAdd New Phone Number to a List of Phone Book Directory:')
 print('2)\tSort Names in Ascending Order')
 print('3)\tSave all Phone Numbers to a File')
 print('4)\tPrint all Phone Book Directory on the Console')
 print('5)\tSearch Phone Number from Phone Directory')
 print('6)\tPlease Write 6 to exit from the menu:')
 ch=input('Please Enter the Choice:')
 return(ch)

#-----#
#main program
if(os.path.isfile('Phone_Directory.txt')== 0):

```

(Contd.)



```

 print('Sorry you Dont have any Contacts in your Phone Address Book.')
 print('Please Create it!!!!')
 directory = []
else:
 print('Already Your Phone Book has Some Contacts')
 print(' You can See it!!!!')
 directory = []
 f=open('Phone_Directory.txt','r')
 for line in f:
 if line.endswith('\n'):
 line = line[:-1]
 directory.append(line.strip().split(','))

 f.close()
#directory = []
c = True
while c:
 ch=get_choice()

 if ch == '1':
 e = Add_Details()
 directory.append(e)

 if ch == '2':
 bub_sort(directory)
 print('Contents of Phone Book Sorted Successfully!!!!')

 if ch == '3':
 Save_Data_To_File(directory)
 print('Data Saved to Phone Book Successfully!!!!')

 if ch == '4':
 Display()

 if ch == '5':
 Search()

 if ch == '6':
 print('Thanks a Lot for using Our Application')
 c = False
#-----#

```

# Importing Modules in Python

APPENDIX



Python programs are written in script mode of Python's IDLE. Once the code is written, the file is saved by **.py** extension. In short, modules are Python's **.py** files which contain Python code. Any Python file can be referenced as a module.

## WRITING AND IMPORTING MODULES

Writing a module is like writing a simple Python program in a file and saving it in **.py** extension. Modules contain definitions of functions, classes and variables, which can be utilised in other programs.

Let us create a simple file Demo.py.

```
def Display():
 print('Hello, Welcome all!')
```

If we try to execute the above code nothing will happen because we have just written the function and it has not been called from elsewhere to perform its action. So, let us create another file named main.py so that we can import the module Demo.py we have just created and then call the function Display() present in file Demo.py from a new file main.py. Therefore, the contents of the main.py file are



**Note:** Syntax to import module is as, we have to write keyword import followed by the name of module which we are going to import.

### Syntax

```
import module_name
```

Thus, we will make use of the import statement in the following **main.py** file to import the module named **Demo.py** as:

```
#main.py

import Demo # Importing Module named Demo
demo.Display() # Call function Display present within Demo.py
```

### Output

```
Hello, Welcome all!
```

### Explanation

In the above program, we are importing a module, therefore we need to call the function by referencing the module by “.”, i.e. dot notation. Thus, we use the **ModuleName.FunctionName()** to reference the function present within the module. The statement **demo.Display()** calls the function **Display()** from module named **demo.py**.

The above code contains the following two lines:

```
import Demo
demo.Display()
```

We can use the **from** keyword and replace the above two lines as

```
from Demo import Display
Display()
```

Thus, we can get the same output even if we use the **from** keyword.



**Note:** The module which we have imported and the file in which we have used the import statement should be in the same directory. With respect to the above example, **Demo.py** and **main.py** should be stored/located at the same location.

In the above example, we have seen how a function present in another file can be called using the import statement. A programmer can use the import statement to import variables and classes present in another file in this manner.

# Python Keywords

## APPENDIX



Given below is a list of keywords reserved by Python. These keywords are special and cannot be used as identifiers.

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

# ASCII Table

## APPENDIX

# IV

**ASCII** stands for **American Standard Code for Information Interchangeable**. It is one of the character encoding systems. ASCII code represents text in a computer. Python uses the **ord()** function to get the ASCII value for any character. It will be useful for a programmer to remember the ASCII values for all the characters given below.

| <i>Dec</i> | <i>Char</i>                 | <i>Dec</i> | <i>Char</i> | <i>Dec</i> | <i>Char</i> | <i>Dec</i> | <i>Char</i> |
|------------|-----------------------------|------------|-------------|------------|-------------|------------|-------------|
| 0          | NUL (null)                  | 32         | SPACE       | 64         | @           | 96         | ~           |
| 1          | SOH (start of heading)      | 33         | !           | 65         | A           | 97         | a           |
| 2          | STX (start of text)         | 34         | "           | 66         | B           | 98         | b           |
| 3          | ETX (end of text)           | 35         | #           | 67         | C           | 99         | c           |
| 4          | EOT (end of transmission)   | 36         | \$          | 68         | D           | 100        | d           |
| 5          | ENQ (enquiry)               | 37         | %           | 69         | E           | 101        | e           |
| 6          | ACK (acknowledge)           | 38         | &           | 70         | F           | 102        | f           |
| 7          | BEL (bell)                  | 39         | '           | 71         | G           | 103        | g           |
| 8          | BS (backspace)              | 40         | (           | 72         | H           | 104        | h           |
| 9          | TAB (horizontal tab)        | 41         | )           | 73         | I           | 105        | i           |
| 10         | LF (NL line feed, new line) | 42         | *           | 74         | J           | 106        | j           |
| 11         | VT (vertical tab)           | 43         | +           | 75         | K           | 107        | k           |
| 12         | FF (NP form feed, new page) | 44         | ,           | 76         | L           | 108        | l           |
| 13         | CR (carriage return)        | 45         | -           | 77         | M           | 109        | m           |
| 14         | SO (shift out)              | 46         | .           | 78         | N           | 110        | n           |
| 15         | SI (shift in)               | 47         | /           | 79         | O           | 111        | o           |

(Contd.)

|    |                            |    |   |    |   |     |     |
|----|----------------------------|----|---|----|---|-----|-----|
| 16 | DLE (data link escape)     | 48 | 0 | 80 | P | 112 | p   |
| 17 | DC1 (device control 1)     | 49 | 1 | 81 | Q | 113 | q   |
| 18 | DC2 (device control 2)     | 50 | 2 | 82 | R | 114 | r   |
| 19 | DC3 (device control 3)     | 51 | 3 | 83 | S | 115 | s   |
| 20 | DC4 (device control 4)     | 52 | 4 | 84 | T | 116 | t   |
| 21 | NAK (negative acknowledge) | 53 | 5 | 85 | U | 117 | u   |
| 22 | SYN (synchronous idle)     | 54 | 6 | 86 | V | 118 | v   |
| 23 | ETB (end of trans. block)  | 55 | 7 | 87 | W | 119 | w   |
| 24 | CAN (cancel)               | 56 | 8 | 88 | X | 120 | x   |
| 25 | EM (end of medium)         | 57 | 9 | 89 | Y | 121 | y   |
| 26 | SUB (substitute)           | 58 | : | 90 | Z | 122 | z   |
| 27 | ESC (escape)               | 59 | ; | 91 | [ | 123 | {   |
| 28 | FS (file separator)        | 60 | < | 92 | \ | 124 |     |
| 29 | GS (group separator)       | 61 | = | 93 | ] | 125 | }   |
| 30 | RS (record separator)      | 62 | > | 94 | ^ | 126 | ~   |
| 31 | US (unit separator)        | 63 | ? | 95 | _ | 127 | DEL |

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