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Key to Conventions Used in this Resource

1) Program code that can be interpreted is displayed using the Courier New font, in italics.

   Example:

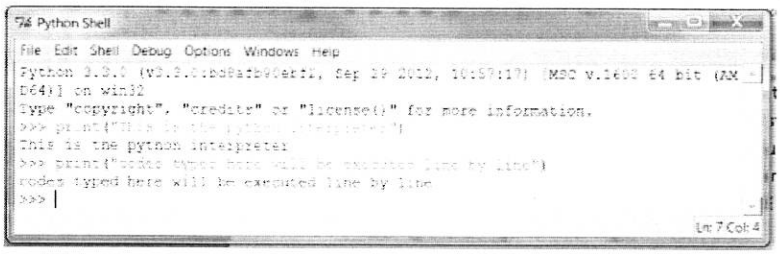
   print("This code can be interpreted")

2) Place holders (normally used for variables) are denoted by the use of angle brackets.

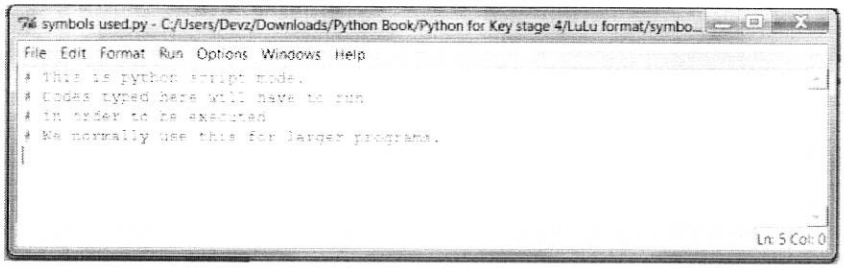
   Example:

   len(<string_name>)

3) This is the Python interpreter. Codes typed here will be interpreted.



4) This is the script mode. Codes written in this mode will have to run in order to be executed. We normally use this for larger programs. Notice that there are no chevrons in the left-hand margin.



Version of Python

The version of Python that is used throughout this resource is version 3.3.0.

Specification Mapping

AQA GCSE Computer Science (4512)

Subject Content	Learning Outcomes	Ref.
3.1.1 Constants, Variables and Data Types	Be able to describe the difference between constants and variables	2.1, 2.2
	Understand when to use constants and variables in problem-solving scenarios	2.1, 2.2
	Understand the different data types available to them	3.0
	Be able to explain the purpose of data types within code	3.0
	Understand and be able to program with one- or two-dimensional array	6.2–6.7
3.1.2 Structures	Be able to explain what a data structure is	8.1
	Be able to create their own data types	8.2–8.4
	Understand and be able to explain why data structures can make coding a solution simpler	8.2
3.1.3 Program Flow Control	Understand the need for structure when designing a coded solution to a problem	5.1, 4.4
	Understand and be able to describe the basic building blocks of coded solutions (i.e. sequencing, selection and iteration)	5.1, 5.2, 5.3
3.1.4 Procedures and Functions	Understand what procedures and functions are in programming terms	4.1
	Know when the use of a procedure or function would make sense and would simplify the coded solution	4.1.1
	Know how to write and use their own simple procedures and functions	4.1, 4.2
	Know about, and be able to describe, common built-in functions in their chosen language	Throughout
	Use common built-in functions in their chosen language when coding solutions to problems	Throughout
	Understand what a parameter is when working with procedures and functions	4.2
	Know how to use parameters when creating efficient solutions to problems	4.2 onwards
	Understand the concept of parameters and return values when working with procedures and functions	4.2
3.1.5 Scope of Variables, Constants, Functions and Procedures	Know what is meant by the scope of a variable, constant, function or procedure	4.4
3.1.6 Error Handling	Be able to discuss and identify the different types of error that can occur within code (i.e. syntax, runtime and logical)	9.2, 9.3, 9.4
	Understand that some errors can be detected and corrected during the coding stage	9.5
	Understand that some errors will occur during the execution of the code	9.3
	Know how to detect errors at execution time and how to handle these errors to prevent the program from crashing, where desirable	9.5
3.1.7 Handling External Data	Know how to use an external file to read and write data in a way that is appropriate for the programming language used and the problem being solved	7.1
	Know how to read and write from an external database in a way that is appropriate for the programming language used and the problem being solved	7.5
3.1.15 Database Concepts	Be able to explain the terms record, field, table, query	7.5
3.1.15a Query Methods (SQL)	Be able to create simple SQL statements to extract, add and edit data stored in a database	7.6
	Have experience in using these SQL statements from within their own coded solutions	7.6, 7.7

OCR GCSE Computing (J275)

Unit A451

Subject Content	Learning Outcomes	Ref.
2.1.7 Programming: *Programming Languages*	c) Explain the difference between high-level code and machine code	0.1
	d) Explain the need for translators to convert high-level code to machine code	0.1
2.1.7 Programming: *Control Flow in Imperative Languages*	g) Understand and use sequence in an algorithm	5.1
	h) Understand and use selection in an algorithm	5.1
	i) Understand and use iteration in an algorithm	5.2, 5.3
2.1.7 Programming: *Handling Data in Algorithms*	j) Define the term variable and constant as used in an imperative language	2.1
	k) Use variables and constants	2.1, 2.2
	l) Describe the data types integer, real, Boolean, character and string	3.0–3.8
	m) Select and justify appropriate data types for a given program	3.0–3.8
	n) Perform common operations on numeric and Boolean data	3.1, 3.2
	o) Use one-dimensional arrays	6.1–6.7
2.1.7 Programming: *Testing*	p) Describe syntax errors which may occur while developing a program	9.2
	q) Understand and identify syntax and logic error	9.2, 9.4

Unit A453

Subject Content	Learning Outcomes	Ref.
2.3.1 Programming Techniques	a) Identify and use variables, operators, inputs, outputs and assignments	2.1
	b) Understand and use the three basic programming constructs used to control the flow of a program: sequence; conditionals; iteration	5.1, 5.2, 5.3
	c) Understand and use suitable loops including count- and condition-controlled loops	5.2, 5.3
	d) Use different types of data including Boolean, string, integer and real appropriately in solutions to problems	3.1–3.8
	e) Understand and use basic string manipulation	3.3
	f) Understand and use basic file handling operations: open, read, write and close	7.1, 7.2, 7.3
	g) Define and use arrays, as appropriate, when solving problems	6.1–6.7

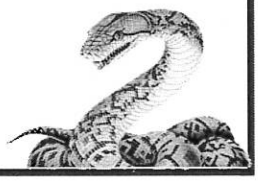
Introduction: Computer Science and Python

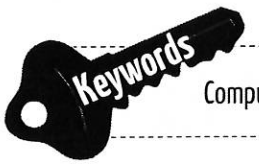
What we will learn:

- ✓ What is computer science?
- ✓ Algorithms
- ✓ High-level and low-level languages
- ✓ Compilers and interpreters

What you need to know before:

- ✓ How to use a computer
- ✓ How to use, download, and install a computer program





Computer science | Programming | Algorithm | Python | Compilers | Interpreters

0.1 Definitions

Computer science is the study of the design of algorithms, their properties and their linguistic and mechanical realisation.

An **algorithm** is a collection of unambiguous and executable operations to perform some task in a finite amount of time.

Computer scientists are therefore concerned with designing computer programs to solve problems. Although computers are fairly recent in the form we know them (the first computer was built some 60 years ago), computer science can trace its roots back far before that. Both the ideas of an algorithm and building some mechanical device to execute them date back some 1,500 years. The single most important skill that a computer scientist must possess is problem solving. The idea of a problem having multiple solutions is prevalent throughout this text. With this in mind, it is therefore vital for the computer scientist to be able to assess and compare solutions and choose an optimal solution. In addition to thinking about a solution, this text is concerned with expressing and implementing the solution in Python code.

Computer programming is an interesting way of creating instructions for a computer to interpret and it produces results for the users.

These instructions can be written using programming languages such as C, C++, Java and Python. This book will focus on programming in Python.

What is Python?

Python is an interpreted, general purpose programming language which conforms to multiple ways of programming called **programming paradigms**. Languages that support multiple programming paradigms are called hybrid languages.

Python is an interpreted language. Python can operate in two modes, namely **interactive mode** and **script mode**. We typically use the interactive mode to test and debug small amounts of code, and the script mode for running larger projects.

Downloading and Installing Python

Python is an open-source programming language and is therefore free to use. You can download Python from *http://www.python.org/download/*. In this resource we will be using version 3.3.0.

Once you have installed the correct version of Python, you can start the IDLE Python GUI. *Figure 1* shows what the interpreter should look like.

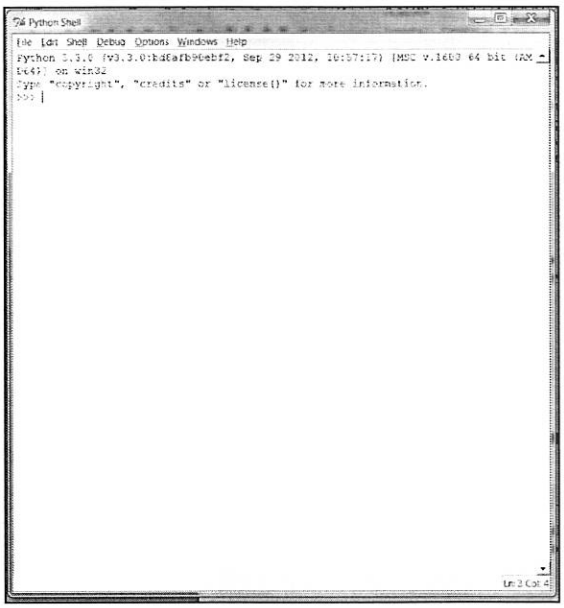


Figure 1

Low-Level vs High-level Language

Python is a **high-level** language. High-level languages are written using codes that are similar to human read language; for example, we use statements such as `print()`, `input()`, to print and take input from the user respectively. One could perhaps guess what these statements do without even seeing them in action.

There are also low-level languages, these are also known as machine language. Typically, computers only understand low-level language (machine language) and therefore all high-level language will have to be translated to machine language before they can be executed. *Table 1* below gives a full comparison of these two types of language.

Low-Level Language	High-Level Language
No conversion needed since the computer already understands machine language; as a result, code will execute faster.	Codes have to be converted to machine language and therefore take a longer time for this conversion.
Much more difficult to read and understand by other programmers as all instructions have to be written in machine code.	Easier to understand as keywords used are closely aligned with everyday language.
Very specific to the computer that the program is written for.	Programs are portable as the language is abstracted away from the underlying computer and CPU.
Only support primitive data types understood by the computer.	Support a wider range of data types, giving the functionality where the user can define their own data type.

Table 1

There are two methods of exaction available to the programmer, namely compiling and interpreting.

Compiler vs Interpreter

A programming language is interpreted if the source code goes directly to an executable format; however, with a compiled language, such as C, an intermediary file is created, called an object code, which is then executed.

The instructions that are written in Python, or any other programming language, are called program code. Compilers then create object code or byte codes of the entire program which is then executed by the computer. On the other hand, interpreters take each line, translate and execute the translated line, before turning its attention to the other line.

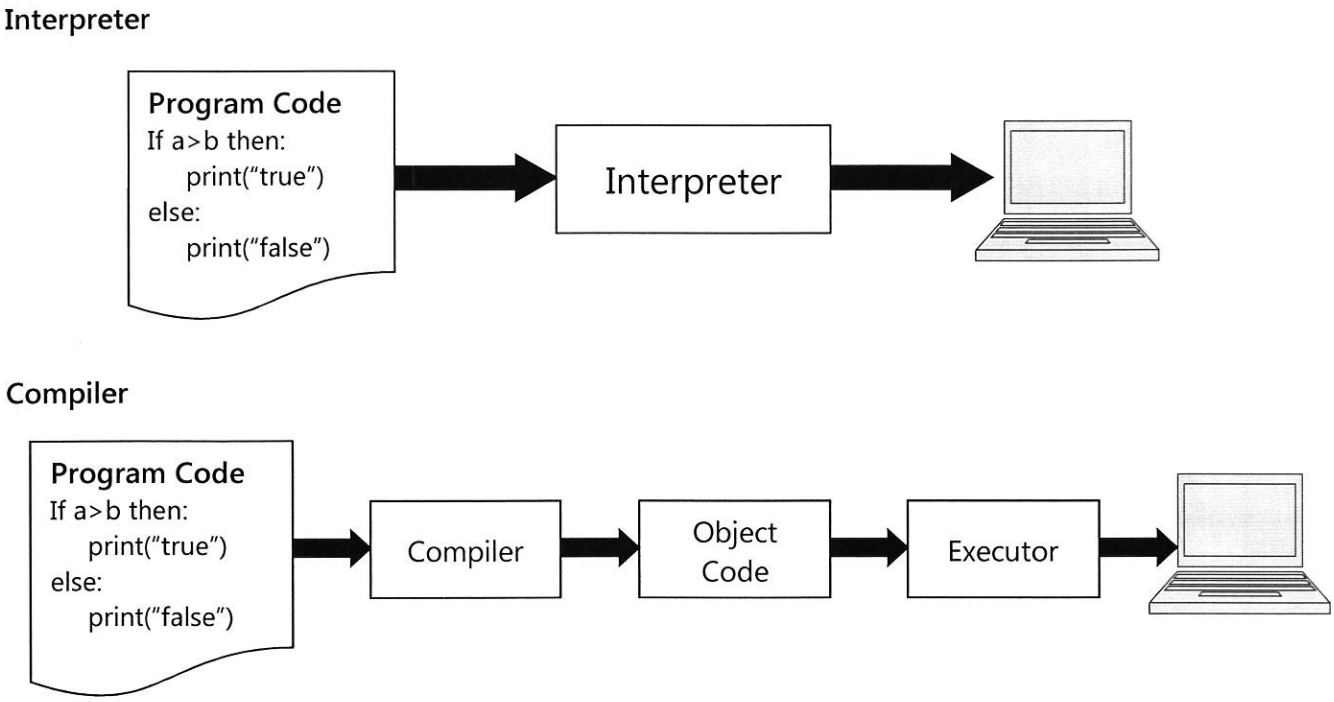


Figure 2

There are clear trade-offs with using compilers and interpreters. Compiled codes are always faster to execute, there are two reasons for this; firstly, the compiler does all the translation and execution at once. Since all the translation is done during compilation, there is no need to do this during execution and therefore the compiled code is executed faster. With the interpreters, each line is translated before execution; the interpreter interleaves, translates and then executes the codes. Secondly, seeing as the entire program is examined during compilation, the compiler has the ability to look at the entire program and find opportunities for optimisation, whether by using less processing power by finding a more efficient method for carrying out a computation or by using fewer resources. The interpreter, however, executes one line at a time and therefore uses more resources and processing time.

Interpreted programs are easier to debug. Quite often one writes a program that is syntactically correct but which produces a different output when executed. With a compiler, sometimes it is virtually impossible to stop a program in the middle of execution to examine the state of the program, whereas with an interpreter it is often easy to do this. After all, an interpreter translates and executes each line and therefore you can stop execution after each line. Fortunately, compilers are now being developed with the facility called **steppers**. Steppers are used to stop programs in the middle of execution and debug (look for errors in) them; these are becoming increasingly available with both interpreters and compilers.

Introduction Practice Exercise

1. Download and install Python. *Tick when complete* ❑

2. What is computer science?

.....

.....

3. What is the difference between a compiler and an interpreter?

.....

.....

.....

.....

4. What are the advantages and disadvantages of using a compiler?

.....

.....

.....

.....

5. What are the advantages and disadvantages of using an interpreter?

.....

.....

.....

.....

6. The central notion of computer science is that of an algorithm. Explain what an algorithm is.

.....

.....

.....

7. What are the two modes that Python can operate in?

1. .....

2. .....

cont. overleaf

8. Python is a high-level language. How does high-level language differ from low-level language?

.....

.....

9. What do programmers use steppers for?

.....

.....

.....

10. What is the difference between programming and debugging?

.....

.....

.....

.....

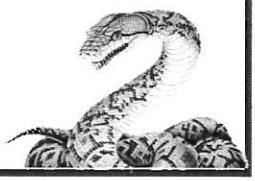
Chapter 1: Numbers and Basic Operations

What we will learn:

- ✓ How to do mathematical calculations
  - Addition
  - Subtraction
  - Multiplication and division
  - Floor quotient
- ✓ Order of operations

What you need to know before:

- ✓ Simple mathematical calculations
- ✓ Order of operations



Keywords: Quotient, Integers, Calculations, Built-in-function

1.1 Let's Write Our First Program

To find the value of any calculation in Python we use the `print()` function. Python will evaluate mathematical statements and return the value of the calculations requested. The `print()` function is a built-in function that prints to the standard output device, which is the monitor in our case. We will discuss functions in more detail in a later chapter. The `print()` function can also write to a file or other streams.

Syntax:

```
print(<value>)
```

Where `<value>` can be a literal or a variable. In this case, it will print the value stored at the memory location.

Examples:

Printing a number

```
>>> print(7)
7
>>>
```

Addition

```
>>> print(2+4)
6
>>>
```

Subtraction

```
>>> print(10-3)
7
>>>
```


Multiplication

```
>>> print(4*3)
12
>>>
```

Division

```
>>> print(12/3)
4.0
>>>
```

Exponent/Power

```
>>> print(5**2)
25
>>>
```

Floored Quotient

```
>>> print(7//2)
3
>>> print(1//2)
0
>>>
```

In mathematics, if we divide 7 by 2, we get 3.5; if we want to get the floored quotient (round the answer down to the nearest whole number) in Python, we can use the floored quotient operator. Note that 1//2 will evaluate to 0 since in mathematics 1 divided by 2 is 0.5.

1.2 Order of Operation

Python evaluates the correct order of operations; therefore, it will give the correct answer to the calculation *3*4+2*.

```
>>> print(3*4+2)
14
>>>
```

Hint: 3*4+2 and 3*(4+2) are two different calculations. Python knows and understands this and will interpret and print the correct result as seen below.

is quite different from:

```
>>> print(3*(4+2))
18
>>>
```

The code below prints the number of seconds in a week:

```
>>> print(7*24*60*60)
604800
>>>
```


Practice Exercise 1

1. Write a program in Python to print out the number of seconds in a 30-day month. ❑

2. Write a program in Python to print out the number of seconds in a year. ❑

3. Use Python as a calculator. The operations are just the same as what we are used to in mathematics. ❑

4. A high-speed train can travel at an average speed of 150 mph. How long will it take a train travelling at this speed to travel from London to Glasgow which is 414 miles away? Give your answer in minutes.

.....

5. Using the help facility on Python. Type help() to start the online facility, then "keywords" to view the keywords that are available in Python. Get help on the "if" keyword. ❑

6. Use the interpreter to execute the following:
   a. 49 / 7 ❑
   b. 8**2 ❑
   c. 20%3 ❑
   d. 17 // 3 ❑
   e. 7**3 ❑

7. Use Python to evaluate the following:
   a. If you are going on holiday to France how many Euros would you get when you convert £500 at an exchange rate of £1 = €1.20.

.....

   b. On return from your holiday, you now have €320. How many GBP would you receive at an exchange rate of £1 = €1.32. Use Python to calculate this.

.....

8. The volume of a sphere is given by $V = \frac{4}{3}\pi r^3$. Use Python to find the volume of a sphere with a radius of 10 cm.

.....

9. Insert brackets in the expression 36/9–2 to get:
   a. 2 ❑
   b. 5.12 ❑

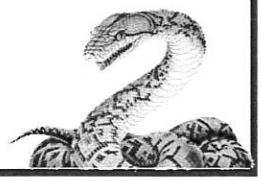
Chapter 2: Values, Variables and Expression

What we will learn:

- ✓ Definitions of values, variables and expressions
- ✓ Assigning vales to variables
- ✓ Evaluate expressions
- ✓ Store values in a statement

What you need to know before:

- ✓ Chapter 1: Evaluate mathematical calculations in Python



Keywords: Values, Expressions, Statements, Variables

2.1 Definitions

Values are any literal that can be stored in a memory location. Values can be numeric, text consisting of characters, or special symbols. We often carry out operations on values.

Examples of values are:

```
6
42
True
False
25
```

A **variable** is a named memory location. We assign values to variables. In Python, a variable must begin with a letter of the alphabet; it can also contain numbers and underscores but should not contain any spaces. We cannot use keywords for variable names, these are reserved in memory for the program to use.

Words such as: `4value, my age, &sales and while` are all invalid and will generate a syntax error if you try to use them in Python. This is because they meet the criteria of naming a variable but are reserved keywords. *Figure 3* shows a list of reserved keywords used in Python.

```
>>> help('keywords')

Here is a list of the Python keywords.  Enter any keyword to get more help.

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

>>>
```

Figure 3

We should also ensure that meaningful names are used so that one can remember what they represent. Examples of some meaningful names are:

```
age
height
name
length_of_room
item23
position23
```

Hint: Use meaningful names to refer to your variables

These are all valid variable names; programmers normally use the underscore (_) character to separate long words as in `length_of_room` above. Another technique used is to join all words together and begin each new word with a capital letter, for example `lengthOfRoom` is a legal variable.

An **expression** is a combination of operator and operations that evaluate to a value. Some examples of expressions are:

```
6
6+5
7*24
(3*23) + 20
a>b
```

An **assignment statement** is used to store the value of an expression in a variable. In Python we assign an expression to a variable. For example:

```
>>> age = 23
>>> temperature = 20
>>> number_of_students = 28
>>>
>>> minutes_in_a_year = 365*24*60
>>> marks = (3*15) + 12
>>>
```

Hint: The first line is read as: age is assigned to 23.
After making these assignment statements, we can use these variables in our program.
Example: *print(age * 2)*
*print(minutes_in_a_year * 60)*

```
>>> print(age, temperature, number_of_students)
23 20 28
>>> print(minutes_in_a_year * 60)
31536000
>>> print(marks * 2)
114
>>>
```

In the example below, we use a variable to store values of the length, width and the calculation of the area of a rectangle.

```
>>> length = 12
>>> width = 4
>>> area_of_rectangle = length *width
>>> print(area_of_rectangle)
48
>>>
```


In this example, we use variables, expressions and statements to find out the total days alive (assuming all years have 365 days).

```
>>> age = 23
>>> number_of_days_alive = age *365
>>> print(number_of_days_alive)
8395
>>>
```

2.2 Multiple Assignments

Python allows us to do multiple assignments. Each statement on the right-hand side is evaluated and the value is stored in the corresponding variable on the left-hand side.

```
>>> age, height = 23, 6
>>> print(age, height)
23 6
>>>
```

The values on the left are actually stored in a tuple (we will discuss this more when we meet lists in Chapter 4) then assigned to the variables on the right. This provides a neat solution for swapping values in Python. For example:

```
>>> age, height = 23, 6
>>> print(age, height)
23 6
>>> age, height = height, age
>>> print(age, height)
6 23
>>>
```

Notice that after the first assignment, age has the value 23 and height has the value 6, after evaluating the statement:

```
age, height = height, age
```

The values are swapped and now age has the value of 6 and height has the value of 23. This is quite significant and in most other programming languages you will have to use a temporary variable to swap the values of two variables.

Practice Exercise 2

1. Write a program that assigns the variables length and width as 18 and 7 respectively. Use the variables to calculate the perimeter and area of the rectangle. ❑

Hint: Perimeter = 2l + 2w and Area = l × w

2. Write a Python program that defines a variable called `days_in_school_each_year` and assign 192 to the variable. The program should then print out the total hours that you spend in school from Year 7 to Year 11, assuming that each day you spend 6 hours in school. ❑

3. What value will be printed on the screen?

```
marks = 25
marks = marks + 10
print(marks)
```

.....

4. Given the code below, what value will be printed to the screen?

```
time_spent = 34 # in minutes
# after one minutes
time_spent = time_spent +1
print(time_spent)
```

Hint: We use # to include comments in our code. Comments are ignored by the interpreter; they are meaningless for the interpreter but give more information to us humans. This is particularly important for maintaining the code at a later date.

.....

5. Which of the values below would be printed on the screen from the code snippet?

a. `5040`
b. `210`
c. `720`
d. `Error`

```
hours_in_a_week = hours_in_a_day * 7
hours_in_a_month = hours_in_a_week * 30 # assuming we have 30 days in
a month
print (hours_in_a_month)
```

6. What is the value of score after running the following code?

```
score = 24
number_of_pieces = 2
new_score = score *2
```

.....

7. a. True or false? An expression can be assigned to a variable.

.....

b. What is the value of y after running the code?

```
x, y = 23, 45
y, x = x, y
```

.....

cont. overleaf

8. Which of the following are not valid Python variable names?

`name`	`country1`	`item34`	`4gs`
`&item`	`_age`	`bestHeight`	`tHiSiSaVaRiAbLe`

9. How do we use the `help()` function in Python?

.....

.....

10. Which of the following statements will assign the value 365 to the variable `days_in_a_year`?

a. `365 = days_in_a_year`
b. `there are 365 days in a year`
c. `days_in_a_year = 365`
d. `Days_in_a_year = 365`

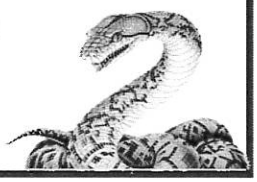
Chapter 3: Data Types

What we will learn:

- ✓ Data type definition
- ✓ Use the type function to find out the data type of an object
- ✓ String operations

What you need to know before:

- ✓ Mathematical calculations in Python
- ✓ Assigning values to variables and expressions
- ✓ Evaluate value of statements



Keywords: Float Integer String List Boolean

3.0 Data Types in Python

Data types tell the interpreter the range of values that can be stored and the kind of operations (addition, subtraction, comparison, concatenation, etc.) that are possible for a given variable. *Table 2* shows some common data types used in Python. They are also used in most other programming languages.

Data type	Values they store	Notation
Integers	Positive and negative whole numbers	int
Floating-point number	Stores any number that can be represented on the number line Decimal or fractional numbers	Float
List	Holds an array of data	[ ]
Character	Single character on the keyboard	Char
Boolean	True/false values	
String	Sequence of character	Str

Table 2

3.1 Integers

Integer is one of the three numeric types in Python (int, float and complex). Integer is a built-in data type which means there is no need to explicitly declare this, but Python knows how to deal with them naturally. We can find out the type of any object in Python by using the `type ()`, function. The type function will return the data type of any given object. We will discuss `class` in Chapter 9.

```
>>> value = 35
>>> type(value)
<class 'int'>
>>>
```

We could declare values to be integers explicitly if we want to, for example:

```
>>> x = int(34)
>>> y = int(24.9)
>>> print(x, y, x-y)
34 24 10
>>>
```


We declare the variable value to be of type integer; notice that *24.9* will be truncated to an integer, and hence *24* will be stored in the variable y. In Python, integers have unlimited precision. *Table 3* summarises the main operations that are defined for integers in Python.

Operation	Example	Explanation
Addition	x + y	Sum of x and y
Subtraction	x – y	Subtract y from x
Multiplication	x * y	Multiply x by y
Division	x / y	Divide x by y
Integer division	x // y	Divide x by y and return the integer value only
Modulo	x % y	Remainder of x / y
Negate	-x	Negative value of x
Absolute value	abs(x)	Absolute value or magnitude of x
Cast	int(x)	x converted to an integer
Power	pow(x, y)	x raised to the power of y
Power	x **y	x raised to the power of y

Table 3

3.2 Floating-Point Number

Floating-point numbers are similar to real numbers as encountered in mathematics. Visually, the main difference is that a floating-point number can have a decimal point. In Python, the floating-point number is based on the data type called `double` in programming language C. The programming language implements data type based on the underlying machine, and therefore the precision of `float` is machine dependent. We use the keyword float for floating-point number in Python.

```
>>> value = 56.34
>>> value
56.34
>>> type(value)
<class 'float'>
>>>
```

Similar to integers, there is no need to explicitly declare a variable to be of type float. Float has the same operations defined in Table 3 above.

3.3 Strings

A string is a collection of characters. Strings are essential in all programming languages, and have a lot of operations defined with them. In Python, we use single or double quotation marks to denote literal strings.

Which quote to use?

Strings begin and end with single or double quotes. You must end with the type of quote that you begin with. This makes it possible to include quotations within a text. For example:

```
>>> message = "Hello Ben I'm happy to learn about string today"
>>> print(message)
Hello Ben I'm happy to learn about string today
>>>
```


Python also allows users to use single quotation marks in a text to allow the use of quotations. For example:

```
>>> message = 'Martin Luther famous speech "I have a dream" is very inspirational'
>>> print(message)
Martin Luther famous speech "I have a dream" is very inspirational
>>>
```

Hint: Begin and end the quote with the same quotation marks.

3.3.1 Assigning Strings to a Variable

The following code assigns the string September to the variable month:

```
>>> month = "September"
>>> month
'September'
>>>
```

It is possible to use square brackets and index number to access individual characters in a string.

```
>>> month = "September"
>>> print(month)
September
>>> letter = month[1]
>>> print(letter)
e
>>>
```

Above, we assign *letter* to `month[1]`, and the letter `e` is printed. This may be surprising as *e* is the second character in the word *'September'*; it turns out that the first position in a string is position 0, therefore the word September is stored in this manner in Python.

Position →	0	1	2	3	4	5	6	7	8
Content	S	e	p	t	e	m	b	e	r

A loop can be used to go through the string month, we will discuss the "for loop" in detail in Chapter 5, when we discuss control structures.

month = "September" will make this assignment:

```
>>> month
'September'
>>> i=0
>>> for letter in month:
        print(month[i])
        i=i+1


S
e
p
t
e
m
b
e
r
>>>
```

Hint: Whenever you use negative index, Python starts from the end of the list, with the last character being -1, therefore
print *month[-3]*
will print *b.*

The emphasis here is on the values of *i*; notice that first time *i* is assigned to 0 and therefore the first print statement will execute *month[0]*.

What will *month[-5]* print?

Hint: Both *month[10]* and *month[-10]* will give an out-of-range error.
IndexError: *string index out of range*

```
>>> month = "September"
>>> month[10]
Traceback (most recent call last):
  File "<pyshell#69>", line 1, in <module>
    month[10]
IndexError: string index out of range
>>> month[-10]
Traceback (most recent call last):
  File "<pyshell#70>", line 1, in <module>
    month[-10]
IndexError: string index out of range
>>>
```

The index error is a common programming error and should be avoided.

3.4 Other String Operations

3.4.1 Subsequence

In Python we can select a subsequence of a string by using a colon in square brackets to denote the start and end position that is required. Python will print the first position and stop just before the end position. If we leave the start position out, then Python will start from the beginning of the string to the end position; in a similar manner if we leave the end position out then Python selects up to the last character in the string.

Syntax: *<string>[<start position>:<end position>]*

Example

```
>>> month = "September"
>>> month[3:6]
'tem'
>>> month[:6]
'Septem'
>>> month[6:]
'ber'
>>>
```

3.4.2 Finding Strings within Strings

The ***find()*** method returns an integer that represents the starting position of where a sub-string occurs in a string. If the sub-string is not contained in the string then -1 is returned.

Syntax: *<string>.find(<substring>)*

Example:

```
>>> hoyle='It is the true nature of mankind to learn from his mistakes'
>>> hoyle.find('nature of mankind')
15
>>> hoyle.find('for every actions')
-1
>>>
```

3.4.3 Finding the Length of a String

The *len()* function returns the number of characters in a string; this includes spaces and special characters. *len()* is a function that can be used on any collection of objects, such as lists that we will discuss in Chapter 6.

Syntax: *len(<string>)*

Example:

```
>>> month='September'
>>> len(month)
9
>>>
```


3.5 Upper-Case Character

The *upper()* method returns a copy of the string with all letters in upper case.

Syntax: *<string>.upper()*

Example:

```
>>> month='September'
>>> month.upper()
'SEPTEMBER'
>>>
```

3.5.1 Lower-Case Character

The *lower()* method returns a copy of the string with all letters in lower case.

Syntax: *<string>.lower()*

Example:

```
>>> month='September'
>>> month.lower()
'september'
>>>
```

3.5.2 Concatenate String (+)

Concatenation refers to joining two or more strings together. We use the "*+ operator*" to do this in Python. Concatenation cannot be used for string and numeric data types together.

Syntax: *<string> + <string>*

Example:

```
>>> greeting = 'hello '
>>> name = 'Benjamin'
>>> greeting + name
'hello Benjamin'
>>>
```

```
>>> 'hello' + 15

Traceback (most recent call last):
  File "<pyshell#14>", line 1, in <module>
    'hello' + 15
TypeError: cannot concatenate 'str' and 'int' objects
>>>
```

The error above is a *type error*; this happens whenever you try to apply an operation that is not defined over the data type, in this case whenever you try to concatenate string and integers.

Hint: You cannot add a numeric value to a string.

Multiplication is defined for strings and integers.

```
>>> 'hello ' *3
'hello hello hello '
>>>
```

3.6 Testing for Membership Using the In Operator

The in operator is used to test for membership within a given sequence. The in operator is not specific to a string but can be used with any collection of objects. The in operator will return TRUE if the element is found, and FALSE otherwise.

The following code tests to see if *p* appears in the word "September".

```
>>> month = "September"
>>> 'p' in month
True
>>> 'v' in month
False
>>>
```

From the code snippet above, seeing as `p` appears in `September`, `True` is returned and `False` is returned when we test if `v` appears in the word.

3.7 Converting Data Type

int()

To convert from one data type to another, the built-in functions are used. To convert to an integer, we use the `int()` function.

Syntax: `int(<value>)`

Where <value> is the value to be converted to an integer; Python will convert this value if it can, otherwise it will give an error message.

Example:

```
>>> value= '45'
>>> type(value)
<class 'str'>
>>> type( int(value))
<class 'int'>
>>>
```

Note that we assign a value to the string '45', this is confirmed by using the `type()` function to check. On the fourth line we check the type of `int(value)`. This statement `int(value)`, converted the string to an integer and hence `int` will print as the type. It is not possible to convert all values to strings as we can see from the example overleaf.


```
>>> type( int('Hello'))
Traceback (most recent call last):
  File "<pyshell#134>", line 1, in <module>
    type( int('Hello'))
ValueError: invalid literal for int() with base 10: 'Hello'
>>>
```

We can convert floating-point numbers to integers.

```
>>> value = 45.9483738
>>> type(value)
<class 'float'>
>>> type( int(value))
<class 'int'>
>>> int(value)
45
>>>
```

Note that *int()* will convert floating-point numbers, but in the conversion Python truncates, in that the number is not rounded up or down, the whole number is simply taken and the rest of the number is ignored.

float()

float() will convert a given value to a floating-point number.

Syntax: *float(<value>)*

Where <value> is the value to be converted to a floating-point number, Python will convert this value if it can, otherwise it will give an error message.

Example:

```
>>> float(32)
32.0
>>>
```

str()

str() will convert a given value to a string.

Syntax: *str(<value>)* where <value> is the value to be converted to a string.

Example:

```
>>> str(45)
'45'
>>>
```

Note that '45' is now a string.

3.8 Taking Input from the User

input()

We use the input() function to prompt the user for data. We can then assign this data to a variable. The default expected value is a string, and therefore the converters discussed in Section 3.3 above would have to be used to change the data to the required type, if this is possible.

Syntax: *input("<prompt>")*

Where <prompt> is the message to be printed on the screen, Python will take input from the standard input (keyboard).

Example:

```
>>> name = input("What is your name? ")
What is your name? Benjamin
>>> print("Hello " + name)
Hello Benjamin
>>>
```

In the following example, the program asks the user to enter two numbers then print the sum to the screen. Note that this will require type conversion.

```
>>> number1 = int( input("Please enter the first number: "))
Please enter the first number: 45
>>> number2 = int( input("Please enter the second number: "))
Please enter the second number: 12
>>> print("The sum is ", number1+number2)
The sum is  57
>>>
```


Practice Exercise 3

1. Write a Python program that stores your favourite quotation in a variable called "quote". ❑

2. Define a variable called "name" that assigns your name to it. ❑

3. Write a Python program that asks the user for three numbers and print their sum. ❑

4. Write a Python program that asks the user for their name and age and print this back to the screen with a warm message. ❑

5. What is the data type of x in the code snippet below?

```
>>> x = 34.67
>>>
```

.....

6. What letter will be printed on the screen after running the following code?

```
>>> title = "Python for key stage 4"
>>> letter = title[3]
>>> print(letter)
```

.....

7. What letter will be printed on the screen after running this code?

```
>>> title = "Python for key stage 4"
>>> letter = title[-5]
>>> print(letter)
```

.....

8. Use the slice operation / subsequence to print "key" from the variable title. ❑

   a. Title = "Python for key stage 4"

9. Use the variable below and the concatenation operation to print the greetings below. ❑

   b. Name = "Benjamin"

   Greetings to print: `"Hello Benjamin, Python is fun"`

10. What will the following code print?

```
title= "Python for key stage 4"
for letter in title:
  print(letter)
```

.....

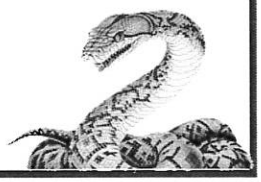
Chapter 4: Functions

What we will learn:

- ✓ Definition of a function
- ✓ Syntax of functions
- ✓ Return values from a function

What you need to know before:

- ✓ Variables
- ✓ Expressions
- ✓ Statements
- ✓ Values



Keywords: Function, Return

4.1 Definition

Functions are blocks of codes that perform specific tasks. It allows us to reuse it and carry out a set of computations more than once. Functions take an input and can return an output. They can also take in multiple inputs or no input, have multiple outputs or no outputs at all. Python provides a lot of useful functions for us, such as `print()`, `type()`, `abs()`, these functions are called built-in because they are supplied as part of the language. We can declare and define our own function to do what we want them to do. Functions that are defined by a user are called user-defined functions. This chapter will focus on user-defined functions.

4.1.1 Why Do We Use Functions?

- Using functions makes our program code more readable. When we define a function, we are actually naming certain sets of instruction that are performing a specific task and therefore making our program code easier to read.
- Functions can reduce our program code significantly by putting repetitive code into a function.
- Change or adjustments can be made in one place.
- Functions facilitate modular design. We can break down a large problem into manageable chunks, work on these chunks in functions then put the entire working piece together for a working solution.
- Functions can be placed into modules so that they can be reused.

4.1.2 Function Syntax

Syntax:

```
def <name>(<ParameterList>):
    <block>
    return <expression>, <expression>
```

Where `<name>` follows the same conventions as a variable.

`<ParameterList>` represents the inputs to the function separated by comma. The return statement is used to specify the output. By default, all functions return a value. If one is not specified using the return keyword then `None` is automatically returned.

```
return <expression>, <expression>, ...
```

Hint: Functions must begin with a letter of the alphabet and cannot contain a space.

Example:

```
>>> def sum(a, b):
        return a+b

>>> sum(12, 10)
22
>>>
```

Whenever we express what the function should do we call this **defining a function**. The function in the example is defining the function sum. The `a` and `b` are referred to as **parameters** and are only valid variables within the definition of the function; the range of the area that the variable is valid is called the **scope of the variable**. Note that `a` and `b` are place holders and are only valid within the definition.

Whenever we use a function, this is referred to as **calling a function**. In the example above, `sum(12, 10)` is a call to the function with arguments 12 and 10.

4.1.3 Returning Values

We can define functions that just do something without explicitly returning a value; for example, the following function will take a name and say hello twice.

```
>>> def hello_twice(name):
        print("Hello "+name)
        print("Hello "+name)


>>> print(hello_twice("Ahmed"))
Hello Ahmed
Hello Ahmed
None
>>>
```

Notice that after calling the function, `None` is printed as the returned value. It turns out that because we did not use the return keyword in the function definition `None` is returned automatically.

4.2 Parameters and Arguments

Some books will use parameters and arguments interchangeably; however, there is a difference. It turns out that parameters are the place holders that are used in defining the function, whereas the arguments are the actual values that are supplied during the function call. Parameters are specific to function definition; in fact the parameters are data types (defines acceptable range and operations) whereas an argument is an instance of the parameter and is used in the function call. Notice that the argument can change with each function call, and is normally executed at runtime.

Python also uses a technique called operator overloading, where operators such as the + can be defined to perform different operations based on the operands that surround it. Since + is defined for strings also (namely concatenation), the following will result in sum concatenating the strings that it receives.

Hint: In *sum(a,b)*, *a* and *b are the* parameters while *sum(4,5)*, 4 and 5 are the arguments.


```
>>> sum('Hello', ' Bobby')
'Hello Bobby'
```

This is a very powerful concept in object-oriented programming and Python, being an object-oriented language, utilises these features.

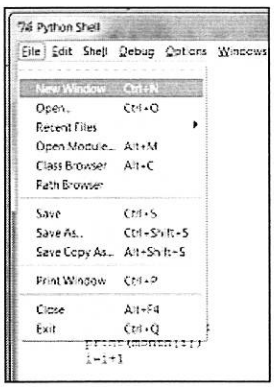
4.3 Saving Your Program Code

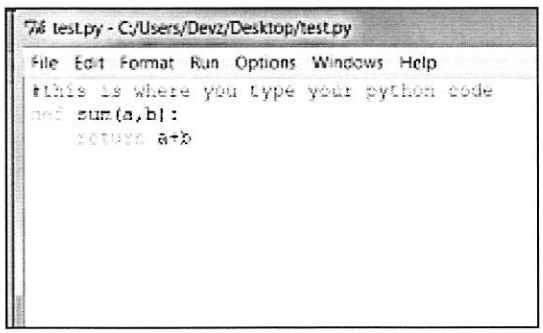
Python can operate in two modes, namely the interactive mode and the script mode. You know that you are in script mode if you have the three chevrons (>>>) and the blinking cursor. In this mode, you type and at the end of the statement Python interprets and produces a result. All of the examples so far have been in interactive mode. You can create a Python file, type all your program code here and then interpret this file. This allows us to make changes and rerun the script. The instructions below will demonstrate how to create a script file.

From the Python interpreter, you can *select file → new window* to start a new window that you can type your program code into.

Save this file with a suitable file name and *.py* as the file extension; this will tell the interpreter that this file is a Python file. Once you finish typing your program code, you can execute your program by selecting *run → run module*. Your output will be displayed in the Python interpreter.

Example: Creating a new script file.





After typing your script you can run it and make changes.

Hint: If we need to add other numbers we simply call the sum function. Python is very dynamic and can reuse the function with strings. For example, calling the sum function with two strings will return both strings concatenated as + is defined for strings.

4.4 Program Flow

A program is executed from top to bottom and line by line unless the flow is diverted by some control structure (we will examine control structures in Chapter 6). It turns out that functions do not affect the program flow. When a function is called, the execution jumps to the definition of the program and replaces the argument(s) with the parameter(s) (recall that the parameters are place holders whereas arguments are the actual values that are sent to the program). The body of the program is executed then execution continues after the line that calls the function.

This process seems pretty straightforward, but when you imagine that a function can call another function who in turn can call other functions, keeping track of where you are can be quite complex. Further, in Python you can send a function as an argument to another function. It turns out that Python has a very efficient method of handling this situation. Here are two simple examples that should demonstrate this point, but you can imagine that these could be more complex calculations.

Imagine that we have a function called "larger" that returns the larger of two given numbers, then:

```
>>> x = 12
>>> y = 7
>>> z = 79
>>> print(larger(larger(x,y),z))
79
>>>
```

This will print the largest of the three numbers. In the example above, you can see that the inner `larger(x,y)` was an argument to the outer larger function. The outer larger function would execute an instance of the larger function returning the value 12, as 12 is larger than 7; then the outer larger would evaluate `larger(12,79)` and finally return 79 to the print function.

Practice Exercise 4

1. Define a function called "`double`", that takes a number and returns the number doubled.

.....

2. Define a function called "`perimeter_of_rectangle`" that takes two numbers to represent the length and width of a rectangle and returns the perimeter of the rectangle. (Remember that the perimeter is twice the length added to twice the width).

.....

3. Define a function called "`area_of_circle`" that takes one number as input to represent the radius and returns the area of the circle. (Remember that the area of a circle is $22/7 * r^2$.)

.....

4. Define a function called "`hello_three_times`" that takes an argument called "`name`" and prints "`hello name`" three times on the screen.

.....

5. Write a program that requests the user's name. The program should then use a function called "`head_name()`", that prints the first character from the given name. ❑

6. Write a program that asks the user for their name. The program should then use a function called "`tail_name()`", that returns the tail of the person's name where the tail of the name is the person's name without the first character.
HINT len(<string>) will return the length of a string. ❑

7. Give three advantages of using functions in a program.

1. .....

.....

2. .....

.....

3. .....

.....

8. What is the difference between parameters and arguments?

.....

.....

.....

.....

.....

cont. overleaf

9. Define a function called "`power_value()`", that takes two integers and returns the first raised to the power of the second.

.....

10. If we had a function called "`absolute_value()`", that takes a number and returns the positive value of the given number. What value will be returned for the following print statements?

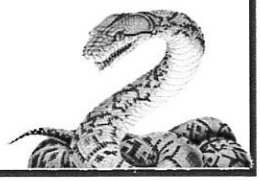
```
print(absolute_value(-5))
print(absolute_value(0))
print(-absolute_value(-5))
```

.....

Chapter 5: Control Structures

What we will learn:
- ✓ Selection structures
- ✓ Loops

What you need to know before:
- ✓ Data types
- ✓ Functions



Keywords: For loop, While loop, If selection, If else structures

Control structures are used to affect the natural program flow. In this section we will discuss a number of control structures that are available in Python.

5.1 Selection or Conditional Statements

The first type of control structure that we will evaluate is statements. Selection statements execute a particular block of code based on the result from some test/condition.
The two selection statements that we will be exploring are IF and IF ELSE statements.

5.1.1 IF Statement

When using the IF statement, we test to see if one condition is true or false. This is called a conditional test. The IF statement executes a block of statement based on the result from a conditional test. The IF statement will only execute if the condition is true. Below is the syntax for an IF statement:

Syntax:

```
if <condition>:
    <block>
```

Hint: The block is only executed whenever the condition is true.

Example:

```
>>> if 5>2:
        print("5 is larger")


5 is larger
>>>
```

Hint: The statement '5 is larger' is printed to the screen, since 5 is indeed greater than 2.

5.1.2 IF ELSE Statement

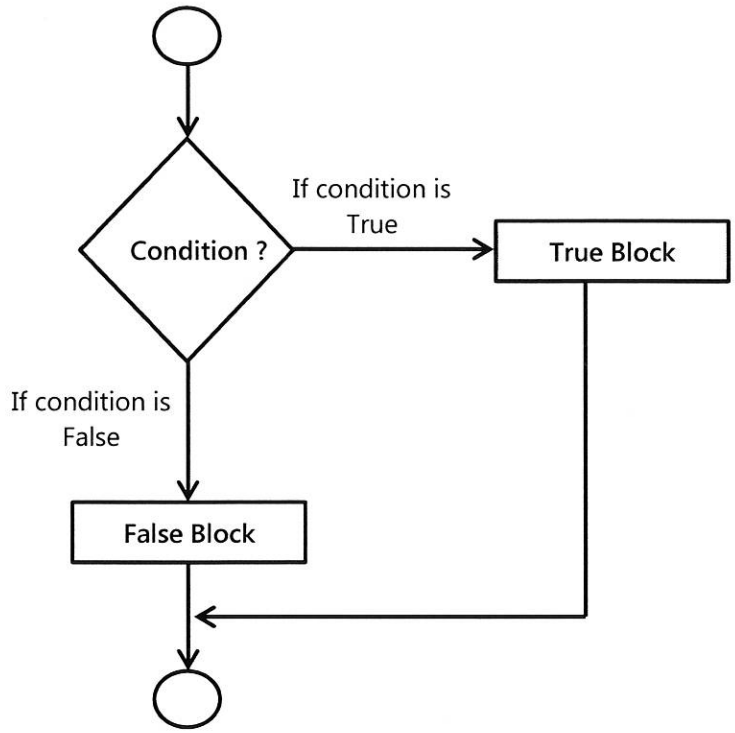
The IF ELSE statement is an extension of the IF statement; it will execute a block when a condition is true and an alternative block if the condition is false.

Syntax:

```
if <condition>:
    <TrueBlock>
else:
    <FalseBlock>
```

<TrueBlock> is executed if the condition is true and *<FalseBlock>* is executed when the condition is false.

The IF ELSE Statement



Example:

```
>>> month = 'September'
>>> if len(month)>10:
        print(month + ' has more than ten characters ')
else:
        print (month + ' has less than ten characters ')


September has less than ten characters
>>>
```

Note: *len(month)* will evaluate to 9, and therefore the condition will be false, hence printing the else clause.

5.2 Loops

Loops allow us to execute a block of code a number of times. Each time the set of instructions is executed it is called **iteration.** Python offers two looping statements, namely the for loop and the while loop.

5.2.1 For Loop

The for loop iterates over the items in a sequence, which can be a string or a list (we will discuss lists in Chapter 6) each time assigning the values in this sequence to a given variable. Note that the terminating condition is that we are at the end of the list.

Syntax:

```
for <variable> in <sequence>:
    <block>
```

<variable> is a variable that is assigned to each value in the sequence.
<sequence> is a string or a list.
<block> is executed each time through the loop.

Example:

```
>>> month = 'September'
>>> for letter in month:
        print(letter)


S
e
p
t
e
m
b
e
r
>>>
```

Example:
If we want to print the month of September, we would assign a variable to iterate the loop and print the values in the list.

The first time it iterates through the loop `S` is assigned to the variable `letter`, and hence the `print()` function will print `S`.

The second time through the loop `e` is assigned to the variable `letter` and will print `e`.

The third time through the loop `p` is assigned to the variable `letter` and will print `p`.

The fourth time through the loop `t` is assigned to the variable `letter` and will print `t`.

This continues to the end of the loop. This is determined by the length of the word.

Notice that we go through the body of the for loop (`print letter`) nine times and each time we print the letters in the assigned string.

5.2.2 The Range Function

The built-in range function is very useful with the for loop and is used to iterate over a sequence of numbers.

Syntax:

```
range(<start>, <stop>,<step>)
```

<start> is optional and if it is not present will default to start at zero (0).
<stop> is not optional and is never included in the generated sequence.
<step> can be used to change the default increment from one (1) to another number.

Example:

```
>>> print(range(10))
range(0, 10)
>>>
>>> #Now we use range() in a for loop
>>> for i in range(10):
        print(i)


0
1
2
3
4
5
6
7
8
9
>>>
```

Notice that *print(range(10))* will generate a virtual tuple from 0–10, and the for loop will iterate through this list 10 times.

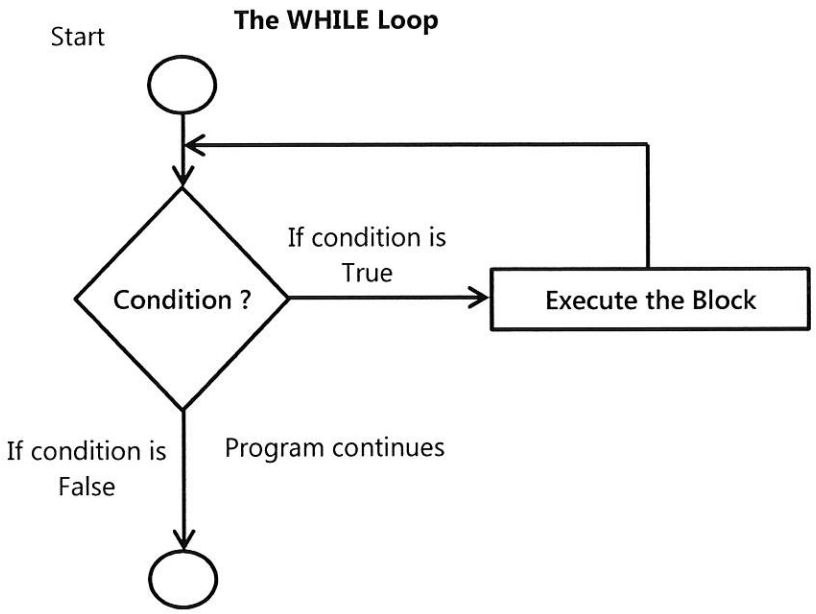
5.2.3 While Loop

While loops are used in situations in which the number of iterations is unknown. It will execute a block as long as a given condition is true.

Syntax:

```
while <condition>:
    <block>
```

While loops evaluate whether an expression or condition is true or false. The block is evaluated until the condition becomes false.



Example:

```
>>> number = 1
>>> while number < 11:
        print(number * number) #Square the number
        number = number + 1


1
4
9
16
25
36
49
64
81
100
>>>
```

Important: There must be statements within the while loop that will allow the condition to become false, or else we could be in a situation where a loop executes forever.

Here we use the while loop to print the square numbers from 1 to 100. Notice that the statement `number = number + 1` will ensure that the condition will become false at some stage.

The `#square the number` is a comment. Comments are ignored by the interpreter; we use them to give more explanation to someone reading our program code.

5.2.4 Break

A break allow us to exit the while loop even when the condition is true. A break should be used with caution and only if there is no alternative.

Typical Use:

```
while <condition>:
      <code>
      If <BreakTest>:
            Break
      <code>
<code after while loop>
```

Here, during the while loop if the break test is met then execution will jump out of the while loop and code after the while loop will be executed.

Example:

```
z=[2,5,7,1,90]

def find_seven(p):
    i=0
    while i!=len(p):
        if p[i]==7:
            print("Breaking out of Loop")
            print("Found at position ", i)
            break
        i=i+1
    print("After the while")

find_seven(z)
```

When we run the code above calling `find_seven(z)`, the following output will be produced.

```
>>> ================================ RESTART ================================
>>>
Breaking out of Loop
Found at position  2
After the while
>>>
```

Notice that seven is at position two in the list and once we find seven we exit the while loop, even though the while condition (`i!=len(p)`) was still true as *i* is two and `len(p)` is five.

Practice Exercise 5

1. Write a Python program that asks the user to enter two numbers; it will use the IF/ELSE statement to print the larger of the two. ❑

2. Write a Python program that asks the user to enter a score; it should print the following message, based on the score of the user: ❑
   a. 50 and above – → "Pass"
   b. 0–49 → "Fail"

3. Develop the program below by using a nested IF statement (IF within IF) to give the following additional information: ❑

50 and above	→ "Pass"
80+	→"Well Done"

   0 – 49 → "Fail"
   <20 → "You need to try harder."

4. Write a Python program that asks the user for a score and prints a grade based on the following: ❑

80–100	A
60–79	B
40–59	C
30–39	D
< 30	U

5. Suppose we calculate the vowel value of a word based on the following rubric:
   a 5 points
   e 4 points
   i 3 points
   o 2 points
   u 1 points

   Write a Python program that asks the user for a word, then calculates and prints the vowel value of the word entered. ❑

6. Define a function called "`larger()`" that takes two integers and returns the larger of the two.

   .....

7. Define a function called "`long_name()`" that takes a name input and returns a Boolean value (true or false) based on the number of characters in the name. Assume a name is long if it contains more than 14 characters.

   .....

cont. overleaf

8. Define a function called "`largest()`" that takes three numbers and returns the largest of the three. HINT: You can write the function from scratch or use the "`larger()`" function that was written before.

.....

9. Write a function called "`print_upto()`" that takes a number as input and prints all the whole numbers from 1, up to and including, the given number. ❑

10. Write a function called "`print_even_upto()`" that takes a number as input and print all the **even** numbers from 1, up to and including, the given number. ❑

11. Write a function called "`magic_number()`" that has a variable assigned to the value 7; the user should be prompted to guess the magic number. The program should give the user feedback on the guess. ❑
    i. If the guess is greater than 7, "Too high"
    ii. If the guess is less than 7, "Too low"
    iii. If the guess is correct, "Well Done"

12. Modify the program above to give the user only 5 guesses. If there are more than 5 guesses then the user should get the following message: "You have gotten your maximum chances". ❑

13. The factorial of a number is the product of all the integers below it. For example, the factorial of 4 is 4*3*2*1 = 24. ❑
    a. Write a function called "`factorial()`" that returns the factorial of the given number, for example `factorial(4)` → `24`

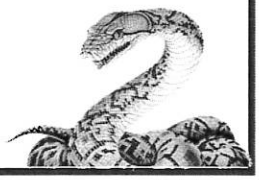
Chapter 6: List

What we will learn:

- ✓ List definition
- ✓ Syntax for creating lists
- ✓ Selecting elements of a list
- ✓ Selecting subsequence of a list

What you need to know before:

- ✓ Data types
- ✓ Assignments



Keywords: List, Sub-list, Elements, Index, Position

6.1 Definition

The list is the most versatile data structure Python uses. It is a mutable collection of data items which can be of the same or different data types. When a data collection is mutable, it means we can change individual items in the collection. The items are written between square brackets and are separated by commas; they can be assigned to a variable.

Syntax:

```
<variable> = [<list_item>, <list_item>, ...]
```

Where *<list_item>* can be empty, or any data type.

Example:

```
>>> days = ["Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday"]
>>> days
['Sunday', 'Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday']
>>>
```

6.1.1 Selecting Individual Elements

As a list is a compound data type, we can select individual elements by indexing these.

```
>>> days[0]
'Sunday'
>>>
```

Using Negative Index

A negative index will return the value at its position from the end of the list.

```
>>> days[-2]
'Friday'
>>>
```


6.2 List Operations

Concatenation

We can concatenate a list by using the concatenation operation (+).

```
>>> x = [1, 2, 3]
>>> y = [6, 7, 8]
>>> z = x+y   #Concatenation Operation
>>> print(z)
[1, 2, 3, 6, 7, 8]
>>>
```

Notice that z now stores the items of x and y.

Multiplication

The multiplication operation has a similar effect on lists as on strings.

```
>>> x = [1, 2, 3]
>>> print(x*3)
[1, 2, 3, 1, 2, 3, 1, 2, 3]
>>>
>>> print(x*4)
[1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3]
>>>
```

Notice that multiplying by three produces the list three times.

Selecting a Subsequence in the List – Slicing

We can select a subsequence in a list by using the slice operation. The slice operation (:) is used to specify the starting and end points to return a section of a list.

```
>>> days
['Sunday', 'Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday']
>>> days[2:5]
['Tuesday', 'Wednesday', 'Thursday']
>>> days[:4]
['Sunday', 'Monday', 'Tuesday', 'Wednesday']
>>> days[5:]
['Friday', 'Saturday']
>>>
```

Sub-selection is also called slicing the list. It is important to note that sub-selection will return a virtual copy of the list and does not mutate the original list; from the example above, days is unaffected, hence printing the value of days will give the entire list.

```
>>> days
['Sunday', 'Monday', 'Tuesday', 'Wednesday', 'Thursday', 'Friday', 'Saturday']
>>>
```

Important: The first number in the slice operation *[<start>:<end>]* is the starting point and the last number is the ending point. If these are left blank then Python assumes that the start position is the beginning of the list and the end position is the end of the list.

6.3 Editing a List

Because lists are mutable, unlike strings, it is possible to change the values in a list.

```
>>> a=[1,3,5]
>>> a
[1, 3, 5]
>>> a[1] = 25 # Change the value at position 1
>>> a #This is the updated a
[1, 25, 5]
>>>
```

Note that we can assign a new edit list by referring to its position and assigning a new value.

6.4 Lists of Lists

Python allows us to have lists of lists:

```
>>> olympic_host = [["London",2012], ["Beijing",2008], ["Athens",2004]]
>>> olympic_host
[['London', 2012], ['Beijing', 2008], ['Athens', 2004]]
>>> olympic_host[1] #print the first element in the list
['Beijing', 2008]
>>> olympic_host[1][0] #element in pos 0 in the list at pos 1
'Beijing'
>>>
```

We can make a few observations from the script above.

- It is possible to have different data types in the same list; above we used string and an integer to represent a year.
- We can have lists of lists *Olympic_host* is a list containing three elements where each element is itself a list containing the Olympic host city and year.
- We can access the individual element in each list by sub-indexing the position, in the example above *Olympic_host[1][0]*.

6.5 List Methods

There are various methods defined on lists, below we will examine some of these methods.

append()

Append will add an element to the end of the list. Append mutates (changes) the list instead of creating a new list, the result of invoking append on a list is that the calling list will have the new element added to the end.

Syntax:

<list>.append(<element>)

<list> is the list to be appended.
<element> is the element to be appended to the list.

Example:

```
>>> x=[3,6,2,15,20]
>>> print(x)
[3, 6, 2, 15, 20]
>>> x.append(45)
>>> print(x)
[3, 6, 2, 15, 20, 45]
>>>
```

Notice that after a call to append with argument 45, the list x now has 45 appended to the end.

insert()

Insert is used to insert an element at a given index. Insert mutates the existing list with the new element inserted.

Syntax:

<list>.insert(<position>, <element>)

<list> is the list that the element should be inserted into.
<position> is the position in the list that the element will be inserted, recall that the first position is position zero (0).
<element> is the element to be inserted into the list.

Example:

```
>>> print(x)
[3, 6, 2, 15, 20, 45]
>>> x.insert(3,35)
>>> print(x)
[3, 6, 2, 35, 15, 20, 45]
>>>
```

Notice that after the insert function is invoked on the list x, 35 is now inserted in position 3.

sort()

The sort function will sort the list.

Syntax:

<list>.sort()

<list> is the list to be sorted.

Example:

```
>>> y=[35, 30, 23, 38, 10, 15, 2]
>>> print(y)
[35, 30, 23, 38, 10, 15, 2]
>>> y.sort()
>>> print(y)
[2, 10, 15, 23, 30, 35, 38]
>>>
```


count()

Count will return the number of occurrences of an element in a list.

Syntax:

```
<list>.count(<element>)
```

<list> is the list that the count is invoked on.
<element> is the element that you search for the occurrence of.

Example:

```
>>> y
[2, 10, 15, 23, 30, 35, 38, 2]
>>> y
[2, 10, 15, 23, 30, 35, 38, 2]
>>> y.count(2)
2
>>> y.count(15)
1
>>> y.count(45)
0
```

Notice that there are two occurrences of 2 and only one of occurrence of 15; there are no occurrences of 45 in the list and hence `y.count(45)` will return 0.

extend()

Extend mutates a list and has the effect of adding a second list to the first list. Note that the second list will still exist in its original state.

Syntax:

```
<list1>.extend(<list2>)
```

<list1> is the list to be mutated.
<list2> is the list that will be added to list 1.

Example:

```
>>> x=[1,2,3,4]
>>> y=[5,6,7]
>>> x
[1, 2, 3, 4]
>>> y
[5, 6, 7]
>>> x.extend(y)
>>> x
[1, 2, 3, 4, 5, 6, 7]
>>> y
[5, 6, 7]
```

After `x.extend(y)` is called, x now contains the elements of both x and y; however, y is unchanged and still exists.

pop()

The pop method will remove and return an element from the list. By default *pop()* invoked in a list will remove and return the last element in a list. You can optionally send the index of an element to be removed from the list and *pop()* will return that element.

Syntax:

```
<list>.pop()
      OR
<list>.pop([<index>])
```

<list> is the list with the elements.
<index> is the optional position of the element to be removed from the list.

Example:

```
>>> x
[8, 5, 12, 9, 20]
>>> x.pop()  #Now we invoke pop() on list x
20
>>> x # print the list x
[8, 5, 12, 9]
>>>
```

In the second example we will remove element one. Recall that element one is the second element in the list.

```
>>> x
[8, 5, 12, 9]
>>> x.pop(1) # remove element 1
5
>>> x  # print the list
[8, 12, 9]
>>>
```

remove()

Remove will delete the first occurrence of the given value in a list. If the element does not occur in the list then a value error is returned.

Syntax:

```
<list>.remove(<element>)
```

<list> is the list with the elements.
<element> is the element to be removed from the list.

Example:

```
>>> x=[8,5,12,9]
>>> x
[8, 5, 12, 9]
>>> x.remove(5)
>>> x
[8, 12, 9]
>>>
```

After *x.remove(5)*, 5 is removed from the list.

reverse()

reverse() will reverse the elements in a list; that is the first element becomes last, second becomes next to last and so on, until the last element becomes first.

Syntax:

```
<list>.reverse()
```

<list> is the list to be reversed.

Example:

```
>>> x
[8, 5, 12, 9]
>>> x.reverse()  # reverse the elements in place
>>> x
[9, 12, 5, 8]
>>>
```

index()

index() will return the position of the first occurrence of the given value. index() will return a value error if the value does not exist in the list.

Syntax:

```
<list>.index(<element>)
```

<list> is the list to be searched.
<element> is the value whose position we are interested in.

Example:

```
>>> x
[8, 5, 12, 9]
>>> x.index(12)
2
>>>
```

6.6 List Methods

len()

In 3.2.3 we discussed the `len()` operator and used it to find the length of a string; we explained that this can be used on any collection of objects. It is worth pointing out that we can use the `len()` operator to find out the number of elements in a list.

Example:

```
>>> x
['Lee', 'Adam', 'Peter', 'Clive']
>>> len(x)
4
>>>
```


In Operator

The in operator discussed in 3.3 will test if an object is a member of a collection.

Example:

```
>>> x
['Lee', 'Adam', 'Peter', 'Clive']
>>> 'Lee' in x
True
>>>
```

We will discuss two additional operators that can be used with lists, namely *min()* and *max()*.

min()

The *min()* operator will return the smallest value in the list.

Syntax:

min(<list>)

<list> is the list that we want to find the smallest element of.

Example:

```
>>> x
['Lee', 'Adam', 'Peter', 'Clive']
>>> min(x)  # return the smallest value of x
'Adam'
>>> y
[5, 6, 7]
>>> min(y) #return the smallest value of y
5
>>>
```

Notice that *min()* will compare both strings and numeric data type.

max()

The *max()* operator will return the largest value in the list.

Syntax:

max(<list>)

<list> is the list that we want to find the largest element of.

Example:

```
>>> x
['Lee', 'Adam', 'Peter', 'Clive']
>>> max(x)   #return the largest value
'Peter'
>>> y
[5, 6, 7]
>>> max(y)   #return the largest value
7
>>>
```


Practice Exercise 6

1. Given the list `bank_holidays_in_month = [1, 0, 1, 1, 2, 0, 0, 1, 0, 0, 0, 2]`, where each element represent the number of bank holiday in a month, for example, in January there is 1, in February 0, March there is 1, etc. Write a function called "`bank_holiday()`", that takes a number to represent the month and returns the number of bank holidays in that month. Example: `bank_holiday(5)` → `2`. ❑

2. Without using the sort() function that is defined on a list, write a function called "`my_sort()`", that takes an unsorted list and returns the sorted list ❑

3. Define a function called "`add_hello()`", that takes any list and appends the word "hello" to the list. ❑

4. Define a function called "`discount_ten()`", that takes a list of floating-point numbers and returns a list with each element having a 10 per cent discount. ❑

5. Define a function called "`remove_five()`", that takes a list as input and removes all occurrences of 5 in the list. Write the function in such a way that you will not receive an error if there are no 5s in the list. ❑

6. A word is a palindrome if it reads the same in both directions. For example, "civic", "radar", "level", "redder", "madam" are all palindromes. Write a function called "`is_palindrome()`", that takes a word and returns "True" if the word is a palindrome or "False" if otherwise. ❑

7. Define a function called "`unique_elements()`" that takes a list and returns a list that only contains unique elements. The program should take repeated elements but only return one value of the element. For example, in the list [1,2,2,3,3,4], it should return the list [1,2,3,4]. ❑

8. Define a function called "`backways()`", that takes a list and returns it in reverse order. ❑

9. Define a function called "`sum_list()`", that takes a list as input and returns the sum of all the elements in the list. ❑

10. Define a function called "`mean_list()`", that takes a list as input and returns the mean of the list. The mean is the sum of all the elements divided by the number of elements, you can use the function above defined in Question 9. ❑

11. Define a function called "`list_of_deviation()`", that takes a list as input and returns a list that represents how much each element deviates from the mean. ❑

cont. overleaf

12. Define a function called "`standard_deviation()`" that returns the standard deviation of a list. Feel free to use the functions defined in Questions 10 and 11 above. We can use the following steps to find the standard deviation: ❑
    a. Find the mean
    b. List of deviation
    c. Squares of the deviation
    d. Sum of the squares of deviation
    e. Divided by one less than the number of items
    f. Square root of this number → use sqrt(), which is defined in the maths module

Example of how to calculate standard deviation:

Given [1, 4, 5, 7, 9, 20]
Mean (1 + 4 + 6 + 8 + 9 + 20) /6 = 8
List of deviations [-7, -4, -2, 0, 1, 12]
Squares of the deviation [49, 16, 4, 0, 1, 144]
Sum of the squares of the deviation = 214
Divided by one less than the number of items in the list 214/5 = 42.8
Now the square root of 42.8 = 6.54
Standard deviation is about 6.54

Chapter 7: Working with Files

What we will learn:

- ✓ How to open files in Python
- ✓ Syntax for manipulating files
- ✓ Creating a database
- ✓ Making queries

What you need to know before:

- ✓ Data types
- ✓ Lists

Keywords: File, Absolute path, Relative path, Database, Query, SQL

Files are used to store data on a secondary storage device. All the data that we have been using so far is data that disappears when we stop running the program. In order to have persistent data, we have to store it on a secondary storage medium. This data can be used after the running program is closed or whenever we wish to do so.

In Python we use the `open()` function, which is a built-in function, to open a file.

Syntax:

```
<variable_name> = open(<filename>, <mode>)
```

`<variable_name>` is a file object and will be used to refer to the opened file.

`<filename>` is the name of the file and extension. If the file is stored in the same directory as the running program then the name of the file is enough, otherwise the full file path is required which can be relative or absolute, we will discuss these later.

`<mode>` refers to the possible operations on the opened file. The possible modes are summarised in the table below.

Mode	Meaning
'r'	Open for reading (default)
'w'	Open for writing. If the file exists, Python will delete all the contents first; if the file does not exist, Python will create a new file
'x'	Create a new file and open it for writing
'a'	Open for writing, appending to the end of the file if it exists
'b'	Binary mode
't'	Text mode (default)
'+'	Open a disk file for updating (reading and writing)
'U'	Universal newline mode (for backward compatibility)

Table 4

Example:

```
#Open the file in write mode
text_file = open("olympic_games.txt", "w")
```

This will create a text file called `Olympic_games.txt` in the current working directory, or if the file exists it will truncate (delete all the contents) the file and open it ready to be written to. `text_file` is the file handler stream created in the program, that we will use to refer to and access the file on disk.

7.1 Writing to a File

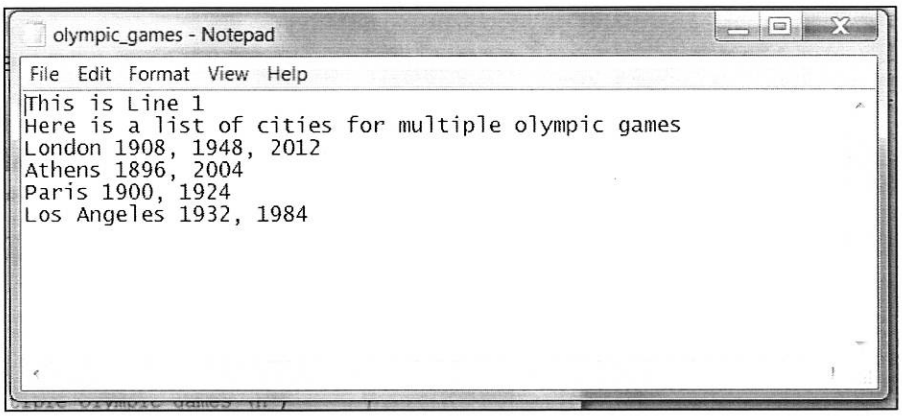
We use the write() function to write contents to a file.

```
print("Writing to a text file with the write() method")

#Open the file in write mode
text_file = open("olympic_games.txt", "w")

text_file.write("This is Line 1\n")
text_file.write("Here is a list of cities for multiple olympic games \n")
text_file.write("London 1908, 1948, 2012 \n")
text_file.write("Athens 1896, 2004 \n")
text_file.write("Paris 1900, 1924 \n")
text_file.write("Los Angeles 1932, 1984 \n")

text_file.close()
```

The code snippet above will create a new file, or open an existing file, called *Olympic_games.txt*; write some information to the file then close the file. A few things are worth noting here.

- *"w"* mode will either create a new file or open an existing one and delete all the contents
- *write()* invoked on the file handler will write the file
- *\n* is an escape sequence used to create new lines in text files
- *close()* invoked on the file handler will close the current opened file. It is always a good idea to close files when you are no longer using them

The following text file can be viewed in the current working directory.



Notice that the name of the file is *olympic_games*, which is the name supplied in the program code. The *\n* inserts a new line in the document.

7.2 Printing a File to the Screen

We use the *read()* function to read data from a file that is open in read mode and the *print()* function to print data in the file handler to the screen.

```
#now open the file and print to the screen
text_file = open("olympic_games.txt", "r")
print(text_file.read())

text_file.close()
```

The snippet above will first close the open stream, then reopen the stream, this time for reading. It will then use the read() function to read the stream and print the contents to the screen using the print() function. Finally, we close the stream.

The entire script and output is repeated below.

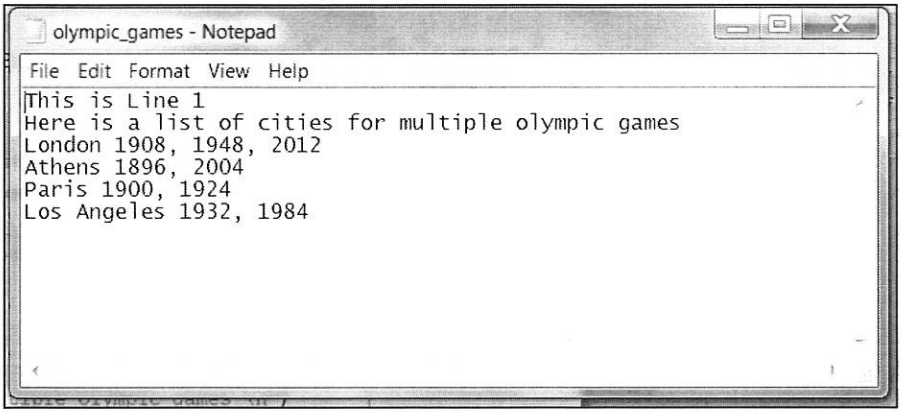
The Script

```
# Creating a file and writing to it using the write method

print("Writing to a text file with the write() method")

#Open the file in write mode
text_file = open("olympic_games.txt", "w")

text_file.write("This is Line 1\n")
text_file.write("Here is a list of cities for multiple olympic games \n")
text_file.write("London 1908, 1948, 2012 \n")
text_file.write("Athens 1896, 2004 \n")
text_file.write("Paris 1900, 1924 \n")
text_file.write("Los Angeles 1932, 1984 \n")

text_file.close()

#now open the file and print to the screen
text_file = open("olympic_games.txt", "r")
print(text_file.read())

text_file.close()
```

The Output

```
>>> ================================ RESTART ================================
>>>
Writing to a text file with the write() method
This is Line 1
Here is a list of cities for multiple olympic games
London 1908, 1948, 2012
Athens 1896, 2004
Paris 1900, 1924
Los Angeles 1932, 1984
```


The Text File
This text file will be created and saved in the current working directory.



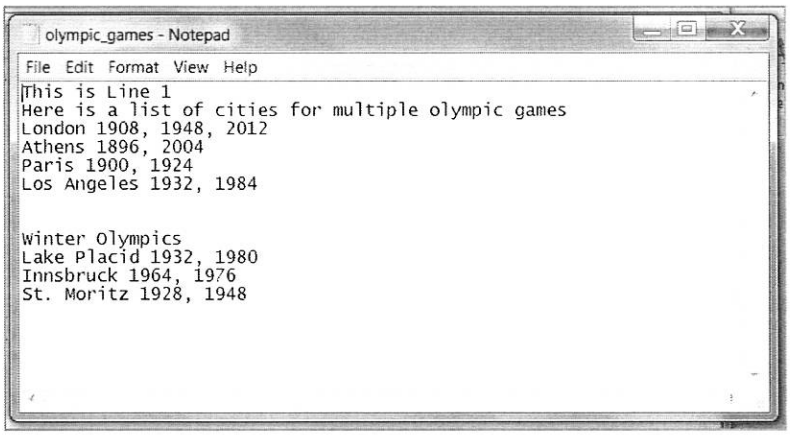
Note that text files take text (string) as input and, therefore, in order to write other data types to a text file they will first have to be converted to string. The *str()* function becomes very handy.

7.3 Appending a File

To add data to a file without deleting what is already there, we open the file in append mode.

```
#First open the file in append mode
text_file = open("olympic_games.txt", "a")

# Now we add the winter games host to the file
text_file.write("\n\nWinter Olympics\n")
text_file.write("Lake Placid 1932, 1980\n")
text_file.write("Innsbruck 1964, 1976\n")
text_file.write("St. Moritz 1928, 1948\n")

#Now close the file
text_file.close()
```

The code above will open the file in append mode and add the winter Olympic cities that have hosted the Games more than once. Again, we close the file after using it. We can then reopen the file and print the contents to the screen. We should see both sets of information in the file, and if we open the text file on our computer we should see the updated text file as seen below.



7.4 File Path

A **directory structure (folder structure)** is the way in which an operating system displays its files to the user. The Windows operating system uses drive names (typically identified by a letter) to denote the root directory or folder. The directory separator is the "\" (backslash), while the Unix-based operating system uses the "/" (forward slash) as its directory separator. A file name is therefore the unique address given to identify a file. There are two ways of stating a file name using the address: 1) relative path and 2) absolute path.

In the previous section, we used a relative file path to open files. Relative file paths start by using the current directory; therefore by running the code, Python will create or open a file called *sample.txt* from the current working directory.

```
>>> new_file = open("sample.txt", "w")
```

The current working directory is the folder that the running program is operating in. We can find out the current working directory by using the function `getcwd()`. The function is a part of the OS module and therefore we will have to import this module before we can use the function. The following code will print the path of the current working directory:

```
>>> import os
>>> print(os.getcwd())
C:\Users\Devz\PythonExercise
>>>
```

To create the file at some other location, we could use the absolute file path, where we give the full address, for example:

```
>>> new_file = open("C:\\Users\\Devz\\PythonExercise\\sample.txt", "w")
>>>
```

This will open or create a file called sample.txt in the specified location *C:\Users\Devz\PythonExercise* It is worth mentioning that in the command above we use double backslash to denote one backslash; the reason for this is that "\" denotes an escape sequence in Python, therefore we use two backslashes for a backslash. Alternatively, we could proceed the file path with "r". File paths such as the one below are called **absolute** file paths; the difference is that the address is given from the topmost folder on the drive.

```
>>> new_file = open(r"C:\Users\Devz\PythonExercise\sample.txt", "w")
>>>
```


7.5 Working with Databases

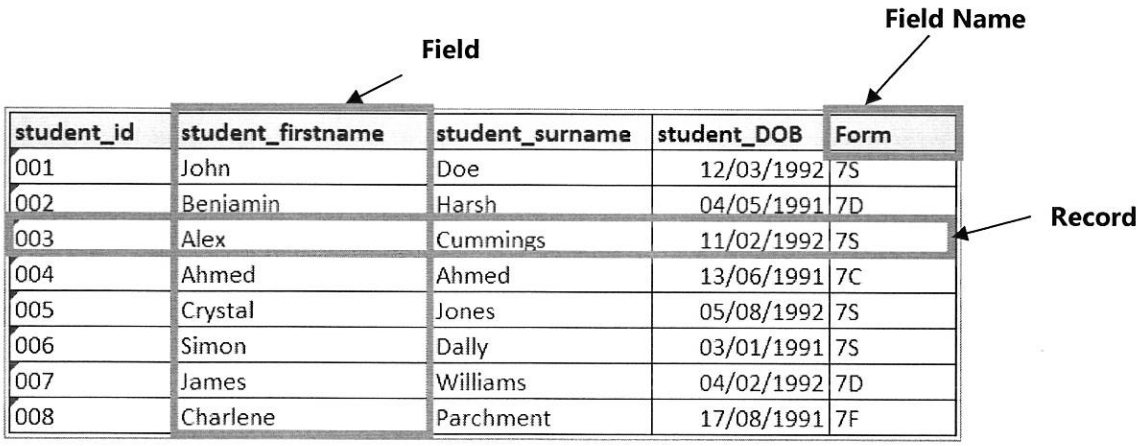
A database is a collection of tables that store data. The software that operates on this data is called a database management system (DBMS). Most databases will contain more than tables, but also queries, triggers and views; each table is identified by a unique name. Almost all organisations will store data and use a database at some point. It is therefore important for us to write programs that can use the data in a database and update the database. The most common operation carried out on a database is a query. Query in its strictest sense is asking the database a question and the database responds by providing all the data items that meet the criteria. Before we discuss queries, it is important to explain some key database terminologies. For the illustration in the table below, we will use a database with a table of students similar to what is used in schools.

Name	Meaning	Examples
Table	A collection of data relevant to one entity	A student's table
Records	Collection of all the data on a single entity	001, John, Doe, 12/03/1992, 7S
Field	Single column of data in a table	John Benjamin Alex Ahmed Crystal Simon
Field Name	The name given to the field	First Name

Table 5

Here is an example of a table within a database with the sections labelled.

Name of Table: Students



student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Beniamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7F

Each field in the data has a data type. The data types are similar to the ones discussed in Chapter 4. The universal language used to create and manipulate databases is called structured query language (SQL pronounced sequel).

Some DBMS, such as Microsoft Access, will generate the SQL codes for the user. In order to use databases in Python, it is worth understanding some SQL commands, we will turn our attention to this.

7.6 SQL

We will discuss the following statements available in SQL:

- CREATE TABLE – *this will create a table in a database*
- SELECT – *display data that is in a table in a database*
- UPDATE – *change data in a table in a database*
- DELETE – *remove data from a table in a database*
- INSERT INTO – *insert new data into a table in a database*

7.6.1 The CREATE TABLE Statement

We first use the CREATE TABLE statement to create the table that we will be using as a running example.

Syntax:

```
CREATE TABLE <table_name>
(
<field_name> <data_type>,
<field_name> <data_type>,
<field_name> <data_type>
)
```

`<table_name>` is the name of the table to be created in the database.
`<field_name>` is the name of the column to be created in the table.
`<data_type>` is the data type of the column.

Example:

```
CREATE TABLE Students
(
student_id text,
student_firstname text,
student_surname text,
student_DOB date,
Form text
)
```

This will create the following table called "Students" in the database

student_id	student_firstname	student_surname	student_DOB	Form

For the rest of the SQL section, we will use the following table as our running example.

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7F

7.6.2 The SELECT Statement

The SELECT statement is used to display data in a table. We can view all the data, or we can specify a criterion, in which case only data that meets the criteria will be displayed.

Syntax:

```
SELECT <field_name> FROM <table_name>
```

<field_name> is the name of the column to be selected.
<table_name> is the name of the table in the database.

Example:

```
SELECT student_firstname FROM Students
```

This will produce the following output:

student_firstname
John
Benjamin
Alex
Ahmed
Crystal
Simon
James
Charlene

```
SELECT student_firstname, student_surname FROM Students
```

This will produce the following output:

student_firstname	student_surname
John	Doe
Benjamin	Harsh
Alex	Cummings
Ahmed	Ahmed
Crystal	Jones
Simon	Dally
James	Williams
Charlene	Parchment

The wildcard (*) is a quick way of selecting all columns in the table and, therefore:

```
SELECT * FROM Students
```

will produce the entire table

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7F

7.6.3 The WHERE Clause

The "Where" clause is used in conjunction with the select statement; this is used to specify a criteria in the selection.

Syntax:

```
SELECT <field_name> FROM <table_name>
WHERE <field_name> operator <value>
```

<field_name> is the name of the column to be selected.
<table_name> is the name of the table in the database.
operator is any operator from the table below.
<value> is any legal value that can be stored in the field name selected.

Operator	Meaning
=	Equal to
<> or !=	Not equal to
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to
BETWEEN	Value between a given range including the bounds
LIKE	Matches a given pattern
IN	To find more than one value in a column

Table 6

Example:

```
SELECT * FROM Students
WHERE Form='7S'
```

This will produce

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
003	Alex	Cummings	11/02/1992	7S
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S

Notice that '7S' requires single quotation marks as the data type is text; there is no need for quotation marks if the data type is numeric.

7.6.4 The UPDATE Statement

This statement is used to change records by updating them in a table in a database.

Syntax:

```
UPDATE <table_name>
SET <column1> = value1, <column2>=value2, ...
WHERE <field_name> = value
```

<table_name> is the name of the table in the database.
<column1> is the first column to be updated.
<column2> is the second column to be updated.
<field_name> specifies the record to be updated.

Note that the WHERE clause specifies the particular record to be updated. If this is left blank, then all the records will be updated.

Example:

```
UPDATE Students
SET Form = '7S'
WHERE student_firstname='Charlene'
```

Before the update:

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7F

After the update:

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7S

Notice that the Charlene is now in form 7S.

7.6.5 The DELETE Statement

This statement is used to remove records from a database.

Syntax:

```
DELETE FROM <table_name>
WHERE <field_name> = value
```

`<table_name>` is the name of the table in the database.
`<field_name> = value` specifies the record to be deleted.

Example:

```
DELETE FROM Students
WHERE student_firstname='Charlene'
```

Before the delete statement:

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7F

After the delete statement:

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D

7.6.6 The INSERT INTO Statement

The insert into statement is used to insert a new record into a database.

Syntax:

```
INSERT INTO <table_name> (column1, coulmn2, column3, ...)
VALUES (value1, value2, value3, ...)
```

<table_name> is the name of the table in the database.
column is the column into which the value should be inserted.
value is the value to be inserted into the matching column.

Note that the column is optional, but SQL will insert the values into consecutive columns if they are omitted. Specifying the column is a good way to insert data into non-consecutive columns.

Example:

```
INSERT INTO Students
VALUES ('009', 'Paul', 'Piggot', '15/07/1992', '7C')
```

Before the insert into statement:

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7F

After the insert into statement:

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S
002	Benjamin	Harsh	04/05/1991	7D
003	Alex	Cummings	11/02/1992	7S
004	Ahmed	Ahmed	13/06/1991	7C
005	Crystal	Jones	05/08/1992	7S
006	Simon	Dally	03/01/1991	7S
007	James	Williams	04/02/1992	7D
008	Charlene	Parchment	17/08/1991	7S
009	Paul	Piggot	15/07/1992	7C

We could have used the field name to specify the columns where we want the data to be inserted, but in this case we want to insert it into all columns and therefore it is not necessary.

7.7 SQL and Python

Python provides the SQL*ite3* library to manipulate lightweight disk databases. Before we try to create or use a database, we first have to import the SQLite3 library. We use the keyword import for this. This is demonstrated below.

```
#we first import the sqlite3 library

import sqlite3
```

Connect

Now that the SQLite3 library is imported, we can connect to and use a database. Similar to files, before we use a database we need to have a handler in our program that interacts with the physical database on a disk or in the RAM. We use the `connect()` function, as defined in the SQLite3 library. This function will open a connection to the SQLite database file. The following code snippet will connect to a database called "School".

```
#we first import the sqlite3 library

import sqlite3

#Create a handler called new_db that connects to db on disk
new_db = sqlite3.connect('C:\\Users\\Devz\\PythonExercise\\school.db')
```

The argument to the function is the file path for the database; notice that we use double backslash '\\' in our file path as single backslash denotes an escape sequence.

Create Cursor Object

In Python, the cursor object allows us to work with and manipulate databases. To create a cursor object we call the cursor method on the connection object. In our example, the connection object is new_db, we will create a new cursor called c.

```
#we first import the sqlite3 library

import sqlite3

#Create a handler called new_db that connects to db on disk
new_db = sqlite3.connect('C:\\Users\\Devz\\PythonExercise\\school.db')

#Create a new cursor object to manipulate the database
c=new_db.cursor()
```

Now that we have a connection to our database and a cursor object, we can execute SQL statements to create our table and insert data into our tables. We will create a table called "Students" with the same properties as before.

Create Table

We first create a table.

```
#Now create a table called Students
c.execute('''CREATE TABLE Students
(student_id text,
student_firstname text,
student_surname text,
student_DOB date,
Form text)
''')
```

Notice that we are using SQL commands to create the table.

Use the INSERT INTO statement to populate the table.

Next, we use the INSERT INTO statement to insert values into our table.

```
#insert data into our table
c.execute('''INSERT INTO Students
          VALUES ('001', 'John', 'Doe', '12/03/1992', '7S')''')
```

Notice that we are using the version where we do not specify the field names as we will be inserting information into all columns.

Commit and Close

We use the `commit()` statement to save/commit the final transaction and finally close the database.

```
#Save changes using the commit() function
new_db.commit()

#Close the connection to the database
new_db.close()
```

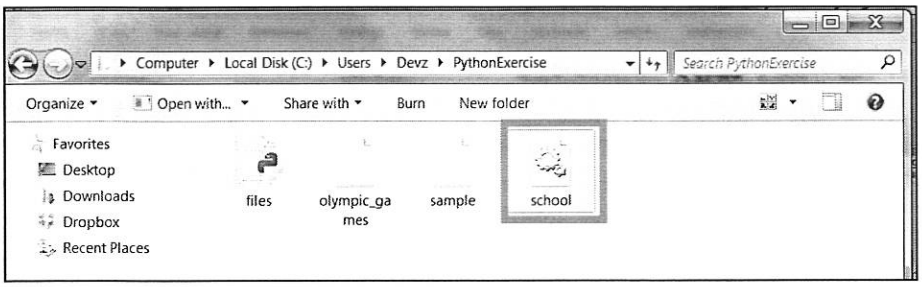

Putting all the codes together:

```
#we first import the sqlite3 library

import sqlite3

#Create a handler called new_db that connects to db on disk
new_db = sqlite3.connect('C:\\Users\\Devz\\PythonExercise\\school.db')

#Create a new cursor object to manipulate the database
c=new_db.cursor()

#Now create a table called Students
c.execute('''CREATE TABLE Students
(student_id text,
student_firstname text,
student_surname text,
student_DOB date,
Form text)
''')

#insert data into our table
c.execute('''INSERT INTO Students
          VALUES ('001', 'John', 'Doe', '12/03/1992', '7S')''')

#Save changes using the commit() function
new_db.commit()

#Close the connection to the database
new_db.close()
```

After executing this code, the database called school.db will be created in the specified location (*C:\Users\Devz\PythonExercise\school.db*), with a table called "Students" and the record inserted.

student_id	student_firstname	student_surname	student_DOB	Form
001	John	Doe	12/03/1992	7S

The physical files are shown below. Note that this file is not readable by normal programs on the computer, and therefore if we open this file we will only see symbols.



We can, however, use Python to read the data from this file and print this data to the screen. The following code snippet reconnects to the database, reads the file and prints the data to the screen.


```
#Re-connect to the database
new_db=sqlite3.connect('C:\\Users\\Devz\\PythonExercise\\school.db')

#Create a cursor object
c=new_db.cursor()

#Use the SELECT statement with wildcard to select all columns
c.execute("SELECT * FROM Students")

#use the fetchone function to fetch one row of data
row=c.fetchone()

#print the row to the screen
print(row)

#Finally close the connection
new_db.close()
```

The result of executing this code is:

```
>>> ================================ RESTART ================================
>>>
('001', 'John', 'Doe', '12/03/1992', '7S')
>>>
```

It is always good practice to close the database connection once you have finished using the database as other processes will not be able to access the opened database.

Here are some other functions defined on the object cursor and a description of what they do.

executemany(...)
: Repeatedly execute a SQL statement

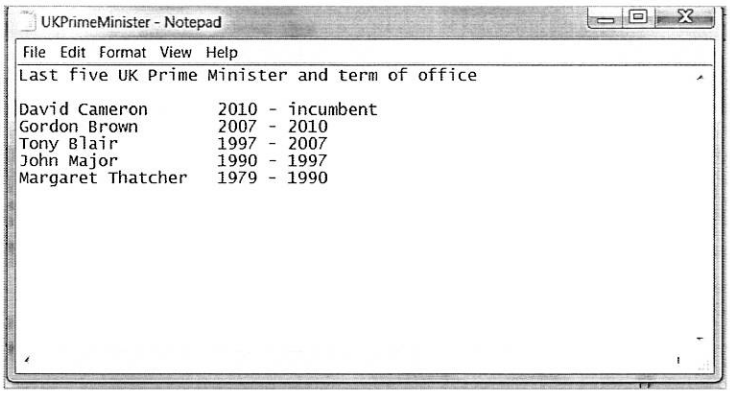
executescript(...)
: Executes multiple SQL statements at once

fethchall(...)
: Fetches all rows from the result set

fethchmany(...)
: Fetches several rows from the result set

Practice Exercise 7

1. a. Create a text file in the current working directory that creates and stores the text file that shows a list of the last five (5) Prime Ministers of the United Kingdom as shown below. ❑



b. Now write a Python program that will read the file called "`UKPrimeMinister.txt`", that was created above, and print the content to the screen. The output is shown below. ❑

```
>>> ================================ RESTART ================================
>>>
Writing text file
Last five UK Prime Minister and term of office

David Cameron       2010 - incumbent
Gordon Brown        2007 - 2010
Tony Blair          1997 - 2007
John Major          1990 - 1997
Margaret Thatcher   1979 - 1990

>>>
```

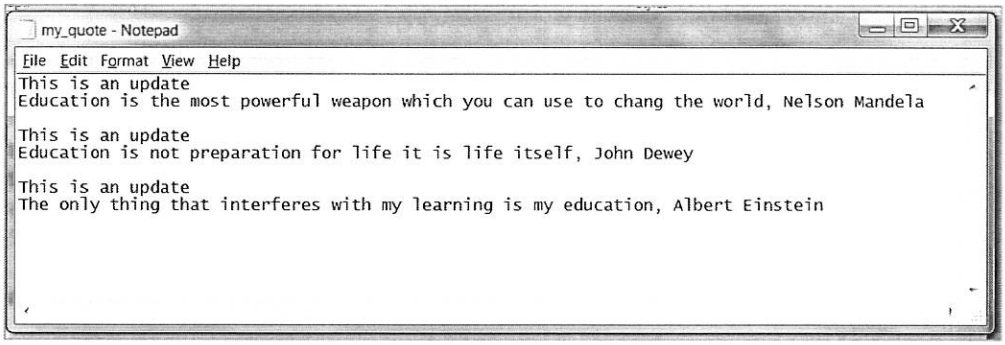
2. The code below should create a text file called "`my_quote.txt`". The function `update_file()` is defined to take a file name and a string containing a quote. The function should open the file called "my_quote.txt" and update it with a new quote. The program should prompt the user to enter a quote three times. Then print the contents of the file to the screen. At the moment there are two things wrong with the code.
   a. Only the last quote is saved in the file
   b. The user is being prompted four times instead of three

   Examine the code and correct it to get the desired outcome. ❑

   Desired Outcome:

```
>>> ================================ RESTART ================================
>>>
Enter your favourite quote: Education is the most powerful weapon which you can use to chang the world, Nelson Mandela
Enter your favourite quote: Education is not preparation for life it is life itself, John Dewey
Enter your favourite quote: The only thing that interferes with my learning is my education, Albert Einstein
This is an update
Education is the most powerful weapon which you can use to chang the world, Nelson Mandela

This is an update
Education is not preparation for life it is life itself, John Dewey

This is an update
The only thing that interferes with my learning is my education, Albert Einstein


>>>
```

Text File:



Code to be Corrected:

```
# update three quotes to a file

file_name = "my_quote.txt"
#create a file called my_quote.txt
new_file = open(file_name, 'w')
new_file.close()



def update_file(file_name, quote):
    #First open the file
    new_file = open(file_name, 'w')
    new_file.write("This is an update\n")
    new_file.write(quote)
    new_file.write("\n\n")

    #now close the file
    new_file.close()

for index in range(1,3):
    quote = input("Enter your favourite quote: ")
    update_file(file_name, quote)


# Now print the contents to the screen
new_file = open(file_name, 'r')
print(new_file.read())

# And finally close the file
new_file.close()
```

3. Complete the following code to create a database called "Library.db" that has a table called "Books". The code should then populate the table with the following information. ❑

book_isbn	book_title	book_type	book_author	publisher
978-0-340-88851-3	A2 Pure Mathematics	Non fictional	Catherine Berry	Hodder Education
978-1-118-10227-5	Android 4 Application Development	Non fictional	Reto Meier	Wiley
0-596-00699-3	Programming C#	Non fictional	Jesse Liberty	O Reilly

It should then print the snippet overleaf back to the screen.

Incomplete Code

```
#we first import the sqlite3 library
import sqlite3

#insert the correct path here
new_db = sqlite3.connect('C:')

#Create a new cursor object to manipulate the database
c=new_db.cursor()

#Now create a table called Students
c.execute('''CREATE TABLE Books
(book_isbn text,
book_title text,
book_type text,
book_author text,
publisher text)
''')
#insert Statements here to add data to the table


new_db.commit()

#Close the connection to the database
new_db.close()


#Re-connect to the database - insert the correct path
new_db=sqlite3.connect('C:')

#Create a cursor object
c=new_db.cursor()

#Use the SELECT statement to select all the data

#use the fetchone function to fetch one row of data
book_library=c.fetchall()

#print the row to the screen
for book in book_library:
    print(book)

#Finally close the connection
new_db.close()
```

4. Explain the effect of running the following code on a database.

a. *SELECT Product.Name, Product.Quantity, Product.Price*

.....

.....

b. *FROM Product*

.....

.....

c. *WHERE Product.Quantity > 20*

.....

.....

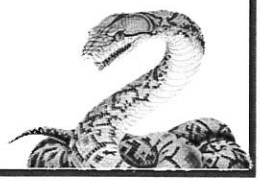
Chapter 8: Creating Your Own Type – Classes

What we will learn:

- ✓ Object-oriented programming
- ✓ What is a class
- ✓ How to create a class
- ✓ Assigning values to a class

What you need to know before:

- ✓ Data types
- ✓ Methods



Keywords: Object-oriented, Object, Attributes, Class, Abstract data type

8.1 Object-Oriented Programming (OOP)

We had a thorough discussion about data types in Chapter 3. It turns out that most applications in real life will require other data types that are not supplied by Python. Luckily, Python provides the facility to create your own data type. New data types created are often referred to as objects and the process is called object-oriented programming. In the Introduction, when we introduced Python, we stated that Python was a hybrid language and supported a multiple programming paradigm (a way of thinking about computation); it turns out that the ability to create classes and manipulate objects qualifies Python to be an object-oriented programming language. As an example, let us consider a student enrolment system used at a school or university. It would be a great idea if we could refer to a student and Python were to understand that we are talking about a person who has a name, address, telephone number, is registered for certain courses, and can do things such as walk, run, take an exam, to name a few. It turns out that these entities (students in this case) are referred to as objects.

An **object** is a thing or an event in our application. Objects can have data items, these are known as **attributes**. Objects also have behaviours which are called **methods**. Earlier in our students example, we classified a student as an object. The diagram below shows the student object with some attributes and behaviours:

Student

Attributes:
Name
Address
Telephone Number

Behaviour:
Can take course
Can talk
Can attend school

8.2 Why Do We Use Classes?

1) *To bring the solution space closer to the problem space.* It is more natural to want to find out the name of a student than just referring to the string name. Computer programs are written to solve problems. Where the problem occurs is referred to as the problem space; for example, the problem space in our example above is a school and, in particular, in a course registration system. Since we are using the computer to solve this problem, then the solution space is in the computer. Using classes will give the programmer the ability to relate real-life entities (students) to the interpreter, bringing the solution space closer to the problem space.

2) *To develop so-called abstract data types (ADT).* Abstract data types are new data types that we can define numerous operations on. For example, if we develop a new ADT called "shapes" we can define interesting methods, such as `draw_self()`, or `colour_self()` which allow the shape to draw and colour itself.

3) *For reuse of code.* If we have a definition of a good ADT, then we can always import that ADT and use the methods that are already defined. Let us say we developed the student registration system mentioned above, and now we want to develop an extra-curricular club program that has student information then there is no need to redefine the student ADT that was developed earlier. Furthermore, other programmers can use ADT that was developed by other programmers.

4) *To enforce data encapsulation.* Data encapsulation is information hiding. It turns out that with classes, a programmer can use a new ADT without knowing the underlining implementation. This allows programmers to develop codes that other programmers can use by accessing the methods that are defined over these ADTs, without worrying about the intricacies of how this is actually accomplished. This also give the unique advantage, where if a new way of accomplishing a task comes about then the writer of the ADT can make this change and the programmer using this code will not struggle. We have seen this modular design in engineering and mechanics before, where the driver of a car is not necessarily concerned about how the pedal uses a lever to connect to the master cylinder which in turn applies the disk pads to the wheel to stop the car. Instead, he is only concerned with the fact that when he pushes on the brake pedal, this will have the effect of stopping the car. The designer of the car can choose whether to use drum brakes, air brakes, disc brakes or another braking system that is not discovered as yet; this will not affect the driver pushing on the pedal to stop the car. In a similar manner, if a more efficient data structure arrives then the designer of the ADT can implement this and all programmers benefit without breaking any code.

8.3 Data Types in Python

We have seen objects before. All data types in Python are objects. The implementation of an object is called a class.

```
>>> name = 'Patrick'
>>> print(type(name))
<class 'str'>
>>>
>>> number = 45
>>> print(type(number))
<class 'int'>
>>>
>>> z = [1,2,3]
>>> print(type(z))
<class 'list'>
>>>
```


From the code snippet on the previous page, we assign "Patrick" to name, and when we print the type() then we see get <class 'str'>. This means that "name" is an instance of a string class. Similarly, "number" is an instance of the integer class and "z" is an instance of the list class.

We have encountered string (a collection of characters) before. We also explored methods that are defined on string. Upper() and lower() are two such methods. It turns out that every string has these methods defined on them; this is the case because in the definition of the string class, upper() and lower() is defined.

```
>>> month = 'September'
>>> print(month.upper())
SEPTEMBER
>>> #now print the lower case of month
>>> print(month.lower())
september
>>>
```

To view all the methods that are defined on an object, we use the `dir()` method.

```
>>> dir(month)
['__add__', '__class__', '__contains__', '__delattr__', '__dir__', '__doc__', '__eq__', '__form
at__', '__ge__', '__getattribute__', '__getitem__', '__getnewargs__', '__gt__', '__hash__', '__
init__', '__iter__', '__le__', '__len__', '__lt__', '__mod__', '__mul__', '__ne__', '__new__',
'__reduce__', '__reduce_ex__', '__repr__', '__rmod__', '__rmul__', '__setattr__', '__sizeof__',
'__str__', '__subclasshook__', 'capitalize', 'casefold', 'center', 'count', 'encode', 'endswith
', 'expandtabs', 'find', 'format', 'format_map', 'index', 'isalnum', 'isalpha', 'isdecimal', 'i
sdigit', 'isidentifier', 'islower', 'isnumeric', 'isprintable', 'isspace', 'istitle', 'isupper'
, 'join', 'ljust', 'lower', 'lstrip', 'maketrans', 'partition', 'replace', 'rfind', 'rindex', '
rjust', 'rpartition', 'rsplit', 'rstrip', 'split', 'splitlines', 'startswith', 'strip', 'swapca
se', 'title', 'translate', 'upper', 'zfill']
>>>
```

Notice that all of these methods are defined on all strings.

8.4 Defining a Class

We use the class keyword followed by the name to define a class.

Syntax:

```
class <class_name>:
      'class_docstring'
      <class_suite>
```

<class_name> is the name of the class following the same conventions as naming variables, discussed in Chapter 1.

'class_docstring' or documentation string explains what the class is about. This should give the user of the class enough information about the class being defined.

<class_suite> is the statement that defines the class. This will contain the methods that define the class and are invoked whenever we have instances of the class.

Example:

```
class Student:
    """ The Student class defines a student with
    attributes: name, age, form
    """
    #Attributes
    name = "not set"
    age = 1
    form = "7"

    #Functions
    def get_name(self):
        return self.name

    def get_age(self):
        return self.age

    def get_form(self):
        return self.form

    def set_name(self, new_name):
        self.name = new_name

    def set_age(self, new_age):
        self.age=new_age

    def set_form(self, new_form):
        self.form = new_form

    def say_hello(self):
        print("hello my name is", self.name, " I'm in form ", self.form)
```

The code snippet above will define the student class. The different sections are discussed below.

The class and docstring:

```
class Student:
    """ The Student class defines a student with
    attributes: name, age, form
    """
```

The keyword class is used, followed by the name of the class and colon.

The docstring or documentation string is used to build the documentation for any application that is using the class. This information also appears when we use the help facility to display the details of the student class.

The attributes:

```
#Attributes
name = "not set"
age = 1
form = "7"
```

This is the section to list the attributes on the class and initialise the default values.

The class functions:

```
#Functions
def get_name(self):
    return self.name

def get_age(self):
    return self.age

def get_form(self):
    return self.form

def set_name(self, new_name):
    self.name = new_name

def set_age(self, new_age):
    self.age=new_age

def set_form(self, new_form):
    self.form = new_form

def say_hello(self):
    print("hello my name is", self.name, " I'm in form ", self.form)
```

The class functions are used to access and change the attributes of the class. Notice the use of the word self. It turns out that we use self with the dot operator to refer to attributes of data items that belong to the class.

8.4.1 Using the Class

When we create a class, this is called an instance of the class. The following code will create an instance of student1 and use some of its functions.

```
#create a new Student
student1 = Student()

#Set the name of Student1 to John Doe
student1.set_name("John Doe")

#Use the accessor method to print the name
print(student1.get_name())

#Say hello from student1
print(student1.say_hello())
```

A few things to note above:

- We declare a variable and assign the name of the class as if it were a function
- Once we create an instance of the class we can now use the class methods

This is the output that we would get.

```
>>> ================================ RESTART ================================
>>>
John Doe
hello my name is John Doe  I'm in form  7
None
>>>
```

Notice that if we create a new instance of the student class and say "hello" we will get a different message.

```
>>> student2 = Student()
>>> print(student2.say_hello())
hello my name is not set  I'm in form  7
None
>>>
```

When we say "hello", the default values are displayed.

Practice Exercise 8

1. Create a class called "Time" with the following attributes: hour, minutes and seconds. These should initialise to (12:00:00), unless the user supplies another time. Create accessor functions with the following names and functionalities. ❑
   a. `get_hour ()` – return the current hour
   b. `get_minute()` – return the current minute
   c. `get_second()` – return the current second
   d. `print_time()` – print the current value of time

   And the following mutator functions:
   e. `set_hour()` – takes a new hour and sets this as hour
   f. `set_minute()` – takes a new minute and sets this as the minute
   g. `set_seconds()` – take a new second and sets this as the second
   h. `increment_second()` – increment second by one second, note that if second is 59, incrementing will increment minute by one and turn seconds to 00.
   i. `increment_minute()` – increment minute by one, note that if the minute is at 59, incrementing minute will result in incrementing hour by one.
   j. `increment_hour()` – will result in incrementing hour by one, if hour is 12, this should return to 1.

2. Write a Python program that inserts the time class and create two instances of time, one with the default time and the other a user-defined time. Use each of the accessor and mutator functions, printing the values before and after the mutator function. ❑

3. Create a class called "Fraction", with the following attributes: numerator and denominator – these should initialise to (0/1), unless the user supplies another fraction. Create accessor functions called: ❑
   a. `get_numerator()` – return the numerator
   b. `get_denominator()` – return the denominator
   c. `print_fraction()` –prints the fraction
   d. `print_type()` – print the type of fraction ("proper" if the denominator is larger than the numerator, "improper" if the numerator is larger than the denominator)

   And the following mutator function
   e. `set_numerator()` – takes a new numerator and set this as numerator
   f. `set_denominator()` – takes a new denominator and set this as denominator
   g. `inverse()` – change the numerator to the denominator and vice versa; this should not change if the numerator is 0

4. Write a Python program that inserts the "Fraction" class and create two instances of fraction, one with the default fraction and the other a user-defined fraction. Use each of the accessor and mutator functions, printing the values before and after the mutator function. ❑

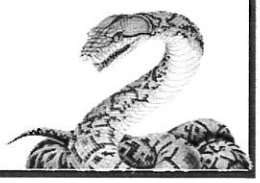
Chapter 9: Dealing with Errors

What we will learn:

- ✓ How to identify errors
- ✓ Categorising different types of error
- ✓ How to fix different errors
- ✓ Example of errors

What you need to know before:

- ✓ Writing simple programs



Keywords: Runtime errors, Syntax, Semantics, Recursive, Exceptions, Errors

9.1 Exceptions and Errors

There are different types of error that can occur when we are writing programs. In this chapter, we will discuss them and examine possible solutions.

Types of Errors

Type of Error	Meaning	Example

Syntax	A syntax error occurs when the programmer uses a token (letter, symbol and operator) somewhere that is not defined in the grammar of the language.
	
	Programming languages have rules, similar to other forms of communication. The interpreter takes the source code and parses the tokens, then sends this parsed byte code to the evaluator to get its meaning.
		`if age<18`
		`  print("Child")`
		
		Here the colon is missing after the condition (`age<18`)

Runtime	A runtime error occurs during execution of a program. The programmer normally thinks about these but can do nothing about them. They are often dealt with by the exception handler.	Program running out of memory Faulty hardware

Semantic or logical	Semantic refers to the meaning of things. These errors happen when there are errors with the logic of the program, which gives unexpected results. The interpreter will not raise an exception or give an error message for semantic errors, but the user will not get the expected result.
	
	In evaluating $\frac{15}{2\pi}$ in Python we would type `15/2*math.pi`
	As division and multiplication have the same precedence, we would get 23.56, instead of the correct answer 2.38. In order to get the correct answer we would have to use brackets; therefore, we would type `15/(2*math.pi)`
		For $\frac{12}{5\pi}$
		
		`12/5*math.pi`
		`incorrect`
		
		`12/(5*math.pi)`
		`correct`

Table 7

In general, the term ***exception*** is used to describe when something goes wrong in a program; this include errors caused by the programmer and external factors, such as hardware failure. Some programming languages make explicit differentiation between an error caused by a programmer and an exception. In Python, the difference is more subtle in that both errors and exceptions are handled by the BaseException class. Subclasses are then derived which are either errors or exceptions.

We will now turn our attention to dealing with these kinds of error and then to exceptions.

9.2 Syntax Error

Syntax errors are quite easy to fix. The interpreter will raise this error where it notices that the error occurred. This is often at the exact location or sometimes in the previous line. For example, if a token such as a closed bracket or a colon is missing from the previous line, the syntax error is normally noticed and highlighted in the following line. The code snippet below demonstrates this.

```
>>> print("I am leaving out the closed bracket here"
      but when I run the program the error is in the wrong place

SyntaxError: invalid syntax
>>>
```

We will also get a syntax error if we group two operators together, for example:

```
>>> 5 + 4 +*
SyntaxError: invalid syntax
>>>
```

This will generate a syntax error, I'll use Backus–Naur Form to explain why we get a syntax error for the example above.

The grammar of almost all programming languages is described in **Backus–Naur Form (BNF)**. BNF was developed by John Backus in the 1950s; he was very influential in developing the FORTRAN programming language. The purpose of BNF is to develop a concise way of describing a programming language. The structure of BNF is:

<non-terminal> → replacement

The replacement can be replaced with zero or more non-terminal or terminal.
Terminals terminates the statement; once it is used it cannot be replaced.

The grammar for mathematical statements can be expressed by the following notation:

```
expression → expression operator expression
expression → number
operator → +, -, *, /, %, ...
number → 0, 1, 2, 3, 4, ...
```

You will notice that there are two lines for defining the expression. Together we call this a recursive definition. A recursive definition is where we define something in terms of itself, but there is also a known definition called the base case. This qualifies the expression as a recursive definition as the expression can be replaced by an expression and also by number, which is a terminal. This is a very powerful concept in computer science and is used to define and break down many large problems.

How do we use this grammar?

Suppose we want to generate the expression **12 + 3 * 15**.
We can use the following steps:

1. Start out with an expression	*Expression*
2. Replace with expression → expression	***expression operator expression***
3. Replace expression → number	***number*** *operator expression*
4. Replace number →12	***12*** *operator expression*
5. Replace operator → +	*12* ***+*** *expression*
6. Replace expression → expression operator expression	*12 +* ***expression operator expression***
7. Replace expression → number	*12 +* ***number*** *operator expression*
8. Replace number → 3	*12 +* ***3*** *operator expression*
9. Replace operator → *	*12 + 3* ******* *expression*
10. Replace expression → number	*12 + 3 ** ***number***
11. Replace number → 15	*12 + 3 ** ***15***

The replaced is highlighted on the right.

Now let us try to generate **5 + 4 +***.

1. Start out with an expression	*Expression*
2. Replace with expression → expression	***expression operator expression***
3. Replace expression → number	***number*** *operator expression*
4. Replace number →5	***5*** *operator expression*
5. Replace operator → +	*5* ***+*** *expression*
6. Replace expression → exp op exp	*5 +* ***expression operator expression***
7. Replace expression → number	*5 +* ***number*** *operator expression*
8. Replace number → 4	*5 +* ***4*** *operator expression*
9. Replace operator → +	*5 + 4* ***+*** *expression*
10. Error we cannot replace expression → operator	***5 + 4 + SyntaxError***

It turns out that it is impossible to generate **5 + 4 + *** using the grammar defined above, and therefore the interpreter will generate a syntax error when to try to parse the expression.

To reduce or eliminate syntax errors:

- Ensure that operators are surrounded by operands (Python uses what is called an infixed notation and therefore, the operator must be in the middle of the operands.
- Ensure that all opening brackets (, {, [have a matching closing bracket], }.).
- Ensure that all opening quotation marks (" or ') have a matching closing quotation mark (" or ').
- Ensure that you include a colon (:) at the end of your IF statements or other control structures.
- Ensure that you are using the correct operator, for example, = means assignment and == is equal to.
- Ensure that you are not trying to use a keyword as a variable name; this will generate a syntax error.
- Ensure that you are using the correct indentation. Python is indent sensitive; typically we indent after a colon (:) and return to the original alignment afterwards.

9.3 Runtime Errors

Runtime errors are more difficult to spot, largely because the program will run without reporting an error to the user which gives the impression that everything is working well. Runtime errors can happen in a few ways:

- The program runs without an output. If this is the case, then check to ensure that there is an output statement in the code, unless the code is a module that will be used for utilities.
- If the program hangs and become inactive. This normally happens when the program enters an indeterminate loop, without statements to make the condition false. This was mentioned when I introduced the while loop. If this happens, the program will run forever. I'll use an example to illustrate this.

```
number = 1
while number<10:
    print("The value of number is ", number)
    # notice that there is no statement to make the condition false
```

  Notice that in the body of the while loop there is no statement that will change the value of number, and therefore the number will always be less than 10, and hence the condition will always be true. If this code snippet was in your code, the error would be clear as there is a print statement in the body of the while loop that will be printing "The value of number is 1" on your screen. Therefore, we could identify where the error is. Now if there was no print statement, for example, the while loop was updating a database or traversing a list for each iteration, then this would become more difficult to identify.

- Runtime errors can happen when we have a recursive call that does not "bottom out". We use the term "bottom out" to refer to the situation when either there is no base case or the function will never get to the base case. Let us think about the recursive definition for expression in BNF that was mentioned in the syntax error section. We defined expression as:
  expression → expression operator expression
  expression → number

  If the second statement were absent (*expression → number*), then it would not be possible to get to a situation where we have expressions in all terminals (numbers and operators).

  Let us use a recursive definition to define a function called `power_number()` that takes two values as input, namely a base and an index.

```
def power_number(base, index):
    if index ==0:
        return 1
    else:
        return base * power_number(base, index-1)
```

  The base condition in this situation is to return 1 whenever the index is equal to 0. This is consistent with mathematics, in that any number raised to the power of zero is equal to 1. Now if this base condition was absent or impossible to get to, then after running for some time the interpreter will return a runtime error, stating that maximum recursion depth is exceeded in comparison.


```
def power_number(base, index):
    if index ==15:
        return 1
    else:
        return base * power_number(base, index-1)


print(power_number(4,12))
```

In the example above, the index will never be equal to 15, as the index starts at 12 from our print statement and decreases in value.

```
ors and Exception/errors.py", line 23, in power_number
    return base * power_number(base, index-1)
  File "C:/Users/Devz/Downloads/Python Book/Python for Key stage 4/Chapter 9 Err
ors and Exception/errors.py", line 23, in power_number
    return base * power_number(base, index-1)
  File "C:/Users/Devz/Downloads/Python Book/Python for Key stage 4/Chapter 9 Err
ors and Exception/errors.py", line 20, in power_number
    if index ==15:
RuntimeError: maximum recursion depth exceeded in comparison
>>>
>>>
```

Whenever you suspect that a recursive definition is not getting to the base case, it is worth using a trace table to go through a simple case, or using print statements to display the value of the variables at strategic locations in the function call.

9.4 Semantic or Logical Error

Semantic refers to the meaning of a language or logic. Semantic errors are even more difficult to spot than runtime errors. Similar to runtime errors, the interpreter will not give you any messages or warnings. The program will even run without hanging, or giving a maximum recursion depth message. Instead, the output will not be the one that you are expecting.

Fortunately there are strategies available to the programmer to identify and correct semantic errors.

- Inserting `print()` statement at strategic locations in your code to see the values of variables is quite helpful.
- The use of trace tables to record the value of variables can be also helpful.
- Sometimes it is worth breaking down complex expressions into simpler statements, rather than having large complex statements.

  If you define a function called `larger()` that takes two numbers and returns the larger of the two. It is possible to use *`larger(num1, larger(num2,num3)`*, to return the larger of three numbers. That is equivalent to:

  ```
  temp_num = larger(num1, num2)
  larger(temp_num, num3)
  ```

  This may seem trivial, but it turns out that it is less likely to make mistakes on simpler expressions than on complex ones.

- Semantic errors often arise from the use of incorrect operators, for example, using the < sign instead of the >.
- It is often worth using brackets to explicitly force the correct order of operation, from our example in the table above:

  In evaluating $\frac{15}{2\pi}$ in Python we would type `15/2*math.pi`

  As division and multiplication have the same precedence, we would get 23.56, instead of the correct answer 2.38. In order to get the correct answer we would have to use brackets, therefore, we would type `15/ (2*math.pi)`

9.5 Dealing with Errors

Even with the best intentions, there will be situations in which errors occur in a program that were not foreseen. Many programming languages provide error handing facilities for such situations. In Python, all exceptions are instances of the BaseException class and are implemented using the try statement. The debugger tool in Python is called the Python debugger and is imported using the `import pdb`. There are two versions of the try statement, namely try-except and try-finally.

9.5.1 The Try Statement

Syntax:

```
try:
<block_to_execute>

except <exception>:
      <block_to_execute>
```

`<block_to_execute>` is the originally intended code.
`except` must include at least one exception, but can include as many as you need.

Example:

```
try:
    x=int(input("Enter a number to divide: "))
    y=int(input("Enter a number to divide by: "))
    print(x/y)
except ZeroDivisionError:
          print("Cannot divide by zero: ")
          y=1
```

This will catch the exception then print a more meaningful statement and continue with the execution of the program.

In the example above, the interpreter will try to execute all the statements in the try block. If the user enters zero for the y value, the ZeroDivisionError exception will be raised. Instead of halting the program, the interpreter will catch the exception in the "except" clause and recover from the unstable state by reassigning y to 1. We could have included other exceptions in the "except" clause, and the interpreter would search until it finds a matching exception to enter into the "except" clause. If no matching exception is found, the program will halt/stop and print the exception to the screen.

The example below shows how we can catch an ImportError (import a file/module that does not exist).

```
>>> import unknown_module
Traceback (most recent call last):
  File "<pyshell#60>", line 1, in <module>
    import unknown_module
ImportError: No module named 'unknown_module'
```

This is the import statement without the exception handler. Note that this would stop the running program.

```
>>> try:
        import unknow_module
except ImportError:
        print("Sorry module not found")


Sorry module not found
>>>
```

With the exception handler, the program will recover and continue to run.

9.5.2 The Try Statement with Multiple Exceptions

There are situations in which more than one exception can occur in a particular code. You have the option of writing multiple except clauses, where you check each exception and resolve it, or you can use one except clause where the interpreter will check through a list of exceptions. It turns out that if there is one way to deal with all exceptions, then the latter is a better option, but if each exception requires a separate solution then having multiple except clauses is the better solution.

If we are writing a program and we want the user to enter a number and then carry out some mathematical operation on this number, we will use the int() function to convert the data entered to an integer. There are two possible exceptions that can occur in this situation, namely:

TypeError: *when an operation or function is attempted that is invalid for the specified data type.*
ValueError: *values have the valid type of arguments, but the arguments have invalid values specified.*

The code below will catch both the ValueError and TypeError exception and will print the associated message. In the situation where the course of action is dependent on the type of error, then the solution below is applicable.

```
try:
    x=int(input("Enter a number: "))
except ValueError:
    print("You entered an incorrect value: ")
except TypeError:
    print("The data type is invalid ")


print("Continuing after the input ...")
```


9.5.3 The Optional Else Clause

The optional else clause is used when you only want to execute statements if no exceptions were raised in the try clause.

```
try:
    x=int(input("Enter a number: "))
except (ValueError, TypeError):
    print("Something went wrong")
else:
    print("Nothing went wrong")
```

Notice that if the user's input is valid, then Python will execute the optional else clause. Notice also that in the code snippet above, we have changed from using multiple except clauses to a single one with multiple exceptions (ValueError and TypeError).

9.5.4 The Try-Finally Statement

If we have multiple statements in the try block and one of the statements raises an exception before the end of the try block, the other statements in the try block will be executed. There are situations in which you want the entire try block to be executed, even if an exception was raised. It turns out that the try-finally statement will resolve this.

Syntax:

```
try:
    <block_to_execute>

finally:
    <finally_block>
```

<block_to_execute> is the originally intended code.
finally must block that; it will be executed regardless of any exception.

Example:

If we are writing a program that opens a file and do some calculations then close the file. It is a good idea to raise an exception after attempting to open the file. If an error occurs while trying to open the file, then the IOError exception is raised. Consider the code below.

```
try:
    test_file = open("example_file.txt", 'w')
    test_file.write("Some operations")
except IOError:
    print("File don't exist ...")
    test_file.close()
```

If we encounter an error while trying to write to the file, the IOError exception will be raised; the "except" clause will handle the exception and close the file. If no exception is raised, then the file will remain open, which is not good for our program. It turns out that the "try-finally" can help to solve this problem. Whenever we use the "try-finally" statement if an exception is raised, then execution is passed to the finally clause and then to the exception handler in the "except" section.

The code snippet below gives this solution.

```
try:
    test_file = open("example_file.txt", 'w')
    try:
        test_file.write("Some operations")
    finally:
        test_file.close()
except IOError:
    print("File don't exist ...")
```

Notice that if the write statement fails then the file will be closed.

Practice Exercise 9

1. What is a syntax error?

.....

2. Why are semantic or logical errors hard to spot?

.....

.....

3. What kind of error is in the code below?

```
def factorial(num):
    if num ==1:
        return 1
    else:
        return num * factorial(num)
```

.....

4. Correct the error in the function above so that it calculates the factorial of a given number. Factorial of n is *n* (n−1) * (n−2) * (n−3) * ..... 1*.

.....

.....

.....

.....

.....

5. What type of error is in the code below?

```
number = 1
while number< 13:
    print(number, " Squared is ", number*number)
```

.....

6. Correct the error so that the code prints the square numbers from 1 to 12.

.....

.....

.....

cont. overleaf

7. Use the grammar below to show how the interpreter parses the expression *8*2/1*

a. `expression → expression operator expression`
b. `expression → number`
c. `operator → +, -, *, /, %, ...`
d. `number → 0, 1, 2, 3, 4, ...`

.....

.....

.....

.....

8. Rewrite the code below so that if there are no exceptions while opening and writing to the file, then the file should close after the update.

```
try:
    test_file = open("new_file.txt", 'w')
    test_file.write("Some operations")
except IOError:
    print("File don't exist ...")
    test_file.close()
```

.....

.....

.....

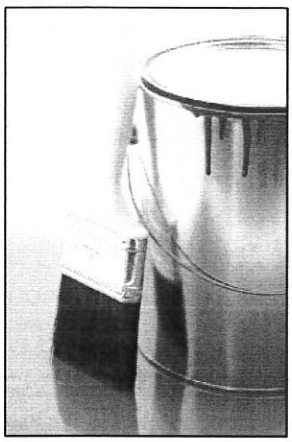
.....

.....

.....

Project Task

Decorating Company



John, a local decorator in your community, has approached you to keep track and cost of his jobs. He lays carpets for customers. He has to give his customers accurate quotes, after he has taken measurements. You are required to develop a computer system that will help him to do this.

Carpets

When a room measurement is taken, the length and the width are taken to find the area of carpet needed in square metres. He also supplies underlay to go under the carpet and gripper to run along the edge to hold the carpet in place. The underlay required is the same as the amount of carpet required. As the gripper goes around the edge of the carpet, the length of gripper required is the perimeter of the carpet.

Some rooms have bay windows, fireplaces and other obstacles; therefore John has to cut the carpet before laying. This does not reduce the price of the carpet. The table below shows the price structure.

Item	Price
Carpets	£22.50 per square metre
Underlay – First Step	£5.99 per square metre
Underlay – Monarch	£7.99 per square metre
Underlay – Royal	£60 per square metre
Gripper	£1.10 per metre

In addition to the raw material, John charges £65 for each hour worked as a minimum for all jobs. He estimates that it requires an hour for each 16 square metres; this is therefore calculated once the amount goes above 16 square metres.

The system should allow the user to:

1. Enter the customer's details
2. List all customers in the system – from this list you should have the ability to add new, delete a customer or view a quote linked to a certain customer
3. Add a new quote
4. List all quotations – with an itemised list of the material and labour costs for each job
5. Save customers and quotation details to an external file

For each customer the system should save:

- First name and surname
- Town
- Telephone number

Each quote consists of:

- A customer – the system should be able to add a new customer or select an existing customer when creating a quote
- The dimensions of the room (length, width)
- Select the type of underlay
- Calculate the overall cost

You should develop the part of the system that allows the user to save a quotation for later use.

Practice Exercises Solutions

Solutions for Practice Exercise 1

```
1)
print(30*24*60*60)

2)
print(365*24*60*60)

3) Use Python as a calculator.
print(84*45)
print(75/15)
print(90-34)
print(23+45)

4)
print( (414/150)*60)

5)
help("keyword")

6)
print(49/7)
print(8**2)
print(20%3)
print(17//3)
print(7**3)

7)
print(500*1.20)

b.
print(320/1.32)

8)
print((4/3)*22/7*10**3)

9) the expression 36/9-2 to get:
a. 2
print( (36/9)-2 )

b. 5.12
print( 36/(9-2) )
```

Solutions for Practice Exercise 2

```
1)
length = 18
width = 7
perimeter = (2*length) + (2*width)
print(perimeter)

2)
days_in_each_school_year = 192
print(5*days_in_each_school_year * 6)

3) What value will be stored in marks:
marks = 25
marks = marks + 10
print(marks)

4)
time_spent = 34
time_spent = time_spent +1
print(time_spent)

5)
Error   --> hours_in_a_day is not defined and
therefore will generate an error..

6) 24

7) False:  An expression can be assigned to a
variable.
#--> A variable can be assigned an
expression, not the other way around..

b)23

8) #4gs      &item        _age

9) By typing help() at the prompt.

10) c. days in a year = 365
```

Solutions for Practice Exercise 3

```
1)
quote = "Your favourite quotation"
print(quote)

2)
name="Patrick"
print(name)

3)
number1= int(input("Please enter the first number: "))
number2= int(input("Please enter the second number: "))
number3= int(input("Please enter the third number: "))

total = number1+number2+number3
print("The sum is ", total)
```



```
4)
name = input("What is your name: ")
age = int( input("How old are you?: "))
print("Hello ", name, ", please accept this warm message")

5)
x=34.67
print(type(x))

6) h

7) a

8)
title = "Python for key stage 4"
print(title[11:14])

9)
Name = "Benjamin"
print("Hello " + Name + ", Python is fun")

10)
"Python for key stage 4"
```

Solutions for Practice Exercise 4

```
1)
def double(num):
    return num*2

number = int(input("Please enter a number to double: "))
print(number, "doubled is ", double(number))


2)
def perimeter_of_rectange(length, width):
    return (2*length)+(2*width)

length = float(input("Please enter a length: "))
width = float(input("Please enter a width: "))

print(perimeter_of_rectange(length,width))

3)
def area_of_circle(r):
    return (22/7)*r**2

radius = float( input("Please enter the radius: "))
print("The area is ", area_of_circle(radius))

4)
def hello_three_times(name):
    print("hello ", name*3)

person = input("Please enter the person to say hello to: ")

print(hello_three_times(person))

5)
def head_name(word):
    return word[0]

name = input("Please enter your name: ")
print("The head of ", name, " is ", head_name(name))
```



```
6)
def tail_name(word):
    return word[1:len(word)]

name = input("Please enter your name: ")

print(tail_name(name))
```

7) Using functions makes our program code more readable. When we define a function we are actually naming a certain set of instructions that are performing a specific task, and therefore making our program code easier to read.

Functions can reduce our program code significantly by putting repetitive code into a function. Changes or adjustments can be made in one place.

Functions facilitate modular design. We can break down a large problem into manageable chunks, work on these chunks in functions, then put the entire working piece together for a working solution.

Functions can be placed into modules so that they can be reused.

8) Parameters are place holders that are used inside the function definition whereas arguments are the actual values that you send when calling the function.

```
9)
def power_value(base, index):
    return base**index

base = float(input("Enter the number for the base: "))
index = float(input("Enter the index: " ))

print("The power is ", power_value(base, index))

10)
def absolute_value(num):
    if num<0:
        return -num
    else:
        return num

print(absolute_value(-5))
print(absolute_value(0))
print(-absolute_value(-5))
```

Solutions for Practice Exercise 5

```
1)
number1 = int(input("Please enter the first number: "))
number2 = int(input("Please enter the second number: "))

if number1> number2:
    print("The larger number is ", number1)
else:
    print("The larger number is ",number2)


2)
score = int( input("Please enter your score: "))

if score>49:
    print("Pass")
else:
    print("Fail")
```



```
3)
score = int( input("Please enter your score: "))

if score>49:
    print("Pass")
    if score>79:
        print("Well Done")
else:
    print("Fail")
    if score <20:
        print("You need to try harder")

4)
score = int(input("Please enter your score: "))

if score> 79:
    print("Your grade is A")
else:
    if score>59:
        print("Your grade is B")
    else:
        if score>39:
            print("Your grade is C")
        else:
            if score>29:
                print("Your score is D")
            else:
                print("Your score is U")

5)
word = input("Please enter a word to find out the vowel worth: ")

def vowel_worth(word):
    value = 0
    for letter in word:
        if letter =='a':
            value = value + 5
        if letter =='e':
            value == value + 4
        if letter =='i':
            value = value + 3
        if letter =='o':
            value = value + 2
        if letter =='u':
            value = value+ 1
    return value

print("The value worth of ", word, " is ", vowel_worth(word))

6)
def larger(first, second):
    if first > second:
        return first
    else:
        return second

number1 = int(input("Please enter the first number: "))
number2 = int(input("Please enter the second number: "))

print("The larger is ",larger(number1, number2))
```



```
7)
def long_name(name):
    if len(name)>13:
        return True
    else:
        return False

test_name = input("Please enter the name to test: ")

print(long_name(test_name))

8)
def larger(first, second):
    if first > second:
        return first
    else:
        return second

def largest(first, second, third):
    return larger(larger(first, second), third)

print("The largest of 12, 45, and 90 is ", largest(12,45, 90) )

9)
def print_upto(number):
    for val in range(1,number+1):
        print(val)

num = int(input("Enter the number to print up to: "))

print(print_upto(num))

10)
def print_even_upto(number):
    for val in range(1,number+1):
        if val%2 ==0:
            print(val)

num = int(input("Enter the number to print up to: "))

print(print_even_upto(num))

11)
def magic_number(guess):
    number = 7
    while guess != number:
        if guess== number:
            print("Well done")
        else:
            if guess> number:
                print("Too high")
                guess = int(input("Please enter a guess: "))
            else:
                print("Too low")
                guess = int(input("Please enter a guess: "))

guess= int(input("Guess the number: "))

magic_number(guess)
```



```
12)
def magic_number(guess):
    number = 7
    count =0
    while (guess != number) and (count <5):
        if guess== number:
            print("Well done")
        else:
            if guess> number:
                count = count +1
                print("Too high")
                guess = int(input("Please enter a guess: "))
            else:
                count = count + 1
                print("Too low")
                guess = int(input("Please enter a guess: "))

guess= int(input("Guess the number: "))

magic_number(guess)

13)
def factorial(num):
    if num == 1:
        return 1
    else:
        return num * factorial(num-1)

number = int (input("Enter the number to find the factorial of: "))

print(factorial(number))
```

Solutions for Practice Exercise 6

```
1)
bank_holidays_in_month = [1, 0, 1, 1, 2, 0, 0, 1, 0, 0, 0, 2]

def bank_holiday(number):
    return bank_holidays_in_month[number-1]

month = int(input("Please enter the number of the month to return bank holidays for "))

print(bank_holiday(month))

2)
my_list = [56, 3, 89, 2, 34, 12]

def my_sort(l):
    sorted_list = False
    sorted_pos = len(l)-1

    print(l)
    while not sorted_list:
        sorted_list = True
        for index in range(sorted_pos):
            if my_list[index] > my_list[index +1]:
                sorted_list = False
                #Swap values
                my_list[index], my_list[index +1] = my_list[index +1], my_list[index]
                print(l)

my_sort(my_list)
print(my_list)
```



```
3)
my_list = [1, 2, 6, 89, 90]

def add_hello(l):
    return l.append("hello")

add_hello(my_list)

print(my_list)

4)
my_list = [150, 46, 69, 120, 36]

def discount_ten(l):
    for index in range(len(l)):
        l[index] = l[index]*1.1

discount_ten(my_list)
print(my_list)

5)
my_list = [12, 4,5, 3, 5, 34]

def remove_five(l):
    while 5 in l:
        l.remove(5)

remove_five(my_list)

print(my_list)

6)
def is_palindrome(word):
    end_pos = -1
    for index in range(int(len(word)/2)):
        if word[index] != word[end_pos]:
            return False
        else:
            end_pos = end_pos -1
    return True

test_word=input("Enter a word to test: ")
decision = is_palindrome(test_word)

print(decision)

7)
y= [ 1,2,2,3,3,4]
def unique_elements(l):
    x=[]
    for index in range(len(l)):
        test_value = l.pop()
        if test_value not in x:
            x.append(test_value)
    print(x)

unique_elements(y)

8)
z = [45, 67, 23, 56]

def backways(l):
    l.reverse()

backways(z)
print(z)
```



```
9)
z = [1, 3, 5, 7, 9, 10]

def sum_list(l):
    total =0
    for element in l:
        total = total + element
    return total

print(sum_list(z))

10)
z = [1, 3, 5, 7, 9, 10]

def sum_list(l):
    total =0
    for element in l:
        total = total + element
    return total

print(sum_list(z))

def mean_list(l):
    return sum_list(l)/len(l)

print(mean_list(z))

11)
z = [1, 3, 5, 7, 9, 10]

def sum_list(l):
    total =0
    for element in l:
        total = total + element
    return total

def mean_list(l):
    return sum_list(l)/len(l)

mean=mean_list(z)

def list_of_deviation(l):
    for index in range(len(l)):
        z[index] = z[index]- mean

list_of_deviation(z)

print(z)

12)
import math

z = [1, 4, 5, 7, 9, 20]

def sum_list(l):
    total =0
    for element in l:
        total = total + element
    return total

def mean_list(l):
    return sum_list(l)/len(l)

mean=mean_list(z)
```



```
#List of deviations
def list_of_deviation(l):
    for index in range(len(l)):
        l[index] = l[index]- mean

#Now square of deviations
def square_list(l):
    for index in range(len(l)):
        l[index] = l[index]*l[index]

def standard_dev(l):
    #mean=mean_list(l)
    list_of_deviation(l)
    square_list(l)
    variance = sum_list(l)
    return math.sqrt(variance/(len(l)-1))

std_dev = standard_dev(z)
print(std_dev)
```

Solutions for Practice Exercise 7

```
1a)
#Create a text file that shows the last five prime ministers in the UK
print("Writing text file")

# first open a file for writing
text_file = open("UKPrimeMinister.txt", "w")
text_file.write("Last five UK Prime Minister and term of office \n\n")
text_file.write("David Cameron       2010 - incumbent\n")
text_file.write("Gordon Brown        2007 - 2010\n")
text_file.write("Tony Blair          1997 - 2007\n")
text_file.write("John Major          1990 - 1997\n")
text_file.write("Margaret Thatcher   1979 - 1990\n")

text_file.close()

#now open the file and print the contents to the screen
text_file = open("UKPrimeMinister.txt", "r")
print(text_file.read())

#Finally close the file
text_file.close()
1b)
#Now write a python program that will read the file called UKPrimeMinister.txt
#that was created above and print the content to the screen.

print("Reading text file")

#now open the file and print the contents to the screen
text_file = open("UKPrimeMinister.txt", "r")
print(text_file.read())

#Finally close the file
text_file.close()

2)
a)Change the mode from 'w' to 'a'
    new_file = open(file_name, 'a')

b) update the range arguments to 0-3
for index in range(0,3):
```



```
3)
#we first import the sqlite3 library
import sqlite3

#Create a handler called new_db that connects to db on disk
new_db = sqlite3.connect('C:\\Users\\Devz\\PythonExercise\\Library.db')

#Create a new cursor object to manipulate the database
c=new_db.cursor()

#Now create a table called Students
c.execute('''CREATE TABLE Books
(book_isbn text,
book_title text,
book_type text,
book_author text,
publisher text)
''')

#insert data into our table
c.execute('''INSERT INTO Books
          VALUES ('978-0-340-88851-3', 'A2 Pure Mathematics', 'Non fictional',
          'Catherine Berry', 'Hodder Education')''')

c.execute('''INSERT INTO Books
          VALUES ('978-1-118-10227-5', 'Android 4 Application Development', 'Non fictional',
          'Reto Meier', 'Wiley')''')

c.execute('''INSERT INTO Books
          VALUES ('0-596-00699-3', 'Programming C#', 'Non fictional',
          'Jesse Liberty', 'O Reilly')''')

#Save changes using the commit() function
new_db.commit()

#Close the connection to the database
new_db.close()

#Re-connect to the database
new_db=sqlite3.connect('C:\\Users\\Devz\\PythonExercise\\Library.db')

#Create a cursor object
c=new_db.cursor()

#Use the SELECT statement with wildcard to select all columns
c.execute("SELECT * FROM Books")

#use the fetchone function to fetch one row of data
book_library=c.fetchall()

#print the row to the screen
for book in book_library:
    print(book)

#Finally close the connection
new_db.close()

4)  Displays the name, quantity and price from a table called Product of all items in the
    table, where the quantity is greater than 20.
```

Solutions for Practice Exercise 8

1)

```
class Time:
    """ The Time class defines a time with attributes:
    hour, minutes and second
    """
    def __init__(self, hour=12, minutes=0, seconds=0):
        self.hour = hour
        self.minutes = minutes
        self.seconds = seconds

    #Attributes
    hour = 12
    minutes = 0
    seconds =0

    def get_hour(self):
        return self.hour

    def get_minutes(self):
        return self.minutes

    def get_seconds(self):
        return self.seconds

    def print_time(self):
        print(self.get_hour(),":",self.get_minutes(),":",self.get_seconds())
    #and the mutator functions
    def set_hour(self, new_hour):
        self.hour, = new_hour

    def set_minutes(self, new_minutes):
        self.minutes = new_minutes

    def set_seconds(self, new_seconds):
        self.seconds = new_seconds

    def increment_seconds(self):
        if self.seconds == 59:
            self.seconds = 0
            self.minutes= self.minutes + 1
        else:
            self.seconds = self.seconds + 1

    def increment_minutes(self):
        if self.minutes == 59:
            self.minutes = 0
            self.hour = self.hour + 1
        else:
            self.minutes = self.minutes + 1

    def increment_hour(self):
        if self.hour == 12:
            self.hour = 1
        else:
            self.hour = self.hour + 1
```



```
2)
print("Creating two instances of time")
time1 = Time()  #Created with default values
time2 = Time(12,45,12)  #user defined time

print("Now print both times ")
print("Default time      --> ", time1.print_time())
print("User defined time -->", time2.print_time())

time1.increment_hour()
time1.increment_minutes()
time1.increment_hour()
print("After using increment functions")
time1.print_time()

time2.increment_hour()
time2.increment_minutes()
time2.increment_hour()
print("After using increment functions")
time2.print_time()

3) class fraction:
    """ The fraction class defines a fraction with attributes:
    numerator, and denominator
    """

    def __init__(self, numerator =0, denominator = 1):
        self.numerator = numerator
        self.denominator = denominator

    #Functions
    def get_numerator(self):
        return self.numerator

    def get_denominator(self):
        return self.denominator

    def print_fraction(self):
        print(self.get_numerator(), "/", self.get_denominator())

    def print_type(self):
        if self.get_numerator() > self.get_denominator():
            return "Improper"
        else:
            return "Proper"

    def set_numerator(self, new_numerator):
        self.numerator = new_numerator

    def set_denominator(self, new_denominator):
        self.denominator = new_denominator


  def inverse(self):
        temp = self.get_numerator()
        self.set_numerator(self.get_denominator())
        self.set_denominator(temp)
```



```
4)
#first create two fractions one with default values
# and the other with user defined values
fraction1 = fraction()
fraction2 = fraction(2,5)

#Now print the two fractions
fraction1.print_fraction()
fraction2.print_fraction()
print("fraction two is ", fraction2.print_type())

fraction2.inverse()
print("After the inverse fraction 2 is ", fraction2.print_type())
fraction2.print_fraction()
```

Solutions for Practice Exercise 9

1) A syntax error is one that breaks the grammar of the language. This occurs when the programmer uses a token (letter, symbol and operator) somewhere that is not defined in the grammar of the language.

2) Semantic or logical errors are difficult to spot because the interpreter will not report a problem to the programmer. The programmer will know that there is a problem whenever the result that they are getting is not what they are expecting. Further, some of these errors only occur under a given situation, which may not even occur during testing.

3) The error is a semantic error. The interpreter will run the program without generating an error, but the function will never compute the factorial of a given number as there is nothing in the function that is bringing the number close to its base case (number ==1). As it is written factorial(number) will keep multiplying a number by itself indefinitely.

```
4)
def factorial(num):
    if num ==1:
        return 1
    else:
        return num * factorial(num-1)
```

5) The error is a semantic error. There is no statement within the while loop to get the terminating condition (number>=13) to this condition, therefore the while loop will run forever, unless interrupted by some external exception.

```
6)
number = 1
while number< 13:
    print(number, " Squared is ", number*number)
    number = number+1

7)   8*2/1
expression
expression operator expression
number operator expression
8 operator expression
8 * expression
8 * expression operator expression
8 * number operator expression
8 * 2 operator expression
8 * 2 / expression
8 * 2 / number
8 * 2 / 1
```



```
8)
try:
    test_file = open("new_file.txt", 'w')
    try:
        test_file.write("Some operations")
    finally:
        test_file.close()
except IOError:
    print("File don't exist ...")
```


Project Task Solution

The solution uses the list data structure extensively and uses classes to store customer and quotation details. For the controlled assessment, you will need to show more in your solution, in particular you will need to show:

- An explanation of the problem – to demonstrate that you understand the problem that you are going to solve
- A plan
- Your proposed solution – pseudo code or flow chart
- Solution development, with annotated code

The solution below is a basic solution with some important features missing, in particular:

- There is no error detection and correction present. The solution assumes that the user will enter the correct data at all times. In particular, when the user is prompted for a number, it is assumed that a number will be entered and nothing else. This needs to be more robust for the actual controlled assessment.
- There is no data validation, for example, in entering length and width, a positive number could be validated.
- Whereas a list is a fast, effective way of storing and accessing data in the computer's memory in real life, it would be more realistic to save the details (customers, quotation) to a database for a more persistent store of data.
- Whereas the solution is meeting the client's need, it would be a better solution to store data, such as the price, in an external file so that the client can change the price from time to time.

The Customer Class

```
class customer():
    '''
    The customer class, storing the information for each customer:
    firstname, surname, town, address
    '''

    def __init__(self, firstname="First name", surname="surname", town="Town",
telephone="070 000 0000"):
        self.firstname=firstname
        self.surname = surname
        self.town = town
        self.telephone = telephone

    def get_firstname(self):
        return self.firstname

    def get_surname(self):
        return self.surname

    def get_town(self):
        return self.town

    def get_telephone(self):
        return self.telephone

    def print_customer(self):
        print("Name is  : ", self.firstname, self.surname)
        print("Town is  : ", self.town)
        print("Telephone: ", self.telephone)
```



```
    def set_firstname(self, new_name):
        self.firstname = new_name

    def set_surname(self, new_surname):
        self.surname = new_surname

    def set_town(self, new_town):
        self.town = new_town

    def set_telephone(self, new_telephone):
        self.telephone = new_telephone
```

The Quotation Class

```
from customer import customer

class quotation():
    '''
    Quotation is  class that stores the information for a quotation, each quote has
    a customer, quotation date, which is input automatically on creation
    dimensions (length and width), underlay_name. length of gripper,
    underlay_price, which is calculated based on underlay selected, and finally
    the total price.
    '''


    def __init__(self, customer, date, length, width, uname, gripper ):
        '''
        Constructor for quote.
        '''
        self.customer = customer
        self.quotation_date = date
        self.length=length
        self.width = width
        self.underlay_name = uname
        self.gripper = gripper
        self.underlay_price = self.set_underlay_price()
        self.total_price = self.set_total_price()

    def get_customer(self):
        return self.customer

    def get_quotation_date(self):
        return self.quotation_date

    def get_length(self):
        return self.length

    def get_width(self):
        return self.width

    def get_underlay_name(self):
        return self.underlay_name

    def get_underlay_price(self):
        return self.underlay_price

    def get_total_price(self):
        return self.total_price

    def get_gripper(self):
        return self.gripper
```



```
    #the print_quotation is used extensively to display the contents of the quote
    def print_quotation(self):
        print("Quotation Details ")
        print(self.customer.print_customer())
        print("Quotation date", self.quotation_date.day, "-",
              self.quotation_date.month, "-", self.quotation_date.year )
        print("Room measurement--> Length:", self.get_length(), "Width:",self.get_width(),
"Area -->",
              self.get_length()*self.get_width(),"sq. mts")
        print("Underlay",self.get_underlay_name())
        print("Underlay price", self.get_underlay_price())
        print("Total Price ", self.get_total_price())

    #Total price calculated to include cost for material, and labour cost
    def set_total_price(self):
        area = self.length*self.width
        if area >=16:
            labour_cost = (area/16) *65
        else:
            labour_cost = 65
        return (area*22.5)+(area*self.get_underlay_price())+labour_cost


    def set_underlay_price(self):
        if self.get_underlay_name() == "First Step":
            return 5.99
        else:
            if self.get_underlay_name() == "Monarch":
                return 7.99
            else:
                if self.get_underlay_name() == "Royal":
                    return 60
                else:
                    return 0

    def set_customer(self, new_customer):
        self.customer = new_customer

    def set_quotation_date(self, new_date):
        self.quotation_date = new_date

    def set_length(self, new_length):
        self.length = new_length

    def set_width(self, new_width):
        self.width = new_width

    def set_underlay_name(self, new_underlay_name):
        self.underlay_name = new_underlay_name
```

The Decorator's Driver File

```
from customer import customer
from quote import quotation
from datetime import datetime
import sys

customer_list = []
quotation_list = []

# main menu
def main_menu():
    print("Welcome to John's Decorating")
```

```
    print("You have the following options:\n")
    print("1)    Add a new customer")
    print("2)    List all customer")
    print("3)    Add a new quote")
    print("4)    List all Quotation")
    print("5)    Save customer details")
    print("6)    Save Quotation to file\n")
    print("0)    Exit")


    choice = int(input("Select one --> "))
    if choice == 1:
        add_customer()
    if choice ==2:
        list_all_customer()
    if choice ==3:
        add_a_quote()
    if choice ==4:
        list_all_quotations()
    if choice ==5:
        save_customer_details()
    if choice ==6:
        save_quotation()

    if choice ==0:
        print("Good bye ..............")
        sys.exit()

def save_quotation():

    print("Saving Quotations ...")
    file_name=input("Enter the file name to save in : ")
    file_name = file_name+"_quotations.txt"
    quote_file = open(file_name,'w')
    for quote in quotation_list:
        quote_file.write(quote.customer.get_firstname()+"\n")
        quote_file.write(str(quote.get_quotation_date())+ "\n")
        quote_file.write(str(quote.get_length())+ "\n")
        quote_file.write(str(quote.get_width())+ "\n")
        quote_file.write(quote.get_underlay_name()+ "\n")
        quote_file.write(str(quote.get_gripper())+ "\n")
        quote_file.write(str(quote.get_underlay_price())+ "\n")
        quote_file.write(str(quote.get_total_price())+ "\n")
    quote_file.close()

    print("File saved")
    main_menu()

#function used to save customers details
def save_customer_details():
    print("Saving Customers' Details ...")
    file_name=input("Enter the file name to save in : ")
    file_name = file_name+"_customers.txt"
    cust_file = open(file_name,'w')
    for cust in customer_list:
        cust_file.write(cust.get_firstname()+"\n")
        cust_file.write(cust.get_surname()+ "\n")
        cust_file.write(cust.get_town()+ "\n")
        cust_file.write(cust.get_telephone()+ "\n")
    cust_file.close()

    print("File saved")
    main_menu()
```



```
#function used to add a new customer, once confirmed save the customer in a
#customer list
def add_customer():
    print("Add customer")
    firstname = input("Enter the customer's first name: ")
    surname = input("Enter the customer's surname:  ")
    town=input("Enter the customer's town: ")
    telephone = input("Please enter the customer's telephone number: ")
    customer1 = customer(firstname, surname,town, telephone)
    customer1.print_customer()
    customer_list.append(customer1)
    print("Customer added successfully ...")
    another = input("Would you like to add another? yes [y]  or no [n] --> ")
    if another=='y':
        add_customer()
    else:
        main_menu()


#list all the quotation in the system
def list_all_quotations():
    number =1
    for quote in quotation_list:
        print("Quotation " , str(number))
        quote.print_quotation()
        number = number +1
        print("\n")

    print("[A] Add new    [D] Delete      [B] Back")
    choice=input("-->")
    if choice=='a' or choice=='A':
        add_a_quote()
    else:
        if choice=='d' or choice=='D':
            print("Enter the quotation number to delete")
            quote_num = int(input("--> "))
            quote = quotation_list[quote_num-1]
            print("Are you sure you want to delete: ")
            quote.print_quotation()
            choice = input("[Y] Yes    [N] No")
            if choice =='y' or choice =='Y':
                quotation_list.remove(quote)
                print("Quotation removed ")
                main_menu()
            else:
                list_all_quotations()
        else:
            main_menu()

def list_all_customer():
    number =1
    for cust in customer_list:
        print("Customer" , str(number))
        cust.print_customer()
        number = number +1
        print("\n")

    print("[A] Add new    [D] Delete   [V] View Quote for customer     [B] Back")

    choice = input("What would you like to do --> ")
    if choice == 'a' or choice=='A':
        add_customer()
    else:
        if choice =='d' or choice =='D':
```



```
            delete_customer()
        else:
            if choice == 'v' or choice =="V":
                view_quote()
            else:
                main_menu()

def add_a_quote():
    print("Add new Quote")
    print("[N] New customer     [E] Exiting customer")
    choice=input("-->")
    if choice == 'n' or choice == 'N':
        customer1 = add_customer_for_quote()
    else:
        customer1 = search_for_existing_customer()

    length = int(input("Enter the length: "))
    width = int(input("Enter the width: "))
    print("Underlay Choice")
    print("[F] First Step (5.99)   [M] Monarch (7.99)     [R] Royal (60)")
    choice=input("-->")
    if choice == 'f' or choice =='F':
        uname = "First Step"
    else:
        if choice =='m' or choice =='M':
            uname="Monarch"
        else:
            uname="Royal"
    gripper = 2*length + 2*width
    quotation1 = quotation(customer1, datetime.now(), length, width, uname, gripper)
    quotation1.print_quotation()
    print("[A] Add    [D] Delete")
    choice=input("-->")
    if choice=='a' or choice =='A':
        quotation_list.append(quotation1)
        print("Quote added successfully")
        main_menu()
    else:
        main_menu()

def add_customer_for_quote():
    print("Add customer For new Quote")
    firstname = input("Enter the customer's first name: ")
    surname = input("Enter the customer's surname:  ")
    town=input("Enter the customer's town: ")
    telephone = input("Please enter the customer's telephone number: ")
    customer1 = customer(firstname, surname,town, telephone)
    #customer1.print_customer()
    customer_list.append(customer1)
    return customer1

def search_for_existing_customer():
    number =1
    print("Here is a list of all customers ")
    for cust in customer_list:
        print("Customer" , str(number))
        cust.print_customer()
        number = number +1
        print("\n")
    print("enter the customer number to add a quote for ")
    cust_number=int(input("-->"))
    customer1=customer_list[cust_number-1]
    return customer1
```

```
def delete_customer():
    print("Delete Customer")
    cust_number=int(input("Enter the customer number to delete --> "))
    customer1 = customer_list[cust_number-1]
    print("Customer")
    customer1.print_customer()
    print("Are you sure you want to delete [Y] Yes    [N] No")
    choice = input("--> ")
    if choice =='y' or choice=='Y':
        customer_list.remove(customer1)
        print("Customer information Deleted  ...")
    main_menu()

def view_quote():
    print("View Quote")
    print("Enter the customer's number to view quote")
    choice = int(input("-->"))
    customer1=customer_list[choice-1]

    #Create a dummy quote, just in case the customer do not have a quote saved
    target_quote = quotation(customer1, datetime.now(), 0, 0, "dummy", 0 )
    #Now search for the quotation with the customer
    for quote in quotation_list:
        if quote.customer == customer1:
            target_quote = quote
    if target_quote.get_underlay_name() == "dummy":
        print("Sorry", customer1.get_firstname(), "does not have a quote ")
        print("Here is a list of all your customers")
        list_all_customer()
    else:
        target_quote.print_quotation()
        choice=input("continue --> ")
        main_menu()

main_menu()
```


Glossary

Absolute path	A path that gives the specific location of a file system regardless of where the address is given from. This should contain the root directory and all other subdirectories to get to a file.
Algorithm	A collection of unambiguous and executable operations to perform some task in a finite amount of time.
Abstract data type (ADT)	These are new data types that numerous operations are defined on.
Argument	These are the actual values that are supplied during the function call. The arguments are then matched with the parameter in the function prototype.
Attributes	Data items that an object possesses.
Boolean	This is a data type having two values, usually denoted true or false.
Built-in function	These are functions made within an application and can be accessed by the end users.
Calculation	Any mathematical operations done with numbers.
Class	It is a user-defined data type that is made up of attributes and methods (these are known as ADT).
Compilers	These create object codes which are passed on to the executors to be interpreted
Computer science	The study of the design of algorithms, their properties and linguistic and mechanical realisation.
Control structures	Blocks of code that dictate the flow of control within a program.
Database	This is a collection of tables that store data.
Data Encapsulation	This is information hiding. It involves reusing codes in a previously defined class. The user does not have to know the attributes or methods of the defined class.
Data types	The range of values that can be stored and the kinds of operation (addition, subtraction, comparison, concatenation, etc.) that are possible on a given variable.
DBMS	Database Management System – software used to arrange tables in a systematic manner.
Directory structure	The way in which an operating system displays its files to the user.
Exception	This is when an error occurs in a program. This can be a programmer or software error.
Expressions	A combination of operator and operations that evaluate to a value.
Float	A data type made up of numbers that have a decimal place.
Function	These are blocks of code that perform a specific task.
Integer	This is a data type made up of any positive or negative whole number.
Interactive mode	A mode in Python where instructions are typed at the Python prompt and an individual line of instruction is executed at a time.

Interpreters	These take each line, translate and execute the translated line, before turning their attention to the other line.
List	This is a mutable collection of data items which can be of the same or different data types.
Object	This is a thing or an event in our application.
Object-oriented programming	A type of programming that defines the data type and functions of a data structure.
Parameter	These are the place holders that are used in defining the function prototype.
Program code	The set of instructions normally written in high-level programming language that the computer follows to complete a task.
Programming paradigm	Different disciplines and principles involved in programming.
Python	Python is an interpreted, general purpose programming language which conforms to multiple ways of programming.
Query	A question that is asked of the database.
Quotient	This is the number of times one quantity can be divided by another quantity. It is the result of a division.
Recursive	A rule or a procedure that can be applied repeatedly.
Relative path	This starts the path by using the current directory.
Runtime error	An error that occurs during the execution of a program.
Script	A program that is normally interpreted, stored as a file.
Semantics	An error in the logics of the program. It encompasses the meaning of the program and its output.
SQL	Structured Query Language – the universal language used to create and manipulate databases.
Statements	This is used to store the value of an expression in a variable.
String	This a data type made up of characters. These can be letters, numbers and symbols.
Syntax	An error of language; usually the code does not conform to the grammar of the language.
Values	Any literal that can be stored in a memory location.
Variables	A named memory location.

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