LATEST UPDATE

The Complete Manual Series

Python

Coding & Programming

The essential step-by-step manual to improving your Python coding skills

OVER 805 GUIDES & TIPS

OVER 160 PAGES!

100% Independent

SEP 2022 EDITION

Want to master your Code?

Then don't miss our NEW Programming & Coding magazine on Readly now!

Click our handy link to read now: https://bit.ly/3OcL1zx

The Complete Manual Series

Python

Coding & Programming

Unlock your imagination with Python...

There are few coding languages that have enjoyed the success of Python. Thanks to Python's unique development, everyone can learn the code that is: helping to drive such technological projects as the Large Hadron Collider, collating the petabytes of data that made up the first image of a Black Hole and creating the next generation of Artificial Intelligence. It doesn't take long to get to grips with Python, but you need to start small. This guide will help you form the foundation of your Python coding future, from installing the language on to your computer, through to forming user interaction and complex variables. There's so much you can do with Python and within these pages you'll find everything you need to know to become a Python programmer, ready for the next level of advanced coding.

Whether you're looking to learn Python for future career prospects, or just have some fun and discover something new, our step-by-step tutorials and guides will give you that much-needed foothold to help you on your way.

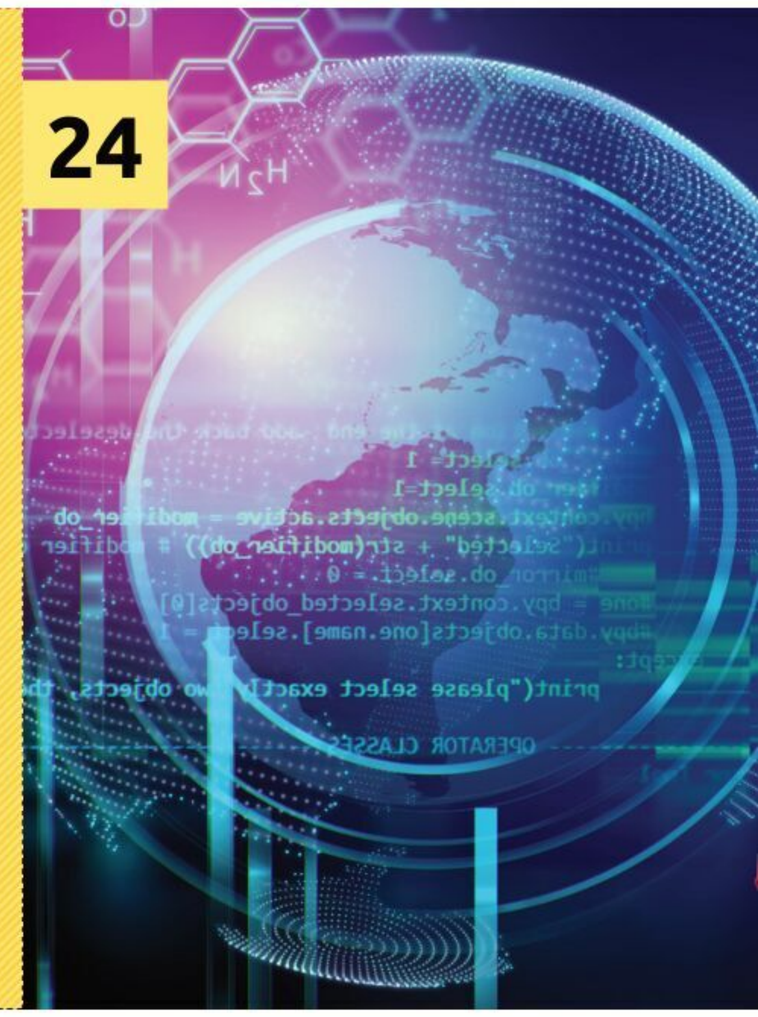
So let's dive in and start coding with Python.

Contents

6 Getting Started

8 Being a Programmer
10 A Brief History of Coding
12 What can You Do with Python?
14 Python in Numbers
16 Why Python?
18 Python on the Pi
20 Using Virtual Machines
22 Creating a Coding Platform

Hello World



24

26 Equipment You Will Need
28 Getting to Know Python
30 How to Set Up Python in Windows
32 How to Set Up Python in Linux
34 Starting Python for the First Time
36 Your First Code
38 Saving and Executing Your Code
40 Executing Code from the Command Line
42 Numbers and Expressions
44 Using Comments
46 Working with Variables
48 User Input
50 Creating Functions
52 Conditions and Loops
54 Python Modules
56 Python Errors
58 Combining What You Know So Far
60 Python in Focus: Stitching Black Holes

62 Working with Data

64 Lists
66 Tuples
68 Dictionaries
70 Splitting and Joining Strings
72 Formatting Strings
74 Date and Time
76 Opening Files
78 Writing to Files
80 Exceptions
82 Python Graphics
84 Combining What You Know So Far
86 Python in Focus: Gaming

Contents

Master Python, C++, Linux & Raspberry Pi with the help of our fantastic Coding Manuals!

Visit us at: www.pclpublications.com

Using Modules

88

90 Calendar Module
92 OS Module
94 Using the Math Module
96 Random Module
98 Tkinter Module
100 Pygame Module
104 Basic Animation
106 Create Your Own Modules
108 Python in Focus: Artificial Intelligence

Code Repository

110

112 Python File Manager
114 Number Guessing Game
116 Random Number Generator
117 Random Password Generator
118 Text to Binary Convertor
120 Basic GUI File Browser
122 Mouse Controlled Turtle
123 Python Alarm Clock
124 Vertically Scrolling Text
126 Python Digital Clock
128 Playing Music with the Winsound Module
130 Text Adventure Script
132 Python Scrolling Ticker Script
133 Simple Python Calculator
134 Hangman Game Script

Understanding Linux

136

138 What is Linux?
140 Using the Filesystem
142 Listing and Moving Files
144 Creating and Deleting Files
146 Create and Remove Directories
148 Copying, Moving and Renaming Files
150 Useful System and Disk Commands
152 Using the Man Pages
154 Editing Text Files
156 Linux Tips and Tricks
158 A-Z of Linux Commands
160 Glossary of Python Terms

Getting Started

Python is a high-level, general-purpose programming language that was developed by Guido van Rossum in the late eighties and is based upon a number of other languages, while being the successor to the popular ABC language.

It has been devised to work on a human level, so it's readable and understandable without needing to delve into obscure volumes of machine code, hexadecimal characters, or even ones and zeros. It's clear, logical, comprehensive, powerful and functional, yet also easy to follow and learn.

You will find Python at the heart of some of the most interesting and cutting-edge technologies in the world. It's the code that binds supercomputer algorithms together; it's used in the space industry, and in science and engineering. AI, and the likes of Alexa and Siri, Cortana and the Google Assistant all utilise Python for their powerful voice recognition technology. It's simply an amazing, versatile and incredible language to learn.

So let's get started and explore what you need to become a Python programmer.

8	Being a Programmer
10	A Brief History of Coding
12	What can You Do with Python?
14	Python in Numbers
16	Why Python?
18	Python on the Pi
20	Using Virtual Machines
22	Creating a Coding Platform

Being a Programmer

Programmer, developer, coder, they're all titles for the same occupation, someone who creates code. What they're creating the code for can be anything from a video game to a critical element on-board the International Space Station. How do you become a programmer though?

Times have changed since programming in the '80s, but the core values still remain.

"It's up to you how far to take your coding adventure!"

```
1   #include<stdio.h>
2   #include<dos.h>
3   #include<stdlib.h>
4   #include<conio.h>
5   void getup()
6   {
7       textcolor(BLACK);
8       textbackground(15);
9       clrscr();
10      window(10,2,70,3);
11      cprintf("Press X to Exit, Press Space to Jump");
12      window(62,2,80,3);
13      cprintf("SCORE : ");
14      window(1,25,80,25);
15      for(int x=0;x<79;x++)
16      cprintf("n");
17      textcolor(0);
18  }
19
20  int t,speed=40;
21  void ds(int jump=0)
22  {
23      static int a=1;
24
25      if(jump==0)
26          t=0;
27      else if(jump==2)
28          t--;
29      else t++;
30      window(2,15-t,18,25);
31      cprintf("                    ");
32      cprintf("          мллллллм");
33      cprintf("          лллллллл");
34      cprintf("          лллллнпп");
35      cprintf(" л       мллллнпп ");
36      cprintf(" ллм  мллллллммм ");
37      cprintf(" пллллллллллл  п ");
38      cprintf("   пллллллллп     ");
39      if(jump==1 || jump==2){
40      cprintf("    ллп пл        ");
41      cprintf("    лм   лм       ");
42      }else if(a==1)
43      {
44      cprintf("    пллп  ппп     ");
45      cprintf("      лм          ");
46      a=2;
47      }
48      else if(a==2)
49      {
50      cprintf("     плм пл       ");
51      cprintf("           лм     ");
52      a=1;
53      }
54      cprintf("                  ");
55      delay(speed);
56  }
57  void obj()
58  {
```

Being able to follow a logical pattern and see an end result is one of the most valued skills of a programmer.

MORE THAN CODE

For those of you old enough to remember the '80s, the golden era of home computing, the world of computing was a very different scene to how it is today. 8-bit computers that you could purchase as a whole, as opposed to being in kit form and you having to solder the parts together, were the stuff of dreams; and getting your hands on one was sheer bliss contained within a large plastic box. However, it wasn't so much the new technology that computers then offered, moreover it was the fact that for the first time ever, you could control what was being viewed on the 'television'.

Instead of simply playing one of the thousands of games available at the time, many users decided they wanted to create their own content, their own games; or simply something that could help them with their homework or home finances. The simplicity of the 8-bit home computer meant that creating something from a few lines of BASIC code was achievable and so the first generation of home-bred programmer was born.

From that point on, programming expanded exponentially. It wasn't long before the bedroom coder was a thing of the past and huge teams of designers, coders, artists and musicians were involved in making a single game. This of course led to the programmer becoming more than simply someone who could fashion a sprite on the screen and make it move at the press of a key.

Naturally, time has moved on and with it the technology that we use. However, the fundamentals of programming remain the same; but what exactly does it take to be a programmer?

The single most common trait of any programmer, regardless of what they're doing, is the ability to see a logical pattern. By this we mean someone who can logically follow something from start to finish and envisage the intended outcome. While you may not feel you're such a person, it is possible to train your brain into this way of thinking. Yes, it takes time but once you start to think in this particular way you will be able to construct and follow code.

Second to logic is an understanding of mathematics. You don't have to be at a genius level but you do need to understand the rudiments of maths. Maths is all about being able to solve a problem and code mostly falls under the umbrella of mathematics.

Being able to see the big picture is certainly beneficial for the modern programmer. Undoubtedly, as a programmer, you will be part of a team of other programmers, and more than likely part of an even bigger team of designers, all of whom are creating a final product. While you may only be expected to create a small element of that final product, being able to understand what everyone else is doing will help you create something that's ultimately better than simply being locked in your own coding cubicle.

Finally, there's also a level of creativity needed to be a good programmer. Again though, you don't need to be a creative genius, just have the imagination to be able to see the end product and how the user will interact with it.

There is of course a lot more involved in being a programmer, including learning the actual code itself. However, with time, patience and the determination to learn, anyone can become a programmer. Whether you want to be part of a triple-A video game team or simply create an automated routine to make your computing life easier, it's up to you how far to take your coding adventure!

A Brief History of Coding

It's easy to think that programming a machine to automate a process, or calculate a value, is a modern concept that's only really happened in the last fifty years or so. However, that assumption is quite wrong, coding has actually been around for quite some time.

01000011 01101111 01100100 01101001 01101110 01100111

Essentially all forms of coding are made up of ones and zeros - on or off states. This works for both a modern computer and even the oldest known computational device.

~87 BC

It's difficult to pinpoint an exact start of when humans began to 'program' a device. However, it's widely accepted that the Antikythera Mechanism is possibly the first 'coded' artefact. It's dated to about 87 BC and is an ancient Greek analogue computer and orrery used to predict astronomical positions.

~850 AD

The Banū Mūsā brothers, three Persian scholars who worked in the House of Wisdom in Baghdad, published the Book of Ingenious Devices in around 850 AD. Among the inventions listed was a mechanical musical instrument: a hydro-powered organ that played interchangeable cylinders automatically.

1800

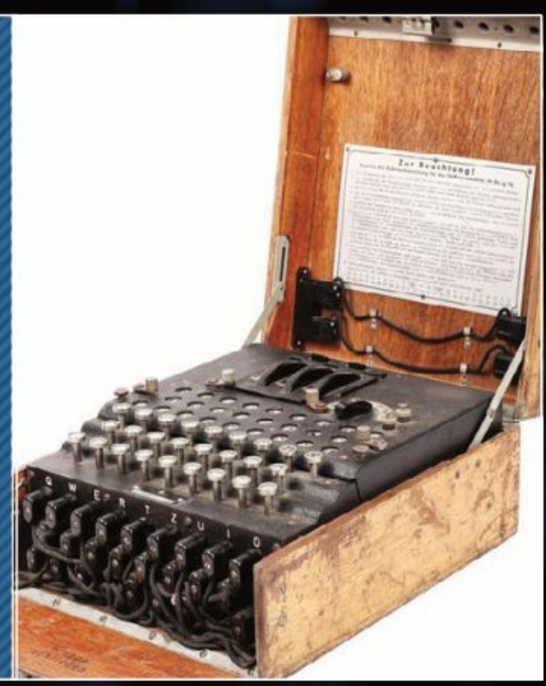
Joseph Marie Jacquard invents a programmable loom, which used cards with punched holes to create the textile design. However, it is thought that he based his design on a previous automated weaving process from 1725, by Basile Bouchon.

1842-1843

Ada Lovelace translated the memoirs of the Italian mathematician, Francis Maneclang, regarding Charles Babbage's Analytical Engine. She made copious notes within her writing, detailing a method of calculating Bernoulli Numbers using the engine. This is recognised as the first computer program. Not bad, considering there were no computers available at the time.

1930-1950

During the Second World War, significant advances were made in programmable machines. Most notably, the cryptographic machines used to decipher military codes used by the Nazis. The Enigma was invented by the German engineer Arthur Scherbius, but was made famous by Alan Turing at Bletchley Park's codebreaking centre.



From the 1970s, the development of the likes of C, SQL, C with Classes (C++), MATLAB, Common Lisp and more, came to the fore. The '80s was undoubtedly the golden age of the home computer, a time when silicon processors were cheap enough for ordinary folk to buy. This led to a boom in home/bedroom coders with the rise of 8-bit machines.

1951-1958

```
MONITOR FOR 6802 1.4          9-14-80  TSC ASSEMBLER  PAGE    2

C000                    ORG    ROM+$0000 BEGIN MONITOR
C000 8E 00 70  START    LDS    #STACK

                 ****************************************
                 * FUNCTION: INITA - Initialize ACIA
                 * INPUT: none
                 * OUTPUT: none
                 * CALLS: none
                 * DESTROYS: acc A

0013             RESETA EQU    %00010011
0011             CTLREG EQU    %00010001

C003 86 13       INITA  LDA A  #RESETA   RESET ACIA
C005 B7 80 04           STA A  ACIA
C008 86 11              LDA A  #CTLREG  SET 8 BITS AND 2 STOP
C00A B7 80 04           STA A  ACIA

C00D 7E C0 F1           JMP    SIGNON   GO TO START OF MONITOR

                 ****************************************
                 * FUNCTION: INCH - Input character
                 * INPUT: none
                 * OUTPUT: char in acc A
                 * DESTROYS: acc A
                 * CALLS: none
                 * DESCRIPTION: Gets 1 character from terminal

C010 B6 80 04  INCH    LDA A  ACIA      GET STATUS
C013 47                ASR A            SHIFT RDRF FLAG INTO CARRY
C014 24 FA             BCC    INCH      RECIEVE NOT READY
C016 B6 80 05          LDA A  ACIA+1    GET CHAR
C019 84 7F             AND A  #$7F      MASK PARITY
C01B 7E C0 79          JMP    OUTCH     ECHO & RTS

                 ****************************************
                 * FUNCTION: INHEX - INPUT HEX DIGIT
                 * INPUT: none
                 * OUTPUT: Digit in acc A
                 * CALLS: INCH
                 * DESTROYS: acc A
                 * Returns to monitor if not HEX input

C01E 8D F0     INHEX   BSR    INCH      GET A CHAR
C020 81 30             CMP A  #'0       ZERO
C022 2B 11             BMI    HEXERR    NOT HEX
C024 81 39             CMP A  #'9       NINE
C026 2F 0A             BLE    HEXRTS    GOOD HEX
C028 81 41             CMP A  #'A
C02A 2B 09             BMI    HEXERR    NOT HEX
C02C 81 46             CMP A  #'F
C02E 2E 05             BGT    HEXERR
C030 80 07             SUB A  #7        FIX A-F
C032 84 0F     HEXRTS  AND A  #$0F      CONVERT ASCII TO DIGIT
C034 39                RTS

C035 7E C0 AF  HEXERR  JMP    CTRL      RETURN TO CONTROL LOOP
```

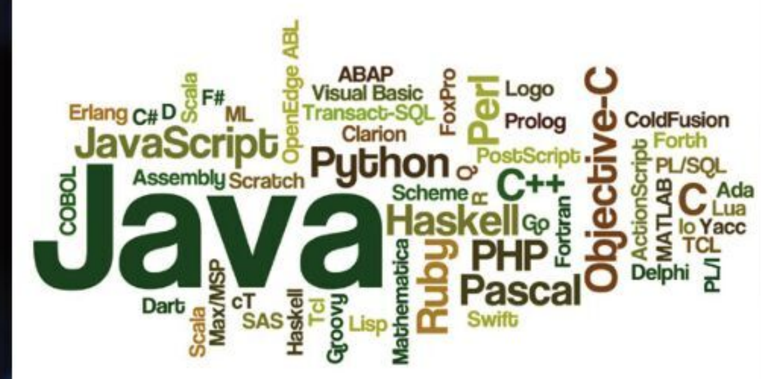
The first true computer code was Assembly Language (ASM) or Regional Assembly Language. ASM was specific to the architecture of the machine on which it was being used. In 1951, programming languages fell under the generic term Autocode. Soon languages such as IPL, FORTRAN and ALGOL 58 were developed.

1959

Computer programming was mainly utilised by universities, the military and big corporations during the '60s and the '70s. A notable step toward a more user-friendly, or home user, language was the development of BASIC (Beginners All-purpose Symbolic Instruction Code) in the mid-sixties.

```
 10 INPUT "What is your name: "; U$
 20 PRINT "Hello "; U$
 25 REM
 30 INPUT "How many stars do you want: "; N
 35 S$ = ""
 40 FOR I = 1 TO N
 50 S$ = S$ + "*"
 55 NEXT I
 60 PRINT S$
 65 REM
 70 INPUT "Do you want more stars? "; A$
 80 IF LEN(A$) = 0 THEN GOTO 70
 90 A$ = LEFT$(A$, 1)
100 IF (A$ = "Y") OR (A$ = "y") THEN GOTO 30
110 PRINT "Goodbye ";
120 FOR I = 1 TO 200
130 PRINT U$; " ";
140 NEXT I
150 PRINT
```

1960-1970



The Internet age brought a wealth of new programming languages and allowed people access to the tools and knowledge needed to learn coding in a better way. Not only could a user learn how to code, they could also freely share their code and source other code to improve their own.

1970-1985

1990s-Present Day

Admiral Grace Hopper was part of the team that developed the UNIVAC I computer and she eventually developed a compiler for it. In time, the compiler she developed became COBOL (Common Business-oriented Language), a computer language that's still in use today.

What can You Do with Python?

Python is an open-source, object-oriented programming language that's simple to understand and write, yet also powerful and extremely malleable. It's these characteristics that help make it such an important language to learn.

Python's ability to create highly readable code within a small set of instructions has a considerable impact on our modern digital world. From the ideal, first programmers' choice to its ability to create interactive stories and games; from scientific applications to artificial Intelligence and web-based applications, the only limit to Python is the imagination of the person coding in it.

It's Python's malleable design that makes it an ideal language for many different situations and roles. Even certain aspects of the coding world, that require more efficient code, still use Python. For example, NASA utilises Python both as a stand-alone language and as a bridge between other programming languages. This way, NASA scientists and engineers are able to get to the data they need without having to cross multiple language barriers; Python fills the gaps and provides the means to get the job done. You'll find lots of examples of this, where Python is acting behind the scenes. This is why it's such an important language to learn.

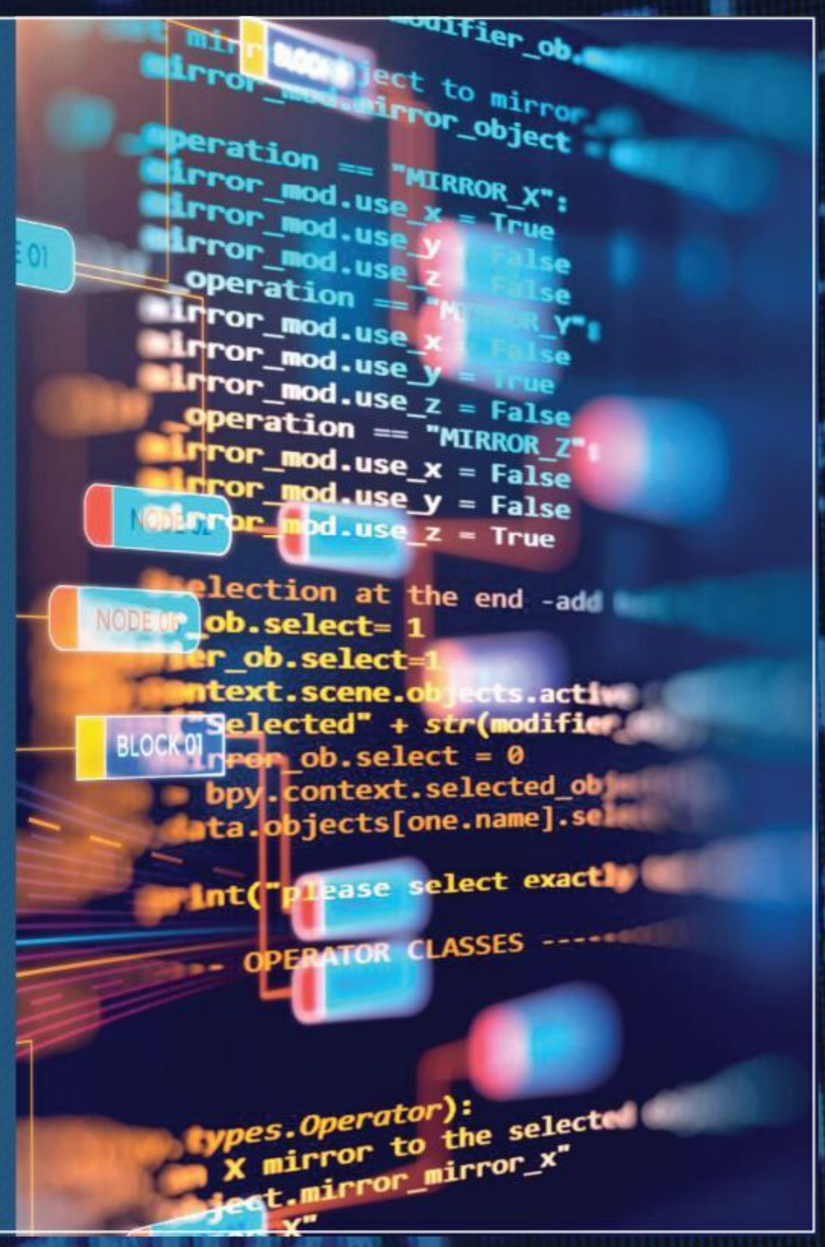
```
Beautiful is better than ugly.
Explicit is better than implicit.
Simple is better than complex.
Complex is better than complicated.
Flat is better than nested.
Sparse is better than dense.
Readability counts.
Special cases aren't special enough to break the rules.
Although practicality beats purity.
Errors should never pass silently.
Unless explicitly silenced.
In the face of ambiguity, refuse the temptation to guess.
There should be one-- and preferably only one --obvious way to do it.
Although that way may not be obvious at first unless you're Dutch.
Now is better than never.
Although never is often better than *right* now.
If the implementation is hard to explain, it's a bad idea.
If the implementation is easy to explain, it may be a good idea.
Namespaces are one honking great idea -- let's do more of those!
```

BIG DATA

Big data is a buzzword you're likely to have come across in the last couple of years. Basically, it means extremely large data sets that are available for analysis to reveal patterns, trends and interactions between humans, society and technology. Of course, it's not just limited to those areas, big data is currently being used in a variety of industries, from social media to health and welfare, engineering to space exploration and beyond.

Python plays a substantial role in the world of big data. It's extensively used to analyse huge chunks of the available big data and extract specific information based on what the user/company requires from the wealth of numbers present. Thanks to an impressive set of data processing libraries, Python makes the act of getting to the data, in amongst the numbers, that counts and presenting it in a fashion that's readable and useable for humans.

There are countless libraries and freely available modules that enable fast, secure and more importantly, accurate processing of data from the likes of supercomputing clusters. For example, CERN uses a custom Python module to help analyse the 600 million collisions per second that the Large Hadron Collider (LHC) produces. A different language handles the raw data, but Python is present to help sift through the data so scientists can get to the content they want without the need to learn a far more complex programming language.



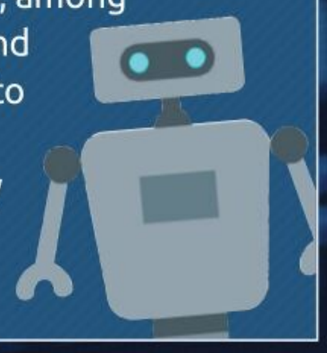
ARTIFICIAL INTELLIGENCE

Artificial Intelligence and Machine Learning are two of the most groundbreaking aspects of modern computing. AI is the umbrella term used for any computing process wherein the machine is doing something intelligent, working and reacting in similar ways to humans. Machine Learning is a subset of AI and provides the overall AI system with the ability to learn from its experiences.

However, AI isn't simply the creation of autonomous robots intent on wiping out human civilisation. Indeed, AI can be found in a variety of day-to-day computing applications where the 'machine', or more accurately the code, needs to learn from the actions of some form of input and anticipate what the input is likely to require, or do, next.

This model can be applied to Facebook, Google, Twitter, Instagram and so on. Have you ever looked up a celebrity on Instagram and then discovered that your searches within other social media platforms are now specifically targeted toward similar celebrities? This is a prime example of using AI in targeted advertising and behind the code and algorithms that predict what you're looking for, is Python.

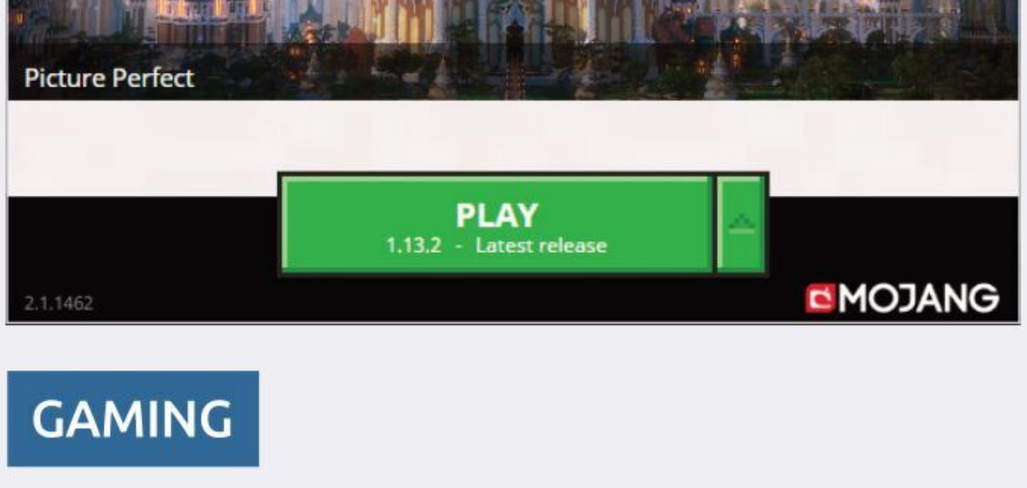
Spotify, for example, uses Python based code, among other things, to analyse your musical habits and offer playlists based on what you've listened to in the past. It's all clever stuff and, moving forward, Python is at the forefront of the way the Internet will work in the future.



WEB DEVELOPMENT

Web development has moved on considerably since the early days of HTML scripting in a limited text editor. The many frameworks and web management services available now means that building a page has become increasingly complex.

With Python, the web developer has the ability to create dynamic and highly secure web apps, enabling interaction with other web services and apps such as Instagram and Pinterest. Python also allows the collection of data from other websites and even apps built within other websites.



GAMING

Although you won't find too many triple-A rated games coded using Python, you may be surprised to learn that Python is used as an extra on many of the high-ranking modern games.

The main use of Python in gaming comes in the form of scripting, where a Python script can add customisations to the core game engine. Many map editors are Python compatible and you will also come across it if you build any mods for games, such as The Sims.

A lot of the online, MMORPG (Massively Multiplayer Online Role-Playing Game) games available utilise Python as a companion language for the server-side elements. These include: code to search for potential cheating, load balancing across the game's servers, player skill matchmaking and to check whether the player's client-side game matches the server's versions. There's also a Python module that can be included in a Minecraft server, enabling the server admin to add blocks, send messages and automate a lot of the background complexities of the game.

PYTHON EVERYWHERE

As you can see, Python is quite a versatile programming language. By learning Python, you are creating a well-rounded skillset that's able to take you into the next generation of computing, either professionally or simply as a hobbyist.

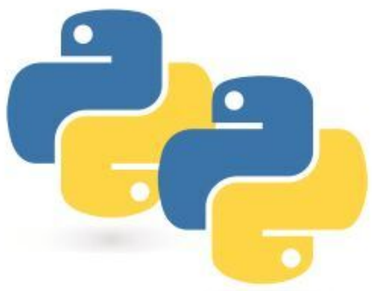
Whatever route you decide to take on your coding journey, you will do well to have Python in your corner.

PYTHON in NUMBERS

There's a lot to like about Python, but don't just take our word for it. Here are some amazing facts and figures surrounding one of the most popular programming languages of recent years.

Python creator **Guido Van Rossum** named Python after reading scripts from **Monty Python's Flying Circus.**

Alexa, Amazon's Virtual Personal Assistant, uses Python to help with speech recognition.



Data analysis and Machine Learning are the two most used Python examples.

As of the end of 2018, Python was the most discussed language on the Internet.

PYTHON AND LINUX SKILLS ARE THE THIRD MOST POPULAR I.T. SKILLS IN THE UK.

Disney Pixar uses Python in its Renderman software to operate between other graphics packages.

OVER 75% OF RECOMMENDED CONTENT FROM NETFLIX IS GENERATED FROM MACHINE LEARNING – CODED BY PYTHON.

90% OF ALL FACEBOOK POSTS ARE FILTERED THROUGH PYTHON-CODED MACHINE LEARNING.

IT'S ESTIMATED THAT OVER 75% OF NASA'S WORKFLOW AUTOMATION SYSTEMS ON-BOARD THE I.S.S. USE PYTHON.

16,000

There are over 16,000 Python jobs posted every six months in the UK.

PYTHON SKILL-BASED POSITIONS ARE THE 16th MOST SOUGHT-AFTER JOBS IN THE UK.

Python Data Science is thought to become the most sought-after job in the coming years.

Google is the top company for hiring Python developers, closely followed by Microsoft.

Data Science, Blockchain and Machine Learning are the fastest growing Python coding skills.

New York and San Francisco are the top Python developer cities in the world.

Python developers enjoy an average salary of

£60,000

95%

95% OF ALL BEGINNER CODERS START WITH AND STILL USE, PYTHON AS THEIR PRIMARY OR SECONDARY LANGUAGE.

75%

75% OF ALL PYTHON DEVELOPERS USE PYTHON 3, WHEREAS 25% STILL USE THE OUTDATED PYTHON 2 VERSION.

79%

79% OF ALL PROGRAMMERS USE PYTHON ON A DAY-TO-DAY BASIS, 21% USE IT AS A SECONDARY LANGUAGE.

49%

49% OF WINDOWS 10 DEVELOPERS USE PYTHON 3 AS THEIR MAIN PROGRAMMING LANGUAGE.

Why Python?

There are many different programming languages available for the modern computer, and some still available for older 8 and 16-bit computers too. Some of these languages are designed for scientific work, others for mobile platforms and such. So why choose Python out of all the rest?

PYTHON POWER

Ever since the earliest home computers were available, enthusiasts, users and professionals have toiled away until the wee hours, slaving over an overheating heap of circuitry to create something akin to magic.

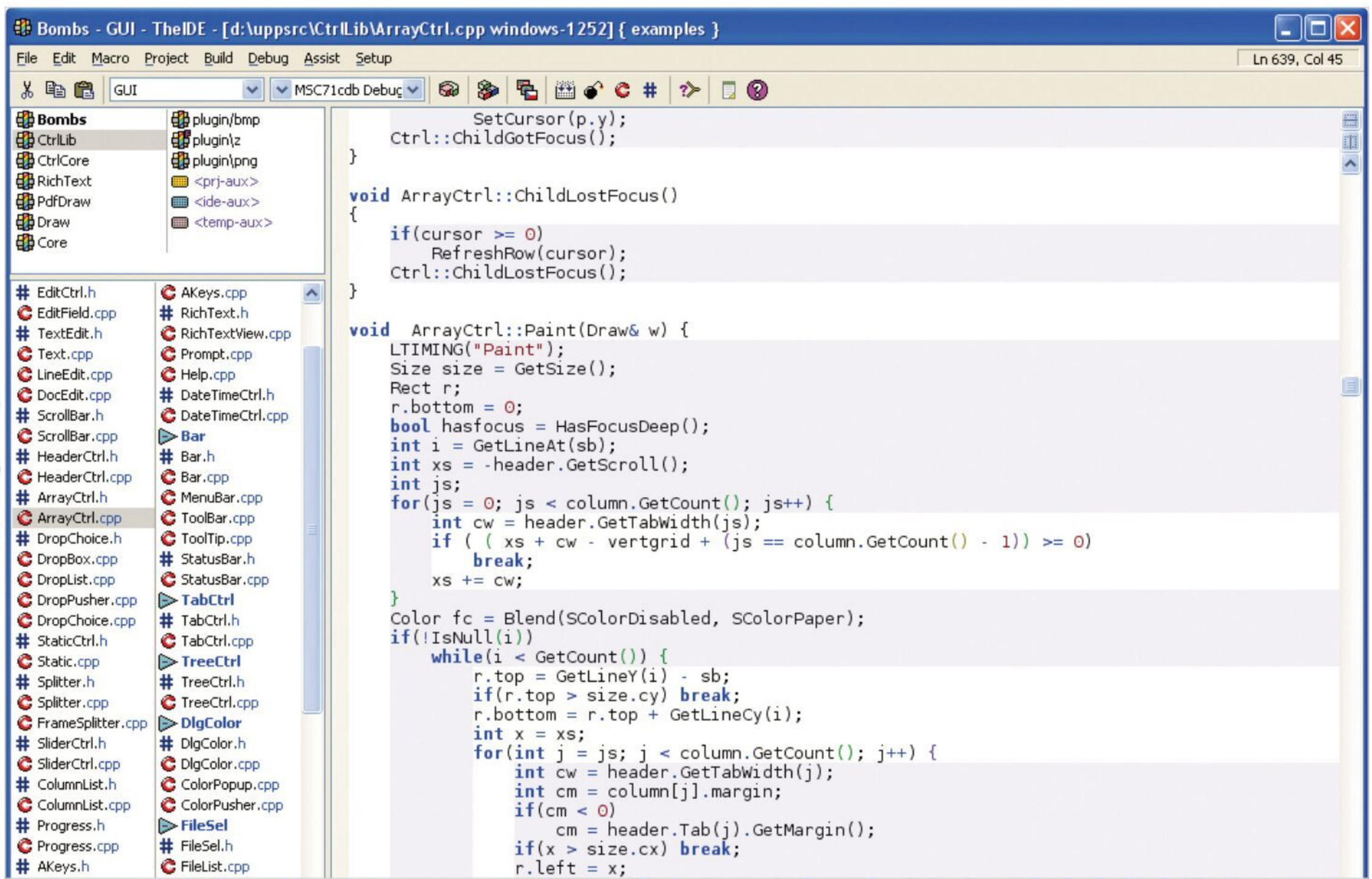
These pioneers of programming carved their way into a new frontier, forging small routines that enabled the letter 'A' to scroll across the screen. It may not sound terribly exciting to a generation that's used to ultra high-definition graphics and open world, multi-player online gaming. However, forty-something years ago it was blindingly brilliant.

Naturally these bedroom coders helped form the foundations for every piece of digital technology we use today. Some went on to become chief developers for top software companies, whereas others pushed the available hardware to its limits and founded the billion pound gaming empire that continually amazes us.

Regardless of whether you use an Android device, iOS device, PC, Mac, Linux, Smart TV, games console, MP3 player, GPS device built-in to a car, set-top box or a thousand other connected and 'smart' appliances, behind them all is programming.

All those aforementioned digital devices need instructions to tell them what to do, and allow them to be interacted with. These instructions form the programming core of the device and that core can be built using a variety of programming languages.

The languages in use today differ depending on the situation, the platform, the device's use and how the device will interact with its



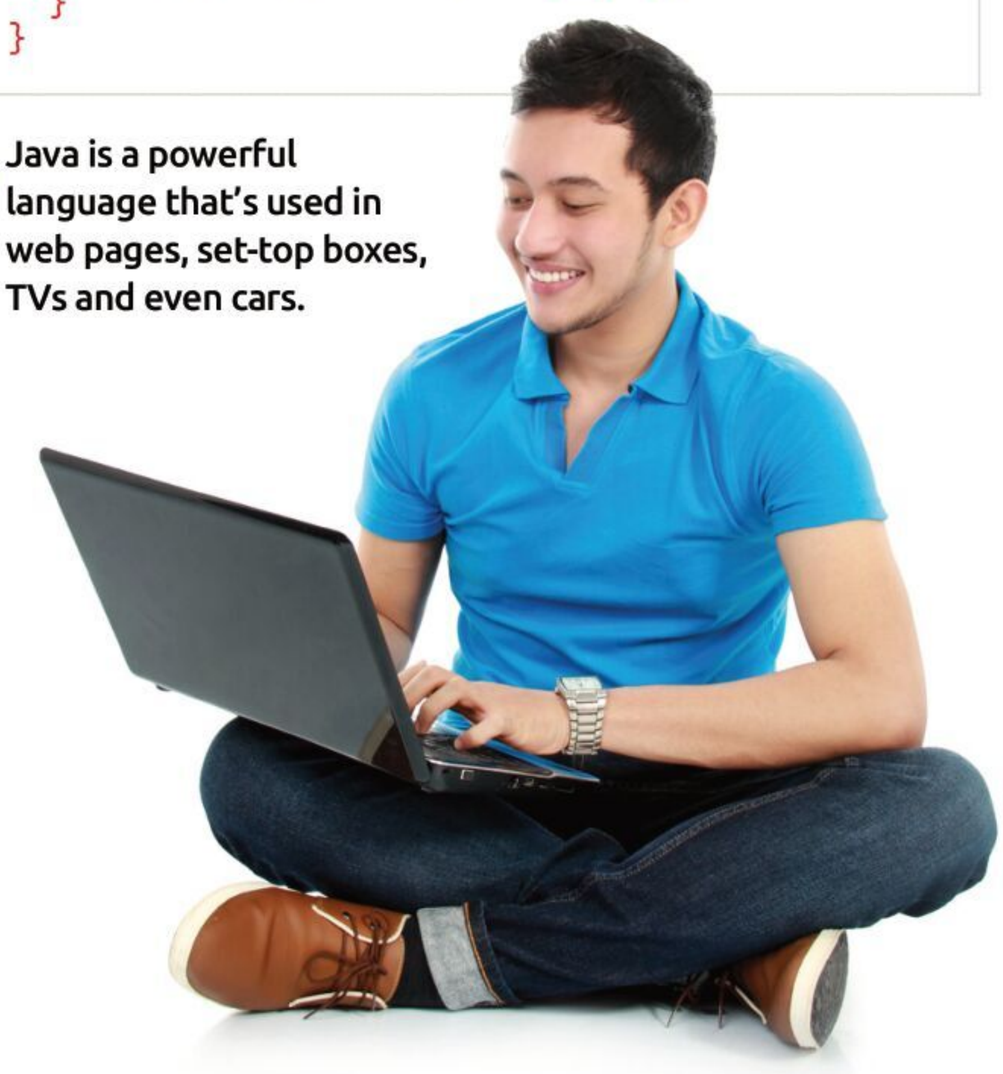
environment or users. Operating systems, such as Windows, macOS and such are usually a combination of C++, C#, assembly and some form of visual-based language. Games generally use C++ whilst web pages can use a plethora of available languages such as HTML, Java, Python and so on.

More general-purpose programming is used to create programs, apps, software or whatever else you want to call them. They're widely used across all hardware platforms and suit virtually every conceivable application. Some operate faster than others and some are easier to learn and use than others. Python is one such general-purpose language.

Python is what's known as a High-Level Language, in that it 'talks' to the hardware and operating system using a variety of arrays, variables, objects, arithmetic, subroutines, loops and countless more interactions. Whilst it's not as streamlined as a Low-Level Language, which can deal directly with memory addresses, call stacks and registers, its benefit is that it's universally accessible and easy to learn.

```
1  //file: Invoke.java
2  import java.lang.reflect.*;
3
4  class Invoke {
5    public static void main( String [] args ) {
6      try {
7        Class c = Class.forName( args[0] );
8        Method m = c.getMethod( args[1], new Class
         [] { } );
9        Object ret =  m.invoke( null, null );
10       System.out.println(
11           "Invoked static method: " + args[1]
12           + " of class: " + args[0]
13           + " with no args\nResults: " + ret );
14     } catch ( ClassNotFoundException e ) {
15       // Class.forName(  ) can't find the class
16     } catch ( NoSuchMethodException e2 ) {
17       // that method doesn't exist
18     } catch ( IllegalAccessException e3 ) {
19       // we don't have permission to invoke that
         method
20     } catch ( InvocationTargetException e4 ) {
21       // an exception ocurred while invoking that
         method
22       System.out.println(
23           "Method threw an: " + e4.
             getTargetException(  ) );
24     }
25   }
26 }
```

Java is a powerful language that's used in web pages, set-top boxes, TVs and even cars.



Python was created over twenty six years ago and has evolved to become an ideal beginner's language for learning how to program a computer. It's perfect for the hobbyist, enthusiast, student, teacher and those who simply need to create their own unique interaction between either themselves or a piece of external hardware and the computer itself.

Python is free to download, install and use and is available for Linux, Windows, macOS, MS-DOS, OS/2, BeOS, IBM i-series machines, and even RISC OS. It has been voted one of the top five programming languages in the world and is continually evolving ahead of the hardware and Internet development curve.

So to answer the question: why Python? Simply put, it's free, easy to learn, exceptionally powerful, universally accepted, effective and a superb learning and educational tool.

```
 40 LET py=15
 70 FOR w=1 TO 10
 71 CLS
 75 LET by=INT (RND*28)
 80 LET bx=0
 90 FOR d=1 TO 20
100 PRINT AT px,py;" U "
110 PRINT AT bx,by;"o"
120 IF INKEY$="p" THEN LET py=p
y+1
130 IF INKEY$="o" THEN LET py=p
y-1              U
135 FOR n=1 TO 100: NEXT n
140 IF py<2 THEN LET py=2
150 IF py>27 THEN LET py=27
180 LET bx=bx+1
185 PRINT AT bx-1,by;" "
190 NEXT d
200 IF (by-1)=py THEN LET s=s+1
210 PRINT AT 10,10;"score=";s
220 FOR v=1 TO 1000: NEXT v
300 NEXT w

0 OK, 0:1
```

BASIC was once the starter language that early 8-bit home computer users learned.

```
print(HANGMAN[0])
attempts = len(HANGMAN) - 1


while (attempts != 0 and "-" in word_guessed):
    print(("\nYou have {} attempts remaining").format(attempts))
    joined_word = "".join(word_guessed)
    print(joined_word)

    try:
        player_guess = str(input("\nPlease select a letter between A-Z" + "\n> ")).
    except: # check valid input
        print("That is not valid input. Please try again.")
        continue
    else:
        if not player_guess.isalpha(): # check the input is a letter. Also checks a
            print("That is not a letter. Please try again.")
            continue
        elif len(player_guess) > 1: # check the input is only one letter
            print("That is more than one letter. Please try again.")
            continue
        elif player_guess in guessed_letters: # check it letter hasn't been guessed
            print("You have already guessed that letter. Please try again.")
            continue
        else:
            pass

    guessed_letters.append(player_guess)

    for letter in range(len(chosen_word)):
        if player_guess == chosen_word[letter]:
            word_guessed[letter] = player_guess # replace all letters in the chosen

    if player_guess not in chosen_word:
```

Python is a more modern take on BASIC, it's easy to learn and makes for an ideal beginner's programming language.

Python on the Pi

If you're considering on which platform to install and use Python, then give some thought to one of the best coding bases available: the Raspberry Pi. The Pi has many advantages for the coder: it's cheap, easy to use, and extraordinarily flexible.

THE POWER OF PI

While having a far more powerful coding platform on which to write and test your code is ideal, it's not often feasible. Most of us are unable to jump into a several hundred-pound investment when we're starting off and this is where the Raspberry Pi can help out.

While having a far more powerful coding platform on which to write and test your code is ideal, it's not often feasible. Most of us are unable to jump into a several hundred-pound investment when we're starting off and this is where the Raspberry Pi can help out.

The Raspberry Pi is a fantastic piece of modern hardware that has created, or rather re-created, the fascination we once all had about computers, how they work, how to code and foundation level electronics. Thanks to its unique mix of hardware and custom software, it has proved itself to be an amazing platform on which to learn how to code; specifically, using Python.

While you're able, with ease, to use the Raspberry Pi to learn to code with other programming languages, it's Python that has been firmly pushed to the forefront. The Raspberry Pi uses Raspbian as its recommended, default operating system. Raspbian is a Linux OS, or to be more accurate, it's a Debian-based distribution of Linux. This means that there's already a built-in element of Python programming, as opposed to a fresh installation of Windows 10, which has no Python-specific base. However, the Raspberry Pi Foundation has gone the extra mile to include a vast range of Python modules, extensions and even examples, out of the box. So, essentially, all you need to do is buy a Raspberry Pi, follow the instructions on how to set one up (by using one of our excellent Raspberry Pi guides found at **www.bdmpublications.com**) and you can start coding with Python as soon as the desktop has loaded.

Significantly, there's a lot more to the Raspberry Pi, which makes it an excellent choice for someone who is starting to learn how to code in Python. The Pi is remarkably easy to set up as a headless node. This means that, with a few tweaks here and there, you're able to remotely connect to the Raspberry Pi from any other computer, or device, on your home network. For example, once you've set up the remote connectivity options, you can simply plug the Pi into the power socket anywhere in your house within range of your wireless router. As long as the Pi is connected, you will be able to remotely access the desktop from Windows or macOS as easily as if you were sitting in front of the Pi with a keyboard and mouse.

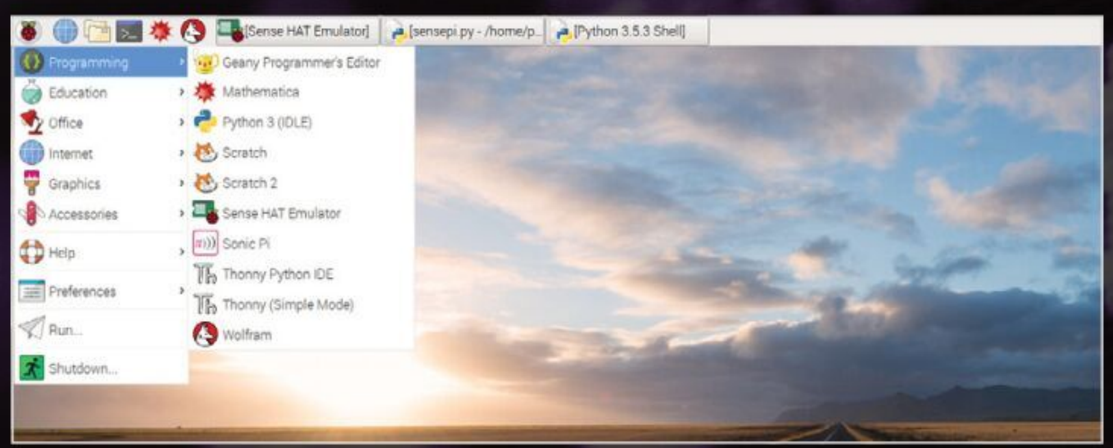
Using this method saves a lot of money, as you don't need another keyboard, mouse and monitor, plus, you won't need to allocate sufficient space to accommodate those extras either. If you're pushed for space and money, then for around £60, buying one of the many kits available will provide the Pi with a pre-loaded SD card (with the latest Raspbian OS), a case, power socket and cables, this is a good idea as you could, with very little effort, leave the Pi plugged into the wall under a desk, while still being able to connect to it and code.

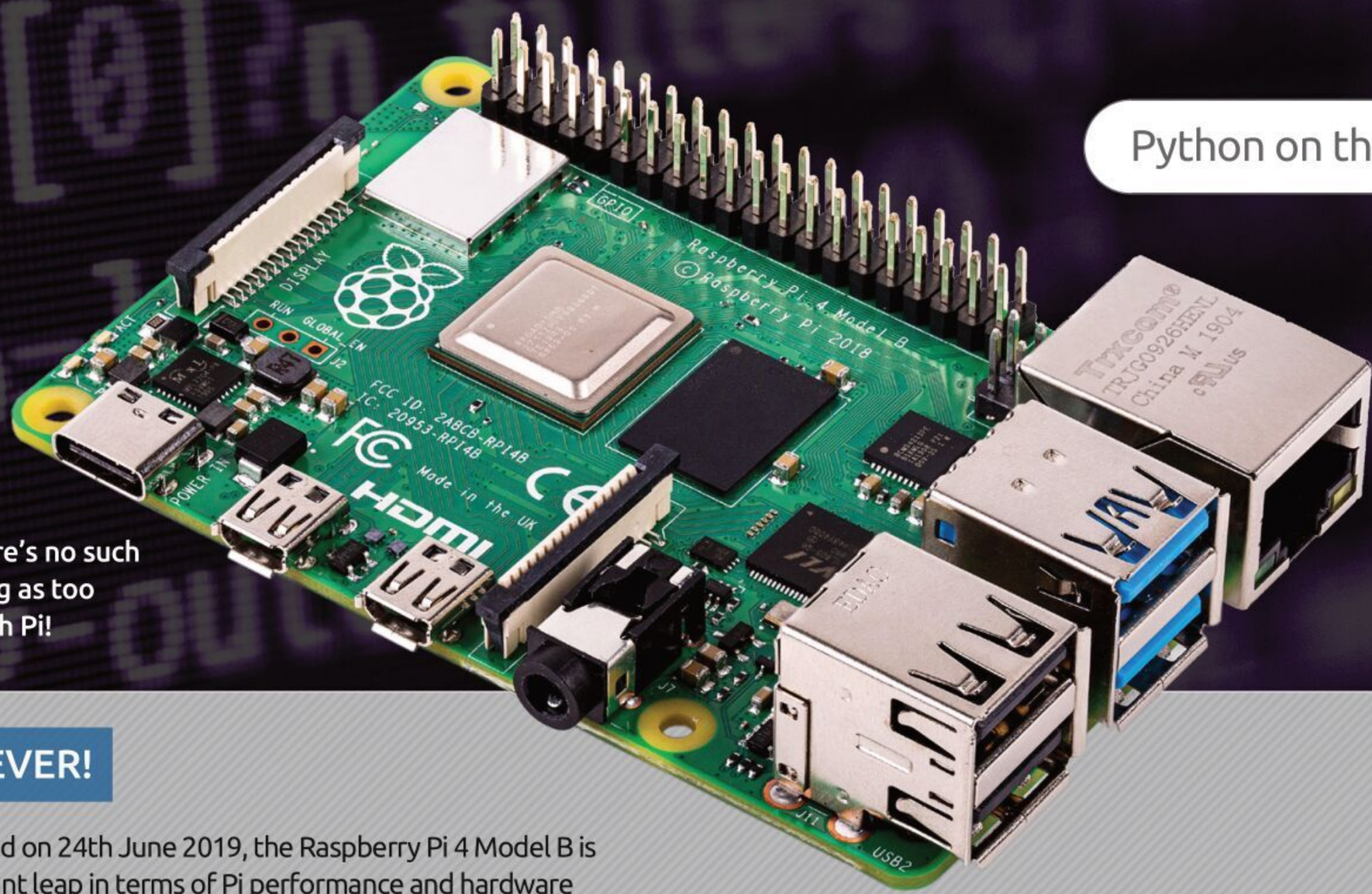
The main advantage is, of course, the extra content that the Raspberry Pi Foundation has included out of the box. The reason for this is that the Raspberry Pi's goal is to help educate the user, whether that's coding, electronics, or some other aspect of computing. To achieve that goal the Pi Foundation includes different IDEs for the user to compile Python code on; as well as both Python 2 and Python 3, there's even a Python library that allows you to communicate with Minecraft.

There are other advantages, such as being able to combine Python code with Scratch (an Object-Oriented programming language developed by MIT, for children to understand how coding works) and being able to code the GPIO connection on the Pi to further control any attached robotics or electronics projects. Raspbian also includes a Sense HAT Emulator (a HAT is a hardware attached piece of circuitry that offers different electronics, robotics and motorisation projects to the Pi), which can be accessed via Python code.

Consequently, the Raspberry Pi is an excellent coding base, as well as a superb project foundation. It is for these, and many other, reasons we've used the Raspberry Pi as our main Python codebase throughout this title. While the code is written and performed on a Pi, you're also able to use it in Windows, other versions of Linux and macOS. If the code requires a specific operating system, then, don't worry; we will let you know in the text.

Everything you need to learn to code with Python is included with the OS!





There's no such thing as too much Pi!

PI 4-EVER!

Introduced on 24th June 2019, the Raspberry Pi 4 Model B is a significant leap in terms of Pi performance and hardware specifications. It was also one of the quickest models, aside from the original Pi, to sell out.

With a new 1.5GHz, 64-bit, quad-core ARM Cortex-A72 processor, and a choice of 1GB, 2GB, or 4GB memory versions, the Pi 4 is one-step closer to becoming a true desktop computer. In addition, the Pi 4 was launched with the startling decision to include dual-monitor support, in the form of a pair of two micro-HDMI ports. You'll also find a pair of USB 3.0 ports, Bluetooth 5.0, and a GPU that's capable of handing 4K resolutions and OpenGL ES 3.0 graphics.

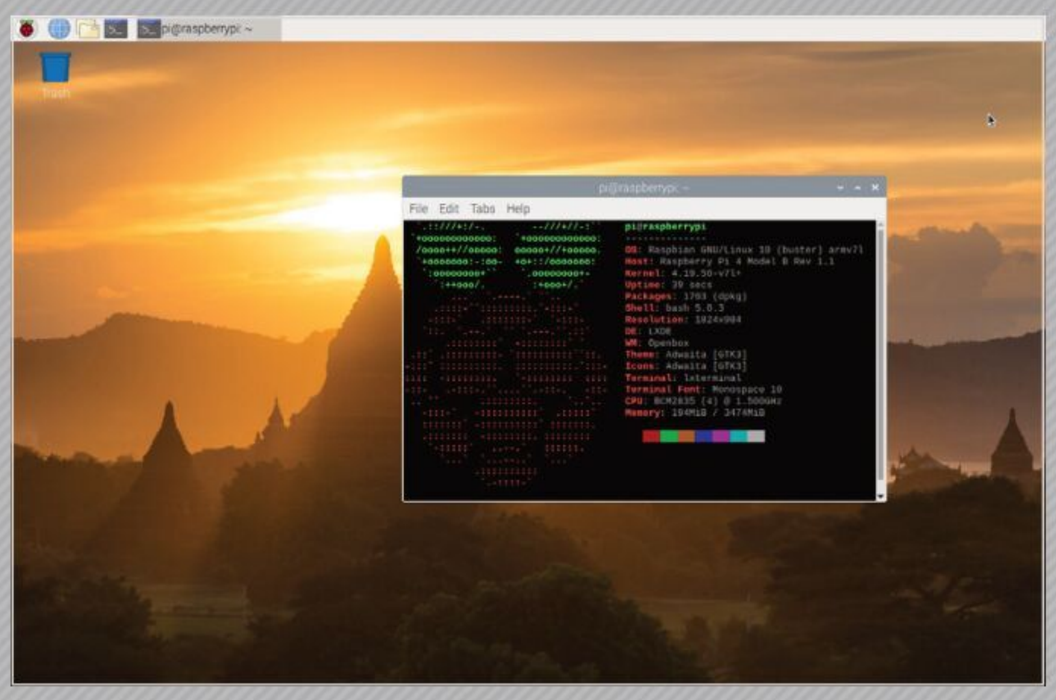
In short, the Pi 4 is the most powerful of the current Raspberry Pi models. However, the different memory versions have an increased cost. The 1GB version costs £34, 2GB is £44, and the 4GB version will set you back £54. Remember to also factor in one or two micro-HDMI cables with your order.

RASPBIAN BUSTER

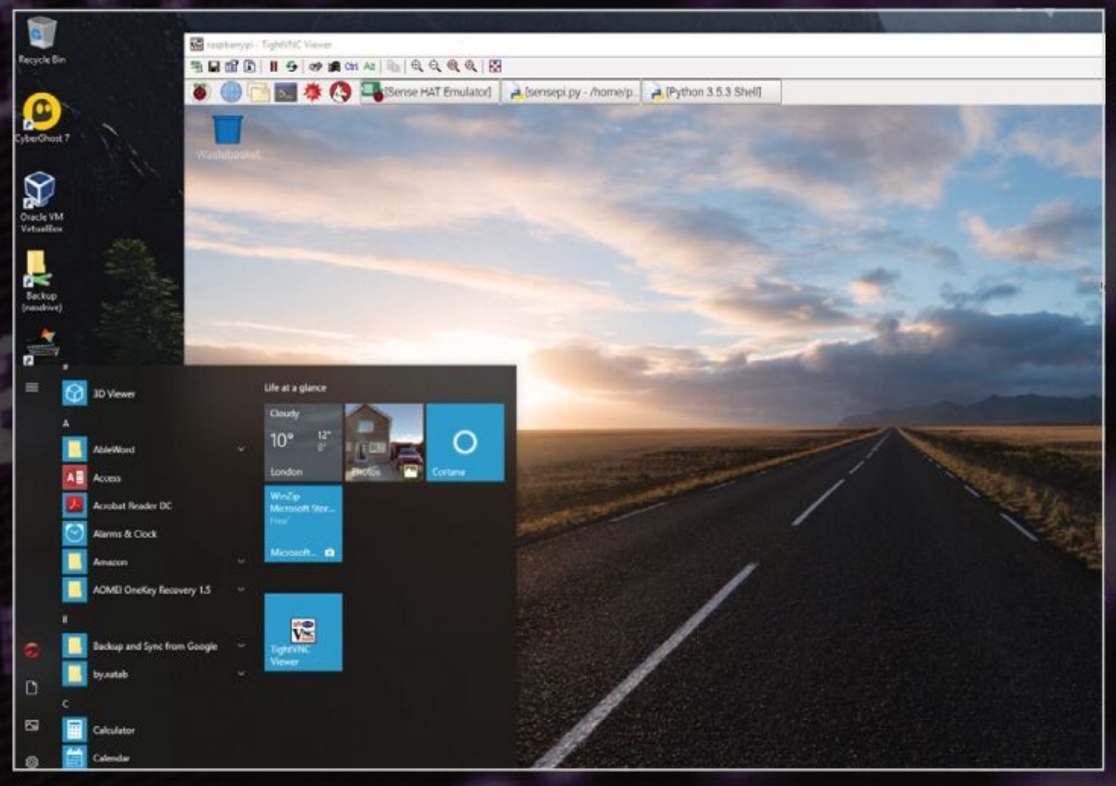
In addition to releasing the Pi 4, the Raspberry Pi team also compiled a new version of the Raspbian operating system, codenamed Buster.

In conjunction with the new hardware the Pi 4 boasts, Buster does offer a few updates. Although on the whole it's very similar in appearance and operation to the previous version of Raspbian. The updates are mainly in-line with the 4K's display and playback, giving the Pi 4 a new set of graphical drivers and performance enhancements.

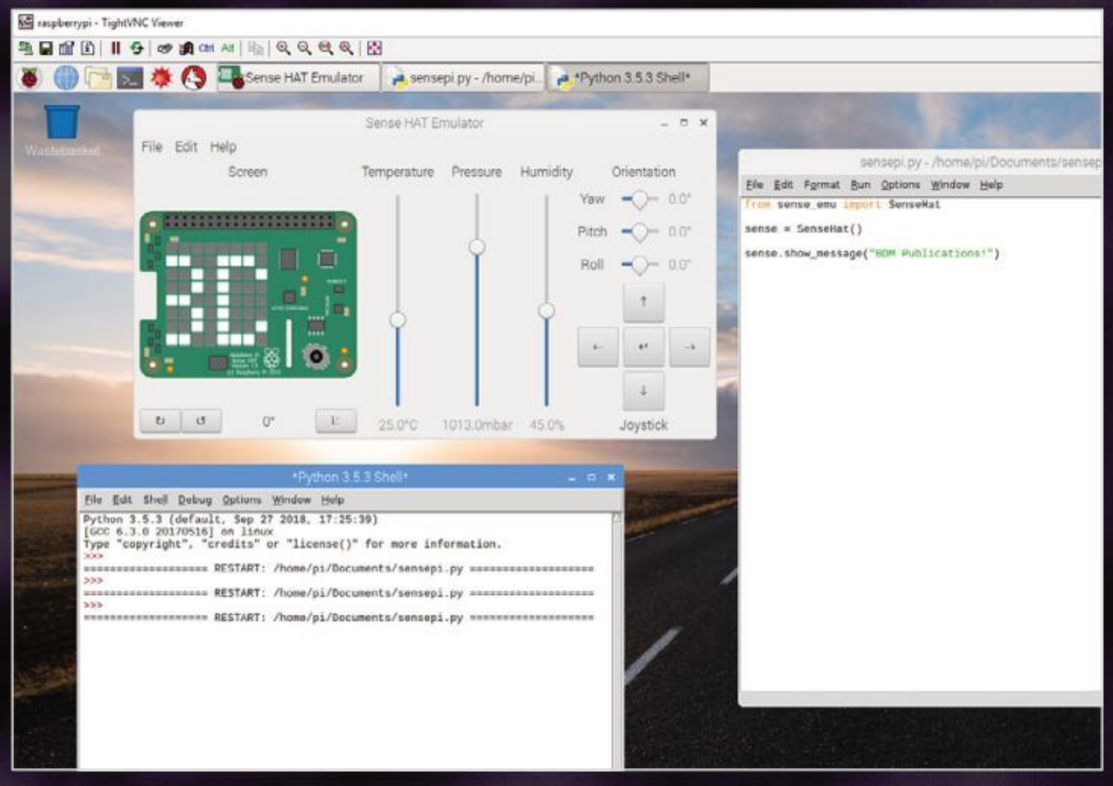
In short, what you see in this book will work with the Raspberry Pi 4 and Raspbian Buster!



Once set up, you can remotely connect to the Pi's desktop from any device/PC.



You can even test connected hardware with Python remotely, via Windows.



Using Virtual Machines

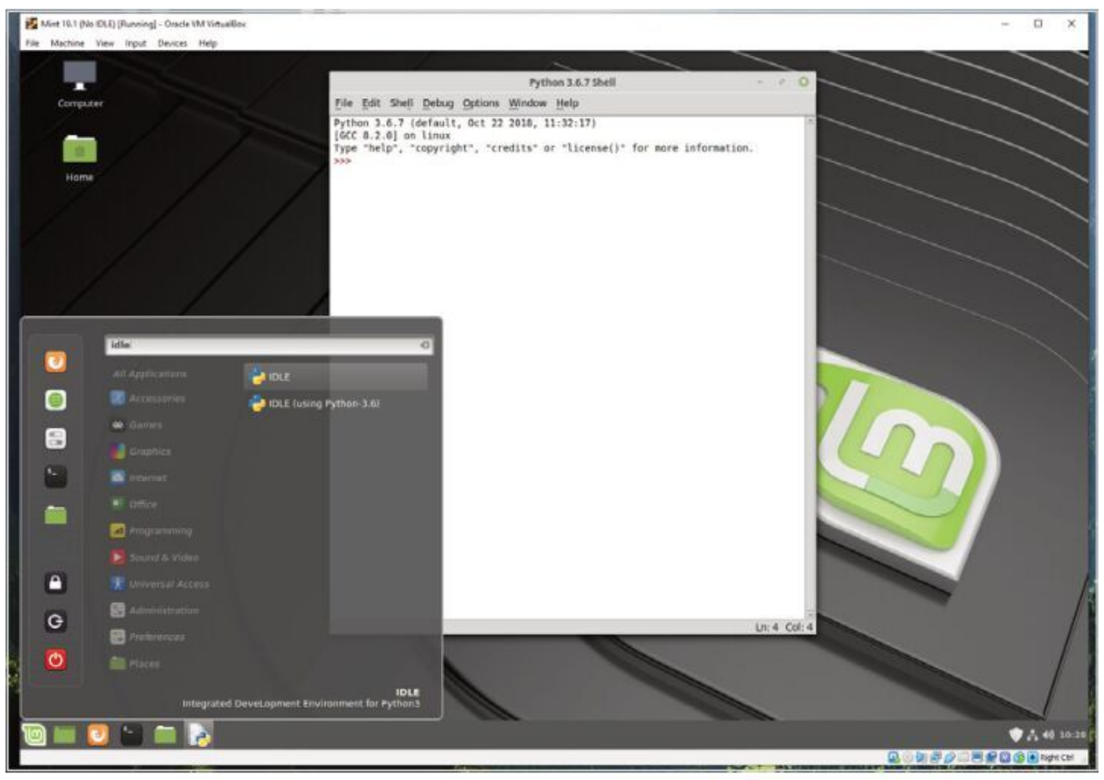
A Virtual Machine allows you to run an entire operating system from within an app on your desktop. This way, you're able to host multiple systems in a secure, safe and isolated environment. In short, it's an ideal way to code.

Sounds good, but what exactly is a Virtual Machine (VM) and how does it work?

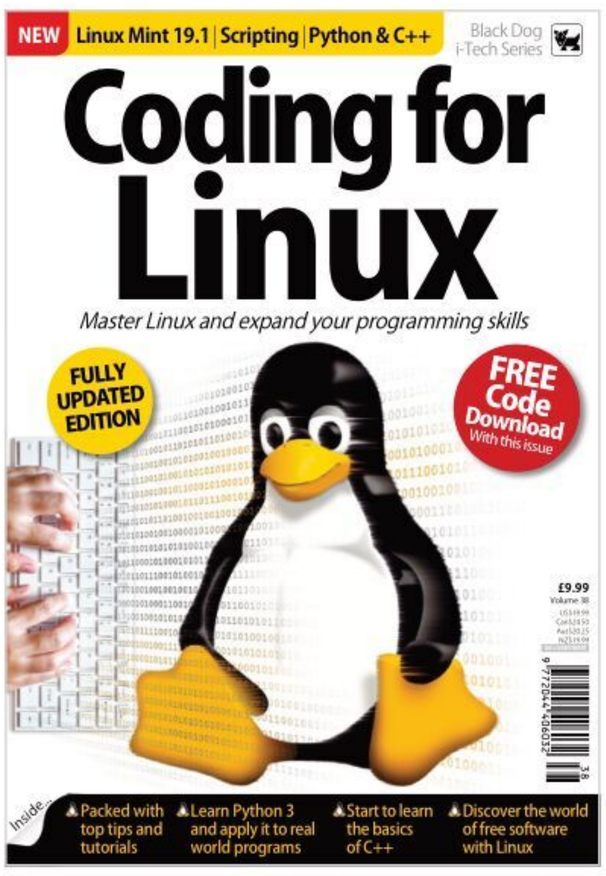
The official definition of a virtual machine is 'an efficient, isolated duplicate of a real computer machine'. This basically means that a virtual machine is an emulated computer system that can operate in exactly the same way as a physical machine, but within the confines of a dedicated virtual machine operator, or Hypervisor.

The Hypervisor itself, is an app that will allow you to install a separate operating system, creating a virtual computer system within itself, complete with access to the Internet, your home network and so on.

The Hypervisor will take resources from the host system - your physical computer, to create the virtual computer. This means that part of your physical computer's: memory, CPU, hard drive space and other shared resources, will be set aside for use in the virtual machine and therefore won't be available to the physical computer until the hypervisor has been closed down.



You're able to install Linux, and code inside a virtual machine on a Windows 10 host.



Our Linux titles contain steps on how to install a hypervisor and OS.

This resource overhead can be crippling for the physical machine if you don't already have enough memory, or hard drive space available, or your computer has a particularly slow processor. While it's entirely possible to run virtual machines on as little as 2GB of memory, it's not advisable. Ideally, you will need a minimum of 8GB of memory (you can get away with 4GB, but again, your physical computer will begin to suffer with the loss of memory to the virtual machine), at least 25 to 50GB of free space on your hard drive and a quad-core processor (again, you can have a dual-core CPU, but that can cause a bottleneck on your physical computer).

The limit to how many different virtual machines you host on your physical computer is restricted, therefore, by the amount of physical system resources you can allocate to each, while still leaving enough for your physical computer to operate on.

VIRTUAL OS

From within a hypervisor you're able to run a number of different operating systems. The type of OS depends greatly on the hypervisor you're running, as some are better at emulating a particular system over others. For example, VirtualBox, a free and easy to use hypervisor from Oracle, is great at running Windows and Linux virtual machines, but isn't so good at Android or macOS. QEMU is good for emulating ARM processors, therefore ideal for Android and such, but it can be difficult to master.

There are plenty of hypervisors available to try for free, with an equal amount commercially available that are significantly more powerful and offer better features. However, for most users, both beginner and professional, VirtualBox does a good enough job.

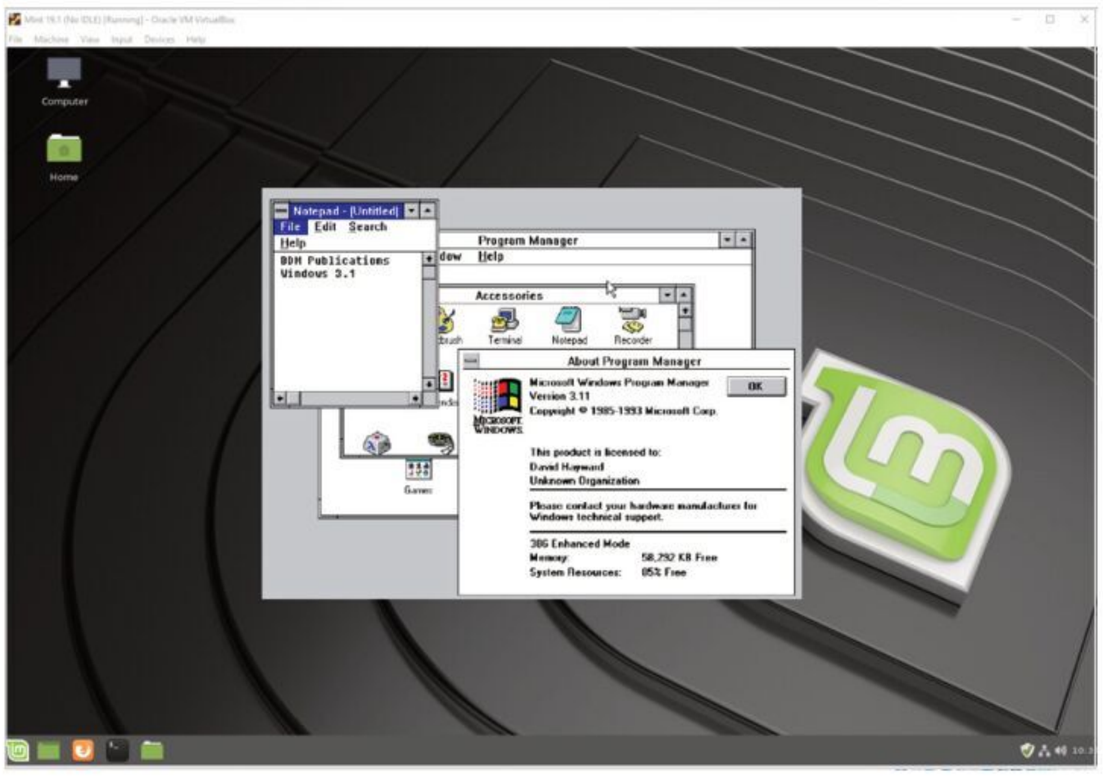
Within a hypervisor, you're able to set up and install any of the newer distributions of Linux, or if you feel the need, you're also able to install some of the more antiquated versions. You can install early versions of Windows, even as far back as Windows 3 complete with DOS 6.22 – although you may find some functionality of the VM lost due to the older drivers (such as access to the network).

With this in mind then, you're able to have an installation of Linux Mint, or the latest version of Ubuntu, running in an app on your Windows 10 PC. This is the beauty of using a virtual machine. Conversely, if your physical computer has Linux as its installed operating system, then with a hypervisor you're able to create a Windows 10 virtual machine – although you will need to have a licence code available to register and activate Windows 10.

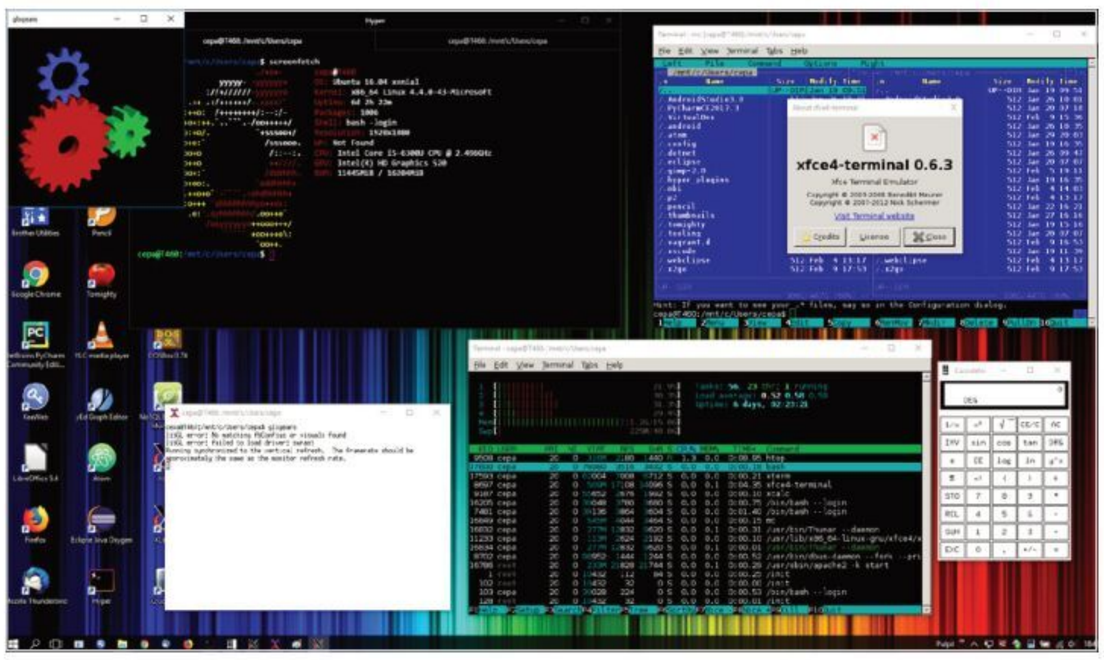
Using virtual machines removes the need to dual-boot. Dual-booting is having two, or more, physical operating systems installed on the same, or multiple, hard drives on a single computer. As the computer powers up, you're given the option to choose which OS you want to boot into. While this sounds like a more ideal scenario it isn't always as straight forward as it sounds, as all the operating systems that are booted into will have full access to the computer's entire system resources.

The problems with dual-booting come when one of the operating systems is updated. Most updates cover security patching, or bug fixing, however, some updates can alter the core - the kernel, of the OS. When these changes are applied, the update may alter the way in which the OS starts up, meaning the initial boot choice you made could be overwritten, leaving you without the ability to access the other operating systems installed on the computer. To rectify this, you'll need to access the Master Boot Record and alter the configuration to re-allow booting into the other systems. There's also the danger of possibly overwriting the first installed OS, or overwriting data and more often than not, most operating systems don't play well when running side-by-side. Indeed, while good, dual-booting has more than its fair share of problems. In contrast, using a virtual machine environment, while still problematic at times, takes out some of the more nasty and disastrous aspects of using multiple operating systems on a single computer.

Even old operating systems can be run inside a virtual machine.



Virtual machines can be as simple, or as complex as your needs require.

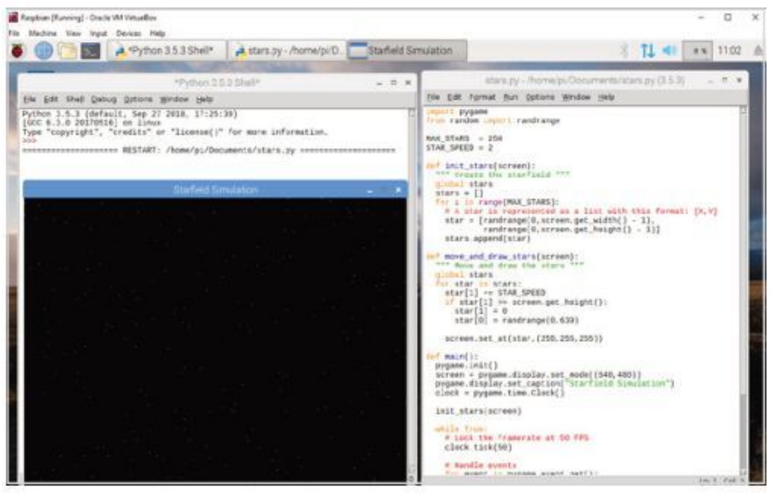


ADVANTAGES FOR CODERS

For the coder, having a virtual machine setup offers many advantages, the most popular being cross-platform code. Meaning if you write code within Windows 10, then with an installation of a Linux distro in a hypervisor, you're able to quickly and effortlessly power up the virtual machine and test your code in a completely different operating system. From this, you're able to iron out any bugs, tweak the code so it works better on a different platform and expand the reach of your code to non-Windows users.

The advantage of being able to configure a development environment, in specific ways for specific projects, is quite invaluable. Using a virtual machine setup greatly reduces the uncertainties that are inherent to having multiple versions of programming languages, libraries, IDEs and modules installed, to support the many different projects you may become involved in as a coder. Elements of code that 'talk' directly to specifics of an operating system can easily be overcome, without the need to clutter up your main, host system with cross-platform libraries, which in turn may have an effect on other libraries within the IDE.

Another element to consider is stability. If you're writing code that could potentially cause some instability to the core OS during its development phase, then executing and testing that code on a virtual machine makes more sense than testing it on your main computer; where having to repeatedly reboot, or reset something due to the code's instabilities, can become inefficient and just plain annoying.



Coding in Python on the Raspberry Pi Desktop OS inside a VM on Windows 10!

The virtual machine environment can be viewed as a sandbox, where you're able to test unsecure, or unstable code without it causing harm, or doing damage, to your main, working computer. Viruses and malware can be isolated within the VM without infecting the main computer, you're able to set up anonymity Internet use within the VM and you're able to install third-party software without it slowing down your main computer.

GOING VIRTUAL

While you're at the early stages of coding, using a virtual machine may seem a little excessive. However, it's worth looking into because coding in Linux can often be easier than coding in Windows, as some versions of Linux have IDEs pre-installed. Either way, virtualisation of an operating system is how many of the professional and successful coders and developers work, so getting used to it early on in your skill set is advantageous.

To start, look at installing VirtualBox. Then consider taking a look at our Linux titles, **https://bdmpublications.com/?s=linux&post_type=product**, to learn how to install Linux in a virtual environment and how best to utilise the operating system.

Creating a Coding Platform

The term 'Coding Platform' can denote a type of hardware, on which you can code, or a particular operating system, or even a custom environment that's pre-built and designed to allow the easy creation of games. In truth it's quite a loose term, as a Coding Platform can be a mixture of all these ingredients, it's simply down to what programming language you intend to code in and what your end goals are.

Coding can be one of those experiences that sounds fantastic, but to get going with it, is often confusing. After all, there's a plethora of languages to choose from, numerous apps that will enable you to code in a specific, or range, of languages and an equally huge amount of third-party software to consider. Then you access the Internet and discover that there are countless coding tutorials available, for the language in which you've decided you want to program, alongside even more examples of code. It's all a little too much at times.

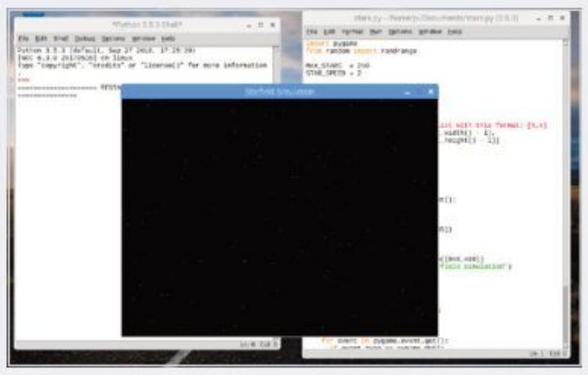
The trick is to slow down and, to begin with, not look too deeply into coding. Like all good projects, you need a solid foundation on which to build your skill and to have all the necessary tools available to hand to enable you to complete the basic steps. This is where creating a coding platform comes in, as it will be your learning foundation while you begin to take your first tentative steps into the wider world of coding.

HARDWARE

Thankfully, coding at the foundation level doesn't require specialist equipment, or a top of the range, liquid hydrogen-cooled PC. If you own a computer, no matter how basic, you can begin to learn how to code. Naturally, if your computer in question is a Commodore 64 then you may have some difficulty following a modern language tutorial, but some of the best programmers around today started on an 8-bit machine, so there's hope yet.

Access to the Internet is necessary to download, install and update the coding development environment, alongside a computer with either: Windows 10, macOS, or Linux installed. You can use other operating systems, but these are the 'big three' and you will find that most code resources are written with one, or all of these, in mind.

SOFTWARE



In terms of software, most of the development environments - the tools that allow you to code, compile the code and execute it - are freely available to download and install. There are some specialist tools available that will cost, but at this level they're not necessary; so don't be fooled into thinking you need to purchase any extra software in order to start learning how to code.

Over time, you may find yourself changing from the mainstream development environment and using a collection of your own, discovered, tools to write your code in. It's all personal preference in the end and as you become more experienced, you will start to use different tools to get the job done.

OPERATING SYSTEMS

Windows 10 is the most used operating system in the world, so it's natural that the vast majority of coding tools are written for Microsoft's leading operating system. However, don't discount macOS and especially Linux.

macOS users enjoy an equal number of coding tools to their Windows counterparts. In fact, you will probably find that a lot of professional coders use a Mac over a PC, simply because of the fact that the Mac operating system is built on top of Unix (the command-line OS that powers much of the world's filesystems and servers). This Unix layer lets you test programs in almost any language without using a specialised IDE.

Linux, however, is by far one of the most popular and important, coding operating systems available. Not only does it have a Unix-like backbone, but also it's also free to download, install and use and comes with most of the tools necessary to start learning how to code. Linux powers most of the servers that make up the Internet. It's used on nearly all of the top supercomputers, as well as specifically in organisations such as NASA, CERN and the military and it forms the base of Android-powered devices, smart TVs and in-car systems. Linux, as a coding platform, is an excellent idea and it can be installed inside a virtual machine without ever affecting the installation of Windows or macOS.

THE RASPBERRY PI

If you haven't already heard of the Raspberry Pi, then we suggest you head over to **www.raspberrypi.org**, and check it out. In short, the Raspberry Pi is a small, fully functional computer that comes with its own customised Linux-based operating system, pre-installed with everything you need to start learning how to code in Python, C++, Scratch and more.

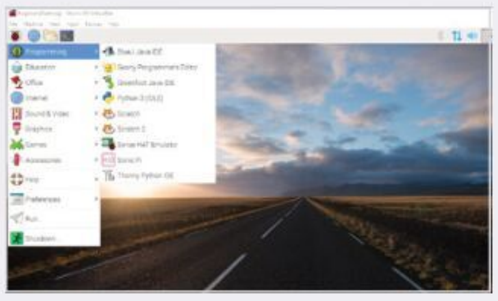
It's incredibly cheap, costing around £35 and allows you to utilise different hardware, in the form of robotics and electronics projects, as well as offering a complete desktop experience. Although not the most powerful computing device in the world, the Raspberry Pi has a lot going for it, especially in terms of being one of the best coding platforms available.

YOUR OWN CODING PLATFORM

Whichever method you choose, remember that your coding platform will probably change, as you gain experience and favour one language over another. Don't be afraid to experiment along the way, as you will eventually create your own unique platform that can handle all the code you enter into it.

VIRTUAL MACHINES

A virtual machine is a piece of software that allows you to install a fully working, operating system within the confines of the software itself. The installed OS will allocate user-defined resources from the host computer, providing memory, hard drive space etc., as well as sharing the host computer's Internet connection.



The advantage of a virtual machine is that you can work with Linux, for example, without it affecting your currently installed host OS. This means that you can have Windows 10 running, launch your virtual machine client, boot into Linux and use all the functionality of Linux while still being able to use Windows.

This, of course, makes it a fantastic coding platform, as you can have different installations of operating systems running from the host computer while using different coding languages. You can test your code without fear of breaking your host OS and it's easy to return to a previous configuration without the need to reinstall everything again.

Virtualisation is the key to most big companies now. You will probably find, for example, rather than having a single server with an installation of Windows Server, the IT team have instead opted for a virtualised environment whereby each Windows Server instance is a virtual machine running from several powerful machines. This cuts down on the number of physical machines, allows the team to better manage resources and enables them to deploy an entire server dedicated to a particular task in a fraction of the time.

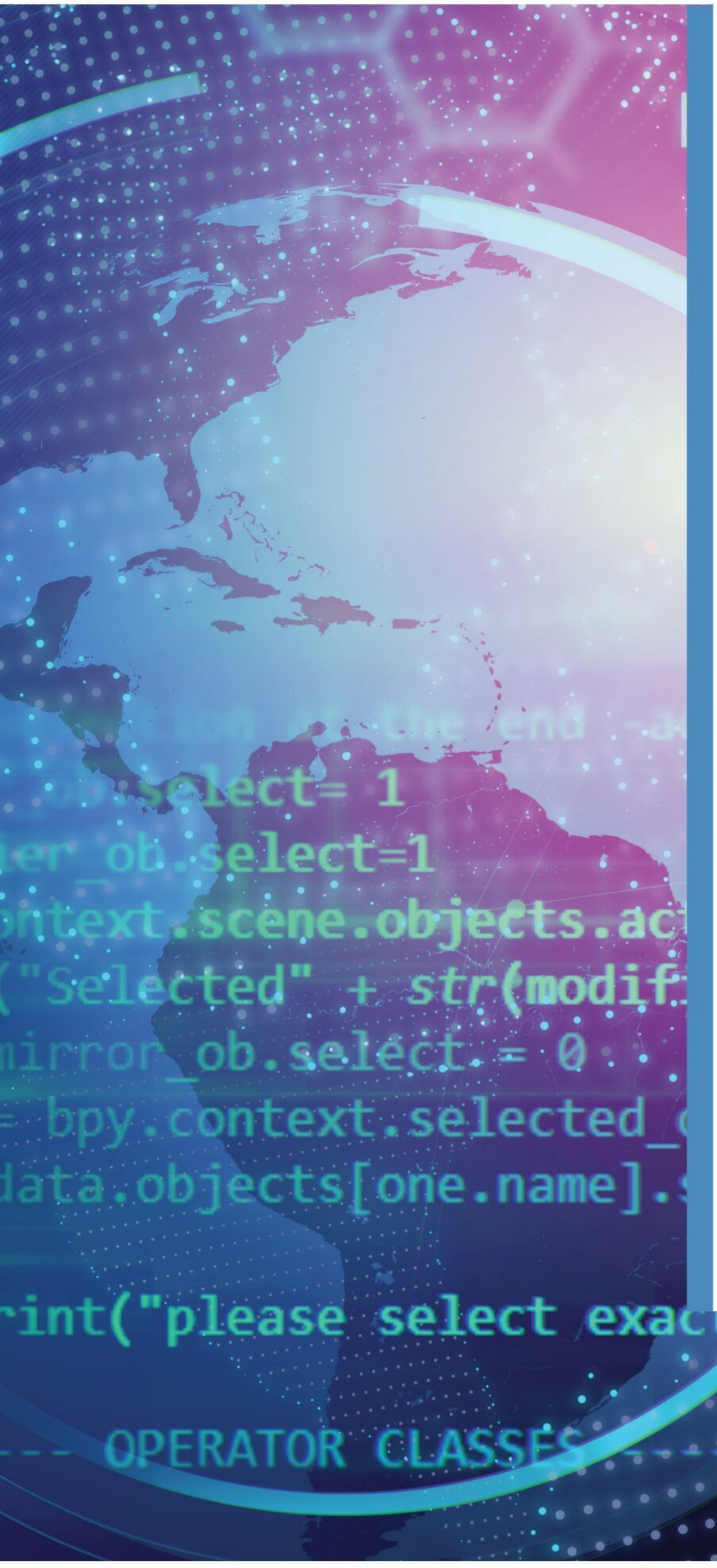
MINIX NEO N42C-4

The NEO N42C-4 is an extraordinarily small computer from mini-PC developer, MINIX. Measuring just 139 x 139 x 30mm, this Intel N4200 CPU powered, Windows 10 Pro pre-installed computer is one of the best coding platforms we've come across.

The beauty, of course, lies in the fact that with increased storage and memory available, you're able to create a computer that can easily host multiple virtual machines. The virtual machines can cover Linux, Android and other operating systems, allowing you to write and test cross-platform code without fear of damaging, or causing problems, with other production or home computers.

The MINIX NEO N42C-4 starts at around £250, with the base 32GB eMMC and 4GB of memory. You'll need to add another hundred and fifty, or so, to increase the specifications, but consider that a license for Windows 10 Pro alone costs £219 from the Microsoft Store and you can begin to see the benefits of opting for a more impressive hardware foundation over the likes of the Raspberry Pi.

Hello, World



Getting started with Python may seem a little daunting at first, but, thankfully, the language has been designed with simplicity in mind. Like most things, you need to start slow, master the basics, learn how to get a result, and how to get what you want from the code.

This section covers numbers and expressions, user input, conditions and loops and the types of errors you will undoubtedly come across in your time with Python: the core foundations of good coding and Python code.

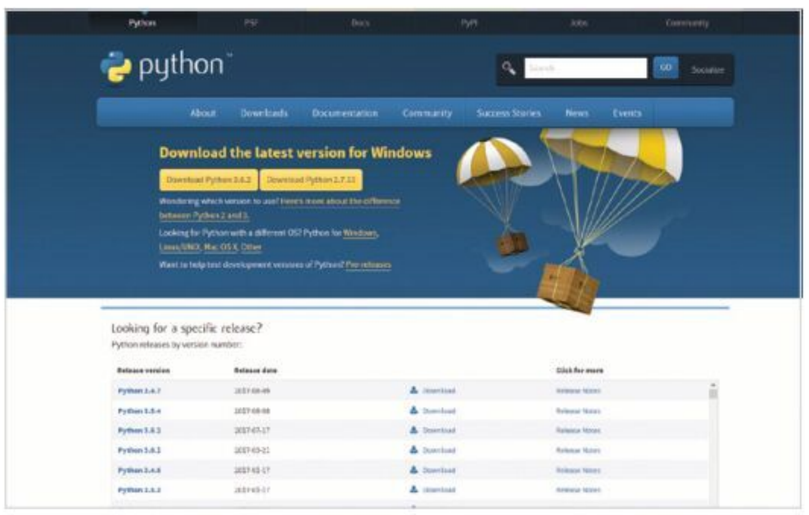
26 Equipment You Will Need
28 Getting to Know Python
30 How to Set Up Python in Windows
32 How to Set Up Python in Linux
34 Starting Python for the First Time
36 Your First Code
38 Saving and Executing Your Code
40 Executing Code from the Command Line
42 Numbers and Expressions
44 Using Comments
46 Working with Variables
48 User Input
50 Creating Functions
52 Conditions and Loops
54 Python Modules
56 Python Errors
58 Combining What You Know So Far
60 Python in Focus: Stitching Black Holes

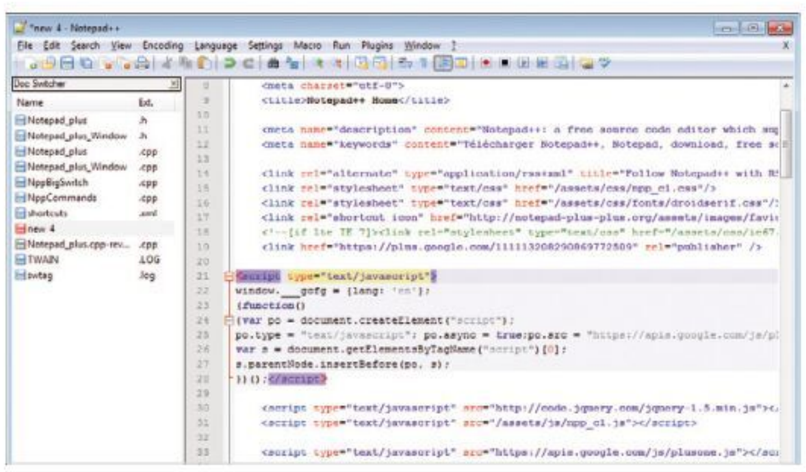
Equipment You Will Need

You can learn Python with very little hardware or initial financial investment. You don't need an incredibly powerful computer and any software that's required is freely available.

WHAT WE'RE USING

Thankfully, Python is a multi-platform programming language available for Windows, macOS, Linux, Raspberry Pi and more. If you have one of those systems, then you can easily start using Python.





☐ COMPUTER

Obviously you're going to need a computer in order to learn how to program in Python and to test your code. You can use Windows (from XP onward) on either a 32 or 64-bit processor, an Apple Mac or Linux installed PC.

☐ AN IDE

An IDE (Integrated Developer Environment) is used to enter and execute Python code. It enables you to inspect your program code and the values within the code, as well as offering advanced features. There are many different IDEs available, so find the one that works for you and gives the best results.

☐ PYTHON SOFTWARE

macOS and Linux already come with Python preinstalled as part of the operating system, as does the Raspberry Pi. However, you need to ensure that you're running the latest version of Python. Windows users need to download and install Python, which we'll cover shortly.

☐ TEXT EDITOR

Whilst a text editor is an ideal environment to enter code into, it's not an absolute necessity. You can enter and execute code directly from the IDLE but a text editor, such as Sublime Text or Notepad++, offers more advanced features and colour coding when entering code.

☐ INTERNET ACCESS

Python is an ever evolving environment and as such new versions often introduce new concepts or change existing commands and code structure to make it a more efficient language. Having access to the Internet will keep you up-to-date, help you out when you get stuck and give access to Python's immense number of modules.

☐ TIME AND PATIENCE

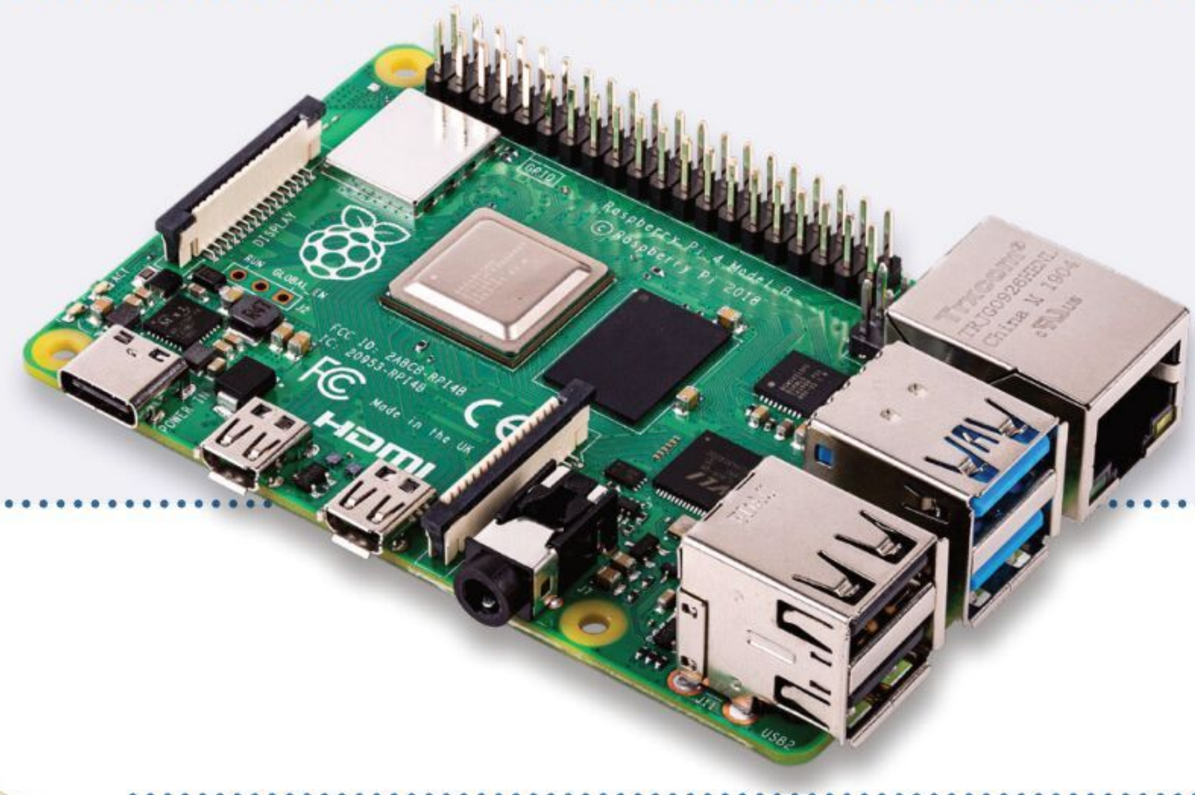
Despite what other books may lead you to believe, you won't become a programmer in 24-hours. Learning to code in Python takes time, and patience. You may become stuck at times and other times the code will flow like water. Understand you're learning something entirely new, and you will get there.

THE RASPBERRY PI

Why use a Raspberry Pi? The Raspberry Pi is a tiny computer that's very cheap to purchase, but offers the user a fantastic learning platform. Its main operating system, Raspbian, comes preinstalled with the latest Python along with many modules and extras.

RASPBERRY PI

The Raspberry Pi 4 Model B is the latest version, incorporating a more powerful CPU, a choice of 1GB, 2GB or 4GB memory versions and Wi-Fi and Bluetooth support. You can pick up a Pi from around £33, increasing up to £54 for the 4GB memory version, or as a part of kit for £50+, depending on the kit you're interested in.

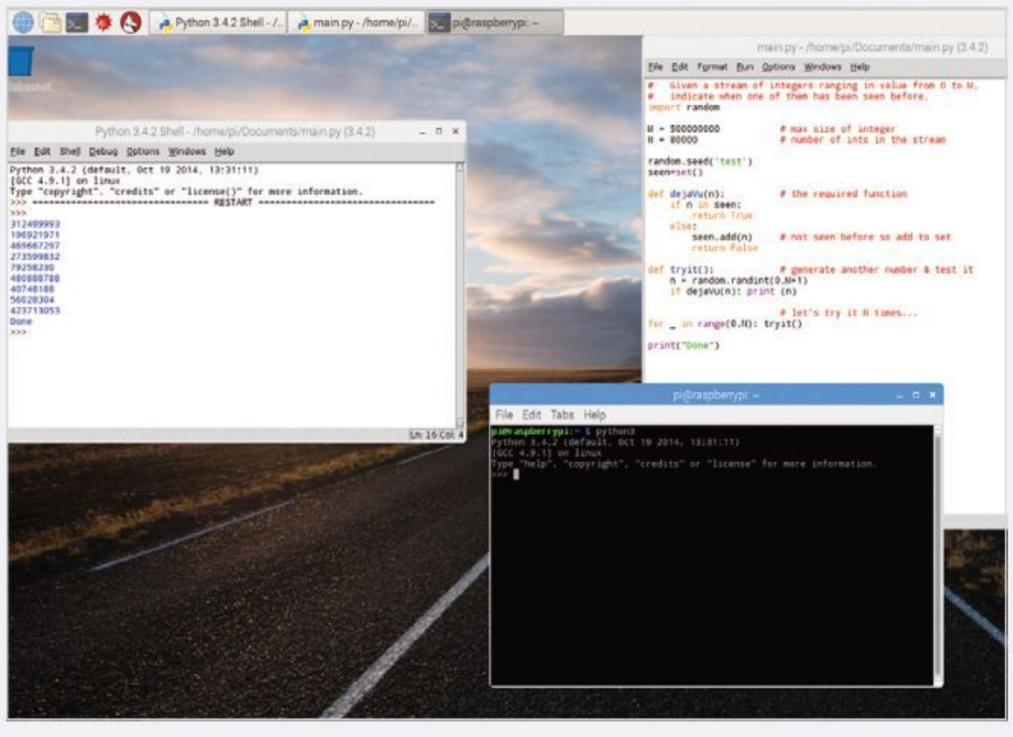


FUZE PROJECT

The FUZE is a learning environment built on the latest model of the Raspberry Pi. You can purchase the workstations that come with an electronics kit and even a robot arm for you to build and program. You can find more information on the FUZE at www.fuze.co.uk.

RASPBIAN

The Raspberry Pi's main operating system is a Debian-based Linux distribution that comes with everything you need in a simple to use package. It's streamlined for the Pi and is an ideal platform for hardware and software projects, Python programming and even as a desktop computer.



BOOKS

We have several great Raspberry Pi titles available via **www.bdmpublications.com**. Our Pi books cover how to buy your first Raspberry Pi, set it up and use it; there are some great step-by-step project examples and guides to get the most from the Raspberry Pi too.

Getting to Know Python

Python is the greatest computer programming language ever created. It enables you to fully harness the power of a computer, in a language that's clean and easy to understand.

WHAT IS PROGRAMMING?

It helps to understand what a programming language is before you try to learn one, and Python is no different. Let's take a look at how Python came about and how it relates to other languages.

PYTHON

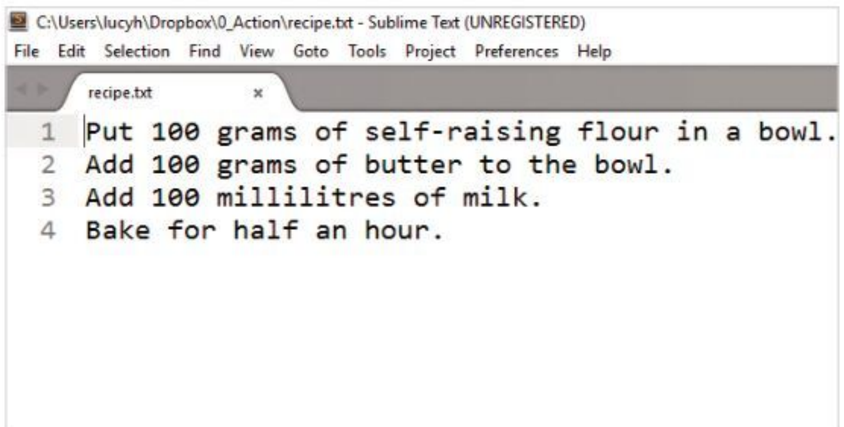
A programming language is a list of instructions that a computer follows. These instructions can be as simple as displaying your name or playing a music file, or as complex as building a whole virtual world. Python is a programming language conceived in the late 1980s by Guido van Rossum at Centrum Wiskunde & Informatica (CWI) in the Netherlands as a successor to the ABC language.

Guido van Rossum, the father of Python.

PROGRAMMING RECIPES

Programs are like recipes for computers. A recipe to bake a cake could go like this:

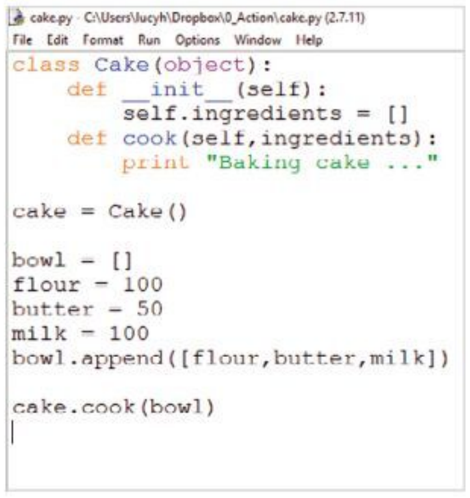
Put 100 grams of self-raising flour in a bowl.
Add 100 grams of butter to the bowl.
Add 100 millilitres of milk.
Bake for half an hour.



CODE

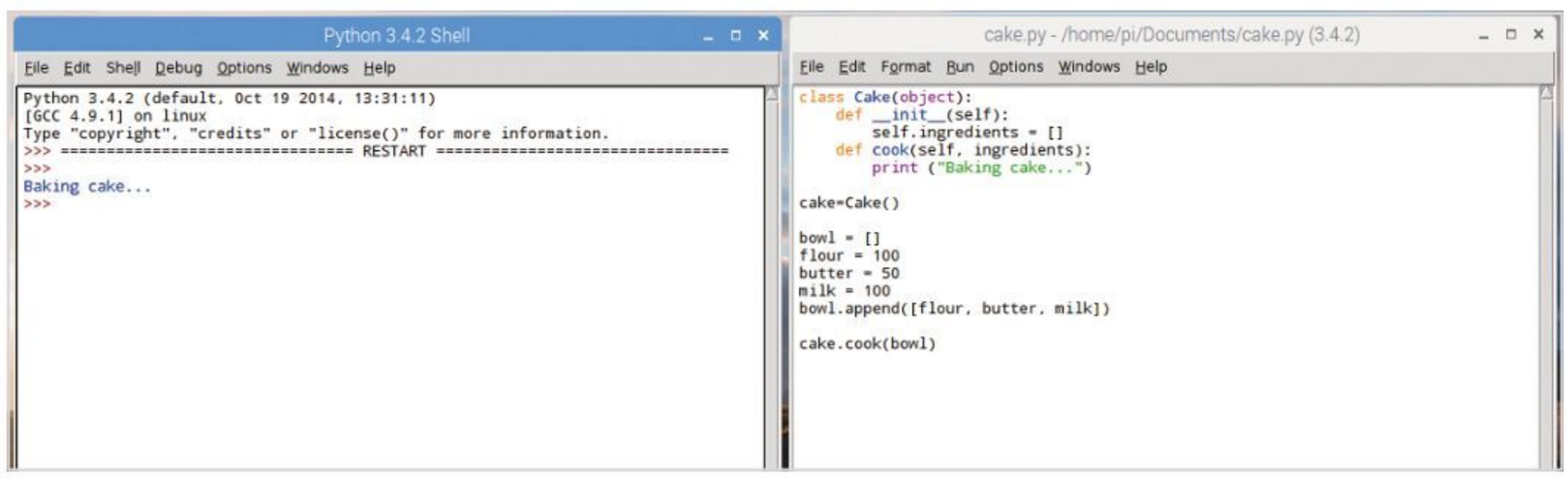
Just like a recipe, a program consists of instructions that you follow in order. A program that describes a cake might run like this:

```
bowl = []
flour = 100
butter = 50
milk = 100
bowl.append([flour,butter,milk])
cake.cook(bowl)
```



PROGRAM COMMANDS

You might not understand some of the Python commands, like bowl.append and cake.cook(bowl). The first is a list, the second an object; we'll look at both in this book. The main thing to know is that it's easy to read commands in Python. Once you learn what the commands do, it's easy to figure out how a program works.

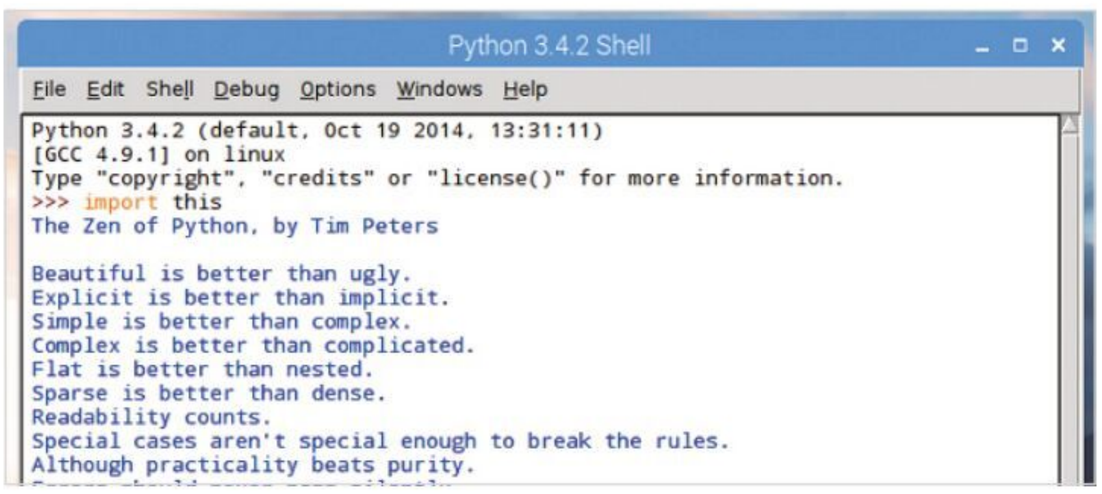


HIGH-LEVEL LANGUAGES

Computer languages that are easy to read are known as "high-level". This is because they fly high above the hardware (also referred to as "the metal"). Languages that "fly close to the metal," like Assembly, are known as "low-level". Low-level languages commands read a bit like this: `msg db ,0xa len equ $ - msg`.

ZEN OF PYTHON

Python lets you access all the power of a computer in a language that humans can understand. Behind all this is an ethos called "The Zen of Python." This is a collection of 20 software principles that influences the design of the language. Principles include "Beautiful is better than ugly" and "Simple is better than complex." Type `import this` into Python and it will display all the principles.



PYTHON 3 VS PYTHON 2

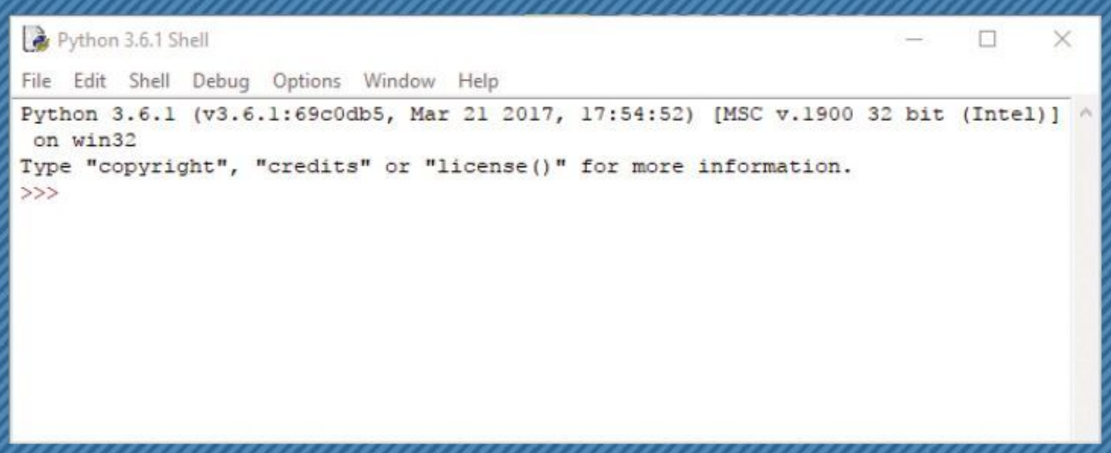
In a typical computing scenario, Python is complicated somewhat by the existence of two active versions of the language: Python 2 and Python 3.

WORLD OF PYTHON

Python 3.7 is the newest release of the programming language. However, if you dig a little deeper into the Python site, and investigate Python code online, you will undoubtedly come across Python 2. Although you can run Python 3 and Python 2 alongside each other, it's not recommended. Always opt for the latest stable release as posted by the Python website.

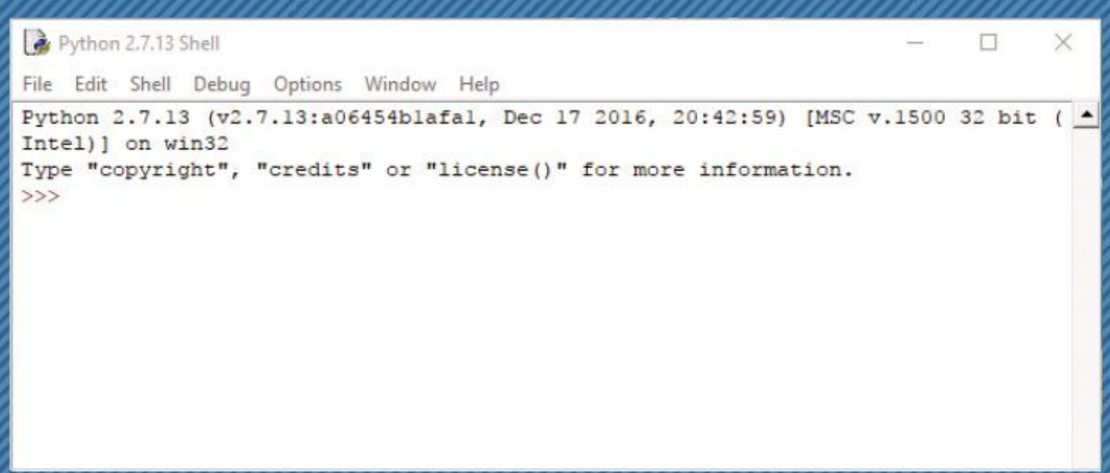
PYTHON 3.X

In 2008 Python 3 arrived with several new and enhanced features. These features provide a more stable, effective and efficient programming environment but sadly, most (if not all) of these new features are not compatible with Python 2 scripts, modules and tutorials. Whilst not popular at first, Python 3 has since become the cutting edge of Python programming.



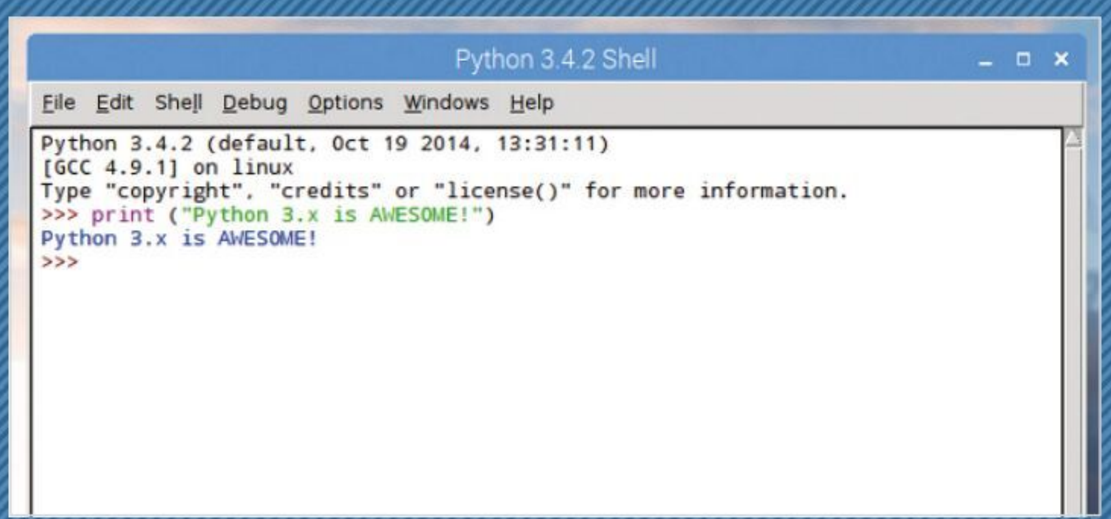
PYTHON 2.X

So why two? Well, Python 2 was originally launched in 2000 and has since then adopted quite a large collection of modules, scripts, users, tutorials and so on. Over the years Python 2 has fast become one of the first go to programming languages for beginners and experts to code in, which makes it an extremely valuable resource.



3.X WINS

Python 3's growing popularity has meant that it's now prudent to start learning to develop with the new features and begin to phase out the previous version. Many development companies, such as SpaceX and NASA use Python 3 for snippets of important code.



How to Set Up Python in Windows

Windows users can easily install the latest version of Python via the main Python Downloads page. Whilst most seasoned Python developers may shun Windows as the platform of choice for building their code, it's still an ideal starting point for beginners.

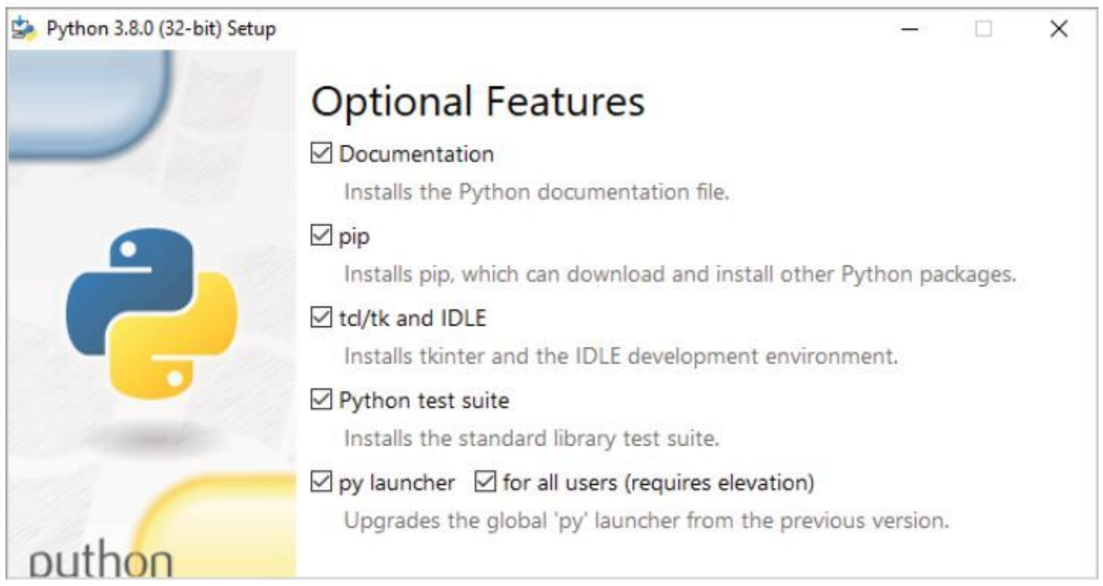
INSTALLING PYTHON 3.X

Microsoft Windows doesn't come with Python preinstalled as standard, so it will be necessary to install it yourself manually. Thankfully, it's an easy process to follow.

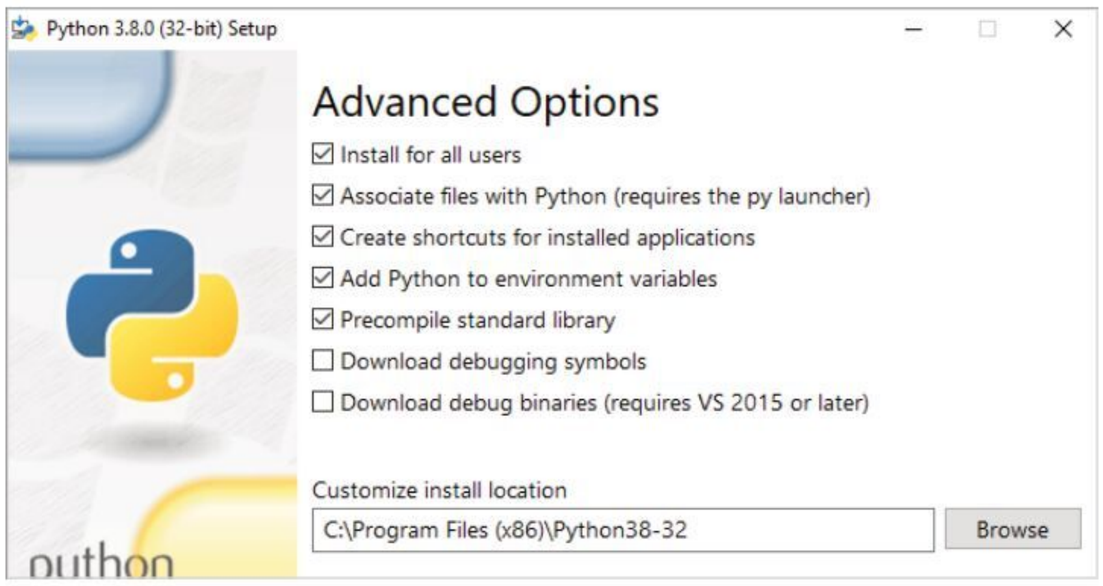
STEP 1 Start by opening your web browser to www.python.org/downloads/. Look for the button detailing the Download link for Python 3.x. Python is regularly updated, changing the last digit for each bug fix and update. Therefore, don't worry if you see Python 3.8, or more, as long as it's Python 3, the code in this book will work fine.

STEP 2 Click the Download button for version 3.x and save the file to your Downloads folder. When the file is downloaded, double-click the executable and the Python installation wizard will launch. From here, you have two choices: Install Now and Customise Installation. We recommend opting for the Customise Installation link.

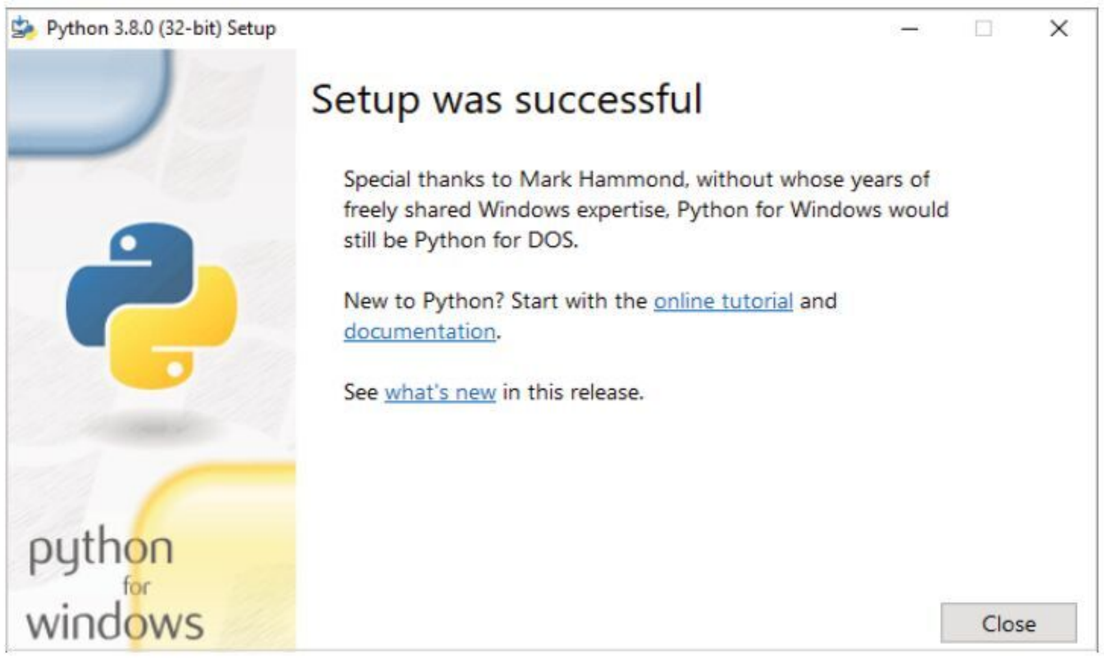
STEP 3 Choosing the Customise option allows you to specify certain parameters, and whilst you may stay with the defaults, it's a good habit to adopt as, sometimes (not with Python, thankfully), installers can include unwanted additional features. On the first screen available, ensure all boxes are ticked and click the Next button.



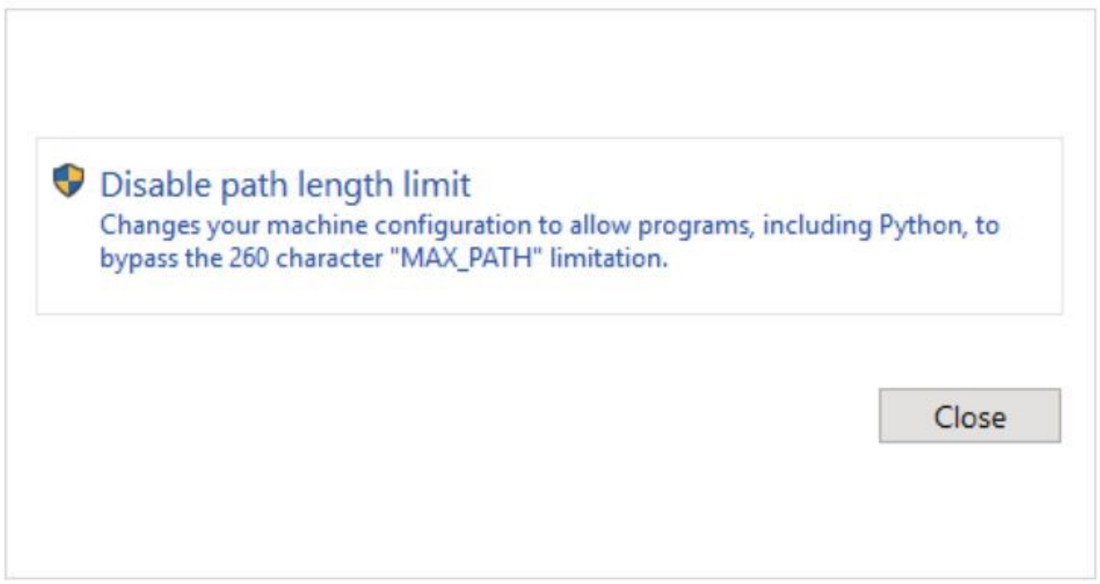
STEP 4 The next page of options include some interesting additions to Python. Ensure the Associate file with Python, Create Shortcuts, Add Python to Environment Variables, Precompile Standard Library and Install for All Users options are ticked. These make using Python later much easier. Click Install when you're ready to continue.



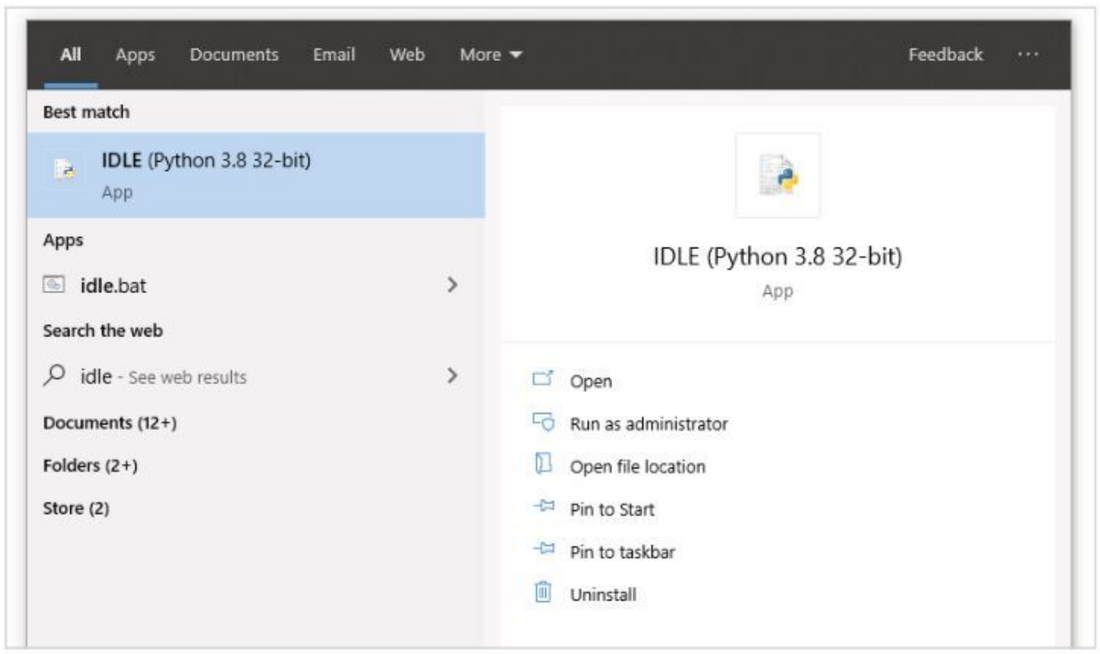
STEP 5 You may need to confirm the installation with the Windows authentication notification. Simply click Yes and Python will begin to install. Once the installation is complete, the final Python wizard page will allow you to view the latest release notes and follow some online tutorials.



STEP 6 Before you close the install wizard window however, it's best to click on the link next to the shield detailed Disable Path Length Limit. This will allow Python to bypass the Windows 260 character limitation, enabling you to execute Python programs stored in deep folders arrangements. Click Yes again, to authenticate the process, then you can Close the installation window.

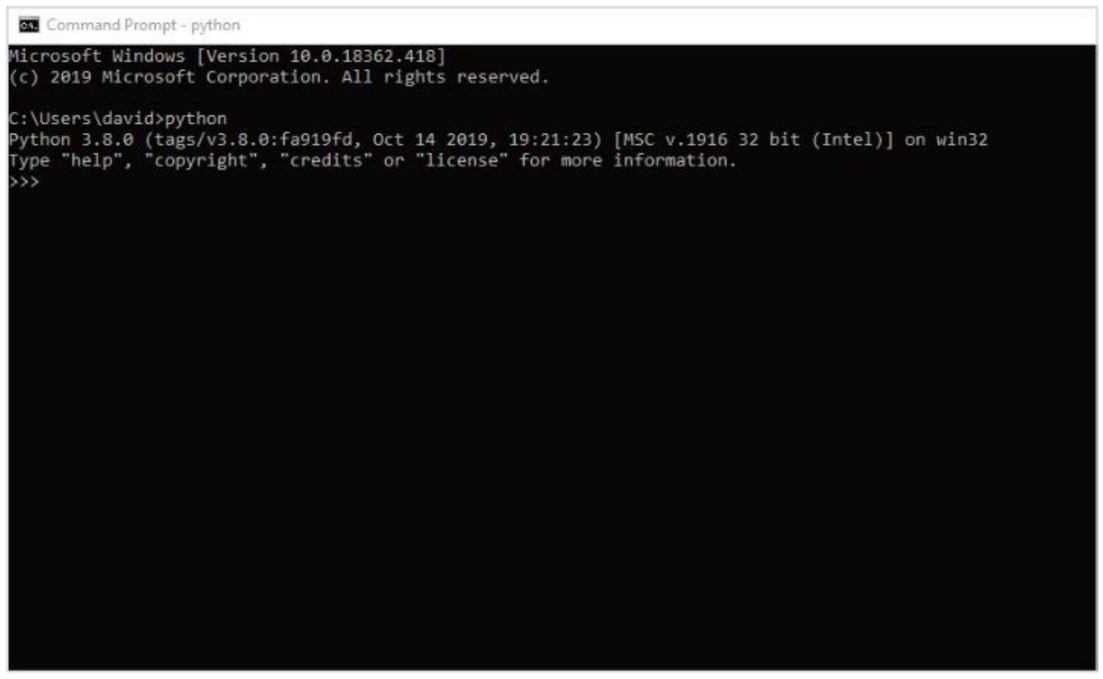


STEP 7 Windows 10 users can now find the installed Python 3.x within the Start button Recently Added section. The first link, Python 3.x (32-bit) will launch the command line version of Python when clicked (more on that in a moment). To open the IDLE, type IDLE into Windows start.

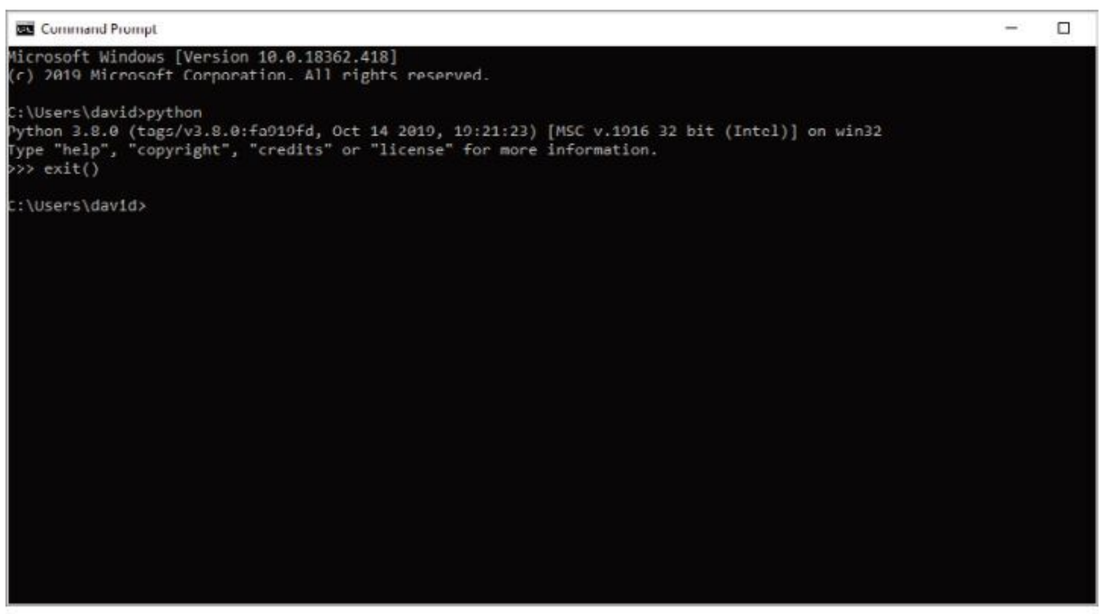


STEP 8 Clicking on the IDLE (Python 3.x 32-bit) link will launch the Python Shell, where you can begin your Python programming journey. Don't worry if your version is newer, as long as it's Python 3.x our code works inside your Python 3 interface.

STEP 9 If you now click on the Windows Start button again, and this time type: CMD, you'll be presented with the Command Prompt link. Click it to get to the Windows command line environment. To enter Python within the command line, you need to type: `python` and press Enter.



STEP 10 The command line version of Python works in much the same way as the Shell you opened in Step 8; note the three left-facing arrows (>>>). Whilst it's a perfectly fine environment, it's not too user-friendly, so leave the command line for now. Enter: `exit()` to leave and close the Command Prompt window.



How to Set Up Python in Linux

While the Raspberry Pi's operating system contains the latest, stable version of Python, other Linux distros don't come with Python 3 pre-installed. If you're not going down the Pi route, then here's how to check and install Python for Linux.

PYTHON PENGUIN

Linux is such a versatile operating system that it's often difficult to nail down just one-way of doing something. Different distributions go about installing software in different ways, so for this particular tutorial we will stick to Linux Mint.

STEP 1 First you need to ascertain which version of Python is currently installed in your Linux system. To begin with, drop into a Terminal session from your distro's menu, or hit the Ctrl+Alt+T keys.

```
david@david-Mint: ~
File  Edit  View  Search  Terminal  Help
david@david-Mint:~$
```

STEP 2 Next, enter: `python --version` into the Terminal screen. You should have the output relating to version 2.x of Python in the display. Most Linux distro come with both Python 2 and 3 by default, as there's plenty of code out there still available for Python 2. Now enter: `python3 --version`.

```
david@david-Mint: ~
File  Edit  View  Search  Terminal  Help
david@david-Mint:~$ python --version
Python 2.7.15rc1
david@david-Mint:~$ python3 --version
Python 3.6.7
david@david-Mint:~$
```

STEP 3 In our case we have both Python 2 and 3 installed. As long as Python 3.x.x is installed, then the code in our tutorials will work. It's always worth checking to see if the distro has been updated with the latest versions, enter: `sudo apt-get update && sudo apt-get upgrade` to update the system.

```
david@david-Mint: ~
File  Edit  View  Search  Terminal  Help
david@david-Mint:~$ python --version
Python 2.7.15rc1
david@david-Mint:~$ python3 --version
Python 3.6.7
david@david-Mint:~$ sudo apt-get update && sudo apt-get upgrade
[sudo] password for david:
```

STEP 4 Once the update and upgrade completes, enter: `python3 --version` again to see if Python 3.x is updated, or even installed. As long as you have Python 3.x, you're running the most recent major version, the numbers after the 3. indicate patches plus further updates. Often they're unnecessary, but they can contain vital new elements.

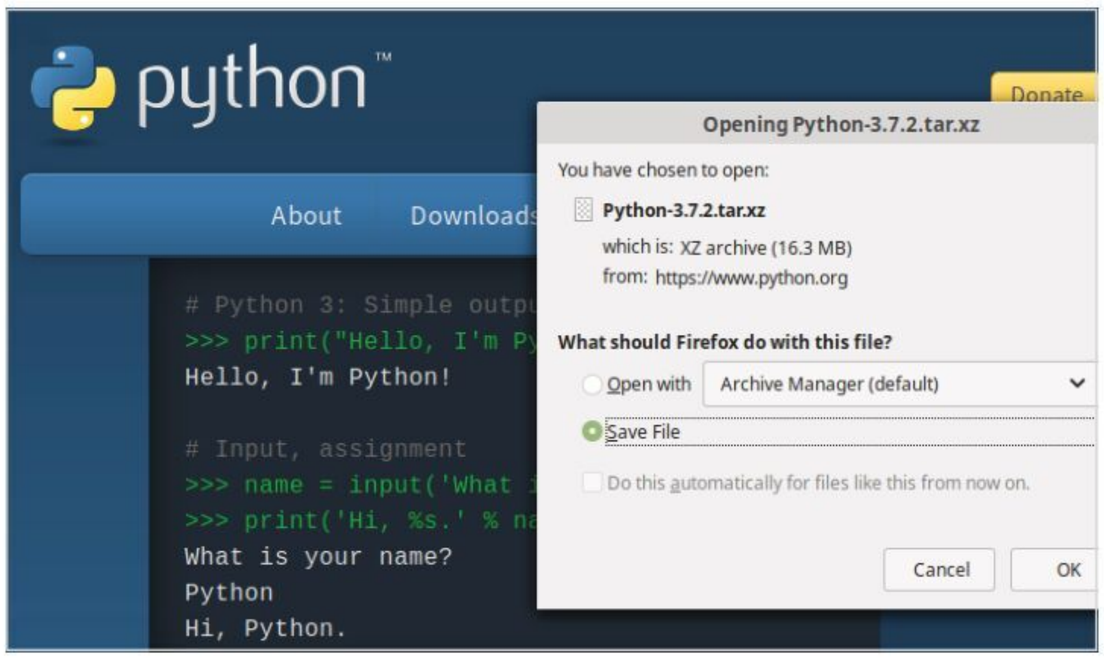
```
File  Edit  View  Search  Terminal  Help
Need to get 1,409 kB of archives.
After this operation, 23.6 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
Get:1 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libasound2 amd6
4 1.1.3-5ubuntu0.2 [359 kB]
Get:2 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 libasound2-data
 all 1.1.3-5ubuntu0.2 [36.5 kB]
Get:3 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 linux-libc-dev
amd64 4.15.0-44.47 [1,013 kB]
Fetched 1,409 kB in 0s (3,023 kB/s)
(Reading database ... 290768 files and directories currently installed.)
Preparing to unpack .../libasound2_1.1.3-5ubuntu0.2_amd64.deb ...
Unpacking libasound2:amd64 (1.1.3-5ubuntu0.2) over (1.1.3-5ubuntu0.1) ...
Preparing to unpack .../libasound2-data_1.1.3-5ubuntu0.2_all.deb ...
Unpacking libasound2-data (1.1.3-5ubuntu0.2) over (1.1.3-5ubuntu0.1) ...
Preparing to unpack .../linux-libc-dev_4.15.0-44.47_amd64.deb ...
Unpacking linux-libc-dev:amd64 (4.15.0-44.47) over (4.15.0-43.46) ...
Setting up libasound2-data (1.1.3-5ubuntu0.2) ...
```

STEP 5 However, if you want the latest, cutting edge version, you'll need to build Python from source. Start by entering these commands into the Terminal:

```
sudo apt-get install build-essential checkinstall
sudo apt-get install libreadline-gplv2-dev
libncursesw5-dev libssl-dev libsqlite3-dev tk-dev
libgdbm-dev libc6-dev libbz2-dev
```

```
david@david-Mint: ~
File  Edit  View  Search  Terminal  Help
david@david-Mint:~$ sudo apt-get install build-essential checkinstall
Reading package lists... Done
Building dependency tree
Reading state information... Done
build-essential is already the newest version (12.4ubuntu1).
The following NEW packages will be installed
  checkinstall
0 to upgrade, 1 to newly install, 0 to remove and 3 not to upgrade.
Need to get 97.1 kB of archives.
After this operation, 438 kB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

STEP 6 Open up your Linux web browser and go to the Python download page: **https://www.python.org/downloads**. Click on the Downloads, followed by the button under the Python Source window. This opens a download dialogue box, choose a location, then start the download process.



STEP 7 In the Terminal, go to the Downloads folder by entering: `cd Downloads/`. Then unzip the contents of the downloaded Python source code with: `tar -xvf Python-3.Y.Y.tar.xz` (replace the Y's with the version numbers you've downloaded). Now enter the newly unzipped folder with: `cd Python-3.Y.Y/`.

```
Python-3.7.2/Objects/clinic/floatobject.c.h
Python-3.7.2/Objects/clinic/funcobject.c.h
Python-3.7.2/Objects/clinic/longobject.c.h
Python-3.7.2/Objects/clinic/dictobject.c.h
Python-3.7.2/Objects/clinic/structseq.c.h
Python-3.7.2/Objects/clinic/tupleobject.c.h
Python-3.7.2/Objects/clinic/moduleobject.c.h
Python-3.7.2/Objects/clinic/odictobject.c.h
Python-3.7.2/Objects/bytearrayobject.c
Python-3.7.2/Objects/typeobject.c
Python-3.7.2/Objects/lnotab_notes.txt
Python-3.7.2/Objects/methodobject.c
Python-3.7.2/Objects/tupleobject.c
Python-3.7.2/Objects/obmalloc.c
Python-3.7.2/Objects/object.c
Python-3.7.2/Objects/abstract.c
Python-3.7.2/Objects/listobject.c
Python-3.7.2/Objects/bytes_methods.c
Python-3.7.2/Objects/dictnotes.txt
Python-3.7.2/Objects/typeslots.inc
david@david-Mint:~/Downloads$ cd Python-3.7.2/
david@david-Mint:~/Downloads/Python-3.7.2$
```

STEP 8 Within the Python folder, enter:

```
./configure
sudo make altinstall
```

This could take a while, depending on the speed of your computer. Once finished, enter: `python3.7 --version` to check the latest installed version. You now have Python 3.7 installed, alongside older Python 3.x.x and Python 2.

```
checking whether compiling and linking against OpenSSL works... no
checking for --with-ssl-default-suites... python
configure: creating ./config.status
config.status: creating Makefile.pre
config.status: creating Misc/python.pc
config.status: creating Misc/python-config.sh
config.status: creating Modules/ld_so_aix
config.status: creating pyconfig.h
creating Modules/Setup
creating Modules/Setup.local
creating Makefile


If you want a release build with all stable optimizations active (PGO, etc),
please run ./configure --enable-optimizations


david@david-Mint:~/Downloads/Python-3.7.2$ sudo make altinstall
```

STEP 9 For the GUI IDLE, you'll need to enter the following command into the Terminal:

```
sudo apt-get install idle3
```

The IDLE can then be started with the command: `idle3`. Note, that IDLE runs a different version to the one you installed from source.

```
david@david-Mint: ~/Downloads/Python-3.7.2
File  Edit  View  Search  Terminal  Help
david@david-Mint:~/Downloads/Python-3.7.2$ sudo apt-get install idle3
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  blt idle idle-python3.6 python3-tk tk8.6-blt2.5
Suggested packages:
  blt-demo tix python3-tk-dbg
The following NEW packages will be installed
  blt idle idle-python3.6 idle3 python3-tk tk8.6-blt2.5
0 to upgrade, 6 to newly install, 0 to remove and 3 not to upgrade.
Need to get 938 kB of archives.
After this operation, 4,221 kB of additional disk space will be used.
Do you want to continue? [Y/n]
```

STEP 10 You'll also need PIP (Pip Installs Packages), which is a tool to help you install more modules and extras. Enter: `sudo apt-get install python3-pip`

Once PIP is installed, check for the latest update with:

```
pip3 install --upgrade pip
```

When complete, close the Terminal and Python 3.x will be available via the Programming section in your distro's menu.

```
david@david-Mint: ~/Downloads/Python-3.7.2
File  Edit  View  Search  Terminal  Help
david@david-Mint:~/Downloads/Python-3.7.2$ sudo apt-get install python3-pip
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  python-pip-whl python3-distutils python3-lib2to3
Recommended packages:
  python3-dev python3-setuptools python3-wheel
The following NEW packages will be installed
  python-pip-whl python3-distutils python3-lib2to3 python3-pip
0 to upgrade, 4 to newly install, 0 to remove and 3 not to upgrade.
Need to get 1,984 kB of archives.
After this operation, 4,569 kB of additional disk space will be used.
Do you want to continue? [Y/n]
```

PYTHON ON macOS

Installation of Python on macOS can be done in much the same way as the Windows installation. Simply go to the Python webpage, hover your mouse pointer over the Downloads link and select Mac OS X from the options. You will then be guided to the Python releases for Mac versions, along with the necessary installers for macOS 64-bit for OS X 10.9 and later.

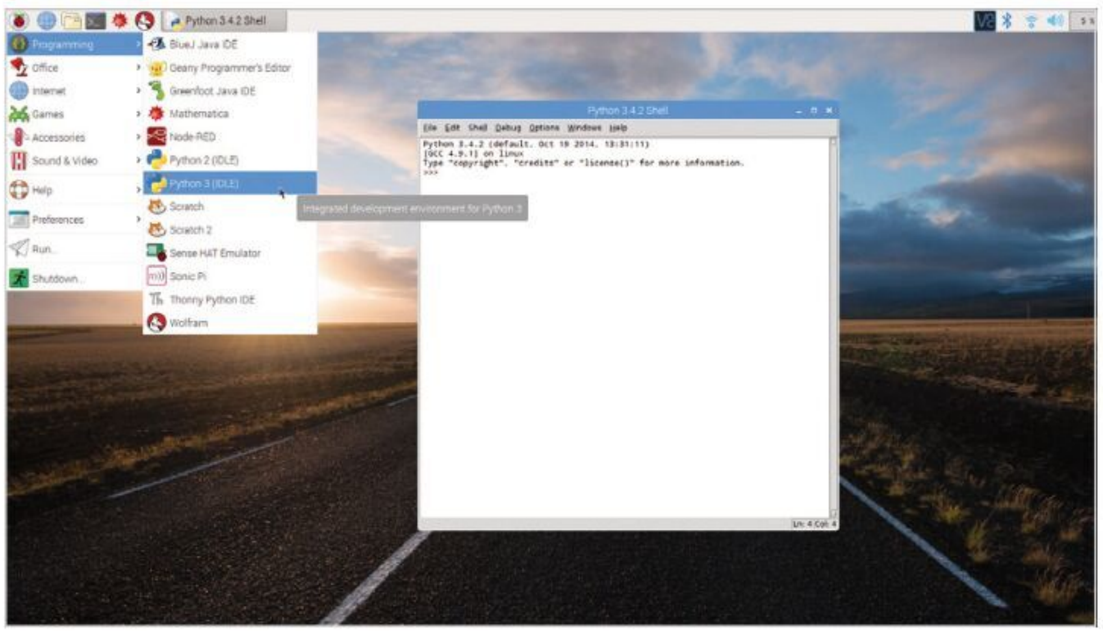
Starting Python for the First Time

The Raspberry Pi offers one of the best all-round solutions on which to learn and code, in particular, Python. Raspbian, the Pi's recommended OS, come pre-installed with the latest stable version of Python 3, which makes it a superb coding platform.

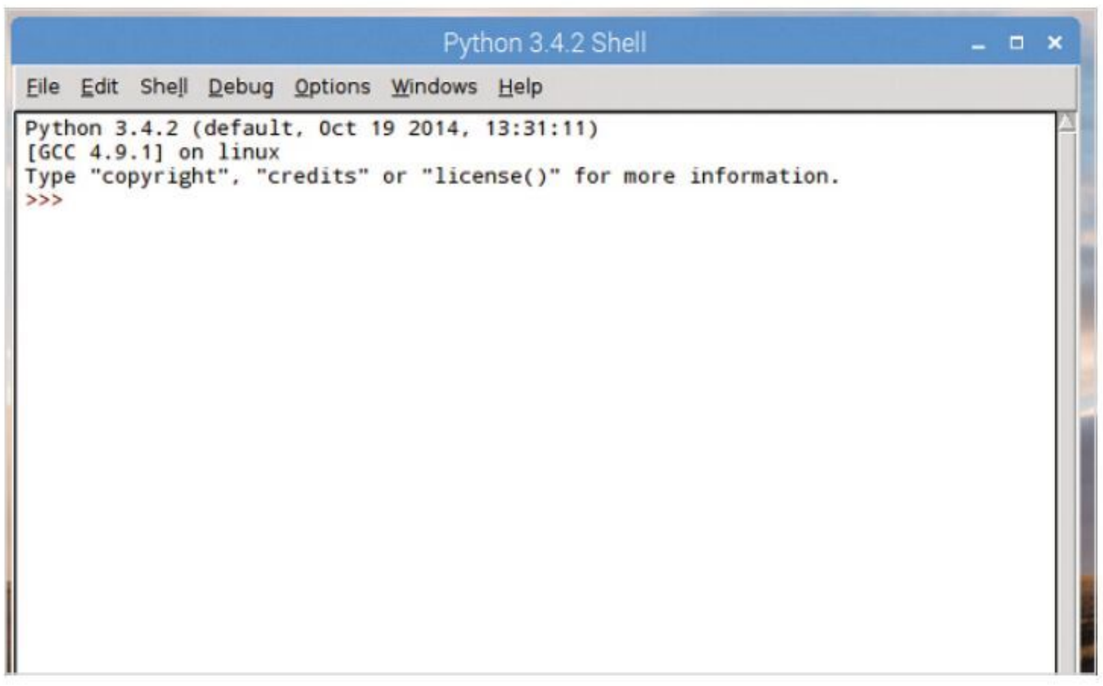
STARTING PYTHON

Everything you need to begin programming with Python is available from the Raspberry Pi desktop. However, if you want, drop into the Terminal and update the system with: sudo apt-get update.

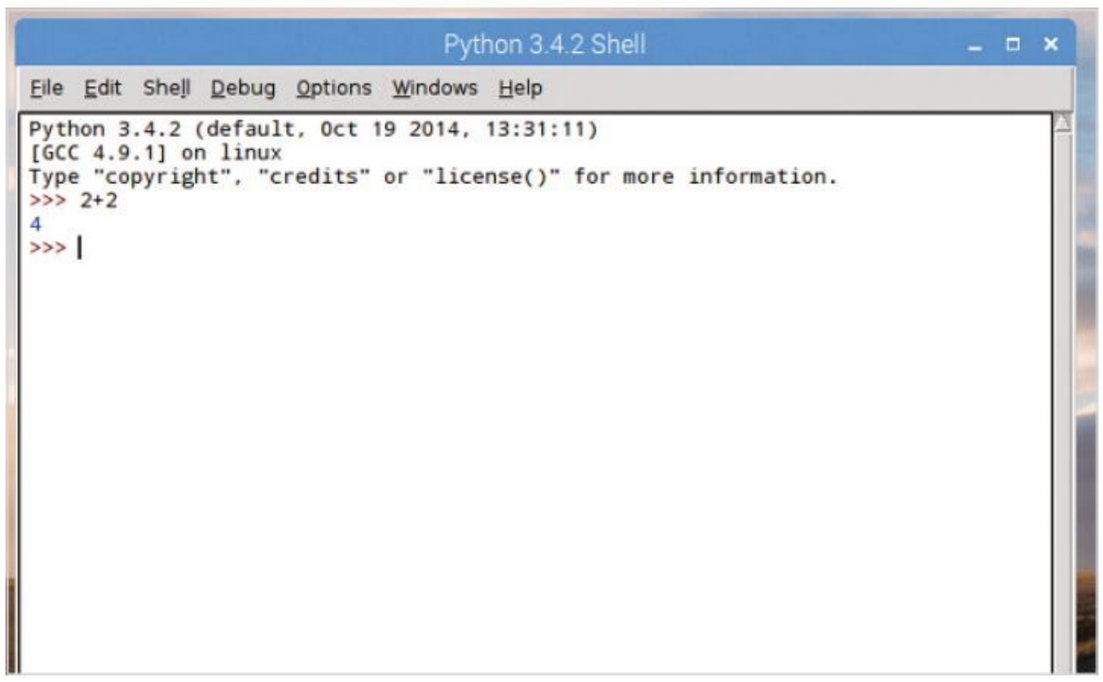
STEP 1 With the Raspbian desktop loaded, click on the Menu button followed by Programming > Python 3 (IDLE). This opens the Python 3 Shell. Windows and Mac users can find the Python 3 IDLE Shell from within the Windows Start button menu and via Finder.



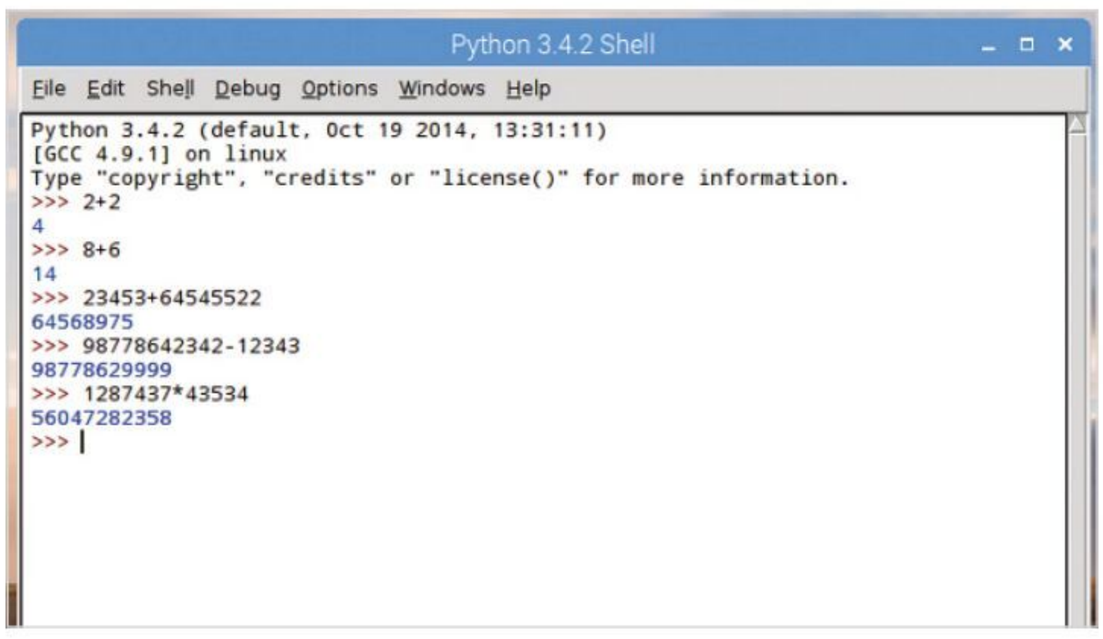
STEP 2 The Shell is where you can enter code and see the responses and output of code you've programmed into Python. This is a kind of sandbox, where you're able to try out some simple code and processes.



STEP 3 For example, in the Shell enter: `2+2`
After pressing Enter, the next line displays the answer: 4. Basically, Python has taken the 'code' and produced the relevant output.



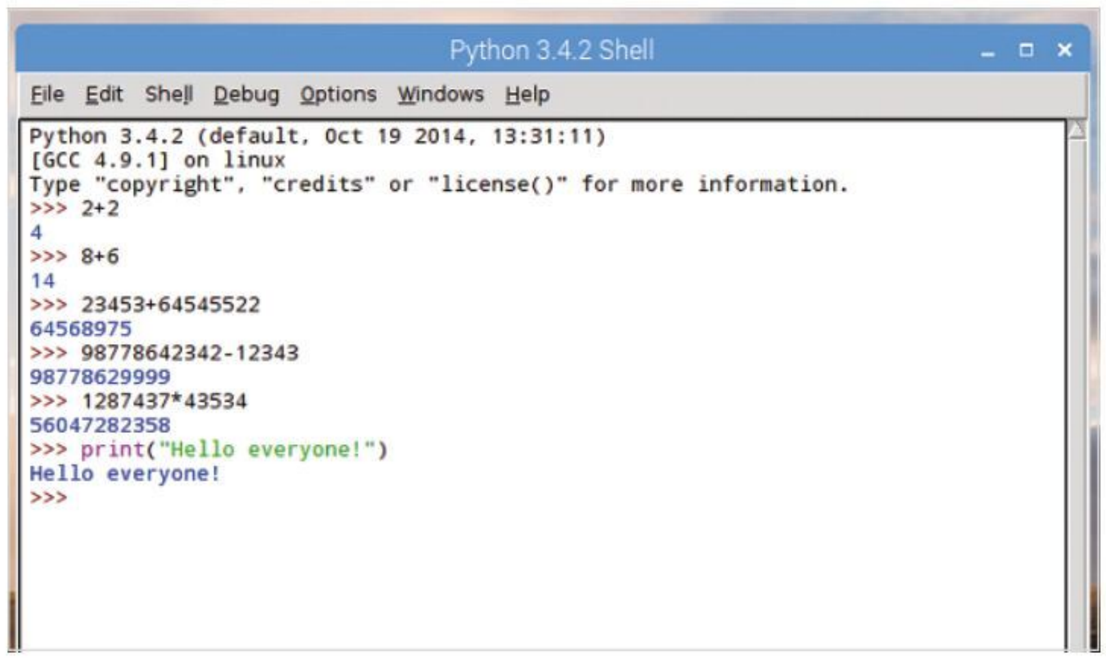
STEP 4 The Python Shell acts very much like a calculator, since code is basically a series of mathematical interactions with the system. Integers, which are the infinite sequence of whole numbers can easily be added, subtracted, multiplied and so on.



STEP 5 While that's very interesting, it's not particularly exciting. Instead, try this:

```
print("Hello everyone!")
```

Just enter it into the IDLE as you've done in the previous steps.



STEP 6 This is a little more like it, since you've just produced your first bit of code. The Print command is fairly self-explanatory, it prints things. Python 3 requires the brackets as well as quote marks in order to output content to the screen, in this case the 'Hello everyone!' bit.

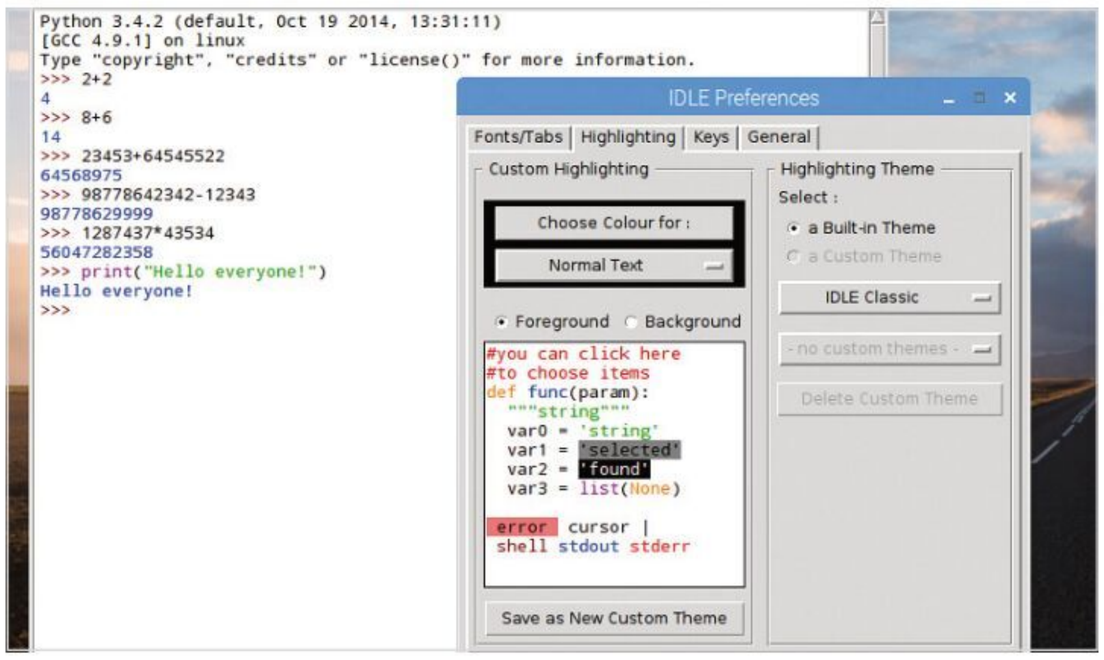
STEP 7 You may have noticed the colour coding within the Python IDLE. The colours represent different elements of Python code. They are:

Black – Data and Variables
Green – Strings
Purple – Functions
Orange – Commands
Blue – User Functions
Dark Red – Comments
Light Red – Error Messages

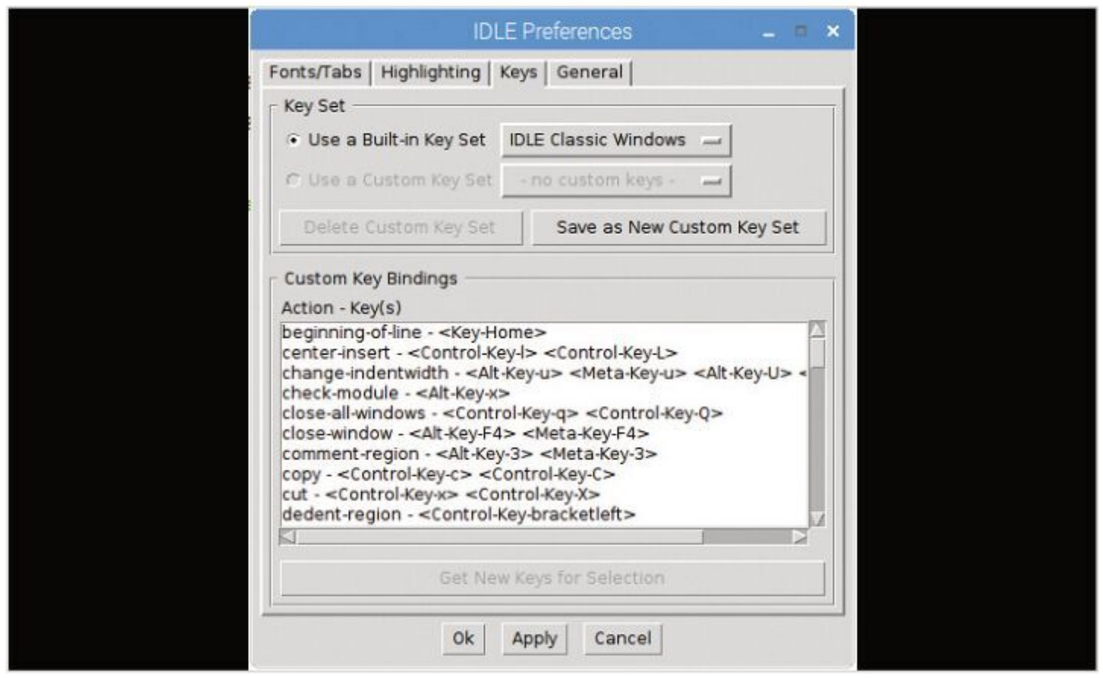
IDLE Colour Coding

Colour	Use for	Examples
Black	Data & variables	23.6 area
Green	Strings	"Hello World"
Purple	Functions	len() print()
Orange	Commands	if for else
Blue	User functions	get_area()
Dark red	Comments	#Remember VAT
Light red	Error messages	SyntaxError:

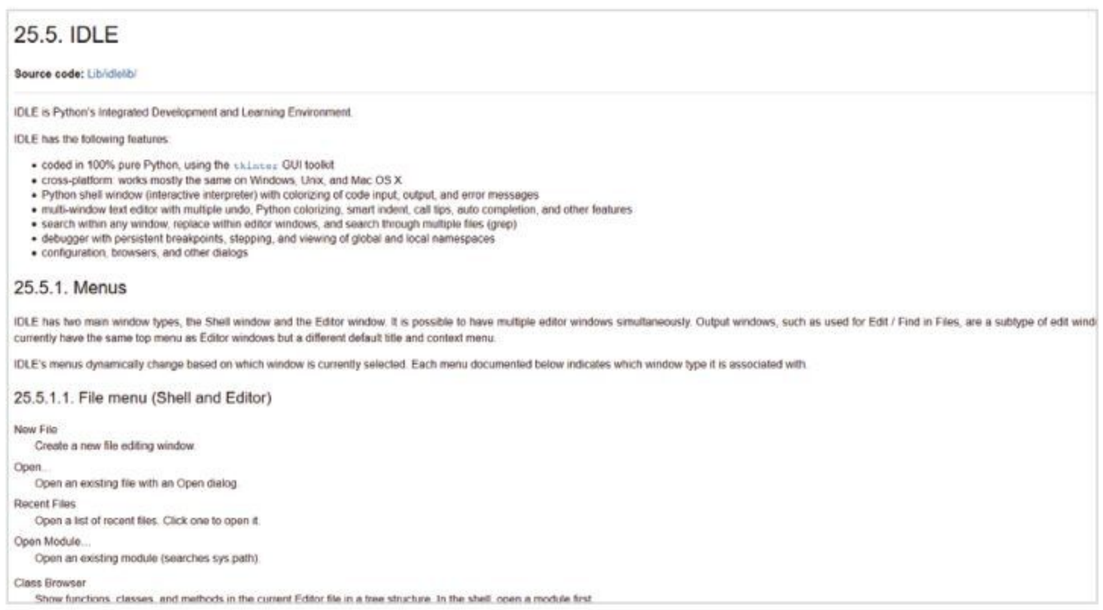
STEP 8 The Python IDLE is a configurable environment. If you don't like the way the colours are represented, then you can always change them via Options > Configure IDLE and clicking on the Highlighting tab. However, we don't recommend that, as you won't be seeing the same as our screenshots.



STEP 9 Just like most programs available, regardless of the operating system, there are numerous shortcut keys available. We don't have room for them all here but within the Options > Configure IDLE and under the Keys tab, you can see a list of the current bindings.



STEP 10 The Python IDLE is a power interface and one that's actually been written in Python using one of the available GUI toolkits. If you want to know the many ins and outs of the Shell, we recommend you take a few moments to view **www.docs.python.org/3/library/idle.html**, which details many of the IDLE's features.



Your First Code

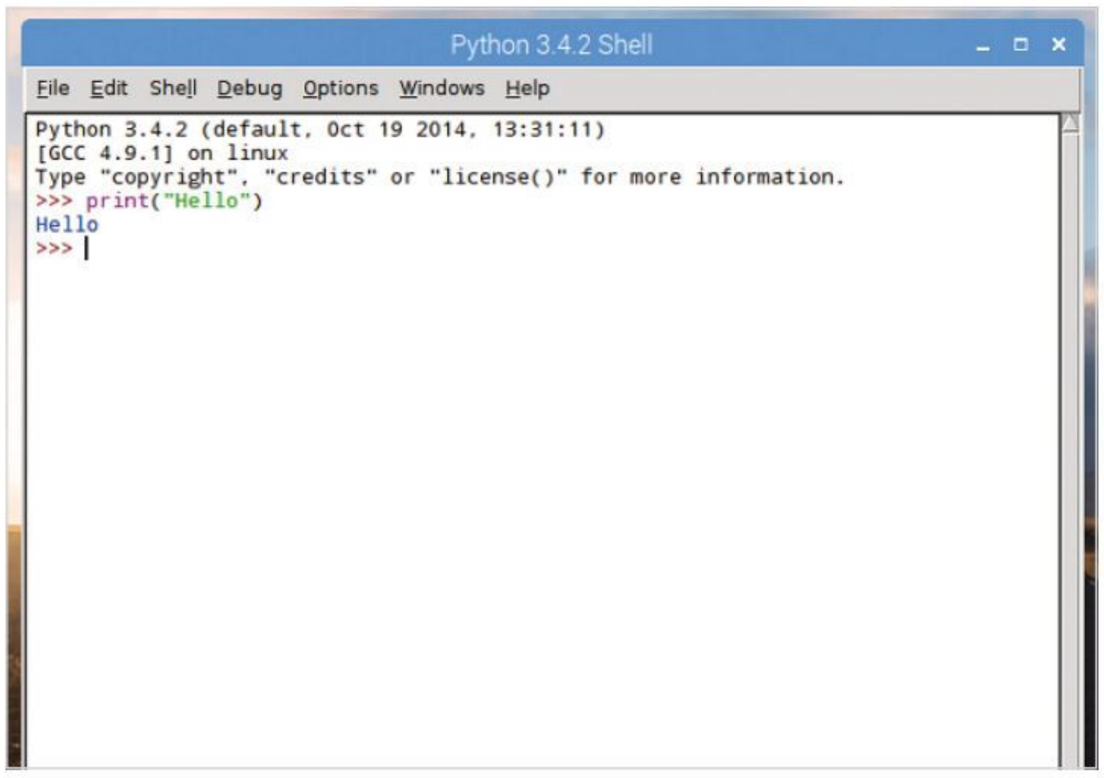
Essentially, you've already written your first piece of code with the 'print("Hello everyone!")' function from the previous tutorial. However, let's expand that and look at entering your code and playing around with some other Python examples.

PLAYING WITH PYTHON

With most languages, computer or human, it's all about remembering and applying the right words to the right situation. You're not born knowing these words, so you need to learn them.

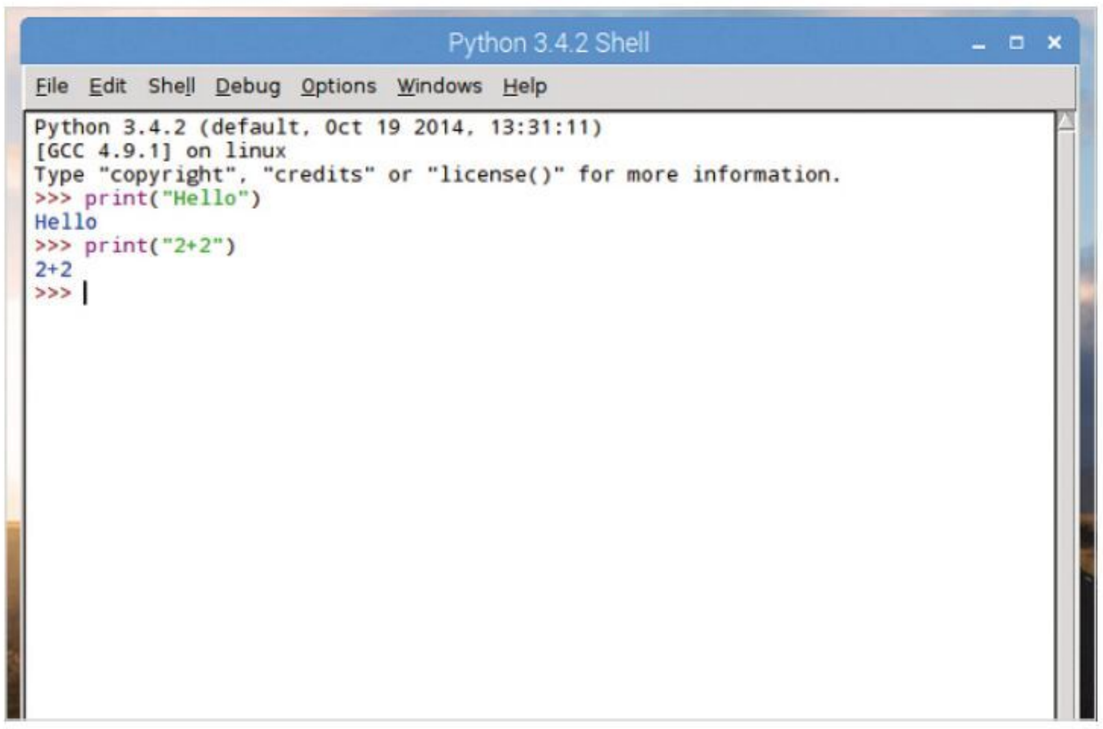
STEP 1 If you've closed Python 3 IDLE, reopen it in whichever operating system version you prefer. In the Shell, enter the familiar following:

```
print("Hello")
```



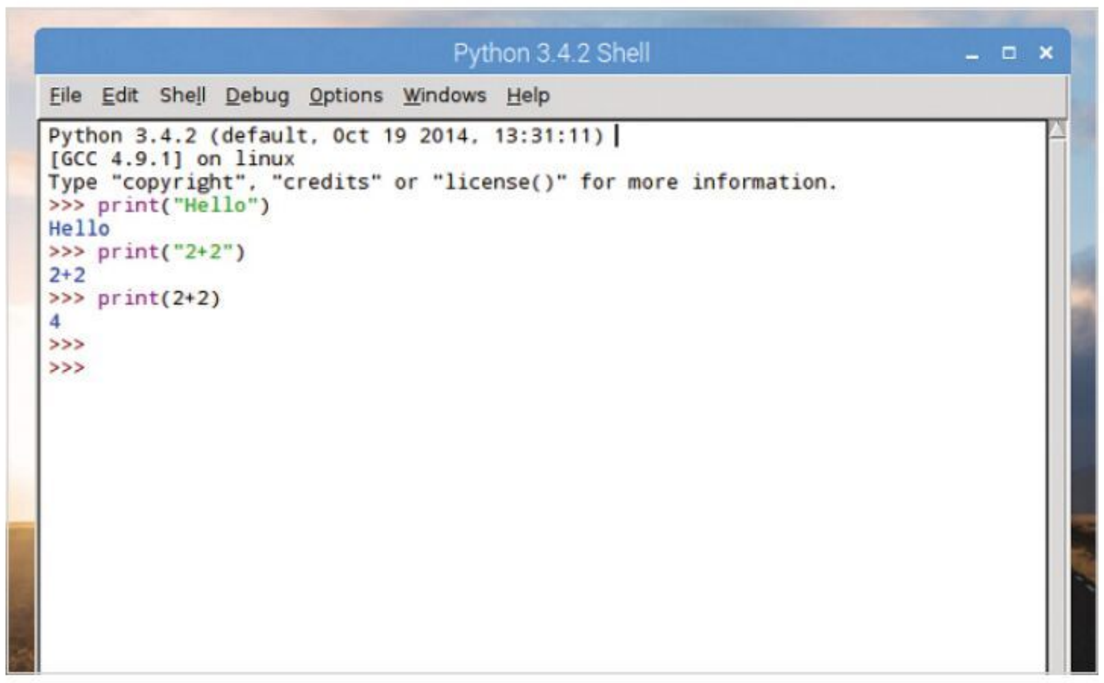
STEP 2 Just as predicted, the word Hello appears in the Shell as blue text, indicating output from a string. It's fairly straightforward and doesn't require too much explanation. Now try:

```
print("2+2")
```



STEP 3 You can see that instead of the number 4, the output is the 2+2 you asked to be printed to the screen. The quotation marks are defining what's being outputted to the IDLE Shell; to print the total of 2+2 you need to remove the quotes:

```
print(2+2)
```

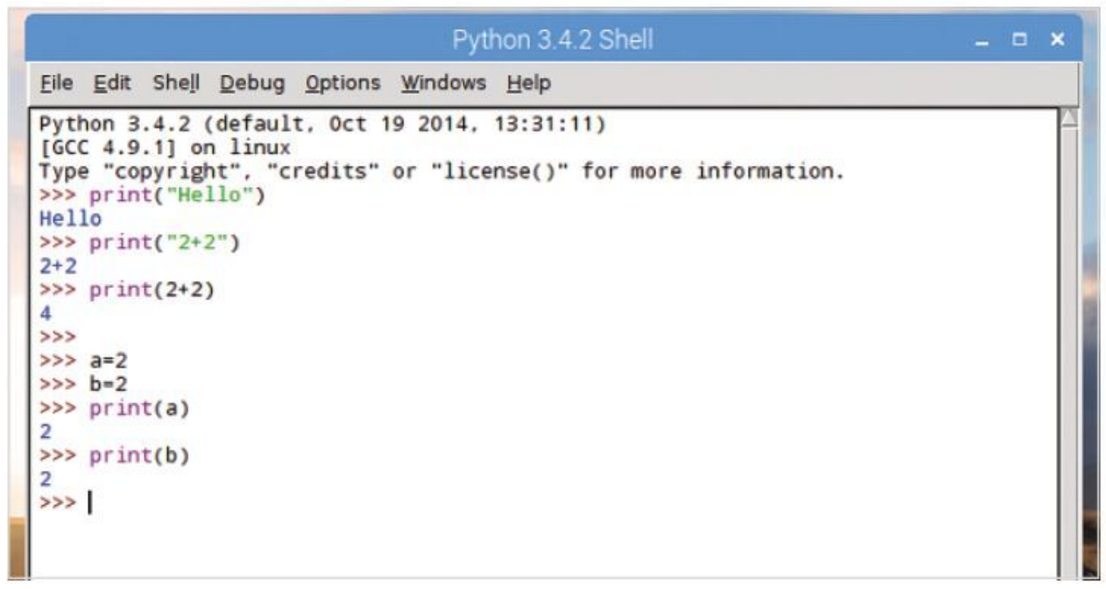


STEP 4 You can continue as such, printing 2+2, 464+2343 and so on to the Shell. An easier way is to use a variable, which is something we will cover in more depth later. For now, enter:

```
a=2
b=2
```

STEP 5 What you have done here is assign the letters a and b two values: 2 and 2. These are now variables, which can be called upon by Python to output, add, subtract, divide and so on for as long as their numbers stay the same. Try this:

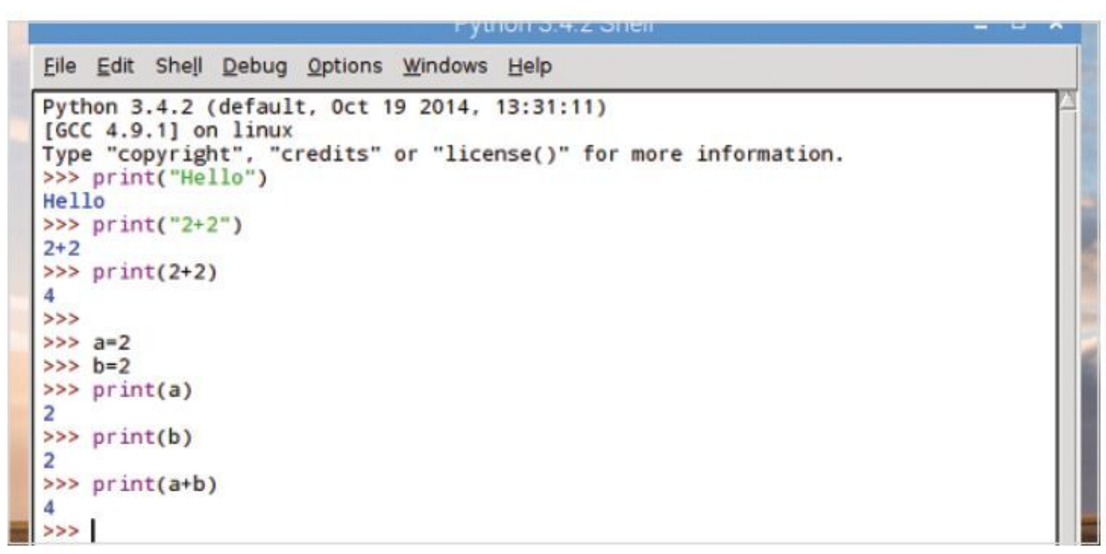
```
print(a)
print(b)
```



STEP 6 The output of the last step displays the current values of both a and b individually, as you've asked them to be printed separately. If you want to add them up, you can use the following:

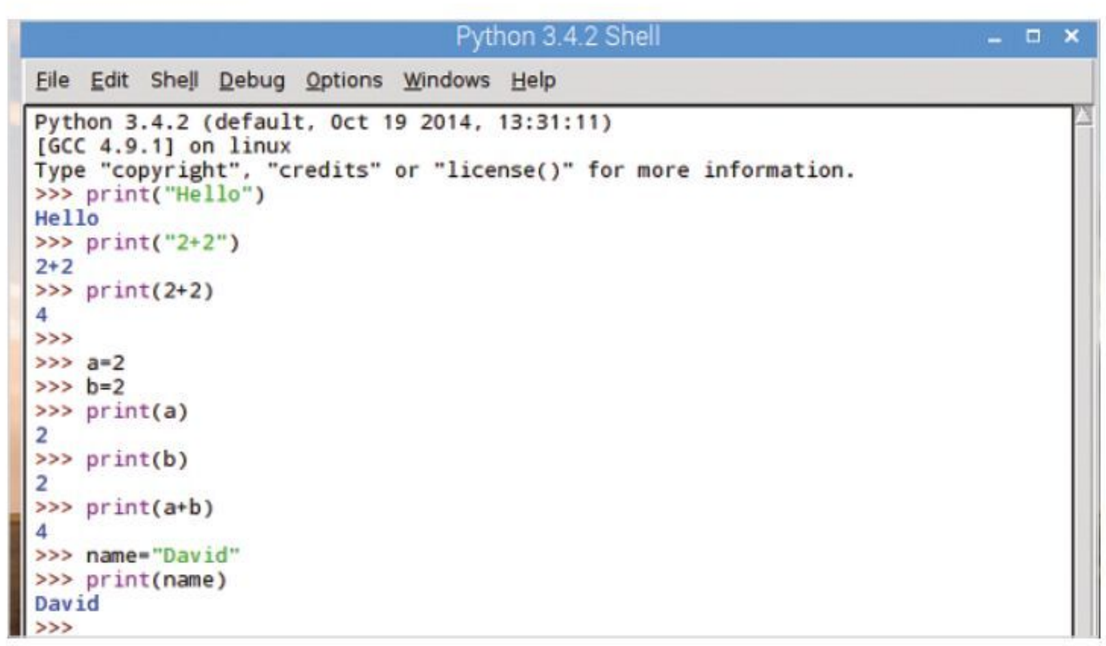
```
print(a+b)
```

This code simply takes the values of a and b, adds them together and outputs the result.



STEP 7 You can play around with different kinds of variables and the Print function. For example, you could assign variables for someone's name:

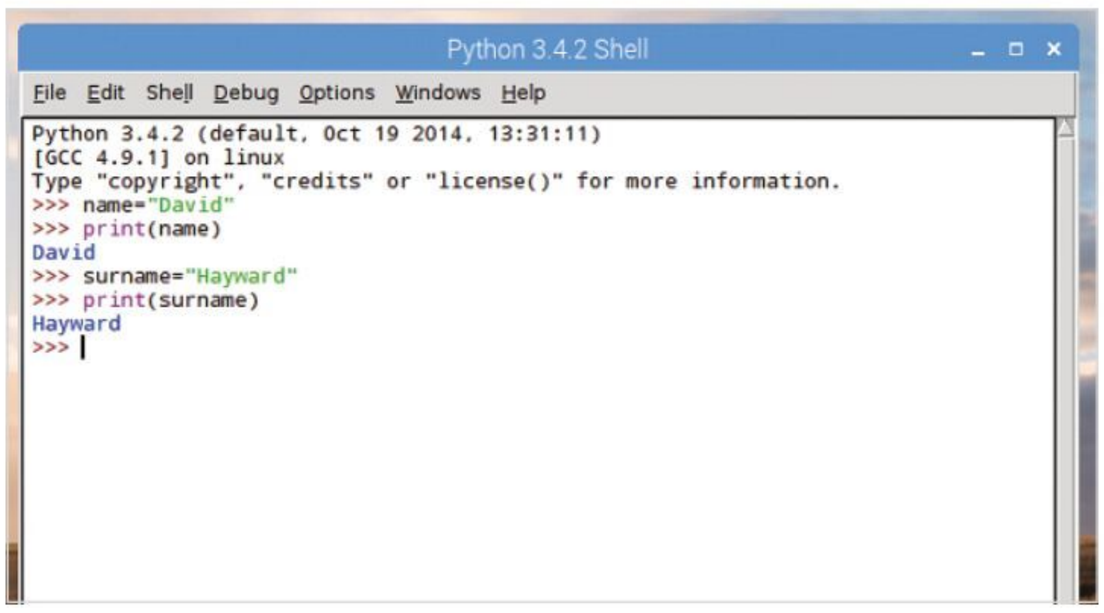
```
name="David"
print(name)
```



STEP 8 Now let's add a surname:

```
surname="Hayward"
print(surname)
```

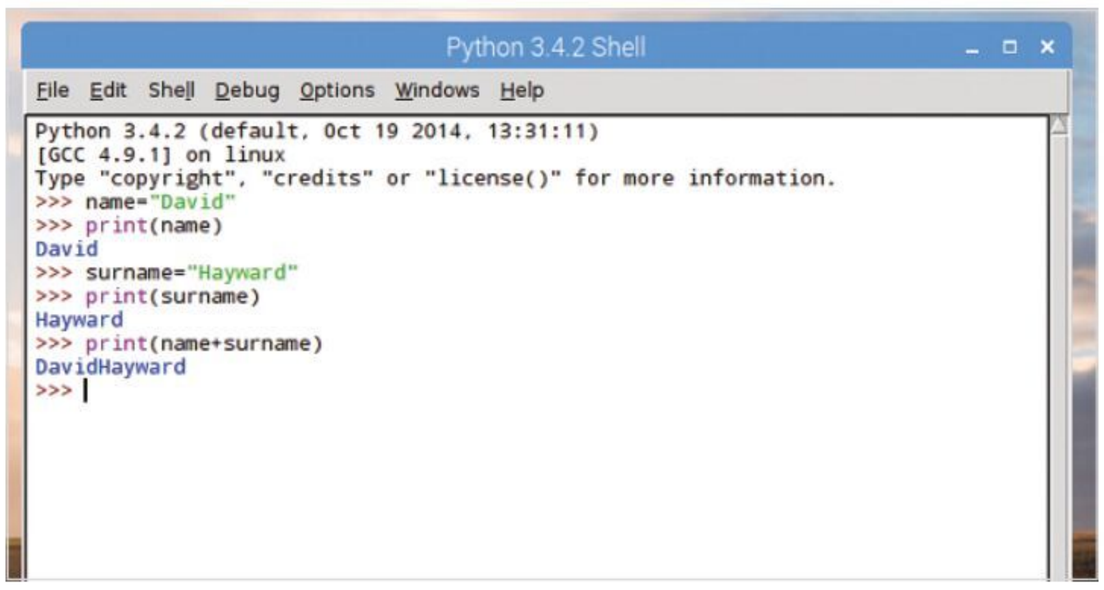
You now have two variables containing a first name and a surname and you can print them independently.



STEP 9 If we were to apply the same routine as before, using the + symbol, the name wouldn't appear correctly in the output in the Shell. Try it:

```
print(name+surname)
```

You need a space between the two, defining them as two separate values and not something you mathematically play around with.



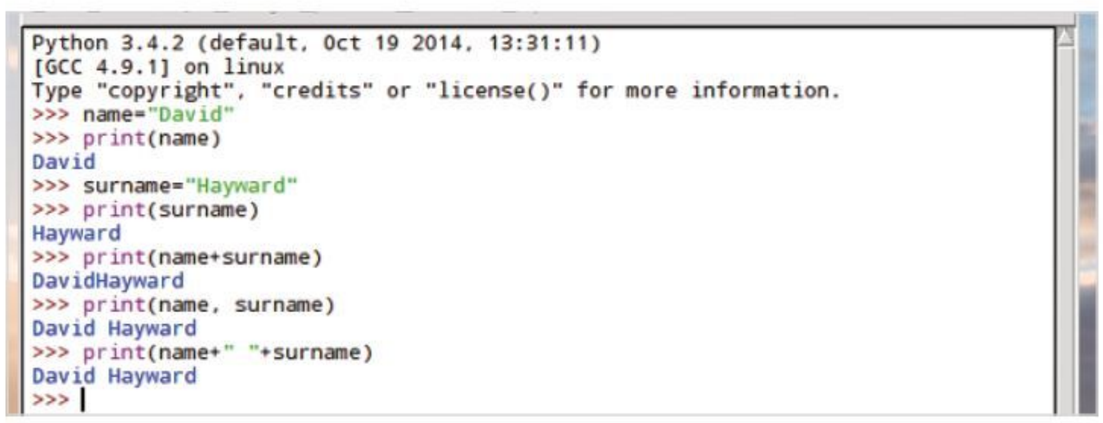
STEP 10 In Python 3 you can separate the two variables with a space using a comma:

```
print(name, surname)
```

Alternatively, you can add the space yourself:

```
print(name+" "+surname)
```

The use of the comma is much neater, as you can see. Congratulations, you've just taken your first steps into the wide world of Python.



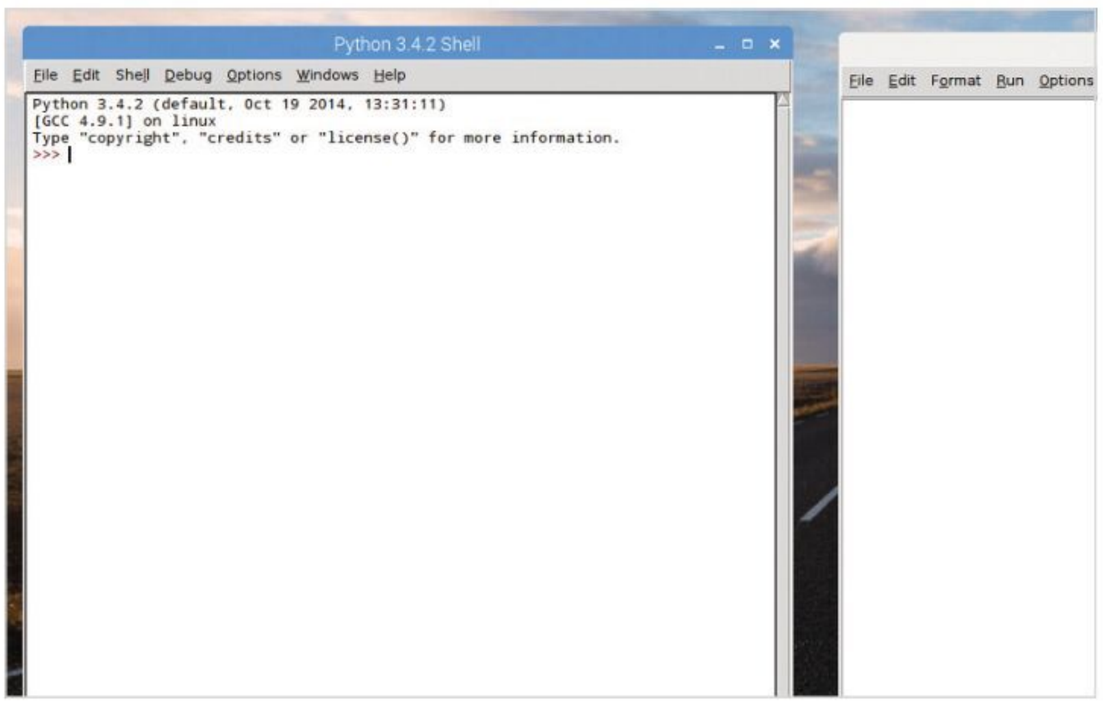
Saving and Executing Your Code

While working in the IDLE Shell is perfectly fine for small code snippets, it's not designed for entering longer program listings. In this section you're going to be introduced to the IDLE Editor, where you will be working from now on.

EDITING CODE

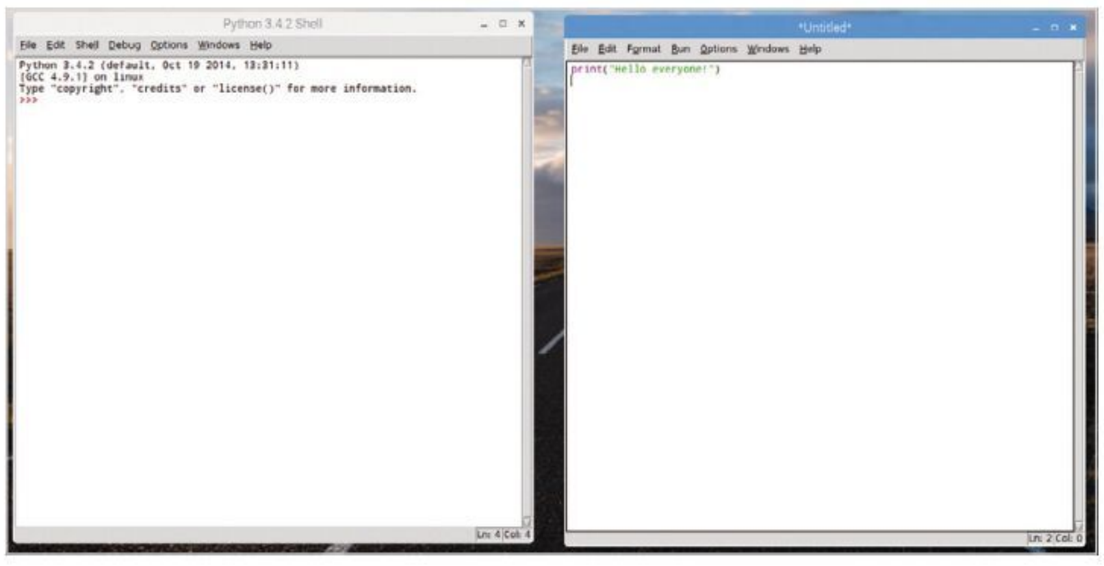
You will eventually reach a point where you have to move on from inputting single lines of code into the Shell. Instead, the IDLE Editor will allow you to save and execute your Python code.

STEP 1 First, open the Python IDLE Shell and when it's up, click on File > New File. This will open a new window with Untitled as its name. This is the Python IDLE Editor and within it you can enter the code needed to create your future programs.

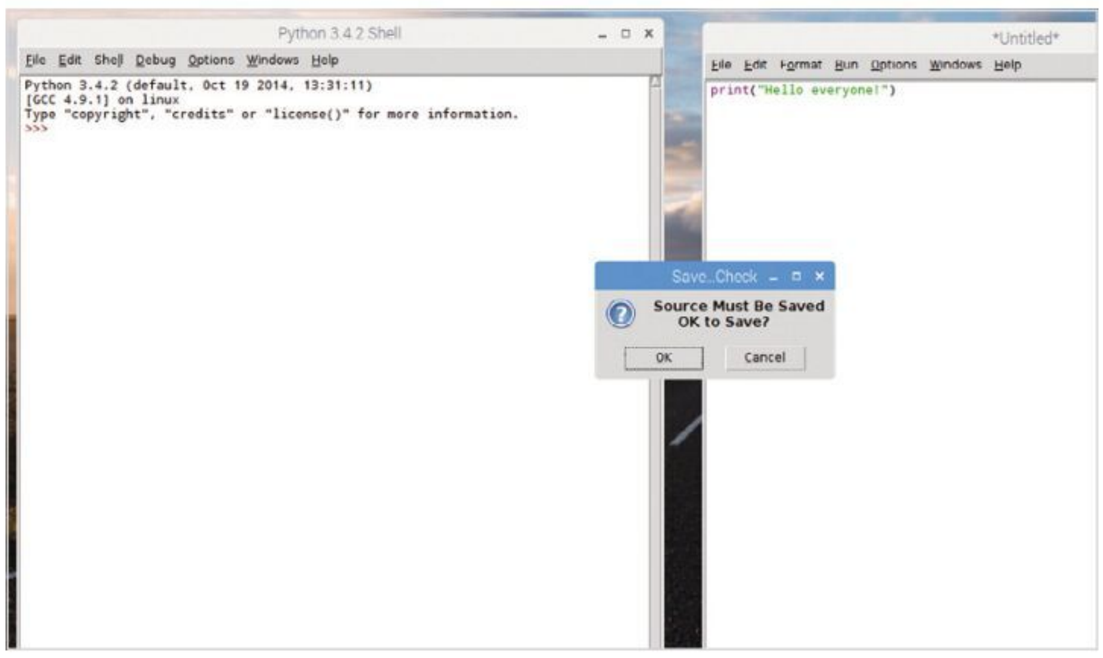


STEP 2 The IDLE Editor is, for all intents and purposes, a simple text editor with Python features, colour coding and so on; much in the same vein as Sublime. You enter code as you would within the Shell, so taking an example from the previous tutorial, enter:

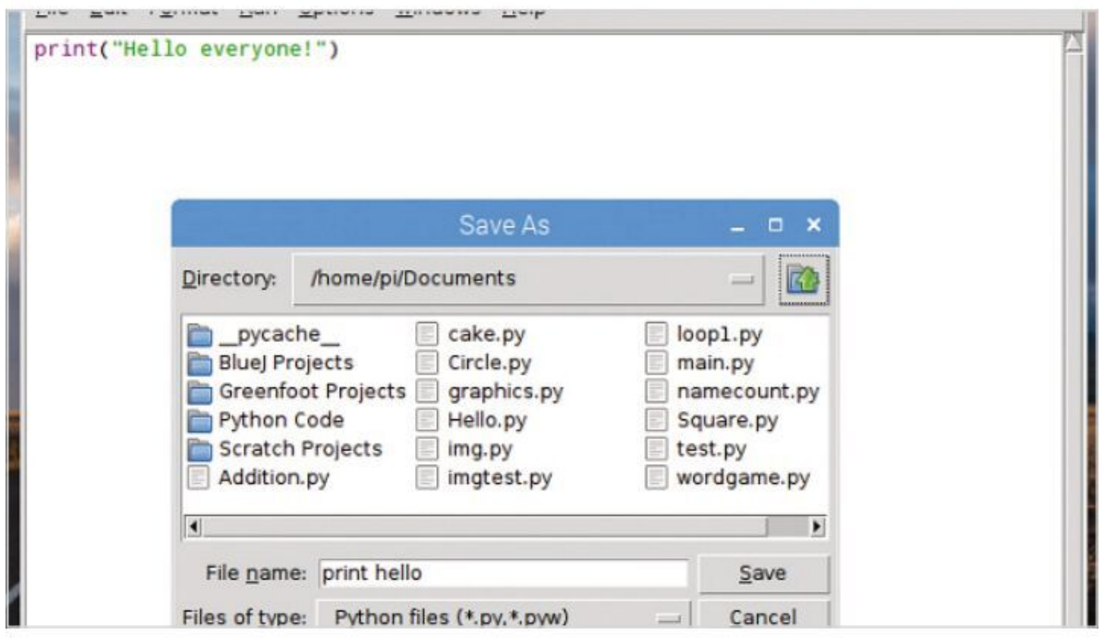
```
print("Hello everyone!")
```



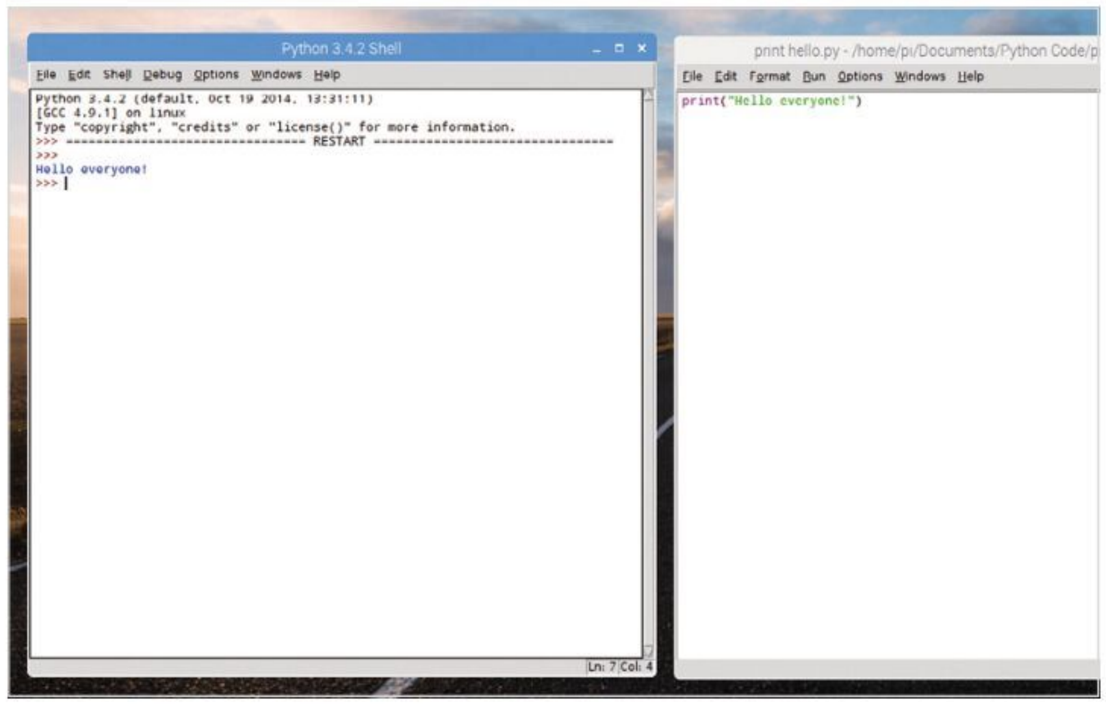
STEP 3 You can see that the same colour coding is in place in the IDLE Editor as it is in the Shell, enabling you to better understand what's going on with your code. However, to execute the code you need to first save it. Press F5 and you get a Save…Check box open.



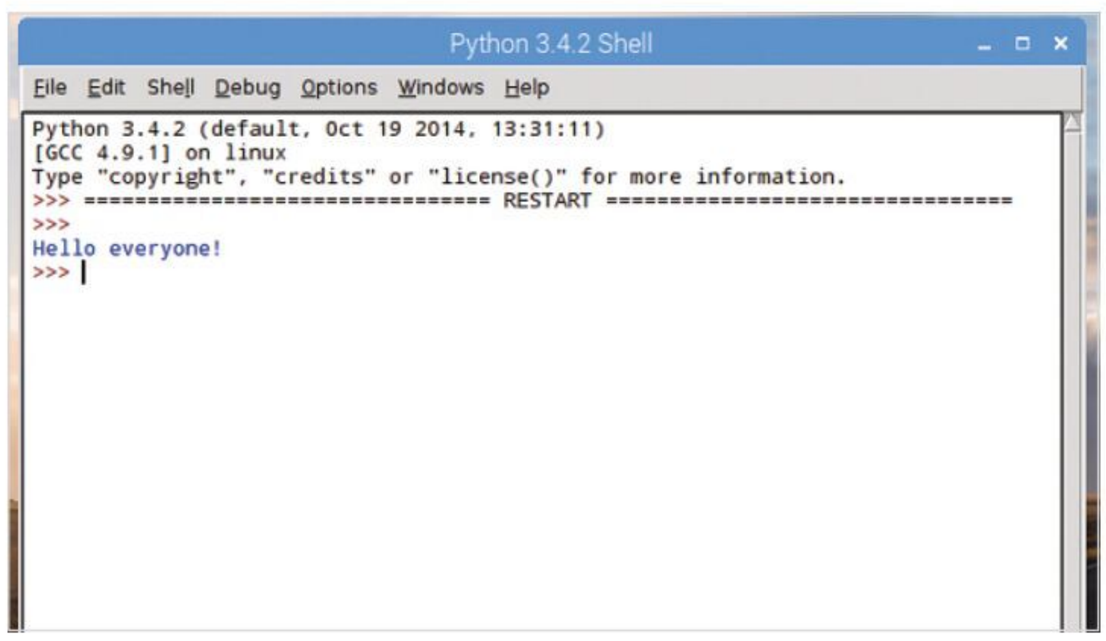
STEP 4 Click on the OK button in the Save box and select a destination where you'll save all your Python code. The destination can be a dedicated folder called Python or you can just dump it wherever you like. Remember to keep a tidy drive though, to help you out in the future.



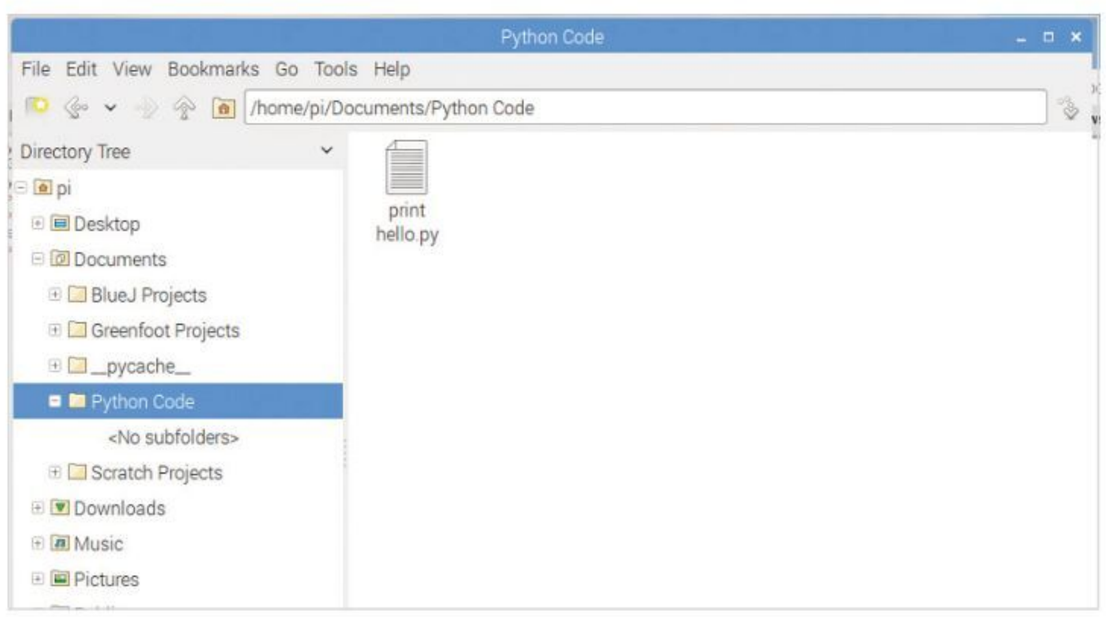
STEP 5 Enter a name for your code, 'print hello' for example, and click on the Save button. Once the Python code is saved it's executed and the output will be detailed in the IDLE Shell. In this case, the words 'Hello everyone!'.



STEP 6 This is how the vast majority of your Python code will be conducted. Enter it into the Editor, hit F5, save the code and look at the output in the Shell. Sometimes things will differ, depending on whether you've requested a separate window, but essentially that's the process. It's the process we will use throughout this book, unless otherwise stated.



STEP 7 If you open the file location of the saved Python code, you can see that it ends in a .py extension. This is the default Python file name. Any code you create will be whatever.py and any code downloaded from the many Internet Python resource sites will be .py. Just ensure that the code is written for Python 3.

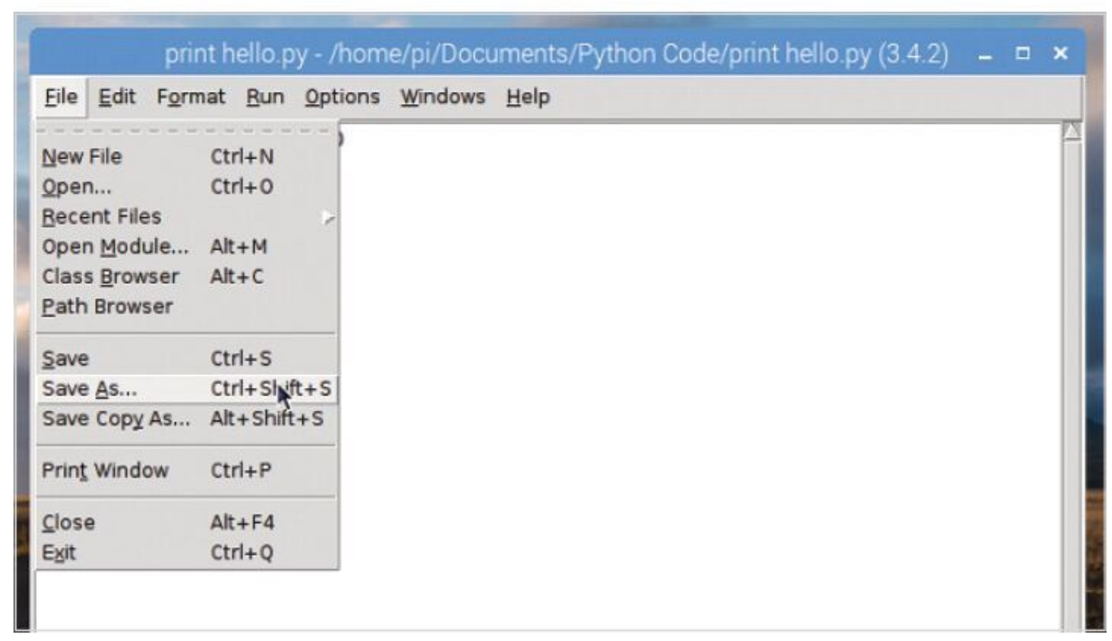


STEP 8 Let's extend the code and enter a few examples from the previous tutorial:

```
a=2
b=2
name="David"
surname="Hayward"
print(name, surname)
print (a+b)
```

If you press F5 now you'll be asked to save the file, again, as it's been modified from before.

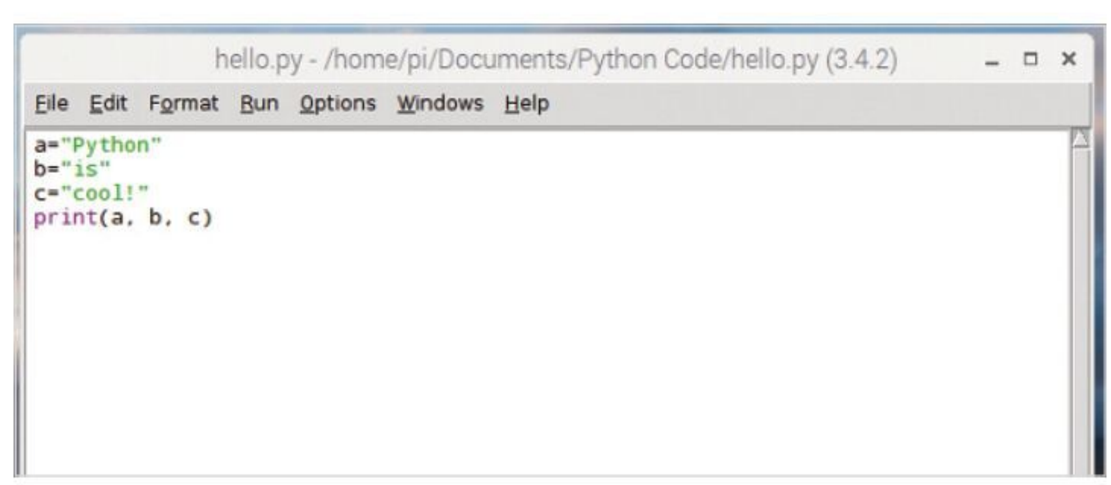
STEP 9 If you click the OK button, the file will be overwritten with the new code entries, and executed, with the output in the Shell. It's not a problem with just these few lines but if you were to edit a larger file, overwriting can become an issue. Instead, use File > Save As from within the Editor to create a backup.



STEP 10 Now create a new file. Close the Editor, and open a new instance (File > New File from the Shell). Enter the following and save it as hello.py:

```
a="Python"
b="is"
c="cool!"
print(a, b, c)
```

You will use this code in the next tutorial.



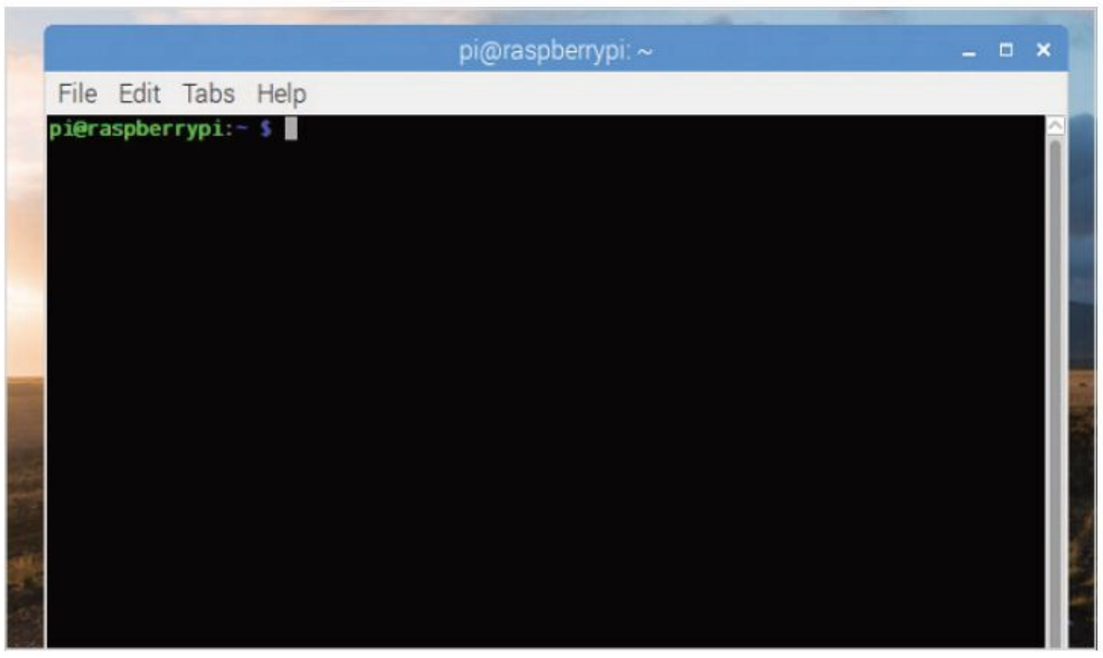
Executing Code from the Command Line

Although we're working from the GUI IDLE throughout this book, it's worth taking a look at Python's command line handling. We already know there's a command line version of Python but it's also used to execute code.

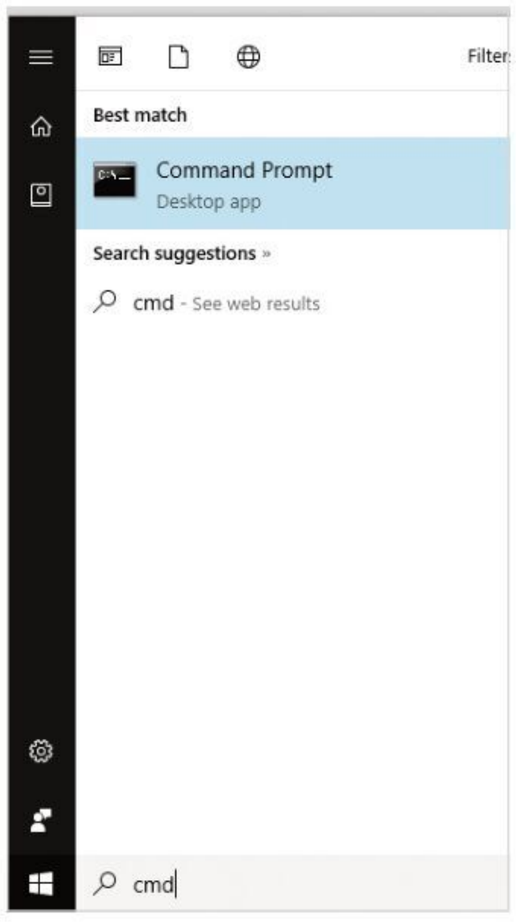
COMMAND THE CODE

Using the code we created in the previous tutorial, the one we named hello.py, let's see how you can run code that was made in the GUI at the command line level.

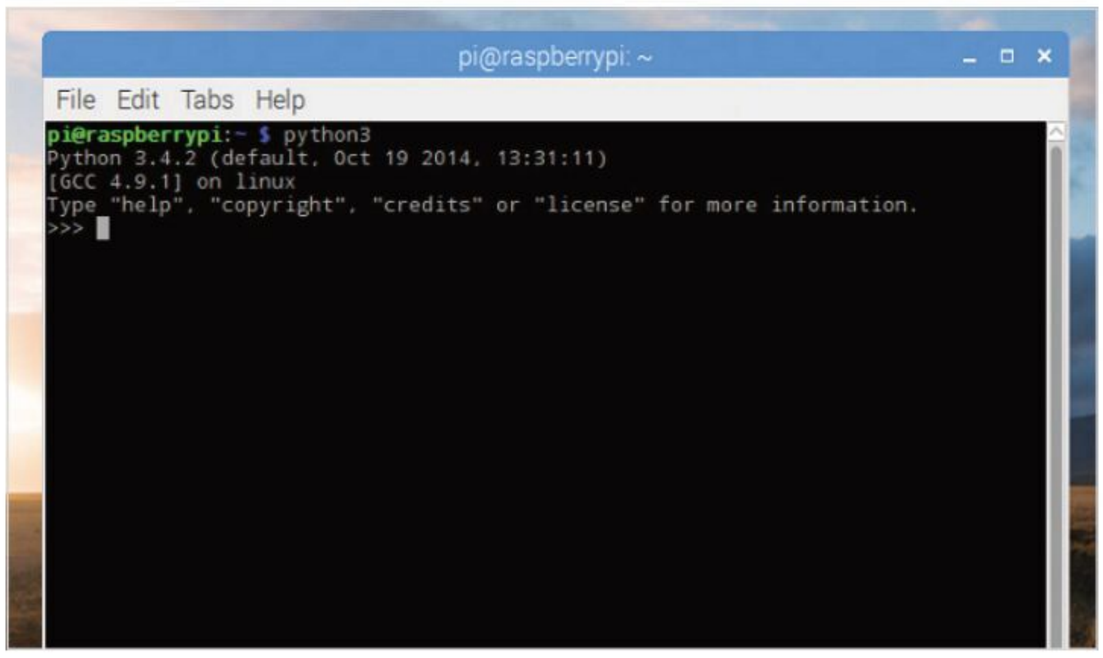
STEP 1 Python, in Linux, comes with two possible ways of executing code via the command line. One of the ways is with Python 2, whilst the other uses the Python 3 libraries and so on. First though, drop into the command line or Terminal on your operating system.



STEP 2 Just as before, we're using a Raspberry Pi: Windows users will need to click the Start button and search for CMD, then click the Command Line returned search; and macOS users can get access to their command line by clicking Go > Utilities > Terminal.



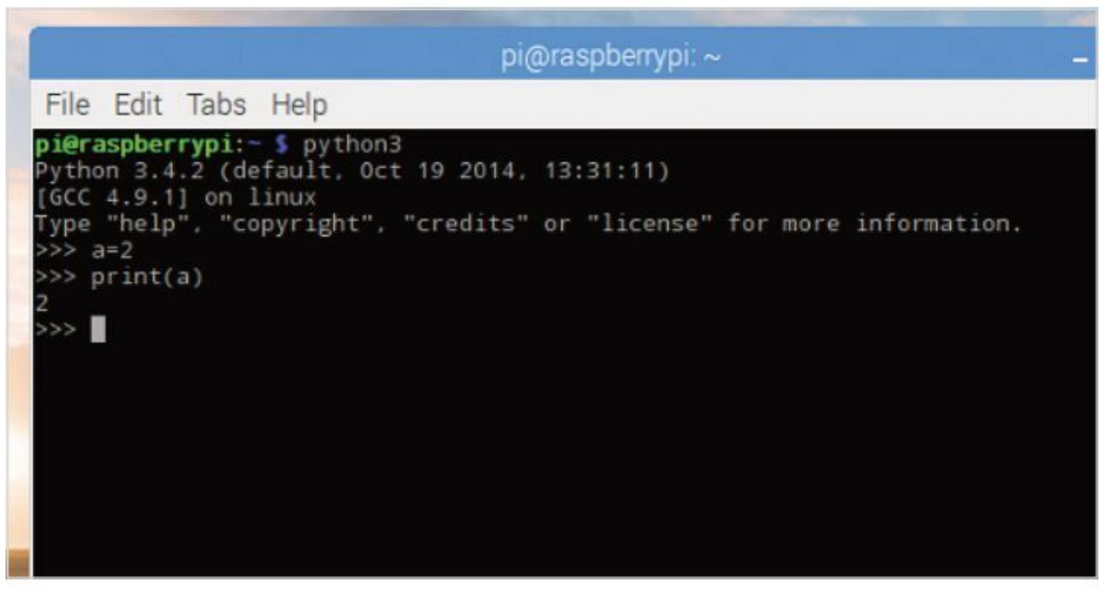
STEP 3 Now you're at the command line we can start Python. For Python 3 you need to enter the command **python3** and press Enter. This will put you into the command line version of the Shell, with the familiar three right-facing arrows as the cursor (>>>).



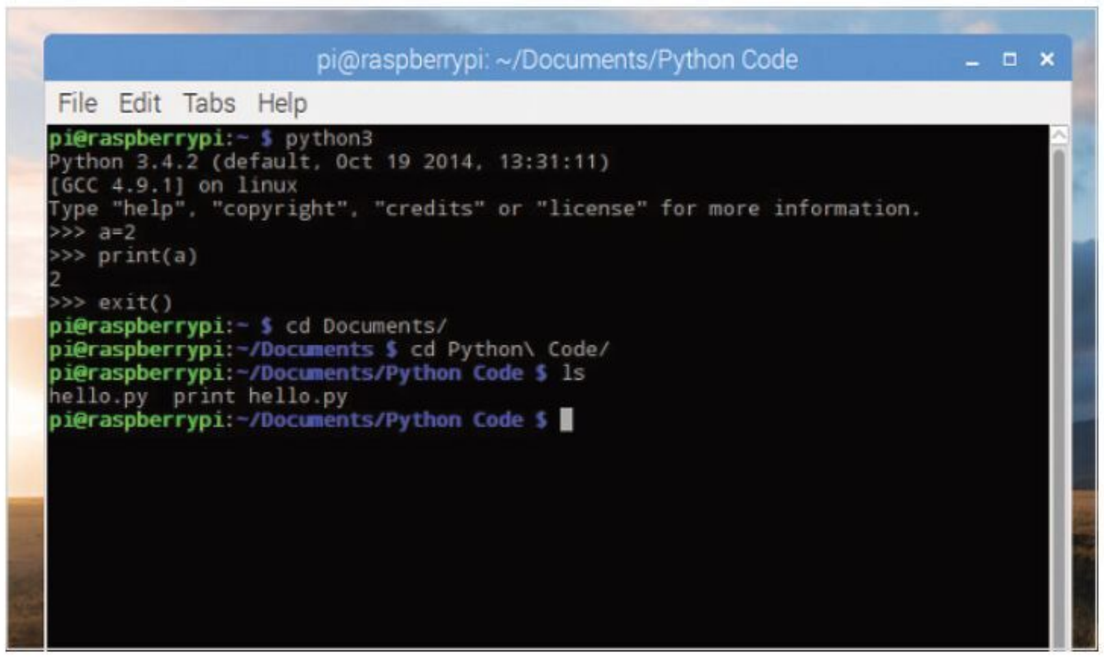
STEP 4 From here you're able to enter the code you've looked at previously, such as:

```
a=2
print(a)
```

You can see that it works exactly the same.



STEP 5 Now enter: **exit()** to leave the command line Python session and return you back to the command prompt. Enter the folder where you saved the code from the previous tutorial and list the available files within; hopefully you should see the hello.py file.

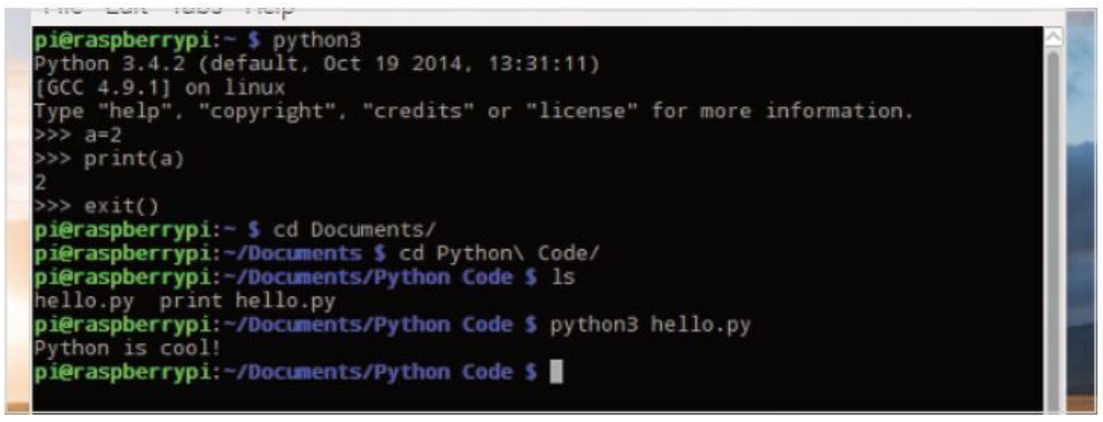


STEP 6 From within the same folder as the code you're going to run, enter the following into the command line:

```
python3 hello.py
```

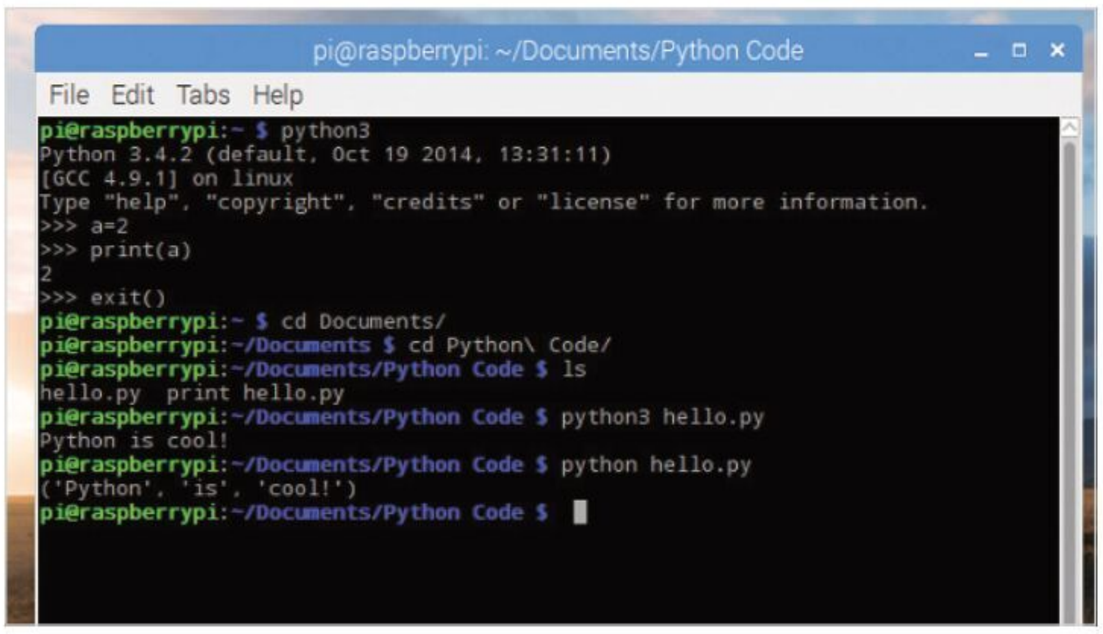
This will execute the code we created, which to remind you is:

```
a="Python"
b="is"
c="cool!"
print(a, b, c)
```

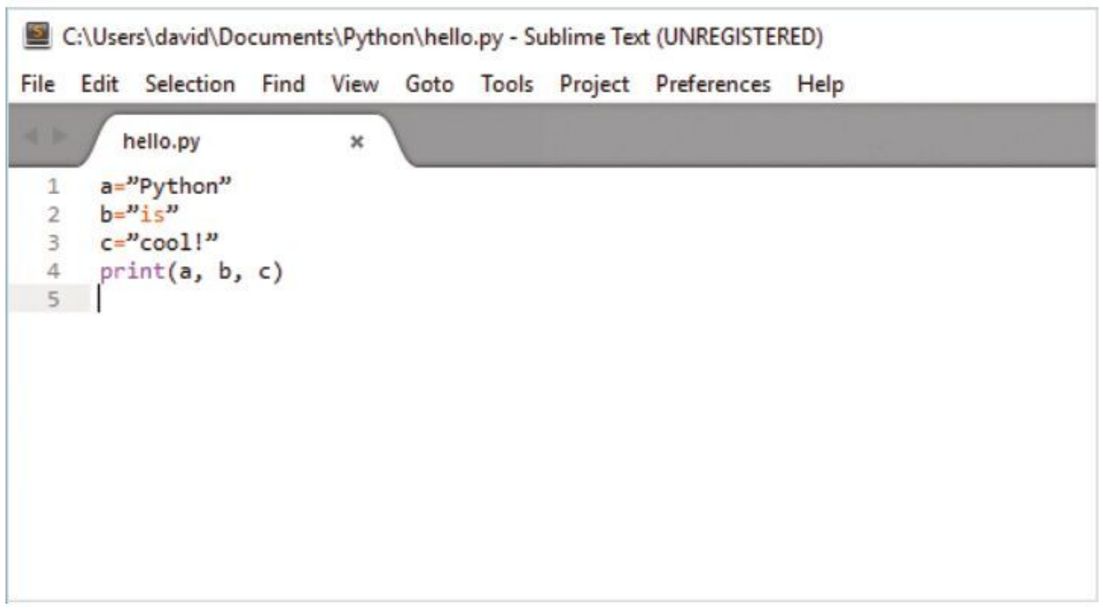


STEP 7 Naturally, since this is Python 3 code, using the syntax and layout that's unique to Python 3, it only works when you use the python3 command. If you like, try the same with Python 2 by entering:

```
python hello.py
```



STEP 8 The result of running Python 3 code from the Python 2 command line is quite obvious. Whilst it doesn't error out in any way, due to the differences between the way Python 3 handles the Print command over Python 2, the result isn't as we expected. Using Sublime for the moment, open the hello.py file.



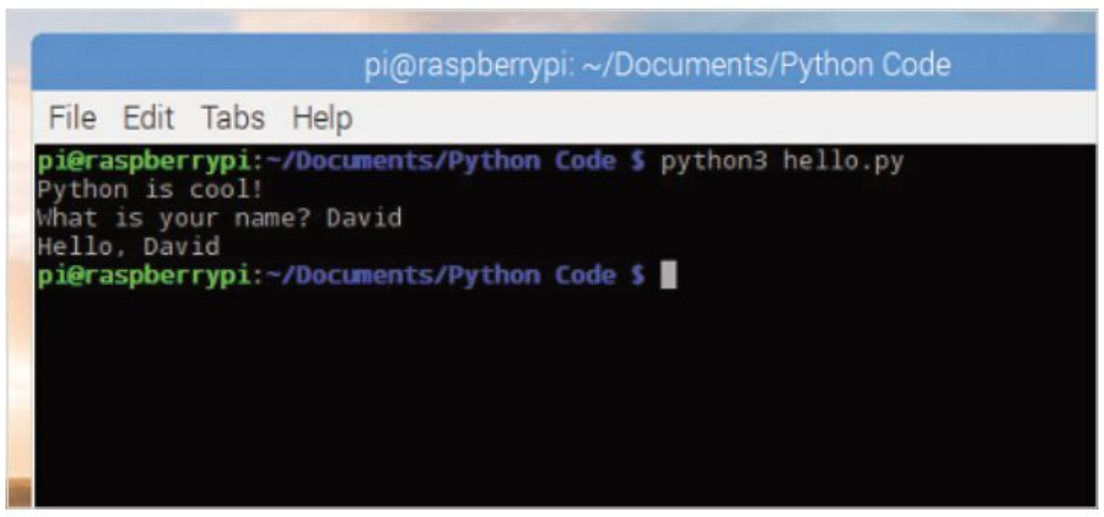
STEP 9 Since Sublime Text isn't available for the Raspberry Pi, you're going to temporarily leave the Pi for the moment and use Sublime as an example that you don't necessarily need to use the Python IDLE. With the hello.py file open, alter it to include the following:

```
name=input("What is your name? ")
print("Hello,", name)
```

STEP 10 Save the hello.py file and drop back to the command line. Now execute the newly saved code with:

```
python3 hello.py
```

The result will be the original Python is cool! statement, together with the added input command asking you for your name, and displaying it in the command window.



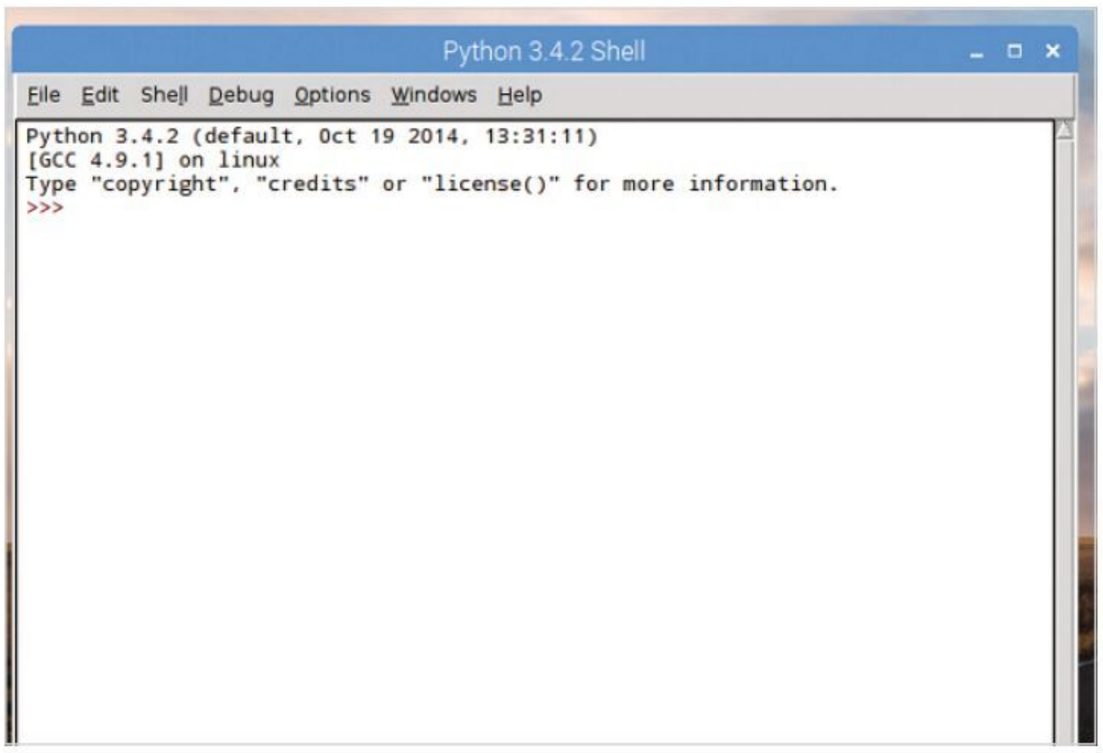
Numbers and Expressions

We've seen some basic mathematical expressions with Python, simple addition and the like. Let's expand on that now and see just how powerful Python is as a calculator. You can work within the IDLE Shell or in the Editor, whichever you like.

IT'S ALL MATHS, MAN

You can get some really impressive results with the mathematical powers of Python; as with most, if not all, programming languages, maths is the driving force behind the code.

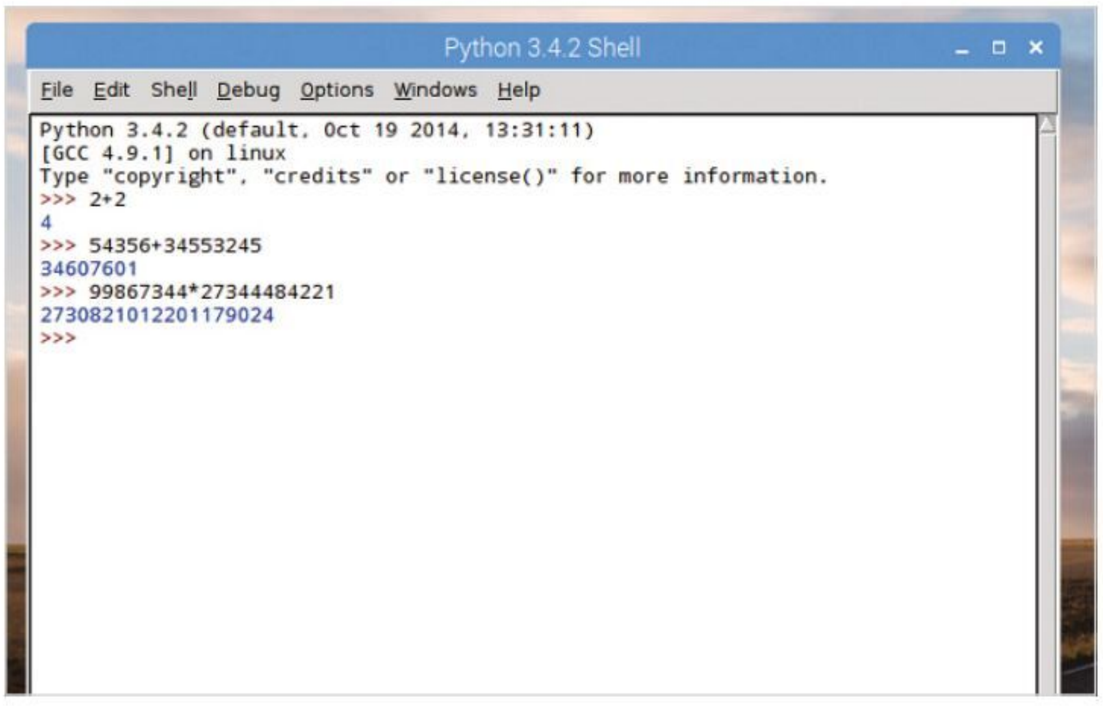
STEP 1 Open up the GUI version of Python 3, as mentioned you can use either the Shell or the Editor. For the time being, you're going to use the Shell just to warm our maths muscle, which we believe is a small gland located at the back of the brain (or not).



STEP 2 In the Shell enter the following:

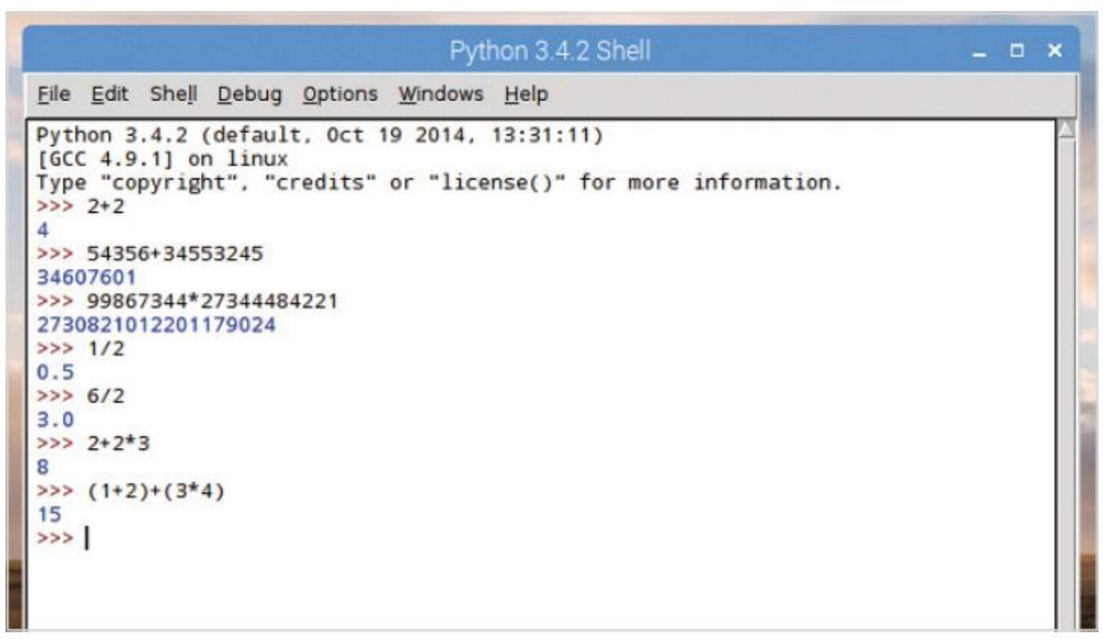
```
2+2
54356+34553245
99867344*27344484221
```

You can see that Python can handle some quite large numbers.



STEP 3 You can use all the usual mathematical operations: divide, multiply, brackets and so on. Practise with a few, for example:

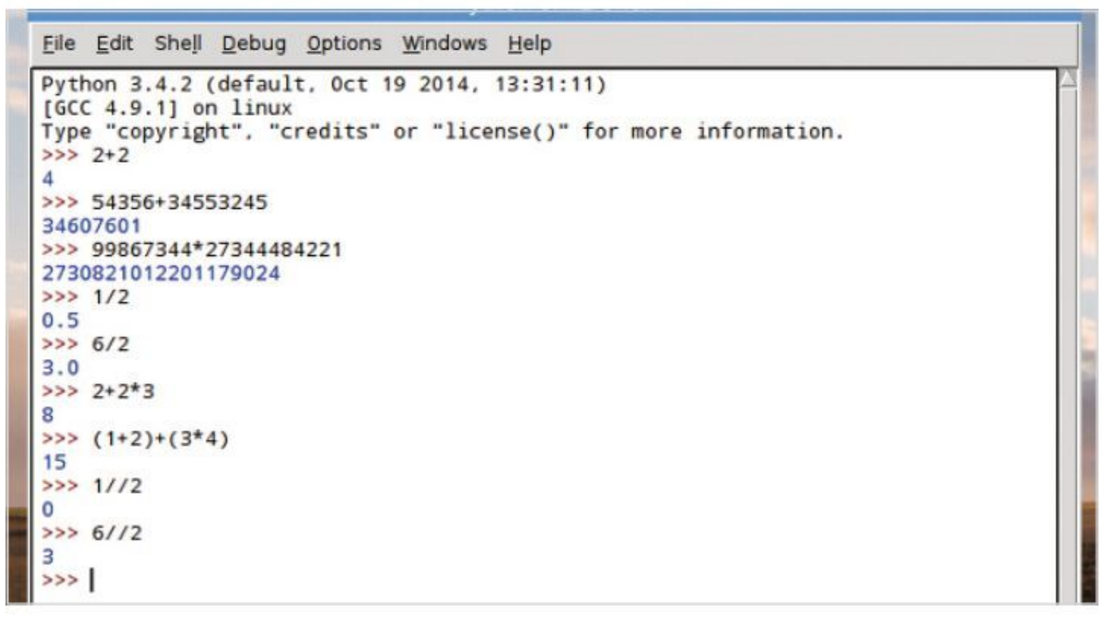
```
1/2
6/2
2+2*3
(1+2)+(3*4)
```



STEP 4 You've no doubt noticed, division produces a decimal number. In Python these are called floats, or floating point arithmetic. However, if you need an integer as opposed to a decimal answer, then you can use a double slash:

```
1//2
6//2
```

And so on.



STEP 5 You can also use an operation to see the remainder left over from division. For example:

```
10/3
```

Will display 3.333333333, which is of course 3.3-recurring. If you now enter:

```
10%3
```

This will display 1, which is the remainder left over from dividing 10 into 3.

```
2730821012201179024
>>> 1/2
0.5
>>> 6/2
3.0
>>> 2+2*3
8
>>> (1+2)+(3*4)
15
>>> 1//2
0
>>> 6//2
3
>>> 10/3
3.3333333333333335
>>> 10%3
1
```

STEP 6 Next up we have the power operator, or exponentiation if you want to be technical. To work out the power of something you can use a double multiplication symbol or double-star on the keyboard:

```
2**3
10**10
```

Essentially, it's 2x2x2 but we're sure you already know the basics behind maths operators. This is how you would work it out in Python.

```
>>> 6/2
3.0
>>> 2+2*3
8
>>> (1+2)+(3*4)
15
>>> 1//2
0
>>> 6//2
3
>>> 10/3
3.3333333333333335
>>> 10%3
1
>>> 2**3
8
>>> 10**10
10000000000
>>>
```

STEP 7 Numbers and expressions don't stop there. Python has numerous built-in functions to work out sets of numbers, absolute values, complex numbers and a host of mathematical expressions and Pythagorean tongue-twisters. For example, to convert a number to binary, use:

```
bin(3)
```

```
>>> 1/2
0.5
>>> 6/2
3.0
>>> 2+2*3
8
>>> (1+2)+(3*4)
15
>>> 1//2
0
>>> 6//2
3
>>> 10/3
3.3333333333333335
>>> 10%3
1
>>> 2**3
8
>>> 10**10
10000000000
>>> bin(3)
'0b11'
>>>
```

STEP 8 This will be displayed as '0b11', converting the integer into binary and adding the prefix 0b to the front. If you want to remove the 0b prefix, then you can use:

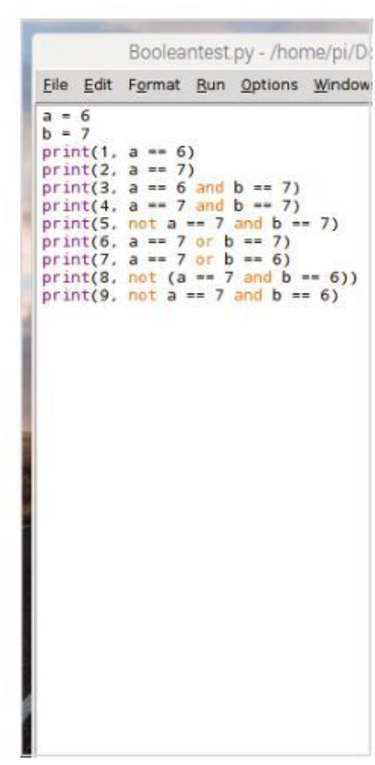
```
format(3, 'b')
```

The Format command converts a value, the number 3, to a formatted representation as controlled by the format specification, the 'b' part.

```
>>> 2+2*3
8
>>> (1+2)+(3*4)
15
>>> 1//2
0
>>> 6//2
3
>>> 10/3
3.3333333333333335
>>> 10%3
1
>>> 2**3
8
>>> 10**10
10000000000
>>> bin(3)
'0b11'
>>> format(3,'b')
'11'
>>>
```

STEP 9 A Boolean Expression is a logical statement that will either be true or false. We can use these to compare data and test to see if it's equal to, less than or greater than. Try this in a New File:

```
a = 6
b = 7
print(1, a == 6)
print(2, a == 7)
print(3, a == 6 and b == 7)
print(4, a == 7 and b == 7)
print(5, not a == 7 and b == 7)
print(6, a == 7 or b == 7)
print(7, a == 7 or b == 6)
print(8, not (a == 7 and b == 6))
print(9, not a == 7 and b == 6)
```



STEP 10 Execute the code from Step 9, and you can see a series of True or False statements, depending on the result of the two defining values: 6 and 7. It's an extension of what you've looked at, and an important part of programming.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> ================================ RESTART ================================
>>>
1 True
2 False
3 True
4 False
5 True
6 True
7 False
8 True
9 False
>>>
```

Using Comments

When writing your code, the flow, what each variable does, how the overall program will operate and so on is all inside your head. Another programmer could follow the code line by line but over time, it can become difficult to read.

#COMMENTS!

Programmers use a method of keeping their code readable by commenting on certain sections. If a variable is used, the programmer comments on what it's supposed to do, for example. It's just good practise.

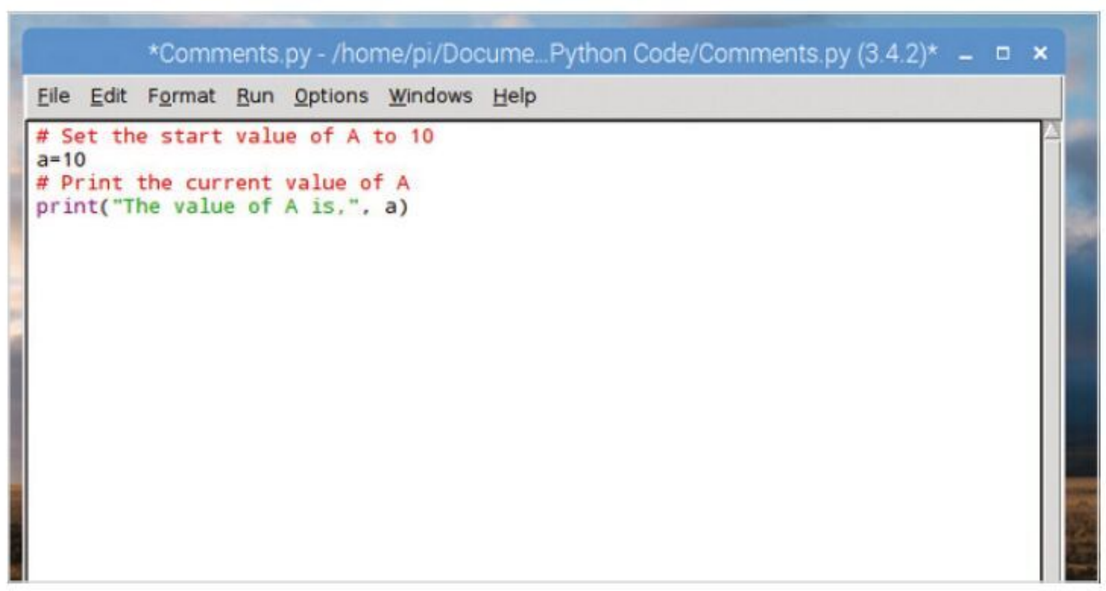
STEP 1 Start by creating a new instance of the IDLE Editor (File > New File) and create a simple variable and print command:

```
a=10
print("The value of A is,", a)
```

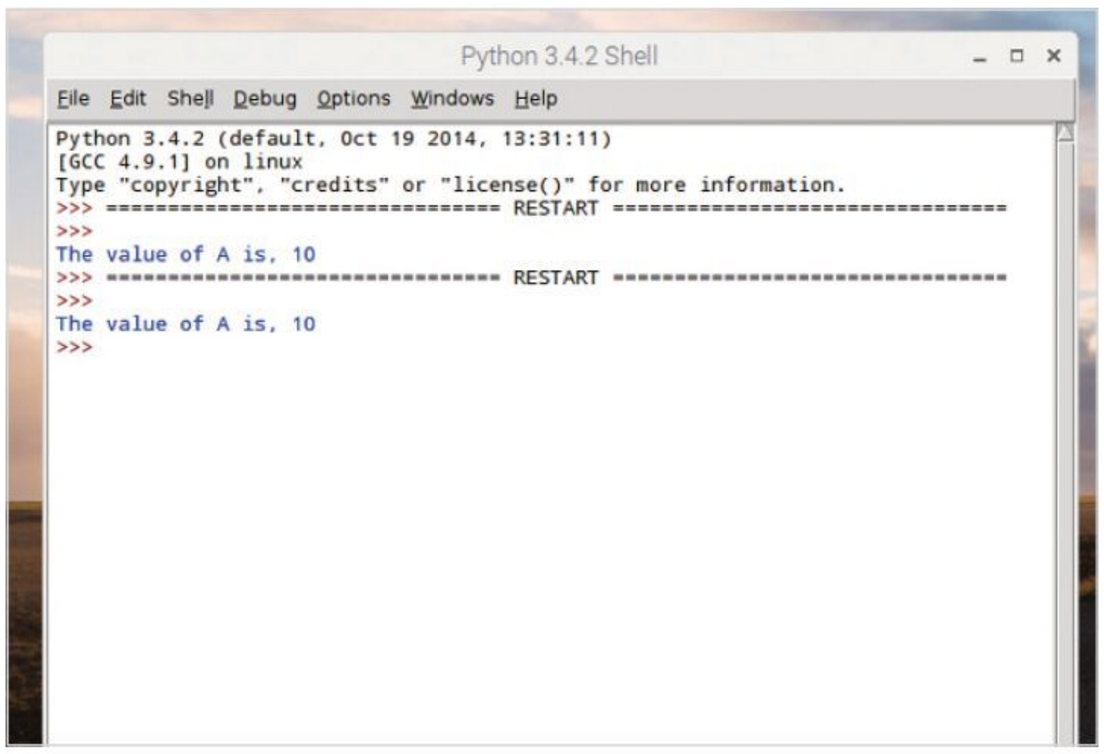
Save the file and execute the code.

STEP 2 Running the code will return the line: The value of A is, 10 into the IDLE Shell window, which is what we expected. Now, add some of the types of comments you'd normally see within code:

```
# Set the start value of A to 10
a=10
# Print the current value of A
print("The value of A is,", a)
```

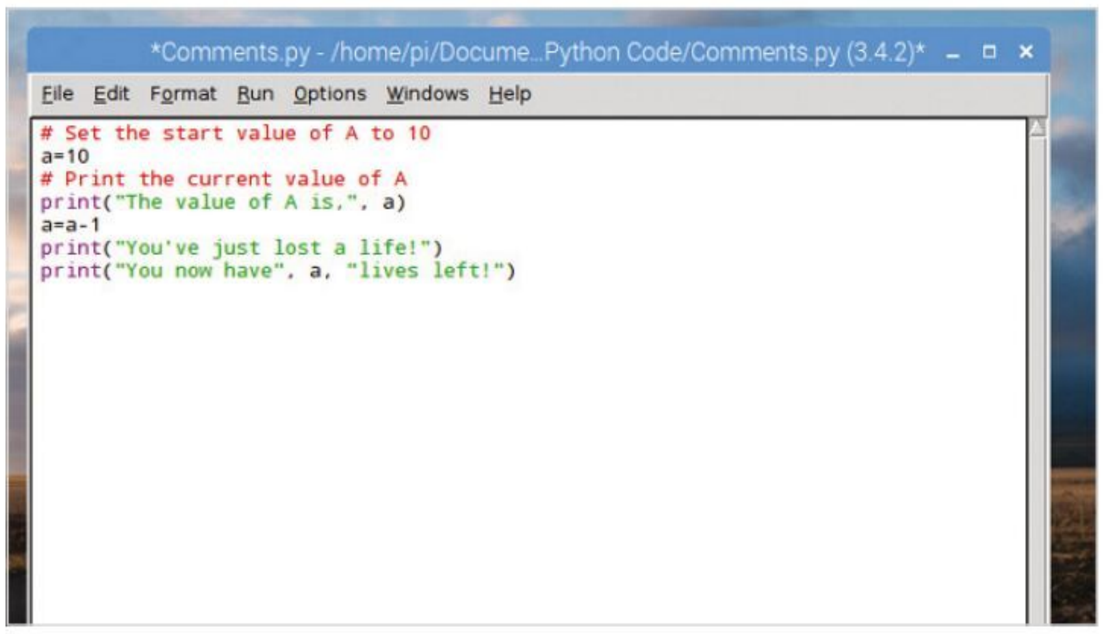


STEP 3 Resave the code and execute it. You can see that the output in the IDLE Shell is still the same as before, despite the extra lines being added. Simply put, the hash symbol (#) denotes a line of text the programmer can insert to inform them, and others, of what's going on without the user being aware.

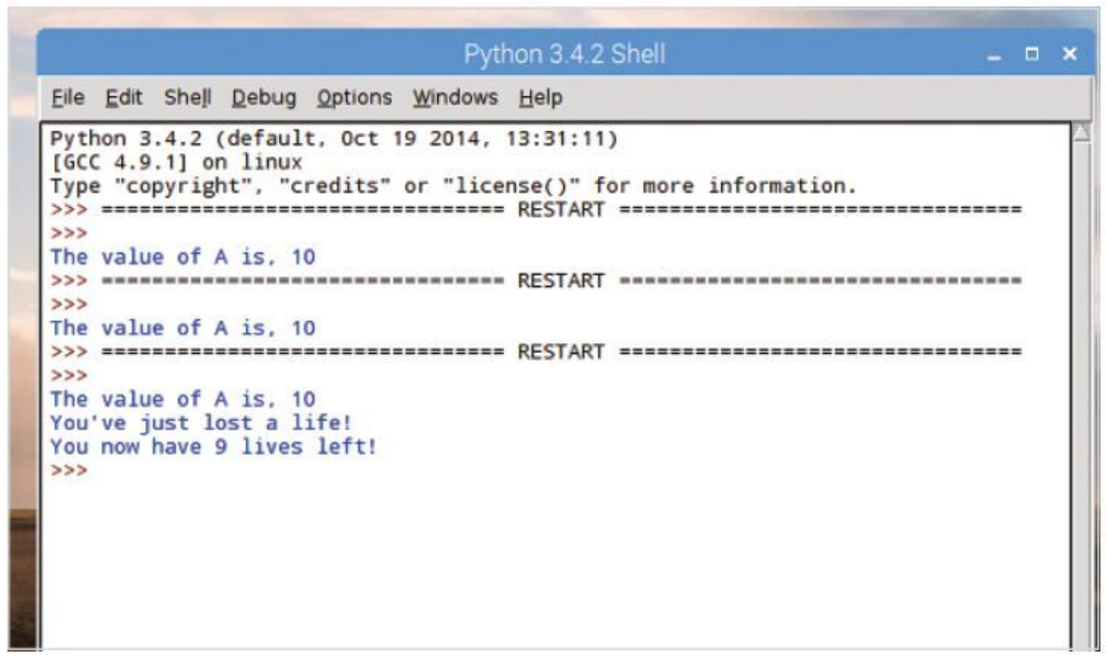


STEP 4 Let's assume that the variable A that we've created is the number of lives in a game. Every time the player dies, the value is decreased by 1. The programmer could insert a routine along the lines of:

```
a=a-1
print("You've just lost a life!")
print("You now have", a, "lives left!")
```

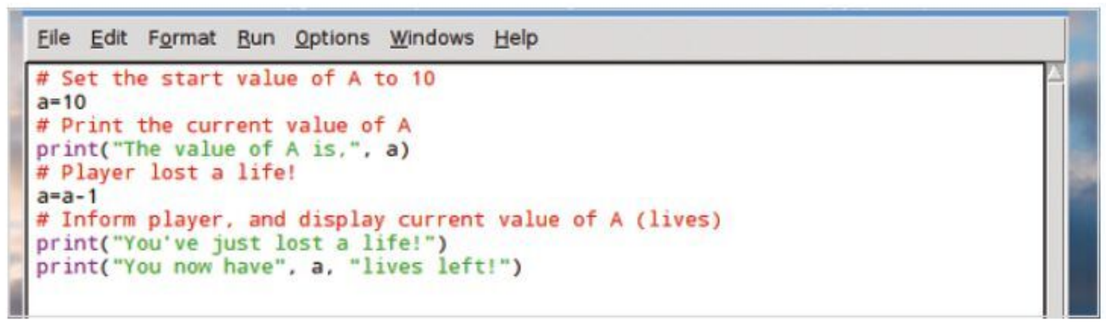


STEP 5 Whilst we know that the variable A is lives, and that the player has just lost one, a casual viewer or someone checking the code may not know. Imagine for a moment that the code is twenty thousand lines long, instead of just our seven. You can see how handy comments are.



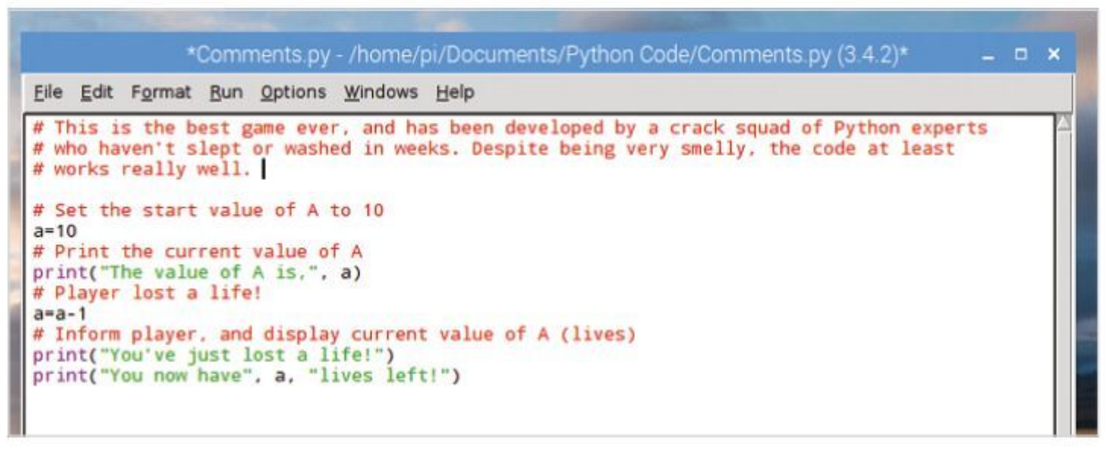
STEP 6 Essentially, the new code together with comments could look like:

```
# Set the start value of A to 10
a=10
# Print the current value of A
print("The value of A is,", a)
# Player lost a life!
a=a-1
# Inform player, and display current value of A
(lives)
print("You've just lost a life!")
print("You now have", a, "lives left!")
```



STEP 7 You can use comments in different ways. For example, Block Comments are a large section of text that details what's going on in the code, such as telling the code reader what variables you're planning on using:

```
# This is the best game ever, and has been
developed by a crack squad of Python experts
# who haven't slept or washed in weeks. Despite
being very smelly, the code at least
# works really well.
```

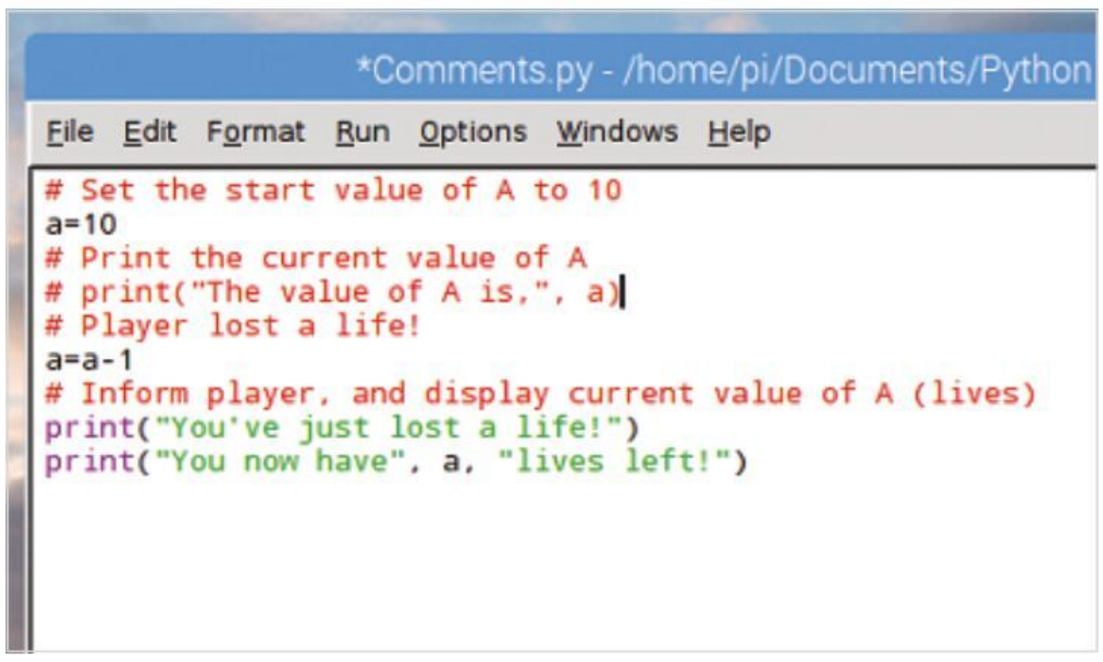


STEP 8 Inline comments are comments that follow a section of code. Take our examples from above, instead of inserting the code on a separate line, we could use:

```
a=10 # Set the start value of A to 10
print("The value of A is,", a) # Print the current
value of A
a=a-1 # Player lost a life!
print("You've just lost a life!")
print("You now have", a, "lives left!") # Inform
player, and display current value of A (lives)
```

STEP 9 The comment, the hash symbol, can also be used to comment out sections of code you don't want to be executed in your program. For instance, if you wanted to remove the first print statement, you would use:

```
# print("The value of A is,", a)
```



STEP 10 You also use three single quotes to comment out a Block Comment or multi-line section of comments. Place them before and after the areas you want to comment for them to work:

```
'''
This is the best game ever, and has been developed
by a crack squad of Python experts who haven't
slept or washed in weeks. Despite being very
smelly, the code at least works really well.
'''
```

Working with Variables

We've seen some examples of variables in our Python code already but it's always worth going through the way they operate and how Python creates and assigns certain values to a variable.

VARIOUS VARIABLES

You'll be working with the Python 3 IDLE Shell in this tutorial. If you haven't already, open Python 3 or close down the previous IDLE Shell to clear up any old code.

STEP 1

In some programming languages you're required to use a dollar sign to denote a string, which is a variable made up of multiple characters, such as a name of a person. In Python this isn't necessary. For example, in the Shell enter: `name="David Hayward"` (or use your own name, unless you're also called David Hayward).

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> name="David Hayward"
>>> print (name)
David Hayward
>>>
```

STEP 2

You can check the type of variable in use by issuing the **type ()** command, placing the name of the variable inside the brackets. In our example, this would be: `type (name)`. Add a new string variable: `title="Descended from Vikings"`.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> name="David Hayward"
>>> print (name)
David Hayward
>>> type (name)
<class 'str'>
>>> title="Descended from Vikings"
>>>
```

STEP 3

You've seen previously that variables can be concatenated using the plus symbol between the variable names. In our example we can use: `print (name + ": " + title)`. The middle part between the quotations allows us to add a colon and a space, as variables are connected without spaces, so we need to add them manually.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> name="David Hayward"
>>> print (name)
David Hayward
>>> type (name)
<class 'str'>
>>> title="Descended from Vikings"
>>> print (name + ": " + title)
David Hayward: Descended from Vikings
>>>
```

STEP 4

You can also combine variables within another variable. For example, to combine both name and title variables into a new variable we use:

```
character=name + ": " + title
```

Then output the content of the new variable as:

```
print (character)
```

Numbers are stored as different variables:

```
age=44
Type (age)
```

Which, as we know, are integers.

```
Python 3.4.
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:1
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()"
>>> name="David Hayward"
>>> print (name)
David Hayward
>>> type (name)
<class 'str'>
>>> title="Descended from Vikings"
>>> print (name + ": " + title)
David Hayward: Descended from Vikings
>>> character=name + ": " + title
>>> print (character)
David Hayward: Descended from Vikings
>>> age=44
>>> type (age)
<class 'int'>
>>>
```

STEP 5 However, you can't combine both strings and integer type variables in the same command, as you would a set of similar variables. You need to either turn one into the other or vice versa. When you do try to combine both, you get an error message:

```
print (name + age)
```

```
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> name="David Hayward"
>>> print (name)
David Hayward
>>> type (name)
<class 'str'>
>>> title="Descended from Vikings"
>>> print (name + ": " + title)
David Hayward: Descended from Vikings
>>> character=name + ": " + title
>>> print (character)
David Hayward: Descended from Vikings
>>> age=44
>>> type (age)
<class 'int'>
>>> print (name+age)
Traceback (most recent call last):
  File "<pyshell#9>", line 1, in <module>
    print (name+age)
TypeError: Can't convert 'int' object to str implicitly
>>> |
```

STEP 6 This is a process known as TypeCasting. The Python code is:

```
print (character + " is " + str(age) + " years old.")
```

or you can use:

```
print (character, "is", age, "years old.")
```

Notice again that in the last example, you don't need the spaces between the words in quotes as the commas treat each argument to print separately.

```
>>> print (name + age)
Traceback (most recent call last):
  File "<pyshell#18>", line 1, in <module>
    print (name + age)
TypeError: Can't convert 'int' object to str implicitly
>>> print (character + " is " + str(age) + " years old.")
David Hayward: Descended from Vikings is 44 years old.
>>> print (character, "is", age, "years old.")
David Hayward: Descended from Vikings is 44 years old.
>>>
>>> |
```

STEP 7 Another example of TypeCasting is when you ask for input from the user, such as a name. for example, enter:

```
age= input ("How old are you? ")
```

All data stored from the Input command is stored as a string variable.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> age= input ("How old are you? ")
How old are you? 44
>>> type(age)
<class 'str'>
>>> |
```

STEP 8 This presents a bit of a problem when you want to work with a number that's been inputted by the user, as age + 10 won't work due to being a string variable and an integer. Instead, you need to enter:

```
int(age) + 10
```

This will TypeCast the age string into an integer that can be worked with.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> age= input ("How old are you? ")
How old are you? 44
>>> type(age)
<class 'str'>
>>> age + 10
Traceback (most recent call last):
  File "<pyshell#2>", line 1, in <module>
    age + 10
TypeError: Can't convert 'int' object to str implicitly
>>> int(age) + 10
54
>>> |
```

STEP 9 The use of TypeCasting is also important when dealing with floating point arithmetic; remember: numbers that have a decimal point in them. For example, enter:

```
shirt=19.99
```

Now enter `type(shirt)` and you'll see that Python has allocated the number as a 'float', because the value contains a decimal point.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> shirt=19.99
>>> type(shirt)
<class 'float'>
>>> |
```

STEP 10 When combining integers and floats Python usually converts the integer to a float, but should the reverse ever be applied it's worth remembering that Python doesn't return the exact value. When converting a float to an integer, Python will always round down to the nearest integer, called truncating; in our case instead of 19.99 it becomes 19.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> shirt=19.99
>>> type(shirt)
<class 'float'>
>>> int(shirt)
19
>>> |
```

User Input

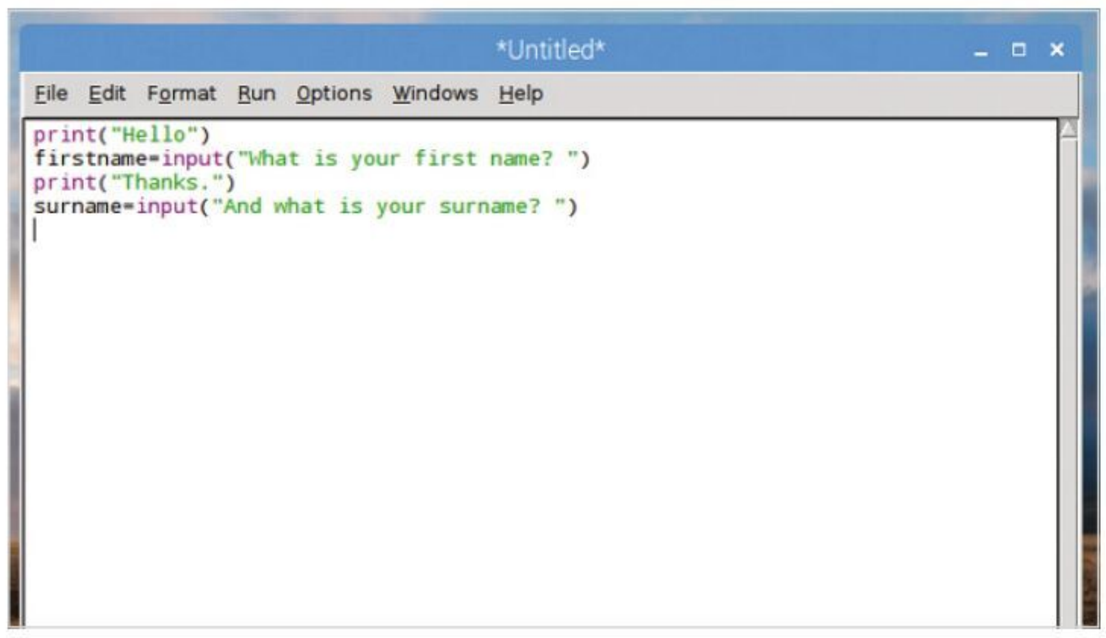
We've seen some basic user interaction with the code from a few of the examples earlier, so now would be a good time to focus solely on how you would get information from the user then store and present it.

USER FRIENDLY

The type of input you want from the user will depend greatly on the type of program you're coding. For example, a game may ask for a character's name, whereas a database can ask for personal details.

STEP 1 If it's not already, open the Python 3 IDLE Shell, and start a New File in the Editor. Let's begin with something really simple, enter:

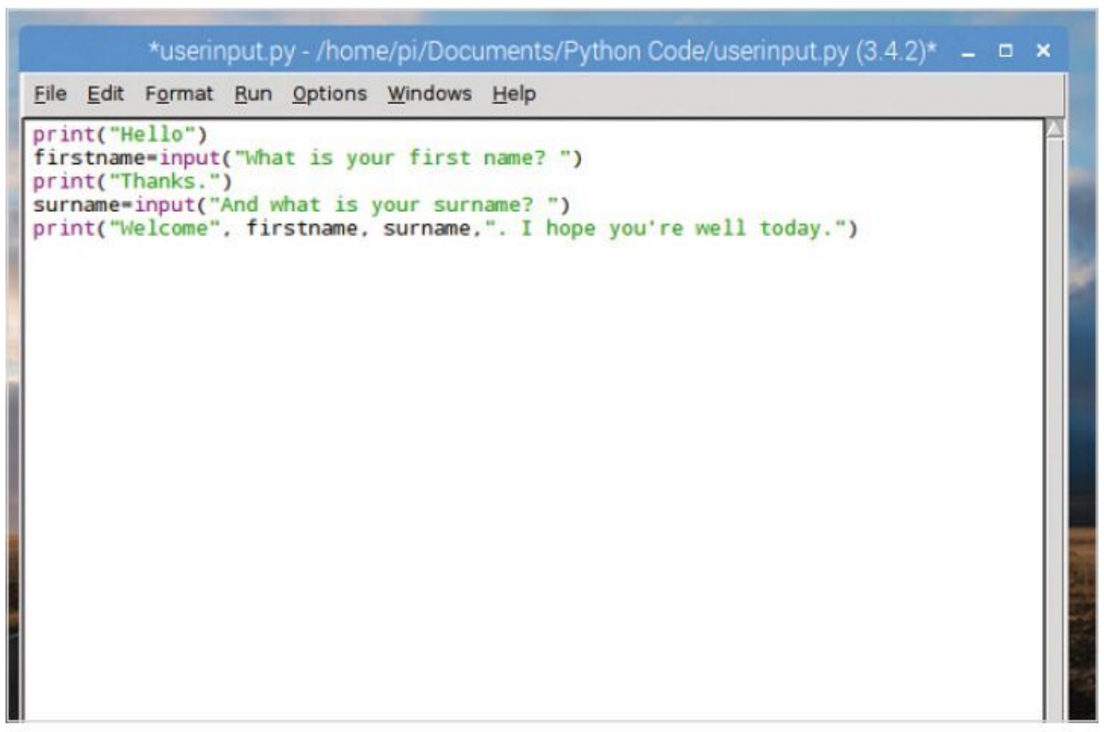
```
print("Hello")
firstname=input("What is your first name? ")
print("Thanks.")
surname=input("And what is your surname? ")
```



STEP 2 Save and execute the code, and as you already no doubt suspected, in the IDLE Shell the program will ask for your first name, storing it as the variable firstname, followed by your surname; also stored in its own variable (surname).

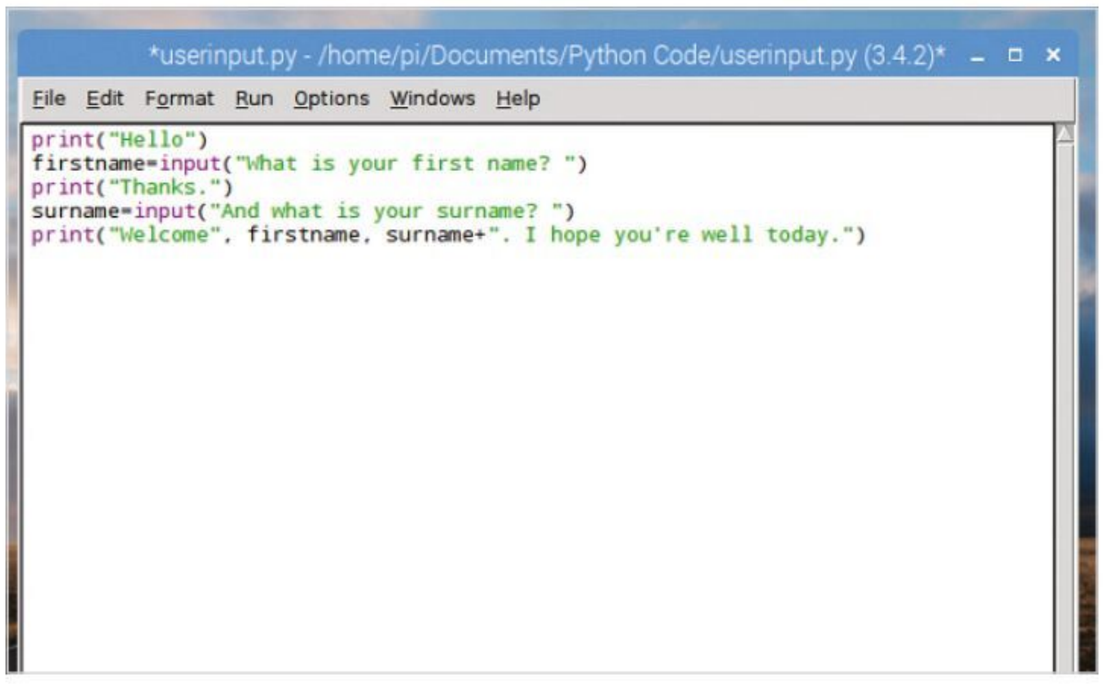
STEP 3 Now that we have the user's name stored in a couple of variables we can call them up whenever we want:

```
print("Welcome", firstname, surname, ". I hope you're well today.")
```



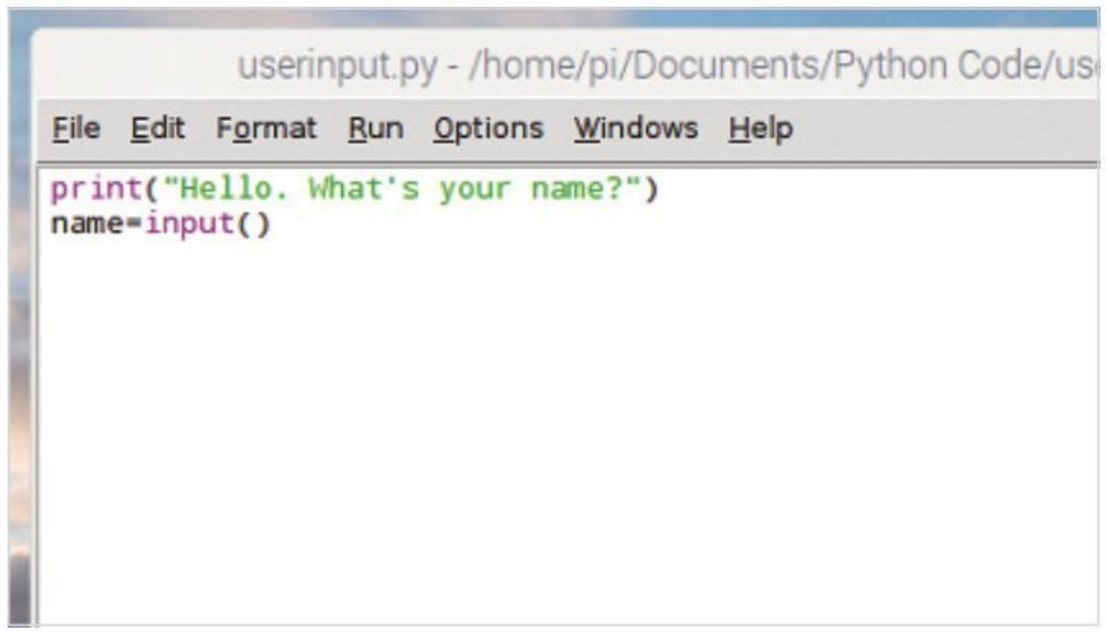
STEP 4 Run the code and you can see a slight issue, the full stop after the surname follows a blank space. To eliminate that we can add a plus sign instead of the comma in the code:

```
print("Welcome", firstname, surname+". I hope you're well today.")
```



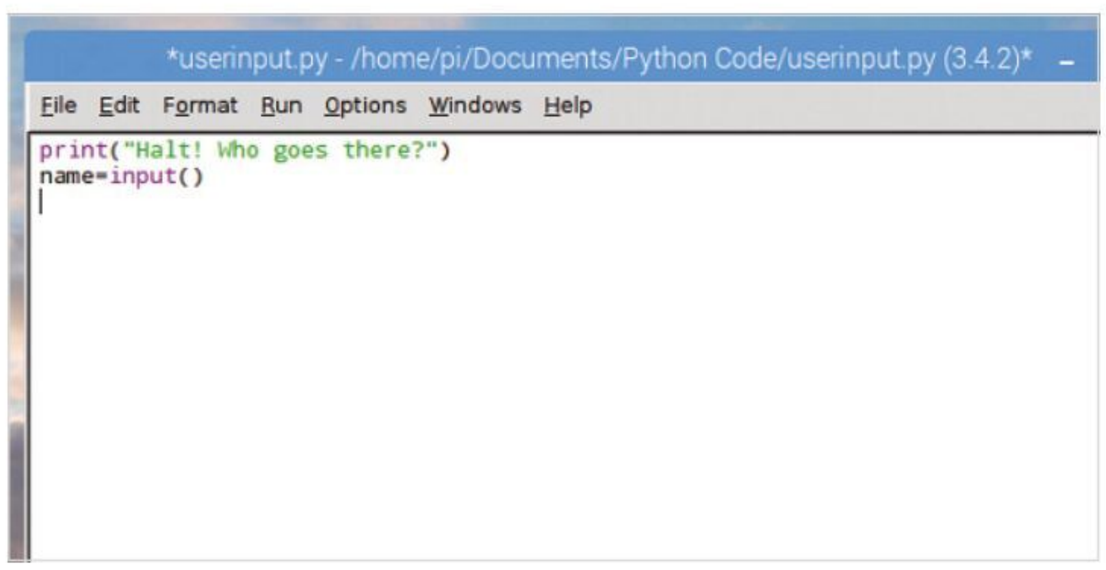
STEP 5 You don't always have to include quoted text within the input command. For example, you can ask the user their name, and have the input in the line below:

```
print("Hello. What's your name?")
name=input()
```



STEP 6 The code from the previous step is often regarded as being a little neater than having a lengthy amount of text in the input command, but it's not a rule that's set in stone, so do as you like in these situations. Expanding on the code, try this:

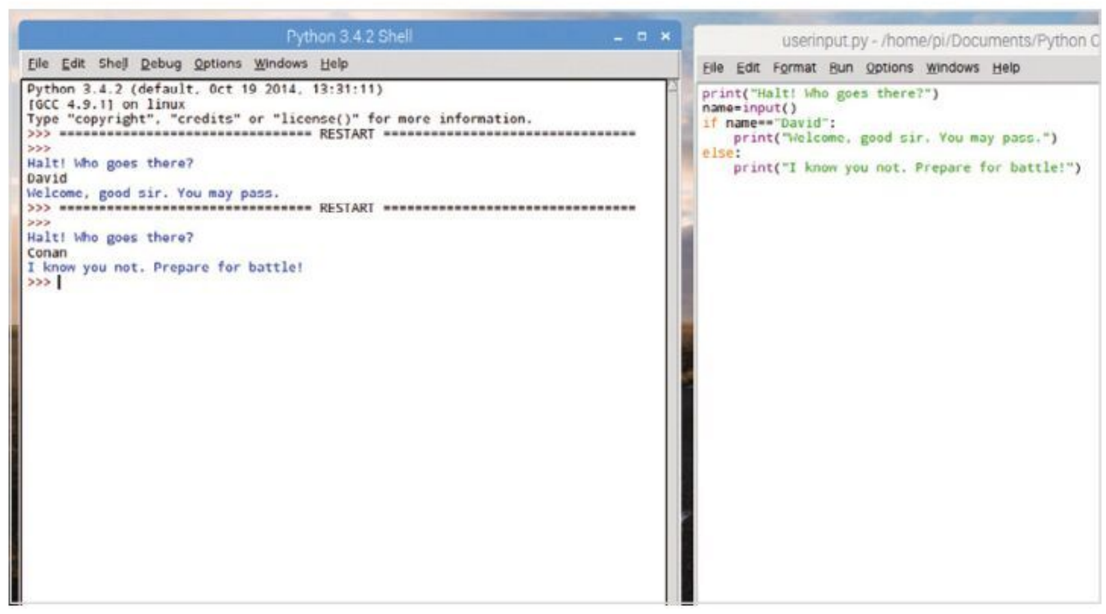
```
print("Halt! Who goes there?")
name=input()
```



STEP 7 It's a good start to a text adventure game, perhaps? Now you can expand on it and use the raw input from the user to flesh out the game a little:

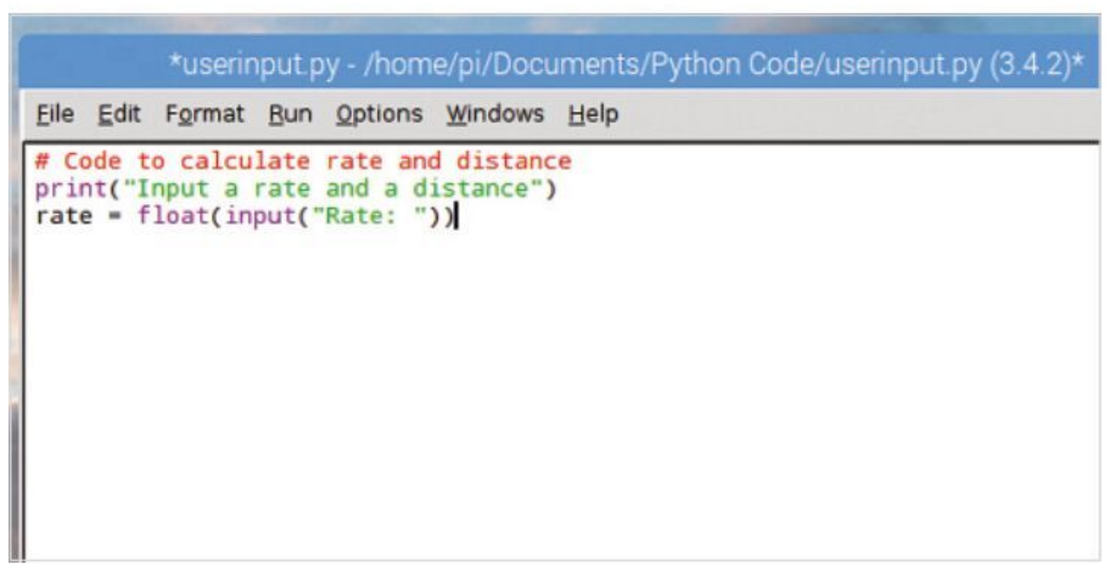
```
if name=="David":
  print("Welcome, good sir. You may pass.")
else:
  print("I know you not. Prepare for battle!")
```

STEP 8 What you've created here is a condition, which we will cover soon. In short, we're using the input from the user and measuring it against a condition. So, if the user enters David as their name, the guard will allow them to pass unhindered. Else, if they enter a name other than David, the guard challenges them to a fight.



STEP 9 Just as you learned previously, any input from a user is automatically a string, so you need to apply a TypeCast in order to turn it into something else. This creates some interesting additions to the input command. For example:

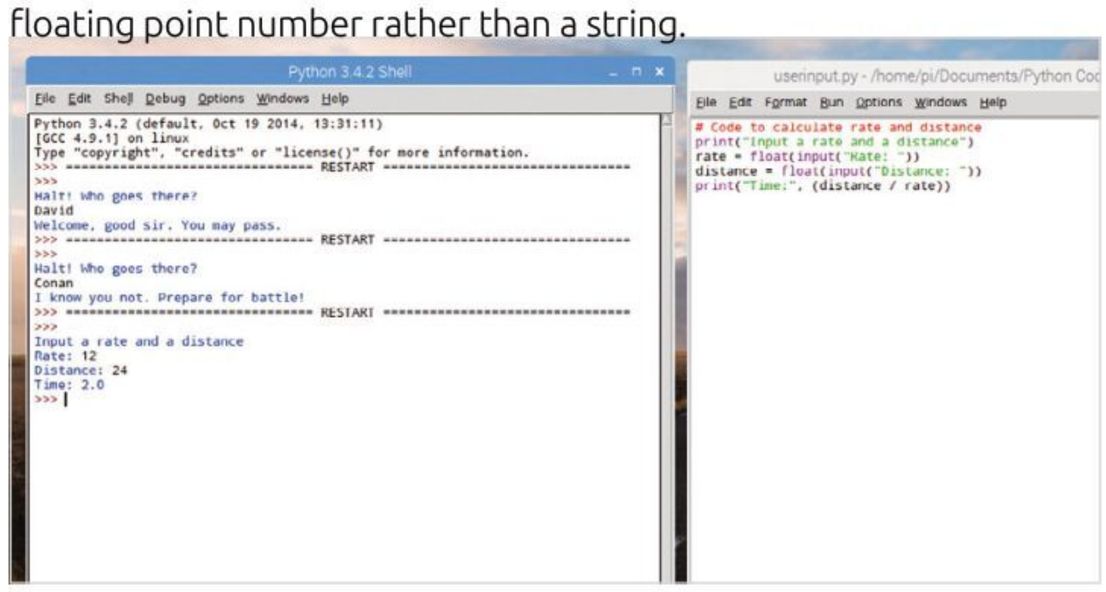
```
# Code to calculate rate and distance
print("Input a rate and a distance")
rate = float(input("Rate: "))
```



STEP 10 To finalise the rate and distance code, we can add:

```
distance = float(input("Distance:
"))
print("Time:", (distance / rate))
```

Save and execute the code and enter some numbers. Using the float(input element, we've told Python that anything entered is a floating point number rather than a string.



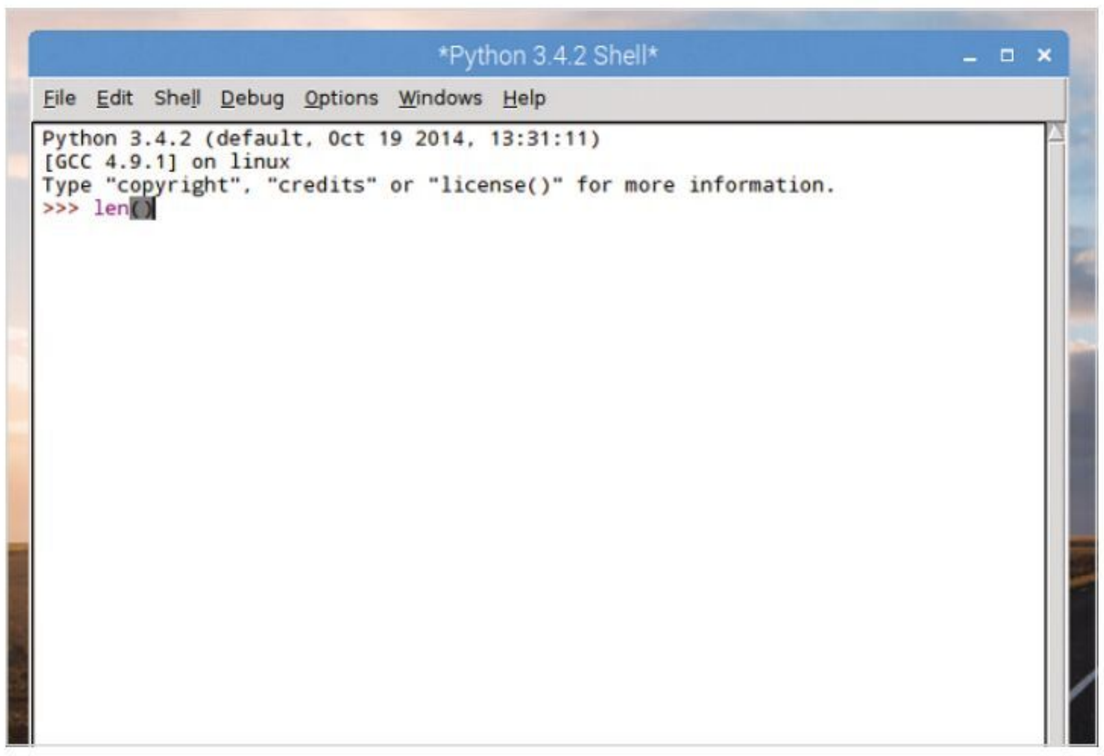
Creating Functions

Now that you've mastered the use of variables and user input, the next step is to tackle functions. You've already used a few functions, such as the print command but Python enables you to define your own functions.

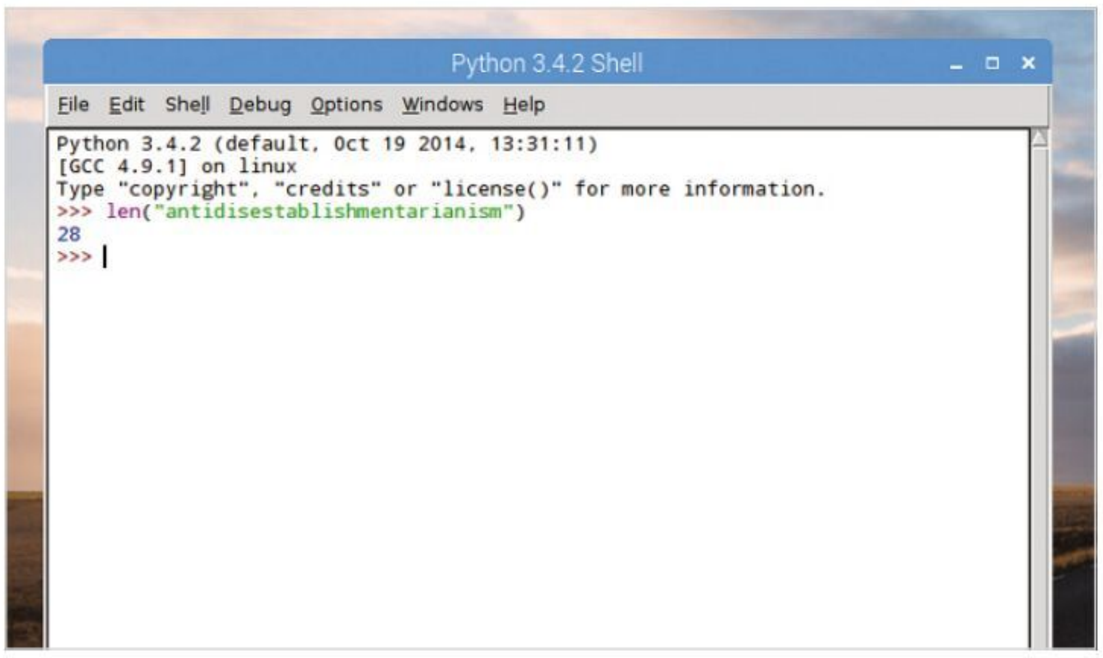
FUNKY FUNCTIONS

A function is a command that you enter into Python to do something. It's a little piece of self-contained code that takes data, works on it and then returns the result.

STEP 1 It's not just data that a function works on. They can do all manner of useful things in Python, such as sort data, change items from one format to another and check the length or type of items. Basically, a function is a short word that's followed by brackets. For example, **len()**, **list()** or **type()**.



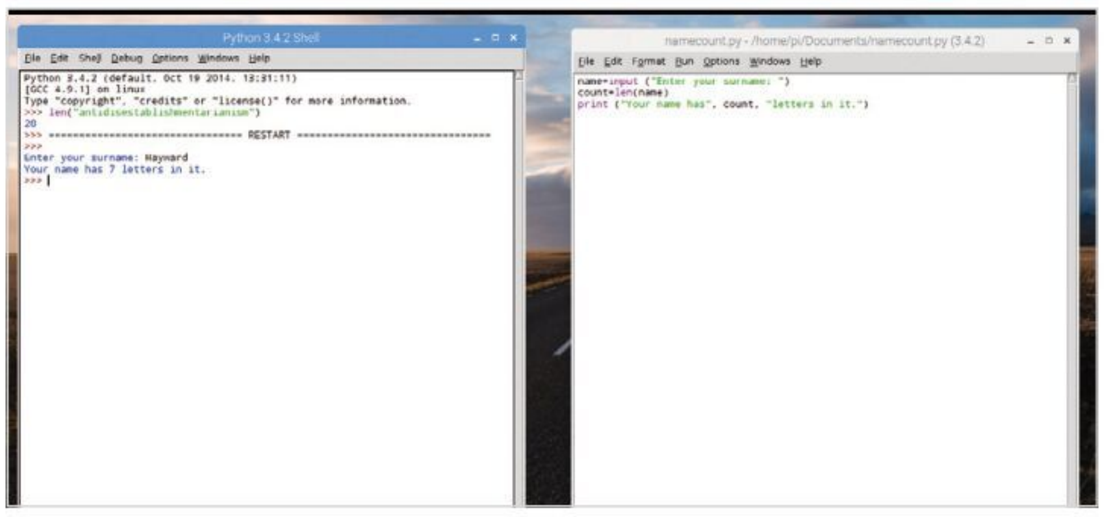
STEP 2 A function takes data, usually a variable, works on it depending on what the function is programmed to do and returns the end value. The data being worked on goes inside the brackets, so if you wanted to know how many letters are in the word antidisestablishmentarianism, then you'd enter: `len("antidisestablishmentarianism")` and the number 28 would return.



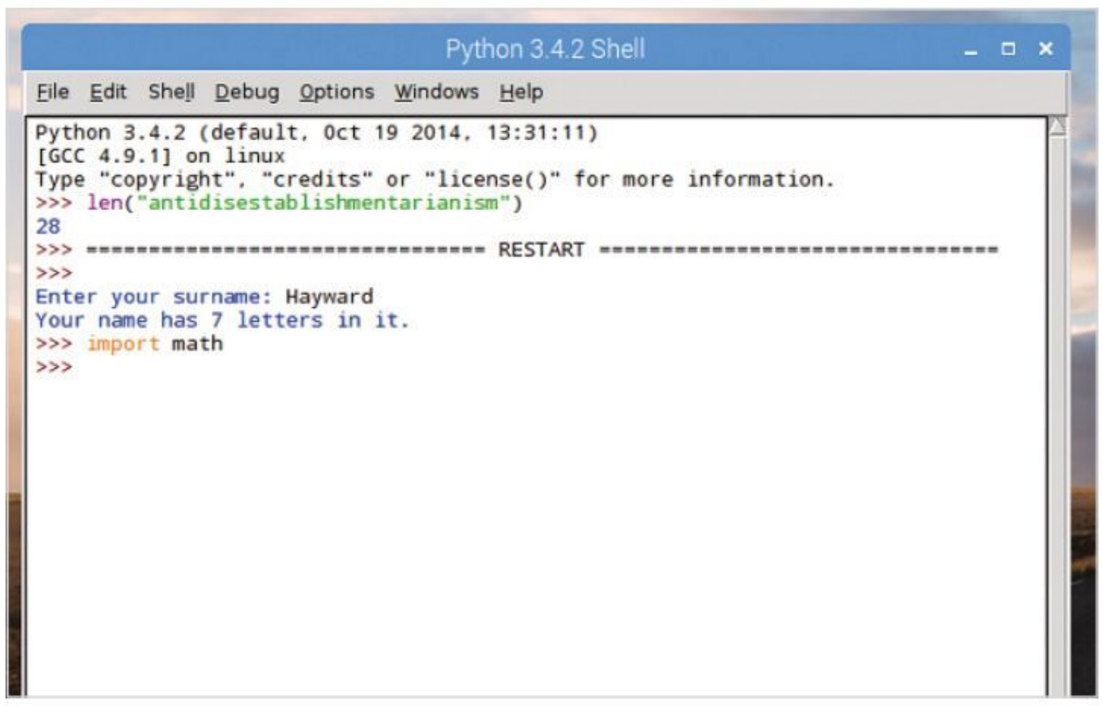
STEP 3 You can pass variables through functions in much the same manner. Let's assume you want the number of letters in a person's surname, you could use the following code (enter the text editor for this example):

```
name=input ("Enter your surname: ")
count=len(name)
print ("Your surname has", count, "letters in
it.")
```

Press F5 and save the code to execute it.



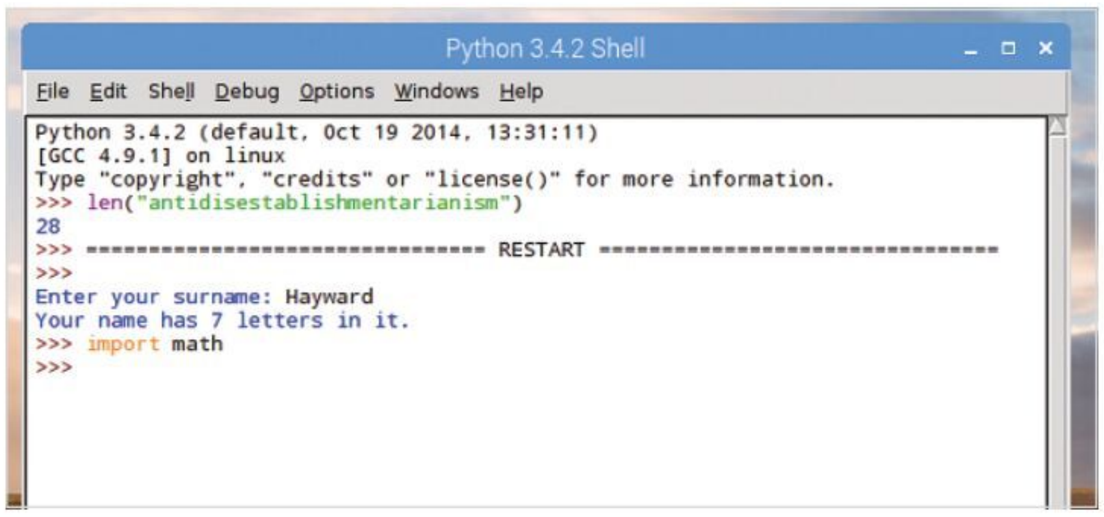
STEP 4 Python has tens of functions built into it, far too many to get into in the limited space available here. However, to view the list of built-in functions available to Python 3, navigate to www.docs.python.org/3/library/functions.html. These are the predefined functions, but since users have created many more, they're not the only ones available.



STEP 5 Additional functions can be added to Python through modules. Python has a vast range of modules available that can cover numerous programming duties. They add functions and can be imported as and when required. For example, to use advanced mathematics functions enter:

```
import math
```

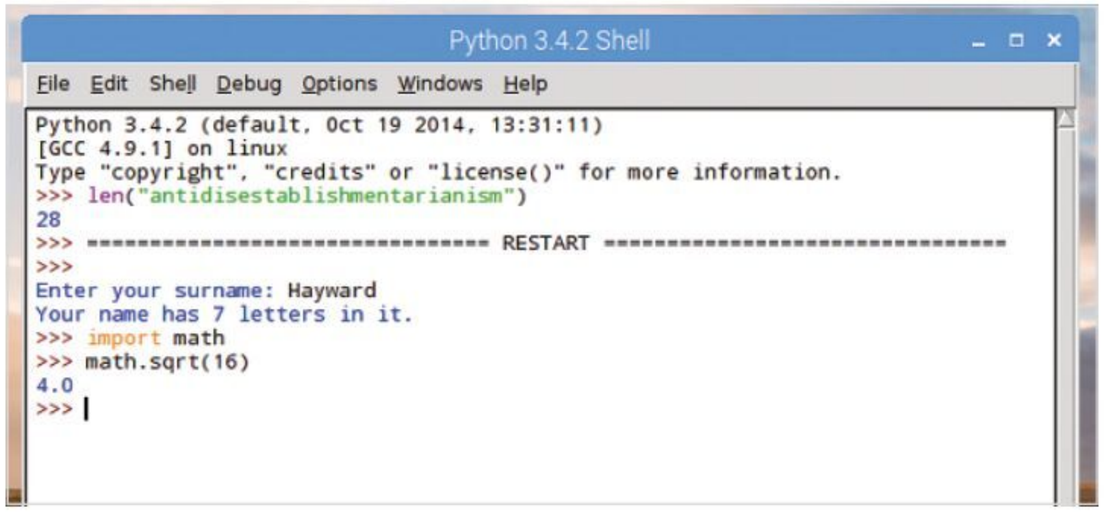
Once entered, you have access to all the Math module functions.



STEP 6 To use a function from a module enter the name of the module followed by a full stop, then the name of the function. For instance, using the Math module, since you've just imported it into Python, you can utilise the square root function. To do so, enter:

```
math.sqrt(16)
```

You can see that the code is presented as module.function(data).



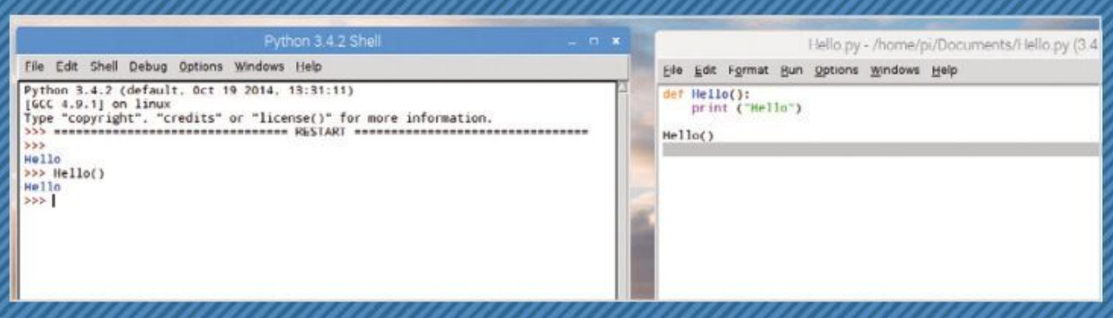
FORGING FUNCTIONS

There are many different functions you can import created by other Python programmers and you will undoubtedly come across some excellent examples in the future; you can also create your own with the def command.

STEP 1 Choose File > New File to enter the editor, let's create a function called Hello, that greets a user. Enter:

```
def Hello():
    print ("Hello")

Hello()
```

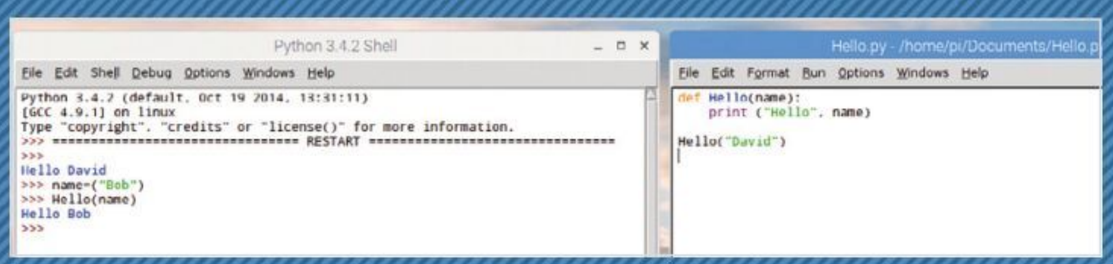
Press F5 to save and run the script. You can see Hello in the Shell, type in Hello() and it returns the new function.



STEP 2 Let's now expand the function to accept a variable, the user's name for example. Edit your script to read:

```
def Hello(name):
    print ("Hello", name)

Hello("David")
```

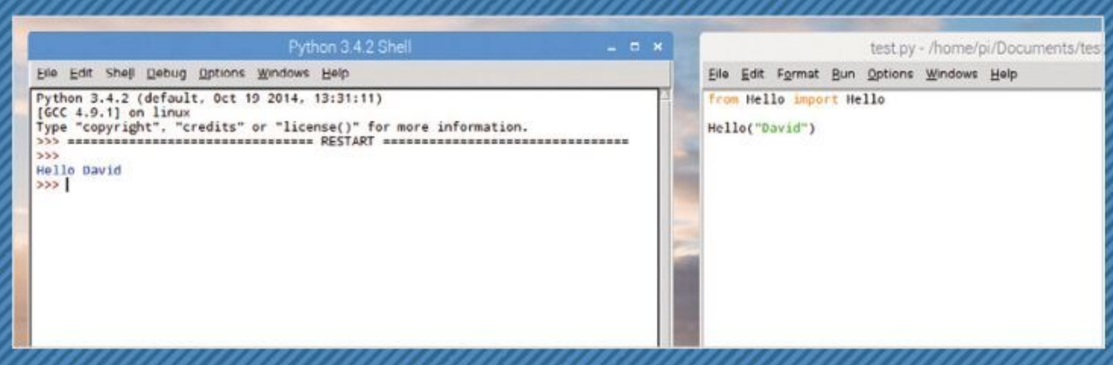
This will now accept the variable name, otherwise it prints Hello David. In the Shell, enter: name=("Bob"), then: Hello(name). Your function can now pass variables through it.



STEP 3 To modify it further, delete the Hello("David") line, the last line in the script and press Ctrl+S to save the new script. Close the Editor and create a new file (File > New File). Enter the following:

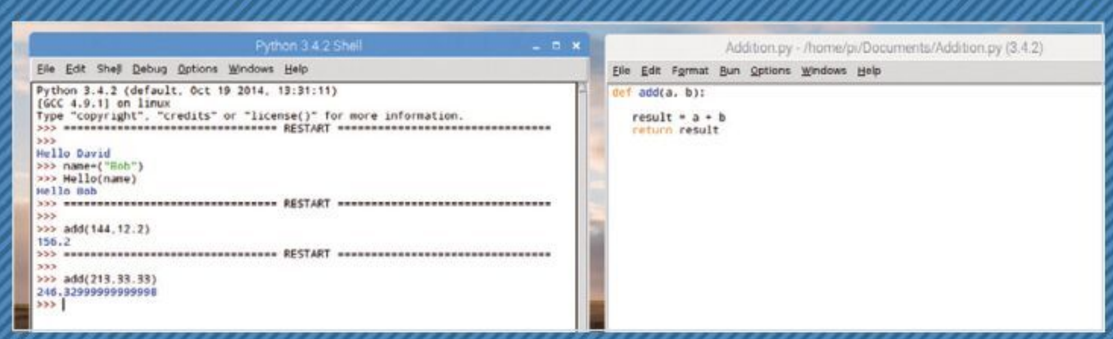
```
from Hello import Hello

Hello("David")
```

Press F5 to save and execute the code.



STEP 4 What you've just done is import the Hello function from the saved Hello.py program and then used it to say hello to David. This is how modules and functions work: you import the module then use the function. Try this one, and modify it for extra credit:

```
def add(a, b):
    result = a + b
    return result
```



Conditions and Loops

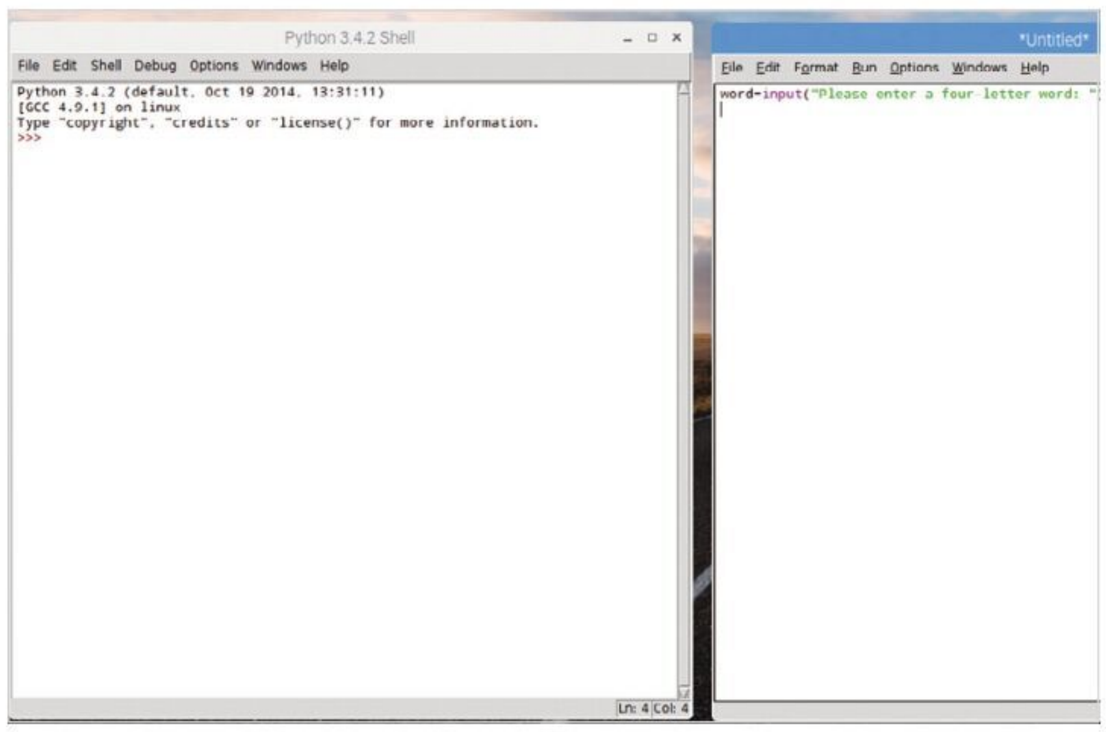
Conditions and loops are what make a program interesting; they can be simple or rather complex. How you use them depends greatly on what the program is trying to achieve; they could be the number of lives left in a game or just displaying a countdown.

TRUE CONDITIONS

Keeping conditions simple to begin with makes learning to program a more enjoyable experience. Let's start then by checking if something is TRUE, then doing something else if it isn't.

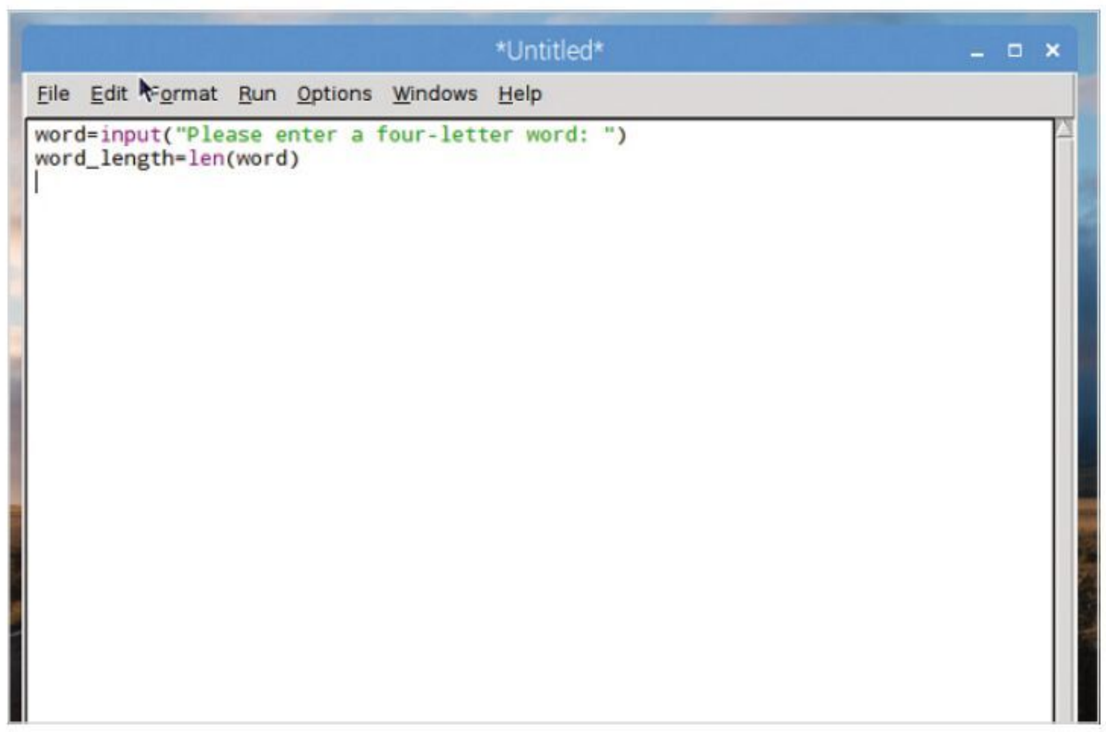
STEP 1 Let's create a new Python program that will ask the user to input a word, then check it to see if it's a four-letter word or not. Start with File > New File, and begin with the input variable:

```
word=input("Please enter a four-letter word: ")
```



STEP 2 Now we can create a new variable, then use the len function and pass the word variable through it to get the total number of letters the user has just entered:

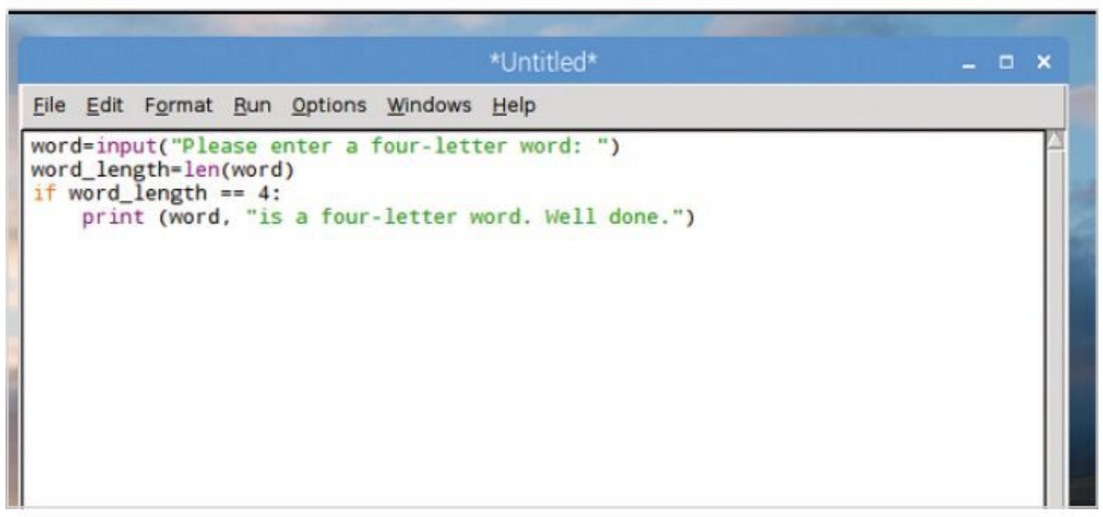
```
word=input("Please enter a four-letter word: ")
word_length=len(word)
```



STEP 3 Now you can use an if statement to check if the word_length variable is equal to four and print a friendly conformation if it applies to the rule:

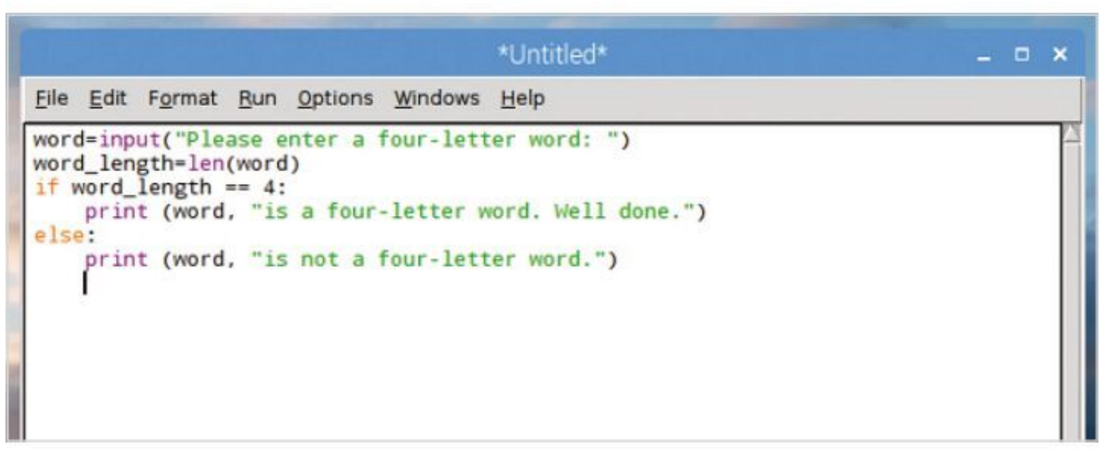
```
word=input("Please enter a four-letter word: ")
word_length=len(word)
if word_length == 4:
   print (word, "is a four-letter word. Well done.")
```

The double equal sign (==) means check if something is equal to something else.

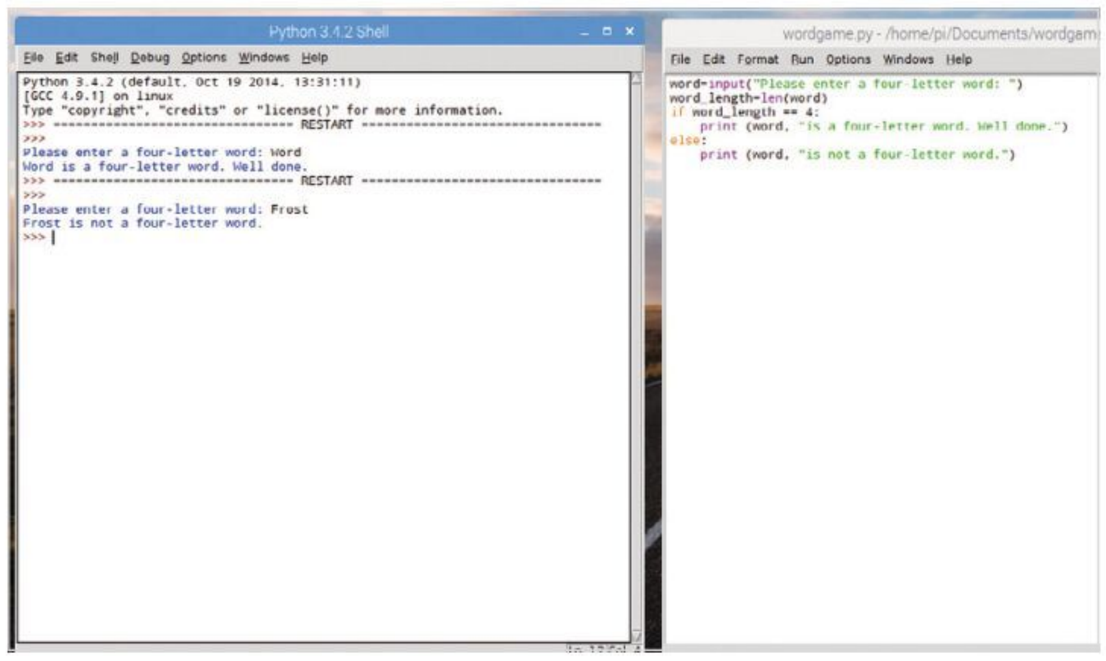


STEP 4 The colon at the end of IF tells Python that if this statement is true do everything after the colon that's indented. Next, move the cursor back to the beginning of the Editor:

```
word=input("Please enter a four-letter word: ")
word_length=len(word)
if word_length == 4:
   print (word, "is a four-letter word. Well
done.")
else:
   print (word, "is not a four-letter word.")
```

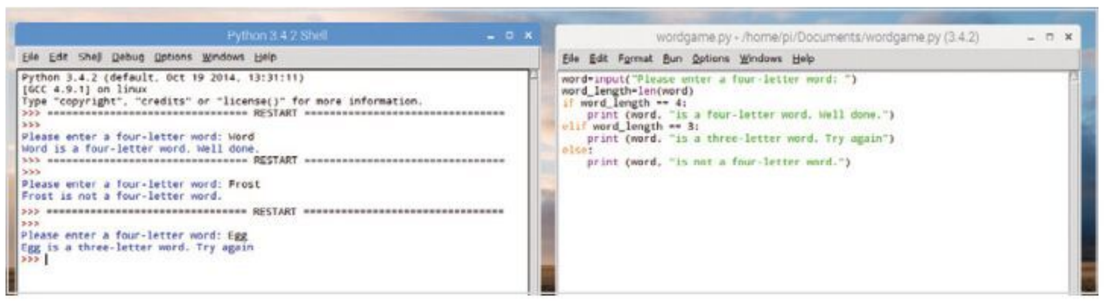


STEP 5 Press F5 and save the code to execute it. Enter a four-letter word in the Shell to begin with, you should have the returned message that it's the word is four letters. Now press F5 again and rerun the program but this time enter a five-letter word. The Shell will display that it's not a four-letter word.



STEP 6 Now expand the code to include another conditions. Eventually, it could become quite complex. We've added a condition for three-letter words:

```
word=input("Please enter a four-letter word: ")
word_length=len(word)
if word_length == 4:
   print (word, "is a four-letter word. Well
done.")
elif word_length == 3:
   print (word, "is a three-letter word. Try again.")
else:
   print (word, "is not a four-letter word.")
```

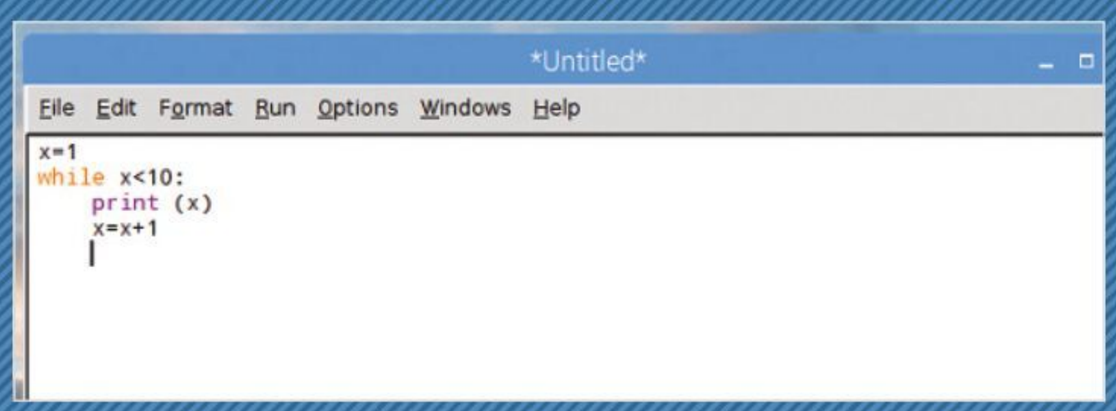


LOOPS

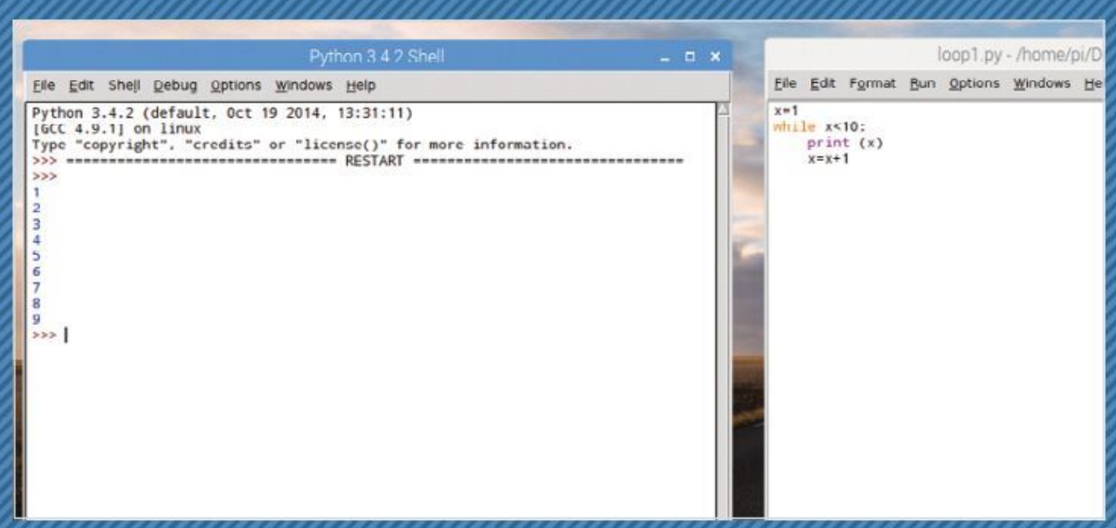
A loop looks quite similar to a condition but they are somewhat different in their operation. A loop will run through the same block of code a number of times, usually with the support of a condition.

STEP 1 Let's start with a simple While statement. Like IF, this will check to see if something is TRUE, then run the indented code:

```
x = 1
while x < 10:
   print (x)
   x = x + 1
```

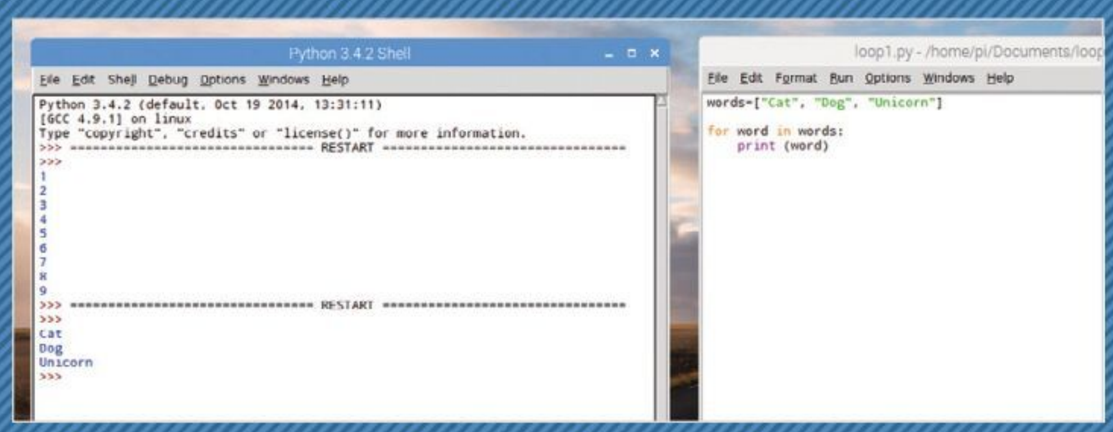


STEP 2 The difference between if and while is when while gets to the end of the indented code, it goes back and checks the statement is still true. In our example x is less than 10. With each loop it prints the current value of x, then adds one to that value. When x does eventually equal 10 it stops.



STEP 3 The For loop is another example. For is used to loop over a range of data, usually a list stored as variables inside square brackets. For example:

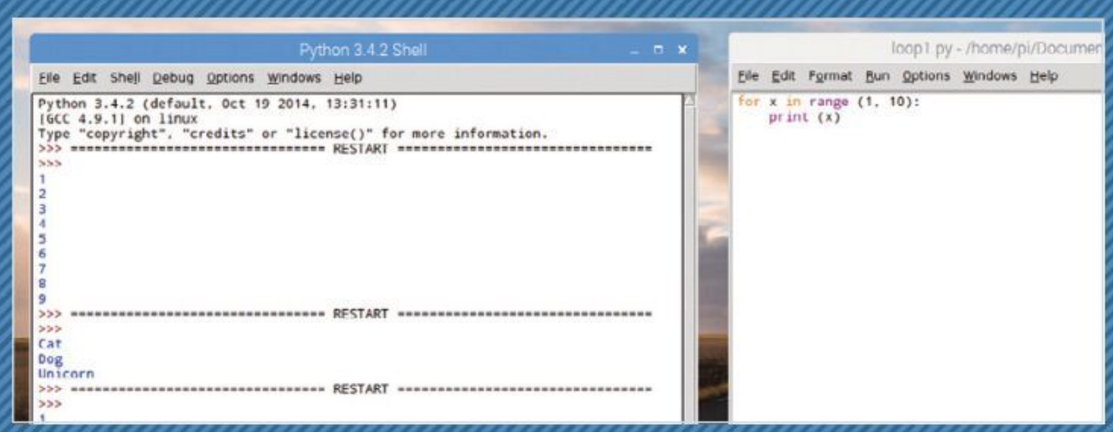
```
words=["Cat", "Dog", "Unicorn"]

for word in words:
   print (word)
```



STEP 4 The For loop can also be used in the countdown example by using the range function:

```
for x in range (1, 10):
 print (x)
```

The x=x+1 part isn't needed here because the range function creates a list between the first and last numbers used.



Python Modules

We've mentioned modules previously, (the Math module) but as modules are such a large part of getting the most from Python, it's worth dedicating a little more time to them. In this instance we're using the Windows version of Python 3.

MASTERING MODULES

Think of modules as an extension that's imported into your Python code to enhance and extend its capabilities. There are countless modules available and as we've seen, you can even make your own.

STEP 1 Although good, the built-in functions within Python are limited. The use of modules, however, allows us to make more sophisticated programs. As you are aware, modules are Python scripts that are imported, such as import math.

```
Python 3.6.2 Shell
File  Edit  Shell  Debug  Options  Window  Help
Python 3.6.2 (v3.6.2:5fd33b5, Jul  8 2017, 04:14:34) [MSC v.1900 32 bit (Intel)]
 on win32
Type "copyright", "credits" or "license()" for more information.
>>> import math
>>>
```

STEP 2 Some modules, especially on the Raspberry Pi, are included by default, the Math module being a prime example. Sadly, other modules aren't always available. A good example on non-Pi platforms is the Pygame module, which contains many functions to help create games. Try: **import pygame**.

```
Python 3.6.2 Shell
File  Edit  Shell  Debug  Options  Window  Help
Python 3.6.2 (v3.6.2:5fd33b5, Jul  8 2017, 04:14:34) [MSC v.1900 32 bit (Intel)]
 on win32
Type "copyright", "credits" or "license()" for more information.
>>> import math
>>> import pygame
Traceback (most recent call last):
  File "<pyshell#1>", line 1, in <module>
    import pygame
ModuleNotFoundError: No module named 'pygame'
>>>
```

STEP 3 The result is an error in the IDLE Shell, as the Pygame module isn't recognised or installed in Python. To install a module we can use PIP (Pip Installs Packages). Close down the IDLE Shell and drop into a command prompt or Terminal session. At an elevated admin command prompt, enter:

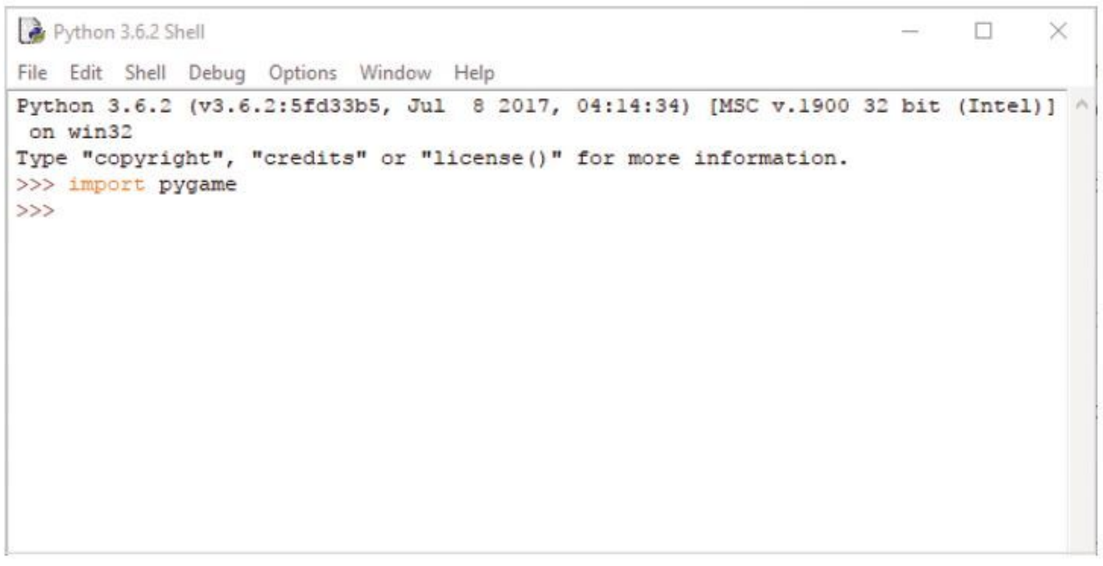
```
pip install pygame
```

```
Command Prompt

C:\Users\david>pip install pygame
```

STEP 4 The PIP installation requires an elevated status due it installing components at different locations. Windows users can search for CMD via the Start button and right-click the result then click Run as Administrator. Linux and Mac users can use the Sudo command, with sudo pip install package.

```
Administrator: Command Prompt
Microsoft Windows [Version 10.0.15063]
(c) 2017 Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>pip install pygame
Collecting pygame
  Using cached pygame-1.9.3-cp36-cp36m-win32.whl
Installing collected packages: pygame
Successfully installed pygame-1.9.3

C:\WINDOWS\system32>
```

STEP 5 Close the command prompt or Terminal and relaunch the IDLE Shell. When you now enter: `import pygame`, the module will be imported into the code without any problems. You'll find that most code downloaded or copied from the Internet will contain a module, mainstream of unique, these are usually the source of errors in execution due to them being missing.



STEP 6 The modules contain the extra code needed to achieve a certain result within your own code, as we've previously experimented with. For example:

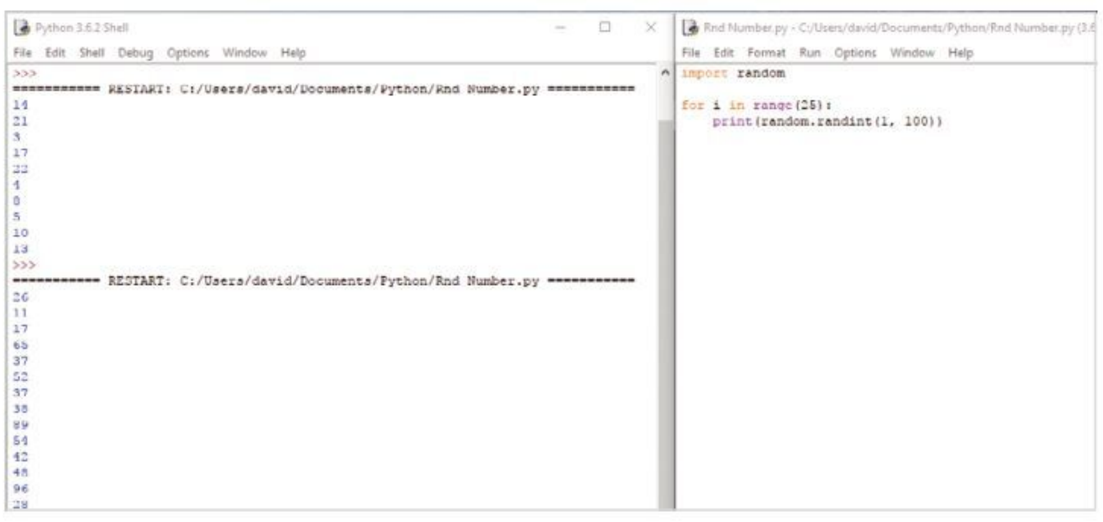
```
import random
```

Brings in the code from the Random Number Generator module. You can then use this module to create something like:

```
for i in range(10):
  print(random.randint(1, 25))
```

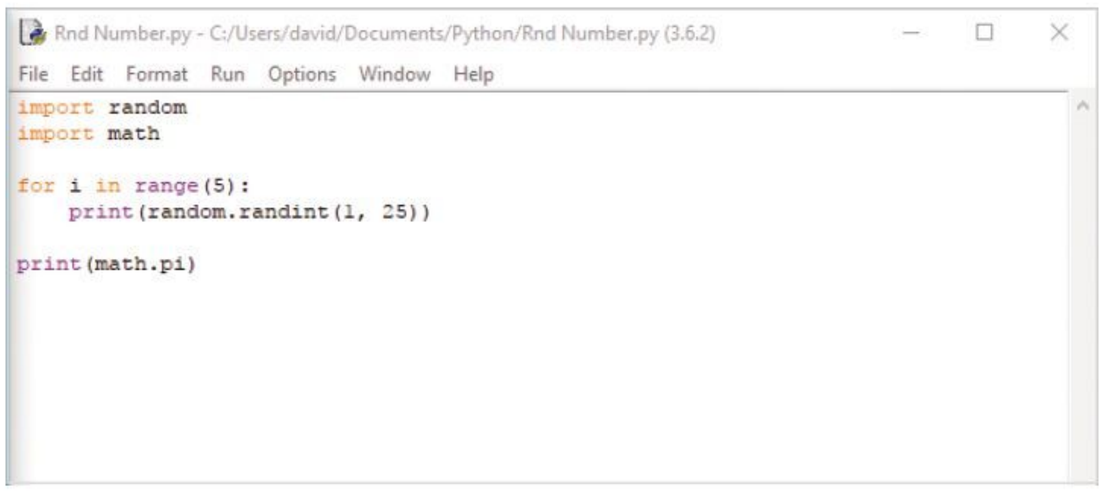
STEP 7 This code, when saved and executed, will display ten random numbers from 1 to 25. You can play around with the code to display more or less, and from a great or lesser range. For example:

```
import random

for i in range(25):
  print(random.randint(1, 100))
```



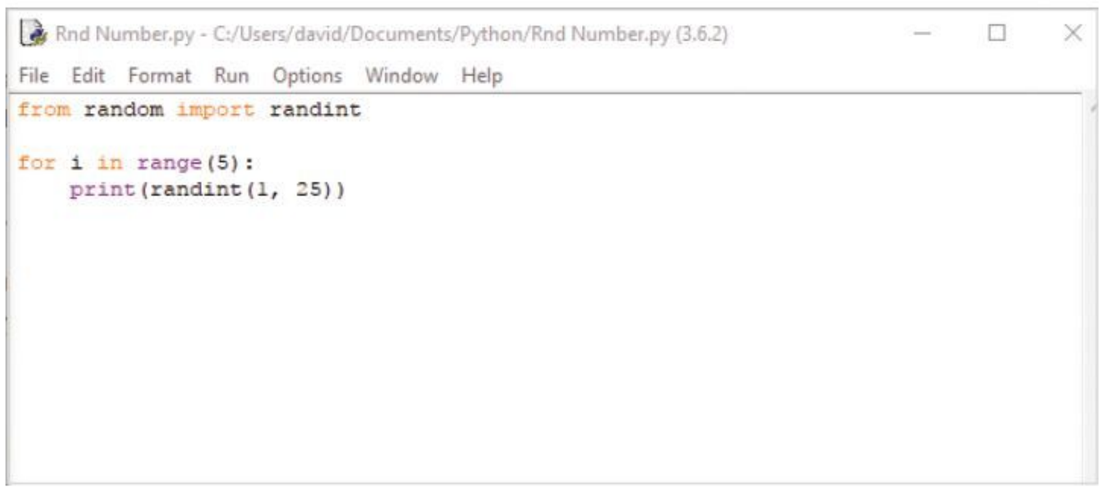
STEP 8 Multiple modules can be imported within your code. To extend our example, use:

```
import random
import math

for I in range(5):
  print(random.randint(1, 25))

print(math.pi)
```



STEP 9 The result is a string of random numbers followed by the value of Pi as pulled from the Math module using the print(math.pi) function. You can also pull in certain functions from a module by using the from and import commands, such as:

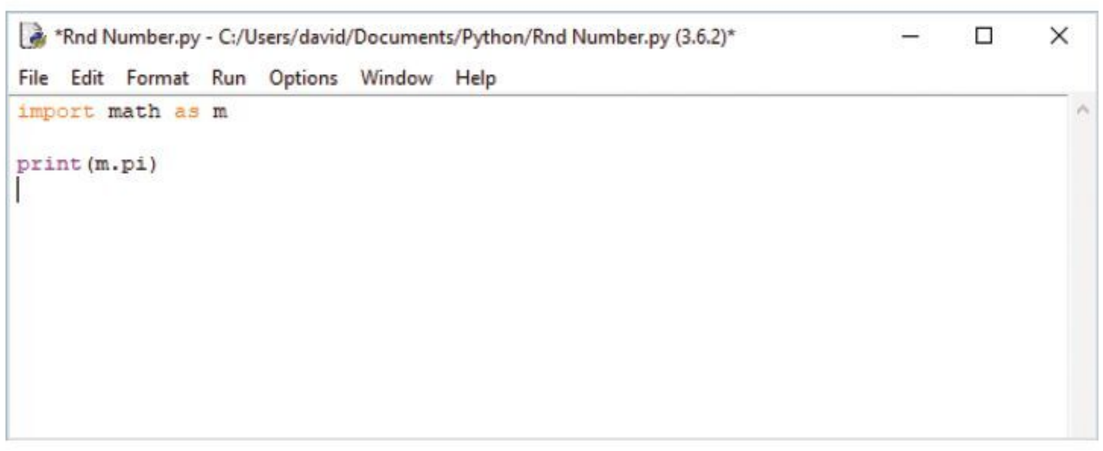
```
from random import randint

for i in range(5):
  print(randint(1, 25))
```



STEP 10 This helps create a more streamlined approach to programming. You can also use import module*, which will import everything defined within the named module. However, it's often regarded as a waste of resources but it works nonetheless. Finally, modules can be imported as aliases:

```
import math as m

print(m.pi)
```

Of course, adding comments helps to tell others what's going on.



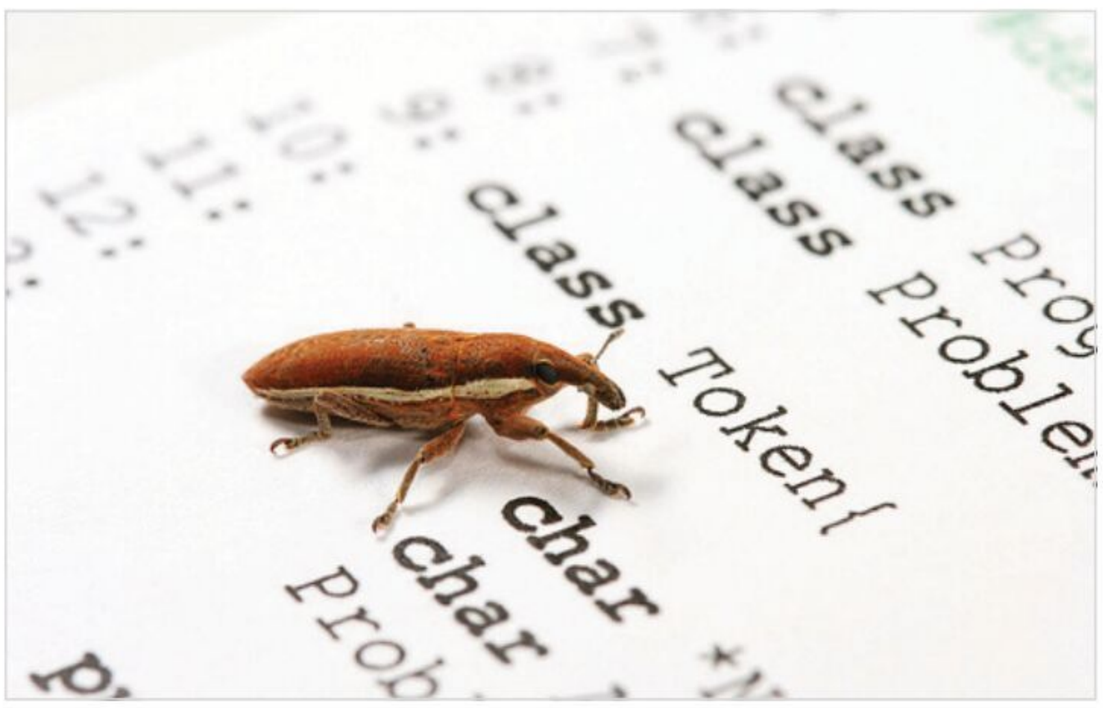
Python Errors

It goes without saying that you'll eventually come across an error in your code, where Python declares it's not able to continue due to something being missed out, wrong or simply unknown. Being able to identify these errors makes for a good programmer.

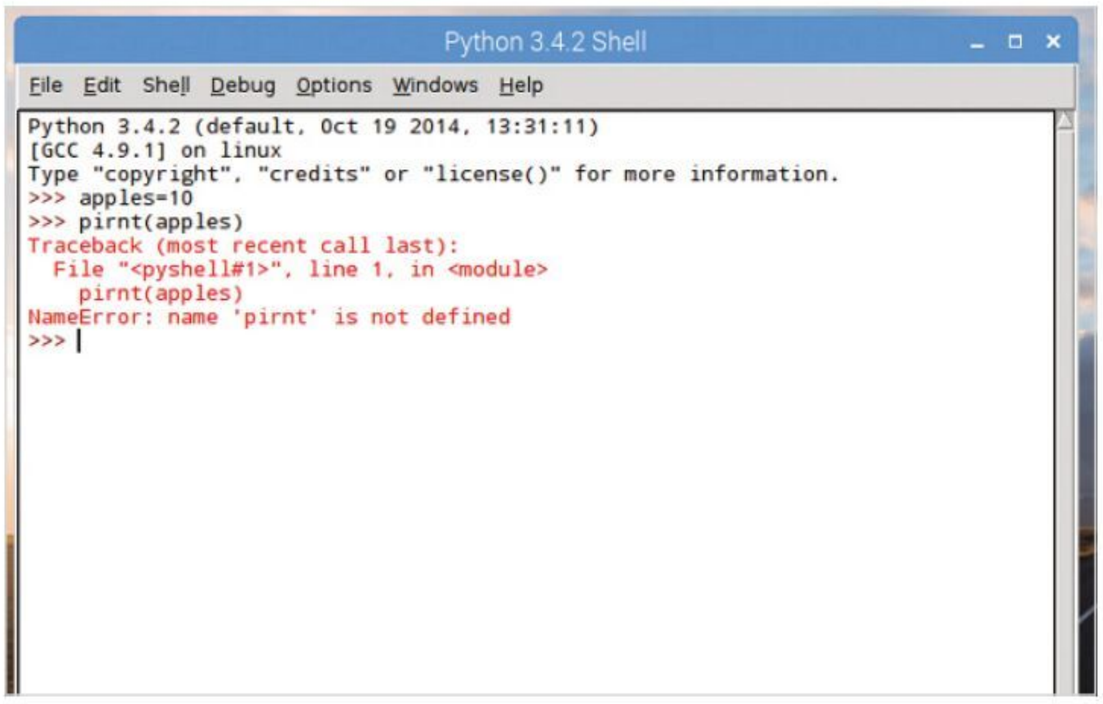
DEBUGGING

Errors in code are called bugs and are perfectly normal. They can often be easily rectified with a little patience. The important thing is to keep looking, experimenting and testing. Eventually your code will be bug free.

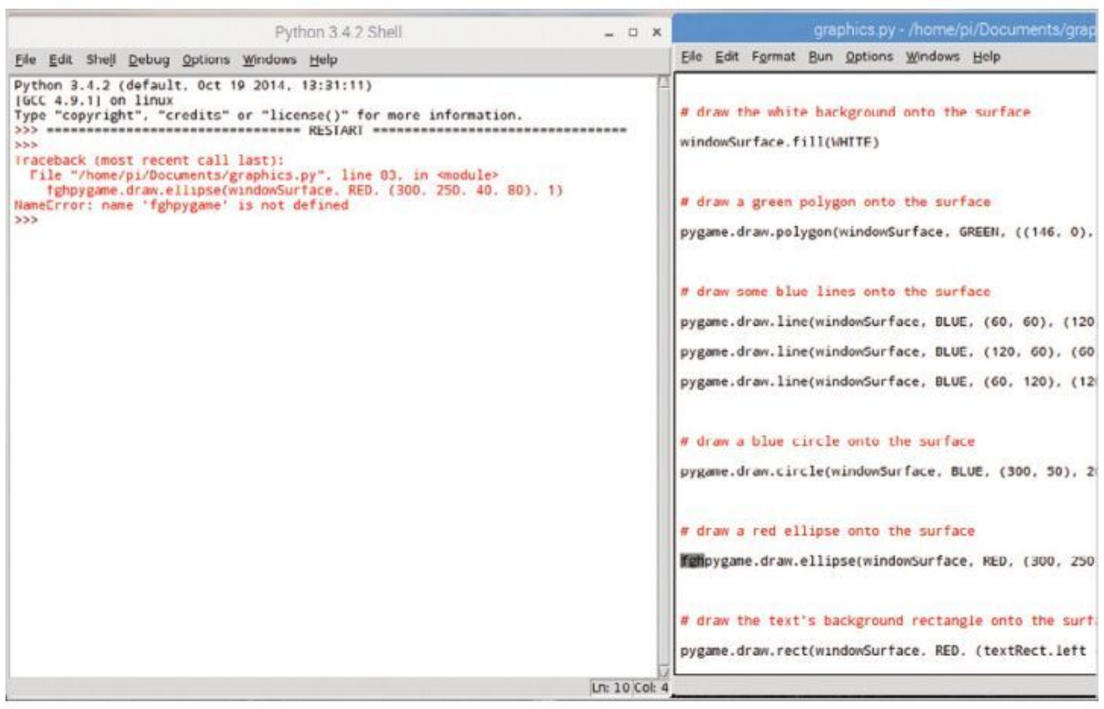
STEP 1 Code isn't as fluid as the written word, no matter how good the programming language is. Python is certainly easier than most languages but even it is prone to some annoying bugs. The most common are typos by the user and whilst easy to find in simple dozen-line code, imagine having to debug multi-thousand line code.



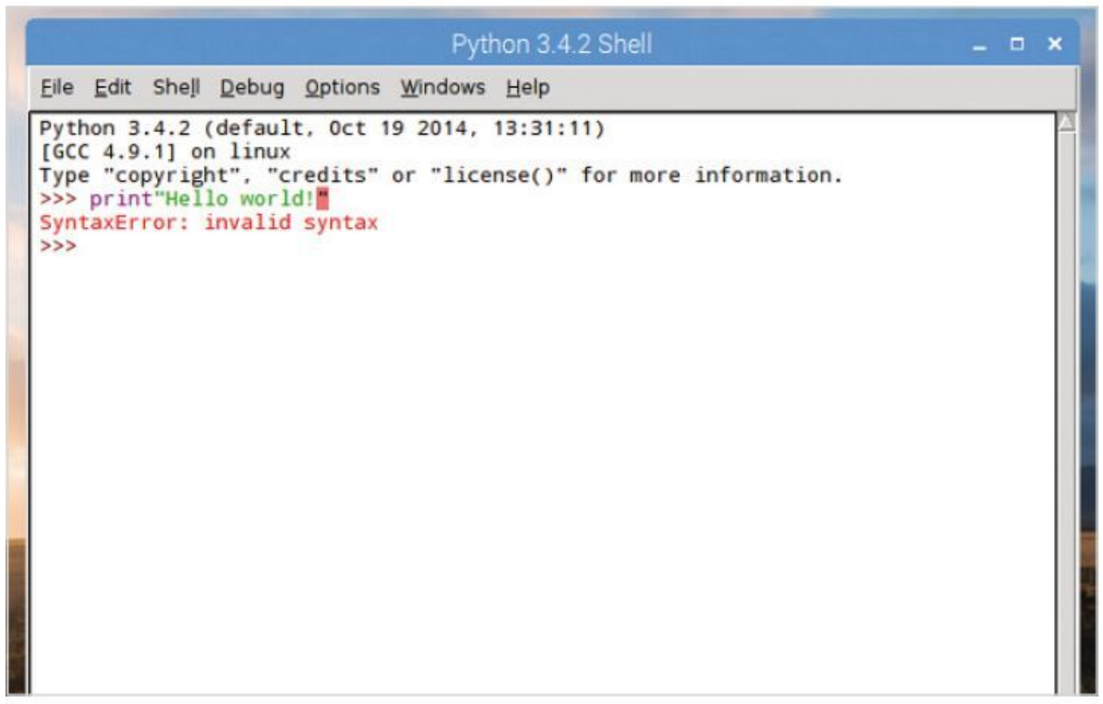
STEP 2 The most common of errors is the typo, as we've mentioned. The typos are often at the command level: mistyping the print command for example. However, they also occur when you have numerous variables, all of which have lengthy names. The best advice is to simply go through the code and check your spelling.



STEP 3 Thankfully Python is helpful when it comes to displaying error messages. When you receive an error, in red text from the IDLE Shell, it will define the error itself along with the line number where the error has occurred. Whilst in the IDLE Editor this is a little daunting for lots of code; text editors help by including line numbering.



STEP 4 Syntax errors are probably the second most common errors you'll come across as a programmer. Even if the spelling is correct, the actual command itself is wrong. In Python 3 this often occurs when Python 2 syntaxes are applied. The most annoying of these is the print function. In Python 3 we use **print("words")**, whereas Python2 uses **print "words"**.



STEP 5

Pesky brackets are also a nuisance in programming errors, especially when you have something like:

```
print(balanced_check(input()))
```

Remember that for every '(' there must be an equal number of ')'.

```
import sys

def balanced_check(data):
    stack = []
    characters = list(data)

    for character in characters:
        reference = {
            '(': ')',
            '{': '}',
            '[': ']'
        }
        if character in reference.keys():
            stack.append(character)

        elif character in reference.values() and len(stack) > 0:
            char = stack.pop()
            if reference.get(char) != character:
                return "NO"
        else:
            return "NO"
```

STEP 6

There are thousands of online Python resources, code snippets and lengthy discussions across forums on how best to achieve something. Whilst 99 per cent of it is good code, don't always be lured into copying and pasting random code into your editor. More often than not, it won't work and the worst part is that you haven't learnt anything.

8

You have a bare except clause; i.e.,

```
try:
    some_code()
except:
    clean_up()
```

The problem with a bare except is that it will catch *all* exceptions, including ones you really don't want to be ignoring (like KeyboardInterrupt and SystemExit). It would be much better if your except block only caught the specific exception you expect, and let all others bubble up as normal.

A few other general comments on your code:

- In line 200, you have this construction:

```
for letter in range(len(chosen_word)):
    if player_guess == chosen_word[letter]:
        word_guessed[letter] = player_guess
```

You're looping over the index variable, but also using the list element. It would be better to write:

```
for idx, letter in enumerate(chosen_word):
    if player_guess == letter:
```

STEP 7

Indents are a nasty part of Python programming that a lot of beginners fall foul of. Recall the If loop from the Conditions and Loops section, where the colon means everything indented following the statement is to be executed as long as it's true? Missing the indent, or having too much of indent, will come back with an error.

File Edit Format Run Options Windows Help

```
word=input("Please enter a four-letter word: ")
word_length=len(word)
if word_length == 4:
print (word, "is a four-letter word. Well done.")
else:
        print (word, "is not a four-letter word.")
```

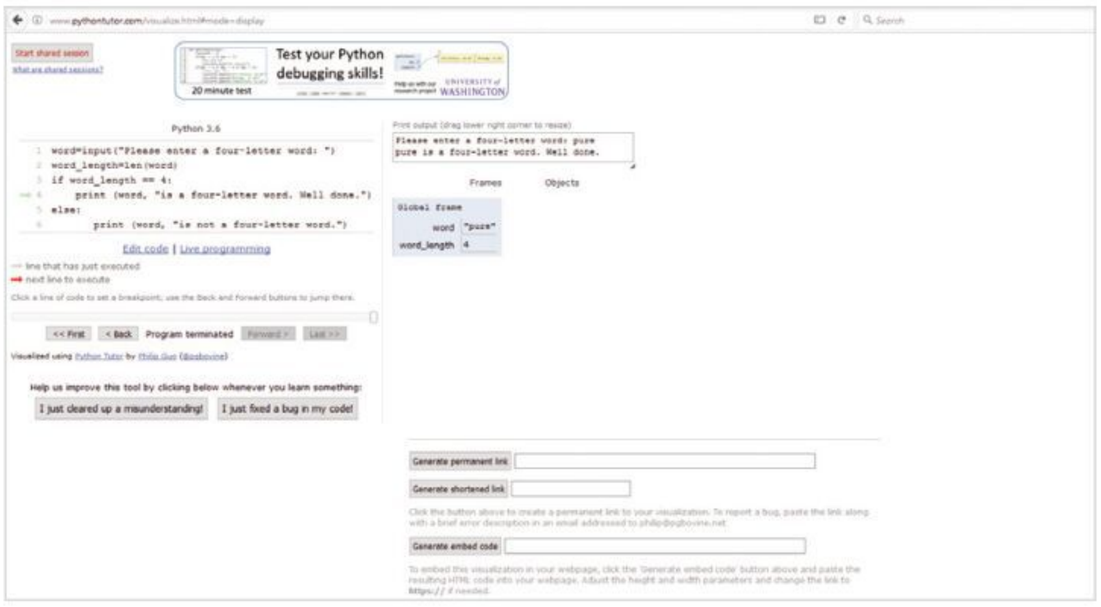
SyntaxError

expected an indented block

OK

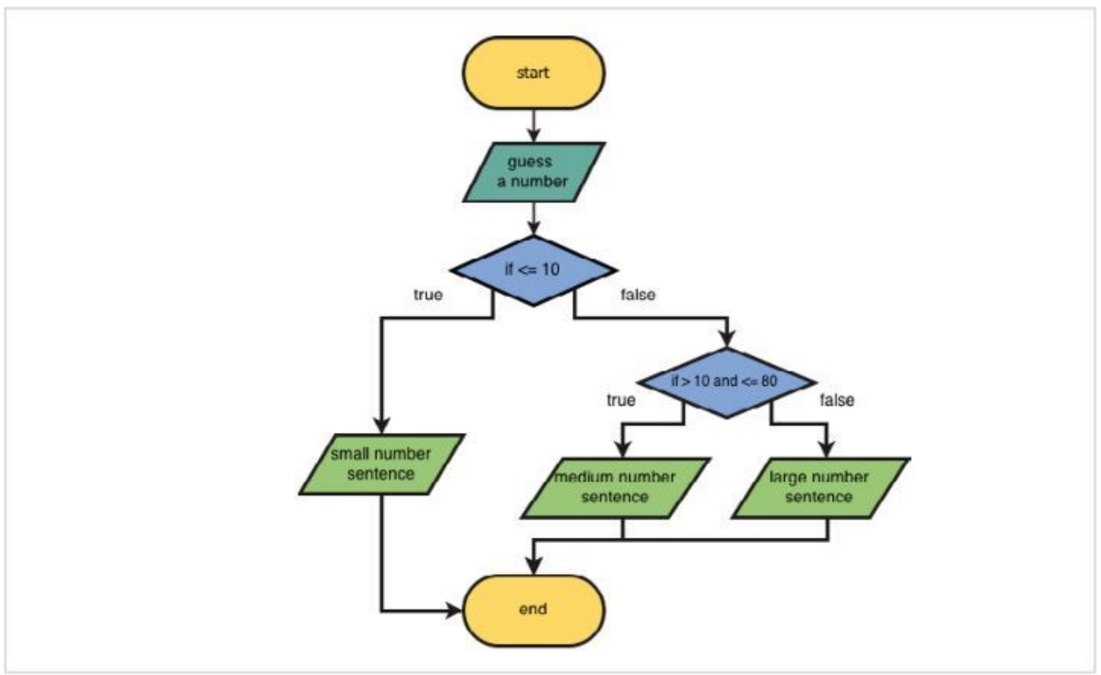
STEP 8

An excellent way to check your code step-by-step is to use Python Tutor's Visualise web page, found at www.pythontutor.com/visualize.html#mode=edit. Simply paste your code into the editor and click the Visualise Execution button to run the code line-by-line. This helps to clear bugs and any misunderstandings.



STEP 9

Planning makes for good code. Whilst a little old school, it's a good habit to plan what your code will do before sitting down to type it out. List the variables that will be used and the modules too; then write out a script for any user interaction or outputs.



STEP 10

Purely out of interest, the word debugging in computing terms comes from Admiral Grace Hopper, who back in the '40s was working on a monolithic Harvard Mark II electromechanical computer. According to legend Hopper found a moth stuck in a relay, thus stopping the system from working. Removal of the moth was hence called debugging.

Combining What You Know So Far

We've reached the end of this section so let's take a moment to combine everything we've looked at so far, and apply it to writing a piece of code. This code can then be used and inserted into your own programs in future; either part of it or as a whole.

PLAYING WITH PI

For this example we're going to create a program that will calculate the value of Pi to a set number of decimal places, as described by the user. It combines much of what we've learnt, and a little more.

STEP 1 Start by opening Python and creating a New File in the Editor. First we need to get hold of an equation that can accurately calculate Pi without rendering the computer's CPU useless for several minutes. The recommended calculation used in such circumstances is the Chudnovsky Algorithm, you can find more information about it at en.wikipedia.org/wiki/Chudnovsky_algorithm.

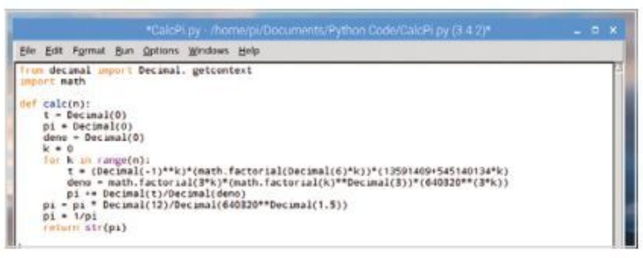
STEP 2 You can utilise the Chudnovsky Algorithm to create your own Python script based on the calculation. Begin by importing some important modules and functions within the modules:

```
from decimal import Decimal, getcontext
import math
```

This uses the decimal and getcontext functions from the Decimal module, both of which deal with large decimal place numbers and naturally the Math module.

STEP 3 Now you can insert the Pi calculation algorithm part of the code. This is a version of the Chudnovsky Algorithm:

```
def calc(n):
    t = Decimal(0)
    pi = Decimal(0)
    deno = Decimal(0)
    k = 0
    for k in range(n):
        t = (Decimal(-1)**k)*(math.factorial
(Decimal(6)*k))*(13591409 +545140134*k)
        deno = math.factorial(3*k)*(math.
factorial(k)**Decimal(3))*(640320**(3*k))
        pi += Decimal(t)/Decimal(deno)
    pi = pi * Decimal(12)/
Decimal(640320**Decimal(1.5))
    pi = 1/pi
    return str(pi)
```



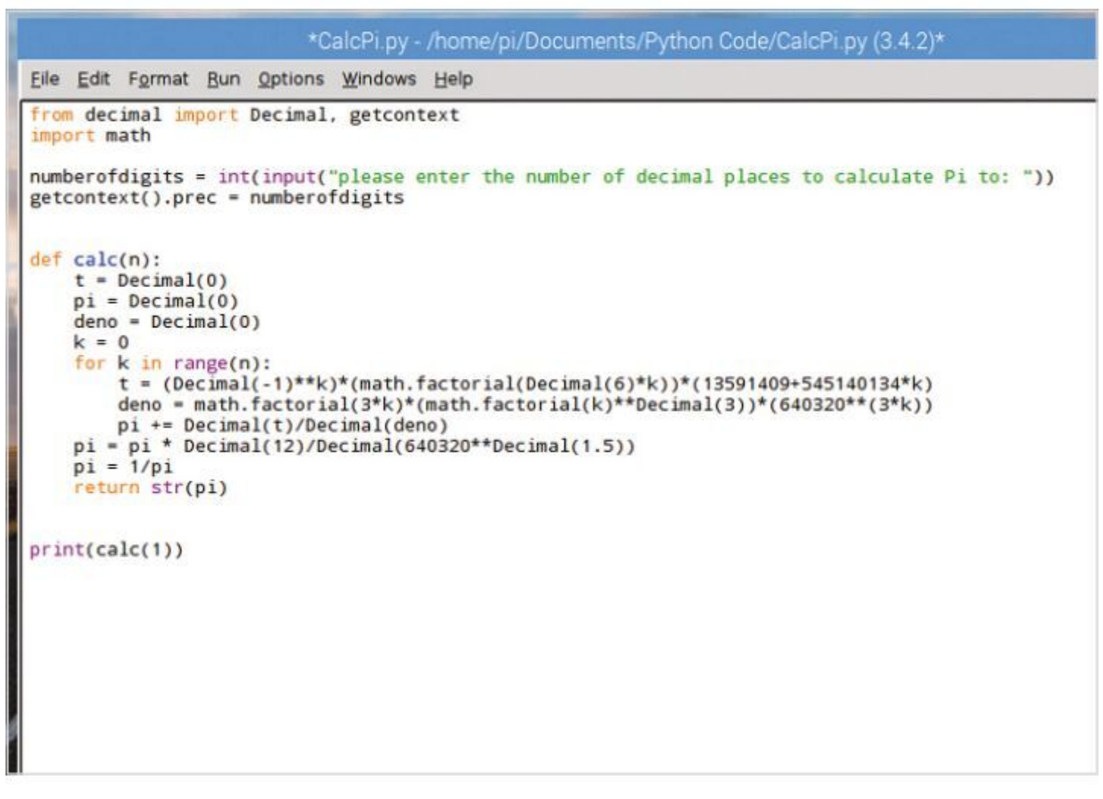
STEP 4 The previous step defines the rules that make up the algorithm and creates the string that will eventually display the value of Pi, according the Chudnovsky brothers' algorithm. You have no doubt already surmised that it would be handy to actually output the value of Pi to the screen. To rectify that you can add:

```
print(calc(1))
```

STEP 5 You can save and execute the code at this point if you like. The output will print the value of Pi to 27 decimal places: **3.141592653589734207668453591**. Whilst pretty impressive on its own, you want some user interaction, to ask the user as to how many places Pi should be calculated.

STEP 6 You can insert an input line before the Pi calculation Def command. It needs to be an integer, as it will otherwise default to a string. We can call it numberofdigits and use the getcontext function:

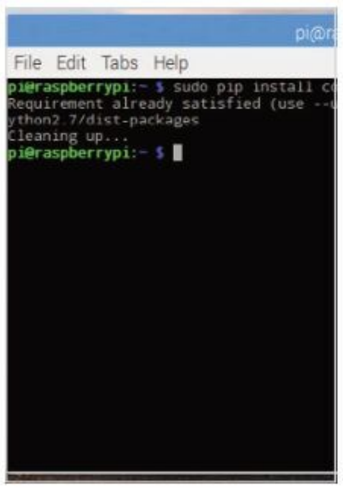
```
numberofdigits = int(input("please enter the
number of decimal place to calculate Pi to: "))
getcontext().prec = numberofdigits
```



STEP 7 You can execute the code now and it asks the user how many decimal places they want to calculate Pi to, outputting the result in the IDLE Shell. Try it with 1000 places but don't go too high or else your computer will be locked up in calculating Pi.

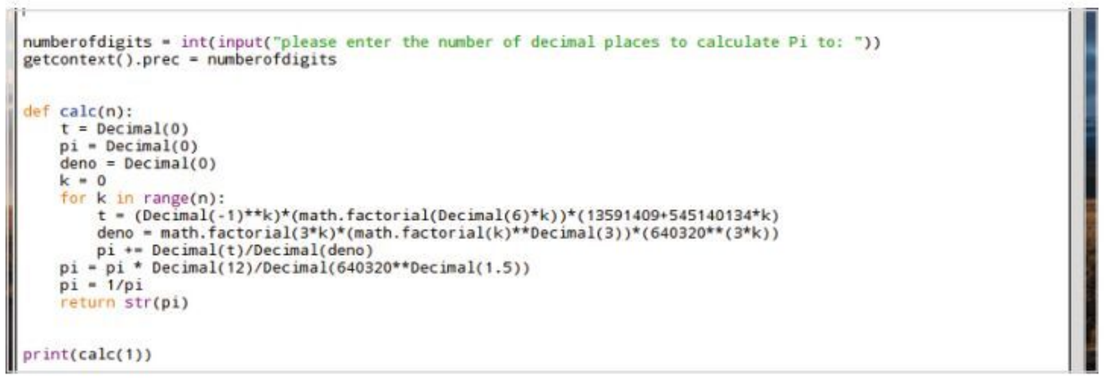
STEP 8 Part of programming is being able to modify code, making it more presentable. Let's include an element that times how long it takes our computer to calculate the Pi decimal places and present the information in a different colour. For this, drop into the command line and import the Colorama module (RPi users already have it installed):

```
pip install colorama
```



STEP 9 Now we need to import the Colorama module (which will output text in different colours) along with the Fore function (which dictates the foreground, ink, colour) and the Time module to start a virtual stopwatch to see how long our calculations take:

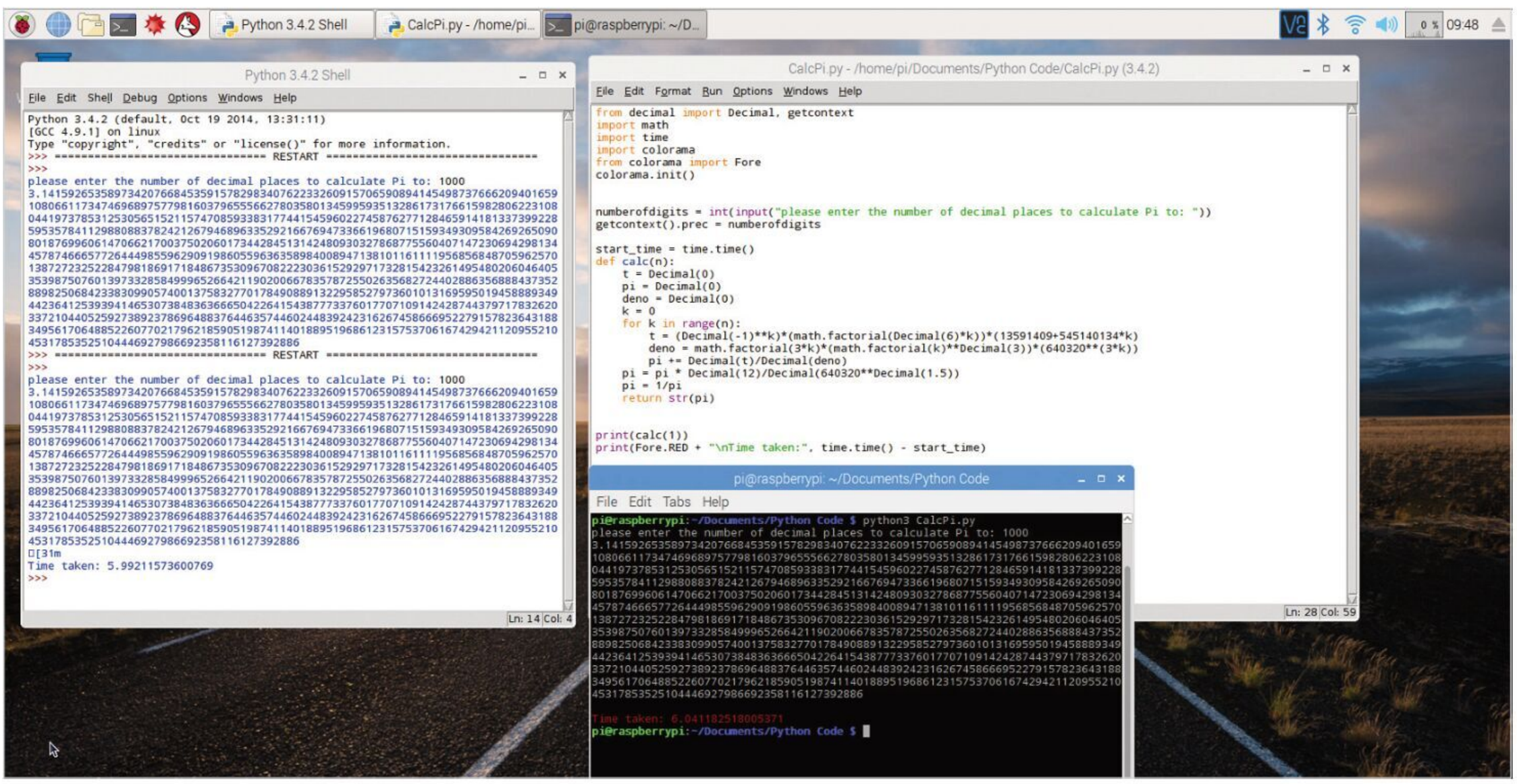
```
import time
import colorama
from colorama import Fore
```



```
numberofdigits = int(input("please enter the number of decimal places to calculate Pi to: "))
getcontext().prec = numberofdigits


def calc(n):
    t = Decimal(0)
    pi = Decimal(0)
    deno = Decimal(0)
    k = 0
    for k in range(n):
        t = (Decimal(-1)**k)*(math.factorial(Decimal(6)*k))*(13591409+545140134*k)
        deno = math.factorial(3*k)*(math.factorial(k)**Decimal(3))*(640320**(3*k))
        pi += Decimal(t)/Decimal(deno)
    pi = pi * Decimal(12)/Decimal(640320**Decimal(1.5))
    pi = 1/pi
    return str(pi)


print(calc(1))
```

STEP 10 To finish our code, we need to initialise the Colorama module and start the time function at the point where the calculation starts, and when it finishes. The end result is a coloured ink displaying how long the process took (in the Terminal or command line):

```
from decimal import Decimal, getcontext
import math
import time
import colorama
from colorama import Fore
colorama.init()

numberofdigits = int(input("please enter the number
of decimal places to calculate Pi to: "))
getcontext().prec = numberofdigits

start_time = time.time()
def calc(n):
    t = Decimal(0)
    pi = Decimal(0)
    deno = Decimal(0)
    k = 0
    for k in range(n):
        t = (Decimal(-1)**k)*(math.
factorial(Decimal(6)*k))*(13591409+545140134*k)
        deno = math.factorial(3*k)*(math.
factorial(k)**Decimal(3))*(640320**(3*k))
        pi += Decimal(t)/Decimal(deno)
    pi = pi * Decimal(12)/
Decimal(640320**Decimal(1.5))
    pi = 1/pi
    return str(pi)

print(calc(1))
print(Fore.RED + "\nTime taken:", time.time() -
start_time)
```



Python in Focus: Stitching Black Holes

One of the biggest scientific, engineering and space-based projects came to a head in 2019, revealing humanity's first glimpse at the universe's most elusive object: a black hole. But what's that got to do with Python?

Imaging a black hole is pretty difficult. The very nature of a black hole means that nothing can escape its immense gravitational field, even light itself. To quote the Wikipedia entry for a black hole:

"A black hole is a region of spacetime exhibiting gravitational acceleration so strong that nothing—no particles or even electromagnetic radiation such as light—can escape from it. The theory of general relativity predicts that a sufficiently compact mass can deform spacetime to form a black hole. The boundary of the region from which no escape is possible is called the event horizon. Although the event horizon has an enormous effect on the fate and circumstances of an object crossing it, no locally detectable features appear to be observed. In many ways, a black hole acts like an ideal black body, as it reflects no light. Moreover, quantum field theory in curved spacetime predicts that event horizons emit Hawking radiation, with the same spectrum as a black body of a temperature inversely proportional to its mass. This temperature is on the order of billionths of a kelvin for black holes of stellar mass, making it essentially impossible to observe."

Not that long ago a black hole was just a collection of theories and mathematics written down on paper, speculated only by the brightest minds of our time. However, as with most things scientific, our understanding of the universe and our abilities to read it have greatly improved and, with the culmination of years of hard work by a collaboration of observatories, scientists and engineers, we got our first image of a black hole.

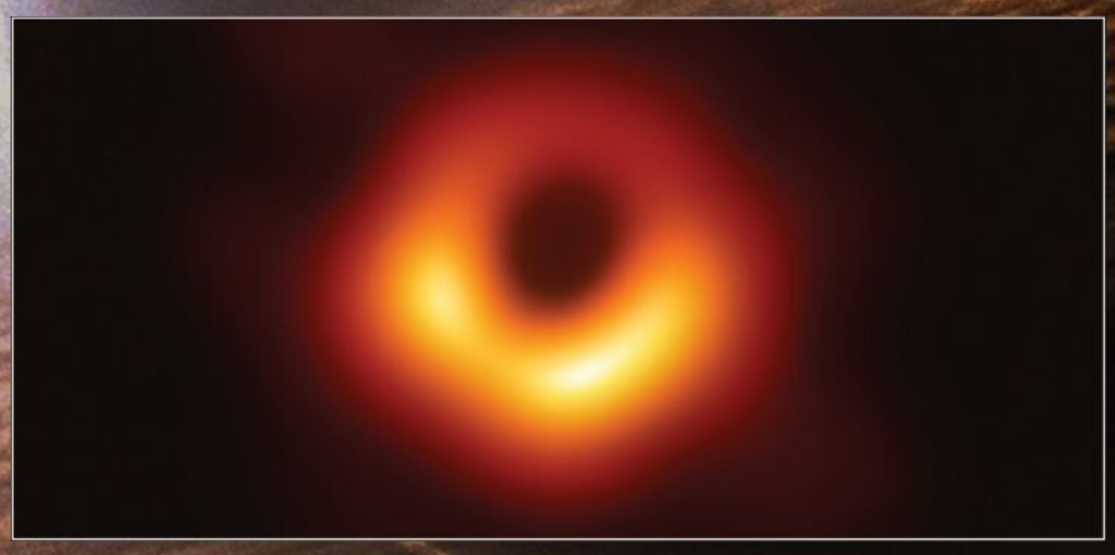
EVENT HORIZON TELESCOPE

One of the problems regarding the imaging of such an object is angular resolution. In Astronomy, the size of the objects in the night sky is referred to by the amount of the sky they take up - units of arc. An arc, or arc second, is a measurement (1/3600 of a degree) that describes the size of an angle in degrees, designated by the symbol °. A full circle is divided into 360° and a right-angle measures 90°. One degree can be divided into 60 arcminutes (abbreviated 60 arcmin or 60'). An arcminute can also be divided into 60 arcseconds (abbreviated 60 arcsec or 60").

For example, looking at the moon, which is roughly 31 arcminutes, imagine drawing a line from you to one side of the moon and another to the opposite side of the moon, the angle between the two lines is the angular size, or angular resolution.

The black hole at the centre of the Messier 87 galaxy, the one that was imaged, is 55 million light years from Earth and has an angular size of 40 microarc seconds, or one millionth of an arcsecond. So, in order to see it, we would need a telescope with a diameter of around 8Km, which simply isn't possible as a single unit.

This is where the Event Horizon Telescope project comes into play. Using a network of eight radio telescopes, scientists were able to take images of the black hole over a period of around six months. Critically timed, using atomic clocks, the telescopes imaged the area of sky containing the black hole and collected the data, swapping from one telescope array to the next as the Earth rotated.



BIG DATA AND PYTHON

This data was then collated across all the telescope arrays to the tune of over a thousand hard drives, which came to an astonishing 5 Petabytes of raw data. The problem now was collating all that data into a workable form and presenting it as an image.

Katie Bouman, a Ph.D. in electrical engineering and computer science from MIT, was pivotal in creating the Python code that was able to stitch all that data together and form the eventual, historic image of a black hole.

Bouman used a number of Python libraries to achieve the result, Numpy, Scipy, Pandas, Jupyter, Matplotlib and Astropy, plus some unique custom Python code – which can be found on Github at **https://github.com/achael/eht-imaging**.

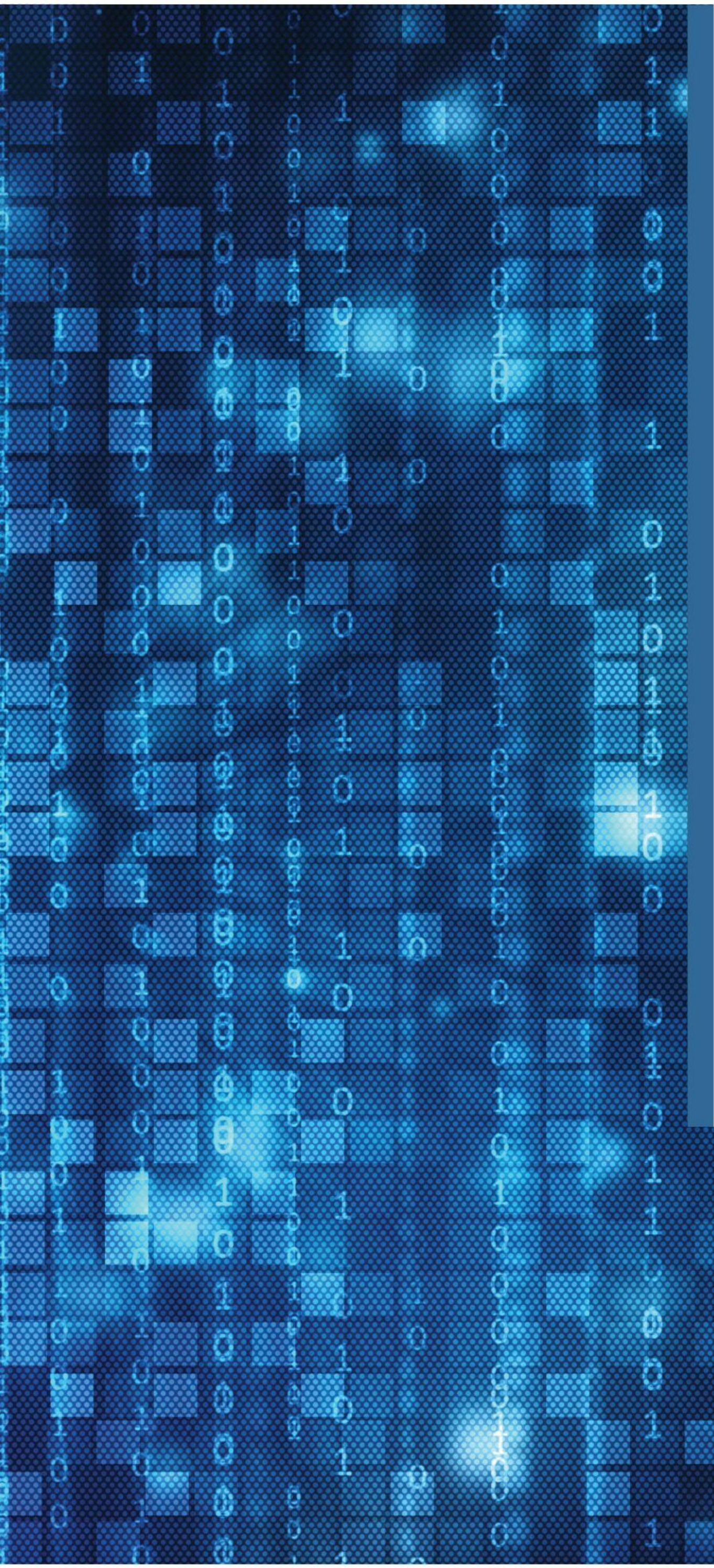
RESULTS

The end result is, of course, the image of the black hole at the centre of the M87 galaxy that's surrounded by a ring of burning gasses. The resolution isn't great, as the team have since admitted, but, as they also state, give it a couple of years and they'll be able to increase the image resolution significantly.

All this is thanks to some clever Python code and some very brilliant scientists and engineers.

```
from os import path, makedirs


# set as true if you want to use a model image, false will load the specified image
makeModel = True
# path to a sample image
sampleimage = '../models/rowan_m87.txt'

# path to array file for loading SEFDs and site locations
array = '../arrays/EHT2017_m87.txt'

# parameters for model image
npix = 128
fov = 200*eh.RADPERUAS
source = 'M87'
ra = 19.414182210498385
dec = -29.241703223636311
zbl = 0.8
rf = 230000000000.0
mjd = 57854

ring_radius = 22*eh.RADPERUAS # the radius of the ring
ring_width = 10*eh.RADPERUAS # the width of the ring
nonun_frac = 0.5 # defines how much brighter the brighter location is on the ring
theta_nonun_rad = 270 # defines the angle of the brightest location
fracpol = 0.4 # fractional polarization on model image
corr = 5 * eh.RADPERUAS # the coherence length of the polarization

# parameters for simulated data
add_th_noise = True # if there are no sefds in obs_orig it will use the sigma for each data point
phasecal = False # if False then add random phases to simulate atmosphere
ampcal = False # if False then add random gain errors
stabilize_scan_phase = True # if true then add a single phase error for each scan to act similar to adhoc phasing
stabilize_scan_amp = True # if true then add a single gain error at each scan
jones = True # apply jones matrix for including noise in the measurements (including leakage)
inv_jones = False # do not invert the jones matrix
frcal = True # True if you do not include effects of field rotation
```

Working with Data



Data is everything; it can topple governments, change election results, and tell us the secrets of the universe. Over these coming pages we look at how you can create lists, tuples, dictionaries and multi-dimensional lists, and then how you can use them to forge exciting and useful programs.

In addition, you will learn how you can use the date and time functions, write to files to your system and even create graphical user interfaces that will take your coding skills to new levels and into new project ideas.

64 Lists
66 Tuples
68 Dictionaries
70 Splitting and Joining Strings
72 Formatting Strings
74 Date and Time
76 Opening Files
78 Writing to Files
80 Exceptions
82 Python Graphics
84 Combining What You Know So Far
86 Python in Focus: Gaming

Lists

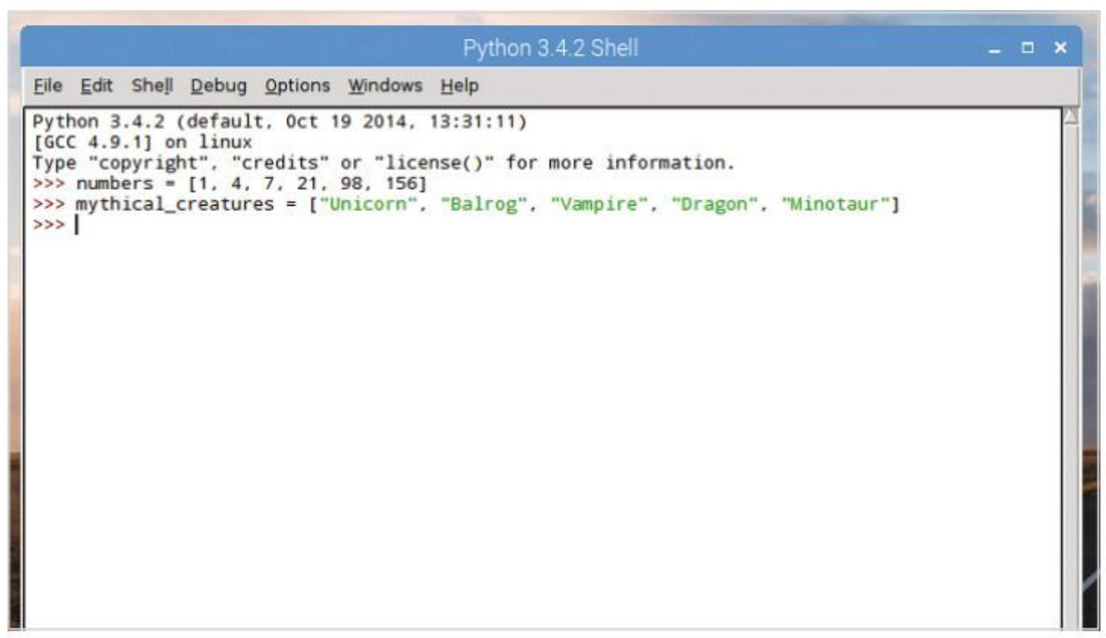
Lists are one of the most common types of data structures you will come across in Python. A list is simply a collection of items, or data if you prefer, that can be accessed as a whole, or individually if wanted.

WORKING WITH LISTS

Lists are extremely handy in Python. A list can be strings, integers and also variables. You can even include functions in lists, and lists within lists.

STEP 1 A list is a sequence of data values called items. You create the name of your list followed by an equals sign, then square brackets and the items separated by commas; note that strings use quotes:

```
numbers = [1, 4, 7, 21, 98, 156]
mythical_creatures - ["Unicorn", "Balrog",
"Vampire", "Dragon", "Minotaur"]
```



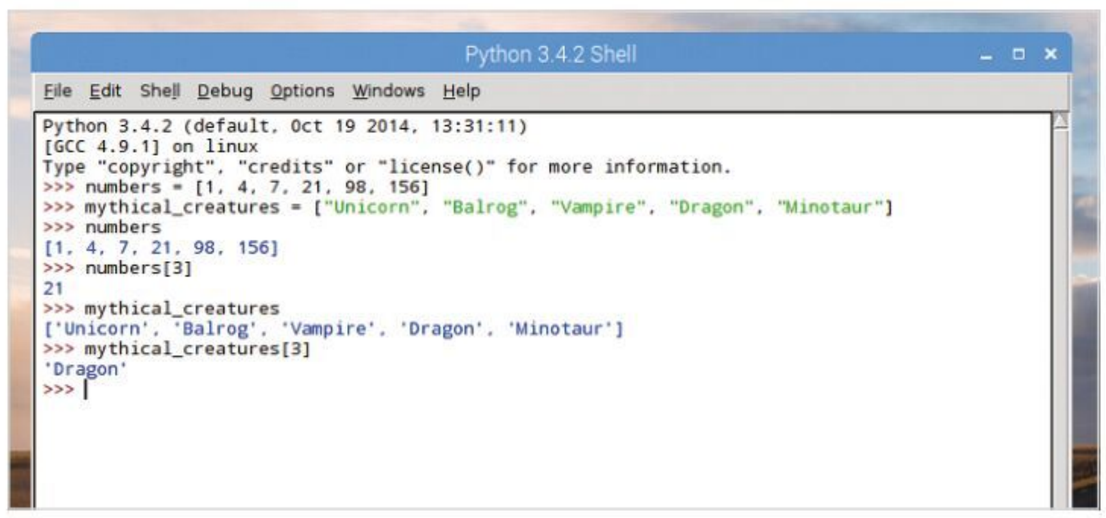
STEP 2 Once you've defined your list you can call each by referencing its name, followed by a number. Lists start the first item entry as 0, followed by 1, 2, 3 and so on. For example:

```
numbers
```

To call up the entire contents of the list.

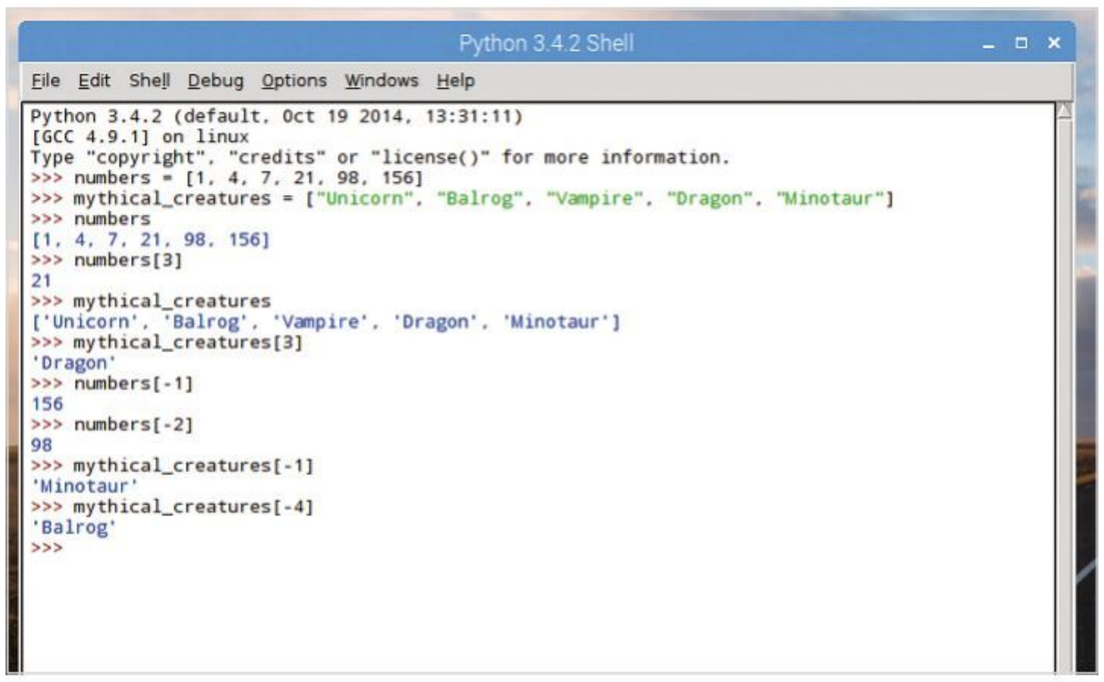
```
numbers[3]
```

To call the third from zero item in the list (21 in this case).



STEP 3 You can also access, or index, the last item in a list by using the minus sign before the item number [-1], or the second to last item with [-2] and so on. Trying to reference an item that isn't in the list, such as [10] will return an error:

```
numbers[-1]
mythical_creatures[-4]
```



STEP 4 Slicing is similar to indexing but you can retrieve multiple items in a list by separating item numbers with a colon. For example:

```
numbers[1:3]
```

Will output the 4 and 7, being item numbers 1 and 2. Note that the returned values don't include the second index position (as you would numbers[1:3] to return 4, 7 and 21).

STEP 5 You can update items within an existing list, remove items and even join lists together. For example, to join two lists you can use:

```
everything = numbers + mythical_creatures
```

Then view the combined list with:

```
everything
```

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> numbers = [1, 4, 7, 21, 98, 156]
>>> mythical_creatures = ["Unicorn", "Balrog", "Vampire", "Dragon", "Minotaur"]
>>> everything = numbers + mythical_creatures
>>> everything
[1, 4, 7, 21, 98, 156, 'Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur']
>>>
```

STEP 6 Items can be added to a list by entering:

```
numbers=numbers+[201]
```

Or for strings:

```
mythical_creatres=mythical_creatures+["Griffin"]
```

Or by using the append function:

```
mythical_creatures.append("Nessie")
numbers.append(278)
```

```
>>> numbers = [1, 4, 7, 21, 98, 156]
>>> mythical_creatures = ["Unicorn", "Balrog", "Vampire", "Dragon", "Minotaur"]
>>> numbers
[1, 4, 7, 21, 98, 156]
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur']
>>> numbers=numbers+[201]
>>> numbers
[1, 4, 7, 21, 98, 156, 201]
>>> mythical_creatures=mythical_creatures+["Griffin"]
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur', 'Griffin']
>>> mythical_creatures.append("Nessie")
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur', 'Griffin', 'Nessie']
>>> numbers.append(278)
>>> numbers
[1, 4, 7, 21, 98, 156, 201, 278]
>>>
```

STEP 7 Removal of items can be done in two ways. The first is by the item number:

```
del numbers[7]
```

Alternatively, by item name:

```
mythical_creatures.remove("Nessie")
```

```
>>> mythical_creatures = ["Unicorn", "Balrog", "Vampire", "Dragon", "Minotaur"]
>>> numbers
[1, 4, 7, 21, 98, 156]
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur']
>>> numbers=numbers+[201]
>>> numbers
[1, 4, 7, 21, 98, 156, 201]
>>> mythical_creatures=mythical_creatures+["Griffin"]
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur', 'Griffin']
>>> mythical_creatures.append("Nessie")
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur', 'Griffin', 'Nessie']
>>> numbers.append(278)
>>> numbers
[1, 4, 7, 21, 98, 156, 201, 278]
>>> del numbers[7]
>>> numbers
[1, 4, 7, 21, 98, 156, 201]
>>> mythical_creatures.remove("Nessie")
>>> mythical_creatures
['Unicorn', 'Balrog', 'Vampire', 'Dragon', 'Minotaur', 'Griffin']
>>>
```

STEP 8 You can view what can be done with lists by entering dir(list) into the Shell. The output is the available functions, for example, insert and pop are used to add and remove items at certain positions. To insert the number 62 at item index 4:

```
numbers.insert(4, 62)
```

To remove it:

```
numbers.pop(4)
```

```
Type "copyright", "credits" or "license()" for more information.
>>> dir(list)
['__add__', '__class__', '__contains__', '__delattr__', '__delitem__', '__dir__'
, '__doc__', '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__'
, '__gt__', '__hash__', '__iadd__', '__imul__', '__init__', '__iter__', '__le__'
, '__len__', '__lt__', '__mul__', '__ne__', '__new__', '__reduce__', '__reduce_e
x__', '__repr__', '__reversed__', '__rmul__', '__setattr__', '__setitem__', '__s
izeof__', '__str__', '__subclasshook__', 'append', 'clear', 'copy', 'count', 'ex
tend', 'index', 'insert', 'pop', 'remove', 'reverse', 'sort']
>>> numbers = [1, 4, 7, 21, 98, 156]
>>> numbers
[1, 4, 7, 21, 98, 156]
>>> numbers.insert(4, 62)
>>> numbers
[1, 4, 7, 21, 62, 98, 156]
#
>>> numbers.pop(4)
62
>>> numbers
[1, 4, 7, 21, 98, 156]
>>>
```

STEP 9 You also use the list function to break a string down into its components. For example:

```
list("David")
```

Breaks the name David into 'D', 'a', 'v', 'i', 'd'. This can then be passed to a new list:

```
name=list("David Hayward")
name
age=[44]
user = name + age
user
```

```
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> list("David")
['D', 'a', 'v', 'i', 'd']
>>> name=list("David Hayward")
>>> name
['D', 'a', 'v', 'i', 'd', ' ', 'H', 'a', 'y', 'w', 'a', 'r', 'd']
>>> age=[44]
>>> user = name + age
>>> user
['D', 'a', 'v', 'i', 'd', ' ', 'H', 'a', 'y', 'w', 'a', 'r', 'd', 44]
>>>
```

STEP 10 Based on that, you can create a program to store someone's name and age as a list:

```
name=input("What's your name? ")
lname=list(name)
age=int(input("How old are you: "))
lage=[age]

user = lname + lage
```

The combined name and age list is called user, which can be called by entering user into the Shell. Experiment and see what you can do.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> ================================ RESTART ================================
>>>
What's your name? Conan of Cimmeria
How old are you: 44
>>> user
['C', 'o', 'n', 'a', 'n', ' ', 'o', 'f', ' ', 'C', 'i', 'm', 'm', 'e', 'r', 'i',
 'a', 44]
>>>
```

```
namelist.py - /home/pi/Docu
File Edit Format Run Options Windows
name=input("What's your name? ")
lname=list(name)
age=int(input("How old are you: "))
lage=[age]

user = lname + lage
```

Tuples

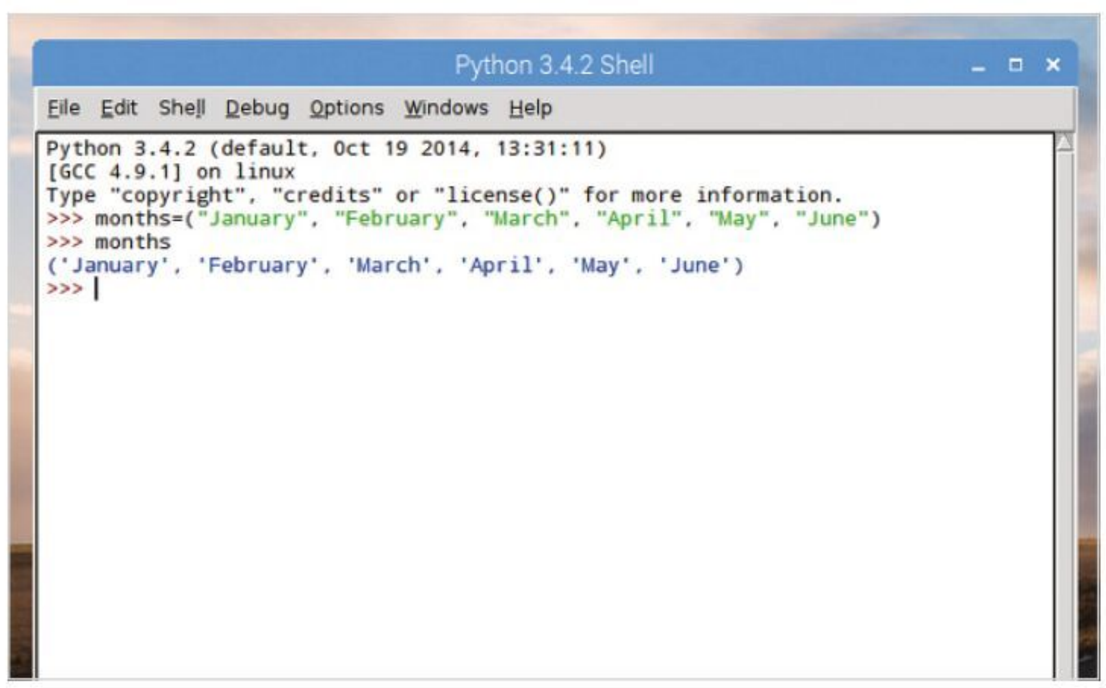
Tuples are very much identical to lists. However, where lists can be updated, deleted or changed in some way, a tuple remains a constant. This is called immutable and they're perfect for storing fixed data items.

THE IMMUTABLE TUPLE

Reasons for having tuples vary depending on what the program is intended to do. Normally, a tuple is reserved for something special but they're also used for example, in an adventure game, where non-playing character names are stored.

STEP 1 A tuple is created the same way as a list but in this instance you use curved brackets instead of square brackets. For example:

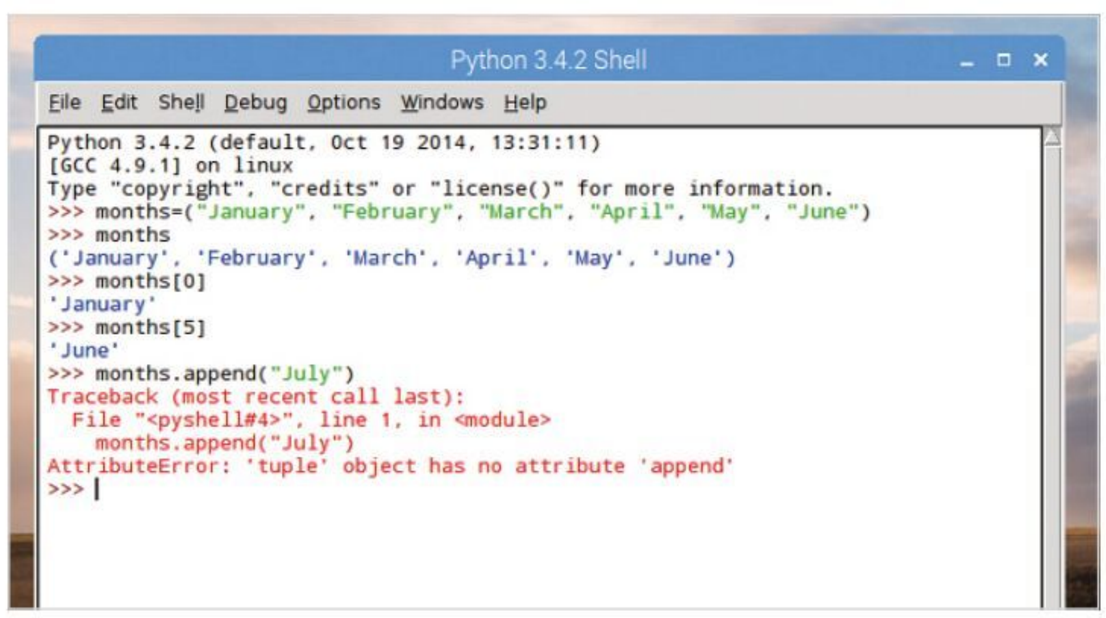
```
months=("January", "February", "March", "April",
"May", "June")
months
```



STEP 2 Just as with lists, the items within a named tuple can be indexed according to their position in the data range, i.e.:

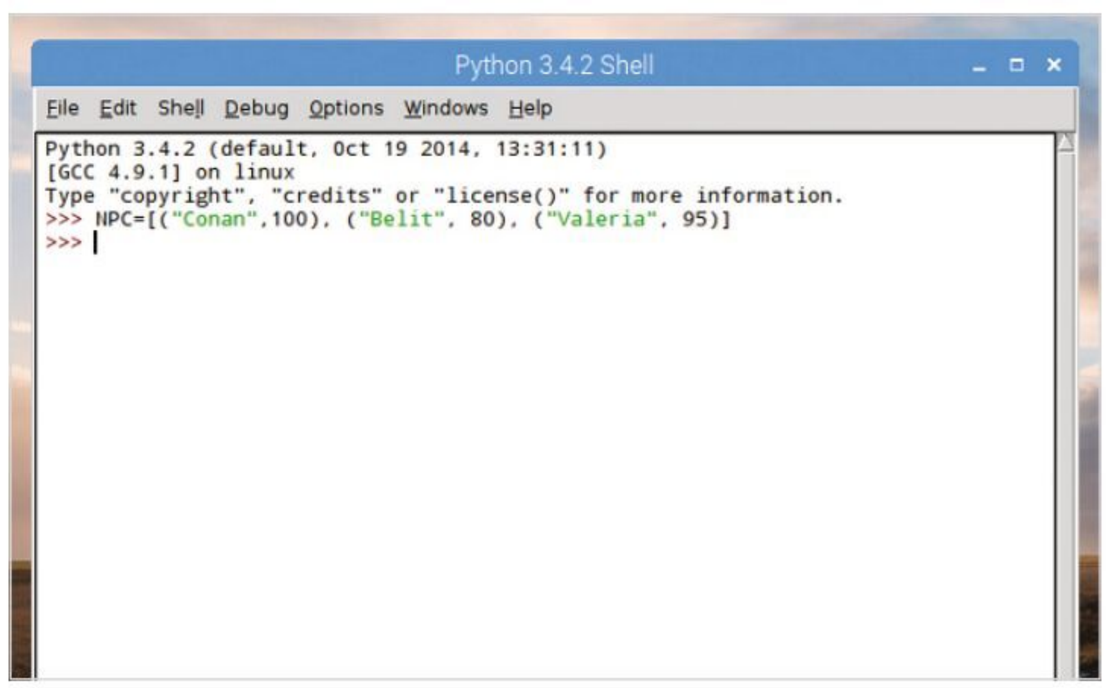
```
months[0]
months[5]
```

However, any attempt at deleting or adding to the tuple will result in an error in the Shell.



STEP 3 You can create grouped tuples into lists that contain multiple sets of data. For instance, here is a tuple called NPC (Non-Playable Characters) containing the character name and their combat rating for an adventure game:

```
NPC=[("Conan", 100), ("Belit", 80), ("Valeria",
95)]
```



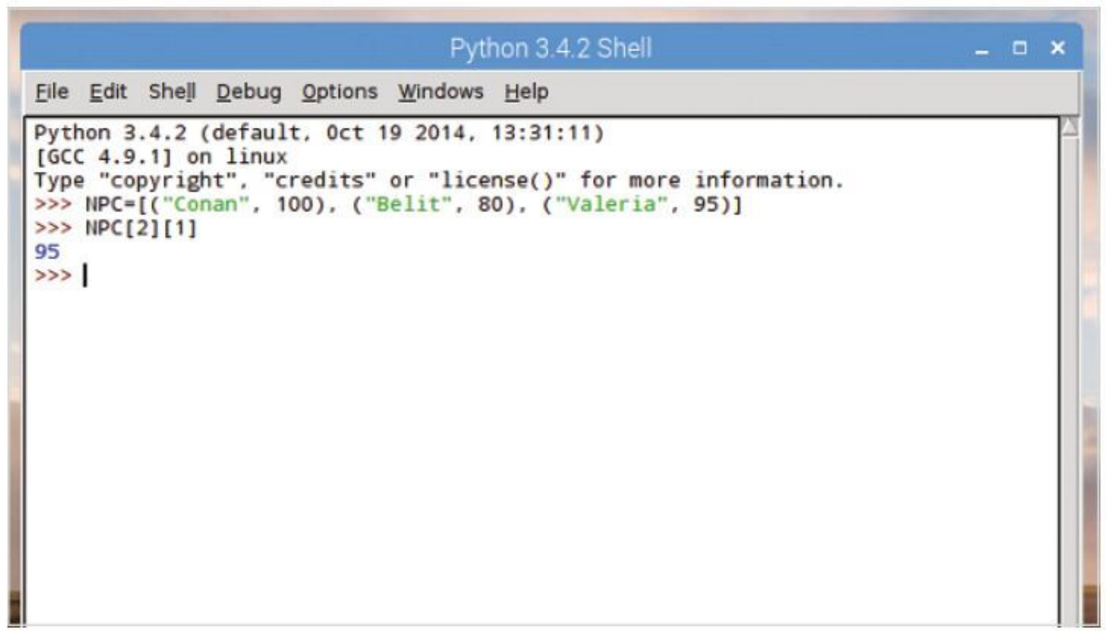
STEP 4 Each of these data items can be accessed as a whole by entering NPC into the Shell; or they can be indexed according to their position NPC[0]. You can also index the individual tuples within the NPC list:

```
NPC[0][1]
```

Will display 100.

STEP 5 It's worth noting that when referencing multiple tuples within a list, the indexing is slightly different from the norm. You would expect the 95 combat rating of the character Valeria to be NPC[4][5], but it's not. It's actually:

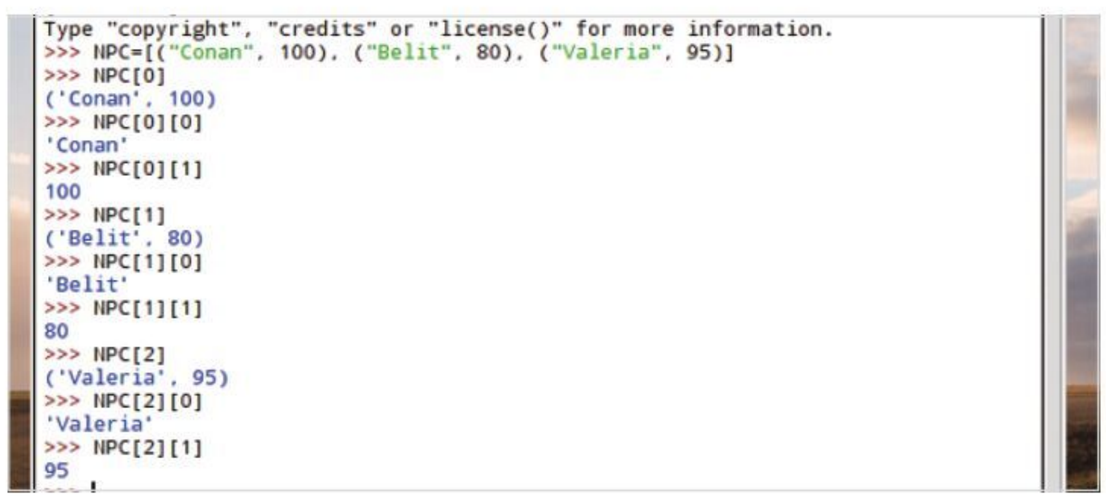
```
NPC[2][1]
```



STEP 6 This means of course that the indexing follows thus:

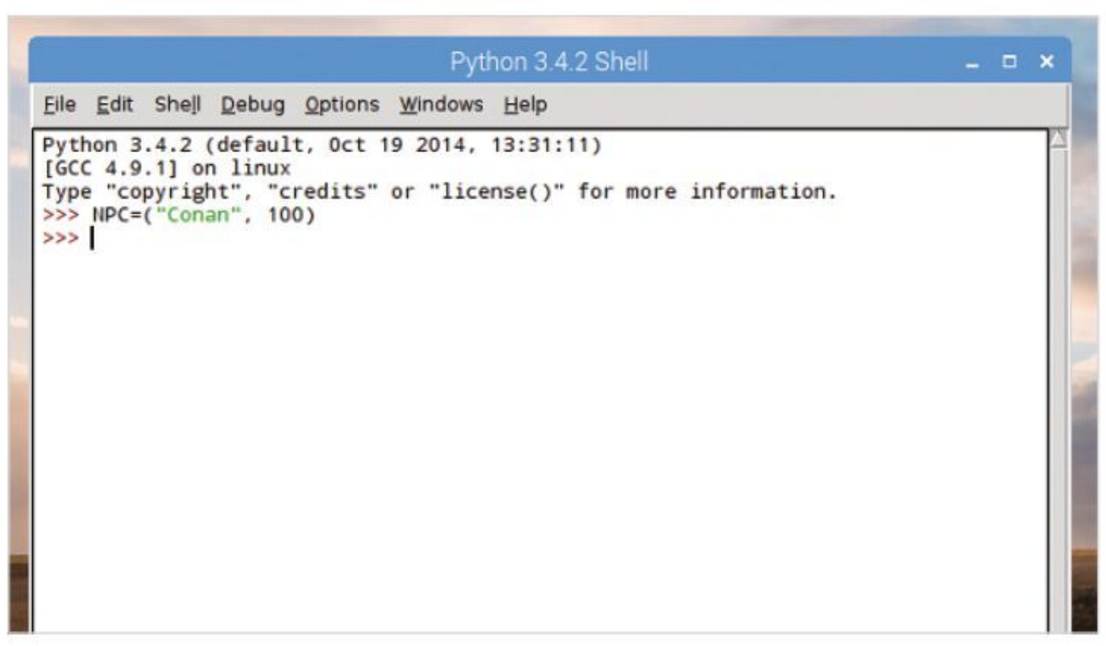
```
0          1, 1
0, 0       2
0, 1       2, 0
1          2,1
1, 0
```

Which as you can imagine, gets a little confusing when you've got a lot of tuple data to deal with.



STEP 7 Tuples though utilise a feature called unpacking, where the data items stored within a tuple are assigned variables. First create the tuple with two items (name and combat rating):

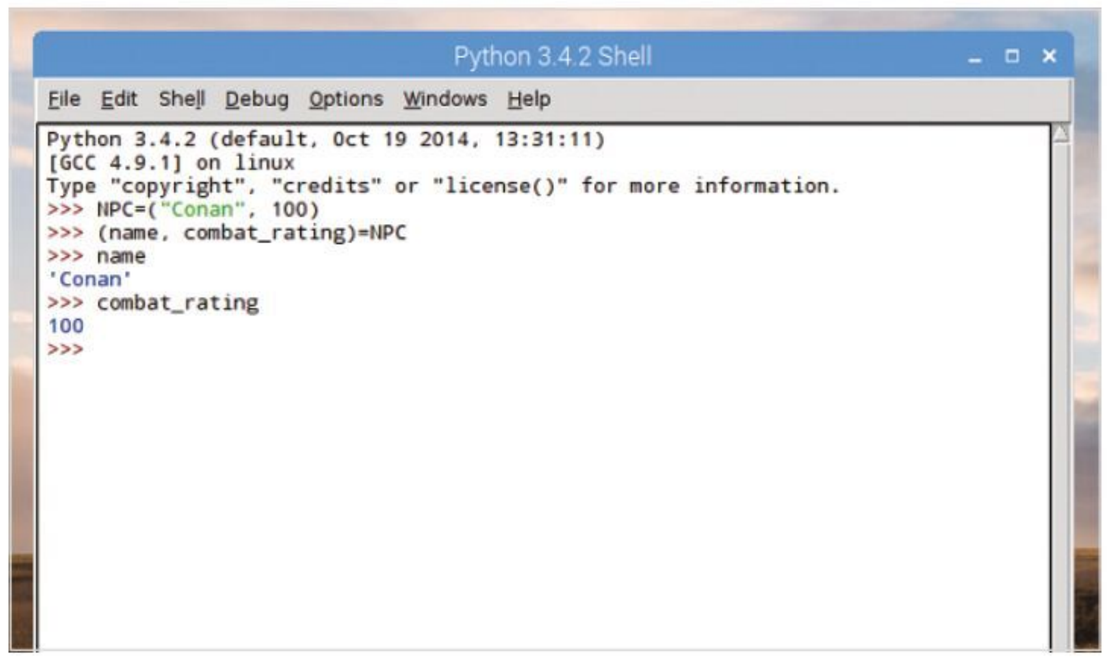
```
NPC=("Conan", 100)
```



STEP 8 Now unpack the tuple into two corresponding variables:

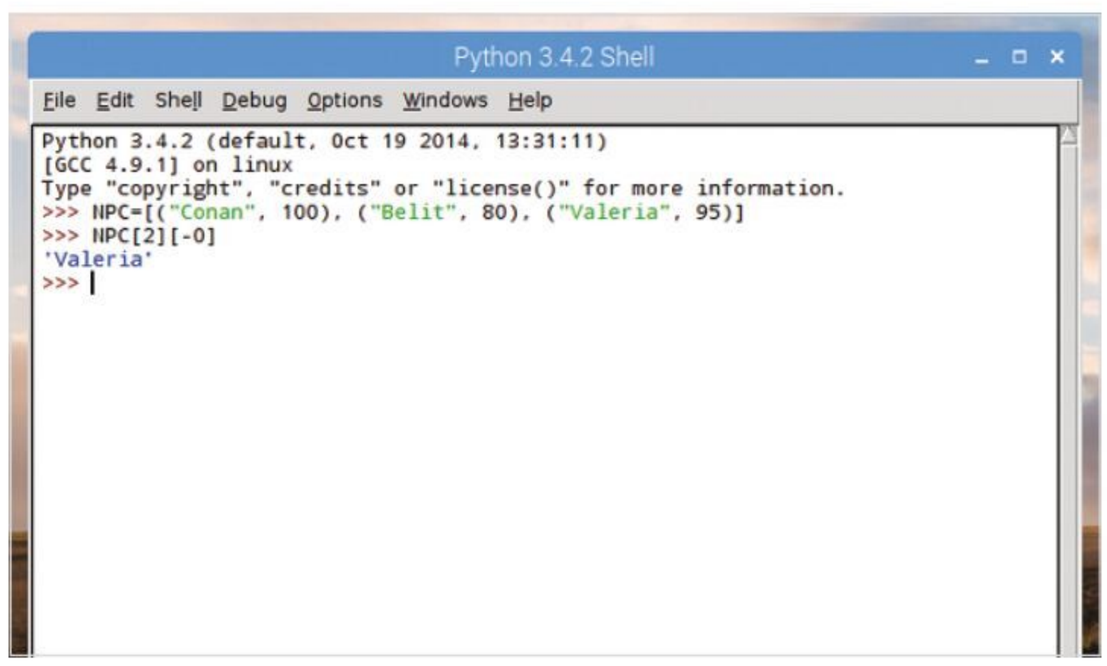
```
(name, combat_rating)=NPC
```

You can now check the values by entering name and combat_rating.



STEP 9 Remember, as with lists, you can also index tuples using negative numbers which count backwards from the end of the data list. For our example, using the tuple with multiple data items, you would reference the Valeria character with:

```
NPC[2][-0]
```

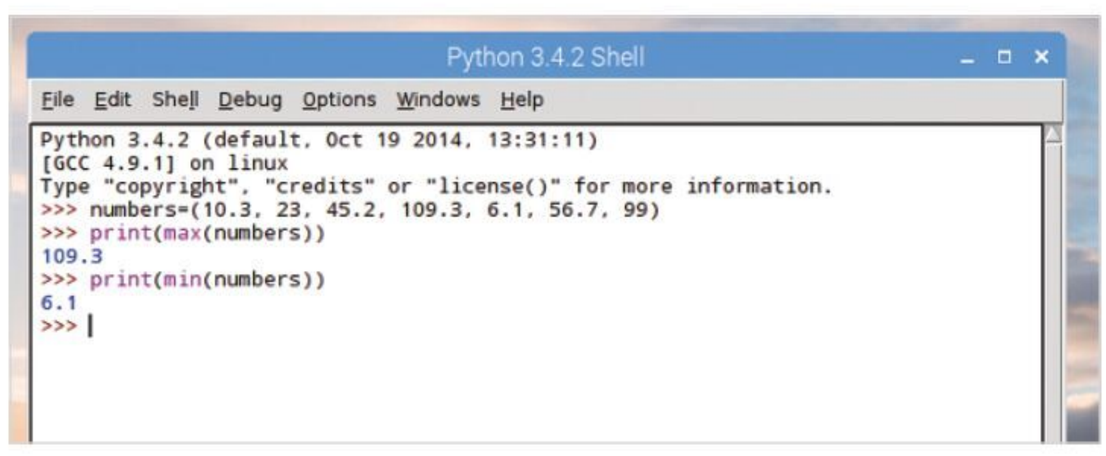


STEP 10 You can use the max and min functions to find the highest and lowest values of a tuple composed of numbers. For example:

```
numbers=(10.3, 23, 45.2, 109.3, 6.1, 56.7, 99)
```

The numbers can be integers and floats. To output the highest and lowest, use:

```
print(max(numbers))
print(min(numbers))
```



Dictionaries

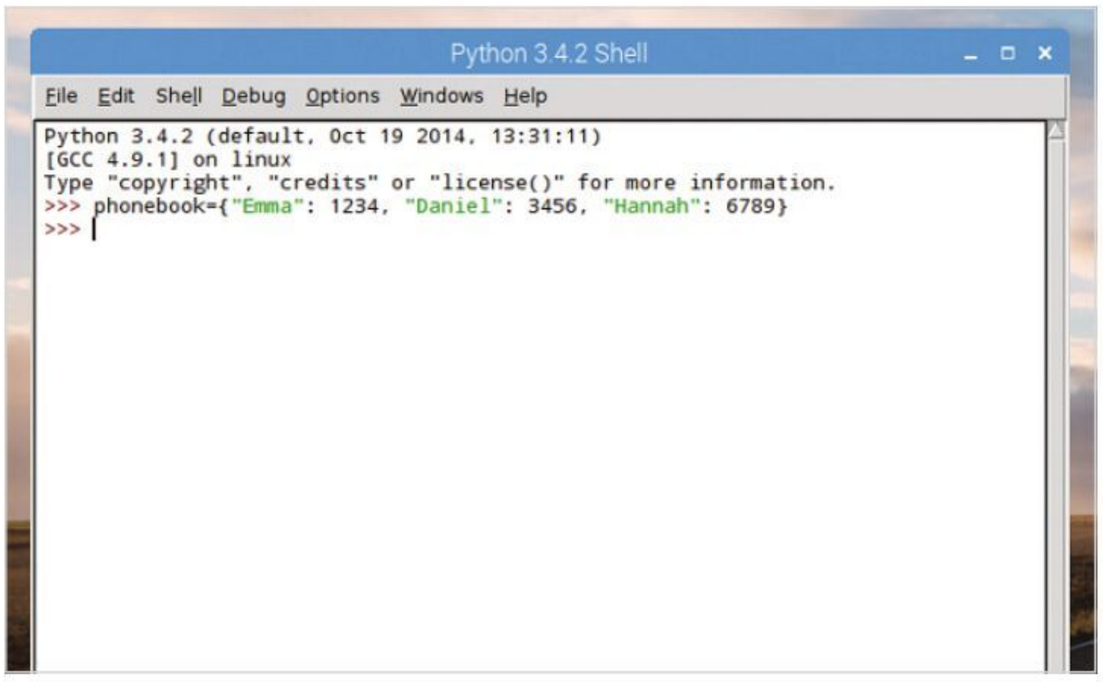
Lists are extremely useful but dictionaries in Python are by far the more technical way of dealing with data items. They can be tricky to get to grips with at first but you'll soon be able to apply them to your own code.

KEY PAIRS

A dictionary is like a list but instead each data item comes as a pair, these are known as Key and Value. The Key part must be unique and can either be a number or string whereas the Value can be any data item you like.

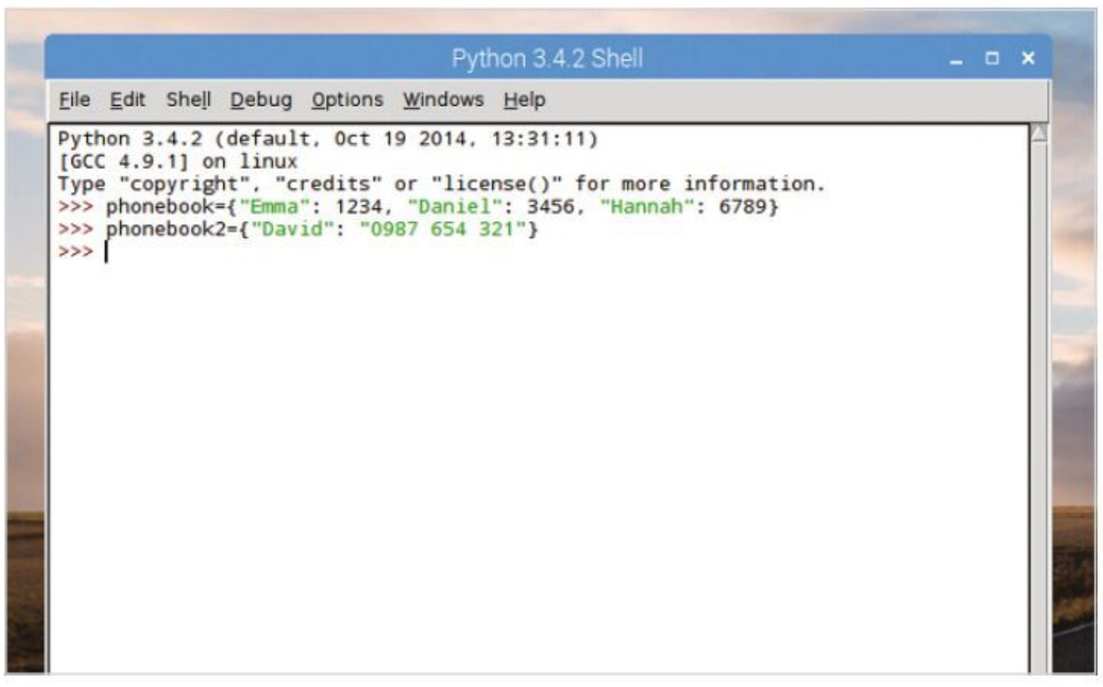
STEP 1 Let's say you want to create a phonebook in Python. You would create the dictionary name and enter the data in curly brackets, separating the key and value by a colon `Key:Value`. For example:

```
phonebook={"Emma": 1234, "Daniel": 3456, "Hannah":
6789}
```

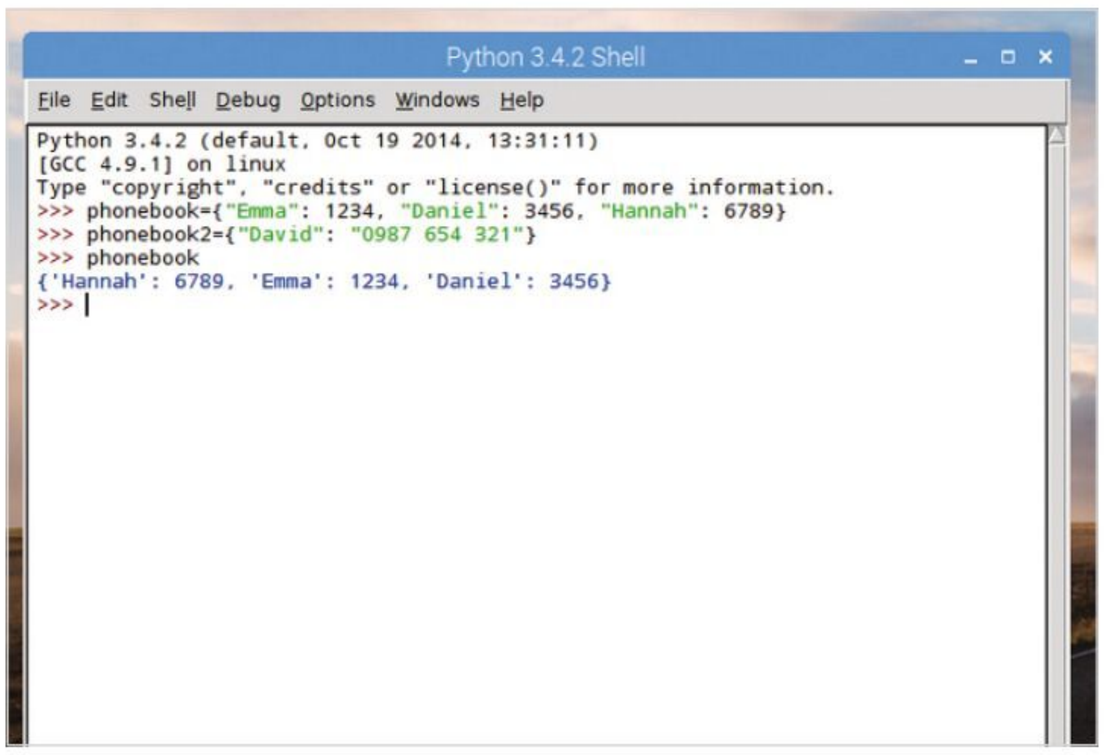


STEP 2 Just as with most lists, tuples and so on, strings need be enclosed in quotes (single or double), whilst integers can be left open. Remember that the value can be either a string or an integer, you just need to enclose the relevant one in quotes:

```
phonebook2={"David": "0987 654 321"}
```

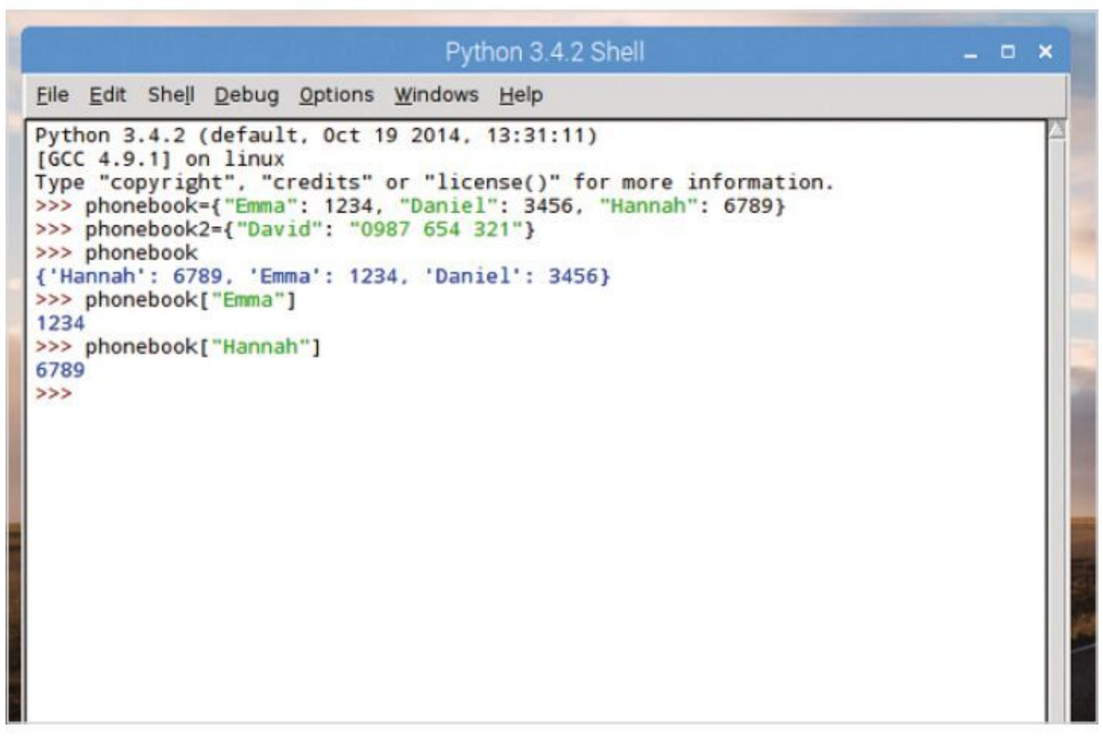


STEP 3 As with lists and tuples, you can check the contents of a dictionary by giving the dictionary a name: phonebook, in this example. This will display the data items you've entered in a similar fashion to a list, which you're no doubt familiar with by now.



STEP 4 The benefit of using a dictionary is that you can enter the key to index the value. Using the phonebook example from the previous steps, you can enter:

```
phonebook["Emma"]
phonebook["Hannah"]
```

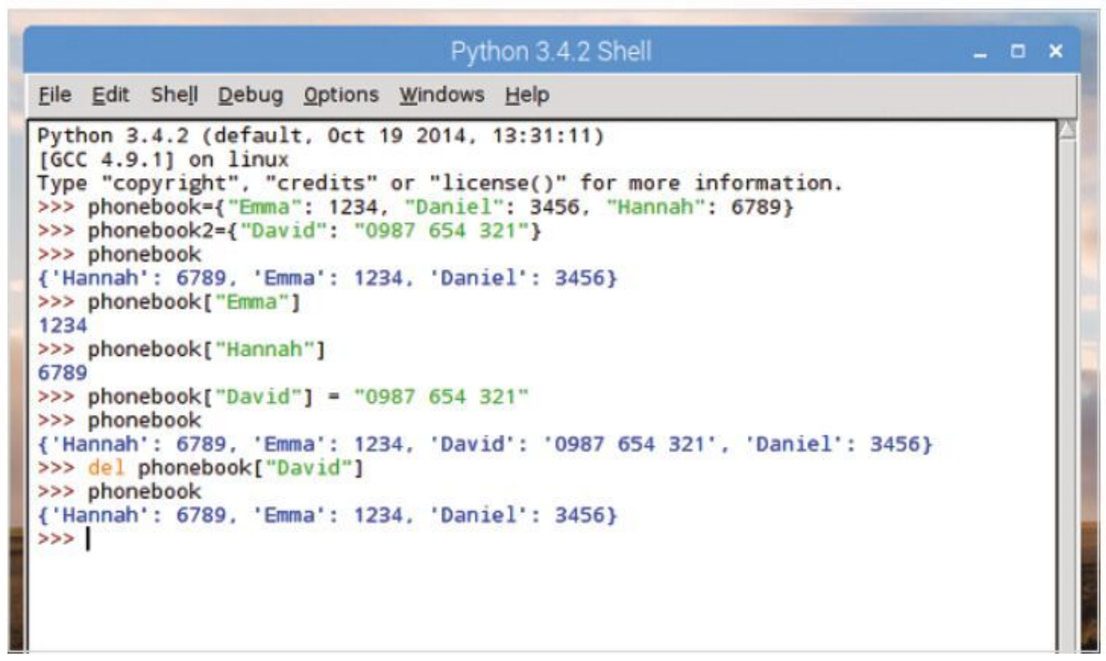


STEP 5 Adding to a dictionary is easy too. You can include a new data item entry by adding the new key and value items like:

```
phonebook["David"] = "0987 654 321"
phonebook
```

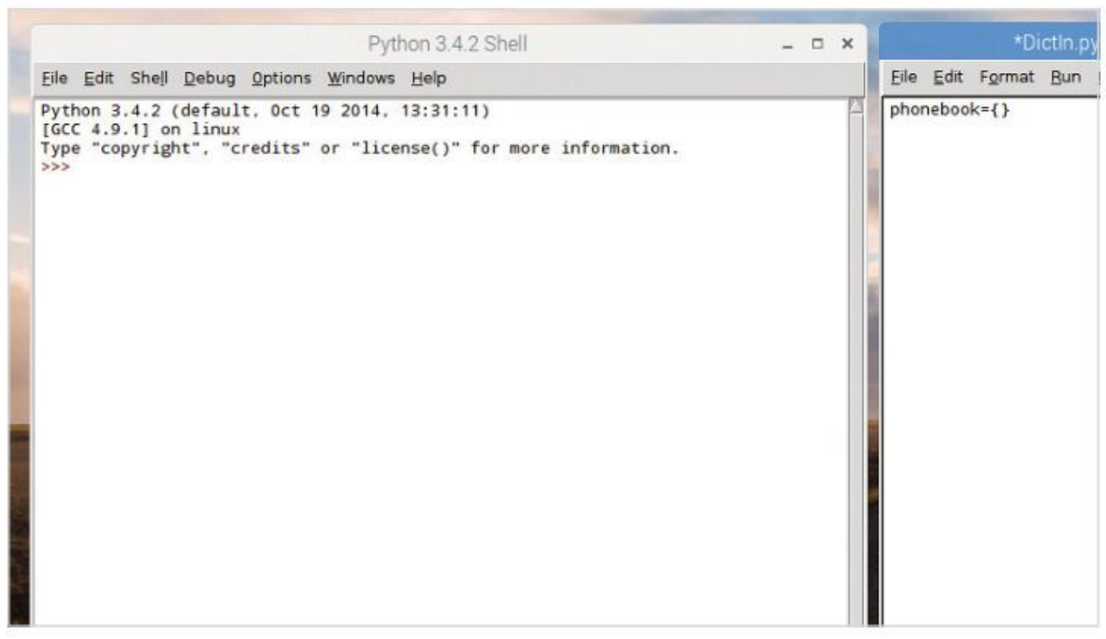
STEP 6 You can also remove items from a dictionary by issuing the del command followed by the item's key; the value will be removed as well, since both work as a pair of data items:

```
del phonebook["David"]
```



STEP 7 Taking this a step further, how about creating a piece of code that will ask the user for the dictionary key and value items? Create a new Editor instance and start by coding in a new, blank dictionary:

```
phonebook={}
```

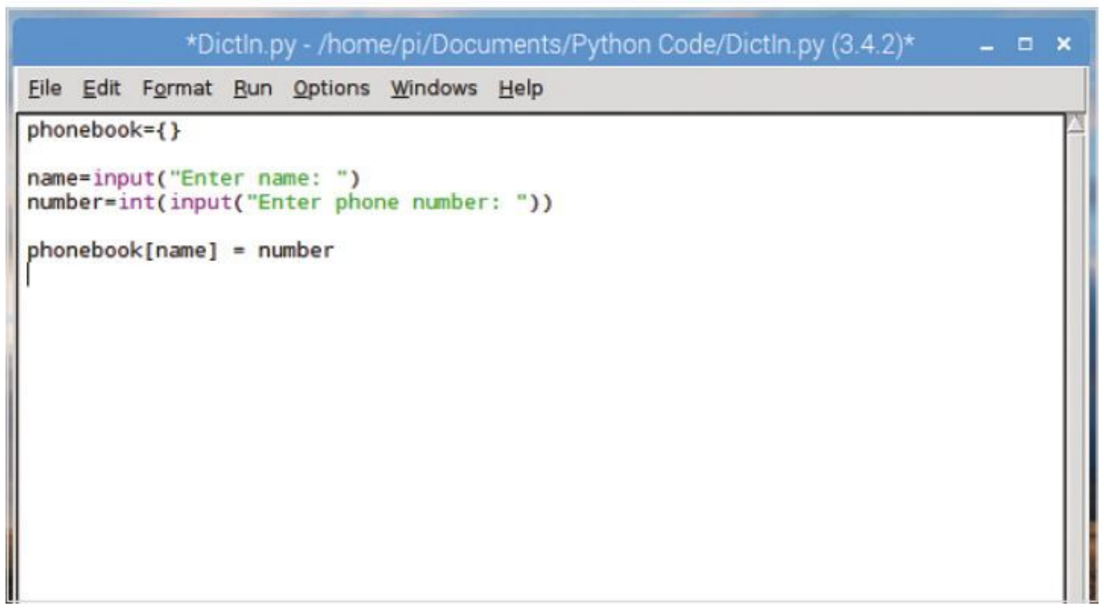


STEP 8 Next, you need to define the user inputs and variables: one for the person's name, the other for their phone number (let's keep it simple to avoid lengthy Python code):

```
name=input("Enter name: ")
number=int(input("Enter phone number: "))
```

STEP 9 Note we've kept the number as an integer instead of a string, even though the value can be both an integer or a string. Now you need to add the user's inputted variables to the newly created blank dictionary. Using the same process as in Step 5, you can enter:

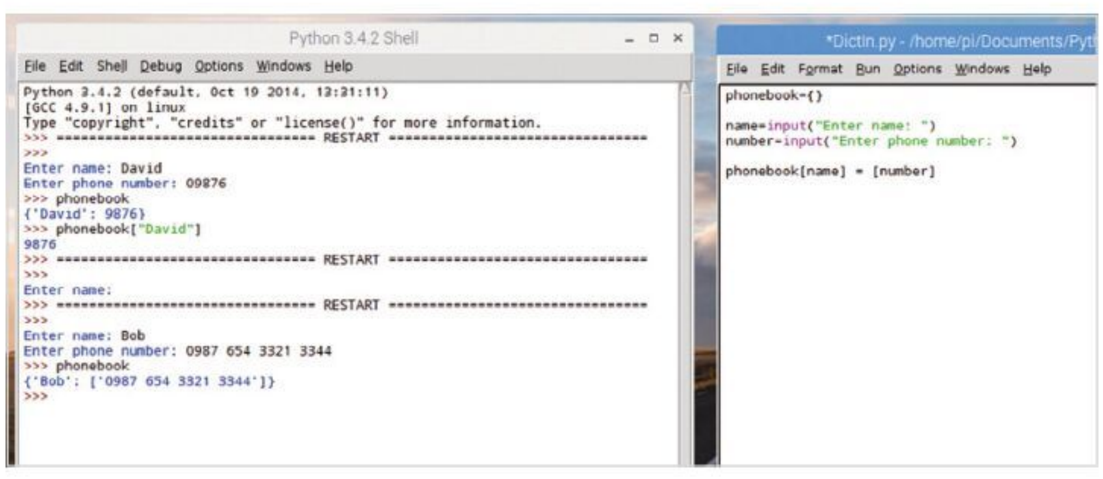
```
phonebook[name] = number
```



STEP 10 Now when you save and execute the code, Python will ask for a name and a number. It will then insert those entries into the phonebook dictionary, which you can test by entering into the Shell:

```
phonebook
phonebook["David"]
```

If the number needs to contain spaces you need to make it a string, so remove the int part of the input.



Splitting and Joining Strings

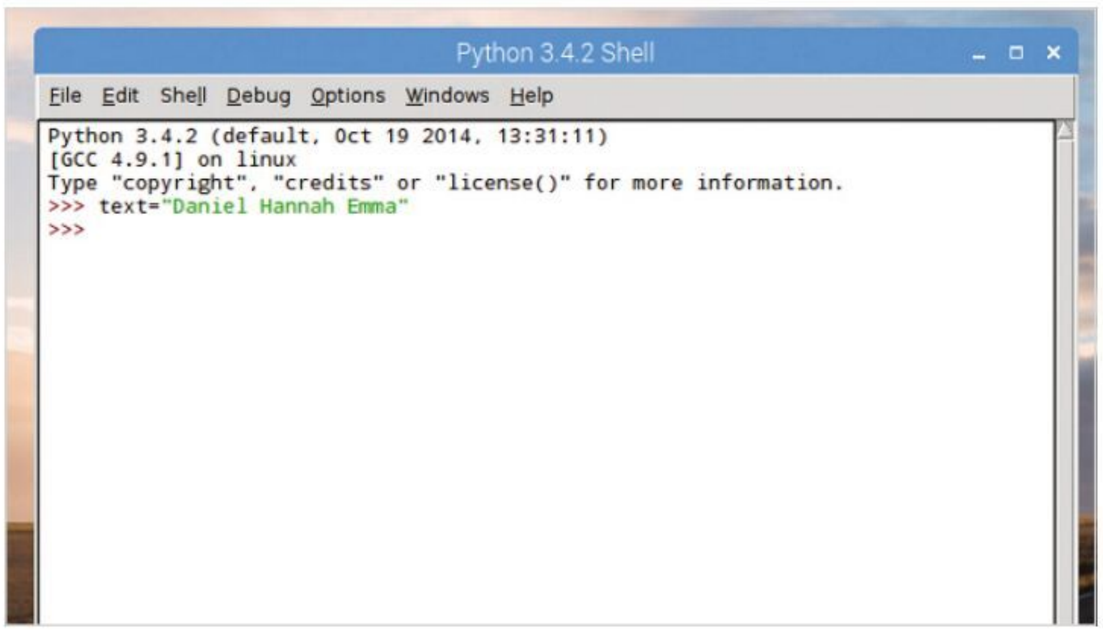
When dealing with data in Python, especially from a user's input, you will undoubtedly come across long sets of strings. A useful skill to learn in Python programming is being able to split those long strings for better readability.

STRING THEORIES

You've already looked at some list functions, using .insert, .remove, and .pop but there are also functions that can be applied to strings.

STEP 1 The main tool in the string function arsenal is .split(). With it you're able to split apart a string of data, based on the argument within the brackets. For example, here's a string with three items, each separated by a space:

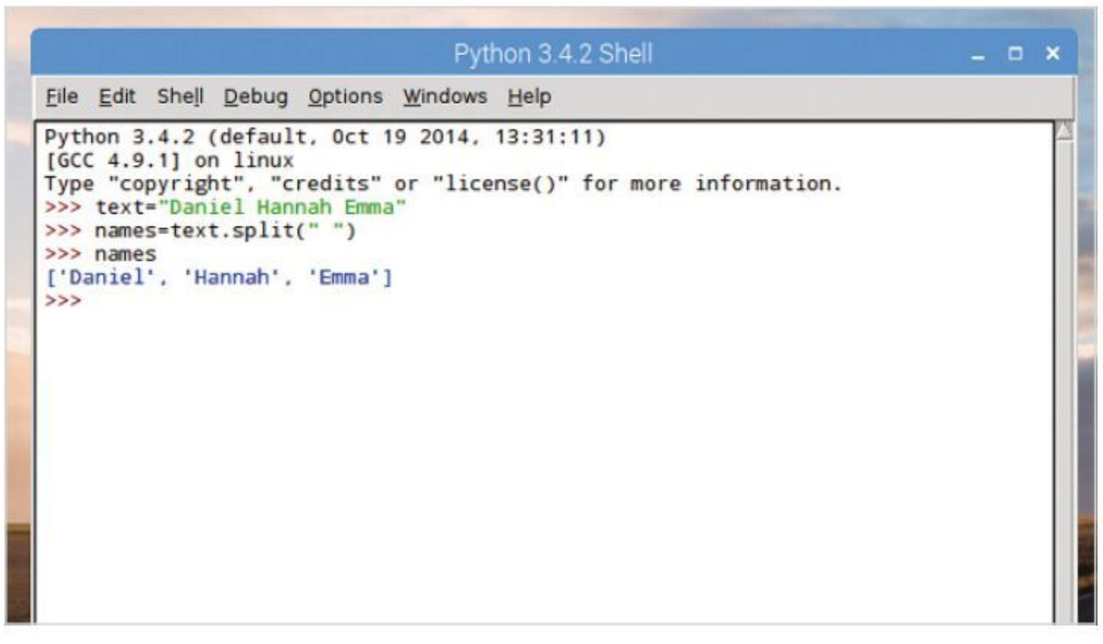
```
text="Daniel Hannah Emma"
```



STEP 2 Now let's turn the string into a list and split the content accordingly:

```
names=text.split(" ")
```

Then enter the name of the new list, names, to see the three items.



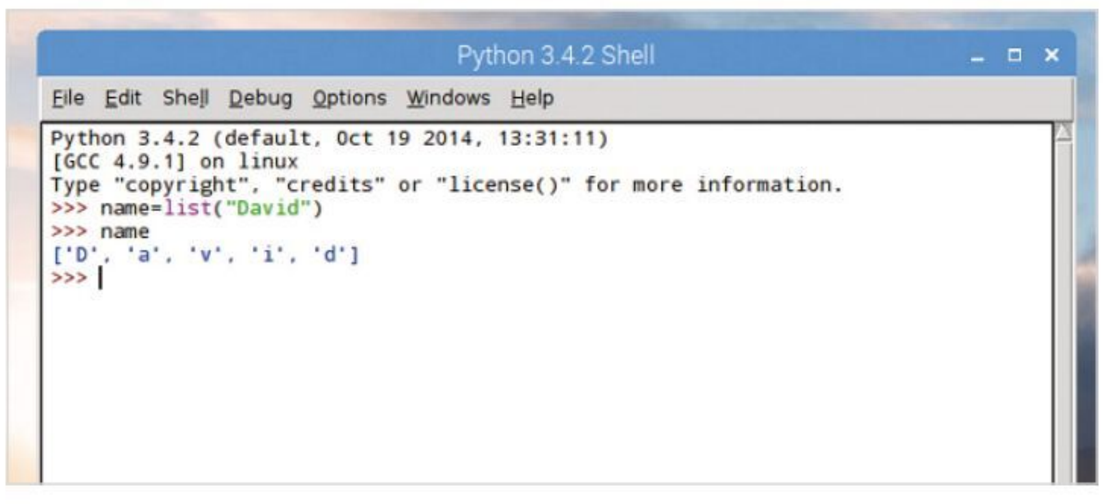
STEP 3 Note that the text.split part has the brackets, quotes, then a space followed by closing quotes and brackets. The space is the separator, indicating that each list item entry is separated by a space. Likewise, CSV (Comma Separated Value) content has a comma, so you'd use:

```
text="January,February,March,April,May,June"
months=text.split(",")
months
```

STEP 4 You've previously seen how you can split a string into individual letters as a list, using a name:

```
name=list("David")
name
```

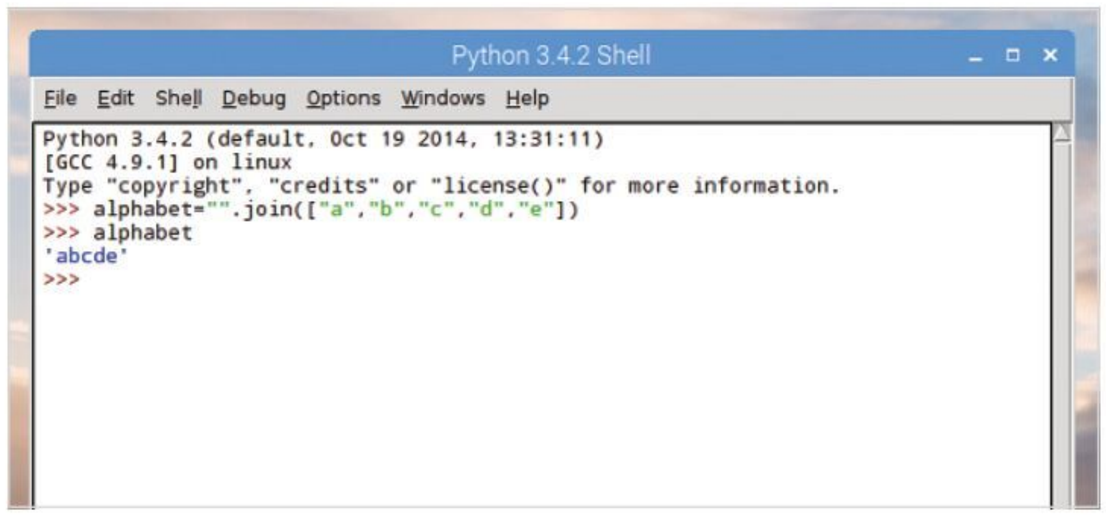
The returned value is 'D', 'a', 'v', 'i', 'd'. Whilst it may seem a little useless under ordinary circumstances, it could be handy for creating a spelling game for example.



STEP 5 The opposite of the .split function is .join, where you will have separate items in a string and can join them all together to form a word or just a combination of items, depending on the program you're writing. For instance:

```
alphabet="".join(["a","b","c","d","e"])
alphabet
```

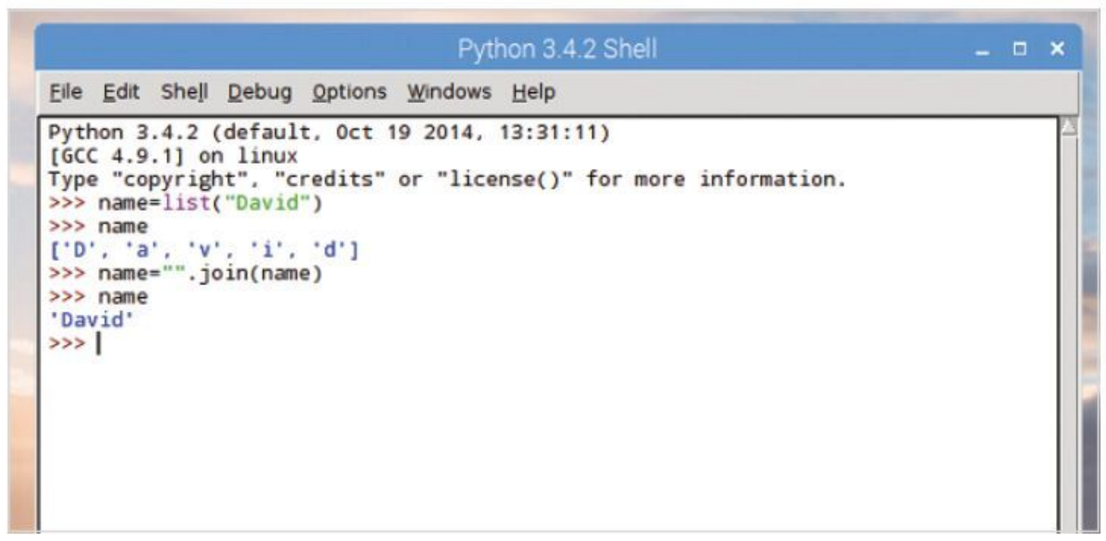
This will display 'abcde' in the Shell.



STEP 6 You can therefore apply .join to the separated name you made in Step 4, combining the letters again to form the name:

```
name="".join(name)
name
```

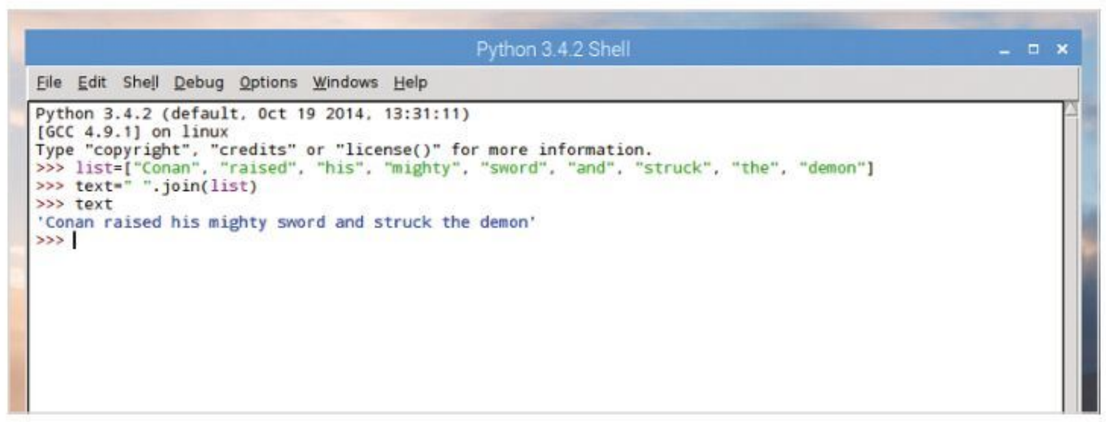
We've joined the string back together, and retained the list called name, passing it through the .join function.



STEP 7 A good example of using the .join function is when you have a list of words you want to combine into a sentence:

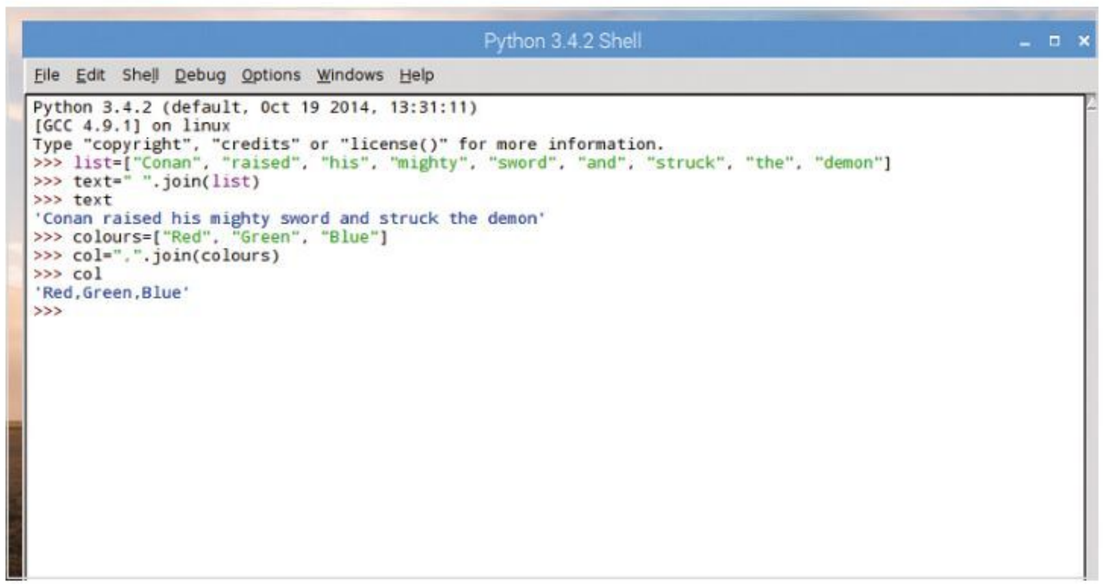
```
list=["Conan", "raised", "his", "mighty", "sword",
"and", "struck", "the", "demon"]
text=" ".join(list)
text
```

Note the space between the quotes before the .join function (where there were no quotes in Step 6's .join).



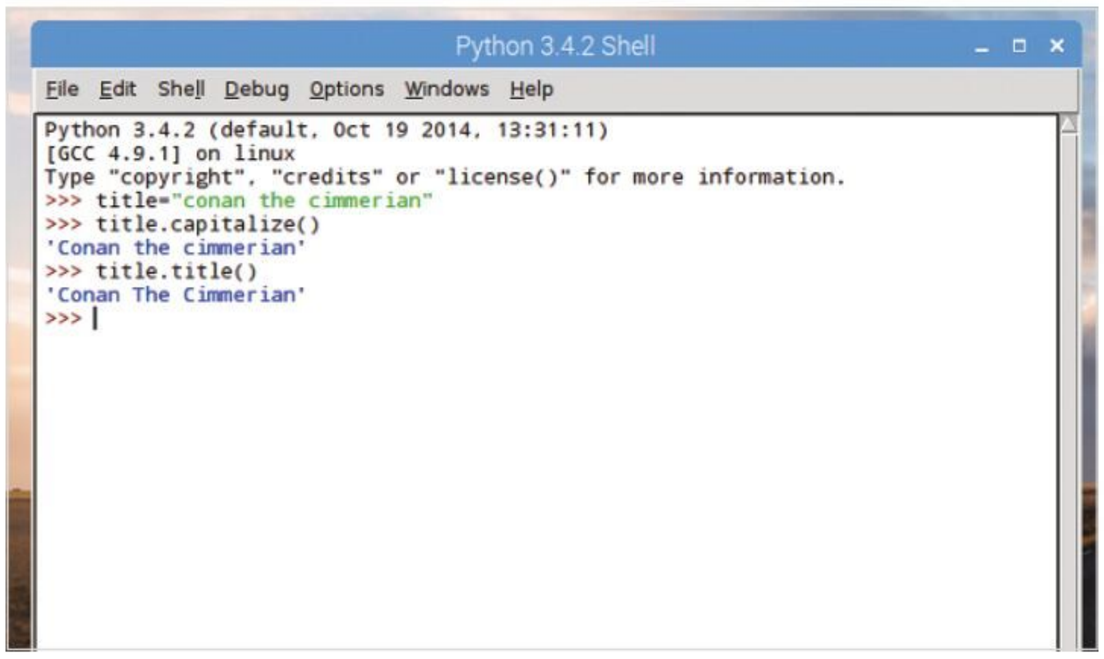
STEP 8 As with the .split function, the separator doesn't have to be a space, it can also be a comma, a full stop, a hyphen or whatever you like:

```
colours=["Red", "Green", "Blue"]
col=",".join(colours)
col
```



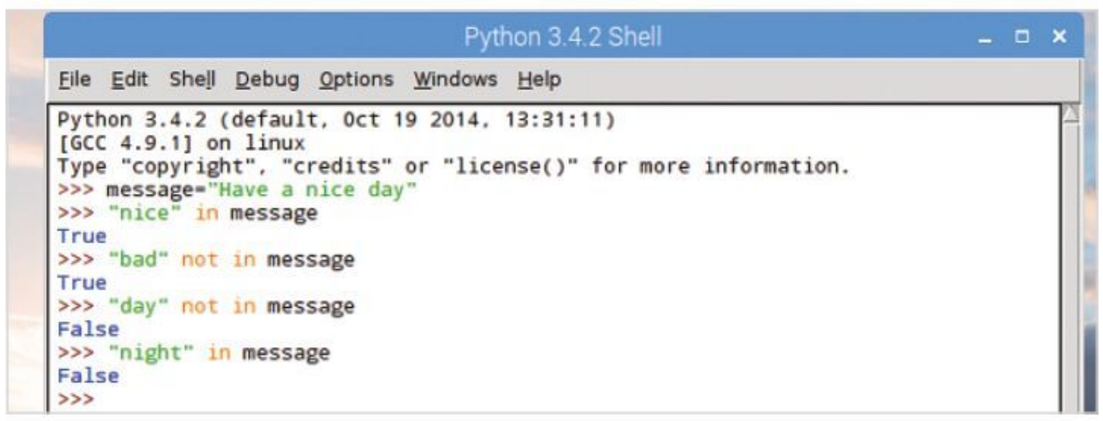
STEP 9 There's some interesting functions you apply to a string, such as .capitalize and .title. For example:

```
title="conan the cimmerian"
title.capitalize()
title.title()
```



STEP 10 You can also use logic operators on strings, with the 'in' and 'not in' functions. These enable you to check if a string contains (or does not contain) a sequence of characters:

```
message="Have a nice day"
"nice" in message

"bad" not in message
"day" not in message
"night" in message
```



Formatting Strings

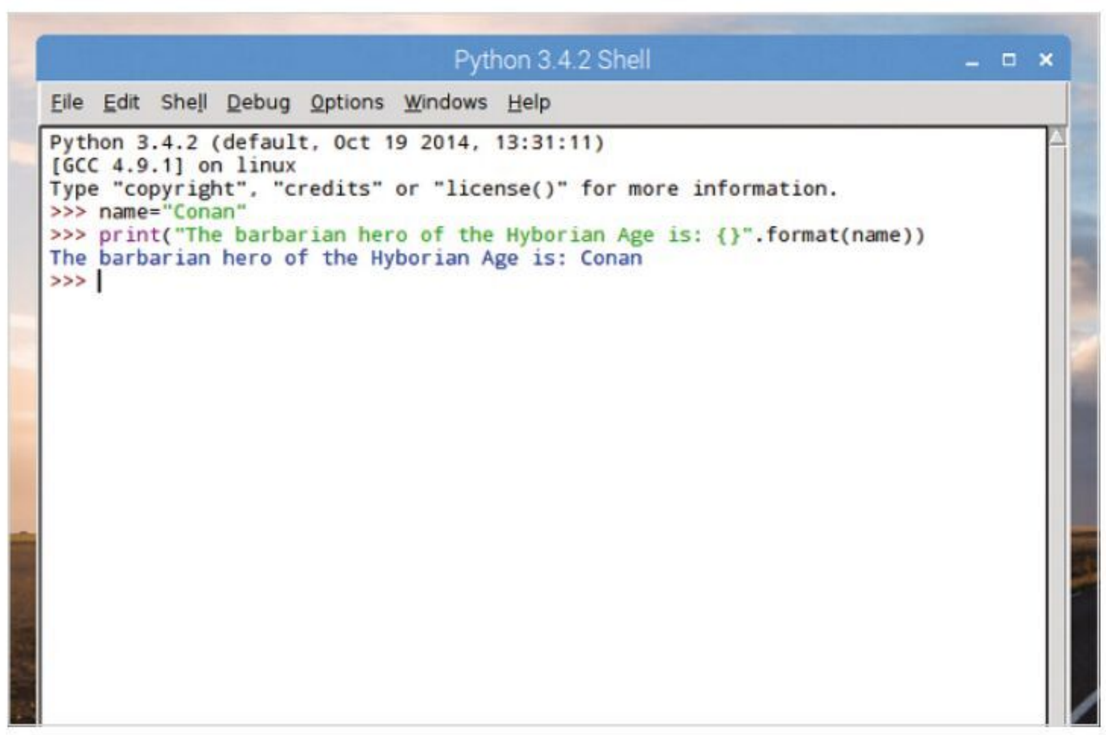
When you work with data, creating lists, dictionaries and objects you may often want to print out the results. Merging strings with data is easy especially with Python 3, as earlier versions of Python tended to complicate matters.

STRING FORMATTING

Since Python 3, string formatting has become a much neater process, using the .format function combined with curly brackets. It's a more logical and better formed approach than previous versions.

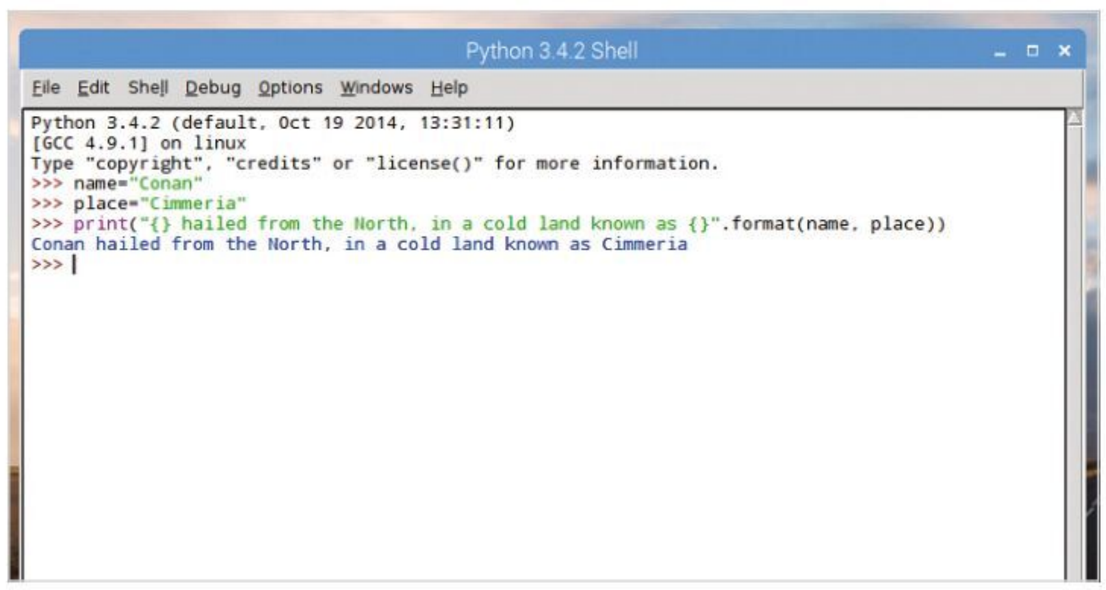
STEP 1 The basic formatting in Python is to call each variable into the string using the curly brackets:

```
name="Conan"
print("The barbarian hero of the Hyborian Age is: {}".format(name))
```



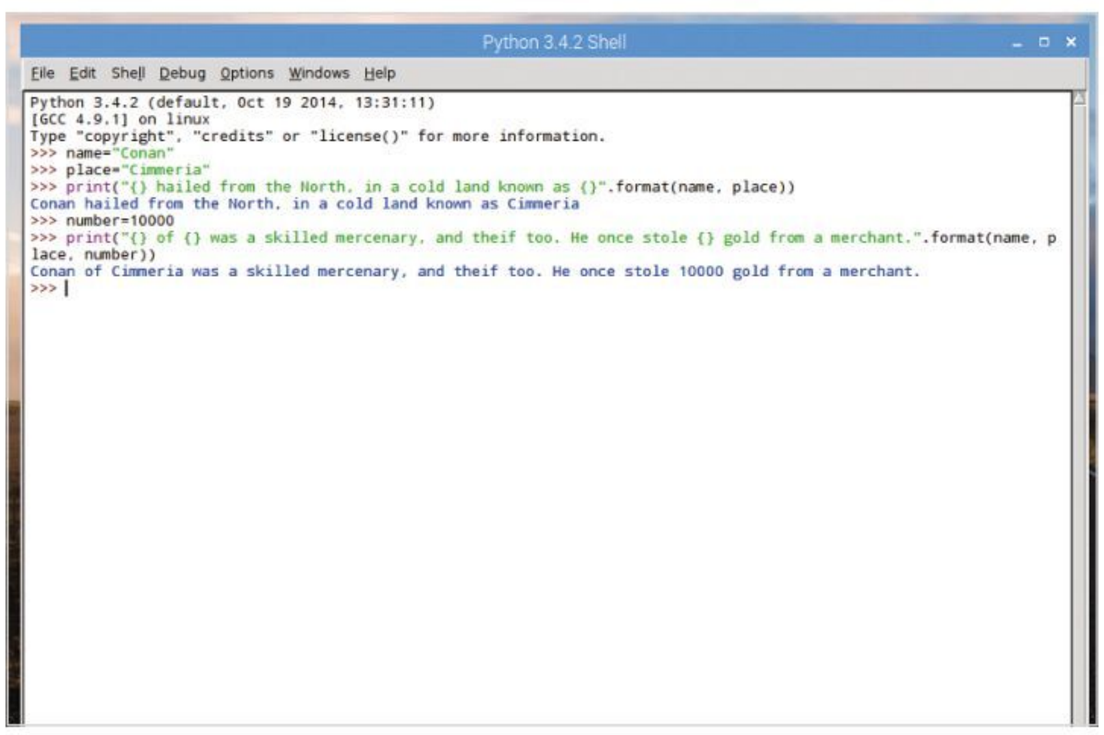
STEP 2 Remember to close the print function with two sets of brackets, as you've encased the variable in one, and the print function in another. You can include multiple cases of string formatting in a single print function:

```
name="Conan"
place="Cimmeria"
print("{} hailed from the North, in a cold land known as {}".format(name, place))
```

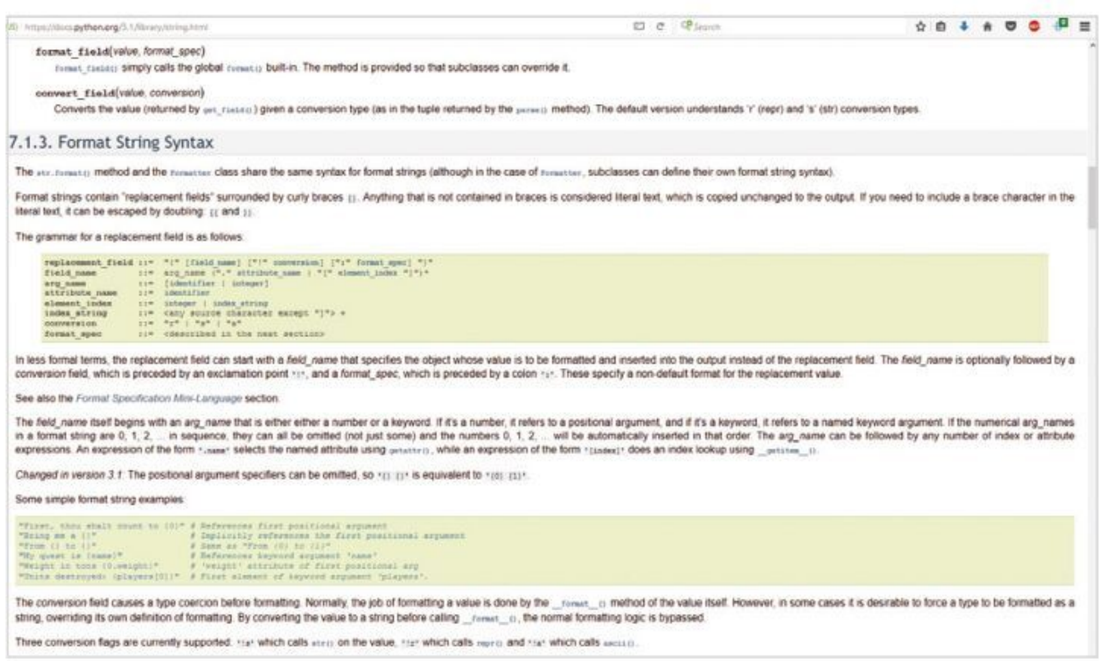


STEP 3 You can of course also include integers into the mix:

```
number=10000
print("{} of {} was a skilled mercenary, and thief too. He once stole {} gold from a merchant.".format(name, place, number))
```

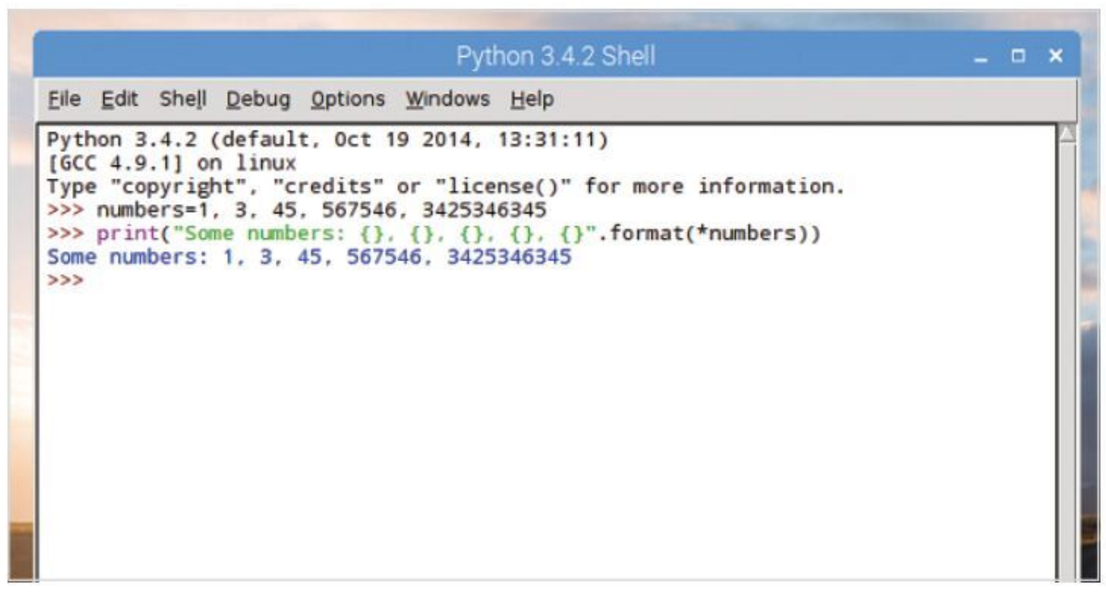


STEP 4 There are many different ways to apply string formatting, some are quite simple, as we've shown you here; others can be significantly more complex. It all depends on what you want from your program. A good place to reference frequently regarding string formatting is the Python Docs webpage, found at www.docs.python.org/3.1/library/string.html. Here, you will find tons of help.



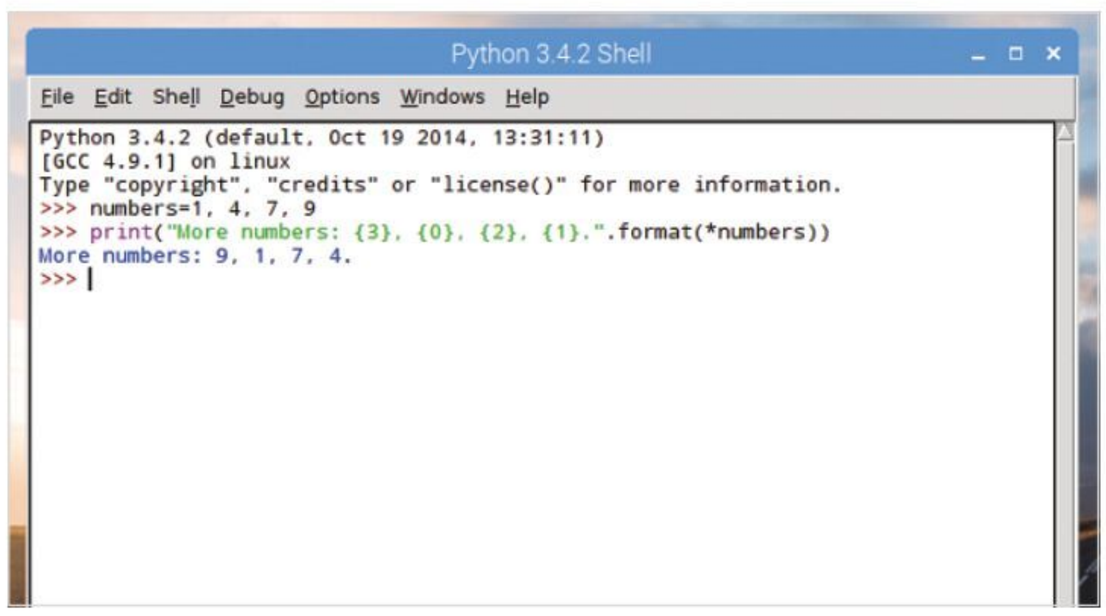
STEP 5 Interestingly you can reference a list using the string formatting function. You need to place an asterisk in front of the list name:

```
numbers=1, 3, 45, 567546, 3425346345
print("Some numbers: {}, {}, {}, {}, {}".
format(*numbers))
```



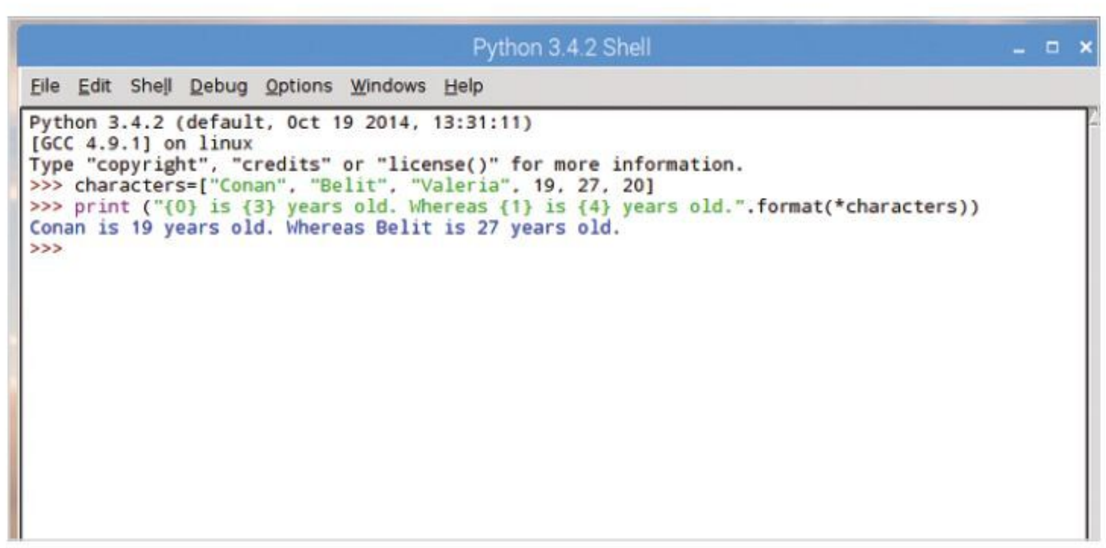
STEP 6 With indexing in lists, the same applies to calling a list using string formatting. You can index each item according to its position (from 0 to however many are present):

```
numbers=1, 4, 7, 9
print("More numbers: {3}, {0}, {2},
{1}.".format(*numbers))
```



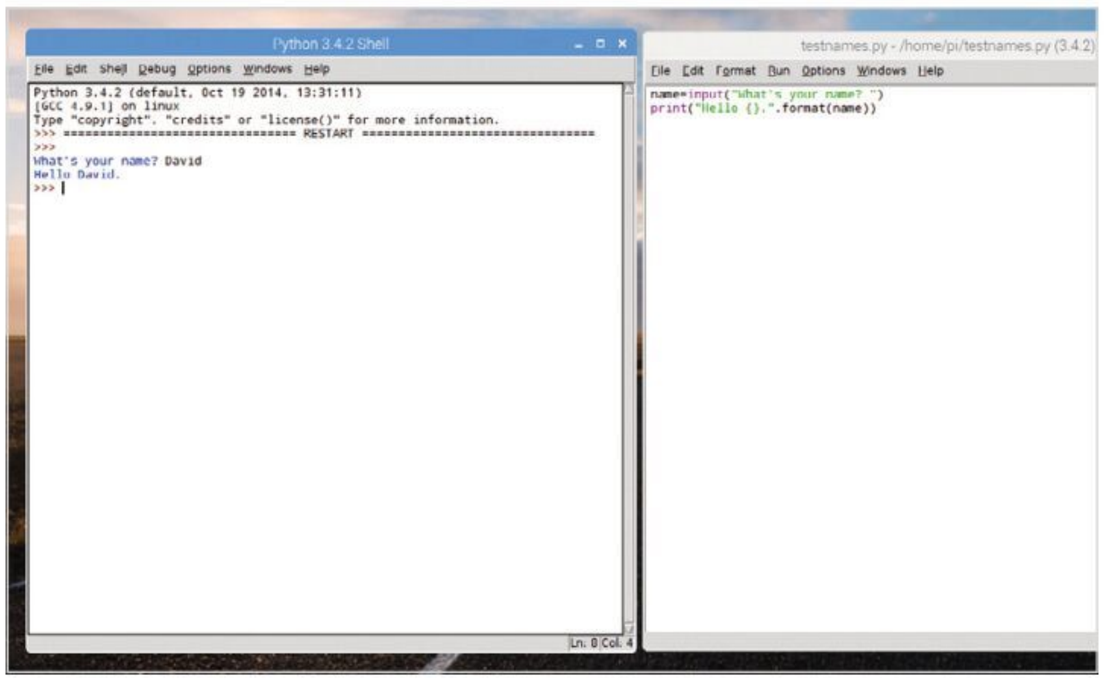
STEP 7 And as you probably suspect, you can mix strings and integers in a single list to be called in the .format function:

```
characters=["Conan", "Belit", "Valeria", 19, 27,
20]
print ("{0} is {3} years old. Whereas {1} is {4}
years old.".format(*characters))
```



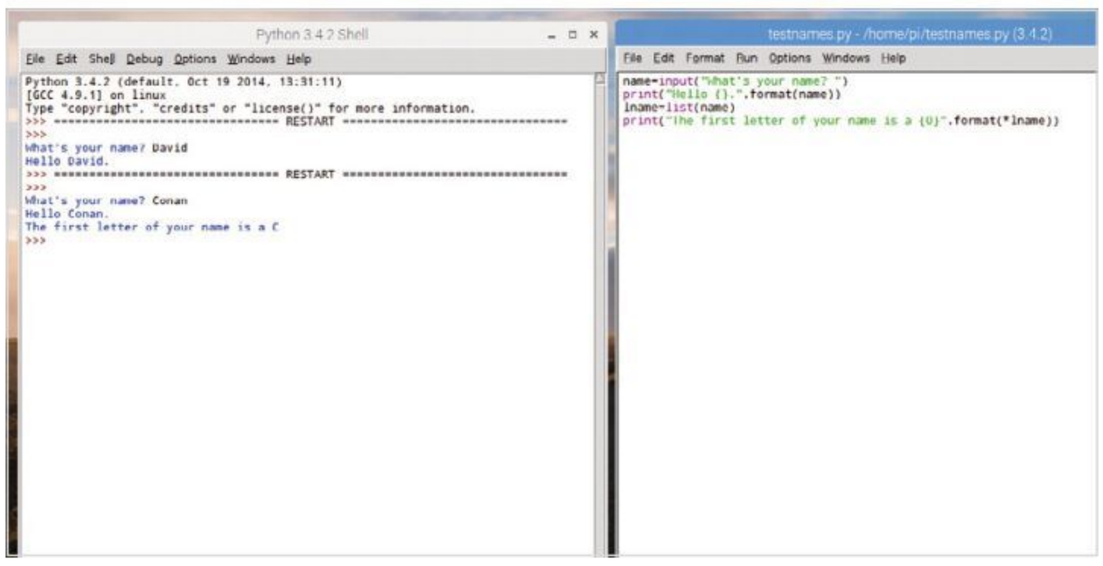
STEP 8 You can also print out the content of a user's input in the same fashion:

```
name=input("What's your name? ")
print("Hello {}.".format(name)
```



STEP 9 You can extend this simple code example to display the first letter in a person's entered name:

```
name=input("What's your name? ")
print("Hello {}.".format(name))
lname=list(name)
print("The first letter of your name is a {0}".
format(*lname))
```

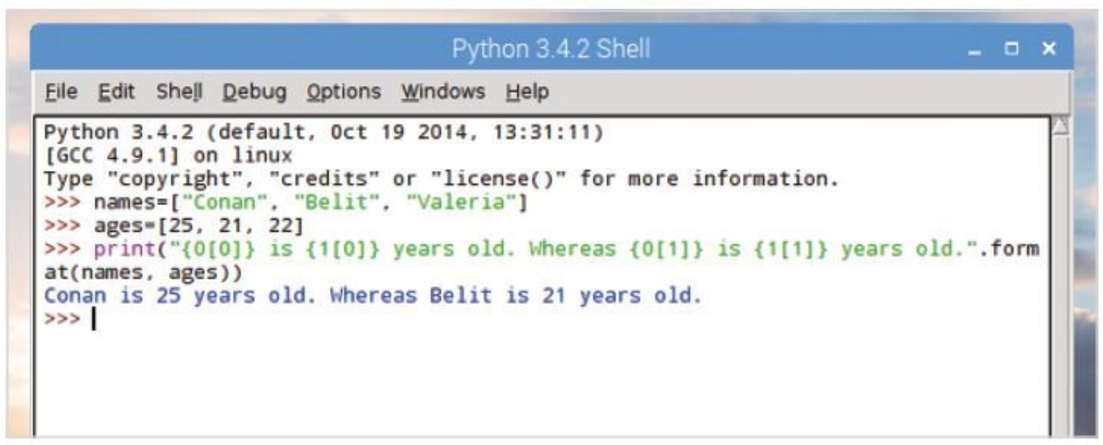


STEP 10 You can also call upon a pair of lists and reference them individually within the same print function. Looking back the code from Step 7, you can alter it with:

```
names=["Conan", "Belit", "Valeria"]
ages=[25, 21, 22]
```

Creating two lists. Now you can call each list, and individual items:

```
print("{0[0]} is {1[0]} years old. Whereas {0[1]}
is {1[1]} years old.".format(names, ages))
```



Date and Time

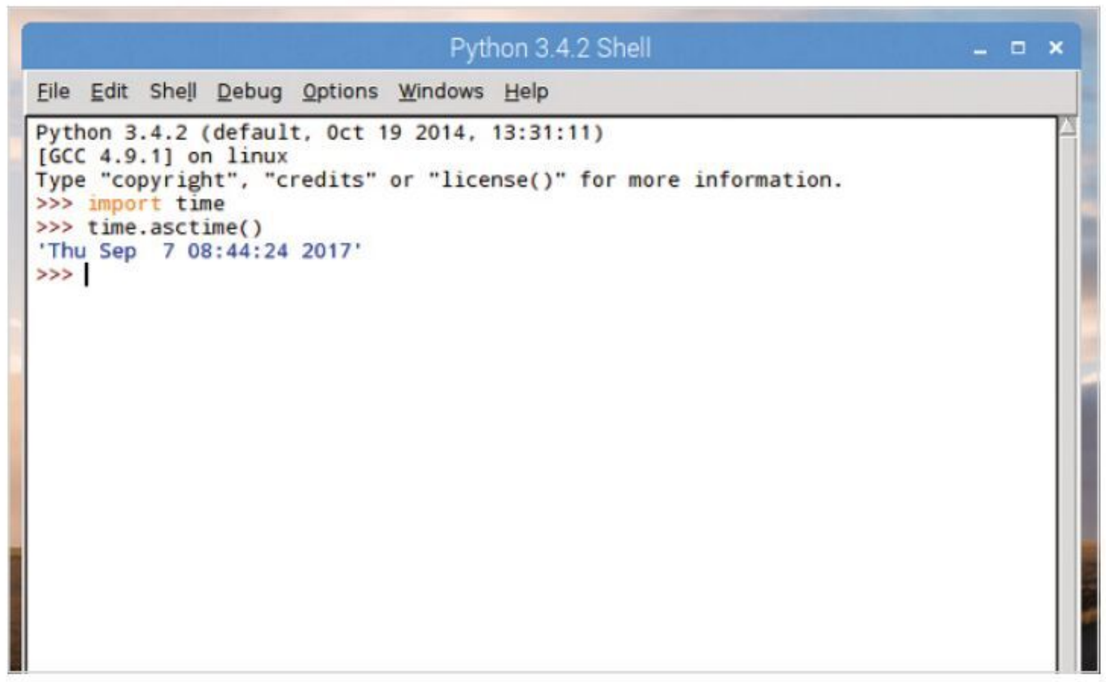
When working with data it's often handy to have access to the time. For example, you may want to time-stamp an entry or see at what time a user logged into the system and for how long. Luckily acquiring the date and time is easy, thanks to the Time module.

TIME LORDS

The Time module contains functions that help you retrieve the current system time, reads the date from strings, formats the time and date and much more.

STEP 1 First you need to import the Time module. It's one that's built-in to Python 3 so you shouldn't need to drop into a command prompt and pip install it. Once it's imported, you can call the current time and date with a simple command:

```
import time
time.asctime()
```



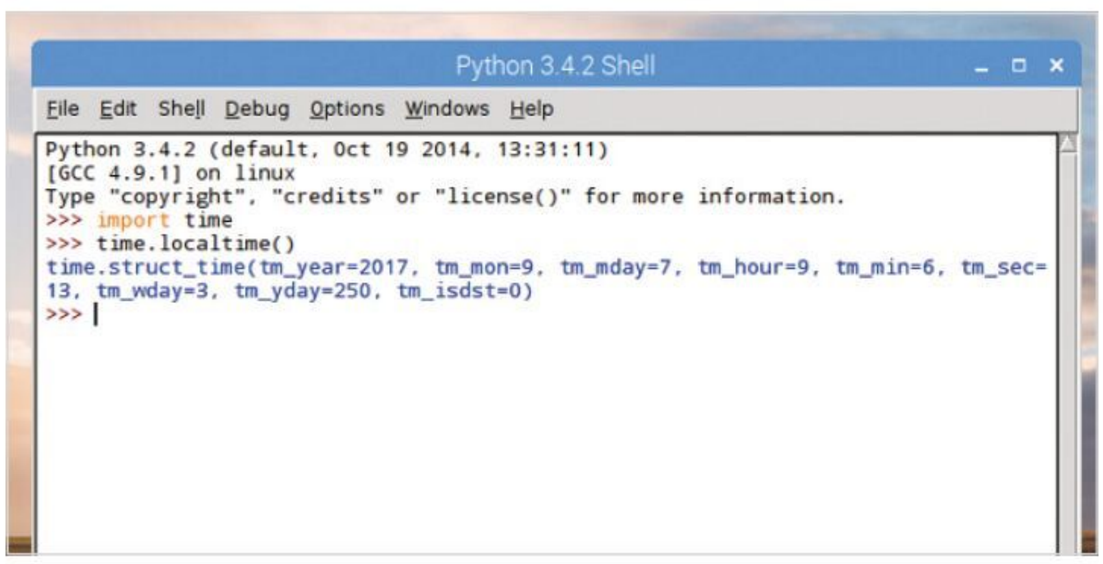
STEP 2 The time function is split into nine tuples, these are divided up into indexed items, as with any other tuple, and shown in the screen shot below.

Index	Field	Values
0	4-digit year	2016
1	Month	1 to 12
2	Day	1 to 31
3	Hour	0 to 23
4	Minute	0 to 59
5	Second	0 to 61 (60 or 61 are leap-seconds)
6	Day of Week	0 to 6 (0 is Monday)
7	Day of year	1 to 366 (Julian day)
8	Daylight savings	-1, 0, 1, -1 means library determines DST

STEP 3 You can see the structure of how time is presented by entering:

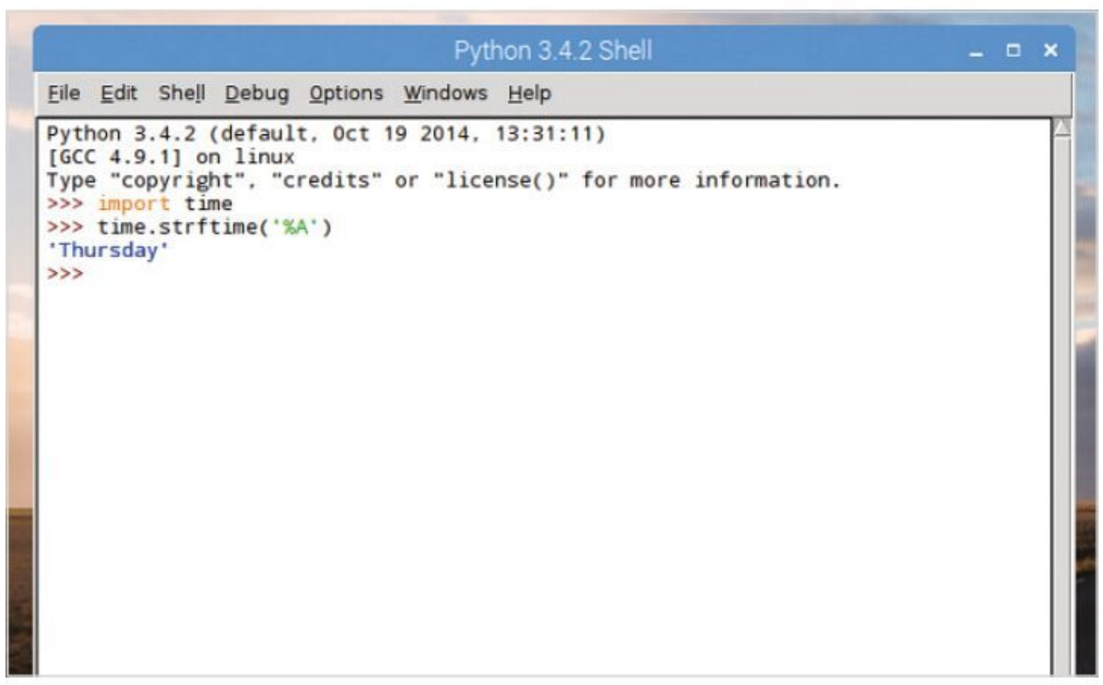
```
time.local.time()
```

The output is displayed as such: `'time.struct_time(tm_year=2017, tm_mon=9, tm_mday=7, tm_hour=9, tm_min=6, tm_sec=13, tm_wday=3, tm_yday=250, tm_isdst=0)'`; obviously dependent on your current time as opposed to the time this book was written.



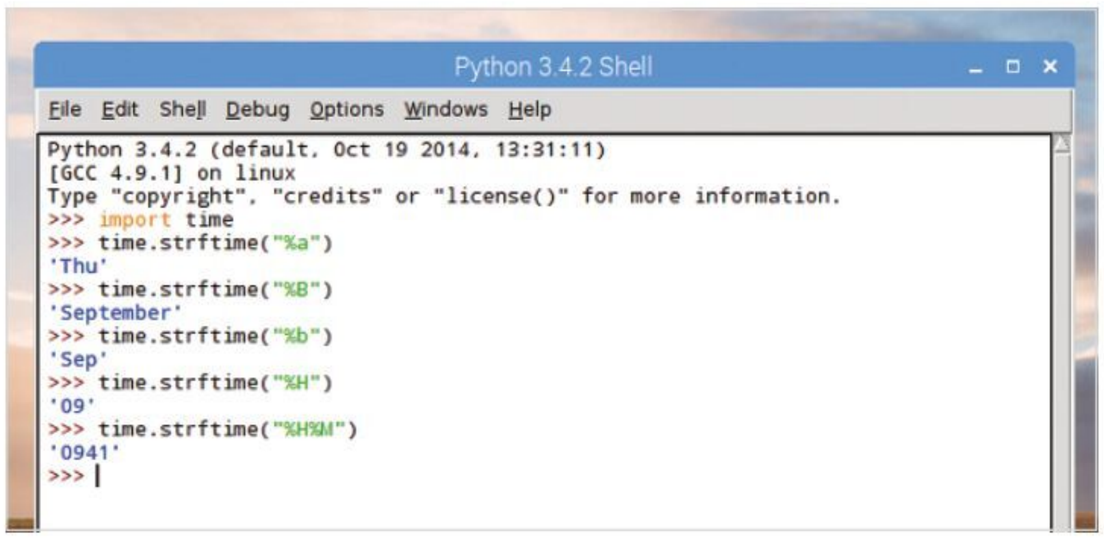
STEP 4 There are numerous functions built into the Time module. One of the most common of these is .strftime(). With it, you're able to present a wide range of arguments as it converts the time tuple into a string. For example, to display the current day of the week you can use:

```
time.strftime('%A')
```



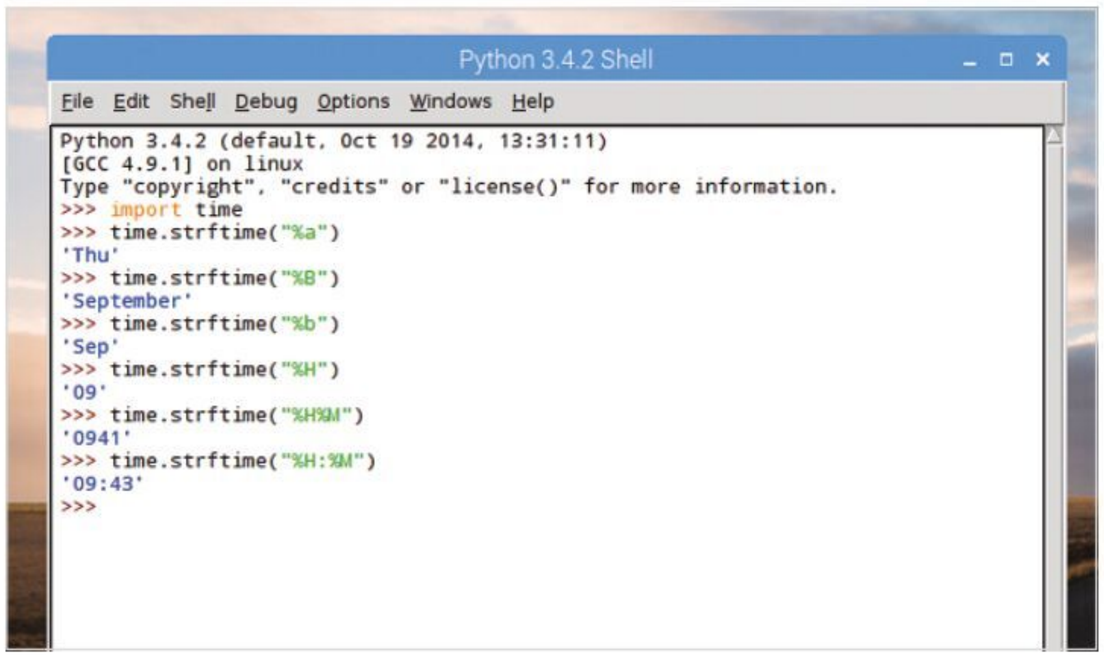
STEP 5 This naturally means you can incorporate various functions into your own code, such as:

```
time.strftime("%a")
time.strftime("%B")
time.strftime("%b")
time.strftime("%H")
time.strftime("%H%M")
```



STEP 6 Note the last two entries, with %H and %H%M, as you can see these are the hours and minutes and as the last entry indicates, entering them as %H%M doesn't display the time correctly in the Shell. You can easily rectify this with:

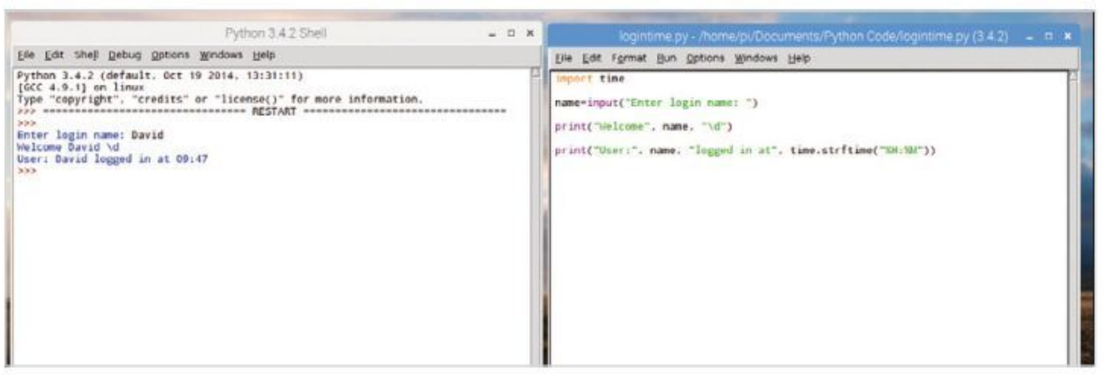
```
time.strftime("%H:%M")
```



STEP 7 This means you're going to be able to display either the current time or the time when something occurred, such as a user entering their name. Try this code in the Editor:

```
import time
name=input("Enter login name: ")
print("Welcome", name, "\d")
print("User:", name, "logged in at", time.
strftime("%H:%M"))
```

Try to extend it further to include day, month, year and so on.



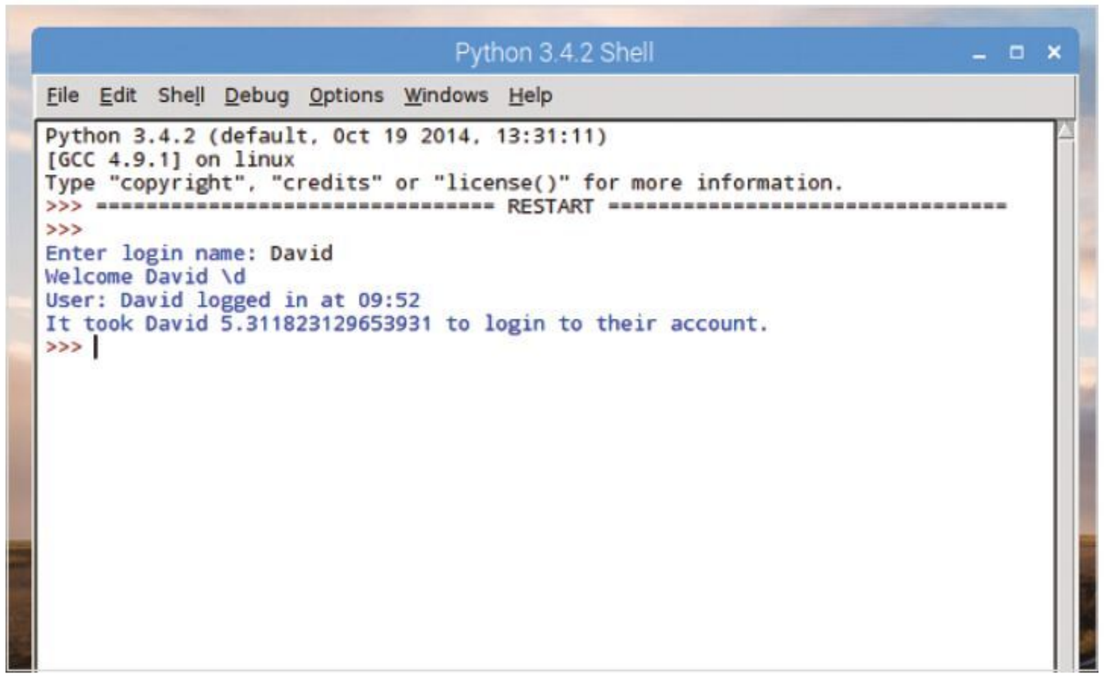
STEP 8 You saw at the end of the previous section, in the code to calculate Pi to however many decimal places the users wanted, you can time a particular event in Python. Take the code from above and alter it slightly by including:

```
start_time=time.time()
```

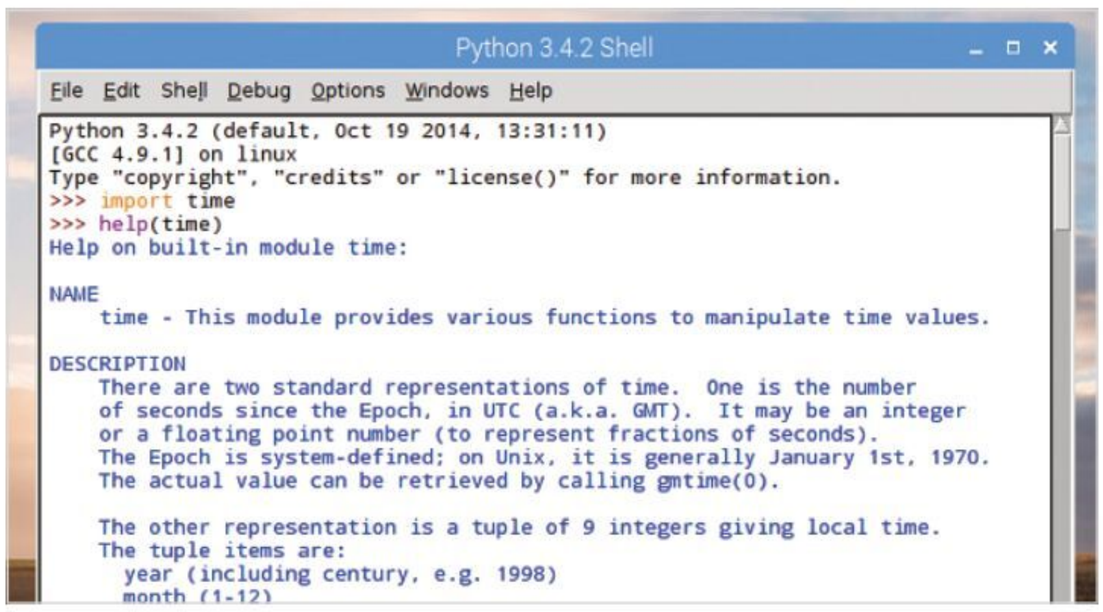
Then there's:

```
endtime=time.time()-start_time
```

STEP 9 The output will look similar to the screenshot below. The timer function needs to be either side of the input statement, as that's when the variable name is being created, depending on how long the user took to log in. The length of time is then displayed on the last line of the code as the `endtime` variable.



STEP 10 There's a lot that can be done with the Time module; some of it is quite complex too, such as displaying the number of seconds since January 1st 1970. If you want to drill down further into the Time module, then in the Shell enter: `help(time)` to display the current Python version help file for the Time module.



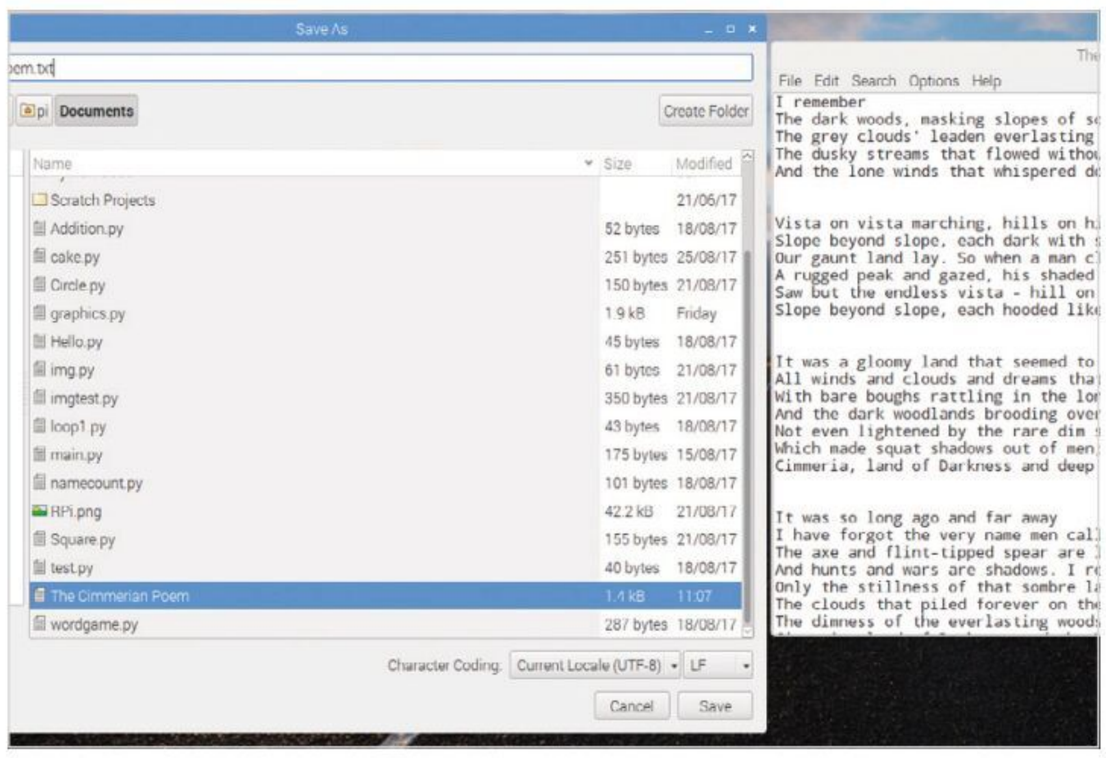
Opening Files

In Python you can read text and binary files in your programs. You can also write to file, which is something we will look at next. Reading and writing to files enables you to output and store data from your programs.

OPEN, READ AND WRITE

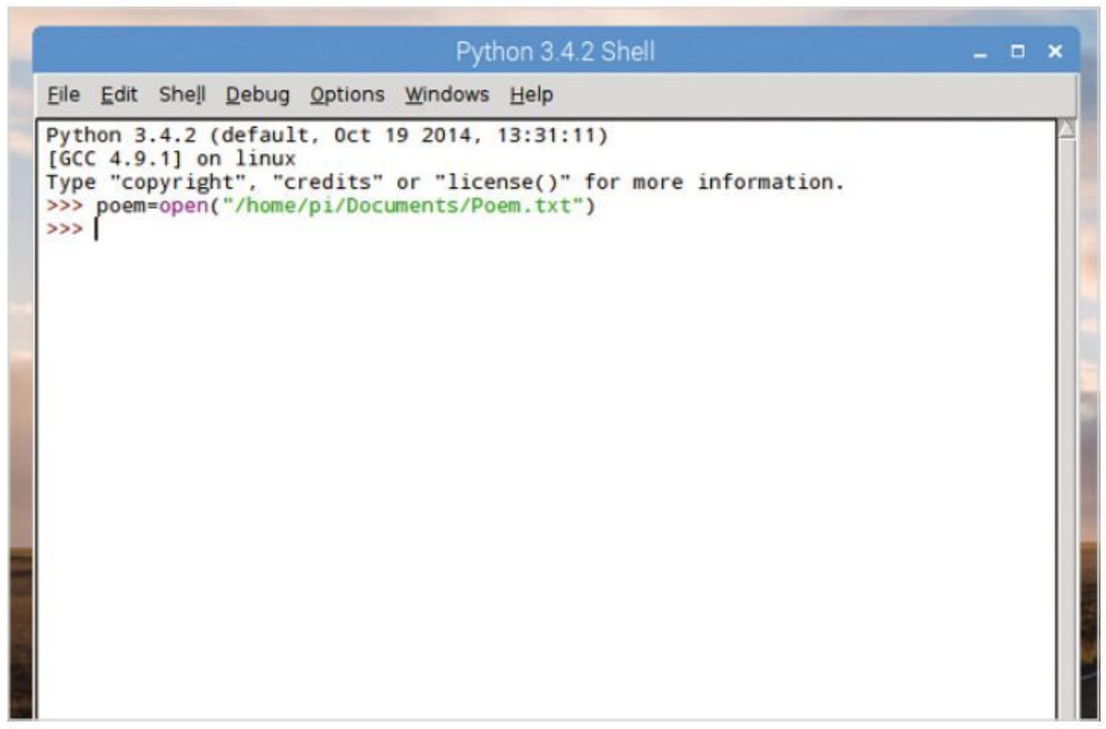
In Python you create a file object, similar to creating a variable, only pass in the file using the open() function. Files are usually categorised as text or binary.

STEP 1 Start by entering some text into your system's text editor. The text editor is best, not a word processor, as word processors include background formatting and other elements. In our example, we have the poem The Cimmerian, by Robert E Howard. You need to save the file as poem.txt.



STEP 2 You use the open() function to pass the file into a variable as an object. You can name the file object anything you like, but you will need to tell Python the name and location of the text file you're opening:

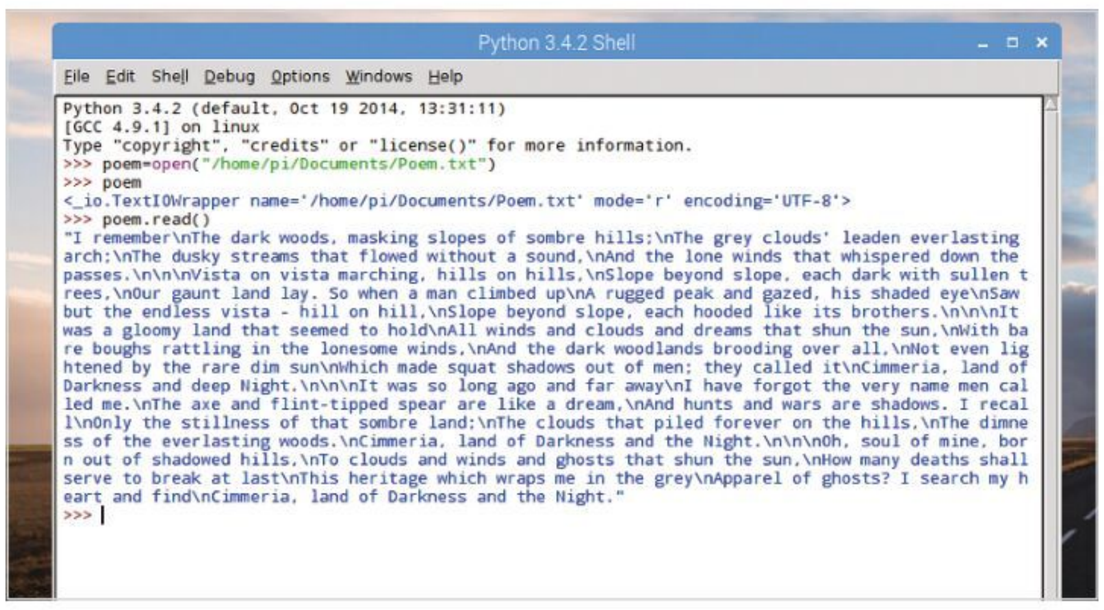
```
poem=open("/home/pi/Documents/Poem.txt")
```



STEP 3 If you now enter poem into the Shell, you will get some information regarding the text file you've just asked to be opened. You can now use the poem variable to read the contents of the file:

```
poem.read()
```

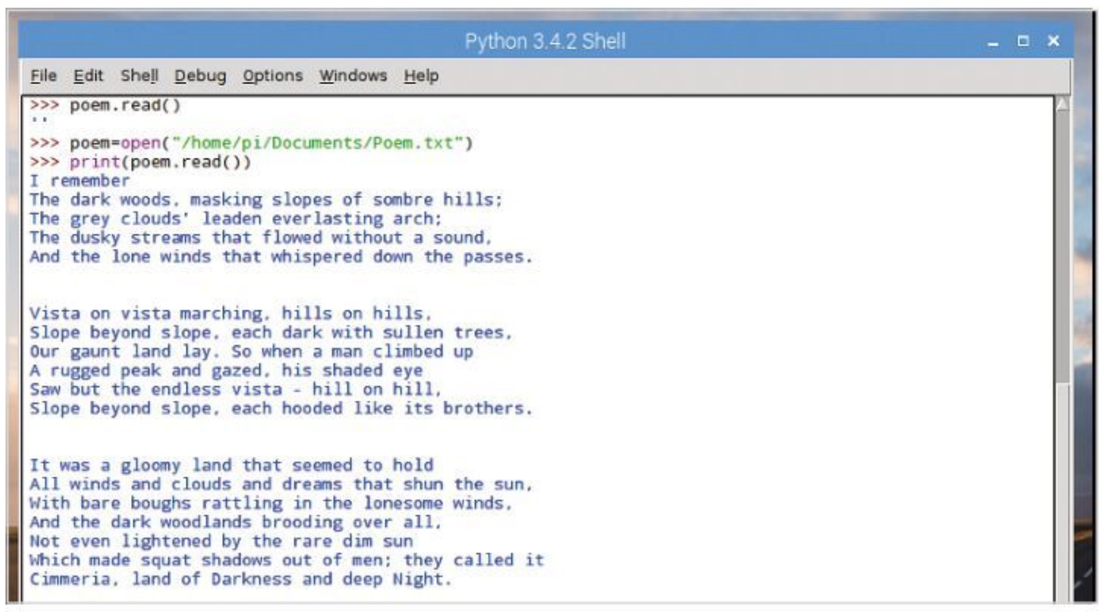
Note than a /n entry in the text represents a new line, as you used previously.



STEP 4 If you enter poem.read() a second time you will notice that the text has been removed from the file. You will need to enter: `poem=open("/home/pi/Documents/Poem.txt")` again to recreate the file. This time, however, enter:

```
print(poem.read())
```

This time, the /n entries are removed in favour of new lines and readable text.



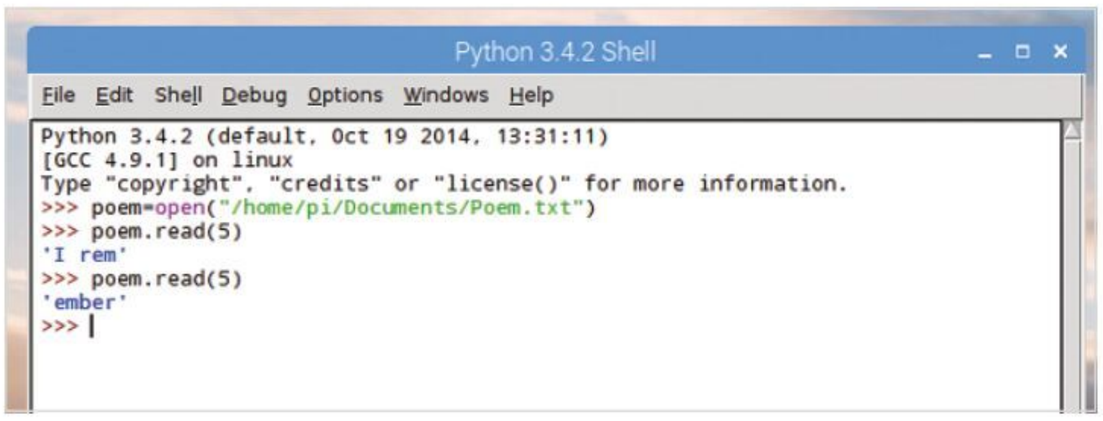
STEP 5 Just as with lists, tuples, dictionaries and so on, you're able to index individual characters of the text. For example:

```
poem.read(5)
```

Displays the first five characters, whilst again entering:

```
poem.read(5)
```

Will display the next five. Entering (1) will display one character at a time.



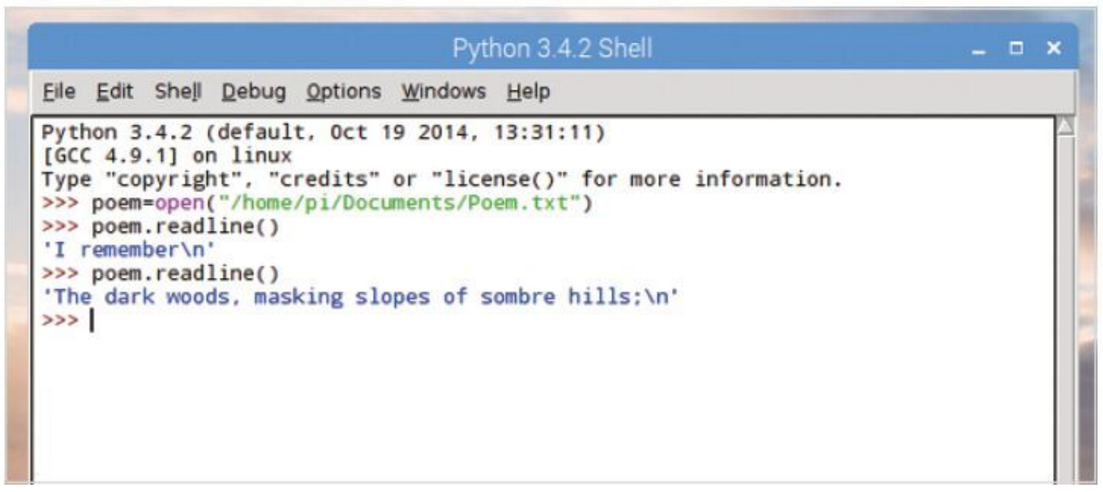
STEP 6 Similarly, you can display one line of text at a time by using the readline() function. For example:

```
poem=open("/home/pi/Documents/Poem.txt")
poem.readline()
```

Will display the first line of the text with:

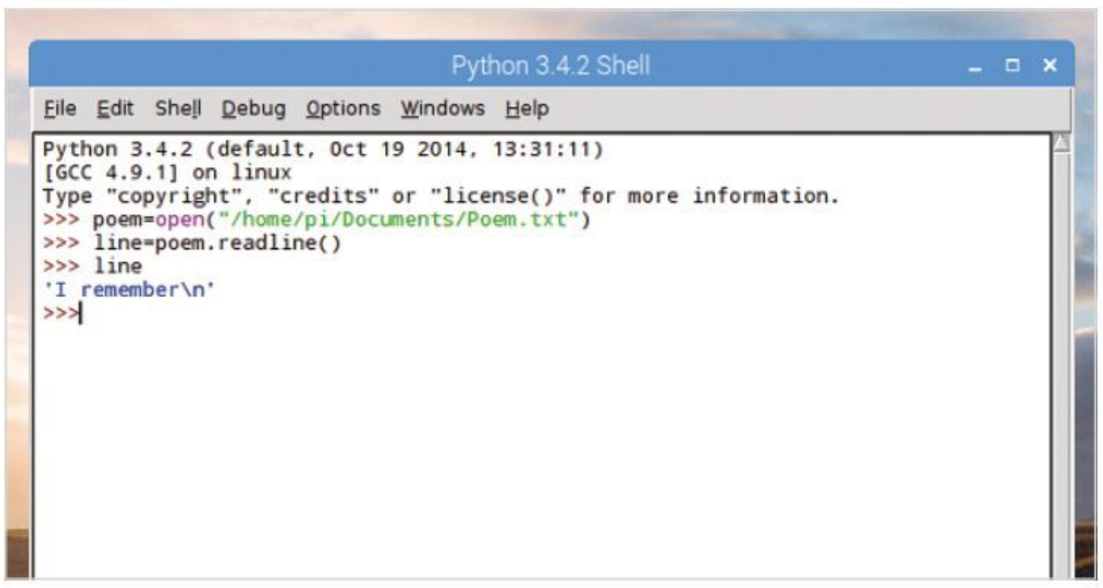
```
poem.readline()
```

Displaying the next line of text once more.



STEP 7 You may have guessed that you can pass the readline() function into a variable, thus allowing you to call it again when needed:

```
poem=open("/home/pi/Documents/Poem.txt")
line=poem.readline()
line
```



STEP 8 Extending this further, you can use readlines() to grab all the lines of the text and store them as multiple lists. These can then be stored as a variable:

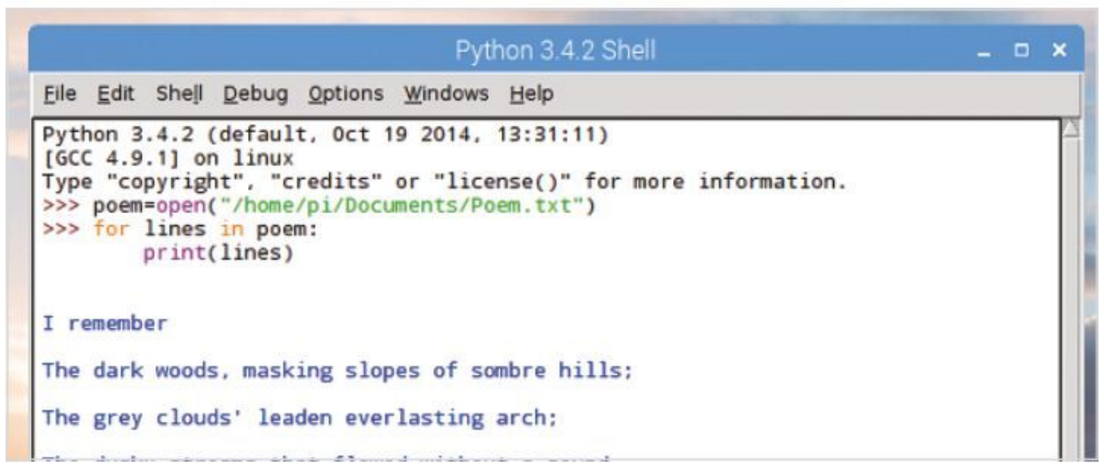
```
poem=open("/home/pi/Documents/Poem.txt")
lines=poem.readlines()
lines[0]
lines[1]
lines[2]
```

STEP 9 You can also use the for statement to read the lines of text back to us:

```
for lines in lines:
   print(lines)
```

Since this is Python, there are other ways to produce the same output:

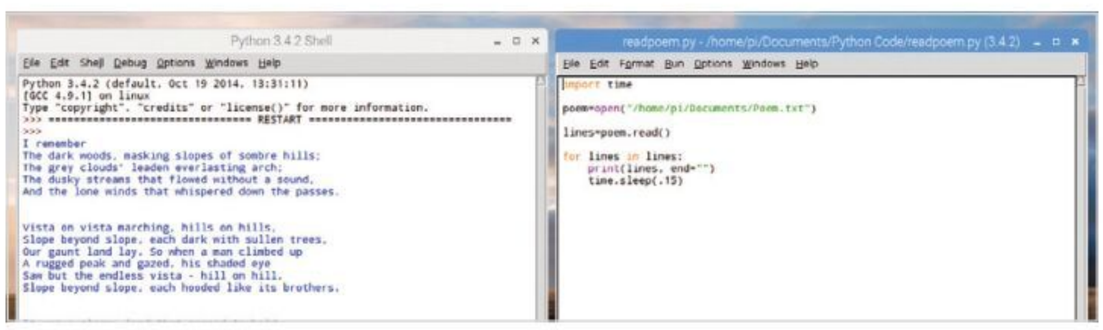
```
poem=open("/home/pi/Documents/Poem.txt")
for lines in poem:
   print(lines)
```



STEP 10 Let's imagine that you want to print the text one character at a time, like an old dot matrix printer would. You can use the Time module mixed with what you've looked at here. Try this:

```
import time
poem=open("/home/pi/Documents/Poem.txt")
lines=poem.read()
for lines in lines:
  print(lines, end="")
  time.sleep(.15)
```

The output is fun to view, and easily incorporated into your own code.



Writing to Files

The ability to read external files within Python is certainly handy but writing to a file is better still. Using the write() function, you're able to output the results of a program to a file, that you can then read() back into Python.

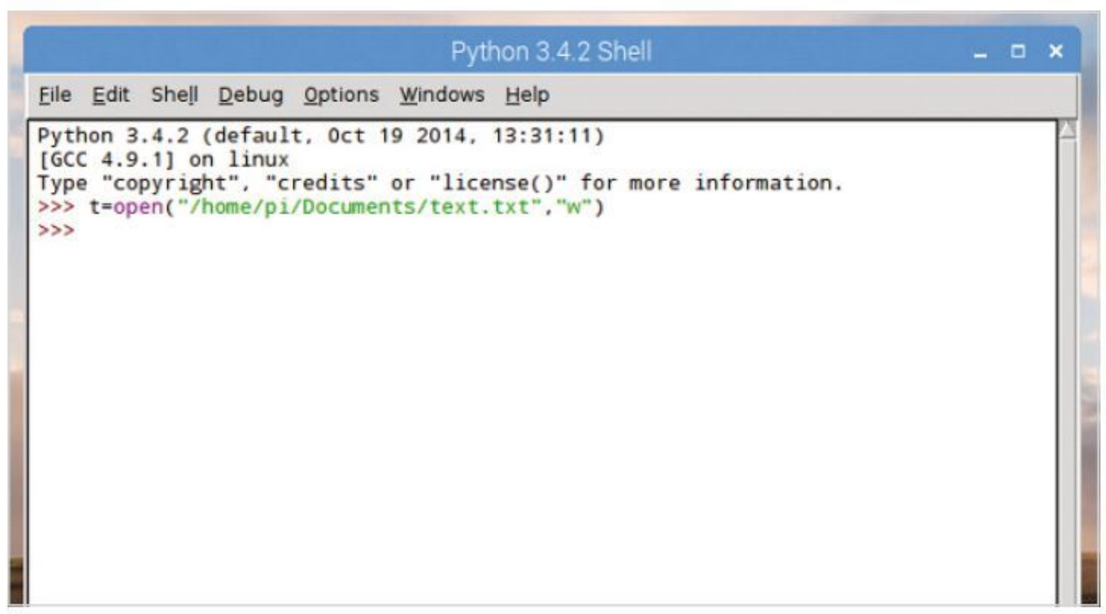
WRITE AND CLOSE

The write() function is slightly more complex than read(). Along with the filename you must also include an access mode which determines whether the file in question is in read or write mode.

STEP 1 Start by opening IDLE and enter the following:

```
t=open("/home/pi/Documents/text.txt","w")
```

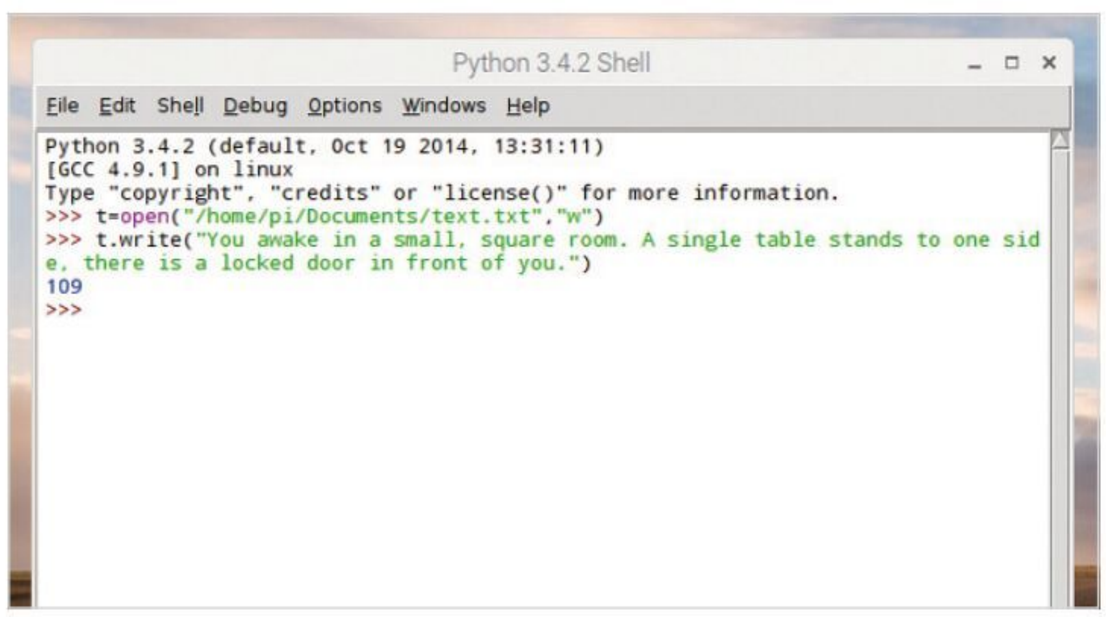
Change the destination from /home/pi/Documents to your own system. This code will create a text file called text.txt in write mode using the variable 't'. If there's no file of that name in the location, it will create one. If one already exits, it will overwrite it, so be careful.



STEP 2 You can now write to the text file using the write() function. This works opposite to read(), writing lines instead of reading them. Try this:

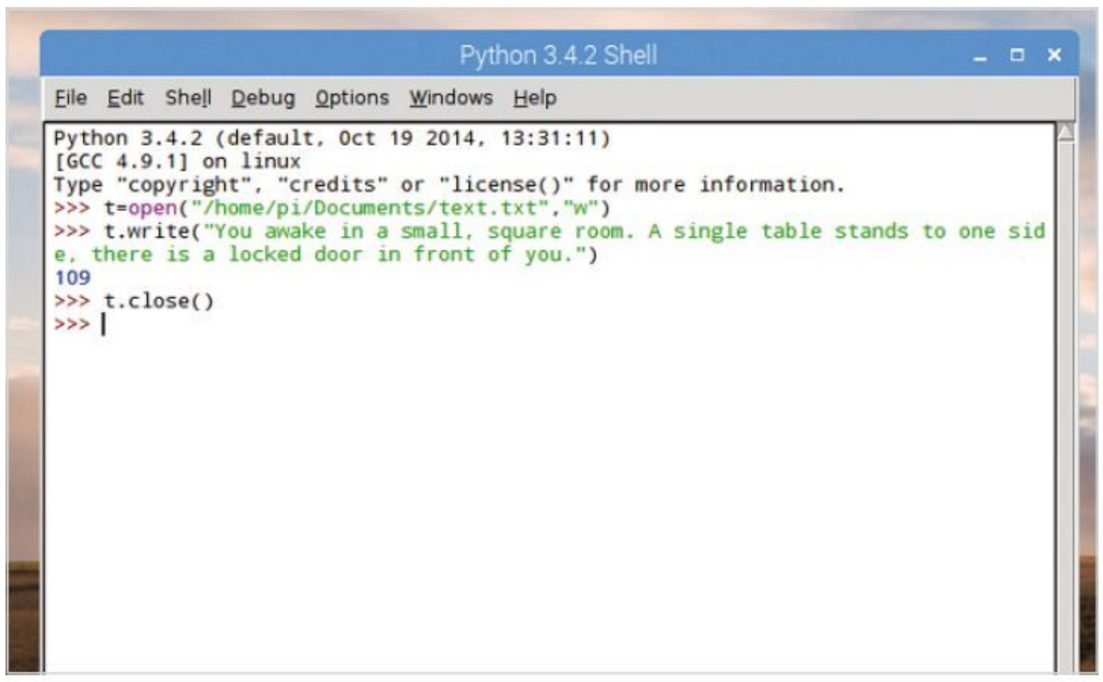
```
t.write("You awake in a small, square room. A single table stands to one side, there is a locked door in front of you.")
```

Note the 109. It's the number of characters you've entered.

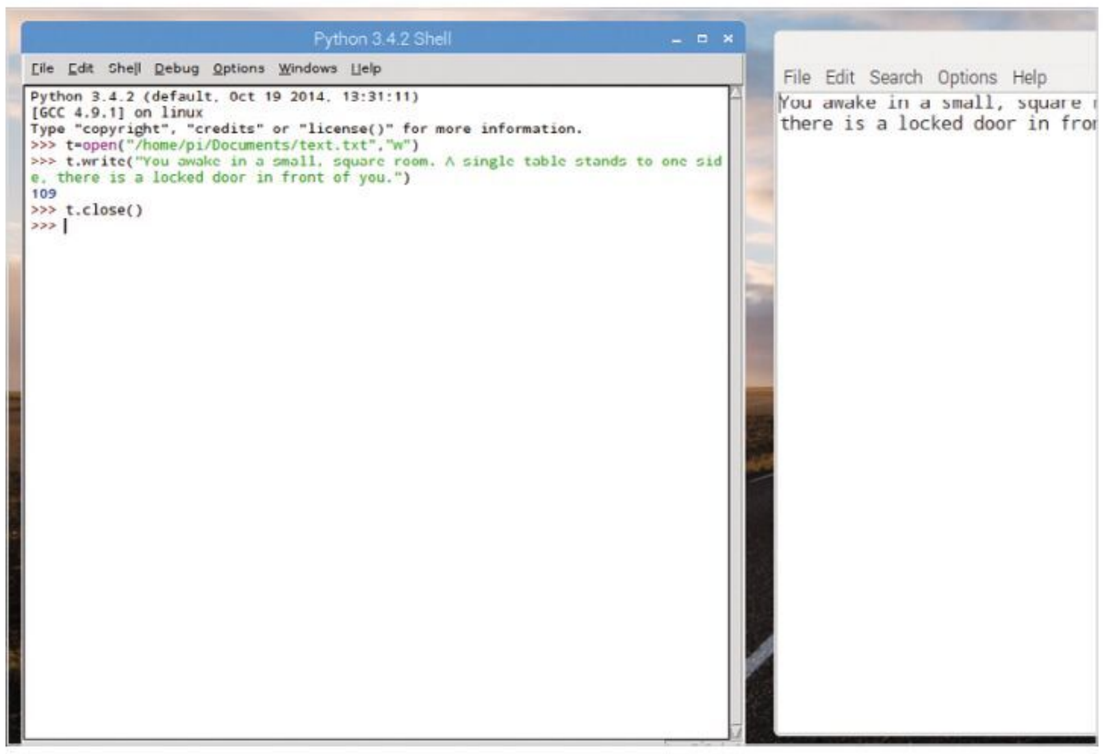


STEP 3 However, the actual text file is still blank (you can check by opening it up). This is because you've written the line of text to the file object but not committed it to the file itself. Part of the write() function is that you need to commit the changes to the file; you can do this by entering:

```
t.close()
```

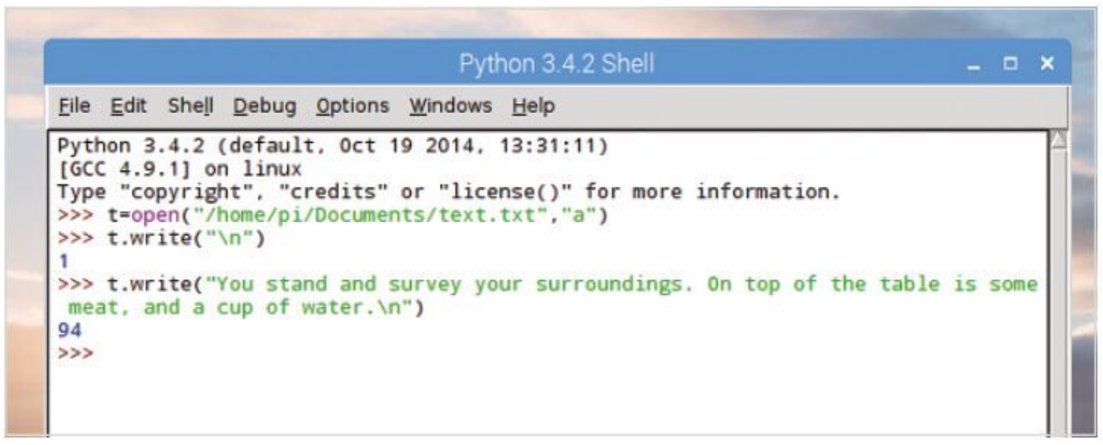


STEP 4 If you now open the text file with a text editor, you can see that the line you created has been written to the file. This gives us the foundation for some interesting possibilities: perhaps the creation of your own log file or even the beginning of an adventure game.



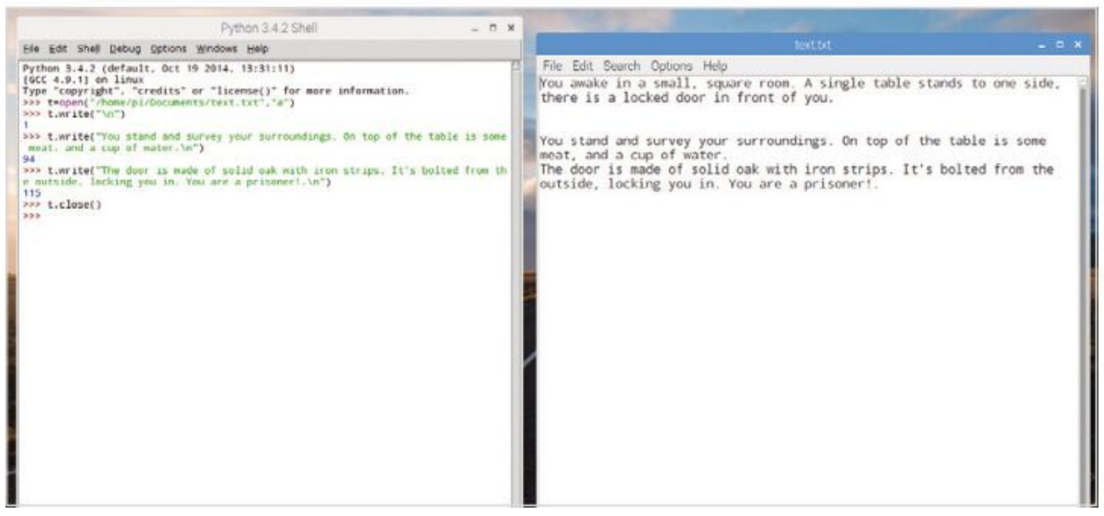
STEP 5 To expand this code, you can reopen the file using 'a', for access or append mode. This will add any text at the end of the original line instead of wiping the file and creating a new one. For example:

```
t=open("/home/pi/Documents/text.txt","a")
t.write("\n")
t.write(" You stand and survey your surroundings.
On top of the table is some meat, and a cup of
water.\n")
```

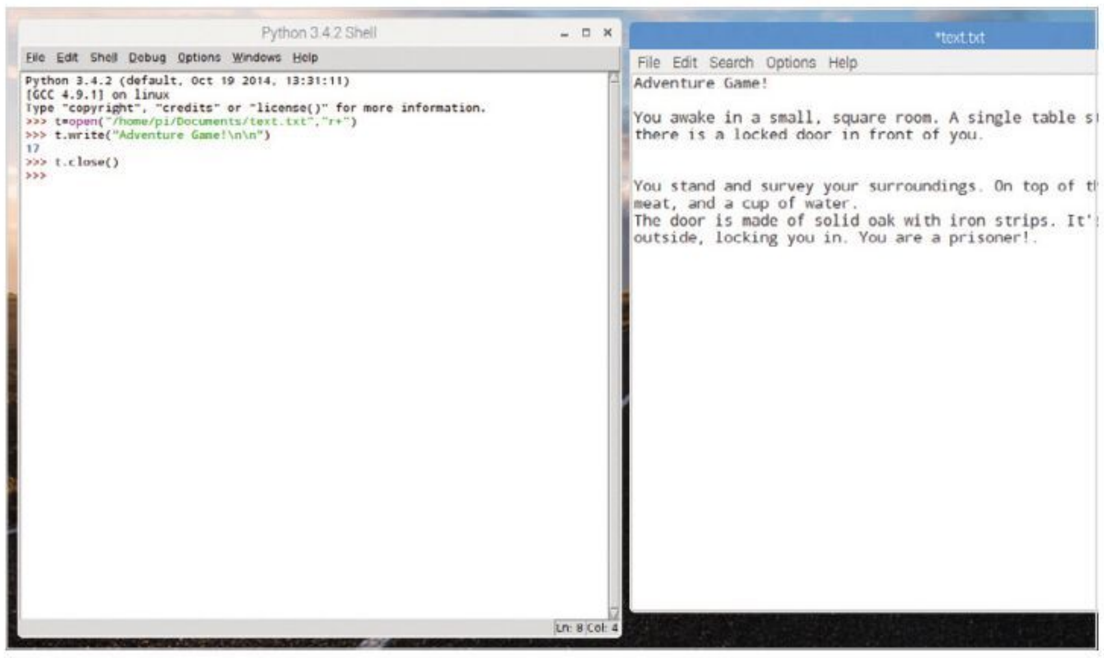


STEP 6 You can keep extending the text line by line, ending each with a new line (\n). When you're done, finish the code with t.close() and open the file in a text editor to see the results:

```
t.write("The door is made of solid oak with iron
strips. It's bolted from the outside, locking you
in. You are a prisoner!.\n")
t.close()
```

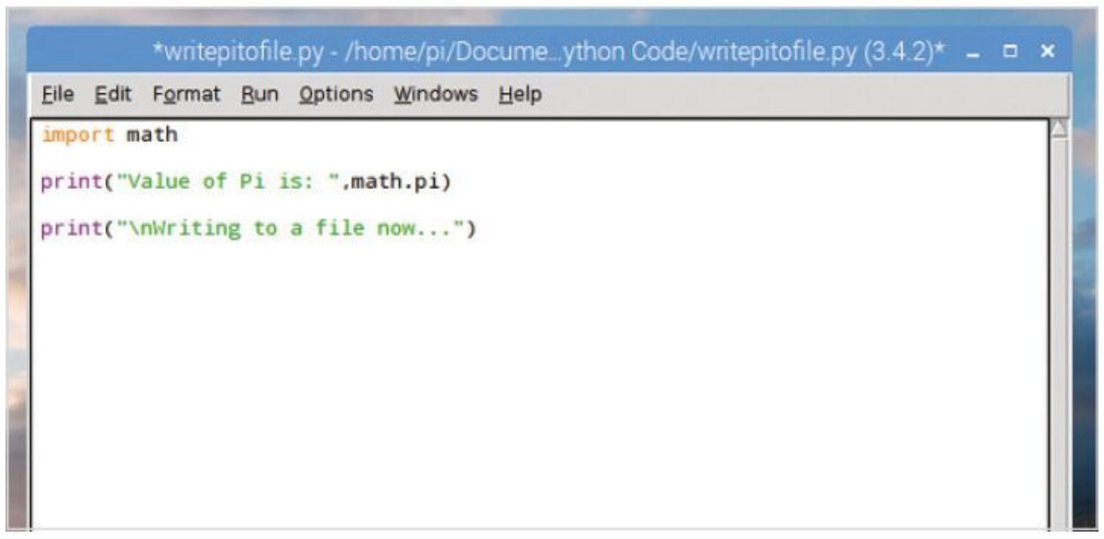


STEP 7 There are various types of file access to consider using the open() function. Each depends on how the file is accessed and even the position of the cursor. For example, r+ opens a file in read and write and places the cursor at the start of the file.



STEP 8 You can pass variables to a file that you've created in Python. Perhaps you want the value of Pi to be written to a file. You can call Pi from the Math module, create a new file and pass the output of Pi into the new file:

```
import math
print("Value of Pi is: ",math.pi)
print("\nWriting to a file now…")
```



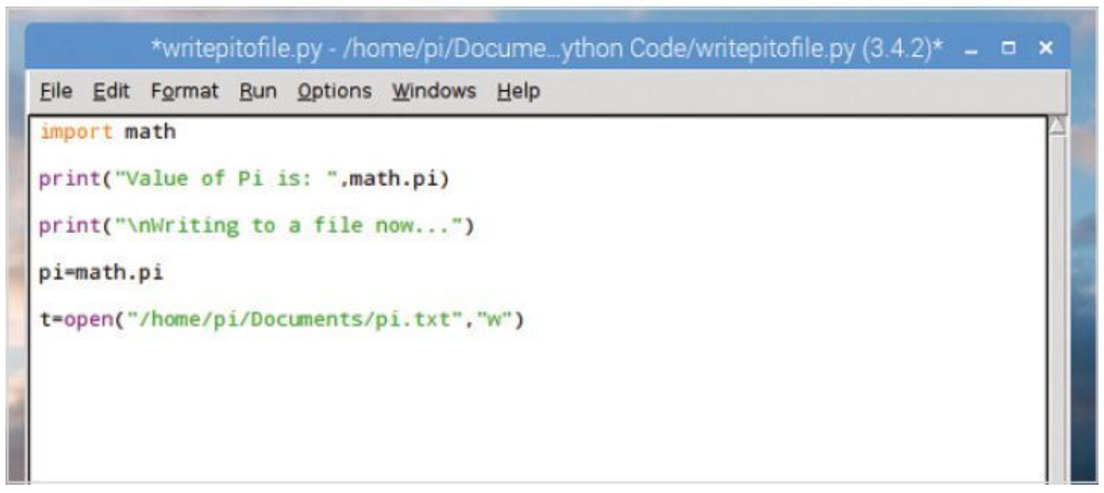
STEP 9 Now let's create a variable called pi and assign it the value of Pi:

```
pi=math.pi
```

You also need to create a new file in which to write Pi to:

```
t=open("/home/pi/Documents/pi.txt","w")
```

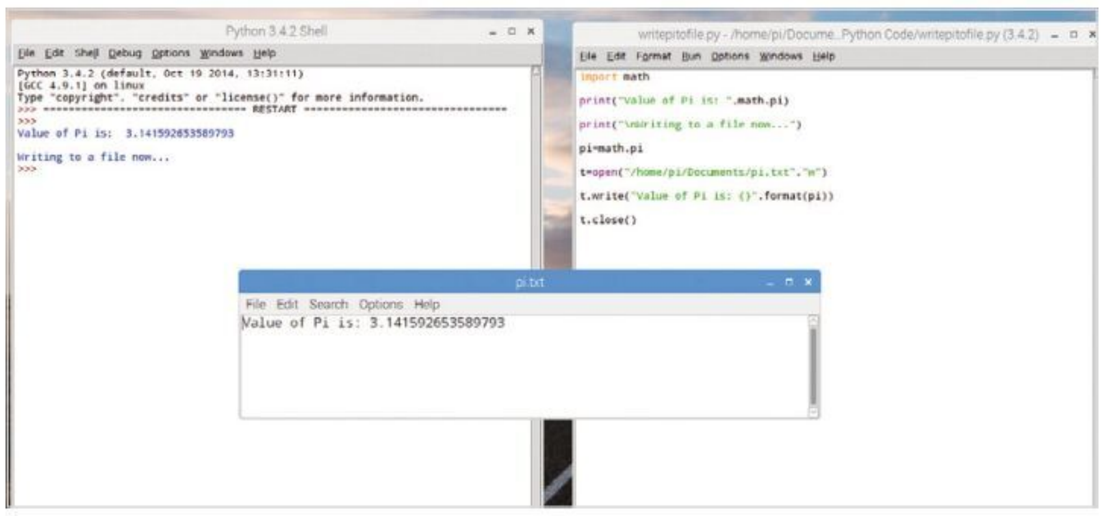
Remember to change your file location to your own particular system setup.



STEP 10 To finish, you can use string formatting to call the variable and write it to the file, then commit the changes and close the file:

```
t.write("Value of Pi is: {}".format(pi))
t.close()
```

You can see from the results that you're able to pass any variable to a file.



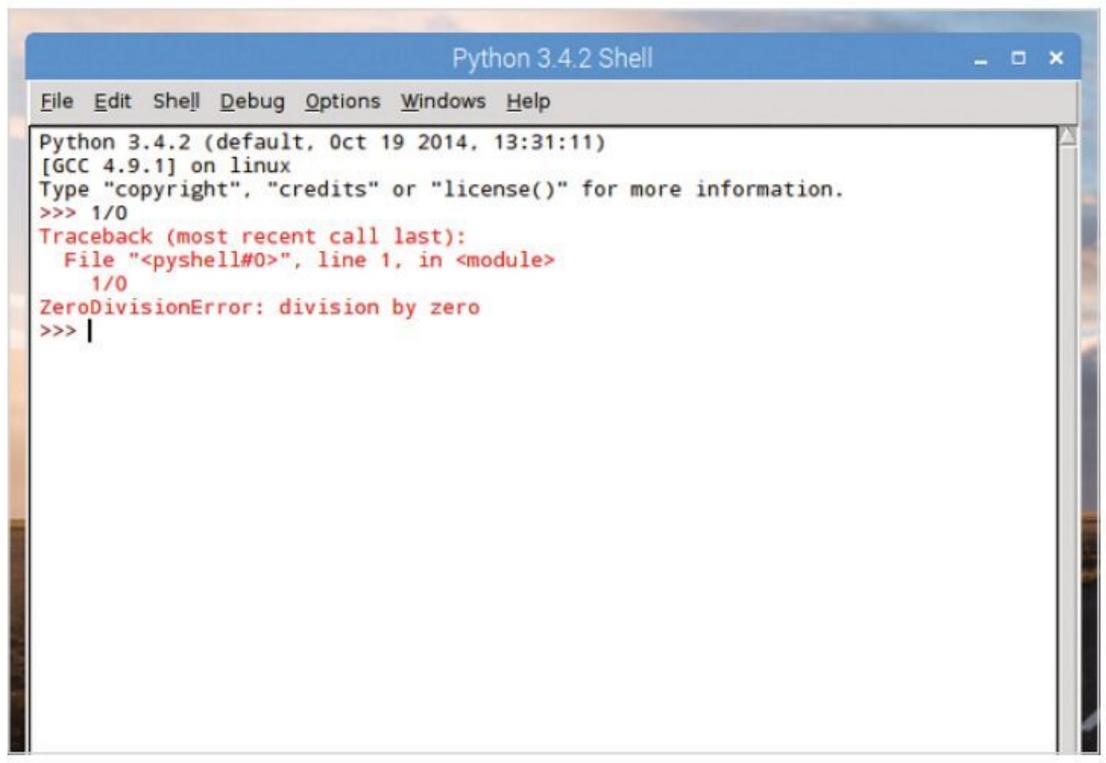
Exceptions

When coding, you'll naturally come across some issues that are out of your control. Let's assume you ask a user to divide two numbers and they try to divide by zero. This will create an error and break your code.

EXCEPTIONAL OBJECTS

Rather than stop the flow of your code, Python includes exception objects which handle unexpected errors in the code. You can combat errors by creating conditions where exceptions may occur.

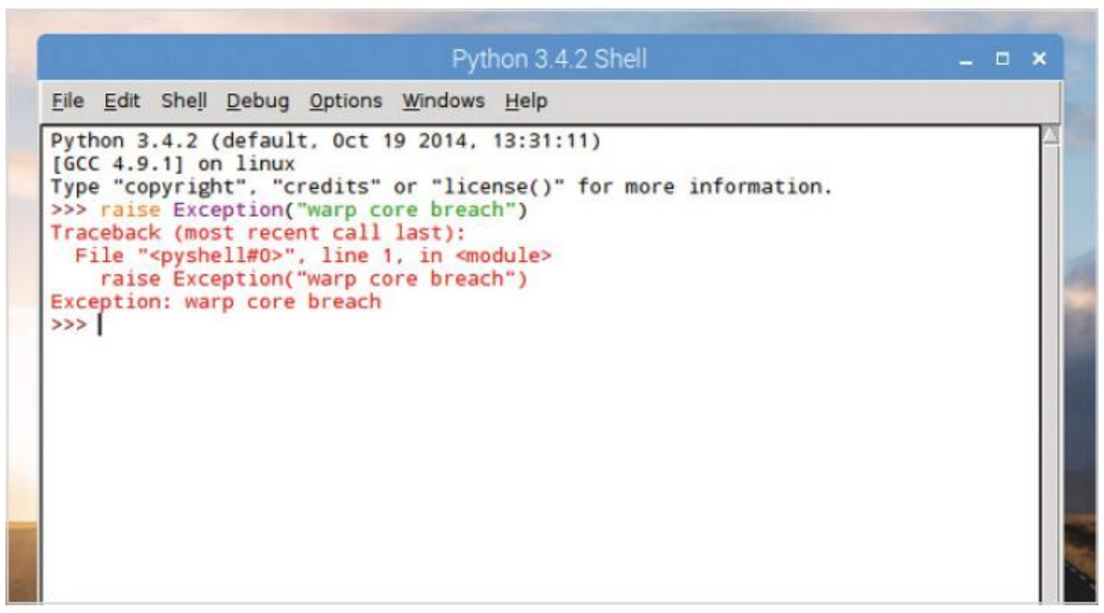
STEP 1 You can create an exception error by simply trying to divide a number by zero. This will report back with the ZeroDivisionError: Division by zero message, as seen in the screenshot. The ZeroDivisionError part is the exception class, of which there are many.



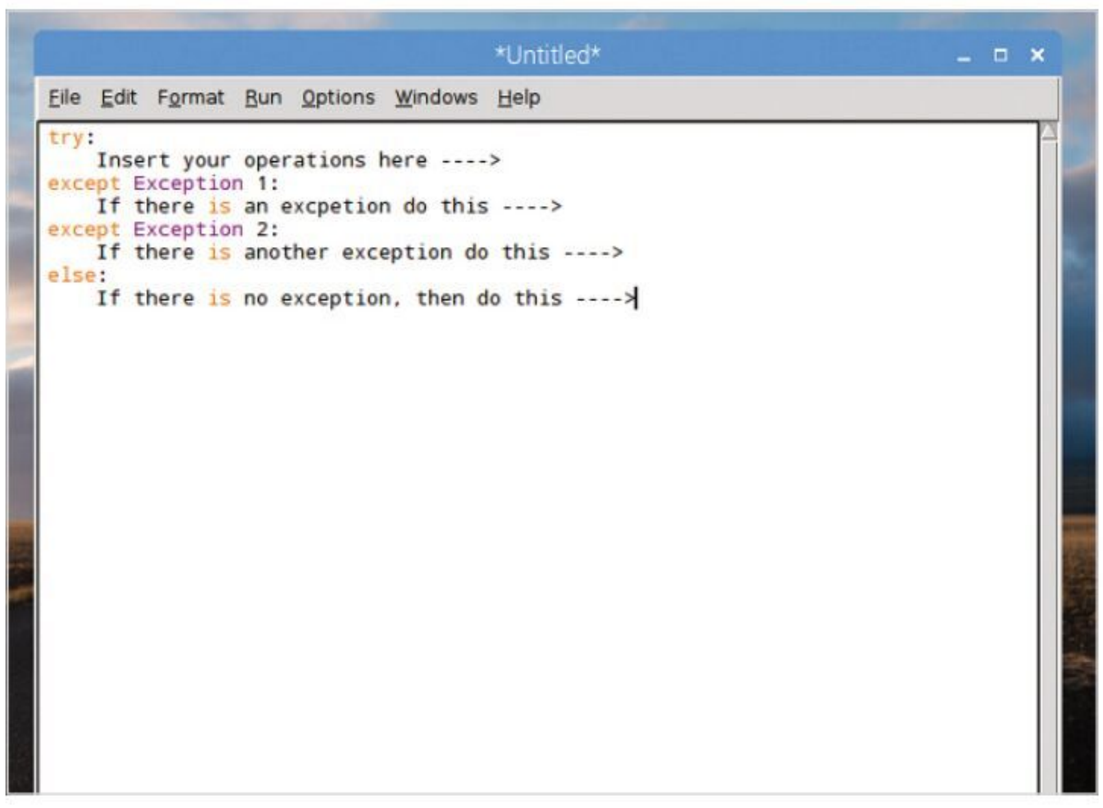
STEP 2 Most exceptions are raised automatically when Python comes across something that's inherently wrong with the code. However, you can create your own exceptions that are designed to contain the potential error and react to it, as opposed to letting the code fail.

STEP 3 You can use the functions raise exception to create our own error handling code within Python. Let's assume your code has you warping around the cosmos, too much however results in a warp core breach. To stop the game from exiting due to the warp core going supernova, you can create a custom exception:

```
raise Exception("warp core breach")
```

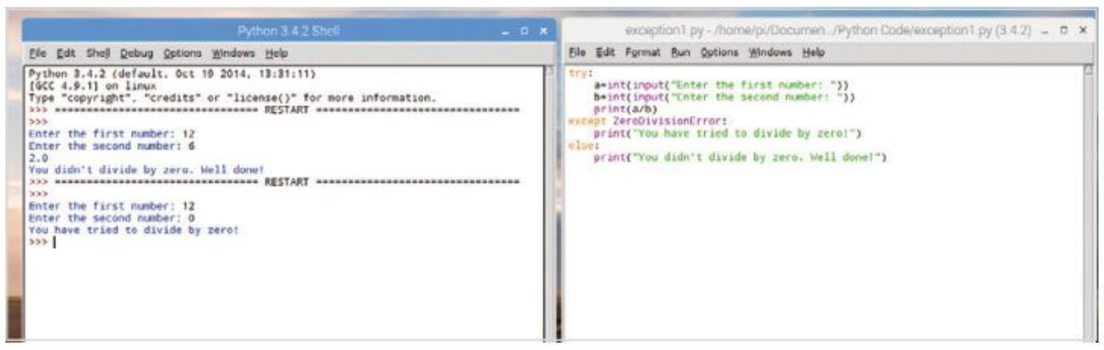


STEP 4 To trap any errors in the code you can encase the potential error within a try: block. This block consists of try, except, else, where the code is held within try:, then if there's an exception do something, else do something else.



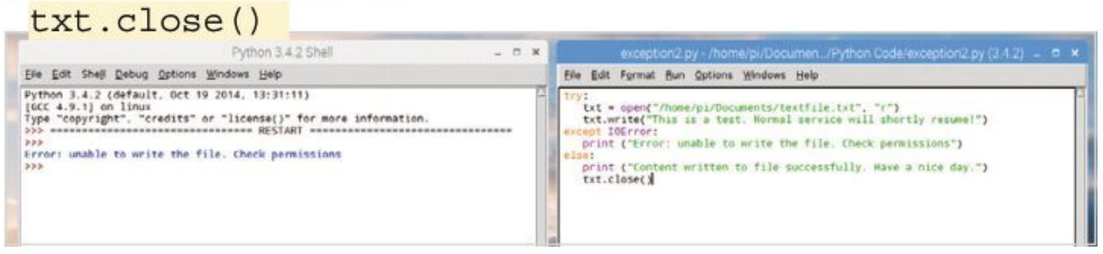
STEP 5 For example, use the divide by zero error. You can create an exception where the code can handle the error without Python quitting due to the problem:

```
try:
  a=int(input("Enter the first number: "))
  b=int(input("Enter the second number: "))
  print(a/b)
except ZeroDivisionError:
  print("You have tried to divide by zero!")
else:
  print("You didn't divide by zero. Well done!")
```

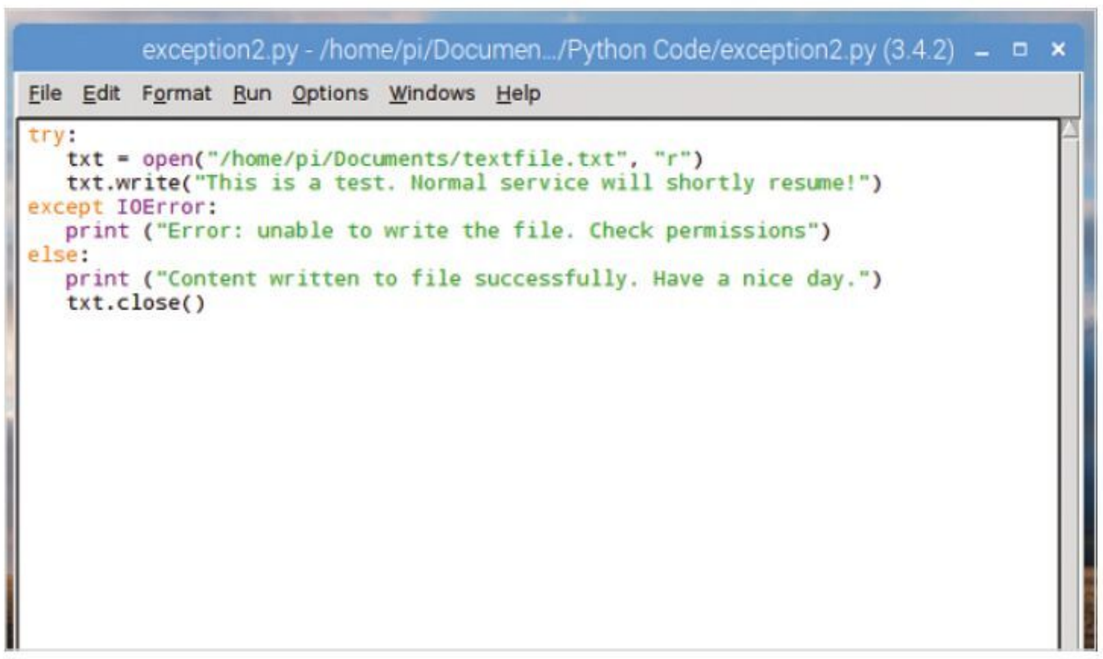


STEP 6 You can use exceptions to handle a variety of useful tasks. Using an example from our previous tutorials, let's assume you want to open a file and write to it:

```
try:
 txt = open("/home/pi/Documents/textfile.txt",
"r")
 txt.write("This is a test. Normal service will
shortly resume!")
except IOError:
 print ("Error: unable to write the file. Check
permissions")
else:
 print ("Content written to file successfully.
Have a nice day.")
 txt.close()
```

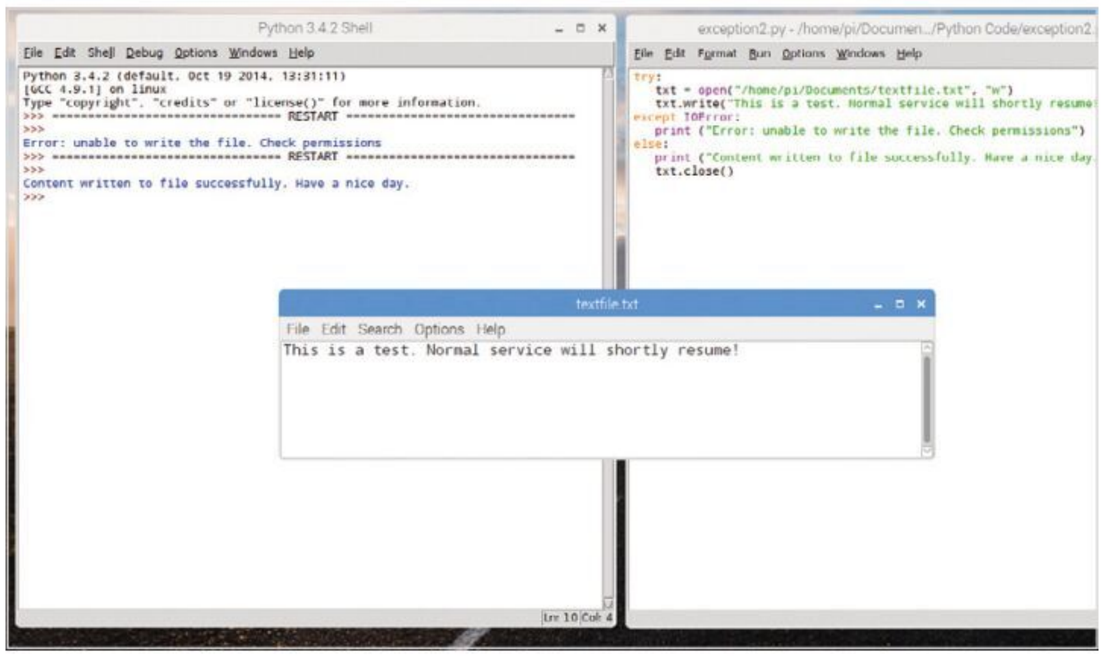


STEP 7 Obviously this won't work due to the file textfile.txt being opened as read only (the "r" part). So in this case rather than Python telling you that you're doing something wrong, you've created an exception using the IOError class informing the user that the permissions are incorrect.



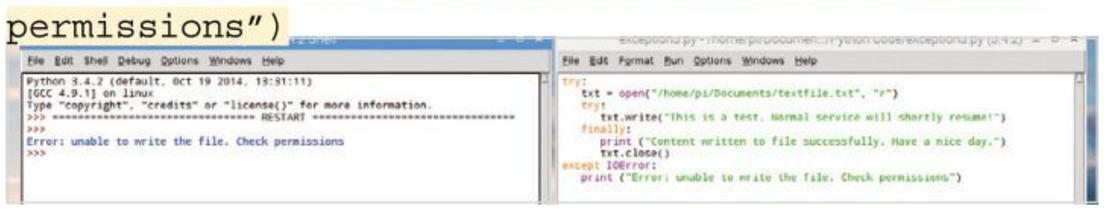
```
try:
   txt = open("/home/pi/Documents/textfile.txt", "r")
   txt.write("This is a test. Normal service will shortly resume!")
except IOError:
   print ("Error: unable to write the file. Check permissions")
else:
   print ("Content written to file successfully. Have a nice day.")
   txt.close()
```

STEP 8 Naturally, you can quickly fix the issue by changing the "r" read only instance with a "w" for write. This, as you already know, will create the file and write the content then commit the changes to the file. The end result will report a different set of circumstances, in this case, a successful execution of the code.

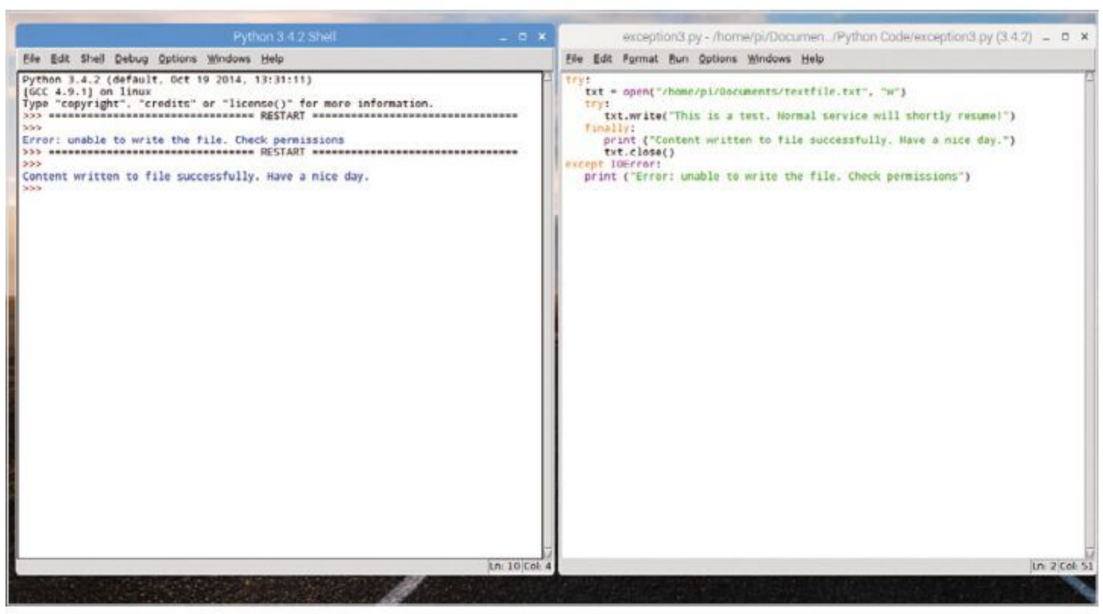


STEP 9 You can also use a finally: block, which works in a similar fashion but you can't use else with it. To use our example from Step 6:

```
try:
 txt = open("/home/pi/Documents/textfile.txt",
"r")
 try:
  txt.write("This is a test. Normal service will
shortly resume!")
 finally:
  print ("Content written to file successfully.
Have a nice day.")
  txt.close()
except IOError:
 print ("Error: unable to write the file. Check
permissions")
```



STEP 10 As before an error will occur as you've used the "r" read-only permission. If you change it to a "w", then the code will execute without the error being displayed in the IDLE Shell. Needless to say, it can be a tricky getting the exception code right the first time. Practise though, and you will get the hang of it.



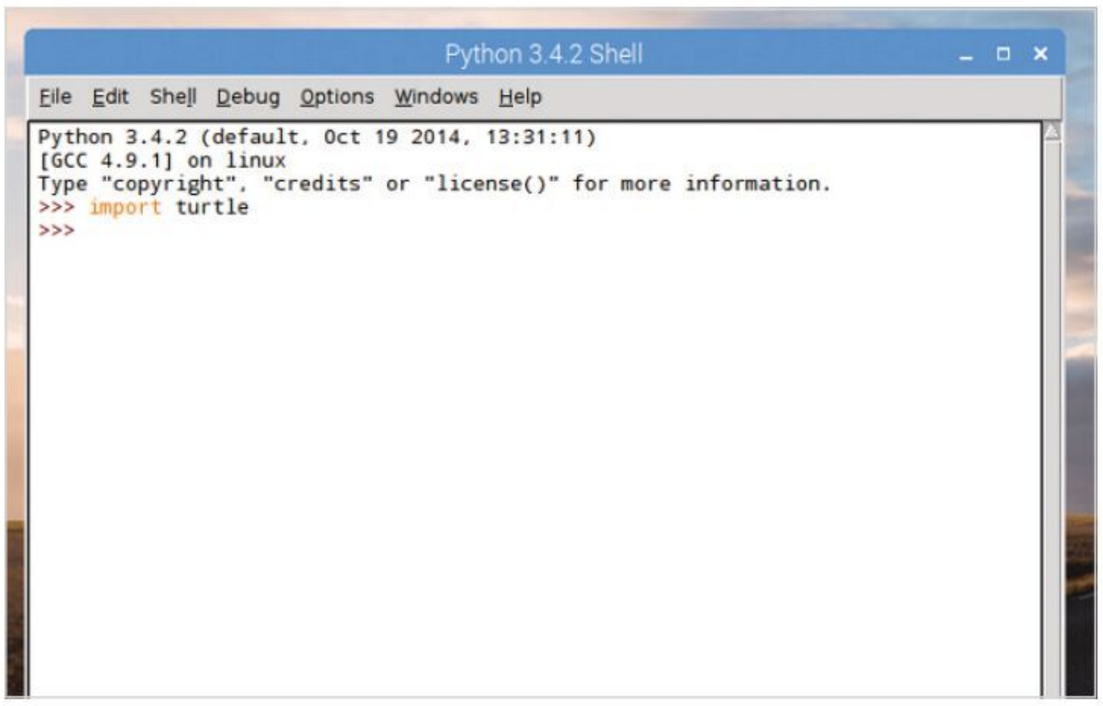
Python Graphics

While dealing with text on the screen, either as a game or in a program, is great, there will come a time when a bit of graphical representation wouldn't go amiss. Python 3 has numerous ways in which to include graphics and they're surprisingly powerful too.

GOING GRAPHICAL

You can draw simple graphics, lines, squares and so on, or you can use one of the many Python modules available, to bring out some spectacular effects.

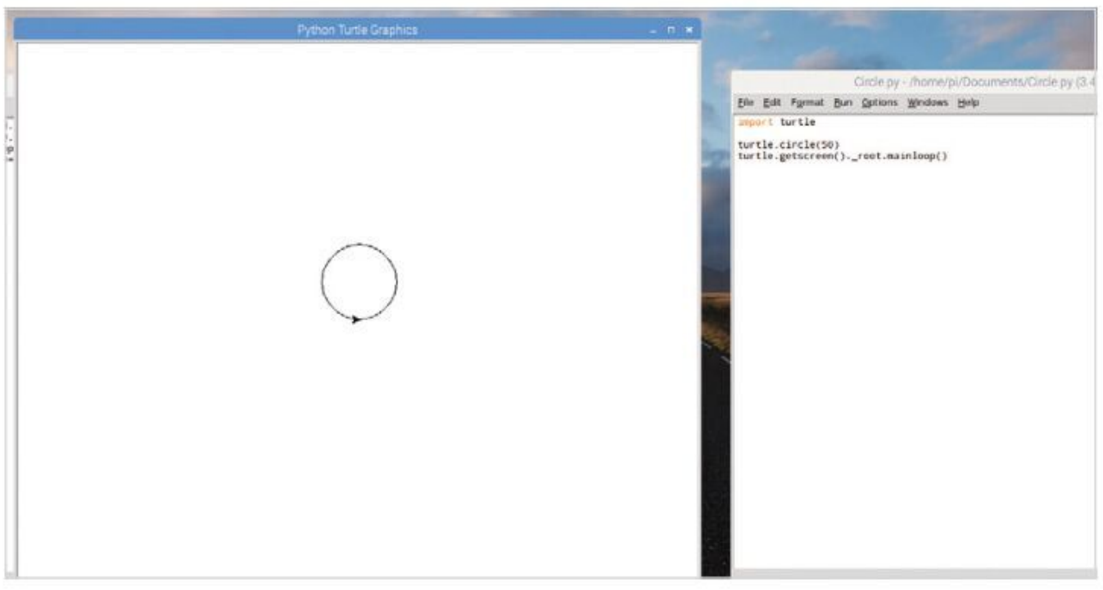
STEP 1 One of the best graphical modules to begin learning Python graphics is Turtle. The Turtle module is, as the name suggests, based on the turtle robots used in many schools, that can be programmed to draw something on a large piece of paper on the floor. The Turtle module can be imported with: `import turtle`.



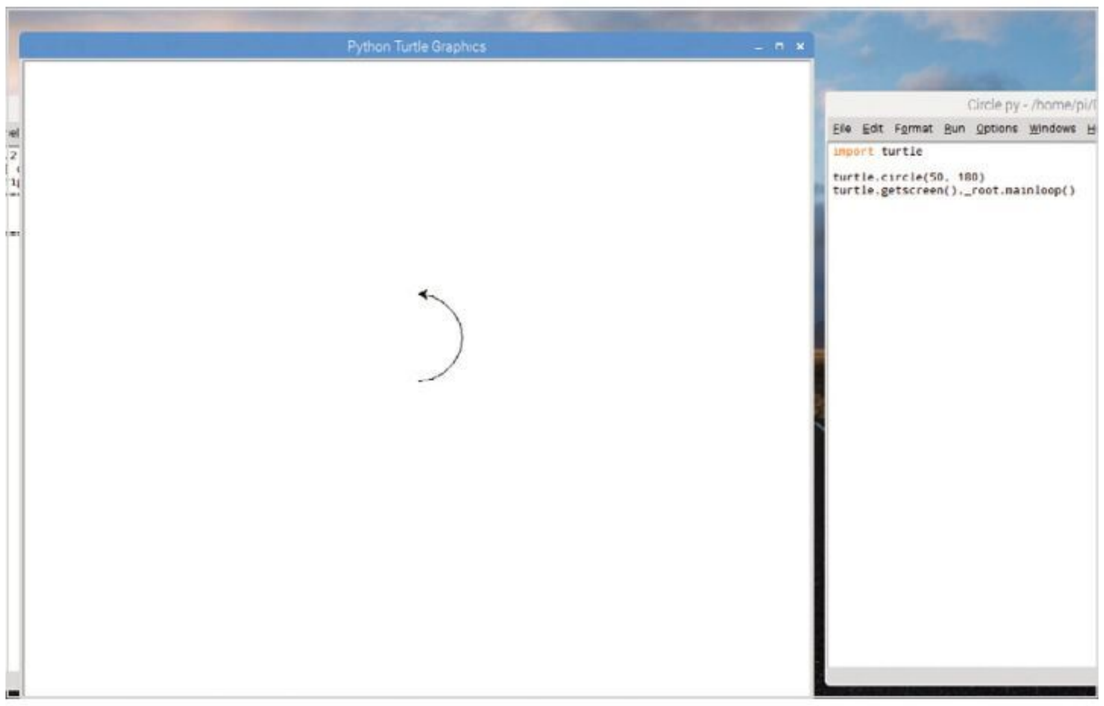
STEP 2 Let's begin by drawing a simple circle. Start a New File, then enter the following code:

```
import turtle

turtle.circle(50)
turtle.getscreen()._root.mainloop()
```

As usual press F5 to save the code and execute it. A new window will now open up and the 'Turtle' will draw a circle.



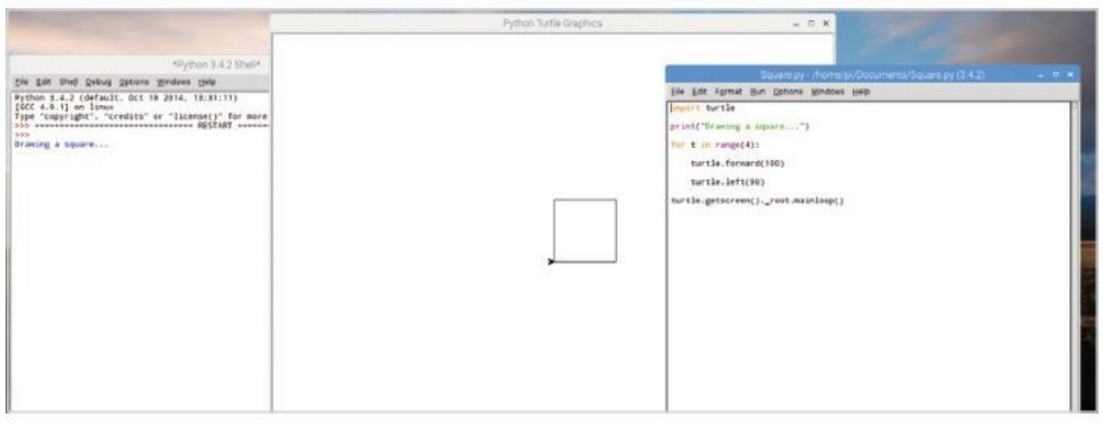
STEP 3 The command turtle.circle(50) is what draws the circle on the screen, with 50 being the size. You can play around with the sizes if you like, going up to 100, 150 and beyond; you can draw an arc by entering: `turtle.circle(50, 180)`, where the size is 50, but you're telling Python to only draw 180° of the circle.



STEP 4 The last part of the circle code tells Python to keep the window where the drawing is taking place to remain open, so the user can click to close it. Now, let's make a square:

```
import turtle

print("Drawing a square...")

for t in range(4):
    turtle.forward(100)
    turtle.left(90)
turtle.getscreen()._root.mainloop()
```

You can see that we've inserted a loop to draw the sides of the square.



STEP 5 You can add a new line to the square code to add some colour:

```
turtle.color("Red")
```

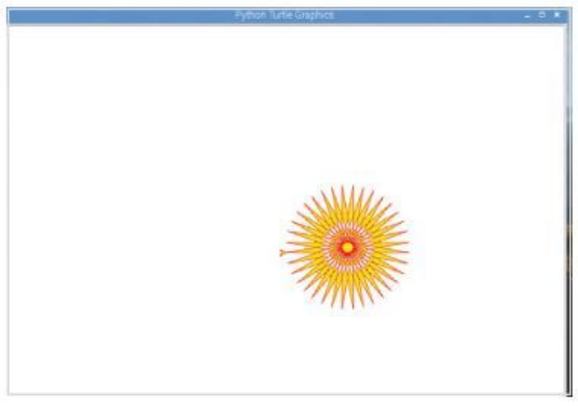
Then you can even change the character to an actual turtle by entering:

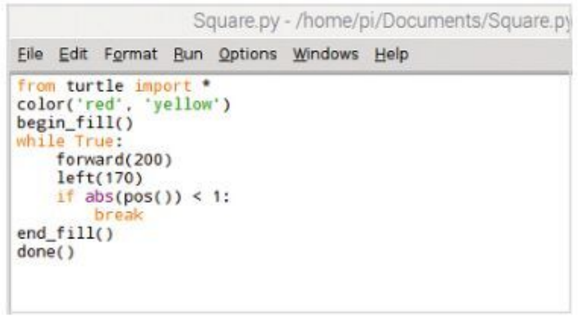
```
turtle.shape("turtle")
```

You can also use the command `turtle.begin_fill()`, and `turtle.end_fill()` to fill in the square with the chosen colours; red outline, yellow fill in this case.

STEP 6 You can see that the Turtle module can draw out some pretty good shapes and become a little more complex as you begin to master the way it works. Enter this example:

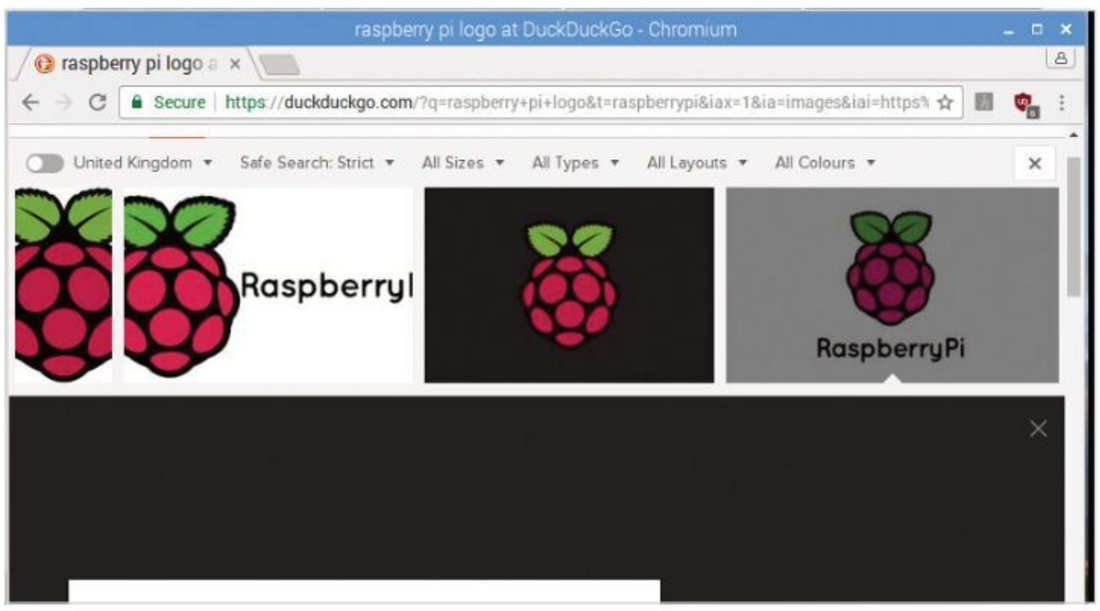
```
from turtle import *
color('red', 'yellow')
begin_fill()
while True:
  forward(200)
  left(170)
  if abs(pos()) < 1:
    break
end_fill()
done()
```





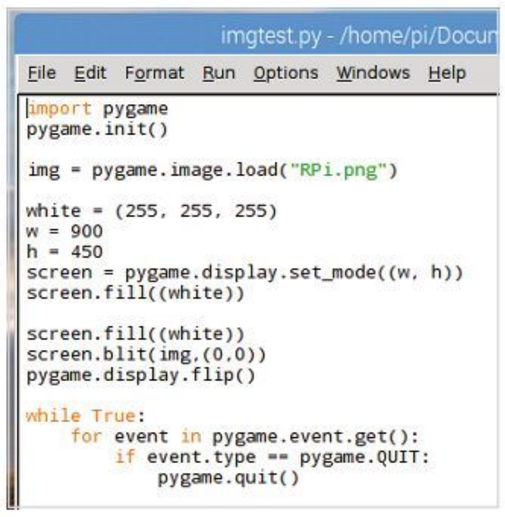
It's a different method, but very effective.

STEP 7 Another way in which you can display graphics is by using the Pygame module. There are numerous ways in which pygame can help you output graphics to the screen but for now let's look at displaying a predefined image. Start by opening a browser and finding an image, then save it to the folder where you save your Python code.



STEP 8 Now let's get the code by importing the Pygame module:

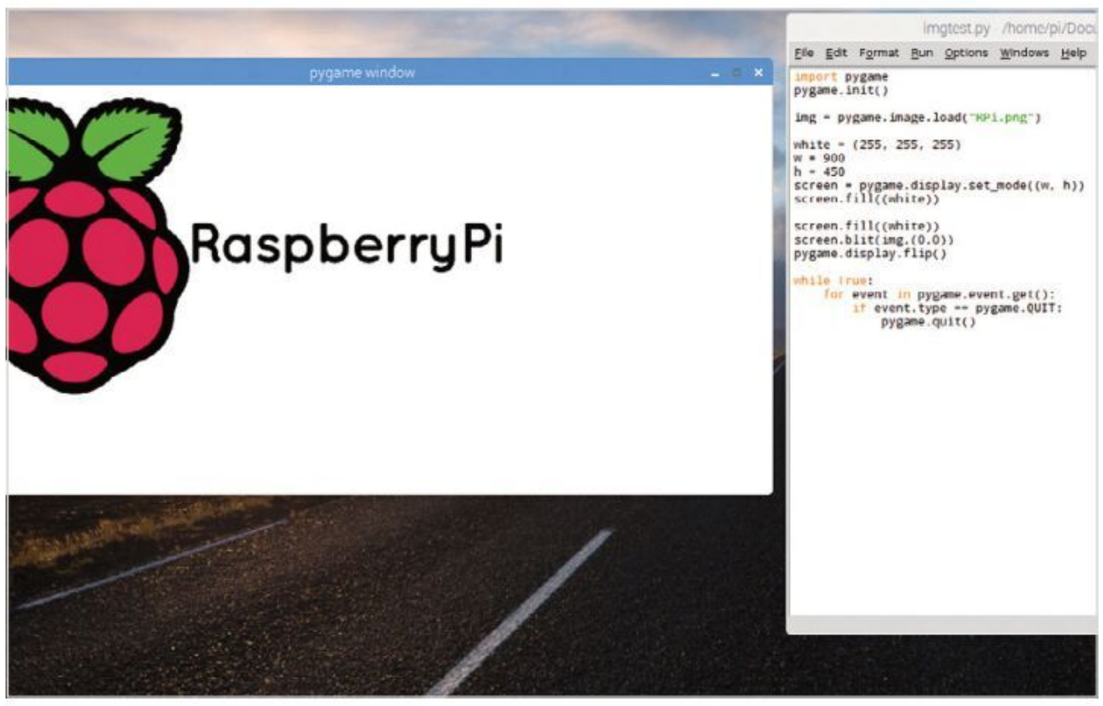
```
import pygame
pygame.init()

img = pygame.image.load("RPi.png")

white = (255, 255, 255)
w = 900
h = 450
screen = pygame.display.
set_mode((w, h))
screen.fill((white))

screen.fill((white))
screen.blit(img,(0,0))
pygame.display.flip()

while True:
  for event in pygame.event.get():
    if event.type == pygame.QUIT:
      pygame.quit()
```



STEP 9 In the previous step you imported pygame, initiated the pygame engine and asked it to import our saved Raspberry Pi logo image, saved as RPi.png. Next you defined the background colour of the window to display the image and the window size as per the actual image dimensions. Finally you have a loop to close the window.

```
w = 900
h = 450
screen = pygame.display.set_mode((w, h))
screen.fill((white))

screen.fill((white))
screen.blit(img,(0,0))
pygame.display.flip()

while True:
    for event in pygame.event.get():
        if event.type == pygame.QUIT:
            pygame.quit()
```

STEP 10 Press F5 to save and execute the code and your image will be displayed in a new window. Have a play around with the colours, sizes and so on and take time to look up the many functions within the Pygame module too.



Combining What You Know So Far

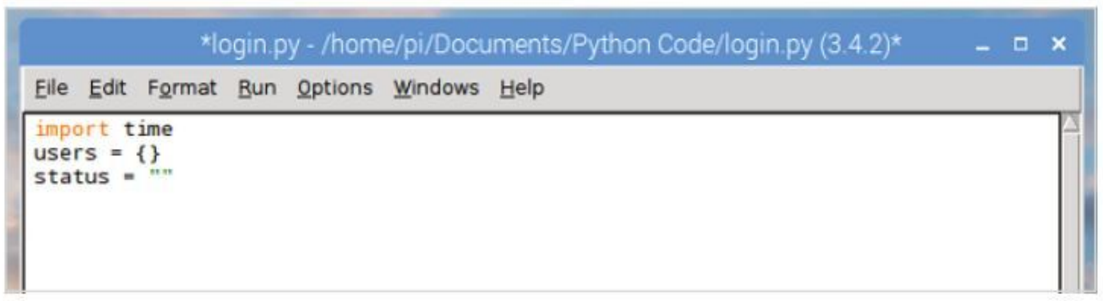
Based on what you've looked at over this section, let's combine it all and come up with a piece of code that can easily be applied into a real-world situation; or at the very least, something which you can incorporate into your programs.

LOGGING IN

For this example, let's look to a piece of code that creates user logins and then allows them to log into the system and write the time they logged in at. You can even include an option to quit the program by pressing 'q'.

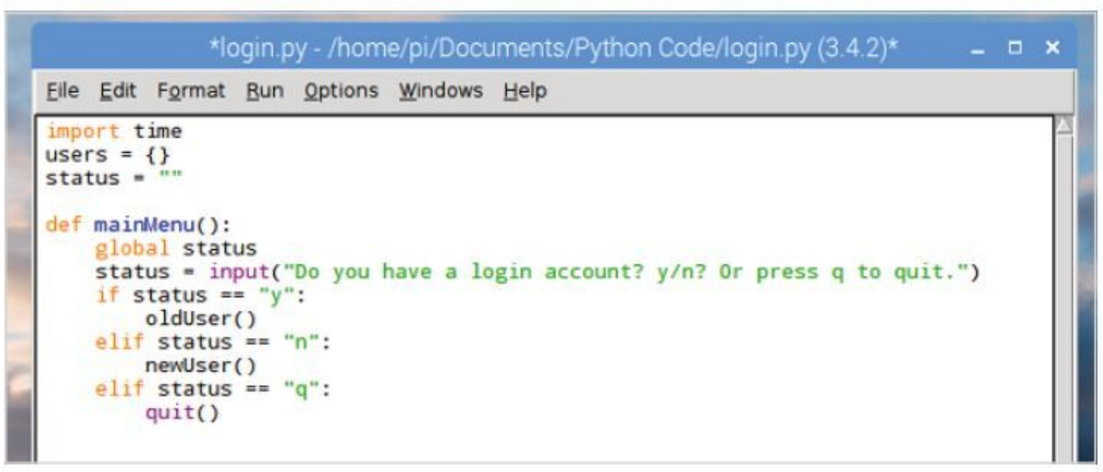
STEP 1 Begin by importing the Time module, creating a new dictionary to handle the usernames and passwords and creating a variable to evaluate the current status of the program:

```
import time
users = {}
status = ""
```



STEP 2 Next you need to define some functions. You can begin by creating the main menu, where all users will return to after selecting the available options:

```
def mainMenu():
  global status
  status = input("Do you have a login account?
y/n? Or press q to quit.")
  if status == "y":
    oldUser()
  elif status == "n":
    newUser()
  elif status == "q":
    quit()
```



STEP 3 The global status statement separates a local variable from one that can be called throughout the code, this way you can use the q=quit element without it being changed inside the function. We've also referenced some newly defined functions: oldUser and newUser which we'll get to next.

```
def mainMenu():
    global status
    status = input("Do you have a login account? y/n? Or press q to quit.")
    if status == "y":
        oldUser()
    elif status == "n":
        newUser()
    elif status == "q":
        quit()
```

STEP 4 The newUser function is next:

```
def newUser():
  createLogin = input("Create a login name: ")

  if createLogin in users:
    print ("\nLogin name already exists!\n")
  else:
    createPassw = input("Create password: ")
    users[createLogin] = createPassw
    print("\nUser created!\n")
    logins=open("/home/pi/Documents/logins.txt",
"a")
    logins.write("\n" + createLogin + " " +
createPassw)
    logins.close()
```

This creates a new user and password, and writes the entries into a file called logins.txt.

STEP 5 You will need to specify your own location for the logins.txt file, since we're using a Raspberry Pi. Essentially, this adds the username and password inputs from the user to the existing users{} dictionary, so the key and value structure remains: each user is the key, the password is the value.

```
def newUser():
    createLogin = input("Create a login name: ")

    if createLogin in users:
        print ("\nLogin name already exists!\n")
    else:
        createPassw = input("Create password: ")
        users[createLogin] = createPassw
        print("\nUser created!\n")
        logins=open("/home/pi/Documents/logins.txt", "a")
        logins.write("\n" + createLogin + " " + createPassw)
        logins.close()
```

STEP 6 Now to create the oldUser function:

```
def oldUser():
  login = input("Enter login name: ")
  passw = input("Enter password: ")

  # check if user exists and login matches
password
  if login in users and users[login] == passw:
    print ("\nLogin successful!\n")
    print ("User:", login, "accessed the system
on:", time.asctime())
  else:
    print ("\nUser doesn't exist or wrong
password!\n")
```

```
    global status
    status = input("Do you have a login account? y/n? Or press q to quit.")
    if status == "y":
        oldUser()
    elif status == "n":
        newUser()
    elif status == "q":
        quit()

def newUser():
    createLogin = input("Create a login name: ")

    if createLogin in users:
        print ("\nLogin name already exists!\n")
    else:
        createPassw = input("Create password: ")
        users[createLogin] = createPassw
        print("\nUser created!\n")
        logins=open("/home/pi/Documents/logins.txt", "a")
        logins.write("\n" + createLogin + " " + createPassw)
        logins.close()

def oldUser():
    login = input("Enter login name: ")
    passw = input("Enter password: ")

    # check if user exists and login matches password
    if login in users and users[login] == passw:
        print ("\nLogin successful!\n")
        print ("User:", login, "accessed the system on:", time.asctime())
    else:
        print ("\nUser doesn't exist or wrong password!\n")
```

STEP 7 There's a fair bit happening here. There are login and passw variables, which are then matched to the users dictionary. If there's a match, then you have a successful login and the time and date of the login is outputted. If they don't match, then you print an error and the process starts again.

```
def oldUser():
    login = input("Enter login name: ")
    passw = input("Enter password: ")

    # check if user exists and login matches password
    if login in users and users[login] == passw:
        print ("\nLogin successful!\n")
        print ("User:", login, "accessed the system on:", time.asctime())
    else:
        print ("\nUser doesn't exist or wrong password!\n")
```

STEP 8 Finally, you need to continually check that the 'q' key hasn't been pressed to exit the program. We can do this with:

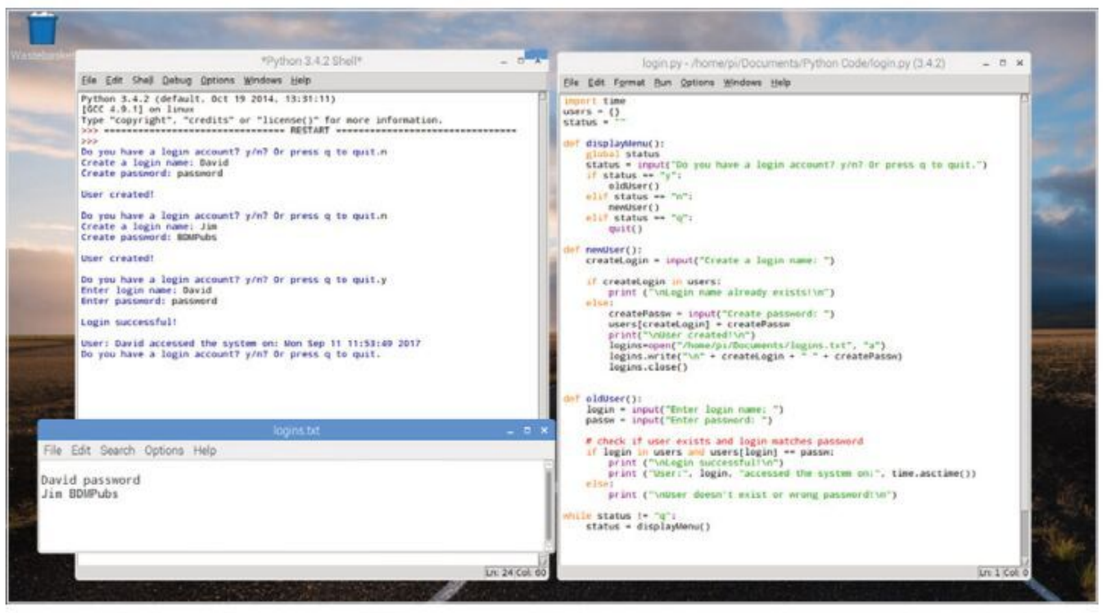
```
while status != "q":
  status = displayMenu()
```

```
*login.py - /home/pi/Documents/Python Code/login.py (3.4.2)*
File Edit Format Run Options Windows Help
import time
users = {}
status = ""

def mainMenu():
    global status
    status = input("Do you have a login account? y/n? Or press q to quit.")
    if status == "y":
        oldUser()
    elif status == "n":
        newUser()
    elif status == "q":
        quit()

def newUser():
    createLogin = input("Create a login name: ")

    if createLogin in users:
        print ("\nLogin name already exists!\n")
    else:
        createPassw = input("Create password: ")
        users[createLogin] = createPassw
        print("\nUser created!\n")
        logins=open("/home/pi/Documents/logins.txt", "a")
        logins.write("\n" + createLogin + " " + createPassw)
        logins.close()

def oldUser():
    login = input("Enter login name: ")
    passw = input("Enter password: ")

    # check if user exists and login matches password
    if login in users and users[login] == passw:
        print ("\nLogin successful!\n")
        print ("User:", login, "accessed the system on:", time.asctime())
    else:
        print ("\nUser doesn't exist or wrong password!\n")

while status != "q":
    status = displayMenu()
```

STEP 9 Although a seemingly minor two lines, the while loop is what keeps the program running. At the end of every function it's checked against the current value of status. If that global value isn't 'q' then the program continues. If it's equal to 'q' then the program can quit.

```
while status != "q":
    status = displayMenu()
```

STEP 10 You can now create users, then log in with their names and passwords, with the logins.txt file being created to store the login data and successful logins being time-stamped. Now it's up to you to further improve the code. Perhaps you can import the list of created users from a previous session and display a graphic upon a successful login?



Python in Focus: Gaming

Although not always considered as the ideal programming language for developing games, Python has come a long way in recent years and is now one of the contributing elements to a huge number of titles.

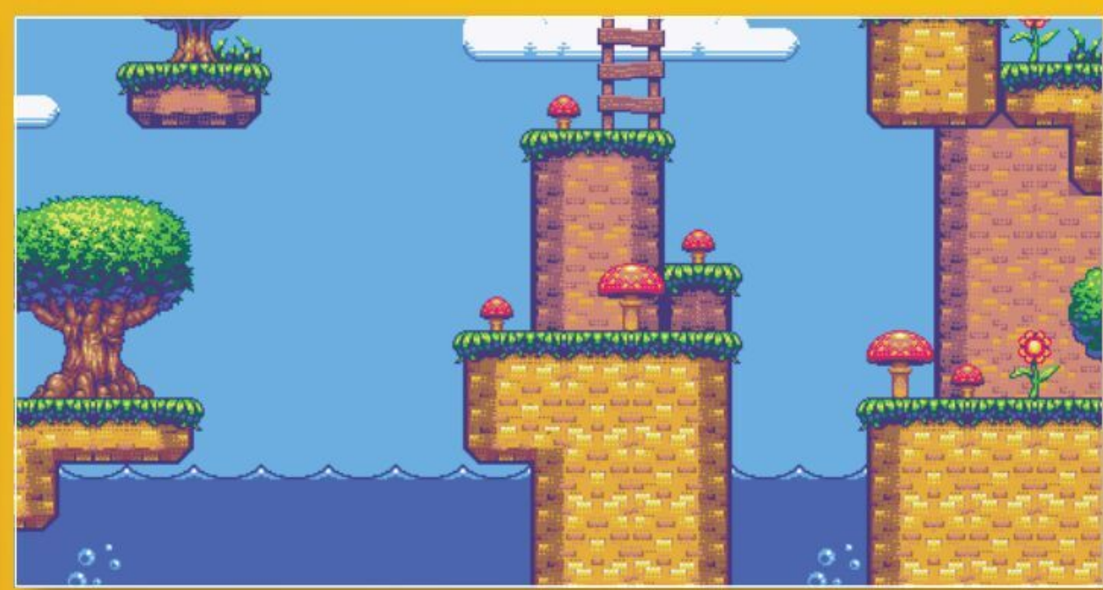
The video game industry generates something in the region of $140 billion each year, and that number is growing fast. It's a long way from the 8-bit days of the Commodore 64 and ZX Spectrum; the arcade titles that used to devour our pocket money and the wood panelled home consoles that Atari lovingly developed. These days, it's all about teams of coders, graphic artists, musicians, PR, projects and development platforms.

GAME CODE

Coding a game from scratch, using raw code, has become something of the past. Most games these days are created using a range of development tools. These tools can be off-the-shelf engines, such as the Unreal Engine, while others are custom built around an original product, such as the world generating engine that Bethesda use for the Skyrim and Fallout series of games. Others examples can be coded from the ground up, but these are generally few and far between. So where does Python fit into all this?

The limiting factor with Python is performance. While most games require a huge degree of performance from the platform for which they are written, Python's code, which is good, isn't really designed to cope with the fast-paced formula on which games such as Battlefield or the Call of Duty series are based. These games are often coded with C++, or some other form of low-level programming language. But that doesn't mean Python is left out in the cold when it comes to game development, in fact it's quite the opposite.

```
MONITOR FOR 6802 1.4          9-14-80  TSC ASSEMBLER  PAGE    2

 C000                    ORG    ROM+$0000 BEGIN MONITOR
 C000 8E 00 70  START    LDS    #STACK

                 ****************************************
                 * FUNCTION: INITA - Initialize ACIA
                 * INPUT: none
                 * OUTPUT: none
                 * CALLS: none
                 * DESTROYS: acc A

 0013            RESETA  EQU    %00010011
 0011            CTLREG  EQU    %00010001

 C003 86 13      INITA   LDA A  #RESETA   RESET ACIA
 C005 B7 80 04           STA A  ACIA
 C008 86 11              LDA A  #CTLREG   SET 8 BITS AND 2 STOP
 C00A B7 80 04           STA A  ACIA

 C00D 7E C0 F1           JMP    SIGNON    GO TO START OF MONITOR

                 ****************************************
                 * FUNCTION: INCH - Input character
                 * INPUT: none
                 * OUTPUT: char in acc A
                 * DESTROYS: acc A
                 * CALLS: none
                 * DESCRIPTION: Gets 1 character from terminal
```



BUILDING TOOLS

In the game industry, Python is mostly limited to the development of in-game tools used by the developers of the game, or to help bridge the gaps between different areas of code. For example, in-game tools coded in Python can be used by designers to create levels for the game, or specific elements that would make up a character's inventory, or even creating dialog between the player and non-playing characters in the game.

You will also find that Python can be used to control the game's AI (Artificial Intelligence), which will give the characters in a game a certain element of life. As an example, the popular Sims games consist of characters other than the one the gamer controls. These Sims will go about their business with their actions determined by the player's choices, this involves an advanced form of Artificial Intelligence that is coded using Python.

Other examples include many of the available open world games, where the introduction of the player will change the course of a village's, Town's, or even city's inhabitant's behaviour. Blow up a few cars in the middle of the street and it'll affect the way the other drivers behave; jump up and down on top of a market stall in the middle of a medieval village and the folk around you will react. This, again, is all down to Python code written within the main code of the game, alongside the game development engine.

PYTHON-POWERED GAMES

Some good examples of the types of games in which Python is used are the following:

Battlefield 2 – Python is used for the game's add-ons and functionality of the player elements.

The Sims – AI, and many of the game's interactions.

Civilisation – Python is used throughout the Civ games, controlling movement and the non-player AI.

Eve Online – Utilises Python for floating point number calculations and other tasks.

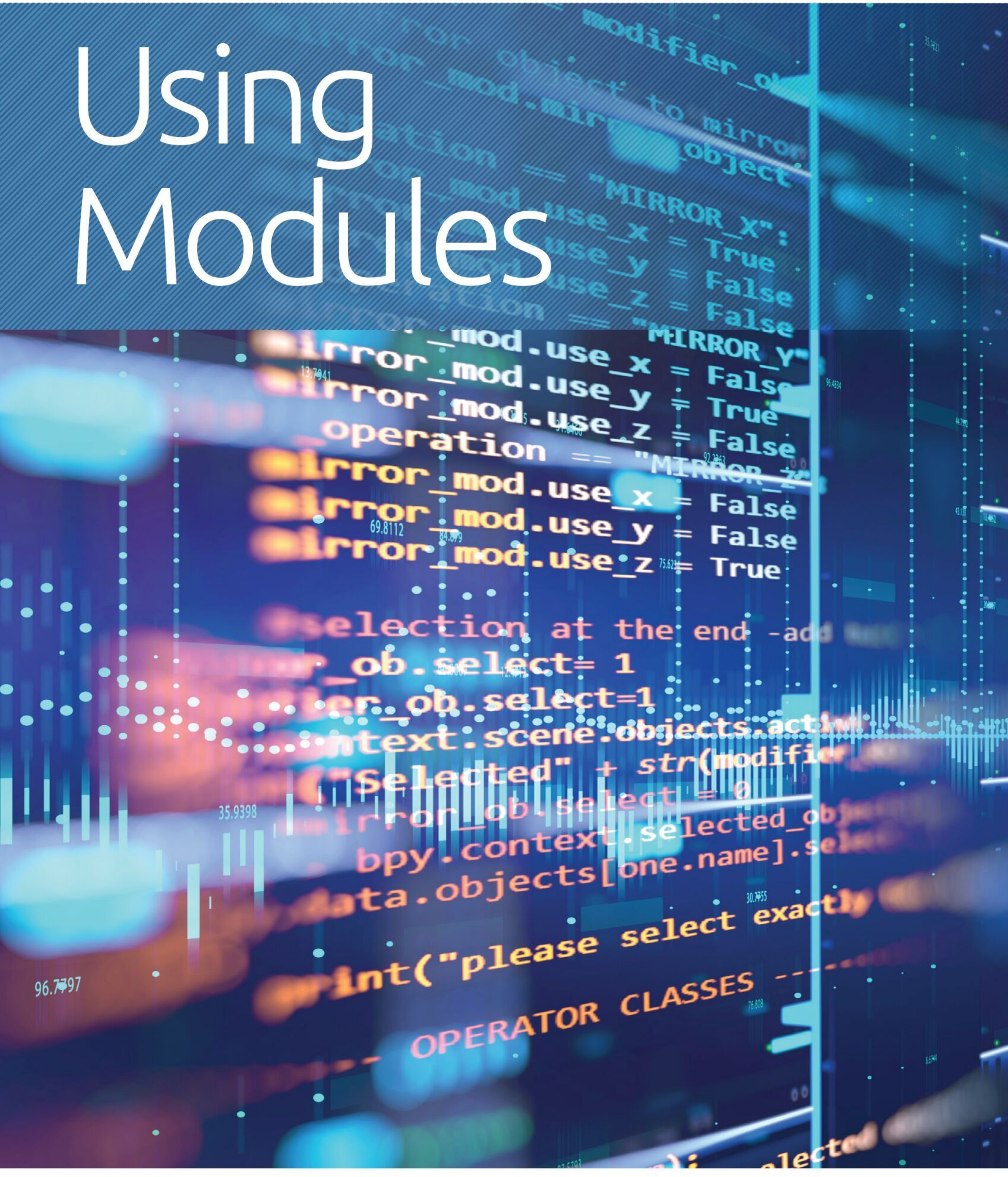
World of Tanks – Python is used to control AI objects and detail the large amount of graphical data.

In particular, it's worth noting that Python's use in games is due to its ability to automate repetitive tasks quickly. While another programming language may be faster at drawing the graphics on the screen, Python can quickly repeat resizing hundreds of textures in batches. There's also Python's excellent and sizeable libraries that can be tweaked for certain tasks, specifically in-game tasks freeing up other components to deliver the performance that modern games need.

KEEP ON GAMING

In short, while Python may not be the ideal language with which to create a modern game entirely, its use is often behind the scenes, in areas where other programming languages will struggle. Python can be used as the glue that sticks elements of game technologies together, creating complex AI or simply designing a dialog box.

Using Modules



A Python module is a Python-created source file that contains the necessary code for classes, functions and global variables. You can bind and reference modules to extend functionality, and create even more spectacular Python programs.

Are you curious about how to improve your use of these modules to add a little something extra to your code? Then read on and learn how they can be used to fashion fantastic code with graphics, animations and operating system specific commands.

90 Calendar Module

92 OS Module

94 Using the Math Module

96 Random Module

98 Tkinter Module

100 Pygame Module

104 Basic Animation

106 Create Your Own Modules

108 Python in Focus: Artificial Intelligence

Calendar Module

Beyond the Time module, the Calendar module can produce some interesting results when executed within your code. It does far more than simply display the date in the Time module-like format, you can actually call up a wall calendar type display.

WORKING WITH DATES

The Calendar module is built into Python 3. However, if for some reason it's not installed you can add it using pip install calendar as a Windows administrator, or sudo pip install calendar for Linux and macOS.

STEP 1 Launch Python 3 and enter: `import calendar` to call up the module and its inherent functions. Once it's loaded into memory, start by entering:

```
sep=calendar.TextCalendar(calendar.SUNDAY)
sep.prmonth(2019, 9)
```

Python 3.5.3 Shell

File Edit Shell Debug Options Window Help

```
Python 3.5.3 (default, Sep 27 2018, 17:25:39)
[GCC 6.3.0 20170516] on linux
Type "copyright", "credits" or "license()" for more information.
>>> import calendar
>>> sep=calendar.TextCalendar(calendar.SUNDAY)
>>> sep.prmonth(2019, 9)
   September 2019
Su Mo Tu We Th Fr Sa
 1  2  3  4  5  6  7
 8  9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30
>>>
>>>
```

STEP 2 You can see that the days of September 2019 are displayed in a wall calendar fashion. Naturally you can change the 2019, 9 part of the second line to any year and month you want, a birthday for example (1973, 6). The first line configures TextCalendar to start its weeks on a Sunday; you can opt for Monday if you prefer.

Python 3.5.3 Shell

File Edit Shell Debug Options Window Help

```
Python 3.5.3 (default, Sep 27 2018, 17:25:39)
[GCC 6.3.0 20170516] on linux
Type "copyright", "credits" or "license()" for more information.
>>> import calendar
>>> sep=calendar.TextCalendar(calendar.SUNDAY)
>>> sep.prmonth(2019, 9)
   September 2019
Su Mo Tu We Th Fr Sa
 1  2  3  4  5  6  7
 8  9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30
>>>
>>> birthday=calendar.TextCalendar(calendar.MONDAY)
>>> birthday.prmonth(1973, 6)
     June 1973
Mo Tu We Th Fr Sa Su
                1  2  3
 4  5  6  7  8  9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30
>>>
```

STEP 3 There are numerous functions within the Calendar module that may be of interest to you when forming your own code. For example, you can display the number of leap years between two specific years:

```
leaps=calendar.leapdays(1900, 2019)
print(leaps)
```

The result is 29, starting from 1904 onward.

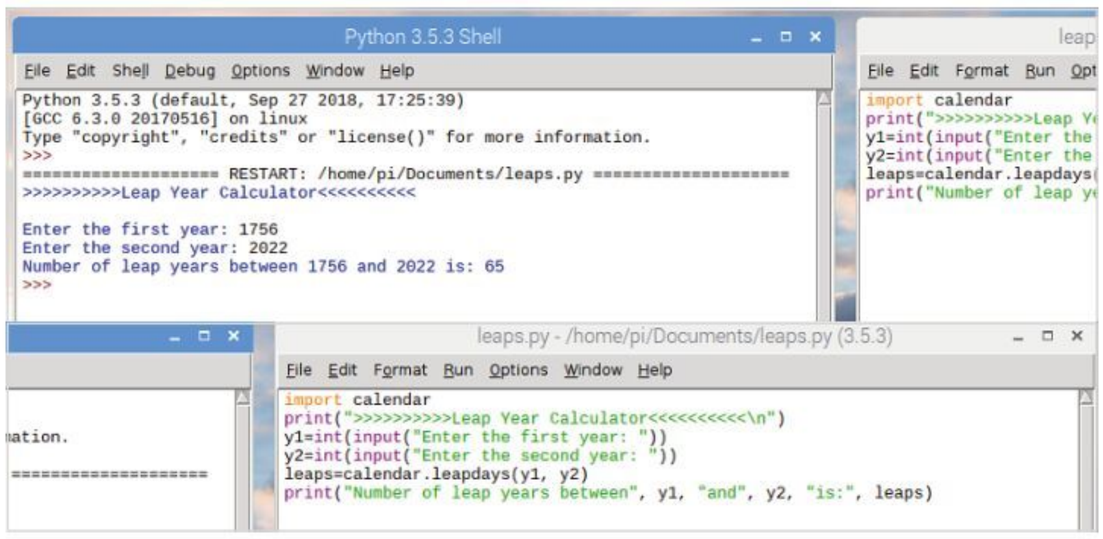
Python 3.5.3 Shell

File Edit Shell Debug Options Window Help

```
Python 3.5.3 (default, Sep 27 2018, 17:25:39)
[GCC 6.3.0 20170516] on linux
Type "copyright", "credits" or "license()" for more information
>>> import calendar
>>> leaps=calendar.leapdays(1900, 2019)
>>> print(leaps)
29
>>>
```

STEP 4 You could even fashion that particular example into a piece of working, user interactive Python code:

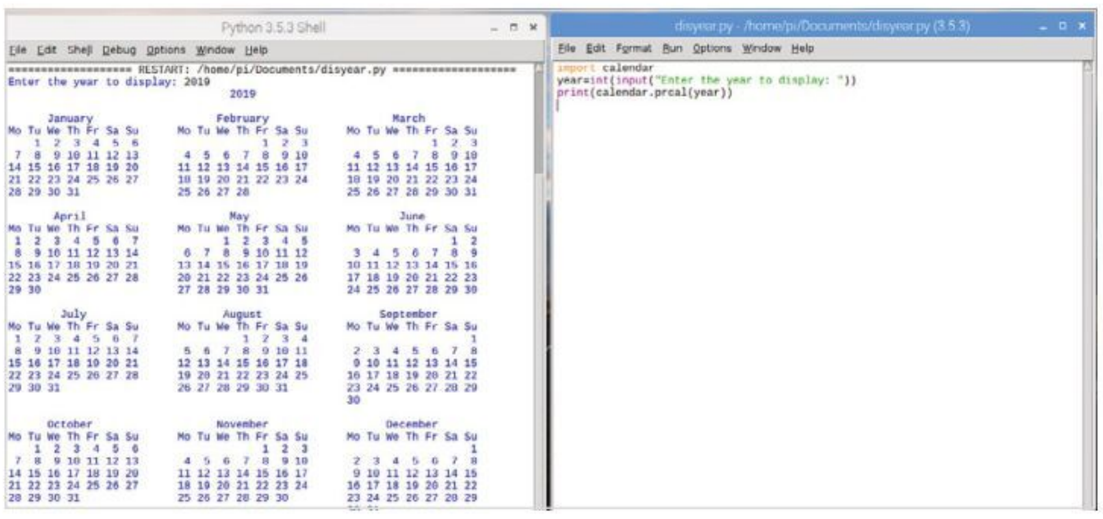
```
import calendar
print(">>>>>>>>>>Leap Year Calculator<<<<<<<<<<\n")
y1=int(input("Enter the first year: "))
y2=int(input("Enter the second year: "))
leaps=calendar.leapdays(y1, y2)
print("Number of leap years between", y1, "and",
y2, "is:", leaps)
```



STEP 5 You can also create a program that will display all the days, weeks and months within a given year:

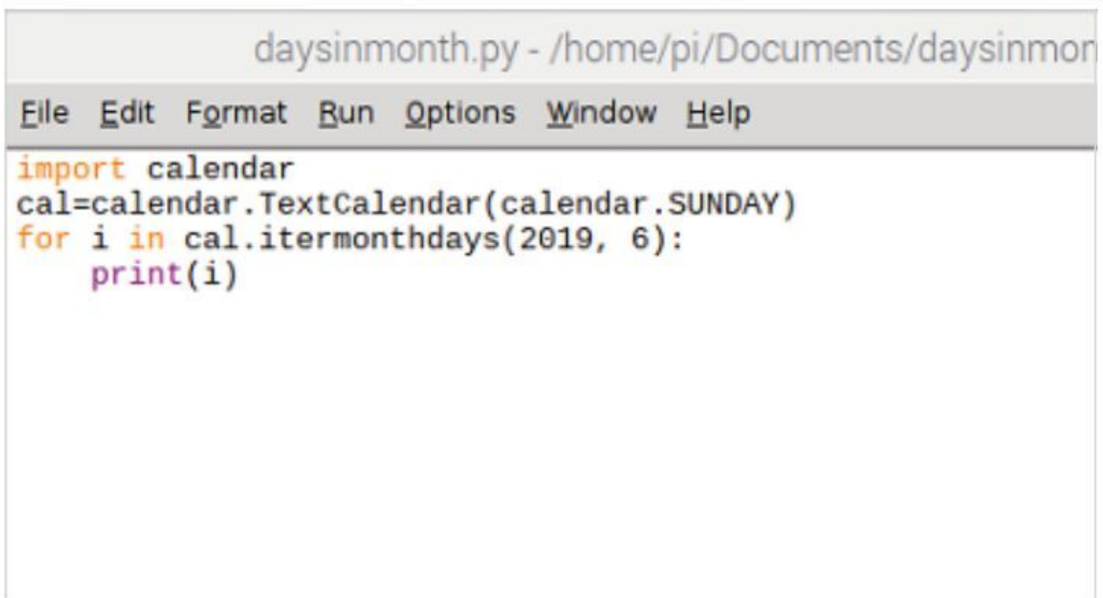
```
import calendar
year=int(input("Enter the year to display: ")
print(calendar.prcal(year))
```

We're sure you'll agree that's quite a handy bit of code to have to hand.

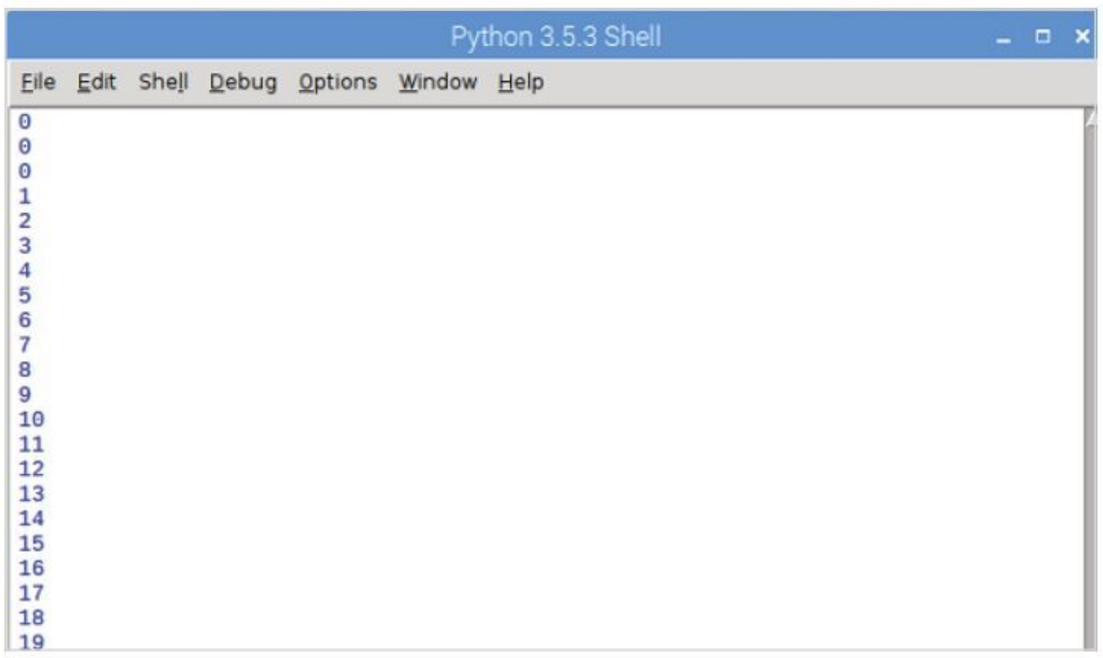


STEP 6 Interestingly we can also list the number of days in a month by using a simple: for loop:

```
import calendar
cal=calendar.TextCalendar(calendar.SUNDAY)
for i in cal.itermonthdays(2019, 6):
        print(i)
```



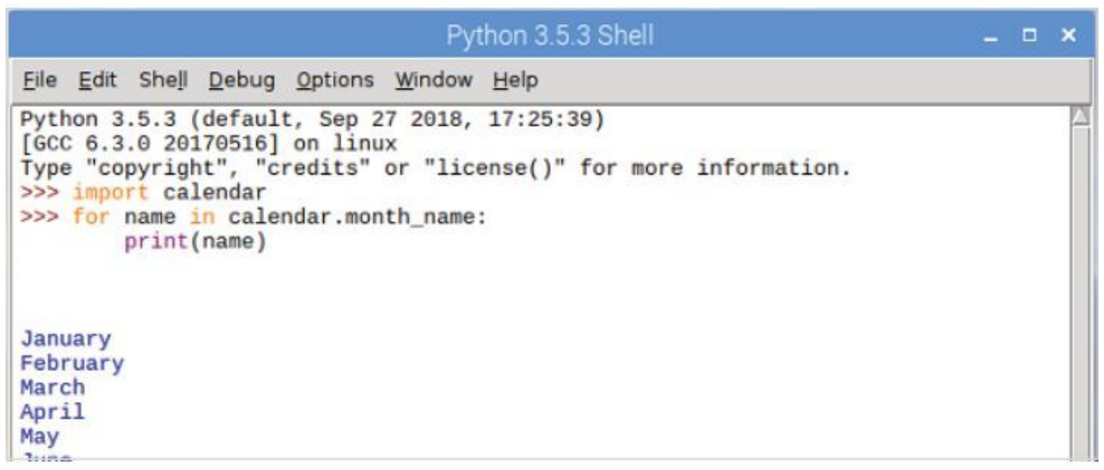
STEP 7 You can see that, at the outset, the code produced some zeros. This is due to the starting day of the week, Sunday in this case, plus overlapping days from the previous month. Meaning the counting of the days will start on Saturday 1st June 2019 and will total 30, as the output correctly displays.



STEP 8 You're also able to print the individual months, or days, of the week:

```
import calendar
for name in calendar.month_name:
   print(name)
```

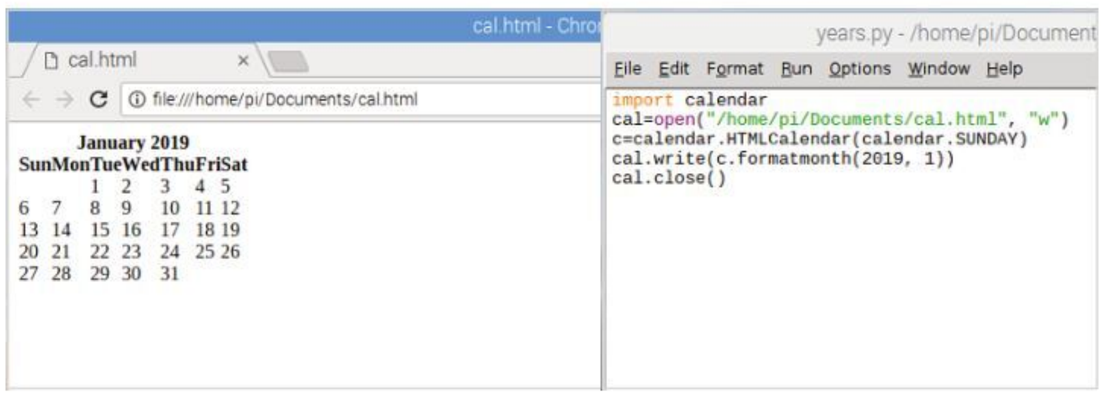
```
import calendar
for name in calendar.day_name:
   print(name)
```



STEP 9 The Calendar module also allows us to write the functions in HTML, so that you can display it on a website. Let's start by creating a new file:

```
import calendar
cal=open("/home/pi/Documents/cal.html", "w")
c=calendar.HTMLCalendar(calendar.SUNDAY)
cal.write(c.formatmonth(2019, 1))
cal.close()
```

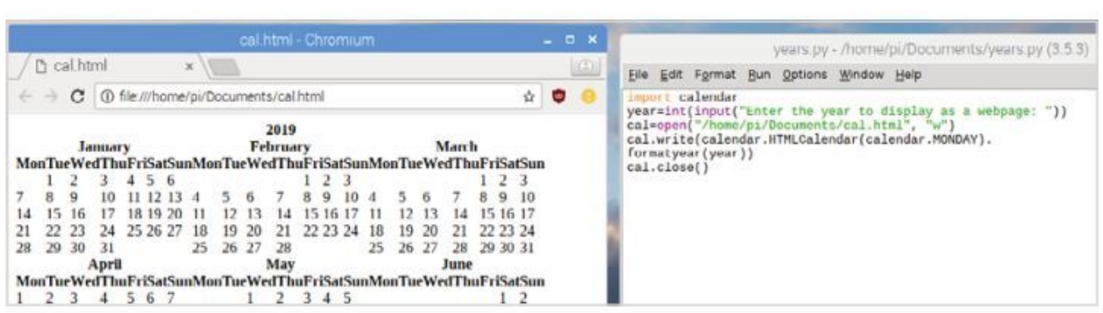
This code will create an HTML file called cal, open it with a browser and it displays the calendar for January 2019.



STEP 10 Of course, you can modify that to display a given year as a web page calendar:

```
import calendar
year=int(input("Enter the year to display as a
webpage: "))
cal=open("/home/pi/Documents/cal.html", "w")
cal.write(calendar.HTMLCalendar(calendar.MONDAY).
formatyear(year))
cal.close()
```

This code asks the user for a year and then creates the necessary webpage. Remember to change your file destination.



OS Module

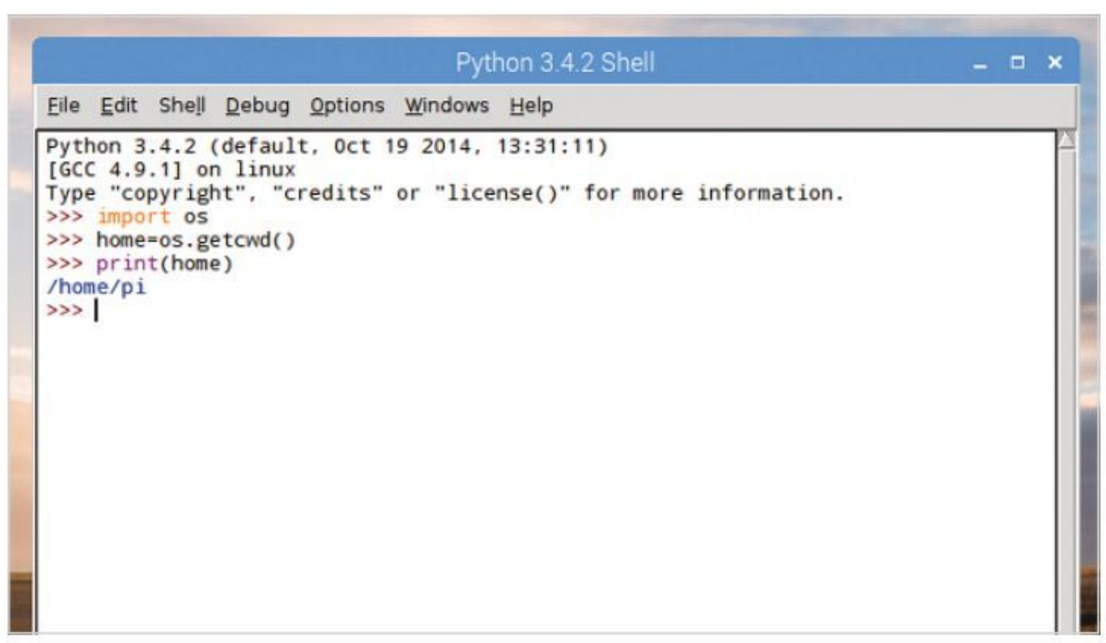
The OS module allows you to interact directly with the built-in commands found in your operating system. Commands vary depending on the OS you're running, as some will work with Windows whereas others will work with Linux and macOS.

INTO THE SYSTEM

One of the primary features of the OS module is the ability to list, move, create, delete and otherwise interact with files stored on the system, making it the perfect module for backup code.

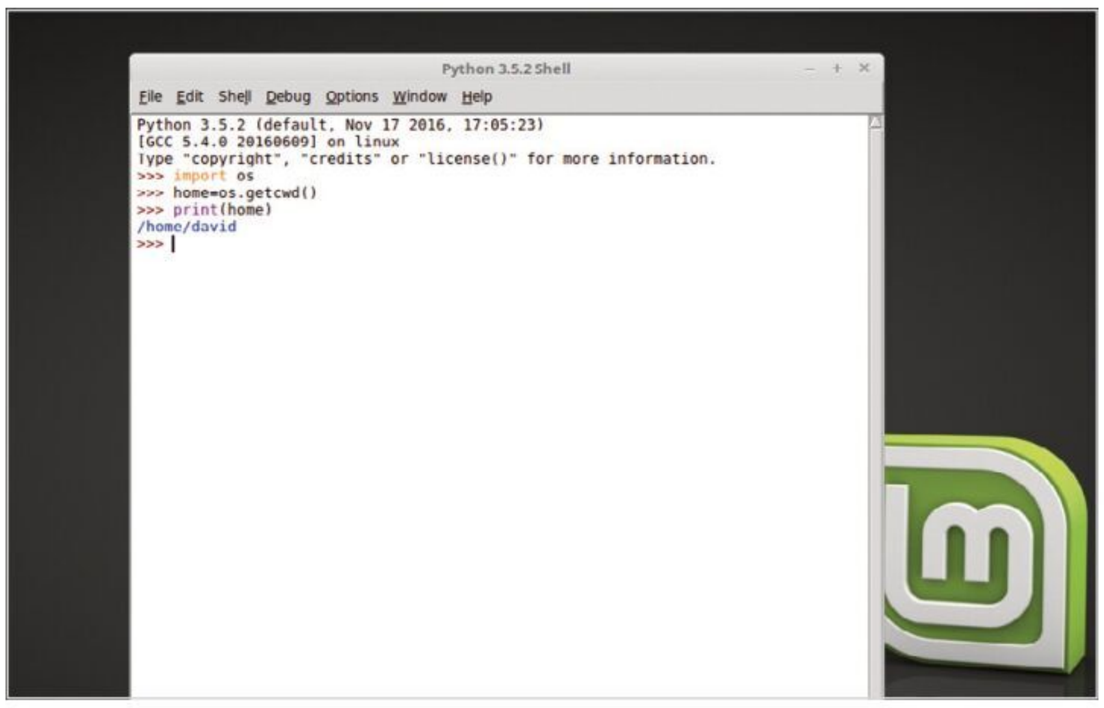
STEP 1 You can start the OS module with some simple functions to see how it interacts with the operating system environment that Python is running on. If you're using Linux or the Raspberry Pi, try this:

```
import os
home=os.getcwd()
print(home)
```



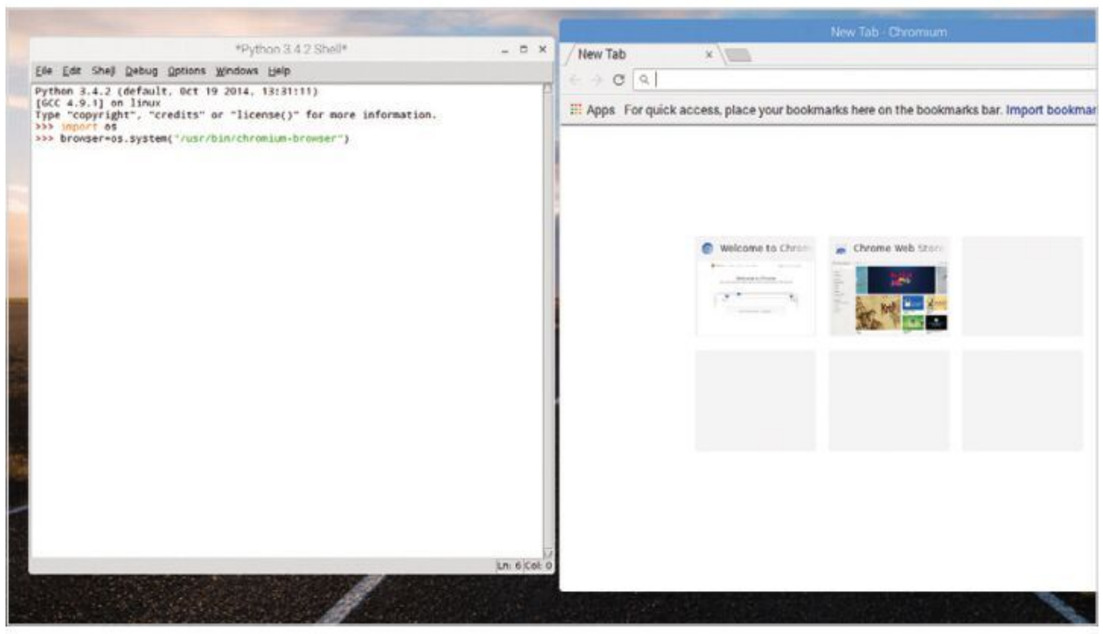
STEP 2 The returned result from printing the variable home is the current user's home folder on the system. In our example that's /home/pi; it will be different depending on the user name you log in as and the operating system you use. For example, Windows 10 will output: C:\Program Files (x86)\Python36-32.

STEP 3 The Windows output is different as that's the current working directory of Python, as determined by the system; as you might suspect, the os.getcwd() function is asking Python to retrieve the Current Working Directory. Linux users will see something along the same lines as the Raspberry Pi, as will macOS users.



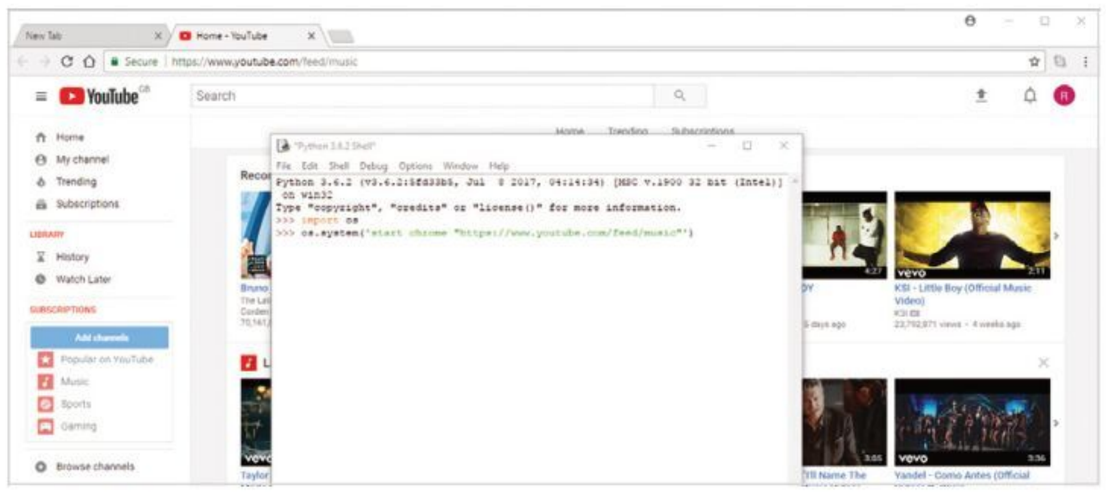
STEP 4 Yet another interesting element to the OS module, is its ability to launch programs that are installed in the host system. For instance, if you wanted to launch the Chromium browser from within a Python program you can use the command:

```
import os
browser=os.system("/usr/bin/chromium-browser")
```



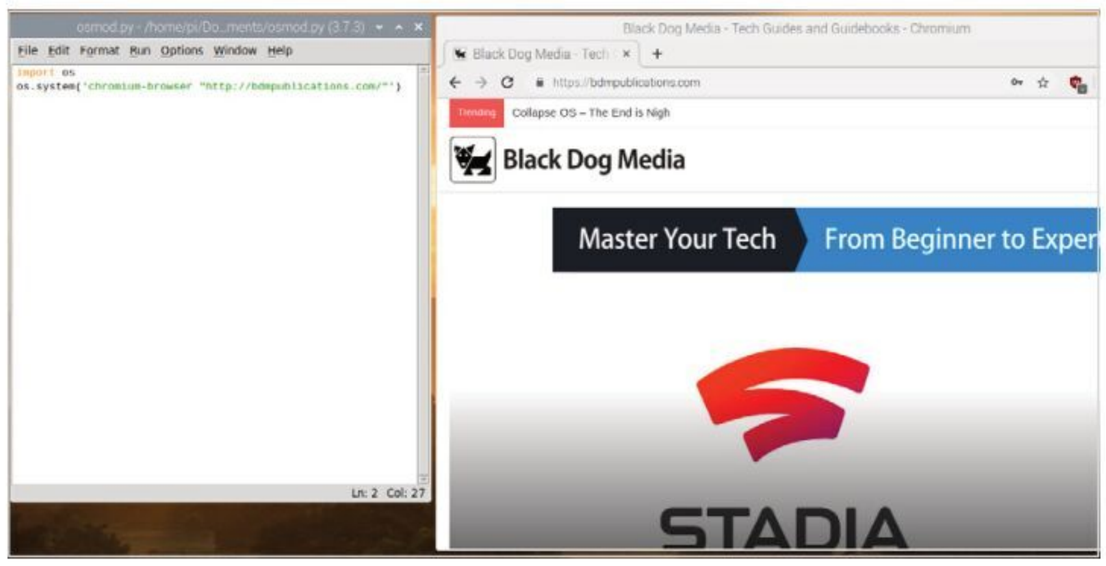
STEP 5 The os.system() function is what allows interaction with external programs; you can even call up previous Python programs using this method. You will obviously need to know the full path and program file name for it to work successfully. However, you can use the following:

```
import os
os.system('start chrome "https://www.youtube.com/feed/music"')
```



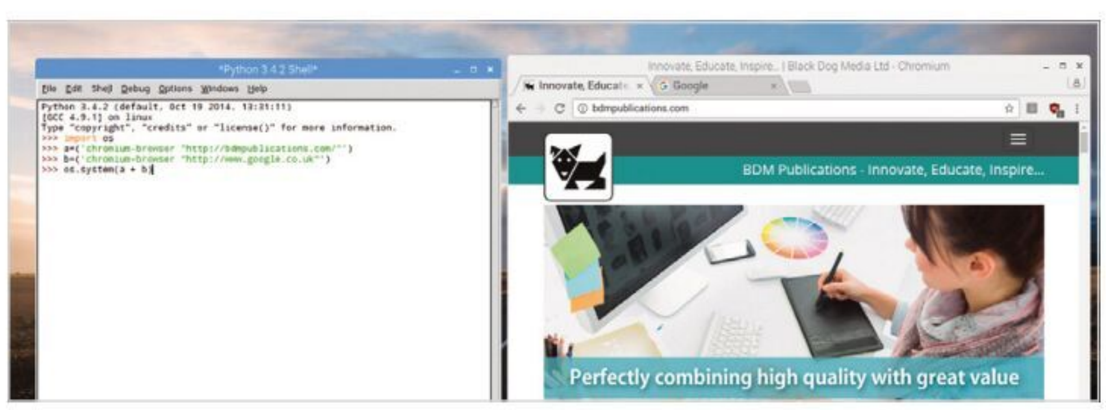
STEP 6 For Step 5's example we used Windows, to show that the OS module works roughly the same across all platforms. In that case, we opened YouTube's music feed page, so it is therefore possible to open specific pages:

```
import os
os.system('chromium-browser "http://bdmpublications.com/"')
```



STEP 7 Note in the previous step's example the use of single and double-quotes. The single quotes encase the entire command and launching Chromium, whereas the double quotes open the specified page. You can even use variables to call multiple tabs in the same browser:

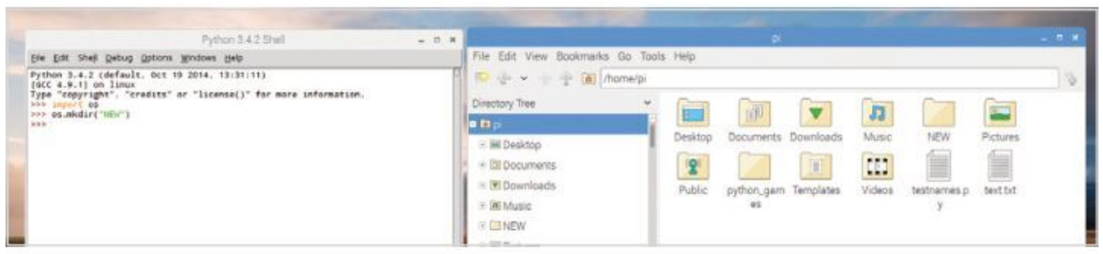
```
import os
a=('chromium-browser "http://bdmpublications.com/"')
b=('chromium-browser "http://www.google.co.uk"')
os.system(a + b)
```



STEP 8 The ability to manipulate directories, or folders if you prefer, is one of the OS module's best features. For example, to create a new directory you can use:

```
import os
os.mkdir("NEW")
```

This creates a new directory within the Current Working Directory, named according to the object in the mkdir function.

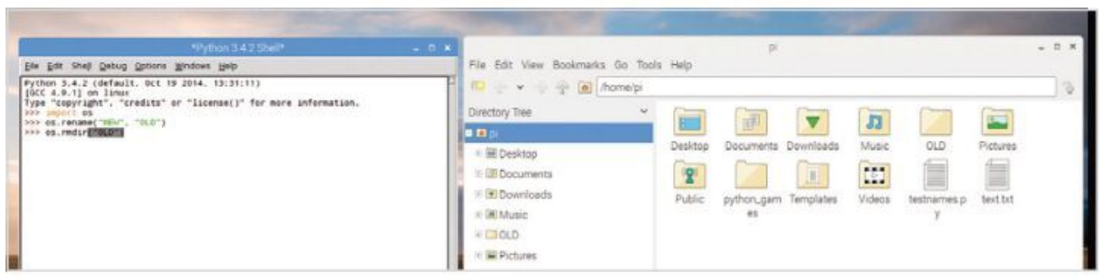


STEP 9 You can also rename any directories you've created by entering:

```
import os
os.rename("NEW", "OLD")
```

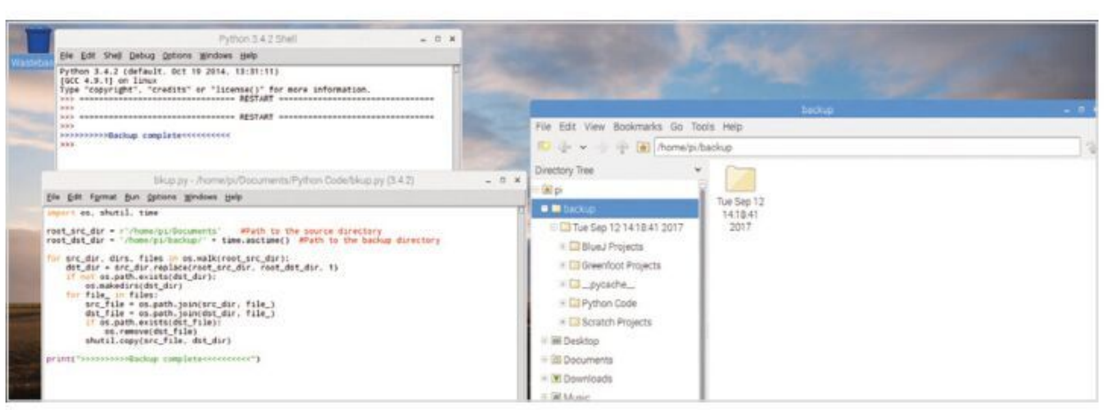
To delete them:

```
import os
os.rmdir("OLD")
```



STEP 10 Another module that goes together with OS is shutil. You can use the Shutil module together with OS and time to create a time-stamped backup directory, and copy files into it:

```
import os, shutil, time

root_src_dir = r'/home/pi/Documents'
root_dst_dir = '/home/pi/backup/' + time.asctime()

for src_dir, dirs, files in os.walk(root_src_dir):
  dst_dir = src_dir.replace(root_src_dir, root_dst_dir, 1)
  if not os.path.exists(dst_dir):
    os.makedirs(dst_dir)
  for file_ in files:
    src_file = os.path.join(src_dir, file_)
    dst_file = os.path.join(dst_dir, file_)
    if os.path.exists(dst_file):
      os.remove(dst_file)
    shutil.copy(src_file, dst_dir)

print(">>>>>>>>>>Backup complete<<<<<<<<<<")
```



Using the Math Module

One of the most used modules you will come across is the Math module. As we've mentioned previously in this book, mathematics is the backbone of programming and there's an incredible number of uses the Math module can have in your code.

E = MC²

The Math module provides access to a plethora of mathematical functions, from simply displaying the value of Pi, to helping you create complex 3D shapes.

STEP 1 The Math module is built-in to Python 3; so there's no need to PIP install it. As with the other modules present, you can import the module's function by simply entering `import math` into the Shell, or as part of your code in the Editor.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> import math
>>> |
```

STEP 2 Importing the Math module will give you access to the module's code. From there, you can call up any of the available functions within Math by using `math`, followed by the name of the function in question. For example, enter:

```
math.sin(2)
```

This displays the sine of 2.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> import math
>>> math.sin(2)
0.9092974268256817
>>> |
```

STEP 3 As you will no doubt be aware by now, if you know the name of the individual functions within the module you can specifically import them. For instance, the Floor and Ceil functions round down and up a float:

```
from math import floor, ceil
floor(1.2) # returns 1
ceil(1.2) # returns 2
```

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> from math import floor, ceil
>>> floor(1.2)
1
>>> ceil(1.2)
2
>>>
```

STEP 4 The Math module can also be renamed as you import it, as with the other modules on offer within Python. This often saves time, but don't forget to make a comment to show someone else looking at your code what you've done:

```
import math as m
m.trunc(123.45) # Truncate removes the fraction
```

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> import math as m
>>> m.trunc(123.45)
123
>>>
```

STEP 5 Although it's not common practise, it is possible to import functions from a module and rename them. In this example, we're importing Floor from Math and renaming it to f. Although where lengthy code is in use, this process can quickly become confusing:

```
from math import floor as f
f(1.2)
```

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> from math import floor as f
>>> f(1.2)
1
>>>
```

STEP 6 Importing all the functions of the Math Module can be done by entering:

```
from math import *
```

While certainly handy, this is often frowned upon by the developer community as it takes up unnecessary resources and isn't an efficient way of coding. However, if it works for you then go ahead.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> from math import *
>>> sqrt(16)
4.0
>>> cos(2)
-0.4161468365471424
>>>
```

STEP 7 Interestingly, some functions within the Math module are more accurate, or to be more precise are designed to return a more accurate value, than others. For example:

```
sum([.1, .1, .1, .1, .1, .1, .1, .1, .1, .1])
```

will return the value of 0.999999999. Whereas:

```
fsum([.1, .1, .1, .1, .1, .1, .1, .1, .1, .1])
```

returns the value of 1.0.

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> from math import *
>>> sum([.1, .1, .1, .1, .1, .1, .1, .1, .1, .1])
0.9999999999999999
>>> fsum([.1, .1, .1, .1, .1, .1, .1, .1, .1, .1])
1.0
>>>
```

STEP 8 For further accuracy, when it comes to numbers the exp and expm1 functions can be used to compute precise values:

```
from math import exp, expm1
exp(1e-5) - 1 # value accurate to 11 places
expm1(1e-5) # result accurate to full precision
```

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> from math import exp, expm1
>>> exp(1e-5) - 1
1.0000050000069649e-05
>>> expm1(1e-5)
1.0000050000166668e-05
>>>
```

STEP 9 This level of accuracy is really quite impressive, but quite niche for the most part. Probably the two most used functions are **e** and **Pi**, where e is the numerical constant equal to 2.71828 (where the circumference of a circle is divided by its diameter):

```
import math
print(math.e)
print(math.pi)
```

```
Python 3.4.2 Shell
File Edit Shell Debug Options Windows Help
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> import math
>>> print(math.e)
2.718281828459045
>>> print(math.pi)
3.141592653589793
>>>
```

STEP 10 The wealth of mathematical functions available through the Math module is vast and covers everything from factors to infinity, powers to trigonometry and angular conversion to constants. Look up **https://docs.python.org/3/library/math.html#** for a list of available Math module functions.

9.2.4. Angular conversion

math.**degrees**(x)
Convert angle x from radians to degrees.

math.**radians**(x)
Convert angle x from degrees to radians.

9.2.5. Hyperbolic functions

Hyperbolic functions are analogs of trigonometric functions that are based on hyperbolas instead of circles.

math.**acosh**(x)
Return the inverse hyperbolic cosine of x.

math.**asinh**(x)
Return the inverse hyperbolic sine of x.

math.**atanh**(x)
Return the inverse hyperbolic tangent of x.

math.**cosh**(x)
Return the hyperbolic cosine of x.

math.**sinh**(x)
Return the hyperbolic sine of x.

math.**tanh**(x)
Return the hyperbolic tangent of x.

9.2.6. Special functions

math.**erf**(x)
Return the error function at x.

The erf() function can be used to compute traditional statistical functions such as the cumulative standard normal distribution:

```
def phi(x):
    'Cumulative distribution function for the standard normal distribution'
    return (1.0 + erf(x / sqrt(2.0))) / 2.0
```

Random Module

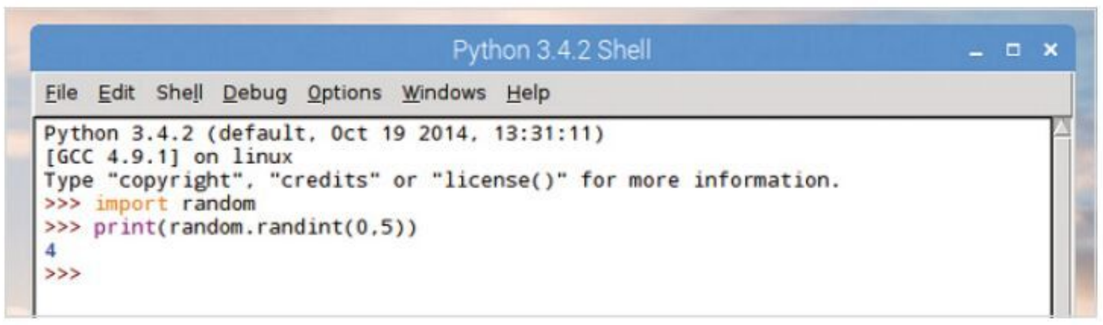
The Random module is one you will likely come across many times in your Python programming lifetime; as the name suggests, it's designed to create random numbers or letters. However, it's not exactly random but it will suffice for most needs.

RANDOM NUMBERS

There are numerous functions within the Random module, which when applied can create some interesting and very useful Python programs.

STEP 1 Just as with other modules you need to import random before you can use any of the functions we're going to look at in this tutorial. Let's begin by simply printing a random number from 1 to 5:

```
import random
print(randomint(0,5))
```

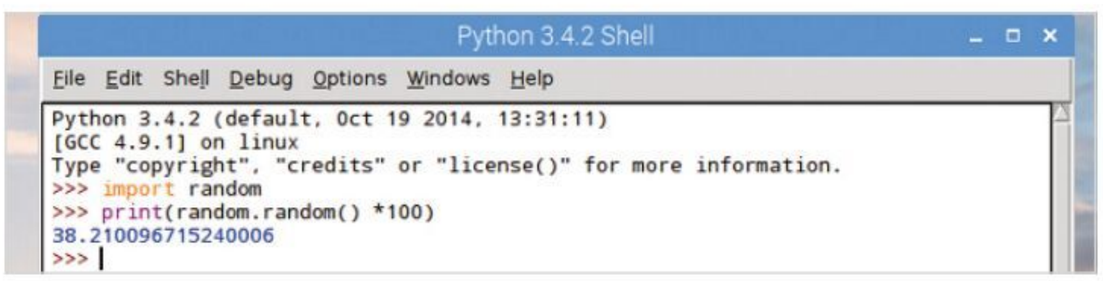


STEP 2 In our example the number four was returned. However, enter the print function a few more times and it will display different integer values from the set of numbers given, zero to five. The overall effect, although pseudo-random, is adequate for the average programmer to utilise in their code.

STEP 3 For a bigger set of numbers, including floating point values, you can extend the range by using the multiplication sign:

```
import random
print(random.random() *100)
```

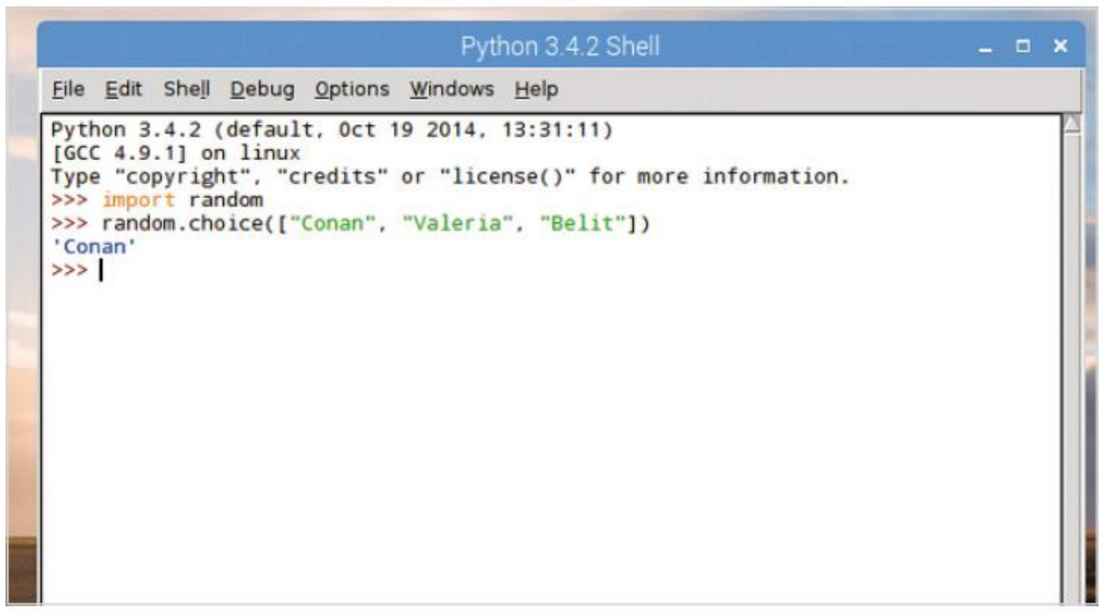
Will display a floating point number between 0 and 100, to the tune of around fifteen decimal points.



STEP 4 However, the Random module isn't used exclusively for numbers. You can use it to select an entry from a list from random, and the list can contain anything:

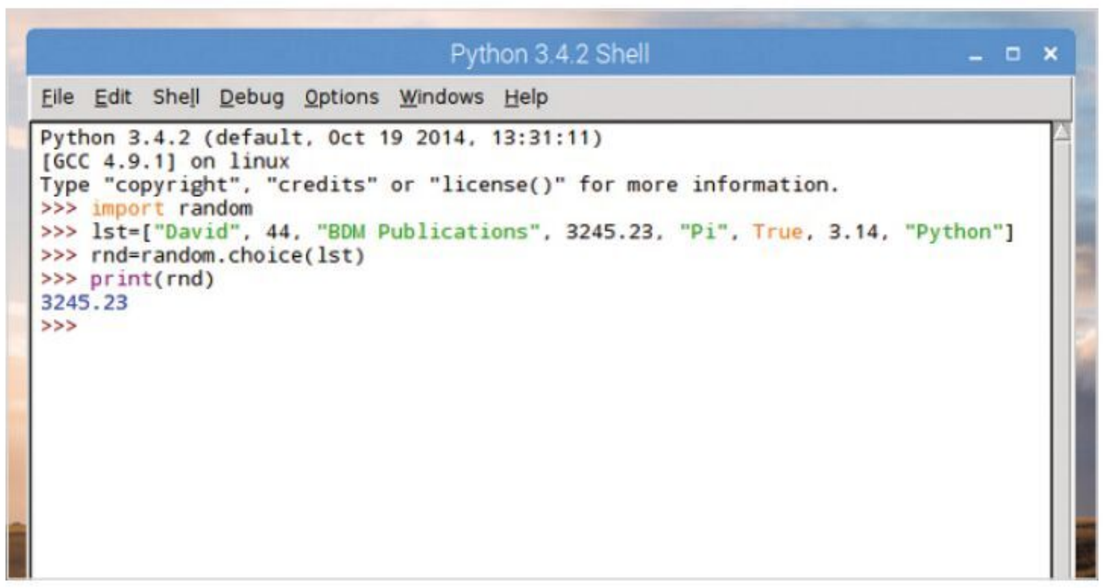
```
import random
random.choice(["Conan", "Valeria", "Belit"])
```

This will display one of the names of our adventurers at random, which is a great addition to a text adventure game.



STEP 5 You can extend the previous example somewhat by having random.choice() select from a list of mixed variables. For instance:

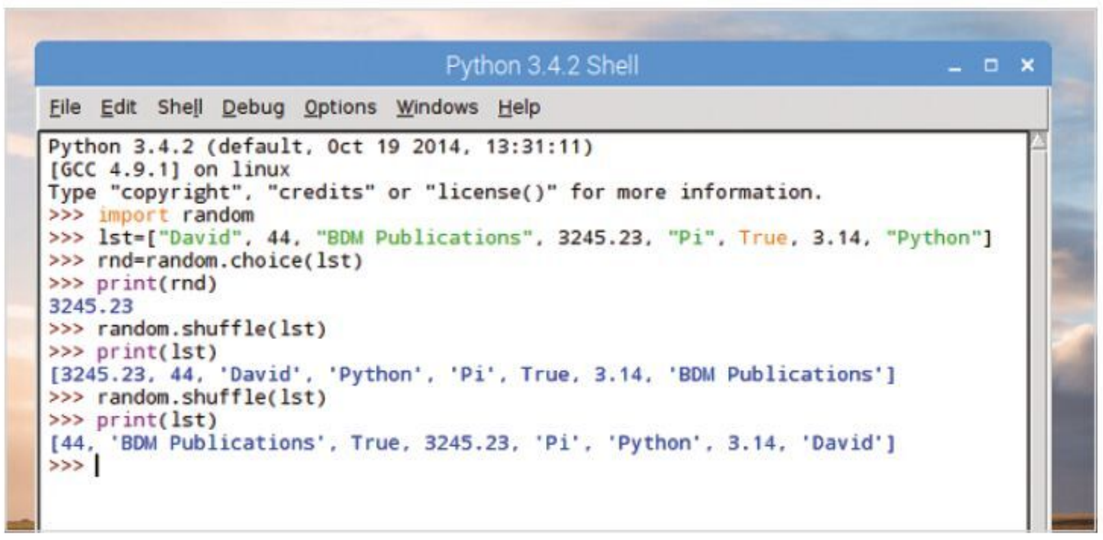
```
import random
lst=["David", 44, "BDM Publications", 3245.23,
"Pi", True, 3.14, "Python"]
rnd=random.choice(lst)
print(rnd)
```



STEP 6 Interestingly, you can also use a function within the Random module to shuffle the items in the list, thus adding a little more randomness into the equation:

```
random.shuffle(lst)
print(lst)
```

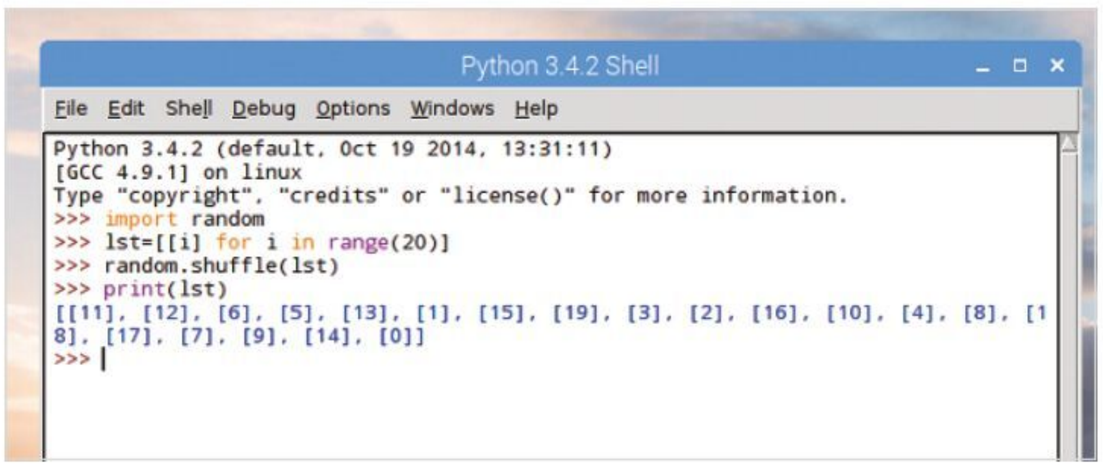
This way, you can keep shuffling the list before displaying a random item from it.



STEP 7 Using shuffle, you can create an entirely random list of numbers. For example, within a given range:

```
import random
lst=[[i] for I in range(20)]
random.shuffle(lst)
print(lst)
```

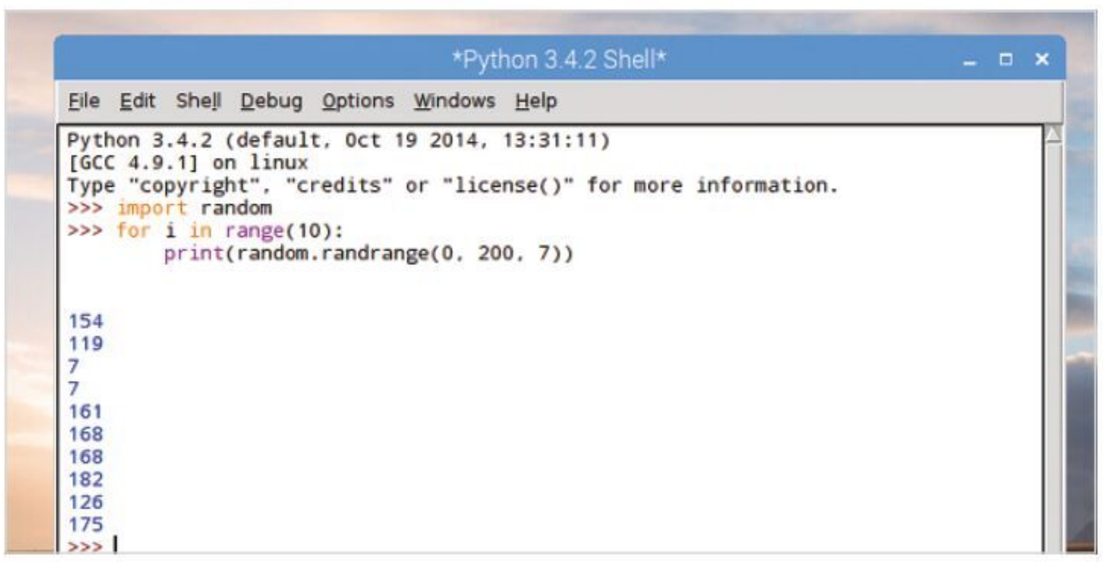
Keep shuffling the list and you can have a different selection of items from 0 to 20 every time.



STEP 8 You can also select a random number from a given range in steps, using the start, stop, step loop:

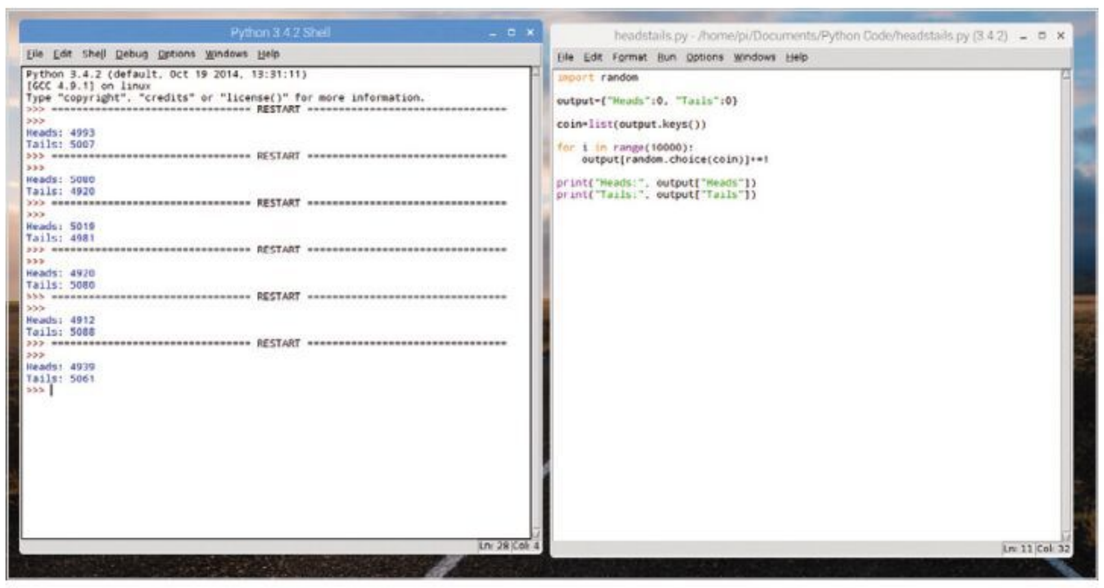
```
import random
for i in range(10):
  print(random.randrange(0, 200, 7))
```

Results will vary but you get the general idea as to how it works.



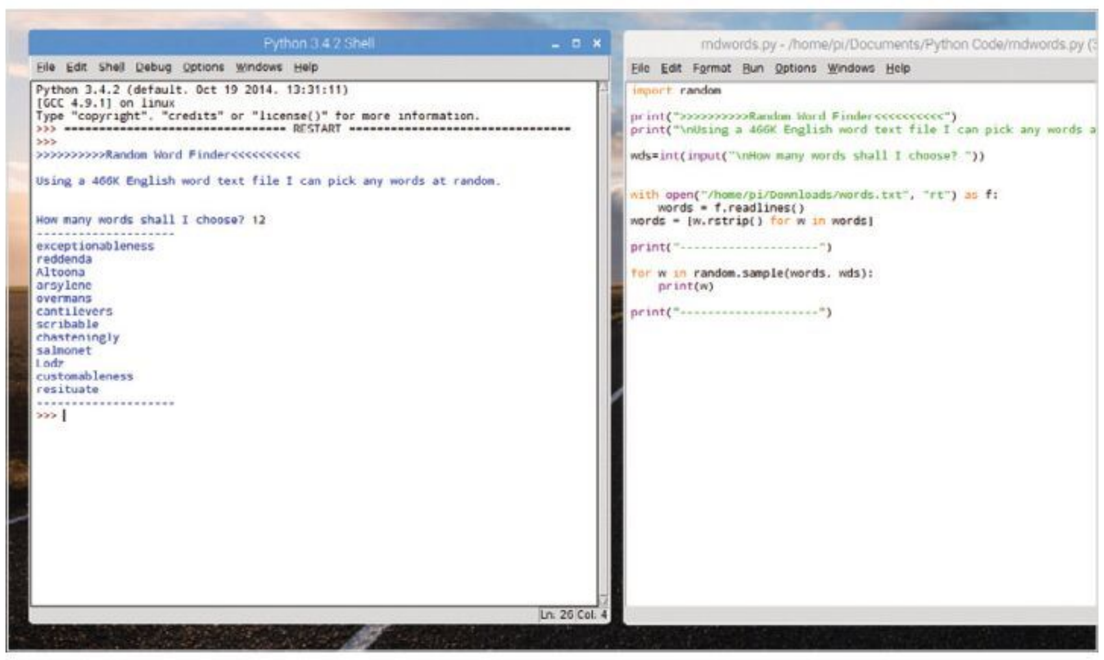
STEP 9 Let's use an example piece of code which flips a virtual coin ten thousand times and counts how many times it will land on heads or tails:

```
import random
output={"Heads":0, "Tails":0}
coin=list(output.keys())

for i in range(10000):
  output[random.choice(coin)]+=1

print("Heads:", output["Heads"])
print("Tails:", output["Tails"])
```



STEP 10 Here's an interesting piece of code. Using a text file containing 466 thousand words, you can pluck a user generated number of words from the file (text file found at: www.github.com/dwyl/english-words):

```
import random

print(">>>>>>>>>>Random Word Finder<<<<<<<<<<")
print("\nUsing a 466K English word text file I can
pick any words at random.\n")

wds=int(input("\nHow many words shall I choose?
"))

with open("/home/pi/Downloads/words.txt", "rt") as
f:
  words = f.readlines()
words = [w.rstrip() for w in words]

print("--------------------")

for w in random.sample(words, wds):
  print(w)

print("--------------------")
```



Tkinter Module

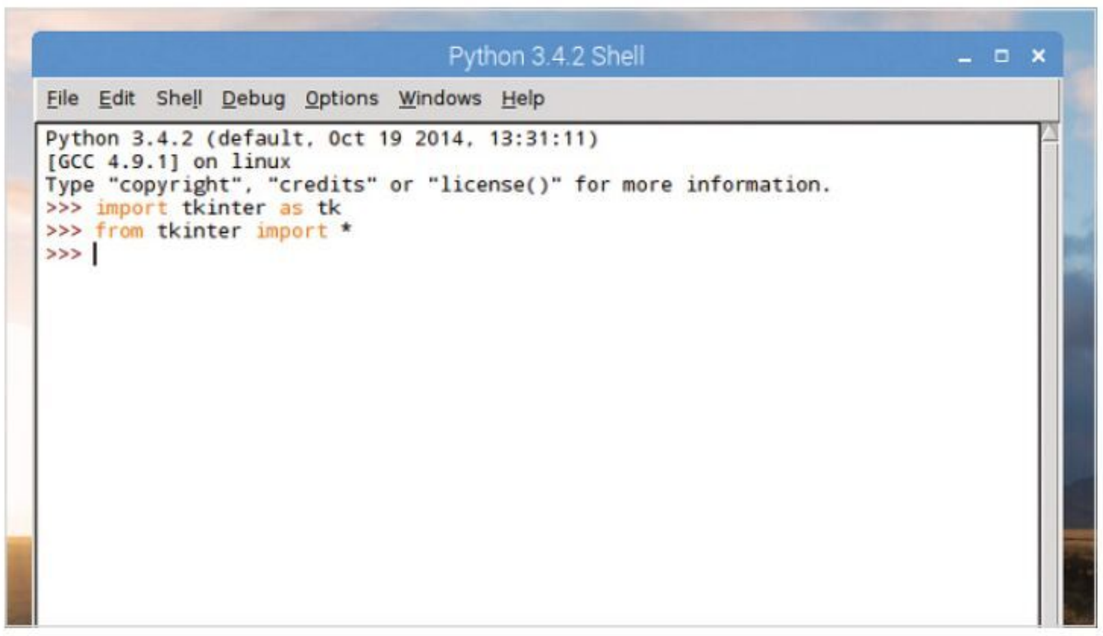
While running your code from the command line, or even in the Shell, is perfectly fine, Python is capable of so much more. The Tkinter module enables the programmer to set up a Graphical User Interface to interact with the user, and it's surprisingly powerful too.

GETTING GUI

Tkinter is easy to use but there's a lot more you can do with it. Let's start by seeing how it works and getting some code into it. Before long you will discover just how powerful this module really is.

STEP 1 Tkinter is usually built into Python 3. However, if it's available when you enter: `import tkinter`, then you need to `pip install tkinter` from the command prompt. We can start to import modules differently than before, to save on typing and by importing all their contents:

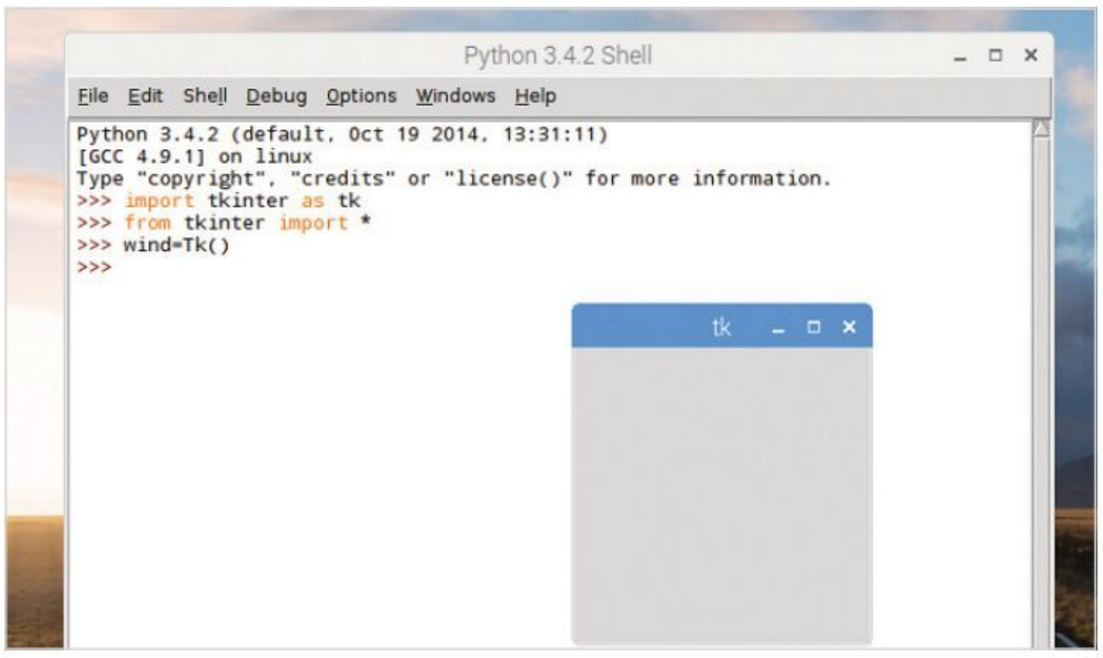
```
import tkinter as tk
from tkinter import *
```



STEP 2 It's not recommended to import everything from a module using the asterisk but it won't do any harm normally. Let's begin by creating a basic GUI window, enter:

```
wind=Tk()
```

This creates a small, basic window. There's not much else to do at this point but click the X in the corner to close the window.



STEP 3 The ideal approach is to add mainloop() into the code to control the Tkinter event loop, but we'll get to that soon. You've just created a Tkinter widget and there are several more we can play around with:

```
btn=Button()
btn.pack()
btn["text"]="Hello everyone!"
```

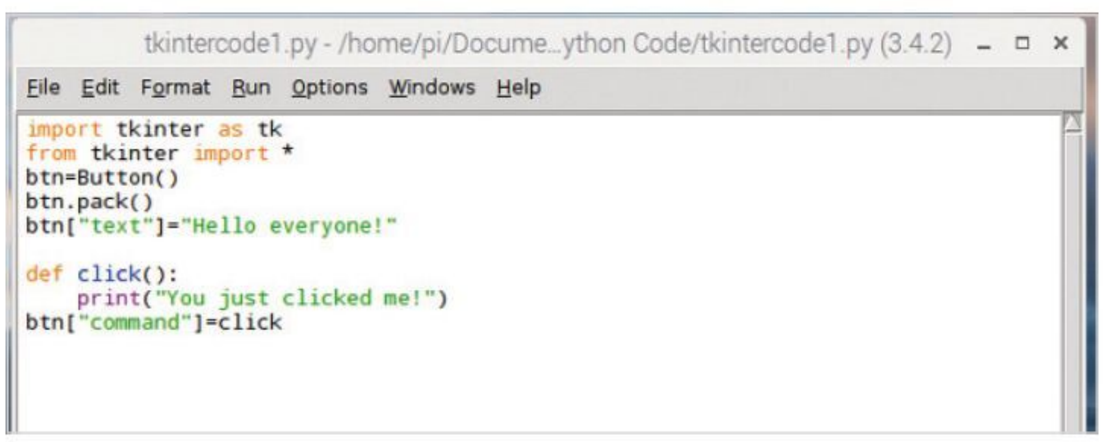
The first line focuses on the newly created window. Click back into the Shell and continue the other lines.

STEP 4 You can combine the above into a New File:

```
import tkinter as tk
from tkinter import *
btn=Button()
btn.pack()
btn["text"]="Hello everyone!"
```

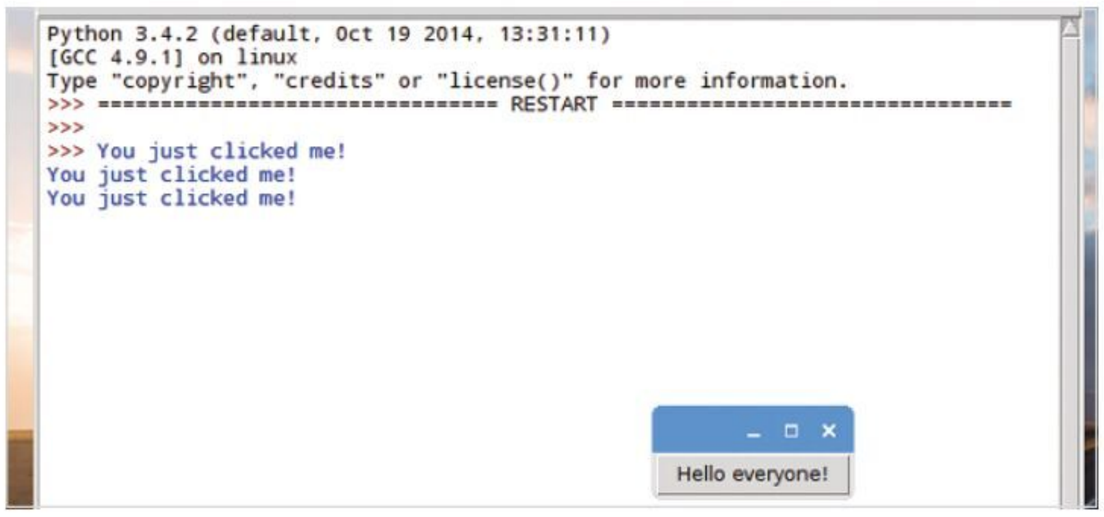
Then add some button interactions:

```
def click():
  print("You just clicked me!")
btn["command"]=click
```



STEP 5

Save and execute the code from Step 5 and a window appears with 'Hello everyone!' inside. If you click the Hello everyone! button, the Shell will output the text 'You just clicked me!'. It's simple but shows you what can be achieved with a few lines of code.



STEP 6

You can also display both text and images within a Tkinter window. However, only GIF, PGM or PPM formats are supported. So find an image and convert it before using the code. Here's an example using the BDM Publishing logo:

```
from tkinter import *

root = Tk()
logo = PhotoImage(file="/home/pi/Downloads/BDM_logo.
gif")
w1 = Label(root, root.title("BDM Publications"),
image=logo).pack(side="right")
content = """  From its humble beginnings in 2004,
the BDM brand quickly grew from a single publication
produced by a team of just two to one of the biggest
names in global bookazine publishing, for two simple
reasons. Our passion and commitment to deliver the
very best product each and every volume. While
the company has grown with a portfolio of over 250
publications delivered by our international staff,
the foundation that it has been built upon remains
the same, which is why we believe BDM isn't just
the first choice it's the only choice for the smart
consumer.  """
w2 = Label(root,
    justify=LEFT,
    padx = 10,
    text=content).pack(side="left")
root.mainloop()
```

STEP 7

The previous code is quite weighty, mostly due to the content variable holding a part of BDM's About page from the company website. You can obviously change the content, the root.title and the image to suit your needs.

STEP 8

You can create radio buttons too. Try:

```
from tkinter import *

root = Tk()

v = IntVar()

Label(root, root.title("Options"), text="""Choose
a preferred language:""",
  justify = LEFT, padx = 20).pack()
Radiobutton(root,
    text="Python",
    padx = 20,
    variable=v,
    value=1).pack(anchor=W)
Radiobutton(root,
    text="C++",
    padx = 20,
    variable=v,
    value=2).pack(anchor=W)

mainloop()
```

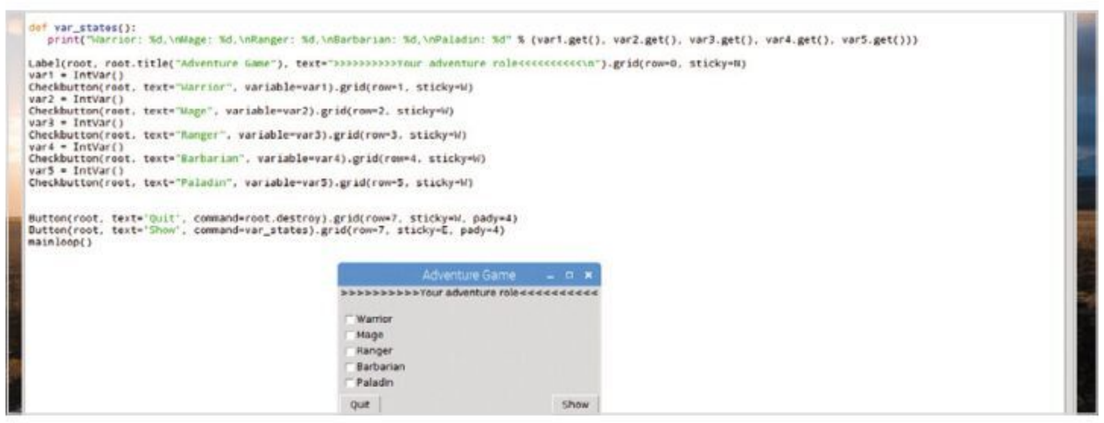
STEP 9

You can also create check boxes, with buttons and output to the Shell:

```
from tkinter import *
root = Tk()

def var_states():
  print("Warrior: %d,\nMage: %d" % (var1.get(),
var2.get()))

Label(root, root.title("Adventure Game"),
text=">>>>>>>>>>Your adventure role<<<<<<<<<<").
grid(row=0, sticky=N)
var1 = IntVar()
Checkbutton(root, text="Warrior", variable=var1).
grid(row=1, sticky=W)
var2 = IntVar()
Checkbutton(root, text="Mage", variable=var2).
grid(row=2, sticky=W)
Button(root, text='Quit', command=root.destroy).
grid(row=3, sticky=W, pady=4)
Button(root, text='Show', command=var_states).
grid(row=3, sticky=E, pady=4)

mainloop()
```

STEP 10

The code from Step 9 introduced some new geometry elements into Tkinter. Note the sticky=N, E and W arguments. These describe the locations of the check boxes and buttons (North, East, South and West). The row argument places them on separate rows. Have a play around and see what you get.



Pygame Module

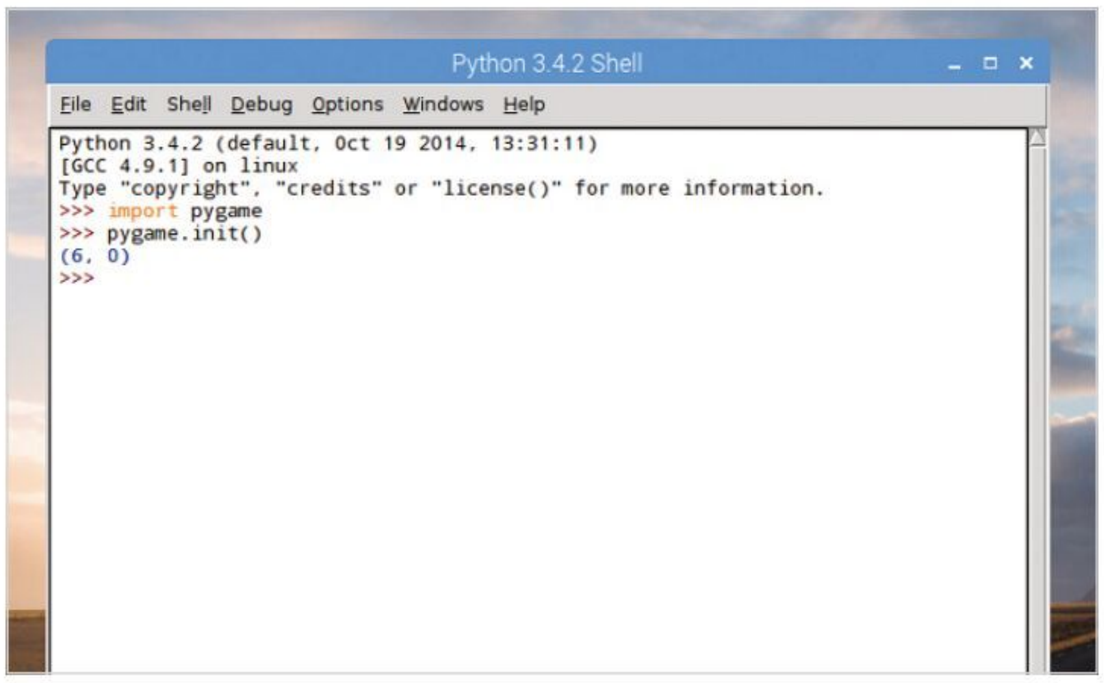
We've had a brief look at the Pygame module already but there's a lot more to it that needs exploring. Pygame was developed to help Python programmers create either graphical or text-based games.

PYGAMING

Pygame isn't an inherent module to Python but those using the Raspberry Pi will already have it installed. Everyone else will need to use: pip install pygame from the command prompt.

STEP 1 Naturally you need to load up the Pygame modules into memory before you're able to utilise them. Once that's done Pygame requires the user to initialise it prior to any of the functions being used:

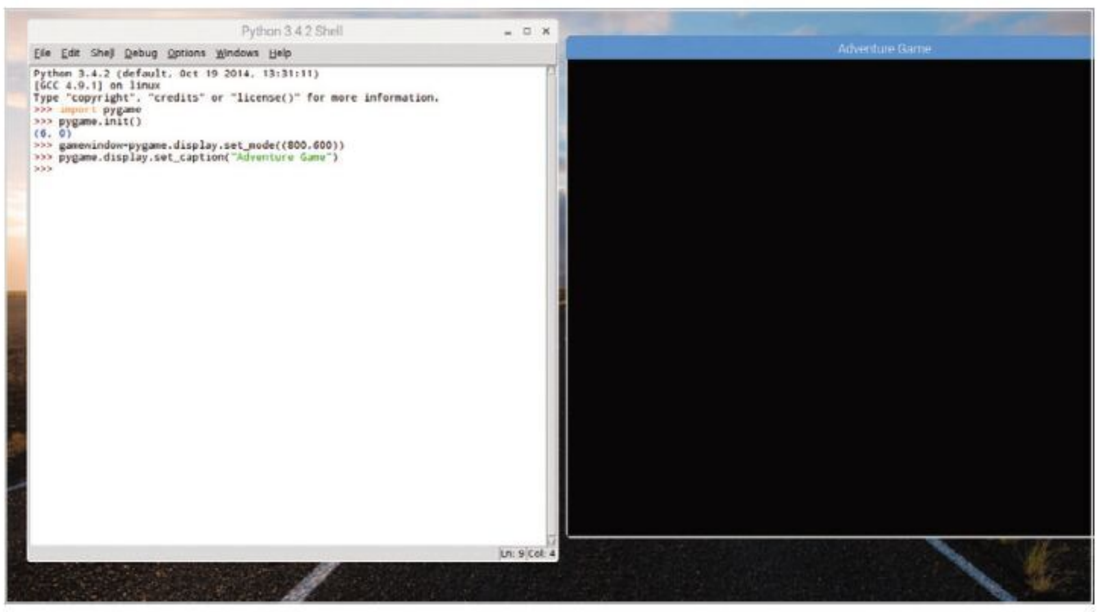
```
import pygame
pygame.init()
```



STEP 2 Let's create a simple game ready window, and give it a title:

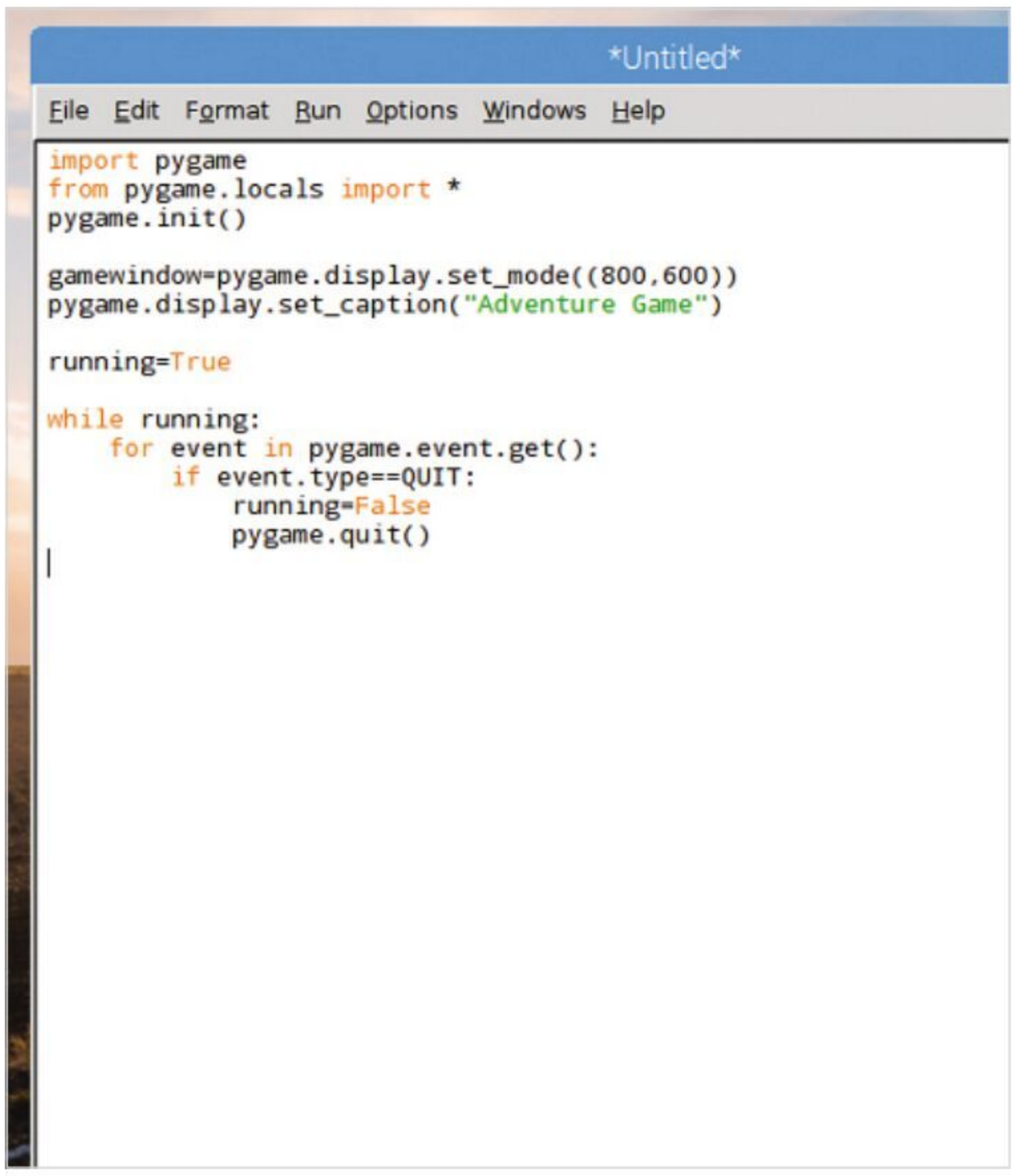
```
gamewindow=pygame.display.set_mode((800,600))
pygame.display.set_caption("Adventure Game")
```

You can see that after the first line is entered, you need to click back into the IDLE Shell to continue entering code; also, you can change the title of the window to anything you like.

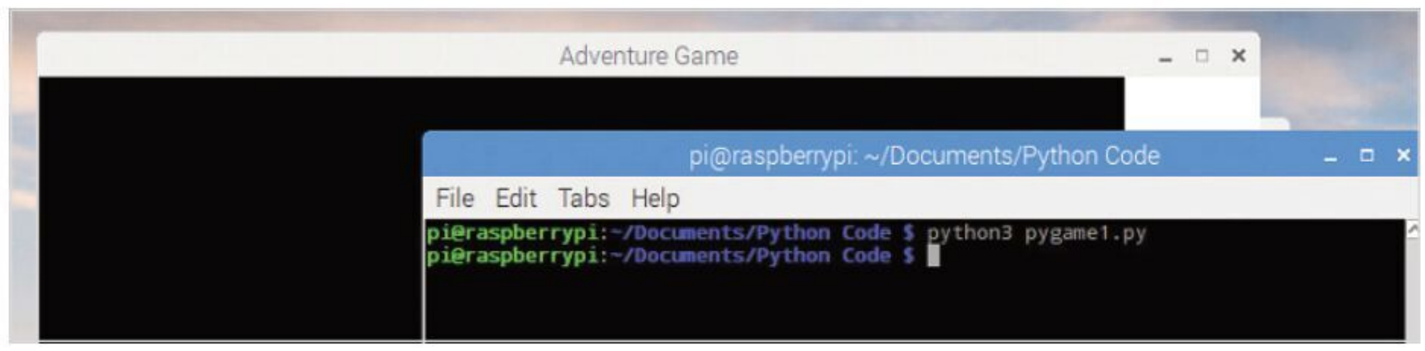


STEP 3 Sadly you can't close the newly created Pygame window without closing the Python IDLE Shell, which isn't very practical. For this reason, you need to work in the editor (New > File) and create a True/False while loop:

```
import pygame
from pygame.locals import *
pygame.init()

gamewindow=pygame.display.set_mode((800,600))
pygame.display.set_caption("Adventure Game")

running=True

while running:
  for event in pygame.event.get():
    if event.type==QUIT:
      running=False
      pygame.quit()
```

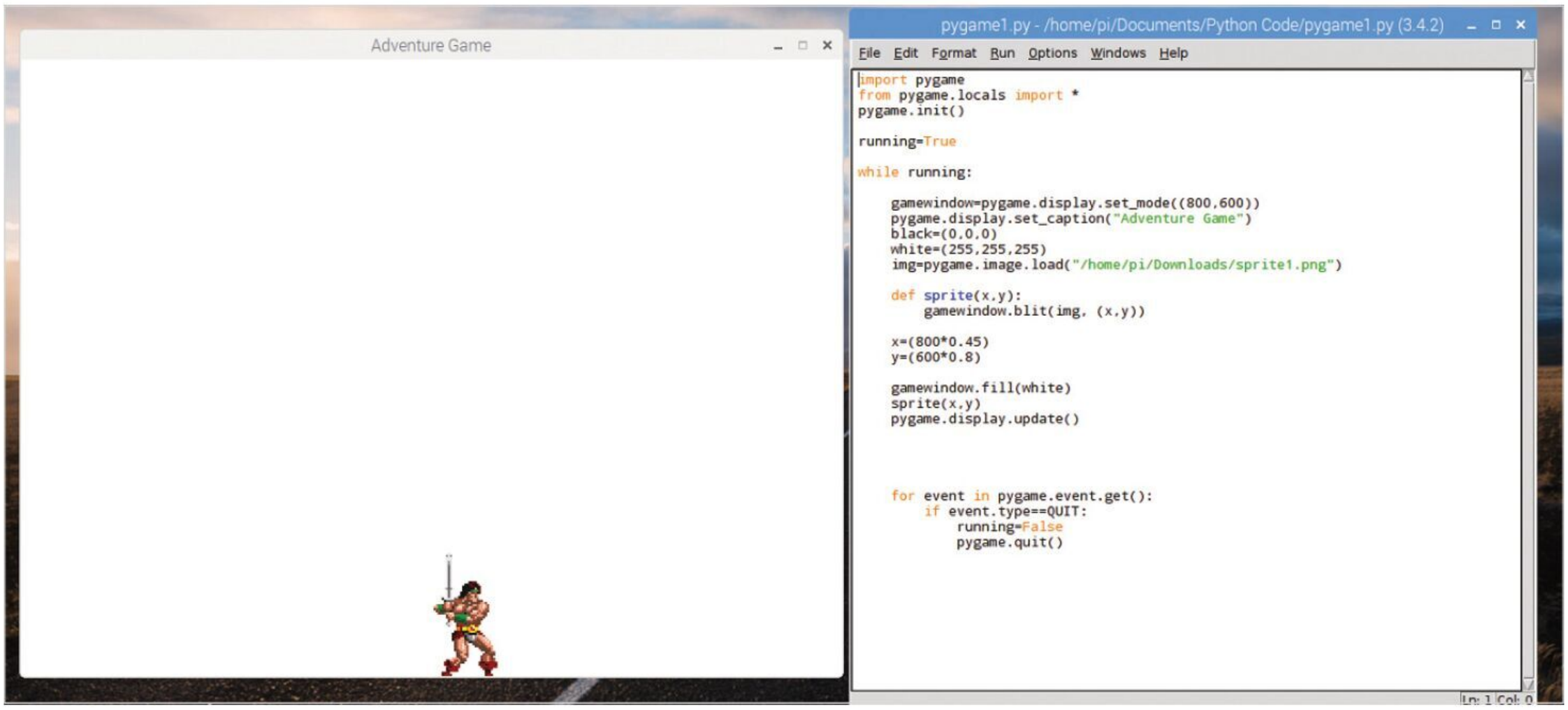


STEP 4 If the Pygame window still won't close don't worry, it's just a discrepancy between the IDLE (which is written with Tkinter) and the Pygame module. If you run your code via the command line, it closes perfectly well.



STEP 5 You're going to shift the code around a bit now, running the main Pygame code within a while loop; it makes it neater and easier to follow. We've downloaded a graphic to use and we need to set some parameters for pygame:

```
import pygame
pygame.init()

running=True

while running:

  gamewindow=pygame.display.set_mode((800,600))
  pygame.display.set_caption("Adventure Game")
  black=(0,0,0)
  white=(255,255,255)
  img=pygame.image.load("/home/pi/Downloads/sprite1.png")

  def sprite(x,y):
    gamewindow.blit(img, (x,y))

  x=(800*0.45)
  y=(600*0.8)

  gamewindow.fill(white)
  sprite(x,y)
  pygame.display.update()

  for event in pygame.event.get():
    if event.type==pygame.QUIT:
      running=False
```



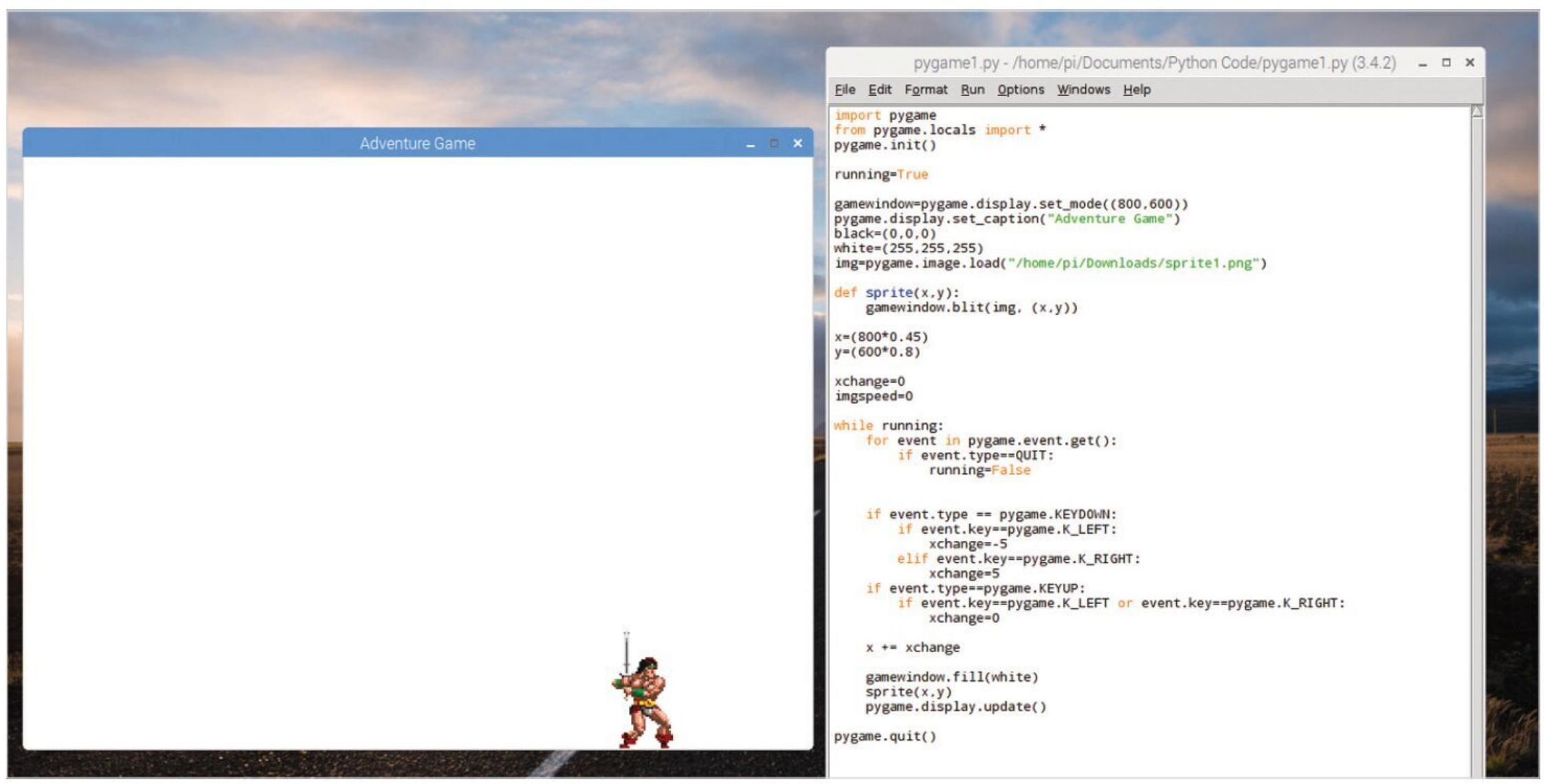
STEP 6 Let's quickly go through the code changes. We've defined two colours, black and white together with their respective RGB colour values. Next we've loaded the downloaded image called sprite1.png and allocated it to the variable img; and also defined a sprite function and the Blit function will allow us to eventually move the image.

```
import pygame
from pygame.locals import *
pygame.init()

running=True

while running:

    gamewindow=pygame.display.set_mode((800,600))
    pygame.display.set_caption("Adventure Game")
    black=(0,0,0)
    white=(255,255,255)
    img=pygame.image.load("/home/pi/Downloads/sprite1.png")

    def sprite(x,y):
        gamewindow.blit(img, (x,y))
```

```
    x=(800*0.45)
    y=(600*0.8)

    gamewindow.fill(white)
    sprite(x,y)
    pygame.display.update()



    for event in pygame.event.get():
        if event.type==QUIT:
            running=False
            pygame.quit()
```

STEP 7 Now we can change the code around again, this time containing a movement option within the while loop, and adding the variables needed to move the sprite around the screen:

```
import pygame
from pygame.locals import *
pygame.init()

running=True

gamewindow=pygame.display.set_mode((800,600))
pygame.display.set_caption("Adventure Game")
black=(0,0,0)
white=(255,255,255)
img=pygame.image.load("/home/pi/Downloads/sprite1.
png")

def sprite(x,y):
  gamewindow.blit(img, (x,y))

x=(800*0.45)
y=(600*0.8)

xchange=0
imgspeed=0

while running:
  for event in pygame.event.get():
    if event.type==QUIT:
      running=False

  if event.type == pygame.KEYDOWN:
    if event.key==pygame.K_LEFT:
      xchange=-5
    elif event.key==pygame.K_RIGHT:
      xchange=5
  if event.type==pygame.KEYUP:
    if event.key==pygame.K_LEFT or event
key==pygame.K_RIGHT:
      xchange=0

  x += xchange

  gamewindow.fill(white)
  sprite(x,y)
  pygame.display.update()

pygame.quit()
```



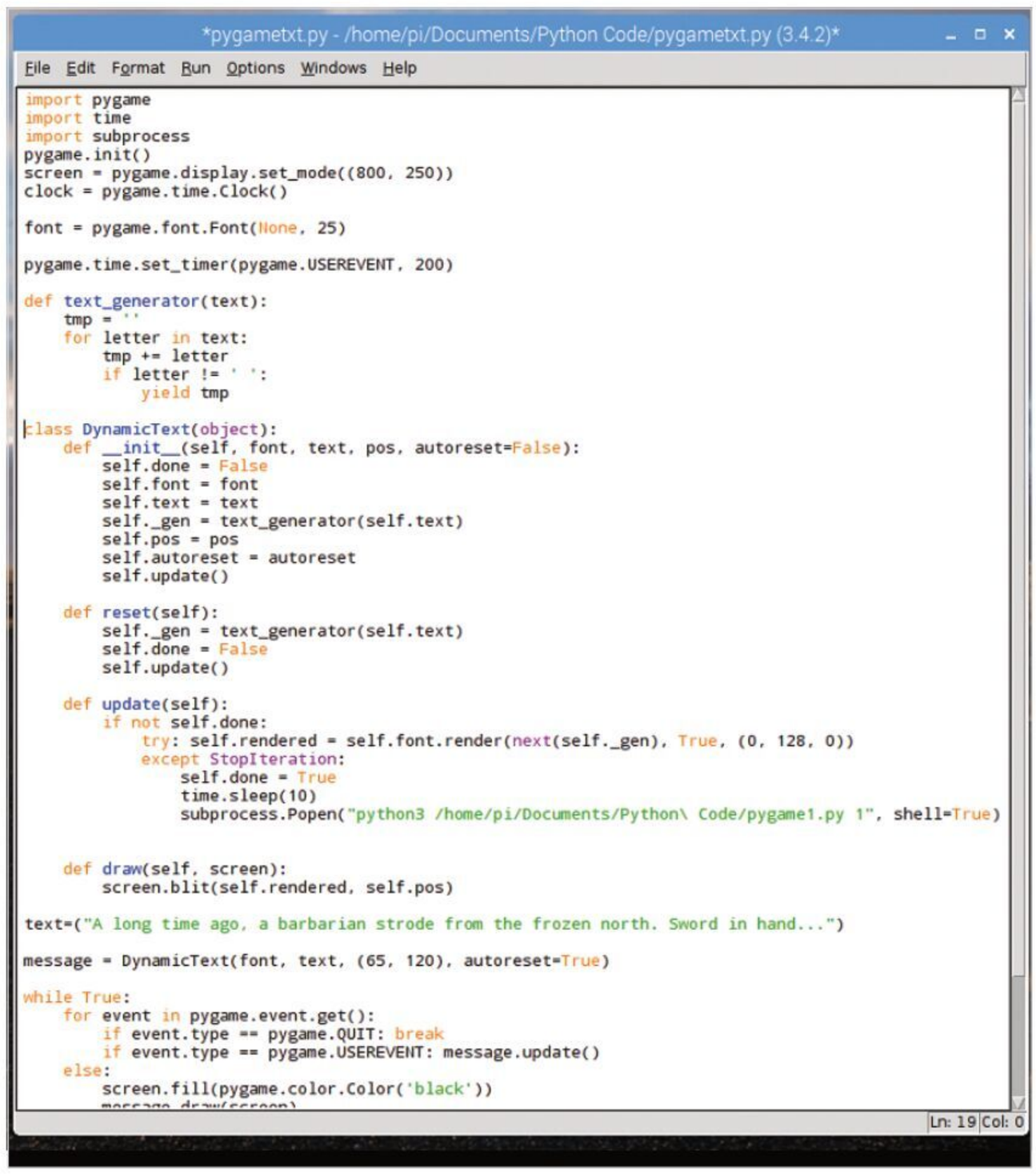
STEP 8 Copy the code down and using the left and right arrow keys on the keyboard you can move your sprite across the bottom of the screen. Now, it looks like you have the makings of a classic arcade 2D scroller in the works.

```
import pygame
from pygame.locals import *
pygame.init()

running=True

gamewindow=pygame.display.set_mode((800,600))
pygame.display.set_caption("Adventure Game")
black=(0,0,0)
white=(255,255,255)
img=pygame.image.load("/home/pi/Downloads/sprite1.png")

def sprite(x,y):
    gamewindow.blit(img, (x,y))

x=(800*0.45)
y=(600*0.8)

xchange=0
imgspeed=0
```

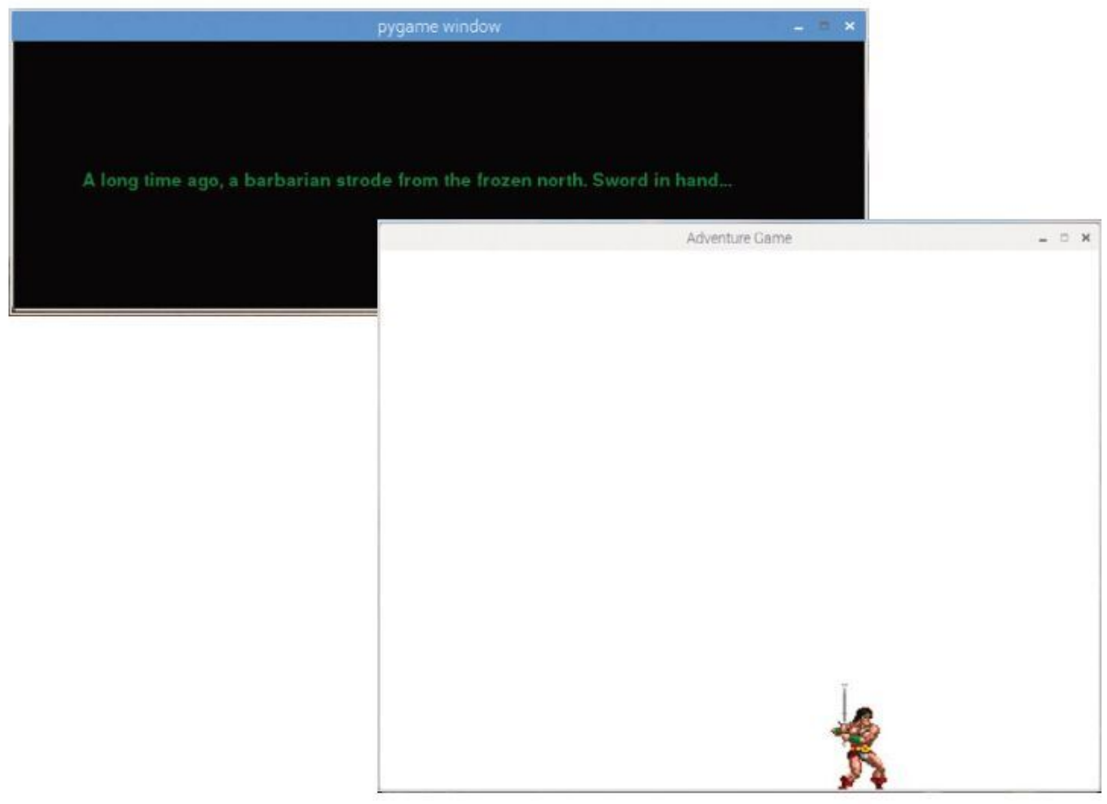
```
while running:
    for event in pygame.event.get():
        if event.type==QUIT:
            running=False


    if event.type == pygame.KEYDOWN:
        if event.key==pygame.K_LEFT:
            xchange=-5
        elif event.key==pygame.K_RIGHT:
            xchange=5
    if event.type==pygame.KEYUP:
        if event.key==pygame.K_LEFT or event.key==pygame.K_RIGHT:
            xchange=0

    x += xchange

    gamewindow.fill(white)
    sprite(x,y)
    pygame.display.update()

pygame.quit()
```

STEP 9 You can now implement a few additions and utilise some previous tutorial code. The new elements are the Subprocess module, of which one function allows us to launch a second Python script from within another; and we're going to create a New File called pygametxt.py:

```
import pygame
import time
import subprocess
pygame.init()
screen = pygame.display.set_mode((800, 250))
clock = pygame.time.Clock()

font = pygame.font.Font(None, 25)

pygame.time.set_timer(pygame.USEREVENT, 200)

def text_generator(text):
  tmp = ''
  for letter in text:
    tmp += letter
    if letter != ' ':
      yield tmp

class DynamicText(object):
  def __init__(self, font, text, pos,
autoreset=False):
    self.done = False
    self.font = font
    self.text = text
    self._gen = text_generator(self.text)
    self.pos = pos
    self.autoreset = autoreset
    self.update()

  def reset(self):
    self._gen = text_generator(self.text)
    self.done = False
    self.update()

  def update(self):
    if not self.done:
      try: self.rendered = self.font.
render(next(self._gen), True, (0, 128, 0))
      except StopIteration:
        self.done = True
        time.sleep(10)
        subprocess.Popen("python3 /home/pi/Documents/
Python\ Code/pygame1.py 1", shell=True)

  def draw(self, screen):
    screen.blit(self.rendered, self.pos)

text=("A long time ago, a barbarian strode from the
frozen north. Sword in hand...")

message = DynamicText(font, text, (65, 120),
autoreset=True)

while True:
  for event in pygame.event.get():
    if event.type == pygame.QUIT: break
    if event.type == pygame.USEREVENT: message.
update()
  else:
    screen.fill(pygame.color.Color('black'))
    message.draw(screen)
    pygame.display.flip()
    clock.tick(60)
    continue
  break

pygame.quit()
```



STEP 10 When you run this code it will display a long, narrow Pygame window with the intro text scrolling to the right. After a pause of ten seconds, it then launches the main game Python script where you can move the warrior sprite around. Overall the effect is quite good but there's always room for improvement.



Basic Animation

Python's modules make it relatively easy to create shapes, or display graphics and animate them accordingly. Animation though, can be a tricky element to get right in code. There are many different ways of achieving the same end result and we'll show you one such example here.

LIGHTS, CAMERA, ACTION

The Tkinter module is an ideal starting point for learning animation within Python. Naturally, there are better custom modules out there, but Tkinter does the job well enough to get a grasp on what's needed.

STEP 1 Let's make a bouncing ball animation. First, we will need to create a canvas (window) and the ball to animate:

```
from tkinter import *
import time

gui = Tk()
gui.geometry("800x600")
gui.title("Pi Animation")
canvas = Canvas(gui,
width=800,height=600,bg='white')
canvas.pack()

ball1 = canvas.create_oval(5,5,60,60, fill='red')

gui.mainloop()
```

STEP 2 Save and Run the code. You will see a blank window appear, with a red ball sitting in the upper left corner of the window. While this is great, it's not very animated. Let's add the following code:

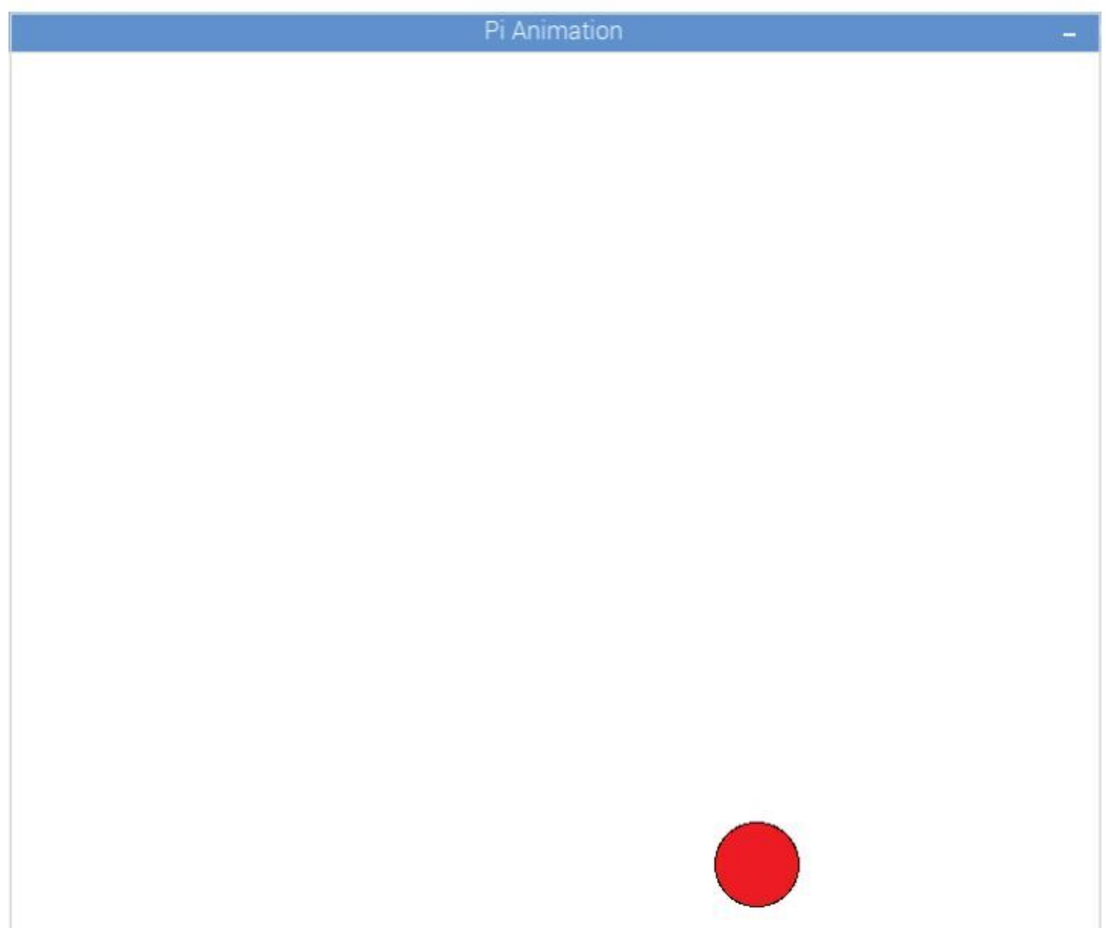
```
a = 5
b = 5

for x in range(0,100):
        canvas.move(ball1,a,b)
        gui.update()
        time.sleep(.01)
```

step2.py - /home/pi/Documents/step2.py (3.5.3)

File Edit Format Run Options Window Help

```
from tkinter import *
import time

gui = Tk()
gui.geometry("800x600")
gui.title("Pi Animation")
canvas = Canvas(gui, width=800, height=600, bg='white')
canvas.pack()

ball1 = canvas.create_oval(5,5,60,60, fill='red')

a = 5
b = 5

for x in range(0,100):
    canvas.move(ball1,a,b)
    gui.update()
    time.sleep(.01)

gui.mainloop()
```

STEP 3 Insert the new code between the `ball1 = canvas.create_oval(5,5,60,60, fill='red')` line and the `gui.mainloop()` line. Save it and Run. You will now see the ball move from the top left corner of the animation window, down to the bottom right corner. You can alter the speed in which the ball traverses the window by altering the `time.sleep(.01)` line. Try (.05).



STEP 4 The `canvas.move(ball1,a,b)` line is the part that moves the ball from one corner to the other; obviously with both a and b equalling 5. We can change things around a bit already, such as the size and colour of the ball, with the line: `ball1 = canvas.create_oval(5,5,60,60, fill='red')` and we can change the values of a and b to something else.

```
ball1 = canvas.create_oval(7,7,60,60, fill='red')

a = 8
b = 3

for x in range(0,100):
    canvas.move(ball1,a,b)
    gui.update()
    time.sleep(.05)
```

STEP 5 Let's see if we can animate the ball so that it bounces around the window until you close the program.

```
xa = 5
ya = 10

while True:
        canvas.move(ball1,xa,ya)
        pos=canvas.coords(ball1)
       if pos[3] >=600 or pos[1] <=0:
            ya = -ya
        if pos[2] >=800 or pos[0] <=0:
            xa = -xa
        gui.update()
       time.sleep(.025)
```

STEP 6 Remove the code you entered in Step 2 and insert the code from Step 5 in its place; again, between the `ball1 = canvas.create_oval(5,5,60,60, fill='red')` and the `gui.mainloop()` lines. Save the code and Run it as normal. If you've entered the code correctly, then you will see the red ball bounce off the edges of the window until you close the program.

STEP 7 The bouncing animation takes place within the `While True` loop. First, we have the values of xa and xy before the loop, both of 5 and 10. The `pos=canvas.coords(ball1)` line takes the value of the ball's location in the window. When it reaches the limits of the window, 800 or 600, it will make the values negative; moving the ball around the screen.

```
xa = 5
ya = 10

while True:
    canvas.move(ball1,xa,ya)
    pos=canvas.coords(ball1)
    if pos[3] >=600 or pos[1] <=0:
        ya = -ya
    if pos[2] >=800 or pos[0] <=0:
        xa = -xa
    gui.update()
    time.sleep(.025)
```

STEP 8 Pygame, however, is a much better module at producing higher-end animations. Begin by creating a New File and entering:

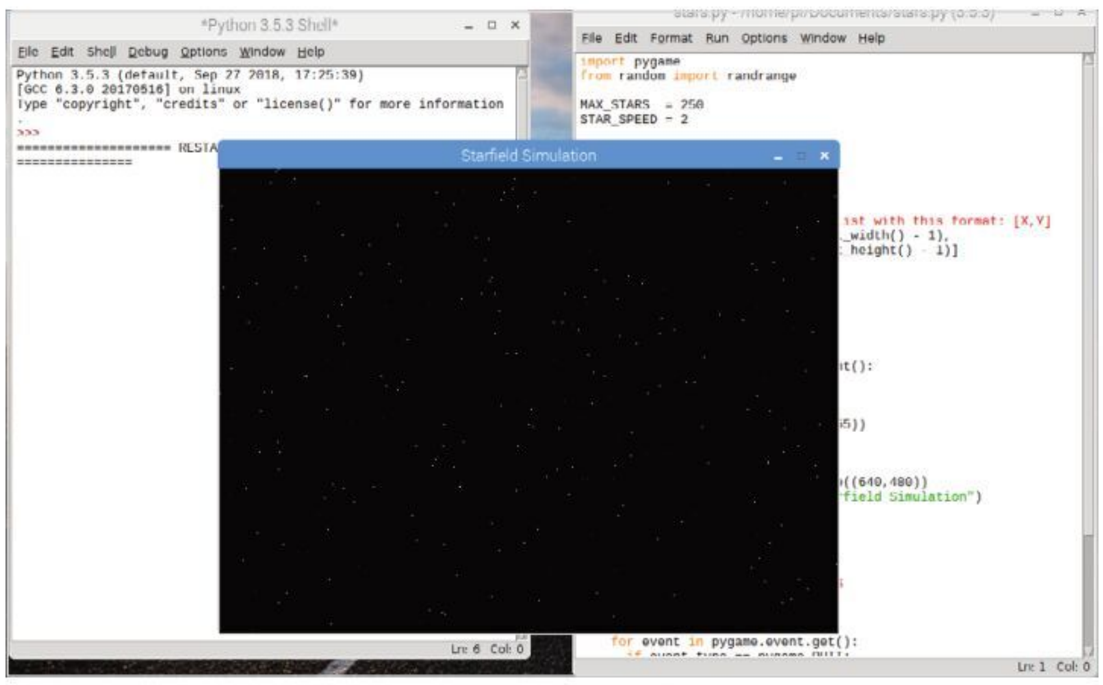
```
import pygame
from random import randrange

MAX_STARS  = 250
STAR_SPEED = 2

def init_stars(screen):
  """ Create the starfield """
  global stars
  stars = []
  for i in range(MAX_STARS):
    # A star is represented as a list with this
format: [X,Y]
    star = [randrange(0,screen.get_width() - 1),
            randrange(0,screen.get_height() - 1)]
    stars.append(star)

def move_and_draw_stars(screen):
  """ Move and draw the stars """
  global stars
  for star in stars:
    star[1] += STAR_SPEED
    if star[1] >= screen.get_height():
      star[1] = 0
      star[0] = randrange(0,639)

    screen.set_at(star,(255,255,255))
```

STEP 9 Now add the following:

```
def main():
  pygame.init()
  screen = pygame.display.set_mode((640,480))
  pygame.display.set_caption("Starfield
Simulation")
  clock = pygame.time.Clock()

  init_stars(screen)

  while True:
    # Lock the framerate at 50 FPS
    clock.tick(50)

    # Handle events
    for event in pygame.event.get():
      if event.type == pygame.QUIT:
        return

    screen.fill((0,0,0))
    move_and_draw_stars(screen)
    pygame.display.flip()

if __name__ == "__main__":
  main()
```

```
def main():
  pygame.init()
  screen = pygame.display.set_mode((640,480))
  pygame.display.set_caption("Starfield Simulation")
  clock = pygame.time.Clock()

  init_stars(screen)

  while True:
    # Lock the framerate at 50 FPS
    clock.tick(50)

    # Handle events
    for event in pygame.event.get():
      if event.type == pygame.QUIT:
        return

    screen.fill((0,0,0))
    move_and_draw_stars(screen)
    pygame.display.flip()

if __name__ == "__main__":
  main()
```

STEP 10 Save and Run the code. You will agree that the simulated starfield code looks quite impressive. Imagine this as the beginning of some game code, or even the start to a presentation? Using a combination of Pygame and Tkinter, your Python animations will look fantastic.



Create Your Own Modules

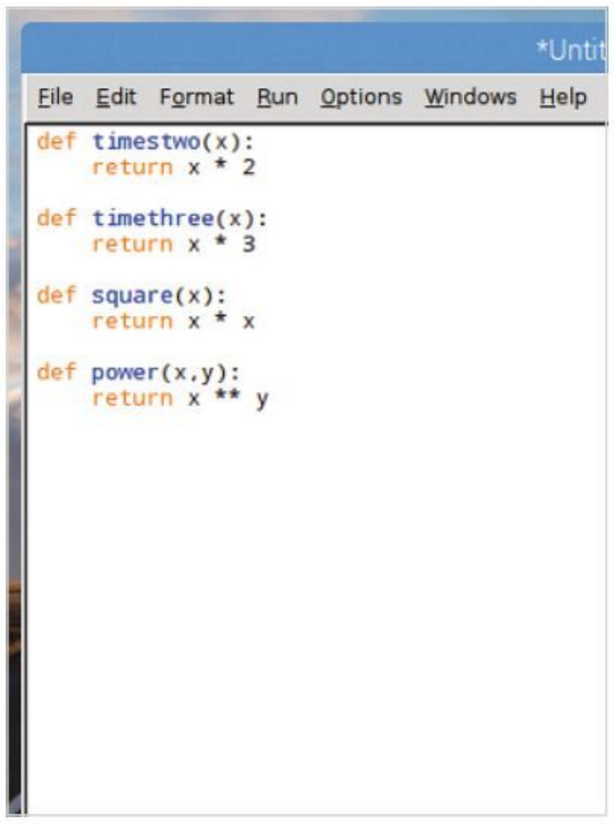
Large programs can be much easier to manage if you break them up into smaller parts and import the parts you need as modules. Learning to build your own modules also makes it easier to understand how they work.

BUILDING MODULES

Modules are Python files, containing code, that you save using a .py extension. These are then imported into Python using the now familiar import command.

STEP 1 Let's start by creating a set of basic mathematics functions. Multiply a number by two, three and square or raise a number to an exponent (power). Create a New File in the IDLE and enter:

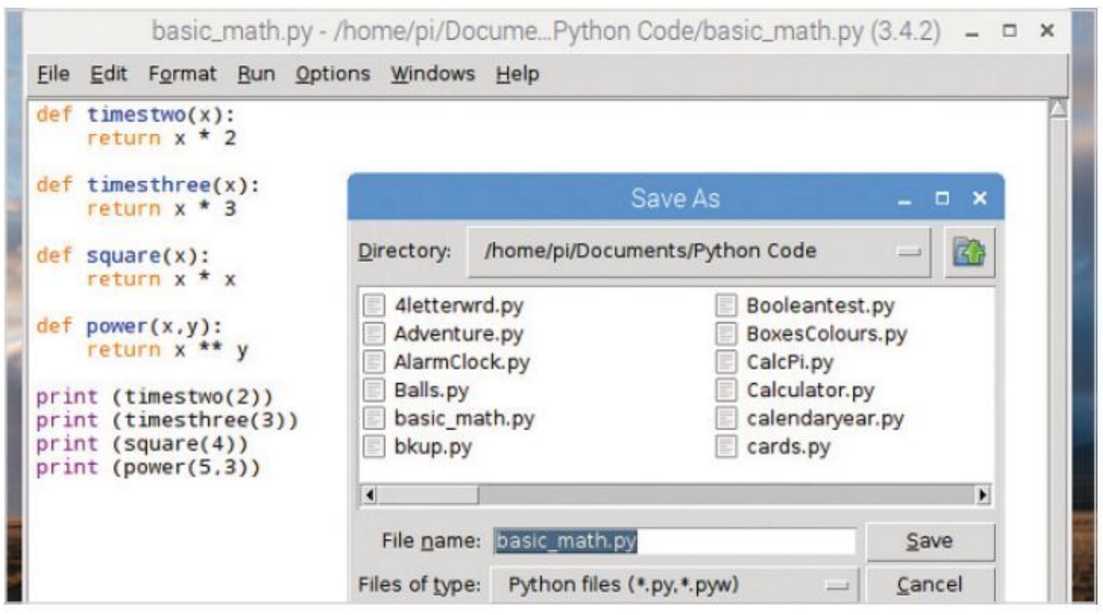
```
def timestwo(x):
        return x * 2

def timesthree(x):
        return x * 3

def square(x):
        return x * x

def power(x,y):
        return x ** y
```



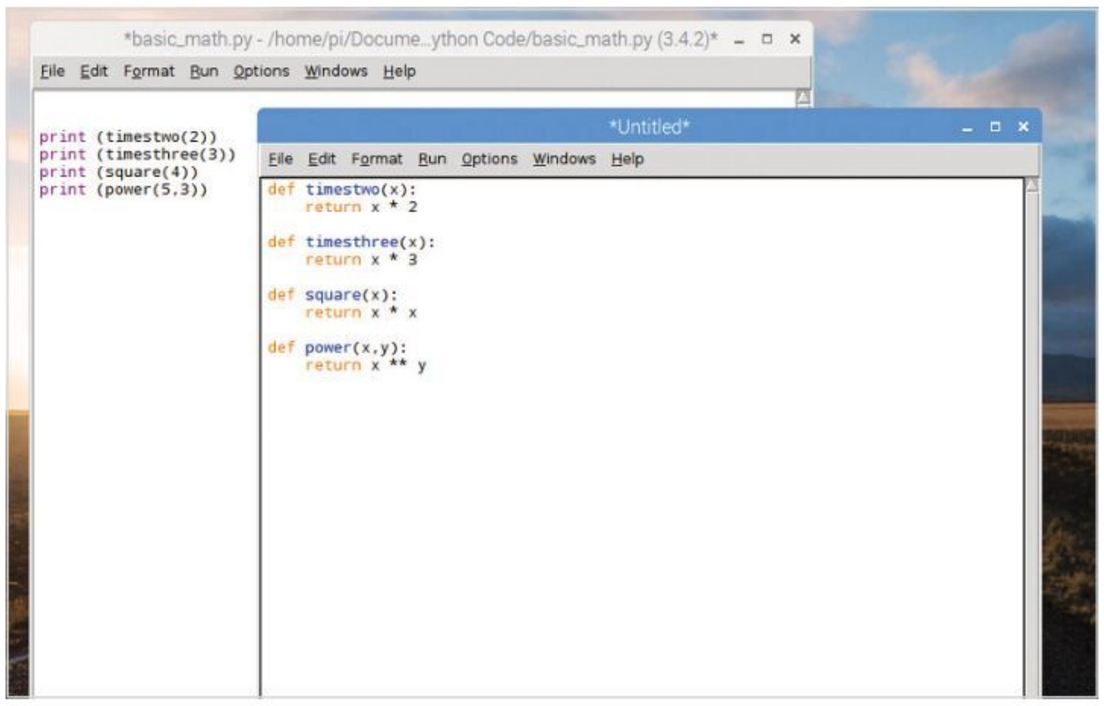
STEP 2 Under the above code, enter functions to call the code:

```
print (timestwo(2))
print (timesthree(3))
print (square(4))
print (power(5,3))
```

Save the program as basic_math.py and execute it to get the results.



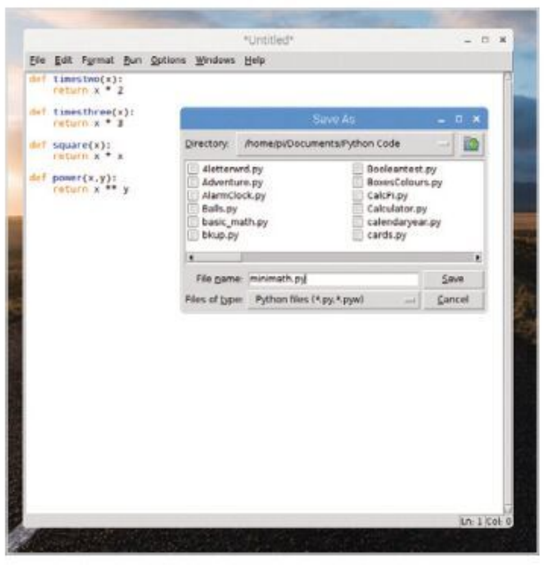
STEP 3 Now you're going to take the function definitions out of the program and into a separate file. Highlight the function definitions and choose Edit > Cut. Choose File > New File and use Edit > Paste in the new window. You now have two separate files, one with the function definitions, the other with the function calls.



STEP 4 If you now try and execute the basic_math.py code again, the error **'NameError: name 'timestwo' is not defined'** will be displayed. This is due to the code no longer having access to the function definitions.

```
Traceback (most recent call last):
  File "/home/pi/Documents/Python Code/basic_math.py", line 3, in <module>
    print (timestwo(2))
NameError: name 'timestwo' is not defined
>>> |
```

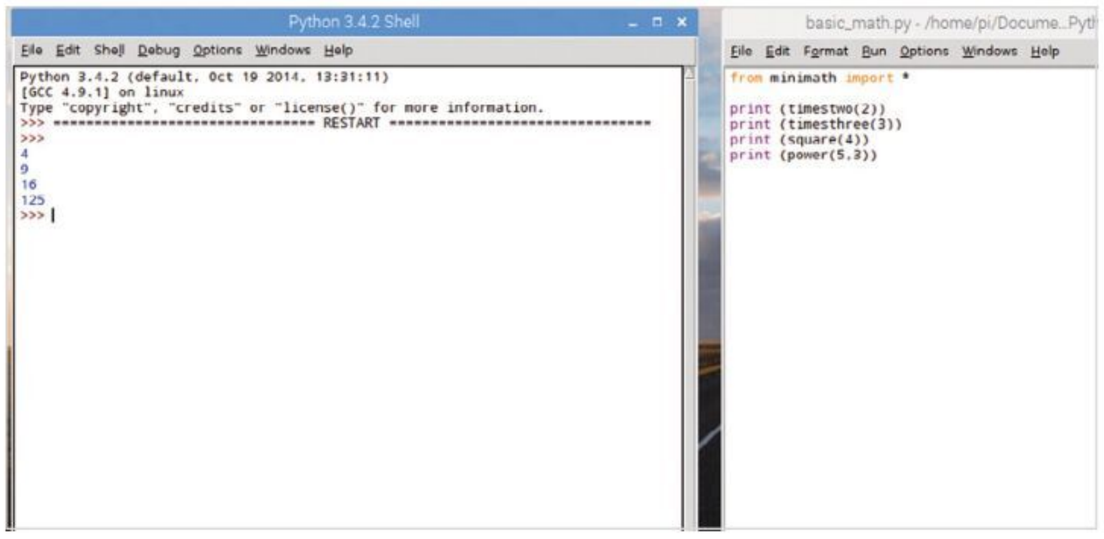
STEP 5 Return to the newly created window containing the function definitions, and click File > Save As. Name this **minimath.py** and save it in the same location as the original **basic_math.py** program. Now close the minimath.py window, so the basic_math.py window is left open.



STEP 6 Back to the basic_math.py window: at the top of the code enter:

```
from minimath import *
```

This will import the function definitions as a module. Press F5 to save and execute the program to see it in action.



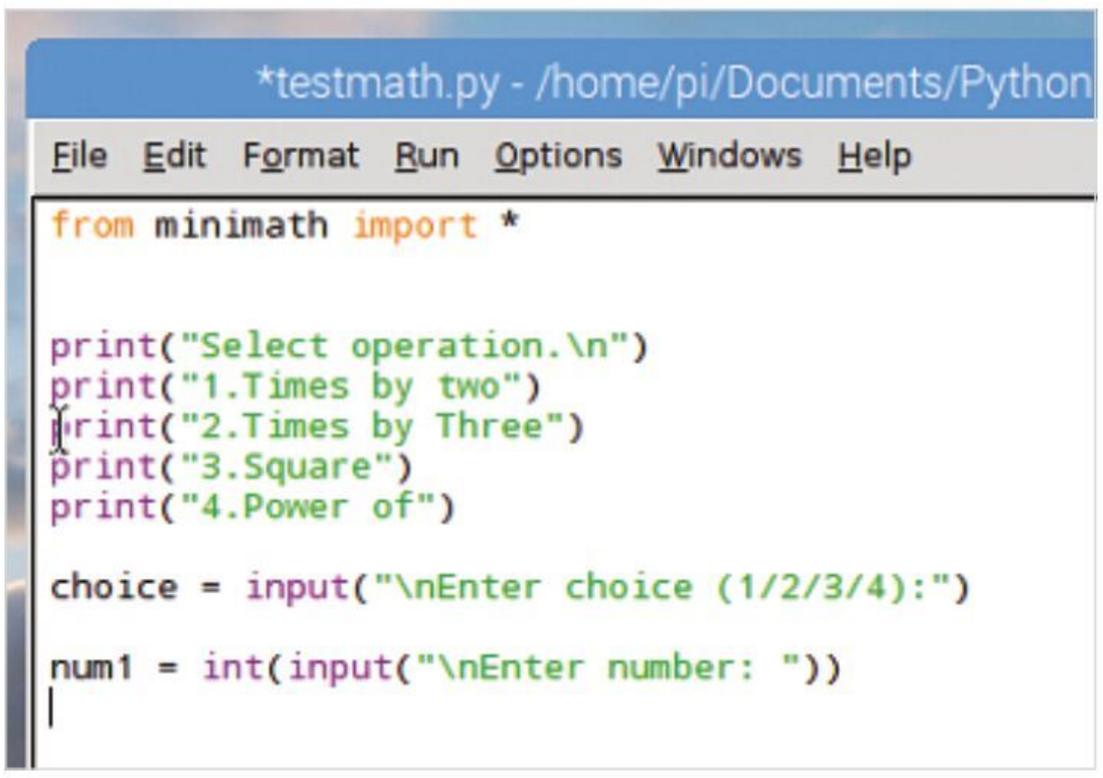
STEP 7 You can now use the code further to make the program a little more advanced, utilising the newly created module to its full. Include some user interaction. Start by creating a basic menu the user can choose from:

```
print("Select operation.\n")
print("1.Times by two")
print("2.Times by Three")
print("3.Square")
print("4.Power of")

choice = input("\nEnter choice (1/2/3/4):")
```

STEP 8 Now we can add the user input to get the number the code will work on:

```
num1 = int(input("\nEnter number: "))
```

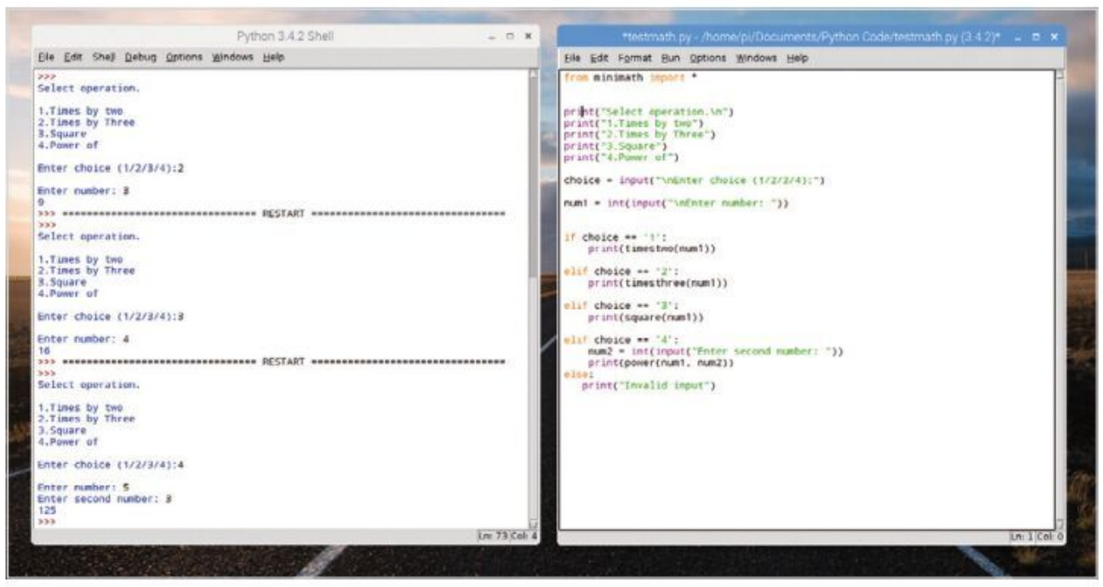
This will save the user-entered number as the variable num1.



STEP 9 Finally, you can now create a range of if statements to determine what to do with the number and utilise the newly created function definitions:

```
if choice == '1':
    print(timestwo(num1))

elif choice == '2':
    print(timesthree(num1))

elif choice == '3':
    print(square(num1))

elif choice == '4':
    num2 = int(input("Enter second number: "))
    print(power(num1, num2))
else:
   print("Invalid input")
```

STEP 10 Note that for the last available options, the Power of choice, we've added a second variable, num2. This passes a second number through the function definition called power. Save and execute the program to see it in action.



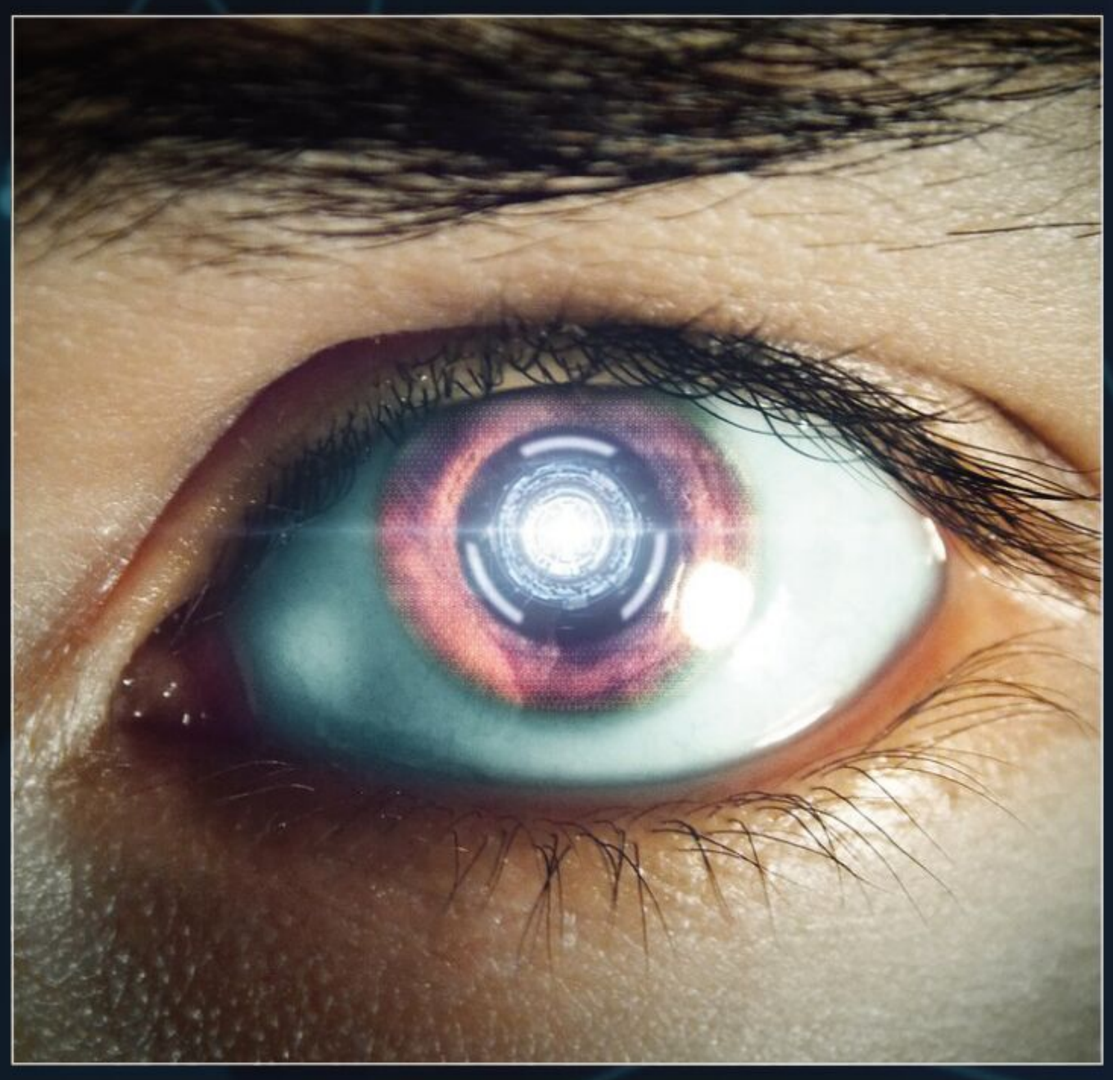
Python in Focus: Artificial Intelligence

Artificial Intelligence (AI) and Machine Learning (ML) are the new hot topics of the IT industry. AI is fast becoming the working science fiction that it has been portrayed as in the past, and behind it is Python.

Despite how close AI and ML are, there are distinct differences between the two technologies. AI refers to the study of how to train a computer to accomplice the things that humans can do significantly better and faster. Whereas, ML is the ability for a computer to learn from its experiences, so that the outcome and performance will eventually become more accurate and accomplished.

While different, they are both essentially discussing the same element: training a system to learn and do things independently. Where AI is said to lead to wisdom, ML reportedly leads to knowledge and, thanks to Python, that gap is getting closer every day.

```
import keras
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D

batch_size = 128
num_classes = 10
epochs = 12

# input image dimensions
img_rows, img_cols = 28, 28

(x_train, y_train), (x_test, y_test) = mnist.load_data()

```



APPLICATIONS

Both AI and ML are hugely present in today's technology. Where, just a few years ago, most of us associated AI with the rise of a super-intelligent legion of killer robots, nowadays you'd be amazed at the numerous examples of AI in your house, and even being carried around with you.

Let's begin with the obvious use of AI and ML, the smartphone. These devices have infiltrated most of our modern world, with global coverage reaching 5.5 billion for 2019 and set to rise to over 6 billion by the end of 2020, it's little surprise to discover that AI and ML are advancing in leaps and bounds.

With nearly all of the population of humanity within reach of a smartphone, the coding behind these devices has been developed to take individuals into account. These devices are designed to learn what the user requires, or uses, the device for. Common numbers called are pushed to the top of the list, in-app and in-game advertising is moulded around our browser and search preferences, as well as other apps we've installed in the past. And even our voices, fingerprints and faces are stored and analysed by AI and ML in order to recognise who we are.

DIGITAL ASSISTANTS

The rise of digital assistants has been one of the kick-starters of AI and ML programming. Siri, Cortana, Alexa and Google Assistant are all coded using Python, and are designed to listen, learn and respond to what we ask of them. With Python, this level of AI is surprisingly simple, thanks to the many libraries and customisation of the language. These frameworks make creating AI and ML easy for intelligent coders, cutting down on the development time in other languages and, thanks to Python's easy to read code and complex algorithms, these developers can devote significant time to improving the performance and accuracy of AI.

Every time we ask one of these digital assistants for something, the Python-driven AI code is reading our voice, determining what it is we're asking by plucking out key words and acting on them. If we ask for a thirty second countdown, it'll start the device's stopwatch function; if we ask for dinner suggestions, it'll open a specific set of web pages, and if we ask it to play some music, it'll interrogate the available music apps to select what it is we wanted. All the time, the AI code is being trained to listen more intently, while the ML is learning from the AI results so that its accuracy is improved for future questions and requests.

BEYOND THE SMARTPHONE

Consider Google, social media and the content you look up. How many times have you entered a search string into Google, such as car parts for a Mk1 Ford Escort and, when you've opened Facebook, you suddenly find a group suggestion of Ford Escort owners? That's AI and ML injecting themselves into your everyday computing tasks.

Another example of AI and ML working together is Gmail's recent addition of suggested completions for sentences you are typing. If you frequently sign off with 'See you soon', or 'All the best', then typing 'See' or 'All' will prompt the ML side of the equation to autofill the remainder of the words for you. All the time, the ML is learning while the AI is telling it what to improve on.

Facial recognition is another element of AI and ML that's been the target of the popular press for some time. Throughout 2019, facial recognition systems on both smartphones and CCTV footage have improved dramatically. Agencies controlling this level of AI now have the ability to single out an individual from a crowded street and, while that's great for law and order, it does pose a potential threat to our privacy. After all, who watches the watcher?

Tesla's work on self-driving cars means they are getting closer to being the norm, and it's Python along with its controlling AI and ML work that's, excuse the pun, driving it forward. In these circumstances, Python is doing a lot of the heavy lifting, providing the connective tissue and libraries that are designed to implement AI and ML. In the background, you'll usually find C++, or some other language, that's supporting the performance and overall program in which the AI and ML are working.

While it's easy to portray a bleak AI future, let's not forget the many great instances of AI we currently enjoy: optical character recognition, handwriting recognition, image processing, helping people with visual and hearing disabilities, advancements in space exploration, engineering improvements, conservation, pharmaceutical and drug improvements and greater freedom for those limited in their ability to travel. It's not all about two AI bots arguing about eliminating the human race.

THE FUTURE OF AI

Whether we'll end up creating true AI, killer robots and self-aware androids is up for debate. There are plenty of arguments for and against the evolution of AI, with many believing that AI will be the worst possible future humans can create – worse even than nuclear war. For the moment, however, we're at the early stages of AI development, but with Python's continual advancements and improved libraries, it may not be too long before we've got an AI system that's getting better by the hour.

Code Repository

SHARE YOUR CODE!

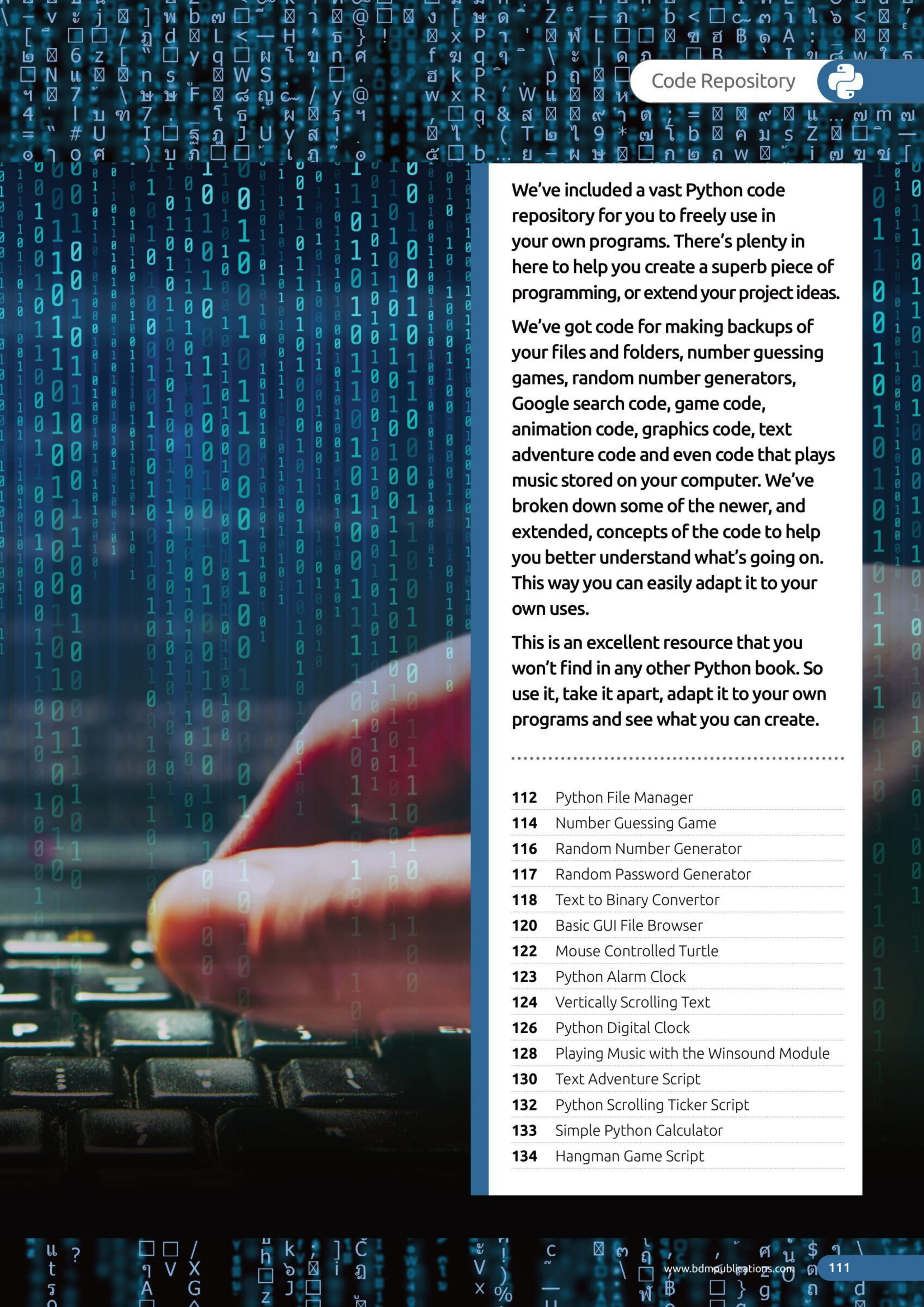
The code listed within this section can be downloaded as a Python file, so you don't have to type it out. Simply visit www.bdmpublications.com/code-portal, sign up for access to the portal and the code is available as a compressed file for you to download and execute.

Maybe you've written something amazing and want to show it off; if so, why not send it in and we can add it to the Code Portal as well as mention it via our social media accounts.

Tell us what the code does, how it works (don't forget to include comments in the code) and what platform to run it on.

Send it in to: enquiries:bdmpublications.com. We look forward to seeing what you've done.

Code Repository



We've included a vast Python code repository for you to freely use in your own programs. There's plenty in here to help you create a superb piece of programming, or extend your project ideas.

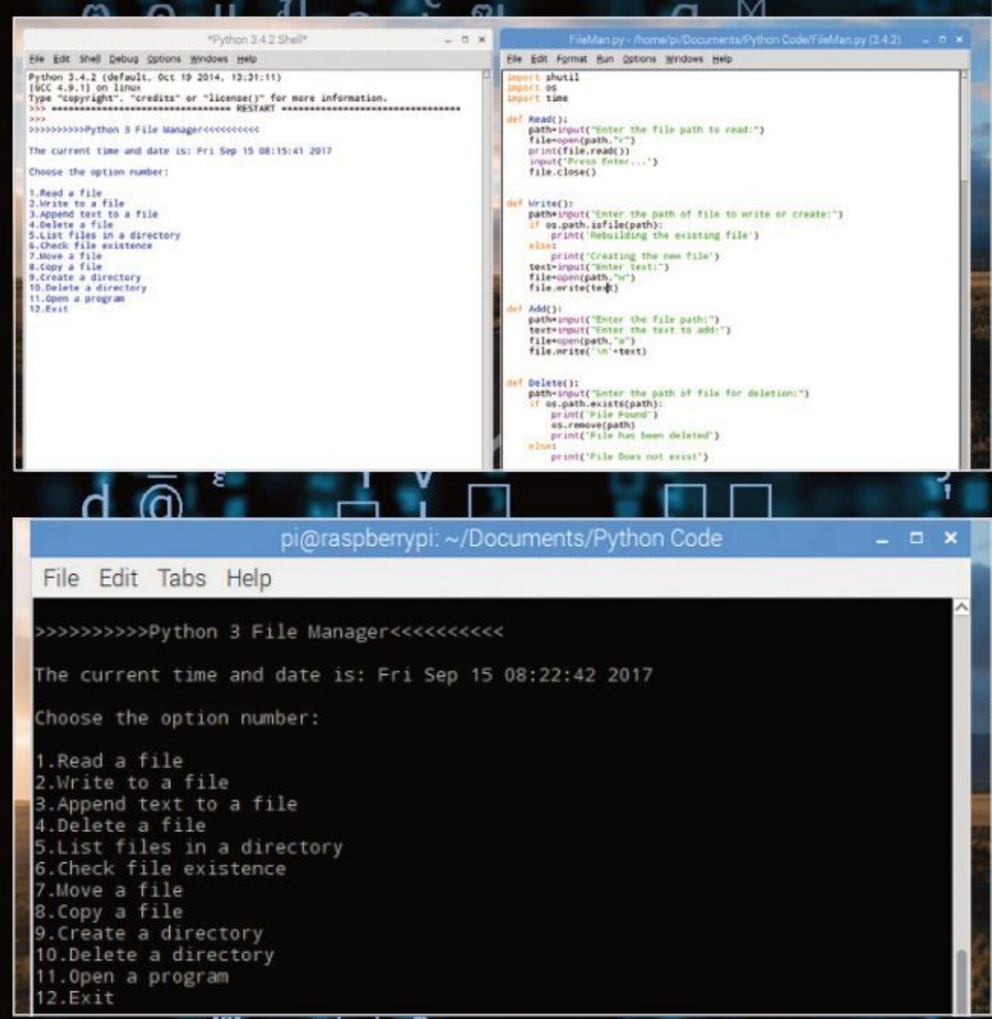
We've got code for making backups of your files and folders, number guessing games, random number generators, Google search code, game code, animation code, graphics code, text adventure code and even code that plays music stored on your computer. We've broken down some of the newer, and extended, concepts of the code to help you better understand what's going on. This way you can easily adapt it to your own uses.

This is an excellent resource that you won't find in any other Python book. So use it, take it apart, adapt it to your own programs and see what you can create.

112 Python File Manager
114 Number Guessing Game
116 Random Number Generator
117 Random Password Generator
118 Text to Binary Convertor
120 Basic GUI File Browser
122 Mouse Controlled Turtle
123 Python Alarm Clock
124 Vertically Scrolling Text
126 Python Digital Clock
128 Playing Music with the Winsound Module
130 Text Adventure Script
132 Python Scrolling Ticker Script
133 Simple Python Calculator
134 Hangman Game Script

Python File Manager

This file manager program displays a list of options that allow you to read a file, write to a file, append to a file, delete a file, list the contents of a directory and much more. It's remarkably easy to edit and insert into your own code, or add to.



1 This part of the code imports the necessary modules. The OS and Subprocess modules deal with the operating system elements of the program.

2 Each def XXX() functions store the code for each of the menu's options. Once the code within the function is complete, the code returns to the main menu for another option.

3 This is part of the code that checks to see what OS the user is running. In Windows the CLS command clears the screen, whereas in Linux and macOS, the Clear command wipes the screen. If the code tries to run CLS when being used in Linux or macOS, an error occurs, which then prompts it to run the Clear command instead.

4 These are the options, from 1 to 12. Each executes the appropriate function when the relevant number is entered.

FILEMAN.PY

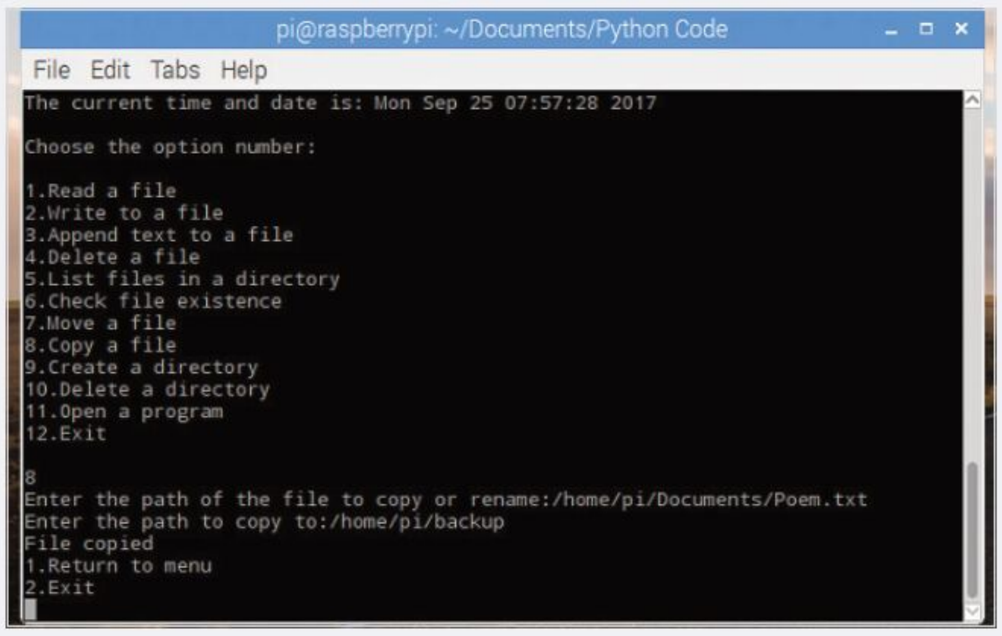
Copy the code below into a New > File and save it as FileMan.py. Once executed it will display the program title, along with the current time and date and the available options.

```
import shutil
import os
import time
import subprocess

def Read():
   path=input("Enter the file path to read:")
   file=open(path,"r")
   print(file.read())
   input('Press Enter...')
   file.close()

def Write():
   path=input("Enter the path of file to write or create:")
   if os.path.isfile(path):
      print('Rebuilding the existing file')
   else:
      print('Creating the new file')
   text=input("Enter text:")
   file=open(path,"w")
   file.write(text)

def Add():
   path=input("Enter the file path:")
   text=input("Enter the text to add:")
   file=open(path,"a")
   file.write('\n'+text)

def Delete():
   path=input("Enter the path of file for deletion:")
   if os.path.exists(path):
      print('File Found')
      os.remove(path)
      print('File has been deleted')
   else:
      print('File Does not exist')

def Dirlist():
   path=input("Enter the Directory path to display:")
   sortlist=sorted(os.listdir(path))
   i=0
   while(i<len(sortlist)):
      print(sortlist[i]+'\n')
      i+=1

def Check():
   fp=int(input('Check existence of \n1.File \n2.
   Directory\n'))
      if fp==1:
         path=input("Enter the file path:")
         os.path.isfile(path)
```

```
        if os.path.isfile(path)==True:
            print('File Found')
        else:
            print('File not found')
    if fp==2:
        path=input("Enter the directory path:")
        os.path.isdir(path)
        if os.path.isdir(path)==False:
            print('Directory Found')
        else:
            print('Directory Not Found')

def Move():
    path1=input('Enter the source path of file to move:')
    mr=int(input('1.Rename \n2.Move \n'))
    if mr==1:
        path2=input('Enter the destination path and file name:')
        shutil.move(path1,path2)
        print('File renamed')
    if mr==2:
        path2=input('Enter the path to move:')
        shutil.move(path1,path2)
        print('File moved')

def Copy():
    path1=input('Enter the path of the file to copy or rename:')
    path2=input('Enter the path to copy to:')
    shutil.copy(path1,path2)
    print('File copied')

def Makedir():
    path=input("Enter the directory name with path to make
    \neg. C:\\Hello\\Newdir \nWhere Newdir is new
    directory:")
    os.makedirs(path)
    print('Directory Created')

def Removedir():
    path=input('Enter the path of Directory:')
    treedir=int(input('1.Deleted Directory \n2.Delete
    Directory Tree \n3.Exit \n'))
    if treedir==1:
        os.rmdir(path)
    if treedir==2:
        shutil.rmtree(path)
        print('Directory Deleted')
    if treedir==3:
        exit()

def Openfile():
    path=input('Enter the path of program:')
    try:
        os.startfile(path)
    except:
        print('File not found')

run=1
while(run==1):
    try:
        os.system('clear')
    except OSError:
        os.system('cls')
    print('\n>>>>>>>>>>Python 3 File Manager<<<<<<<<<<\n')
    print('The current time and date is:',time.asctime())
    print('\nChoose the option number: \n')
    dec=int(input('''1.Read a file
2.Write to a file
3.Append text to a file
4.Delete a file
5.List files in a directory
6.Check file existence
7.Move a file
8.Copy a file
9.Create a directory
10.Delete a directory
11.Open a program
12.Exit

'''))
    if dec==1:
        Read()
    if dec==2:
        Write()
    if dec==3:
        Add()
    if dec==4:
        Delete()
    if dec==5:
        Dirlist()
    if dec==6:
        Check()
    if dec==7:
        Move()
    if dec==8:
        Copy()
    if dec==9:
        Makedir()
    if dec==10:
        Removedir()
    if dec==11:
        Openfile()
    if dec==12:
        exit()
    run=int(input("1.Return to menu\n2.Exit \n"))
    if run==2:
        exit()
```

3

4



Imports

There are three modules to import here: Shutil, OS and Time. The first two deal with the operating system and file management and manipulation; and the Time module simply displays the current time and date.

Note how we've included a try and except block to check if the user is running the code on a Linux system or Windows. Windows uses CLS to clear the screen, while Linux uses clear. The try block should work well enough but it's a point of possible improvement depending on your own system.

Number Guessing Game

This is a simple little piece of code but it makes good use of the Random module, print and input, and a while loop. The number of guesses can be increased from 5 and the random number range can easily be altered too.

NumberGuess.py - /home/pi/Docum...hon Code/NumberGuess.py (3.4.2)

File Edit Format Run Options Windows Help

```
import random

guessesUsed = 0
Name=input('Hello! What is your name? ')
number = random.randint(1, 30)
print('Greetings, ' + Name + ', I\'m thinking of a number between 1 and 30.')
while guessesUsed < 5:
    guess=int(input('Guess the number within 5 guesses...'))
    guessesUsed = guessesUsed + 1
    if guess < number:
        print('Too low, try again.')
    if guess > number:
        print('Too high, try again.')
    if guess == number:
        break
if guess == number:
    guessesUsed = str(guessesUsed)
    print('Well done, ' + Name + '! You guessed correctly in ' + guessesUsed + '

if guess != number:
    number = str(number)
    print('Sorry, out of guesses. The number I was thinking of is ' + number)
```

Python 3.4.2 Shell

File Edit Shell Debug Options Windows Help

```
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> ================================ RESTART ================================
>>>
Hello! What is your name? David
Greetings, David, I'm thinking of a number between 1 and 30.
Guess the number within 5 guesses...26
Too high, try again.
Guess the number within 5 guesses...20
Too high, try again.
Guess the number within 5 guesses...15
Well done, David! You guessed correctly in 3 guesses.
>>> |
```

NumberGuess.py - /home/pi/Docum...hon Code/NumberGuess.py (3.4.2)

File Edit Format Run Options Windows Help

```
import random

guessesUsed = 0
Name=input('Hello! What is your name? ')
number = random.randint(1, 30)
print('Greetings, ' + Name + ', I\'m thinking of a number between 1 and 30.')
while guessesUsed < 5:
    guess=int(input('Guess the number within 5 guesses...'))
    guessesUsed = guessesUsed + 1
    if guess < number:
        print('Too low, try again.')
    if guess > number:
        print('Too high, try again.')
    if guess == number:
        break
if guess == number:
    guessesUsed = str(guessesUsed)
    print('Well done, ' + Name + '! You guessed correctly in ' + guessesUsed + '

if guess != number:
    number = str(number)
    print('Sorry, out of guesses. The number I was thinking of is ' + number)
```


NUMBERGUESS.PY

Copy the code and see if you can beat the computer within five guesses. It's an interesting bit of code that can be quite handy when your implementing a combination of the Random module alongside a while loop.

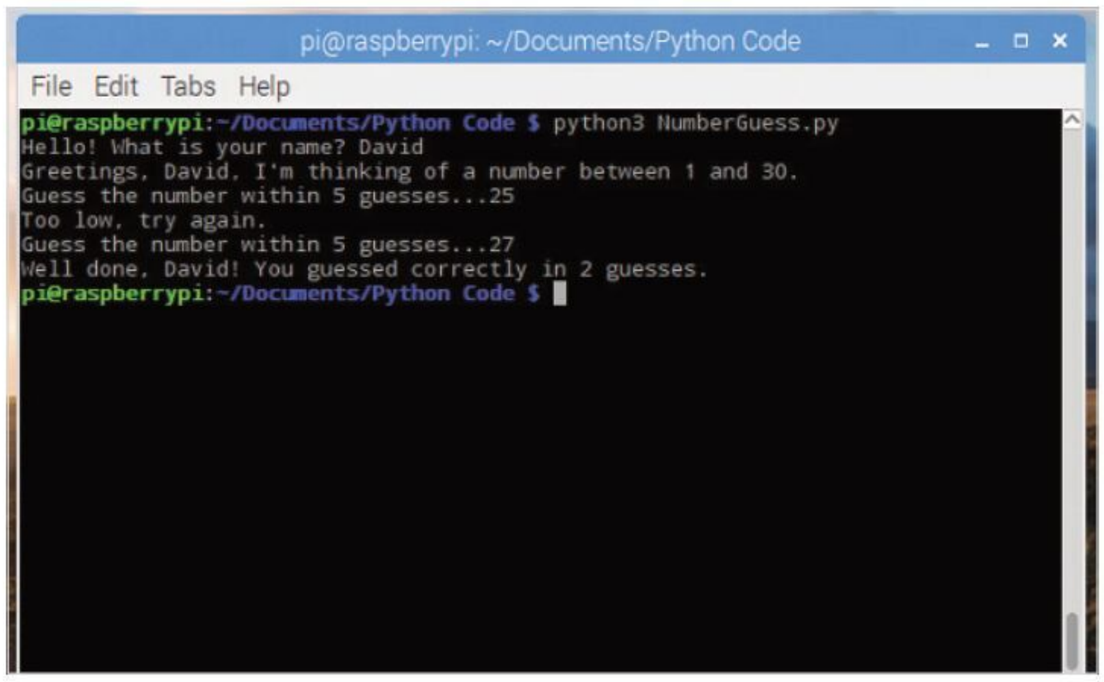
```
import random

guessesUsed = 0
Name=input('Hello! What is your name? ')
number = random.randint(1, 30)
print('Greetings, ' + Name + ', I\'m thinking of a
number between 1 and 30.')
while guessesUsed < 5:
   guess=int(input('Guess the number within 5 guesses...'))
   guessesUsed = guessesUsed + 1
   if guess < number:
      print('Too low, try again.')
   if guess > number:
      print('Too high, try again.')
   if guess == number:
      break
if guess == number:
   guessesUsed = str(guessesUsed)
   print('Well done, ' + Name + '! You guessed
   correctly in ' + guessesUsed + ' guesses.')

if guess != number:
   number = str(number)
   print('Sorry, out of guesses. The number I was
   thinking of is ' + number)
```

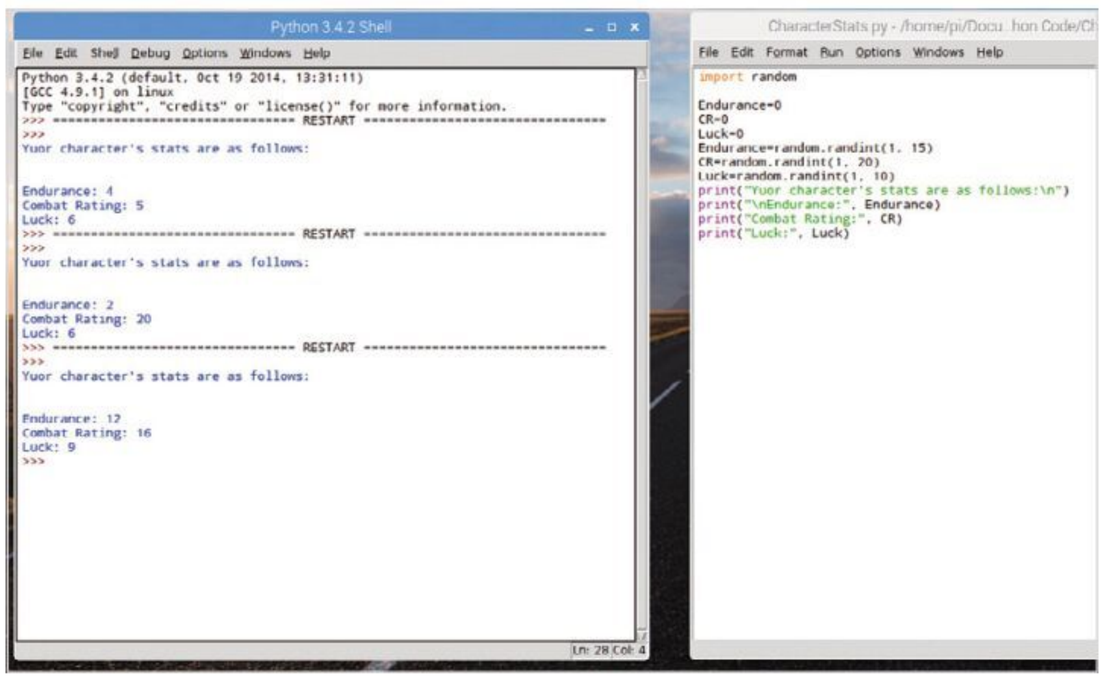
1 2 3

1 Although this is a reasonably easy to follow program, there are some elements to the code that are worth pointing out. To begin with, you need to import the Random module, as you're using random numbers within the code.

2 This section of the code creates the variables for the number of guesses used, along with the name of the player, and also sets up the random number between 1 and 30. If you want a wider range of random number selection, then increase the **number=random.randint(1, 30)** end value of 30; don't make it too high though or the player will never be able to guess it. If the player guesses too low or too high, they are given the appropriate output and asked to try again, while the number of guesses is less than five. You can also increase the number of guesses from 5 by altering the **while guessesUsed < 5:** value.

3 If the player guessed the correct number then they are given a 'well done' output, along with how many guesses they used up. If the player runs out of guesses, then the game over output is displayed instead, along with revealing the number the computer was thinking of. Remember, if you do alter the values of the random number chosen by the computer, or the number of guesses the player can take, then along with the variable values, you also need to amend the instructions given in the print statements at the start of the code.





Code Improvements

Since this is such as simple script to apply to a situation, there's plenty of room to mess around with it and make it more interesting. Perhaps you can include an option to take score, the best out of three rounds. Maybe an elaborate way to congratulate the player for getting a 'hole in one' correct guess on their first try.

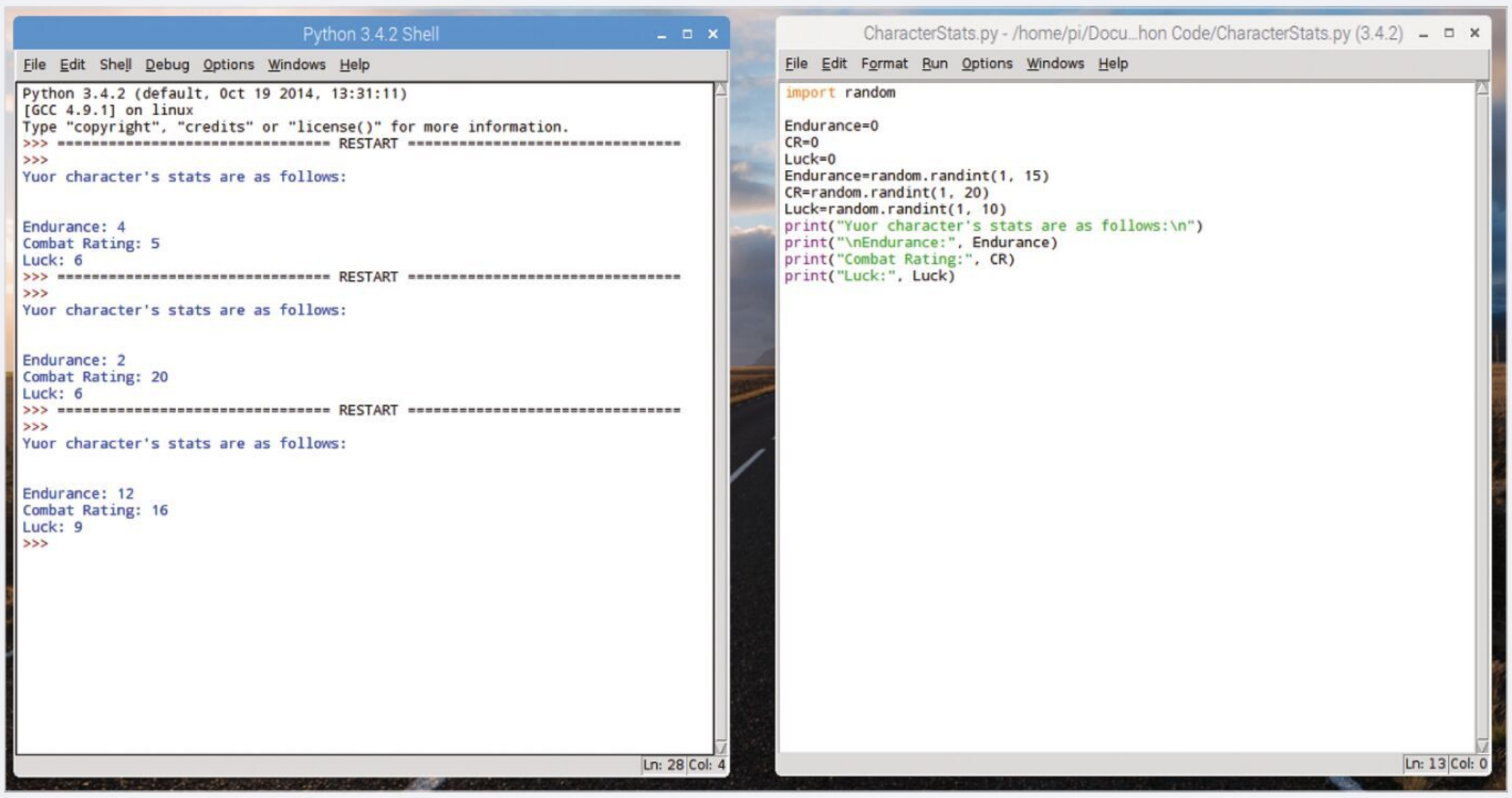
Moreover, the number guessing game code does offer some room for implementing into your code in a different manner. What we mean by this is, the code can be used to retrieve a random number between a range, which in turn can give you the start of a character creation defined function within an adventure game.

Imagine the start of a text adventure written in Python, where the player names their character. The next step is to roll the virtual random dice to decide what that character's combat rating, strength, endurance and luck values are. These can then be carried forward into the game under a set of variables that can be reduced or increased depending on the circumstances the player's character ends up in.

For example, as per the screenshot provided, you could use something along the lines of:

```
Endurance=0
CR=0
Luck=0
Endurance = random.randint(1, 15)
CR = random.randint(1, 20)
Luck = random.randint(1, 10)
Print("Your character's stats are as follows:\n")
Print("Endurance:", Endurance)
Print("Combat Rating:", CR)
Print("Luck:", Luck)
```

The player can then decide to either stick with their roll or try again for the hope of better values being picked. There's ample ways in which to implement this code into a basic adventure game.



Random Number Generator

User input and the ability to manipulate that input are important elements with any programming language. It's what separates a good program from a great program, one that allows the user to interact and see the results of that interaction.

RNDNUMGEN.PY

It might be simple but this little piece of code will ask the user for two sets of numbers, a start and a finish. The code will then pluck out a random number between the two sets and display it.

```
from random import *

print("\n>>>>>>>>>>Random Number Generator<<<<<<<<<<\n")
nmb1=int(input("Enter the start number: "))
nmb2=int(input("Enter the last number: "))

x = randint(nmb1, nmb2)
print("\nThe random number between",nmb1,"and",nmb2,"is:\n")
print(x)
```

More Input

While an easy code to follow, it could be more interesting if you prompt the user for more input. Perhaps you can provide them with addition, subtraction, multiplication elements with their numbers. If you're feeling clever, see if you can pass the code through a Tkinter window or even the Ticker window that's available on Page 128.

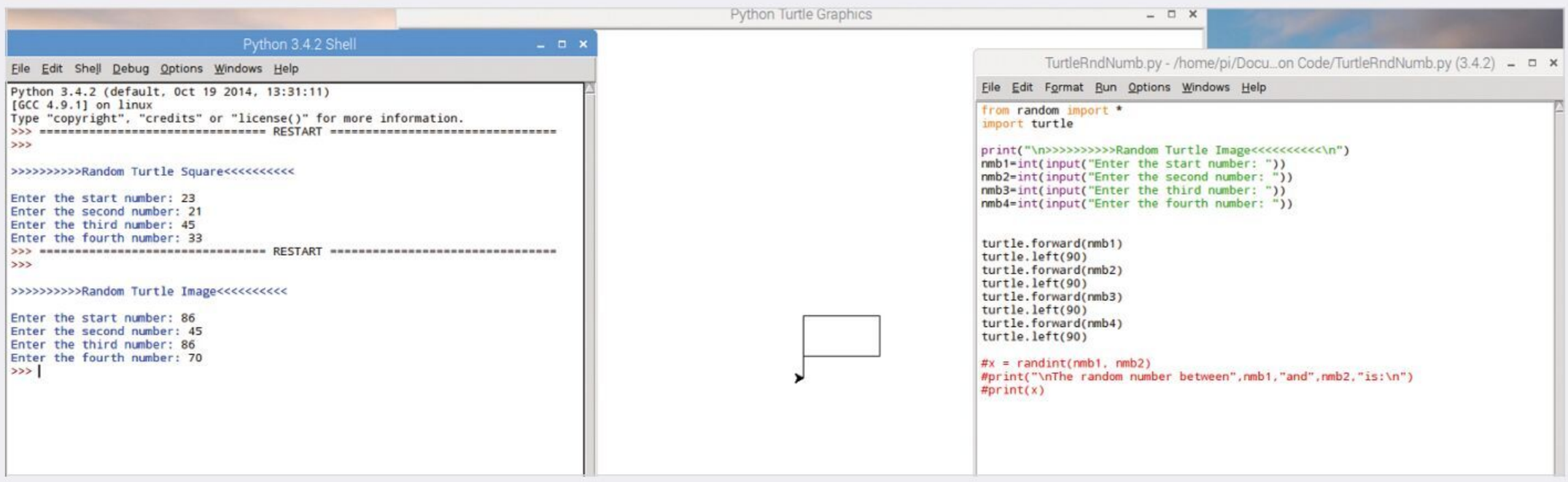
Furthermore, the core of the code can be used in a text adventure game, where the character fights something and their health, along with the enemy's, is reduced by a random number. This can be mixed with the previous code from Page 90's Number Guessing Game, where we defined the stats for the adventure game's character.

You can also introduce the Turtle module into the code and perhaps set some defined rules for drawing a shape, object or something based on a user inputted random value from a range of numbers. It takes a little working out but the effect is certainly really interesting.

For example, the code could be edited to this:

```
from random import *
import turtle

print("\n>>>>>>>>>>Random Turtle Image<<<<<<<<<<\n")
nmb1=int(input("Enter the start number: "))
nmb2=int(input("Enter the second number: "))
nmb3=int(input("Enter the third number: "))
nmb4=int(input("Enter the fourth number: "))


turtle.forward(nmb1)
turtle.left(90)
turtle.forward(nmb2)
turtle.left(90)
turtle.forward(nmb3)
turtle.left(90)
turtle.forward(nmb4)
turtle.left(90)
```

Whilst it's a little rough around the edges, you can easily make it more suitable.



Random Password Generator

We're always being told that our passwords aren't secure enough; well here's a solution for you to implement into your own future programs. The random password generator code below will create a 12-letter string of words (both cases) and numbers each time it's executed.

RNDPASSWORD.PY

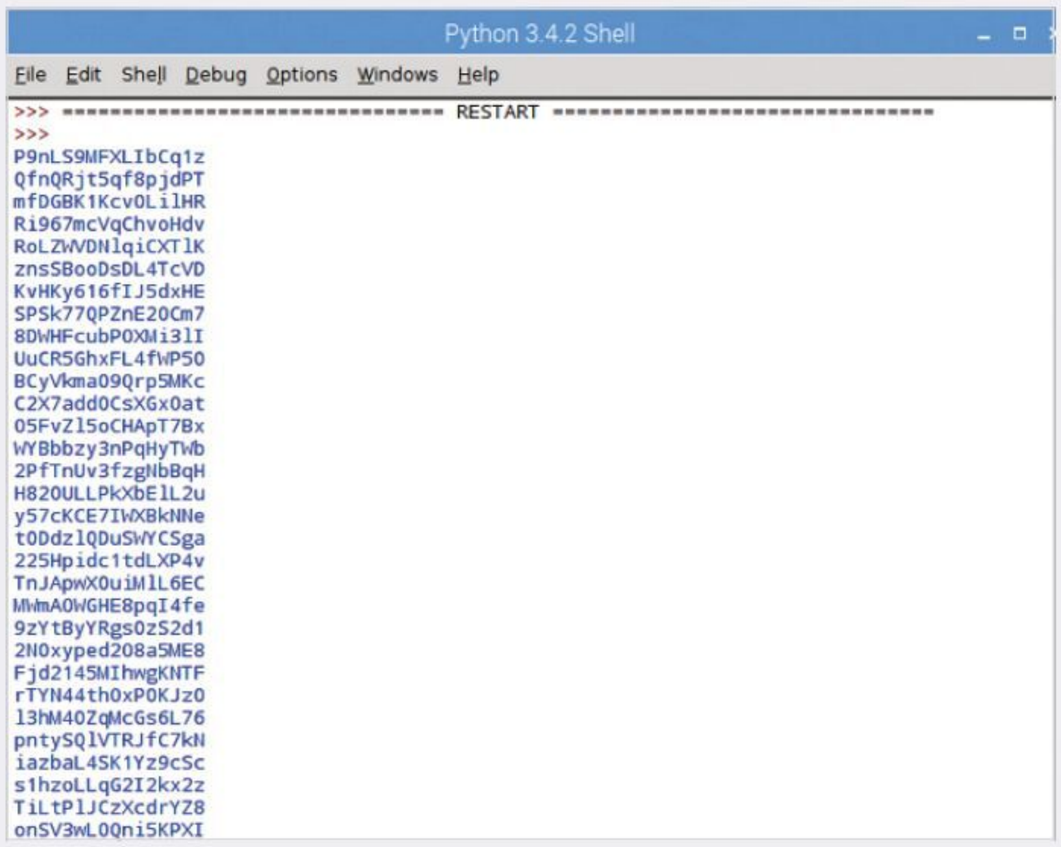
Copy the code and run it; each time you'll get a random string of characters that can easily be used as a secure password which will be very difficult for a password cracker to hack.

```
import string
import random

def randompassword():
   chars=string.ascii _ uppercase + string.ascii _
   lowercase + string.digits
   size= 8
   return ''.join(random.choice(chars) for x in
   range(size,20))

print(randompassword())
```

Secure Passwords

There's plenty you can do to modify this code and improve it further. For one, you can increase the number of characters the generated password displays and perhaps you can include special characters too, such as signs and symbols. Then, you can output the chosen password to a file, then securely compress it using the previous random number generator as a file password and send it to a user for their new password.

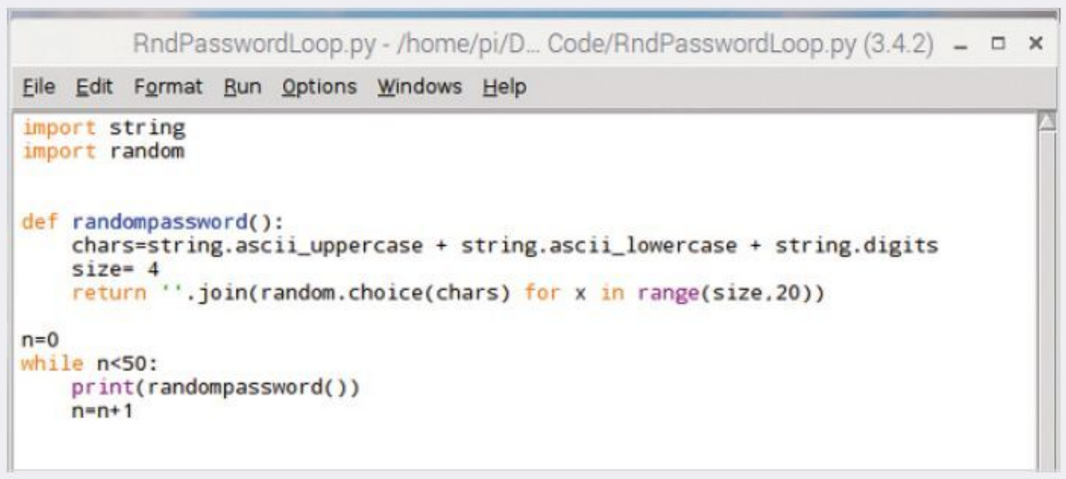
An interesting aspect to this code is the ability to introduce a loop and print any number of random passwords. Let's assume you have a list of 50 users for a company and you're in charge of generating a random password for them each month.



Adding a loop to print a password fifty times is extremely easy, for example:

```
import string
import random


def randompassword():
   chars=string.ascii _ uppercase + string.ascii _
   lowercase + string.digits
   size= 4
   return ''.join(random.choice(chars) for x in
   range(size,20))

n=0
while n<50:
   print(randompassword())
   n=n+1
```

This will output fifty random passwords based on the previous random selection of characters.



Text to Binary Convertor

While it may not seem too exciting, this text to binary convertor is actually quite good fun. It also only uses two lines of code, so it's extremely easy to insert into your own script.

TXT2BIN.PY

Naturally we're using the format function to convert the user's entered text string into its binary equivalent. If you want to check its accuracy, you can plug the binary into an online convertor.

```
text=input("Enter text to convert to Binary: ")

print(' '.join(format(ord(x), 'b') for x in text))
```

Python 3.4.2 Shell

```
Python 3.4.2 (default, Oct 19 2014, 13:31:11)
[GCC 4.9.1] on linux
Type "copyright", "credits" or "license()" for more information.
>>> ================================ RESTART ================================
>>>
>>>>>>>>>>Text to Binary Convertor<<<<<<<<<<

Enter text to convert to Binary: David
1000100 1100001 1110110 1101001 1100100
>>>
```

Txt2Bin.py - /home/pi/Documents/Python Code/Txt2Bin.py (3.4.2)

```
print(">>>>>>>>>>Text to Binary Convertor<<<<<<<<<<\n")

text=input("Enter text to convert to Binary: ")

print(' '.join(format(ord(x), 'b') for x in text))
```

pi@raspberrypi: ~/Documents/Python Code

```
pi@raspberrypi:~/Documents/Python Code $ python3 Txt2Bin.py
>>>>>>>>>>Text to Binary Convertor<<<<<<<<<<

Enter text to convert to Binary: David
1000100 1100001 1110110 1101001 1100100
pi@raspberrypi:~/Documents/Python Code $
```

Txt2Bin.py - /home/pi/Documents/Python Code/Txt2Bin.py (3.4.2)

```
print(">>>>>>>>>>Text to Binary Convertor<<<<<<<<<<\n")

text=input("Enter text to convert to Binary: ")

print(' '.join(format(ord(x), 'b') for x in text))
```

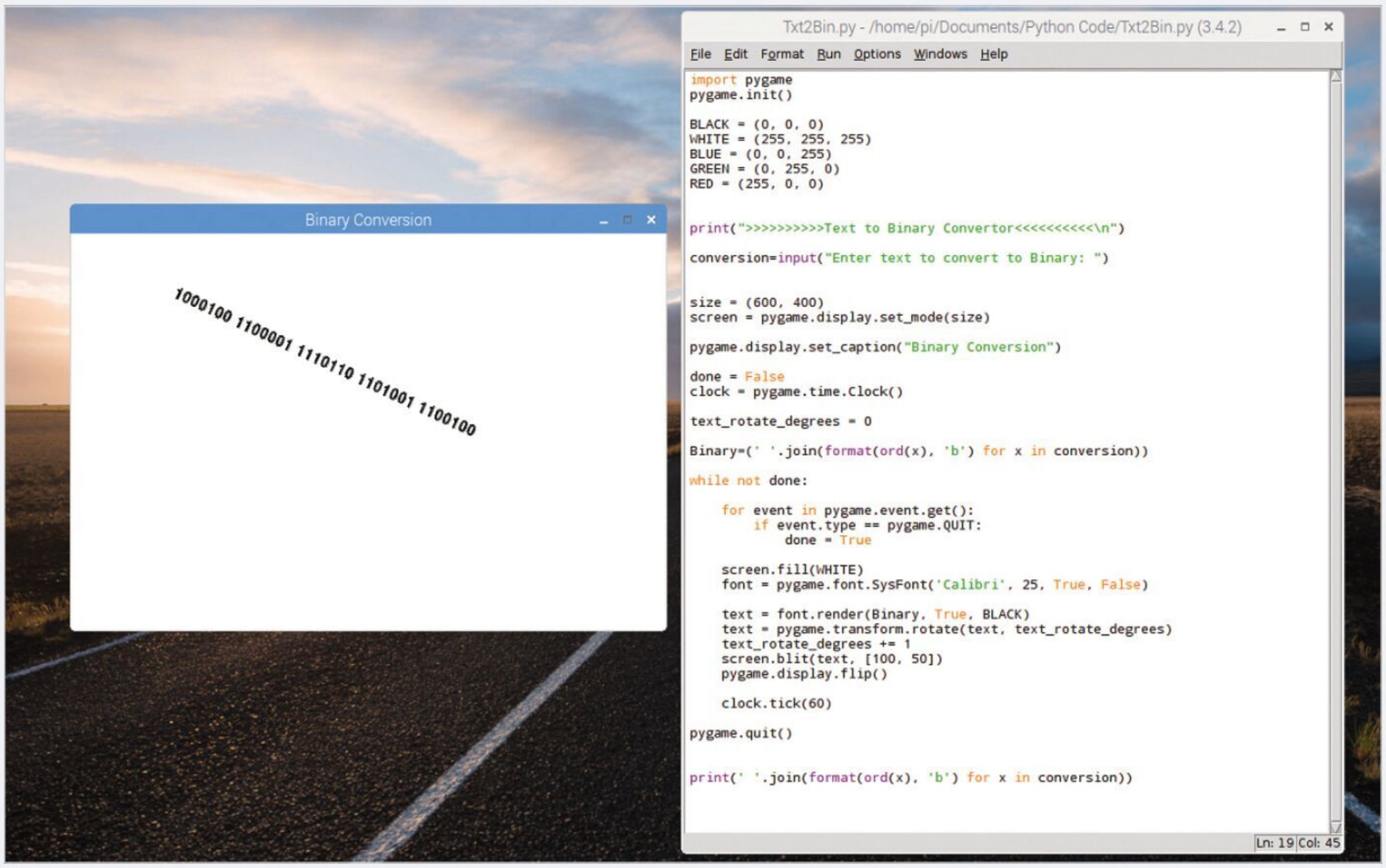
1000010 1101001 1101110 1100001 1110010 1111001

The text to binary convertor does offer some room for improvement and enhancement. There are many uses: it could be utilised in a password or secret word script, as part of an adventure game or just a novel way to display someone's name.

With regards to improvements, you could display the binary conversion in a Pygame window, using the animated text options from page 100. You could also ask the user if they wanted to have another go, or even ask if they wanted the binary output to be saved to a file.

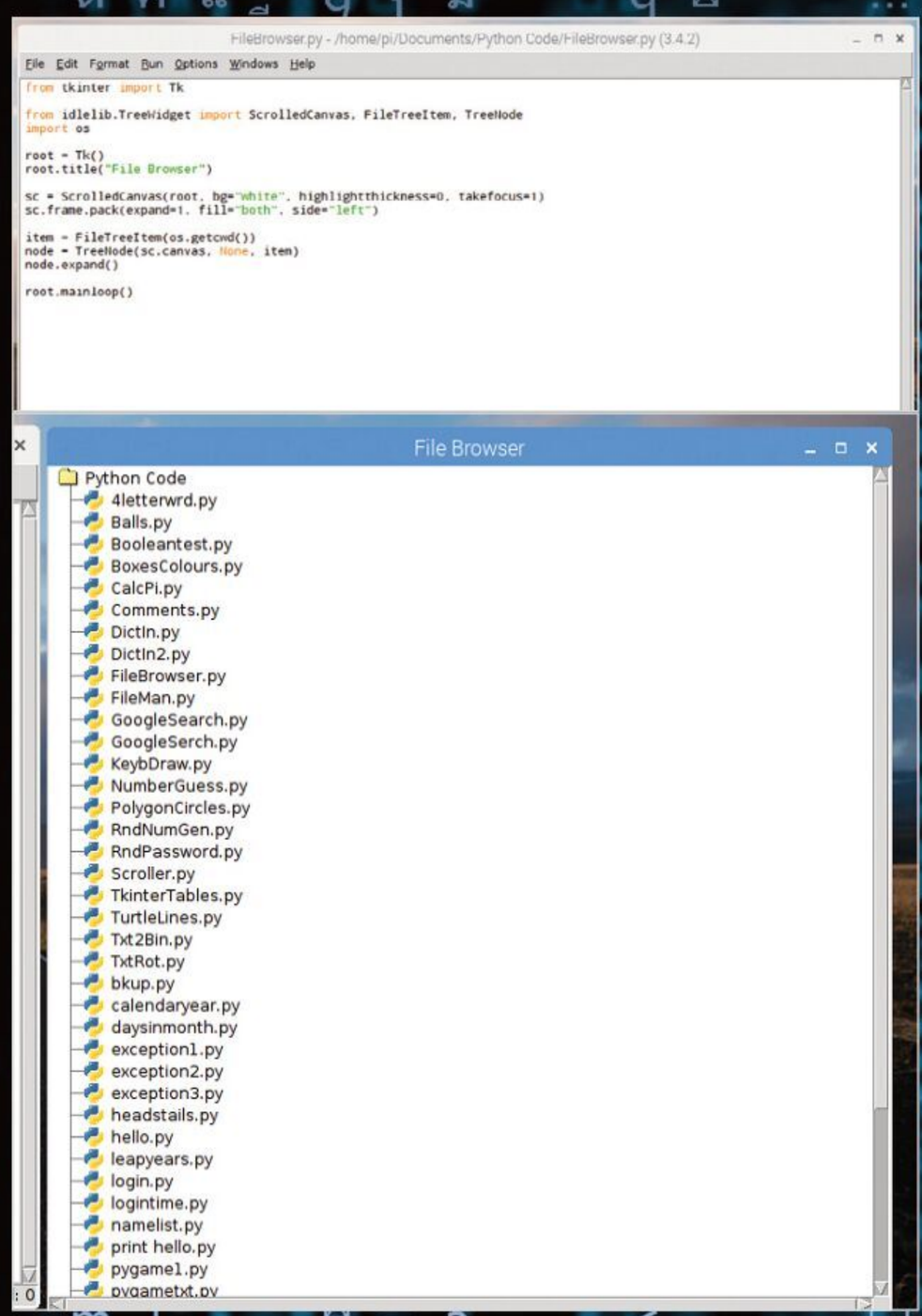
With regards to rendering the outputted binary conversion to a Pygame window, complete with rotating text, you can use:

```
import pygame
pygame.init()

BLACK = (0, 0, 0)
WHITE = (255, 255, 255)
BLUE = (0, 0, 255)
GREEN = (0, 255, 0)
RED = (255, 0, 0)

print(">>>>>>>>>>Text to Binary Convertor<<<<<<<<<<\n")

conversion=input("Enter text to convert to Binary: ")

size = (600, 400)
screen = pygame.display.set _ mode(size)

pygame.display.set _ caption("Binary Conversion")

done = False
clock = pygame.time.Clock()

text _ rotate _ degrees = 0

Binary=(' '.join(format(ord(x), 'b') for x
   in conversion))

while not done:

   for event in pygame.event.get():
      if event.type == pygame.QUIT:
         done = True

   screen.fill(WHITE)
   font = pygame.font.SysFont('Calibri', 25, True, False)

   text = font.render(Binary, True, BLACK)
   text = pygame.transform.rotate(text, text _
   rotate _ degrees)
   text _ rotate _ degrees += 1
   screen.blit(text, [100, 50])
   pygame.display.flip()

   clock.tick(60)

pygame.quit()

print(' '.join(format(ord(x), 'b') for x in conversion))
```



Basic GUI File Browser

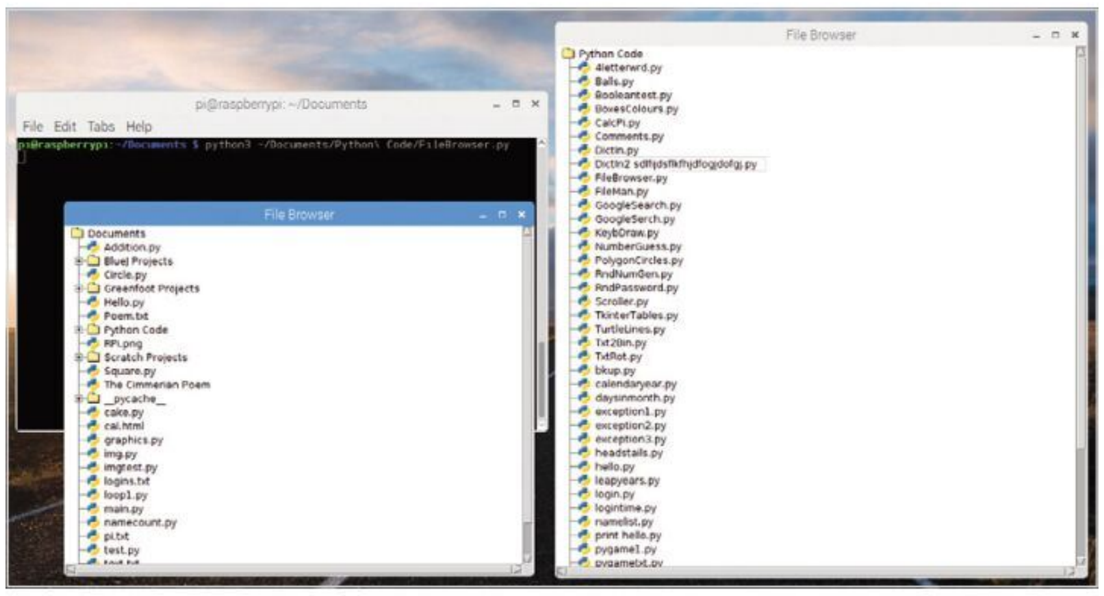
Here's a helpful and interesting piece of code. It's an extremely basic file browser that's presented in a graphical user interface using the Tkinter module. There's a lot you can learn from this code and implement into your own programs.

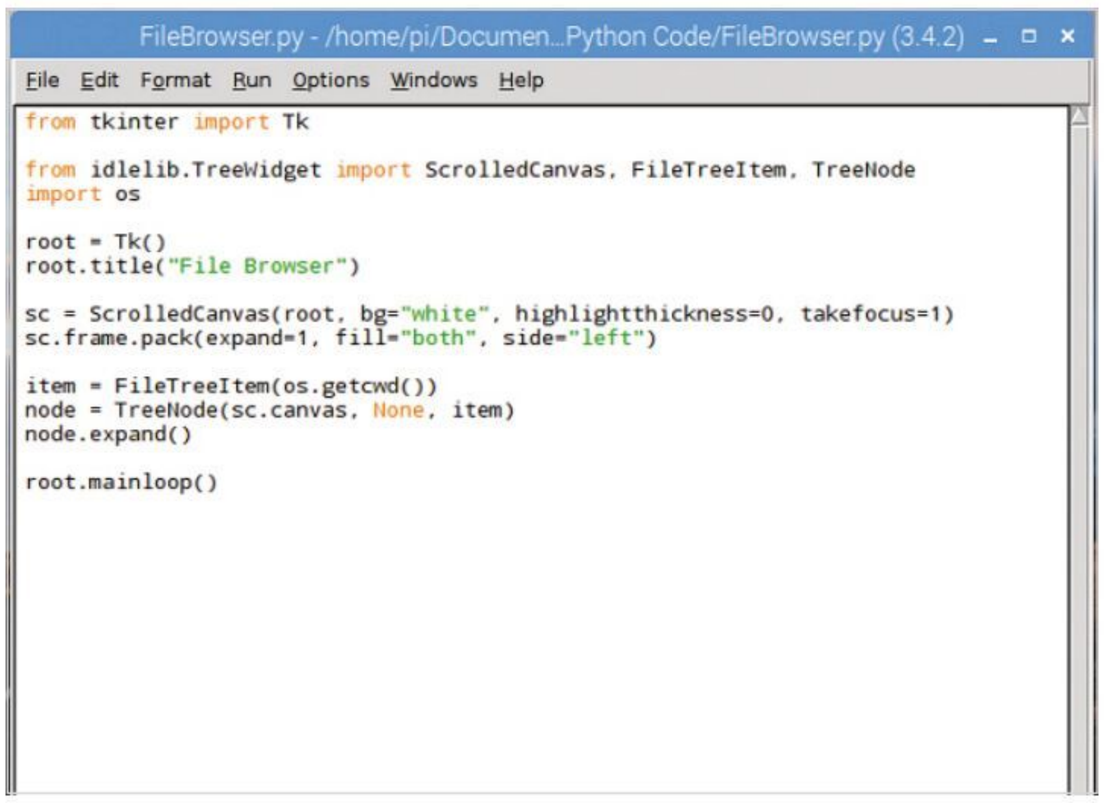


FILEBROWSER.PY

Tkinter is the main module in use here but we're also using idlelib, so you may need to pip install any extras if the dependencies fail when you execute the code.

```
from tkinter import Tk

from idlelib.TreeWidget import ScrolledCanvas,
FileTreeItem, TreeNode
import os

root = Tk()
root.title("File Browser")

sc = ScrolledCanvas(root, bg="white",
highlightthickness=0, takefocus=1)
sc.frame.pack(expand=1, fill="both", side="left")

item = FileTreeItem(os.getcwd())
node = TreeNode(sc.canvas, None, item)
node.expand()

root.mainloop()
```





Advanced Filing

When executed, the code will display the current directory's contents. If you want to see the contents of another directory, you can run the code from a command line within the chosen directory; just remember to call the code from where it's located on your system, as per the second screenshot. You can also double-click any of the file names shown in the directory tree and rename them.

This is an interesting piece of code and one that you can insert into your own programs. You can extend the code to include a user specified directory to browse, perhaps your own unique file icons too. If you're using Linux, create an alias to execute the code and then you can run it from wherever you are in the system.

Windows users may have some trouble with the above code, an alternative can be achieved by using the following:

```
from tkinter import *
from tkinter import ttk
from tkinter.filedialog import askopenfilename

root = Tk(  )

def OpenFile():
   name = askopenfilename(initialdir="C:/",
                  filetypes =(("Text File", "*.txt"),("All
                  Files","*.*")),
                  title = "Choose a file."
                           )
   print (name)
   try:
      with open(name,'r') as UseFile:
         print(UseFile.read())
   except:
      print("No files opened")


Title = root.title( "File Opener")
label = ttk.Label(root, text ="File
Open",foreground="red",font=("Helvetica", 16))
label.pack()


menu = Menu(root)
root.config(menu=menu)

file = Menu(menu)

file.add _ command(label = 'Open', command = OpenFile)
file.add _ command(label = 'Exit', command =
lambda:exit())

menu.add _ cascade(label = 'File', menu = file)

root.mainloop()
```

It's not quite the same but this code allows you to open files in your system via the familiar Windows Explorer. It's worth experimenting with to see what you can do with it.

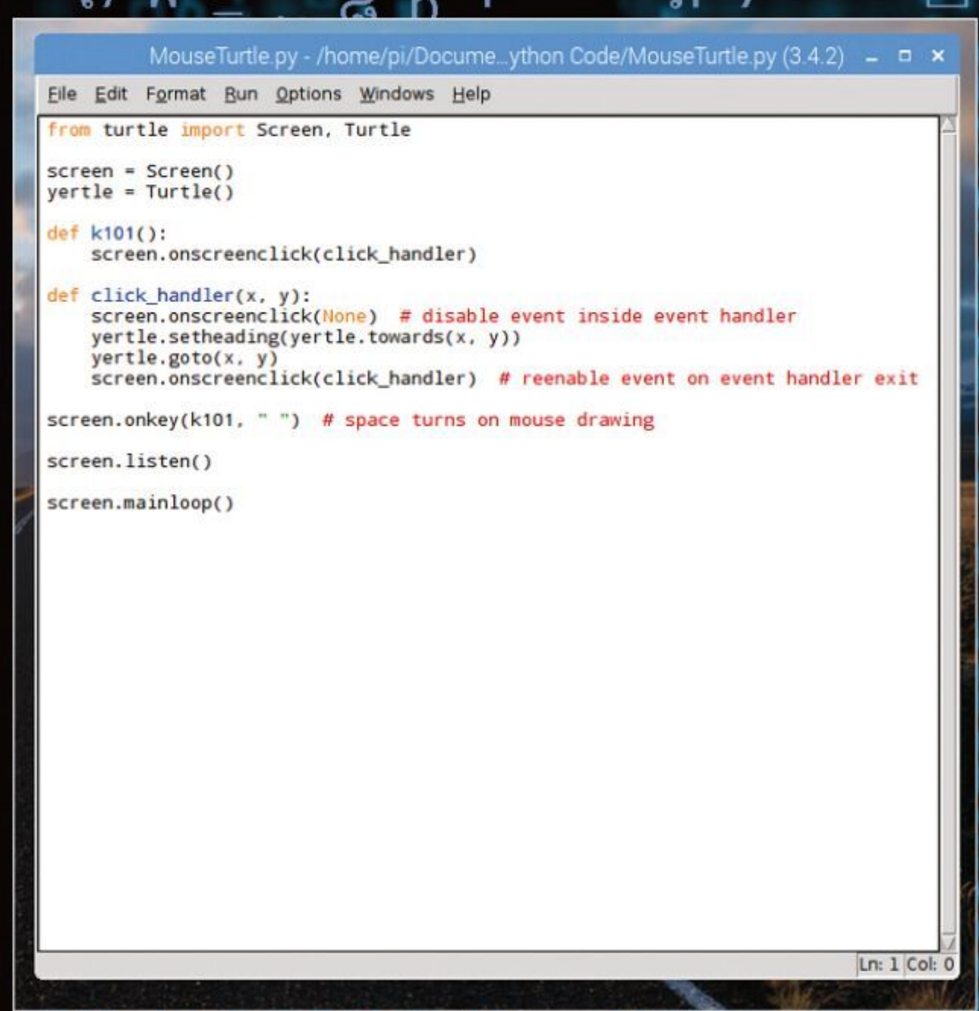
filetest1.py - C:\Users\david\Documents\Python\filetest1.py (3.6.2)

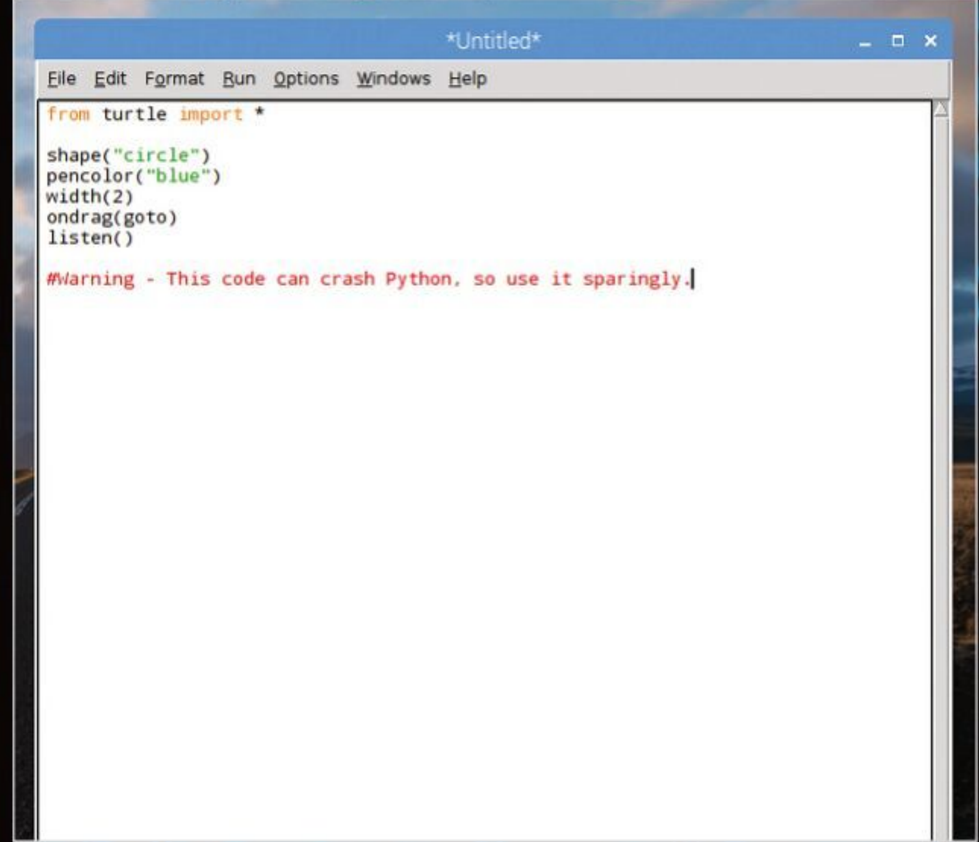
File Edit Format Run Options Window Help

```
from tkinter import *
from tkinter import ttk
from tkinter.filedialog import askopenfilename

root = Tk(  )

def OpenFile():
    name = askopenfilename(initialdir="C:/",
                           filetypes =(("Text File", "*.txt"),("All Files","*.*")),
                           title = "Choose a file."
                           )
    print (name)
    try:
        with open(name,'r') as UseFile:
            print(UseFile.read())
    except:
        print("No files opened")


Title = root.title( "File Opener")
label = ttk.Label(root, text ="File Open",foreground="red",font=("Helvetica", 16))
label.pack()


menu = Menu(root)
root.config(menu=menu)

file = Menu(menu)

file.add_command(label = 'Open', command = OpenFile)
file.add_command(label = 'Exit', command = lambda:exit())

menu.add_cascade(label = 'File', menu = file)


root.mainloop()
```

Mouse Controlled Turtle

We've already seen the Turtle module being controlled by the user via the keyboard but now we thought we'd see how the user can use their mouse as a drawing tool within Python. We have two possible code examples here, pick which works best for you.





MOUSETURTLE.PY

The first piece of code presents the standard Turtle window. Press Space and then click anywhere on the screen for the Turtle to draw to the mouse pointer. The second allows you to click the Turtle and drag it around the screen; but be warned, it can crash Python.

1st Code Example:

```
from turtle import Screen, Turtle

screen = Screen()
yertle = Turtle()

def k101():
   screen.onscreenclick(click _ handler)

def click _ handler(x, y):
   screen.onscreenclick(None)  # disable event inside
   event handler
   yertle.setheading(yertle.towards(x, y))
   yertle.goto(x, y)
   screen.onscreenclick(click _ handler)  # reenable
   event on event handler exit

screen.onkey(k101, " ")  # space turns on mouse drawing

screen.listen()

screen.mainloop()
```

2nd Code Example:

```
from turtle import *
shape("circle")
pencolor("blue")
width(2)
ondrag(goto)
listen()
```

Ninja TurtleMouse

This code utilises some interesting skills. Obviously it will stretch your Python Turtle skills to come up with any improvements, which is great, but it could make for a nice piece of code to insert into something a young child will use. Therefore it can be a fantastic project for a younger person to get their teeth into; or perhaps even as part of a game where the main character is tasked to draw a skull and crossbones or something similar.

Python Alarm Clock

Ever taken a quick break from working at the computer, then suddenly realised many minutes later that you've spent all that time on Facebook? Introducing the Python alarm clock code, where you can drop into the command prompt and tell the code how many minutes until the alarm goes off.

ALARMCLOCK.PY

This code is designed for use in the command prompt, be that Windows, Linux or macOS. There are some instructions on how to use it in the main print section but essentially it's: python3 AlarmClock.py 10 (to go off in ten minutes).

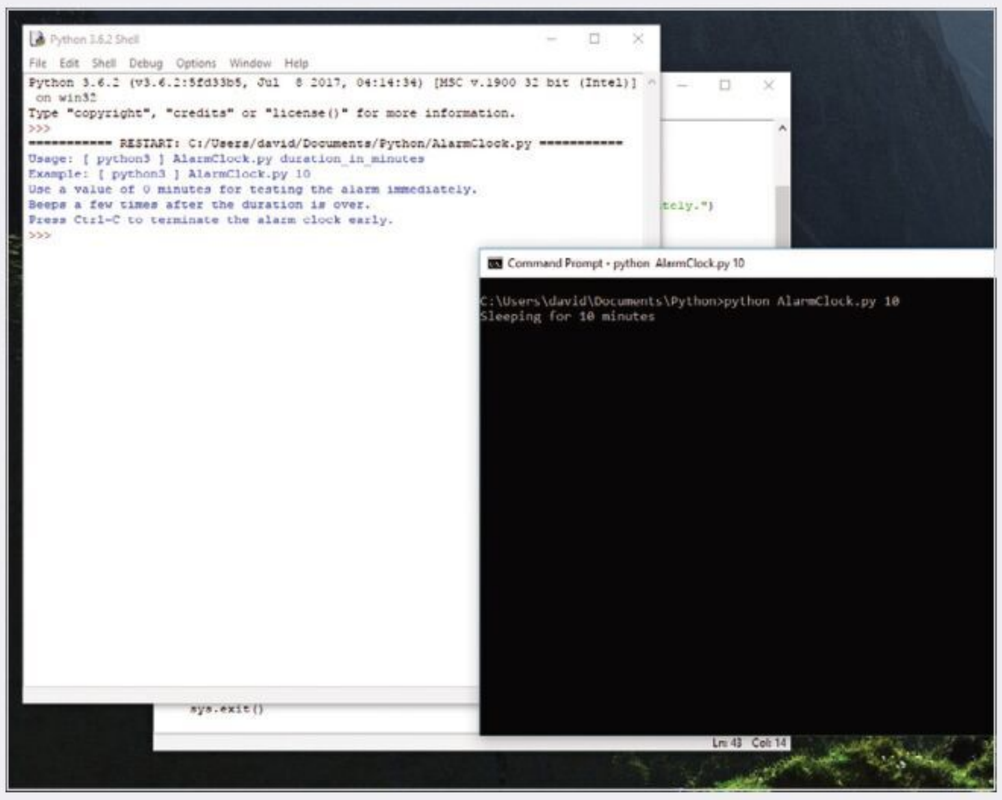
```
import sys
import string
from time import sleep

sa = sys.argv
lsa = len(sys.argv)
if lsa != 2:
   print ("Usage: [ python3 ] AlarmClock.py duration _
   in _ minutes")
   print ("Example: [ python3 ] AlarmClock.py 10")
   print ("Use a value of 0 minutes for testing the
   alarm immediately.")
   print ("Beeps a few times after the duration is over.")
   print ("Press Ctrl-C to terminate the alarm
   clock early.")
   sys.exit(1)

try:
   minutes = int(sa[1])
except ValueError:
   print ("Invalid numeric value (%s) for minutes" % sa[1])
   print ("Should be an integer >= 0")
   sys.exit(1)

if minutes < 0:
   print ("Invalid value for minutes, should be >= 0")
   sys.exit(1)

seconds = minutes * 60

if minutes == 1:
   unit _ word = " minute"
else:
   unit _ word = " minutes"
```

```
try:
   if minutes > 0:
      print ("Sleeping for " + str(minutes) + unit _ word)
      sleep(seconds)
   print ("Wake up")
   for i in range(5):
      print (chr(7)),
      sleep(1)
except KeyboardInterrupt:
   print ("Interrupted by user")
   sys.exit(1)
```

Wakey Wakey

There's some good use of try and except blocks here, alongside some other useful loops that can help you get a firmer understanding of how they work in Python. The code itself can be used in a variety of ways: in a game where something happens after a set amount of time or simply as a handy desktop alarm clock for your tea break.

Linux users, try making the alarm clock code into an alias, so you can run a simple command to execute it. Then, why not integrate a user input at the beginning to ask the user for the length of time they want until the alarm goes off, rather than having to include it in the command line.



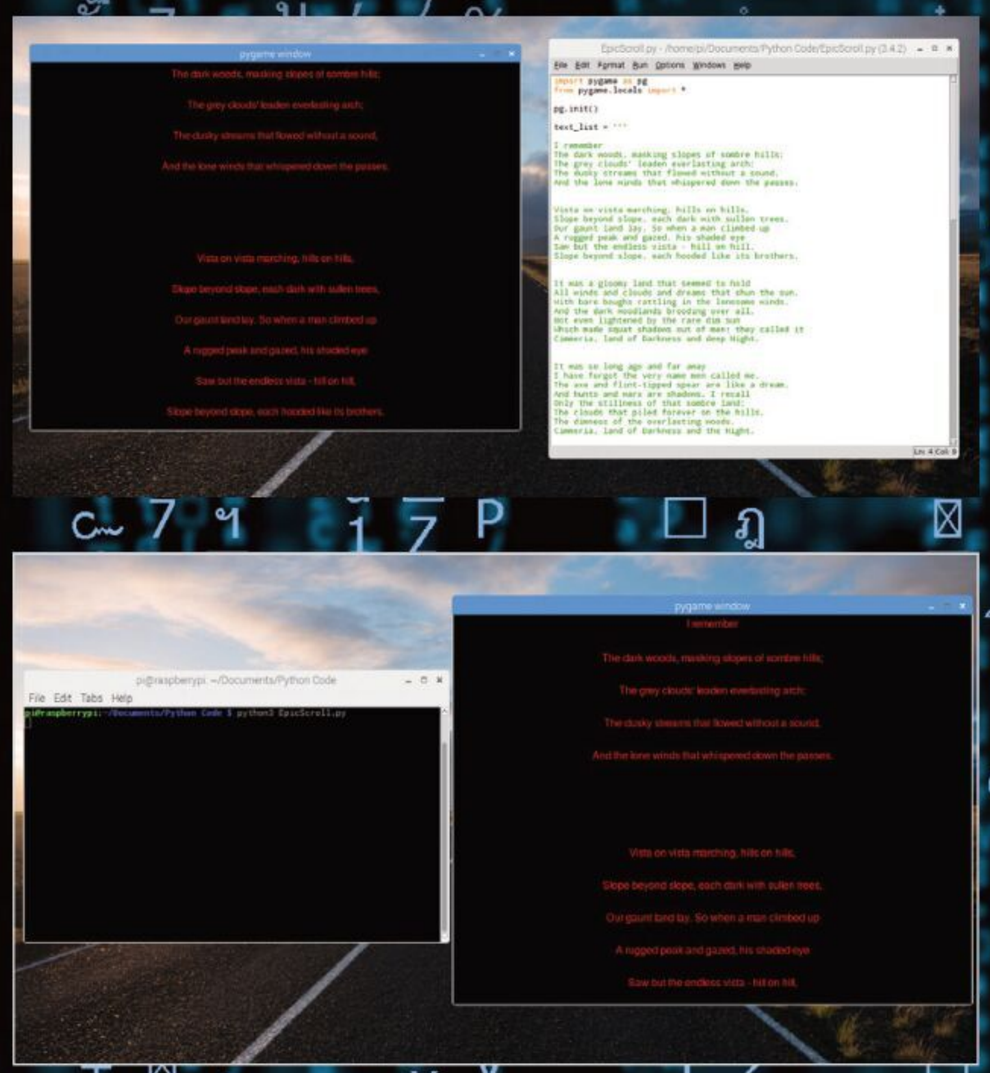
Windows users, if Python 3 is the only version installed on your system then you will need to execute the code without adding the 3 to the end of the Python command. For example:

```
python AlarmClock.py 10
```

Again, you could easily incorporate this into a Windows batch file and even set a schedule to activate the alarm at certain times of the day.

Vertically Scrolling Text

What's not to like about vertically scrolling text? Its uses are many: the beginning of a game or introduction to something epic, like the beginning of every Star Wars movie; a list of credits at the end of something, such as a Python presentation. The list goes on.



EPICSCROLL.PY

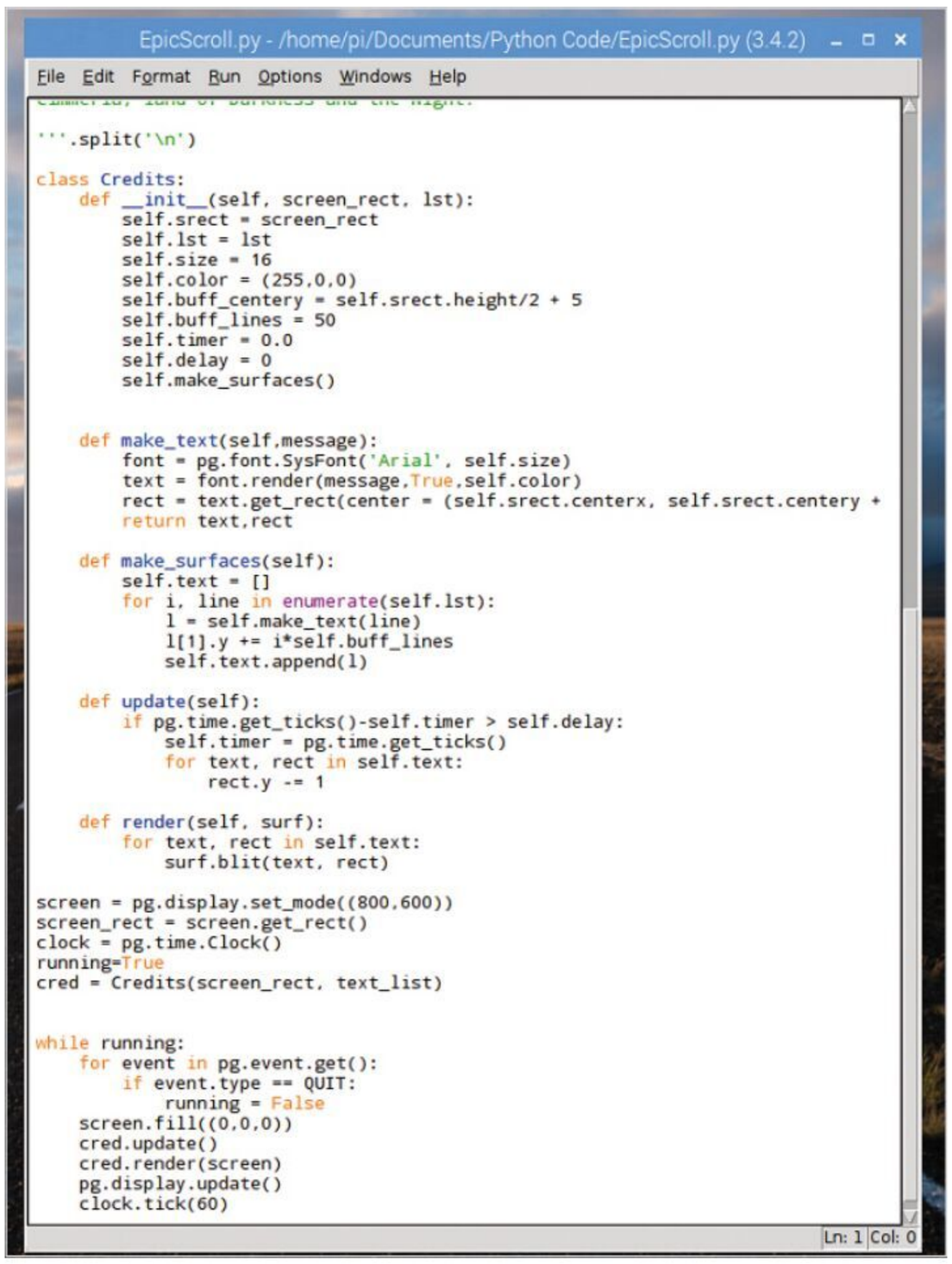
We've used the poem Cimmeria by Robert E. Howard for the code's scrolling text, along with a dramatic black background and red text. We think you'll agree, it's quite epic.

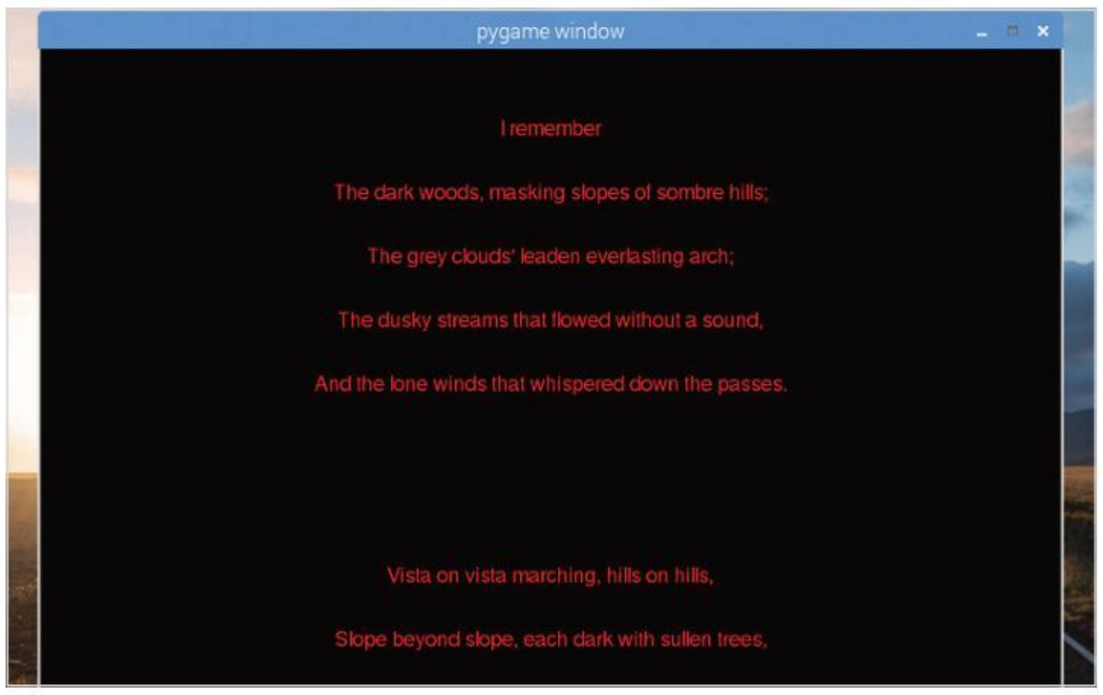
```
import pygame as pg
from pygame.locals import *

pg.init()

text _ list = '''

I remember
The dark woods, masking slopes of sombre hills;
The grey clouds' leaden everlasting arch;
The dusky streams that flowed without a sound,
And the lone winds that whispered down the passes.


Vista on vista marching, hills on hills,
Slope beyond slope, each dark with sullen trees,
Our gaunt land lay. So when a man climbed up
A rugged peak and gazed, his shaded eye
Saw but the endless vista - hill on hill,
Slope beyond slope, each hooded like its brothers.


It was a gloomy land that seemed to hold
All winds and clouds and dreams that shun the sun,
With bare boughs rattling in the lonesome winds,
And the dark woodlands brooding over all,
Not even lightened by the rare dim sun
Which made squat shadows out of men; they called it
Cimmeria, land of Darkness and deep Night.


It was so long ago and far away
I have forgot the very name men called me.
The axe and flint-tipped spear are like a dream,
And hunts and wars are shadows. I recall
Only the stillness of that sombre land;
The clouds that piled forever on the hills,
The dimness of the everlasting woods.
Cimmeria, land of Darkness and the Night.


Oh, soul of mine, born out of shadowed hills,
To clouds and winds and ghosts that shun the sun,
How many deaths shall serve to break at last
This heritage which wraps me in the grey
Apparel of ghosts? I search my heart and find
Cimmeria, land of Darkness and the Night!

'''.split('\n')
```

```
class Credits:
   def _ _ init _ _ (self, screen _ rect, lst):
      self.srect = screen _ rect
      self.lst = lst
      self.size = 16
      self.color = (255,0,0)
      self.buff _ centery = self.srect.height/2 + 5
      self.buff _ lines = 50
      self.timer = 0.0
      self.delay = 0
      self.make _ surfaces()


   def make _ text(self,message):
      font = pg.font.SysFont('Arial', self.size)
      text = font.render(message,True,self.color)
      rect = text.get _ rect(center = (self.srect.
      centerx, self.srect.centery + self.buff _ centery) )
      return text,rect

   def make _ surfaces(self):
      self.text = []
      for i, line in enumerate(self.lst):
         l = self.make _ text(line)
         l[1].y += i*self.buff _ lines
         self.text.append(l)

   def update(self):
      if pg.time.get _ ticks()-self.timer > self.delay:
         self.timer = pg.time.get _ ticks()
         for text, rect in self.text:
            rect.y -= 1

   def render(self, surf):
      for text, rect in self.text:
         surf.blit(text, rect)

screen = pg.display.set _ mode((800,600))
screen _ rect = screen.get _ rect()
clock = pg.time.Clock()
running=True
cred = Credits(screen _ rect, text _ list)


while running:
   for event in pg.event.get():
      if event.type == QUIT:
         running = False
   screen.fill((0,0,0))
   cred.update()
   cred.render(screen)
   pg.display.update()
   clock.tick(60)
```

A Long Time Ago...

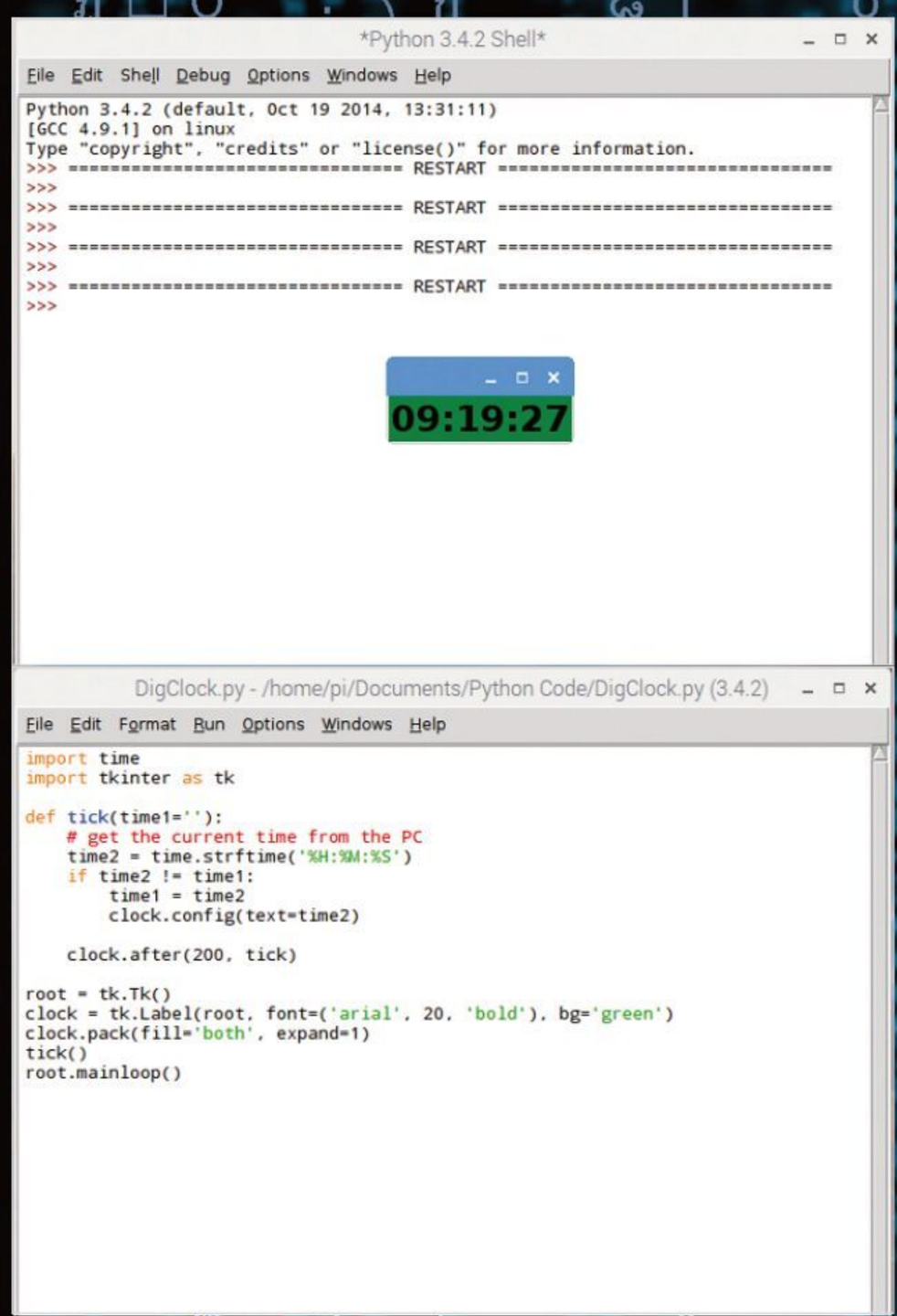
The obvious main point of enhancement is the actual text itself. Replace it with a list of credits, or an equally epic opening storyline to your Python game, and it will certainly hit the mark with whoever plays it. Don't forget to change the screen resolution if needed; we're currently running it at 800 x 600.





Python Digital Clock

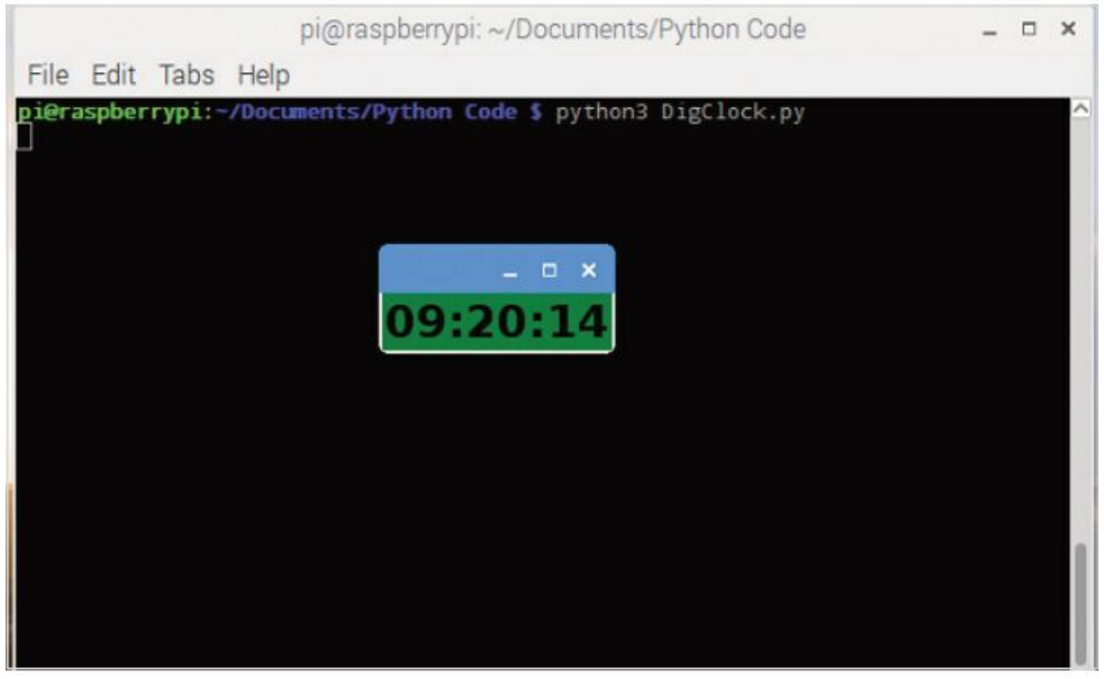
There is already a clock displayed on the desktop of most operating systems but it's always handy to have one on top of the currently open window. To that end, why not create a Python digital clock that can be a companion desktop widget for you.

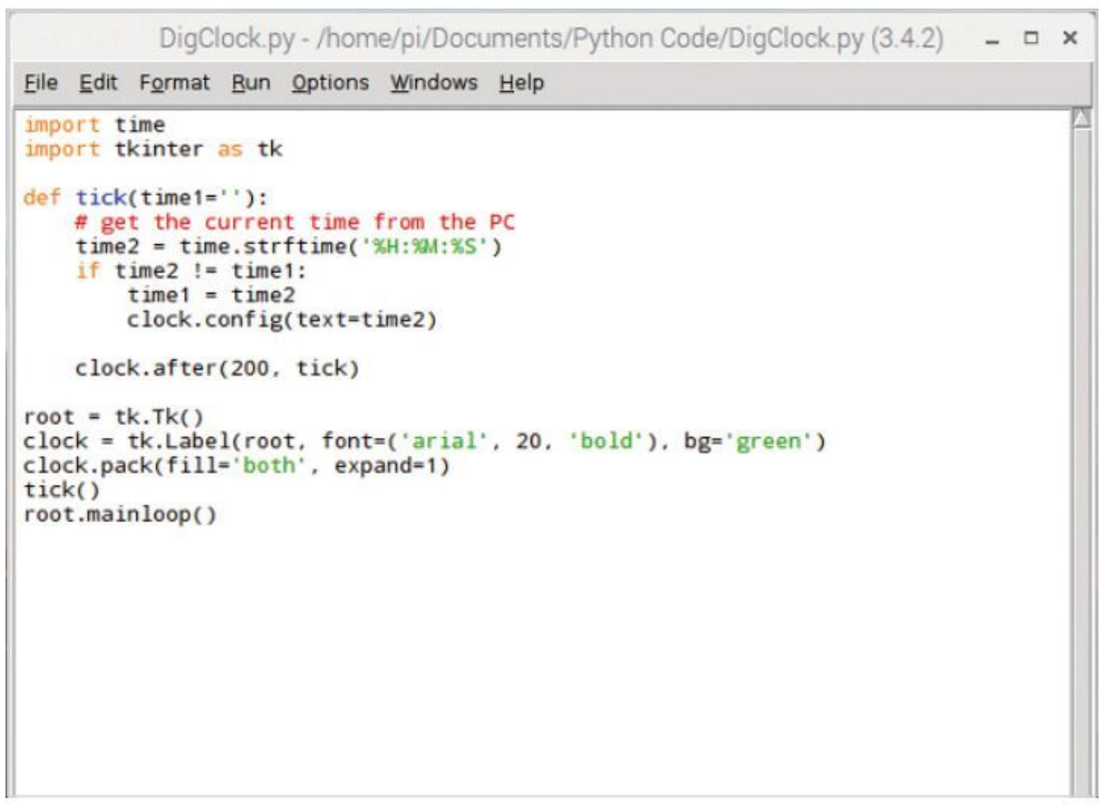


DIGCLOCK.PY

This is a surprisingly handy little script and one that we've used in the past instead of relying on a watch or even the clock in the system tray of the operating system.

```
import time
import tkinter as tk

def tick(time1='’):
   # get the current time from the PC
   time2 = time.strftime(‘%H:%M:%S’)
   if time2 != time1:
      time1 = time2
      clock.config(text=time2)

   clock.after(200, tick)

root = tk.Tk()
clock = tk.Label(root, font=(‘arial’, 20, ‘bold’),
bg=’green’)
clock.pack(fill=’both’, expand=1)
tick()
root.mainloop()
```



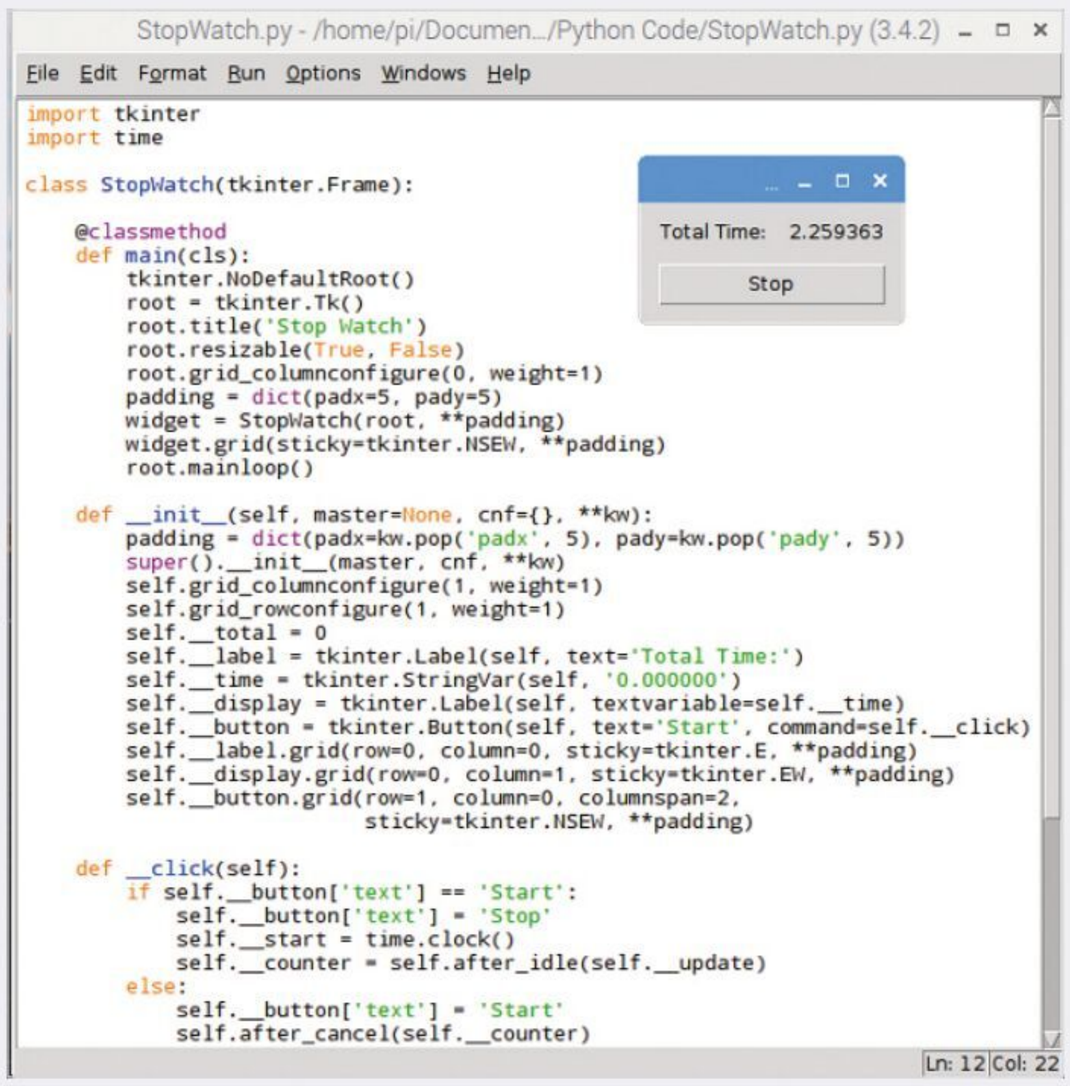


Tick Tock

This is a piece of code we've used many times in the past to keep track of time while working on multiple monitors and with just a quick glance to where we've placed it on the screen.

The Tkinter box can be moved around without affecting the time, maximised or closed by the user at will. We haven't given the Tkinter clock window a title, so you can add to that easily enough by snipping the code from other examples in this book.

Another area of improvement is to include this code when Windows or Linux starts, so it automatically pops up on the desktop. See also, if you're able to improve its functionality by including different time zones: Rome, Paris, London, New York, Moscow and so on.

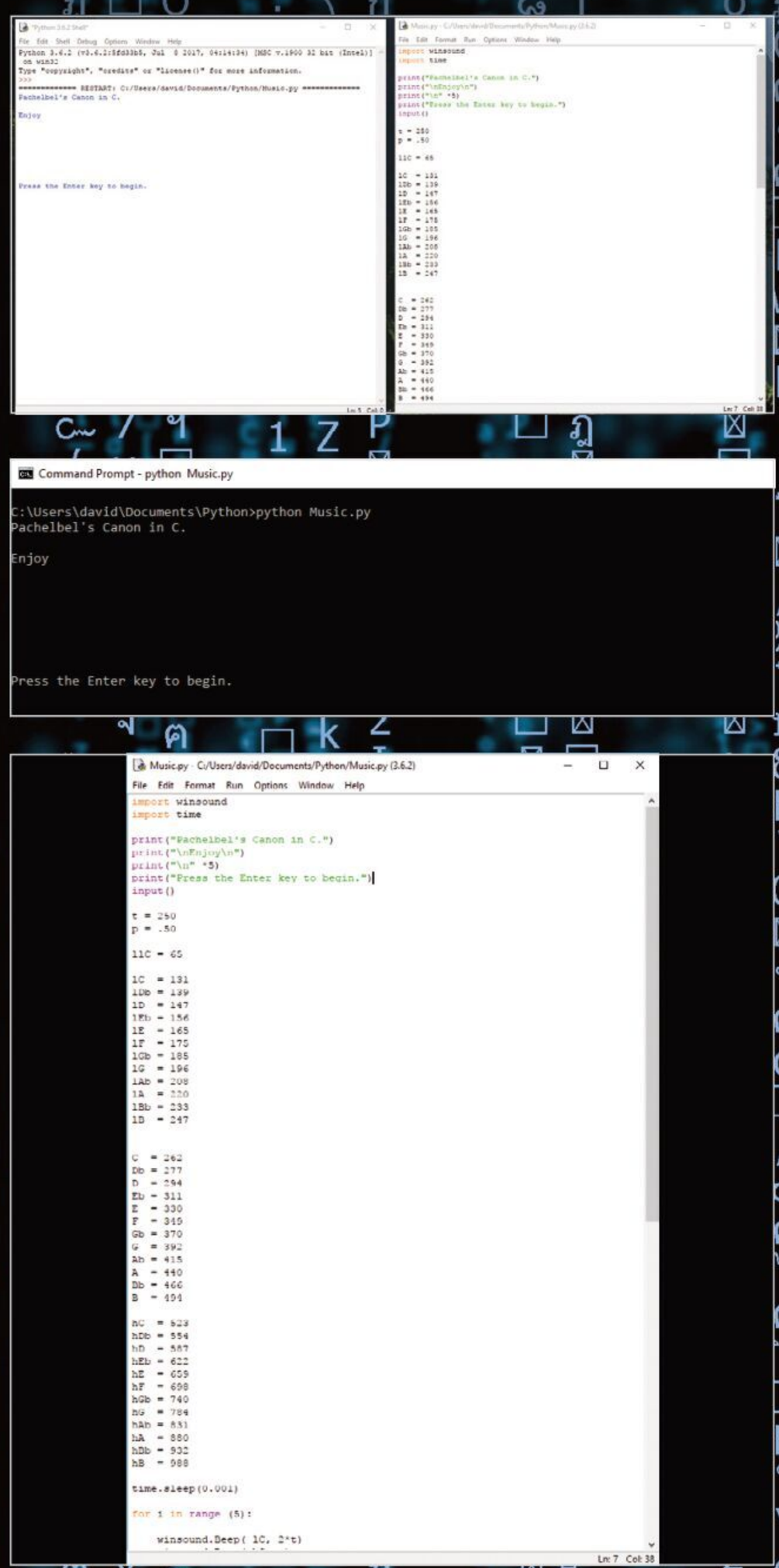


Another example, expanding on the original code, could be a digital stopwatch. For that you could use the following:

```
import tkinter
import time

class StopWatch(tkinter.Frame):

    @classmethod
    def main(cls):
        tkinter.NoDefaultRoot()
        root = tkinter.Tk()
        root.title('Stop Watch')
        root.resizable(True, False)
        root.grid _ columnconfigure(0, weight=1)
        padding = dict(padx=5, pady=5)
        widget = StopWatch(root, **padding)
        widget.grid(sticky=tkinter.NSEW, **padding)
        root.mainloop()

    def _ _ init _ _ (self, master=None, cnf={}, **kw):
        padding = dict(padx=kw.pop('padx', 5), pady=kw.
        pop('pady', 5))
        super(). _ _ init _ _ (master, cnf, **kw)
        self.grid _ columnconfigure(1, weight=1)
        self.grid _ rowconfigure(1, weight=1)
        self. _ _ total = 0
        self. _ _ label = tkinter.Label(self,
        text='Total Time:')
        self. _ _ time = tkinter.StringVar(self,
            '0.000000')
        self. _ _ display = tkinter.Label(self,
        textvariable=self. _ _ time)
        self. _ _ button = tkinter.Button(self,
        text='Start', command=self. _ _ click)
        self. _ _ label.grid(row=0, column=0,
        sticky=tkinter.E, **padding)
        self. _ _ display.grid(row=0, column=1,
        sticky=tkinter.EW, **padding)
        self. _ _ button.grid(row=1, column=0,
        columnspan=2,sticky=tkinter.NSEW, **padding)

    def _ _ click(self):
        if self. _ _ button['text'] == 'Start':
        self. _ _ button['text'] = 'Stop'
        self. _ _ start = time.clock()
        self. _ _ counter = self.after _ idle(self. _ _ update)
    else:
        self. _ _ button['text'] = 'Start'
        self.after _ cancel(self. _ _ counter)

    def _ _ update(self):
        now = time.clock()
        diff = now - self. _ _ start
        self. _ _ start = now
        self. _ _ total += diff
        self. _ _ time.set('{:.6f}'.format(self. _ _ total))
        self. _ _ counter = self.after _ idle(self. _ _ update)

if _ _ name _ _ == '_ _ main _ _':
    StopWatch.main()
```

Playing Music with the Winsound Module

Of course, instead of playing an existing MP3, you can always make your own music. The code below will play out Pachelbel's Canon in D, no less.



MUSIC.PY

The code utilises both the Time and Winsound modules, defining the tone and pitch and inserting small pauses of .5 of a second.

```
import winsound
import time

t = 250
p = .50
```

1

```
11C = 65

1C  = 131
1Db = 139
1D  = 147
1Eb = 156
1E  = 165
1F  = 175
1Gb = 185
1G  = 196
1Ab = 208
1A  = 220
1Bb = 233
1B  = 247

C  = 262
Db = 277
D  = 294
Eb = 311
E  = 330
F  = 349
Gb = 370
G  = 392
Ab = 415
A  = 440
Bb = 466
B  = 494

hC  = 523
hDb = 554
hD  = 587
hEb = 622
hE  = 659
hF  = 698
hGb = 740
hG  = 784
hAb = 831
hA  = 880
hBb = 932
hB  = 988
```

2

```
time.sleep(0.001)
```

```
for i in range (5):

   winsound.Beep( lC, 2*t)
   winsound.Beep( hC, t)
   winsound.Beep( hE, t)
   winsound.Beep( hG, t)
   time.sleep(p)

   winsound.Beep( lG, 2*t)
   winsound.Beep( G, t)
   winsound.Beep( B, t)
   winsound.Beep( hD, t)
   time.sleep(p)

   winsound.Beep( lA, 2*t)
   winsound.Beep( A, t)
   winsound.Beep( hC, t)
   winsound.Beep( hE, t)
   time.sleep(p)

   winsound.Beep( lE, 2*t)
   winsound.Beep( E, t)
   winsound.Beep( G, t)
   winsound.Beep( B, t)
   time.sleep(p)

   winsound.Beep( lF, 2*t)
   winsound.Beep( F, t)
   winsound.Beep( A, t)
   winsound.Beep( hC, t)
   time.sleep(p)

   winsound.Beep( llC, 2*t)
   winsound.Beep( C, t)
   winsound.Beep( E, t)
   winsound.Beep( G, t)
   time.sleep(p)

   winsound.Beep( lF, 2*t)
   winsound.Beep( F, t)
   winsound.Beep( A, t)
   winsound.Beep( hC, t)
   time.sleep(p)

   winsound.Beep( lG, 2*t)
   winsound.Beep( G, t)
   winsound.Beep( B, t)
   winsound.Beep( hD, t)
   time.sleep(p)
```

3

1 The start of the code imports the Winsound and Tie modules; remember, this is a Windows-only Python script. The variable t is setting the duration, while p equals .5, which you can use for the time.sleep function.

2 These variables set the frequencies, with the corresponding numbers, which can be used in the next section of the code.

3 Winsound.beep requires a frequency and duration within the brackets. The frequencies come from the large set of variables called in the second section of the code and the duration is through the t variable set at the start of the code. There's a half-second, using the variable p, pause between blocks of winsound.beep statements.

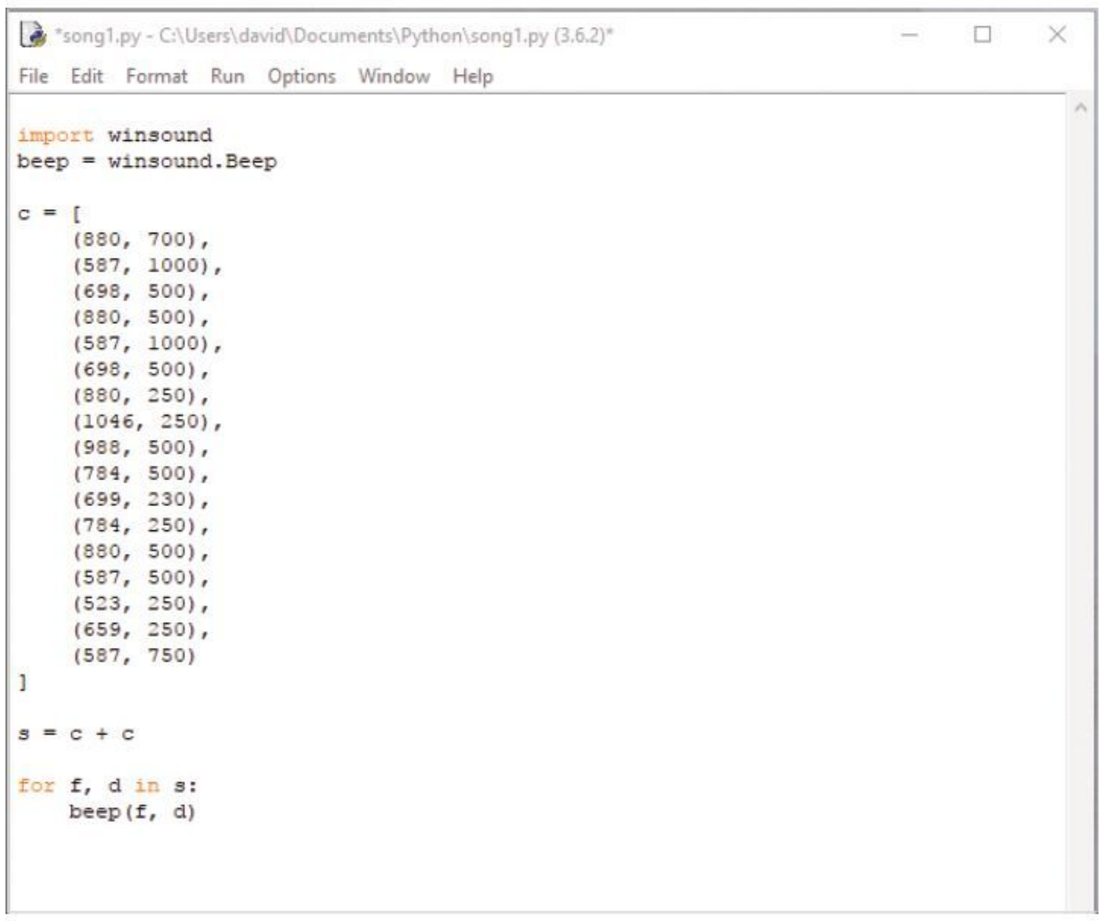
Sweet Music

Obviously the Winsound module is a Windows-only set of functions for Python. Open your IDLE in Windows and copy the code in. Press F5 to save and execute, then press the Enter key, as instructed in the code, to start the music.

Naturally you can swap out the winsound.Beep frequency and durations to suit your own particular music; or you can leave it as is and enjoy. Perhaps play around with the various methods to make other music.

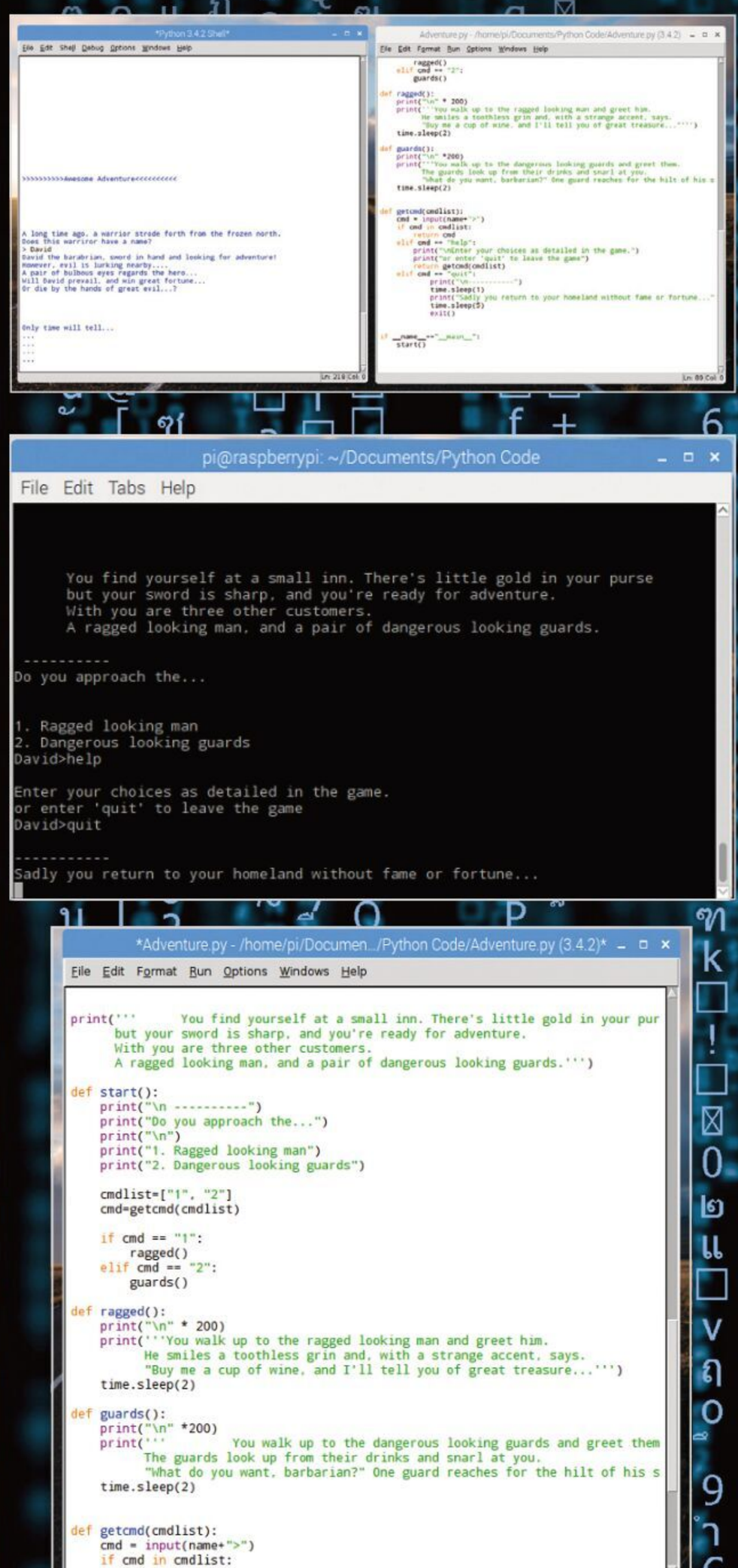
For example, players of the Nintendo classic game, The Legend of Zelda: Ocarina of Time, can enjoy the game's titular musical intro by entering:

```
import winsound
beep = winsound.Beep

c = [
   (880, 700),
   (587, 1000),
   (698, 500),
   (880, 500),
   (587, 1000),
   (698, 500),
   (880, 250),
   (1046, 250),
   (988, 500),
   (784, 500),
   (699, 230),
   (784, 250),
   (880, 500),
   (587, 500),
   (523, 250),
   (659, 250),
   (587, 750)
]

s = c + c

for f, d in s:
   beep(f, d)
```



Text Adventure Script

Text adventures are an excellent way to build your Python coding skills and have some fun at the same time. This example that we created will start you on the path to making a classic text adventure; where it will end is up to you.



ADVENTURE.PY

The Adventure game uses just the Time module to begin with, creating pauses between print functions. There's a help system in place to expand upon, as well as the story itself.

```
import time

print("\n" * 200)
print(">>>>>>>>>>Awesome Adventure<<<<<<<<<<\n")
print("\n" * 3)
time.sleep(3)
print("\nA long time ago, a warrior strode forth from
the frozen north.")
time.sleep(1)
print("Does this warrior have a name?")
name=input("> ")
print(name, "the barbarian, sword in hand and looking
for adventure!")
time.sleep(1)
print("However, evil is lurking nearby....")
time.sleep(1)
print("A pair of bulbous eyes regards the hero...")
time.sleep(1)
print("Will", name, "prevail, and win great fortune...")
time.sleep(1)
print("Or die by the hands of great evil...?")
time.sleep(1)
print("\n" *3)
print("Only time will tell...")
time.sleep(1)
print('...')
time.sleep(1)
print('...')
time.sleep(1)
print('...')
time.sleep(1)
print('...')
time.sleep(5)
print("\n" *200)

print('''      You find yourself at a small inn. There's
   little gold in your purse but your sword is sharp,
   and you're ready for adventure.
   With you are three other customers.
   A ragged looking man, and a pair of dangerous
   looking guards.''')

def start():
   print("\n ----------")
   print("Do you approach the...")
   print("\n")
   print("1. Ragged looking man")
   print("2. Dangerous looking guards")

   cmdlist=["1", "2"]
   cmd=getcmd(cmdlist)
```

```
   if cmd == "1":
      ragged()
   elif cmd == "2":
      guards()

def ragged():
   print("\n" * 200)
   print('''You walk up to the ragged looking man and
   greet him.
      He smiles a toothless grin and, with a strange
      accent, says.
      "Buy me a cup of wine, and I'll tell you of
      great treasure...''')
   time.sleep(2)

def guards():
   print("\n" *200)
   print('''You walk up to the dangerous looking guards
   and greet them.
      The guards look up from their drinks and
      snarl at you.
      "What do you want, barbarian?" One guard reaches
      for the hilt of his sword...''')
   time.sleep(2)
```

```
def getcmd(cmdlist):
   cmd = input(name+">")
   if cmd in cmdlist:
      return cmd
   elif cmd == "help":
      print("\nEnter your choices as detailed in
      the game.")
      print("or enter 'quit' to leave the game")
      return getcmd(cmdlist)
   elif cmd == "quit":
      print("\n-----------")
      time.sleep(1)
      print("Sadly you return to your homeland without
      fame or fortune...")
      time.sleep(5)
      exit()


if _ _ name _ _ =="_ _ main _ _ ":
   start()
```

Adventure Time

This, as you can see, is just the beginning of the adventure and takes up a fair few lines of code. When you expand it, and weave the story along, you'll find that you can repeat certain instances such as a chance meeting with an enemy or the like.

We've created each of the two encounters as a defined set of functions, along with a list of possible choices under the cmdlist list, and cmd variable, of which is also a defined function. Expanding on this is quite easy, just map out each encounter and choice and create a defined function around it. Providing the user doesn't enter quit into the adventure, they can keep playing.

There's also room in the adventure for a set of variables designed for combat, luck, health, endurance and even an inventory or amount of gold earned. Each successful combat situation can reduce the main character's health but increase their combat skills or endurance. Plus, they could loot the body and gain gold, or earn gold through quests.

Finally, how about introducing the Random module. This will enable you to include an element of chance in the game. For example, in combat, when you strike an enemy you will do a random amount of damage as will they. You could even work out the maths behind improving the chance of a better hit based on your or your opponent's combat skills, current health, strength and endurance. You could create a game of dice in the inn, to see if you win or lose gold (again, improve the chances of winning by working out your luck factor into the equation).

Needless to say, your text adventure can grow exponentially and prove to be a work of wonder. Good luck, and have fun with your adventure.

Adventure.py - /home/pi/Documents/Python Code/Adventure.py (3.4.2)

File Edit Format Run Options Windows Help

```
print("\n" *200)

CR=0
Strength=0
Health=0
Luck=0

print("The mountains of the north make for a hard life.")
print("Press Enter to roll the dice and see how strong", name, "is:")
input()
Strength=random.randint(1,20)
print(name, "has a Strength value of:", Strength)
print("\nIt's a hard life indeed, and all northeners are born warriors.")
print("Press Enter to roll the dice and see the Combat Rating for", name+".")
input()
CR=random.randint(1, 30)
print(name, "has a Combat Rating of:", CR)
print("\nYour Health is the total of your Strength and Combat Rating.")
print("Press Enter to see", name+"'s", "Health value.")
input()
Health=Strength+CR
print(name, "has a Health value of:", Health)
print("\nEveryone needs a certain amount of luck to survive.")
print("Press Enter to roll the dice and see how lucky", name, "is.")
input()
Luck=random.randint(1, 15)
if Luck > 13:
    print(name, "is luck indeed, and has a Luck value of:", Luck)
else:
    print(name, "has a Luck value of:", Luck)
time.sleep(5)
print("\n" *200)
print("Here's your character stats:\n")
print(name)
print("\nCombat Rating =", CR)
print("Strength =", Strength)
print("Health =", Health)
print("Luck =", Luck)
print("\n" *5)
print("Press Enter to start your adventure...")
input()
print("\n" *200)


print('''      You find yourself at a small inn. There's little gold in your purse
      but your sword is sharp, and you're ready for adventure.
      With you are three other customers.
      A ragged looking man, and a pair of dangerous looking guards.''')

def start():
    print("\n ----------")
    print("Do you approach the...")
    print("\n")
    print("1. Ragged looking man")
    print("2. Dangerous looking guards")
```

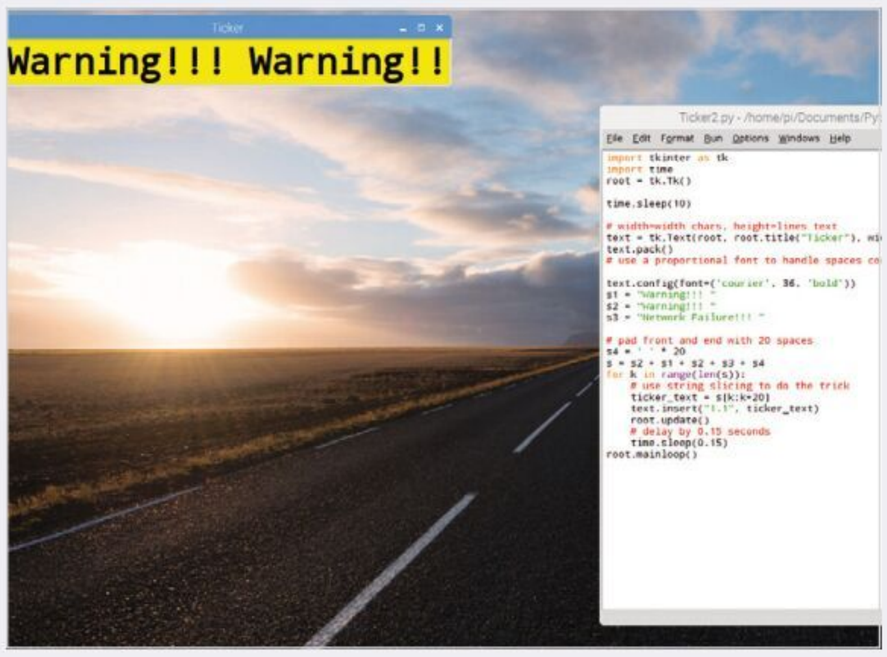
Python Scrolling Ticker Script

You may be surprised to hear that one of the snippets of code we're often asked for is some form of scrolling ticker. Whilst we've covered various forms of scrolling text previously, the ticker is something that seems to keep cropping up. So, here it is.

Ticker Time

The obvious improvements to the Ticker code lie in the speed of the text and what the text will display. Otherwise you can change the background colour of the ticker window, the font and the font colour, along with the geometry of the Tkinter window if you want to.

Yet another interesting element that could be introduced is one of the many text to Speech modules available for Python 3. You could pip install one, import it, then as the ticker displays the text, the text to speech function will read out the variable at the same time, since the entire text is stored in the variable labelled 's'.



The ticker example can be used for system warnings, perhaps something that will display across your work or home network detailing the shutting down of a server over the weekend for maintenance; or even just to inform everyone as to what's happening. We're sure you will come up with some good uses for it.

TICKER.PY

We're using Tkinter here along with the Time module to determine the speed the text is displayed across the window.

```
import time
import tkinter as tk

root = tk.Tk()
canvas = tk.Canvas(root, root.title("Ticker Code"),
height=80, width=600, bg="yellow")
canvas.pack()
font = ('courier', 48, 'bold')
text _ width = 15

#Text blocks insert here....

s1 = "This is a scrolling ticker example. As you
can see, it's quite long but can be a lot longer if
necessary... "
s2 = "We can even extend the length of the ticker
message by including more variables... "
s3 = "The variables are within the s-values in
the code. "
s4 = "Don't forget to concatenate them all before the
For loop, and rename the 'spacer' s-variable too."

# pad front and end of text with spaces
s5 = ' ' * text _ width
# concatenate it all
s = s5 + s1 + s2 + s3 + s4 + s5
x = 1
y = 2
text = canvas.create _ text(x, y, anchor='nw', text=s,
font=font)
dx = 1
dy = 0  # use horizontal movement only

# the pixel value depends on dx, font and length of text
pixels = 9000

for p in range(pixels):
   # move text object by increments dx, dy
   # -dx --> right to left
   canvas.move(text, -dx, dy)
   canvas.update()
   # shorter delay --> faster movement
   time.sleep(0.005)
   #print(k)  # test, helps with pixel value

root.mainloop()
```

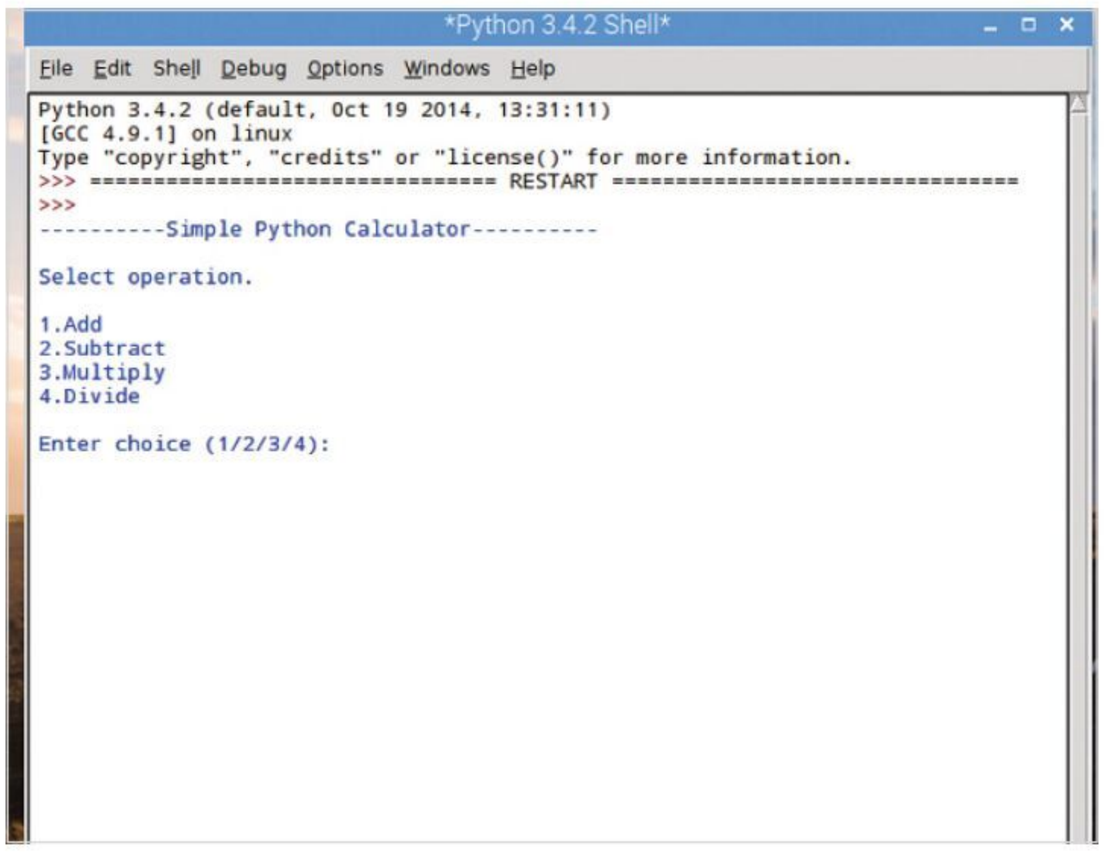
Simple Python Calculator

Sometimes the simplest code can be the most effective. Take for example, this Simple Python Calculator script. It's based on the Create Your Own Modules section seen earlier but doesn't utilise any external modules.

CALCULATOR.PY

We created some function definitions to begin with, then lead on to the user menu and inputs. It's an easy piece of code to follow and as such can also be expanded well too.

```
print("----------Simple Python Calculator----------\n")

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

def subtract(x, y):
   return x - y

def multiply(x, y):
   return x * y

def divide(x, y):
   return x / y

print("Select operation.\n")
print("1.Add")
print("2.Subtract")
print("3.Multiply")
print("4.Divide")

choice = input("\nEnter choice (1/2/3/4):")

num1 = int(input("\nEnter first number: "))
num2 = int(input("Enter second number: "))

if choice == '1':
   print(num1,"+",num2,"=", add(num1,num2))

elif choice == '2':
   print(num1,"-",num2,"=", subtract(num1,num2))

elif choice == '3':
   print(num1,"*",num2,"=", multiply(num1,num2))

elif choice == '4':
   print(num1,"/",num2,"=", divide(num1,num2))
else:
   print("Invalid input")
```



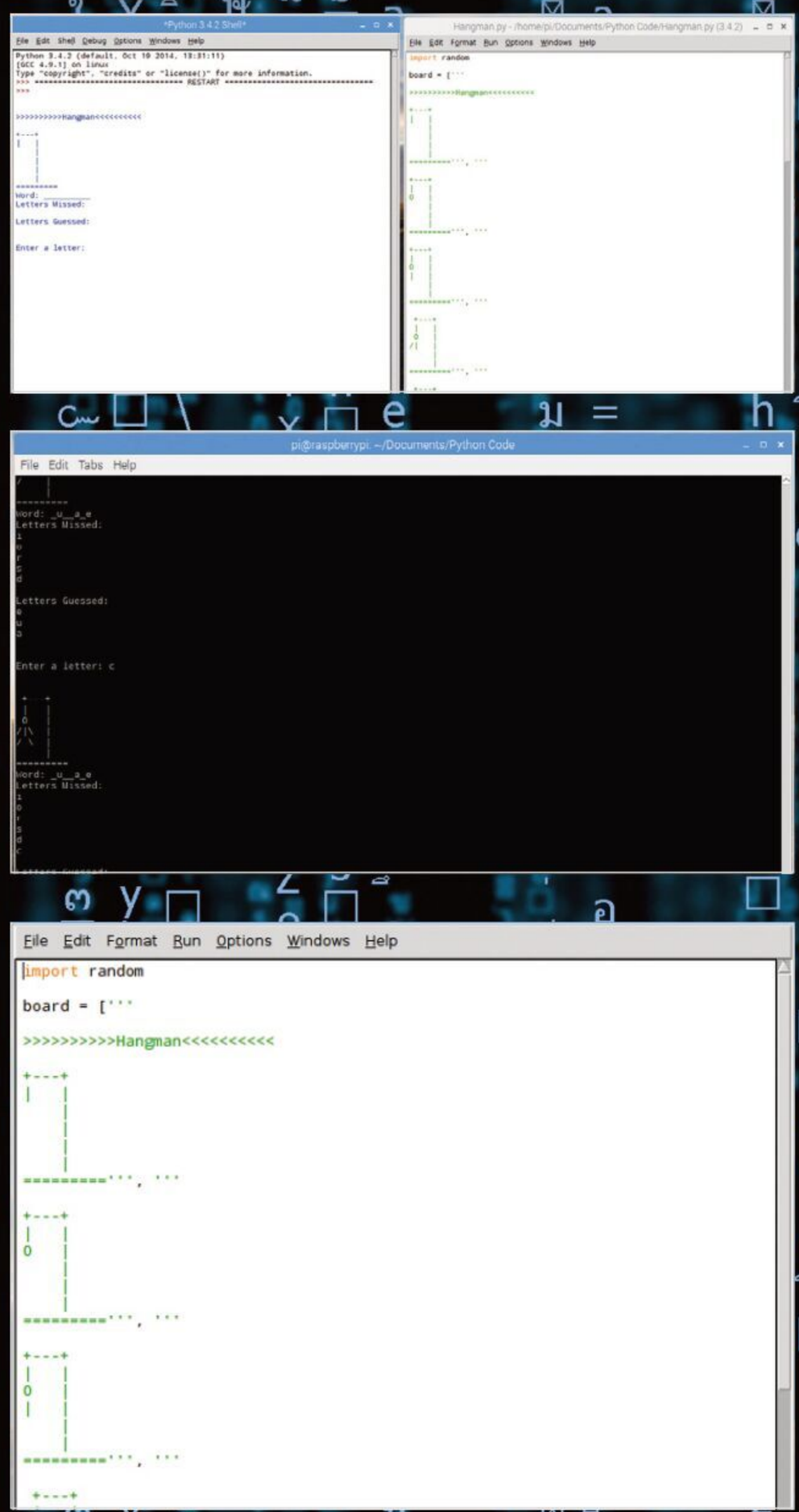
Improved Calculations

The obvious contender for improvement here is using the Create Your Own Modules route and extracting the function definitions as a module. You can then call the module and focus on the body of the code.

The other area of improvement is code itself. Where there's just a single shot at making a calculation, you could encase it in a while loop, so once a value is presented the user is sent back to the main menu. Perhaps, improvement to the Invalid Input section is worth looking into as well.

Hangman Game Script

Hangman is a great game to program into Python. It can be extremely complex, displaying graphics, the number of guesses left in the secret word, a huge bank of available words picked at random and countless other elements. It can also be quite simple. Here we have a mix between the two.



HANGMAN.PY

We've made a Hangman game board (the gallows) out of characters that can be displayed in the IDLE Shell, along with a huge bank of words to randomly choose from.

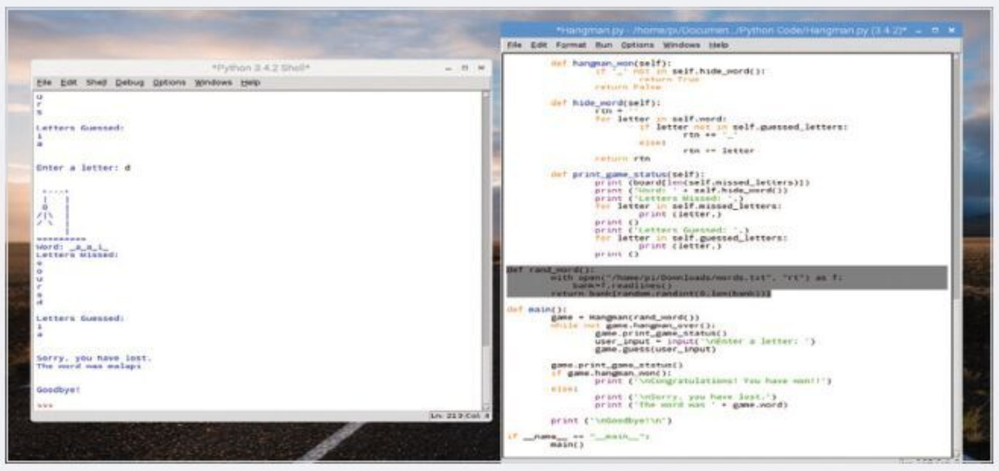
```
import random

board = ['''

>>>>>>>>>>Hangman<<<<<<<<<<

+---+
|   |
    |
    |
    |
    |
=========''', '''

+---+
|   |
O   |
    |
    |
    |
=========''', '''

+---+
|   |
O   |
|   |
    |
    |
=========''', '''

 +---+
 |   |
 O   |
/|   |
     |
     |
=========''', '''

 +---+
 |   |
 O   |
/|\  |
     |
     |
=========''', '''

 +---+
 |   |
 O   |
/|\  |
/    |
```

```
         |
=========''', '''

 +---+
 |     |
 O     |
/|\   |
/ \    |
         |
=========''']


class Hangman:
   def _ _ init _ _ (self,word):
      self.word = word
      self.missed _ letters = []
      self.guessed _ letters = []

   def guess(self,letter):
      if letter in self.word and letter not in self.
      guessed _ letters:
         self.guessed _ letters.append(letter)
      elif letter not in self.word and letter not in
      self.missed _ letters:
         self.missed _ letters.append(letter)
      else:
         return False
      return True

   def hangman _ over(self):
      return self.hangman _ won() or (len(self.missed _
      letters) == 6)

   def hangman _ won(self):
      if '_' not in self.hide _ word():
         return True
      return False

   def hide _ word(self):
      rtn = ''
      for letter in self.word:
         if letter not in self.guessed _ letters:
            rtn += '_'
         else:
            rtn += letter
      return rtn

   def print _ game _ status(self):
      print (board[len(self.missed _ letters)])
      print ('Word: ' + self.hide _ word())
      print ('Letters Missed: ',)
      for letter in self.missed _ letters:
         print (letter,)
      print ()
      print ('Letters Guessed: ',)
      for letter in self.guessed _ letters:
         print (letter,)
      print ()

def rand _ word():
   bank = 'ability about above absolute accessible
   accommodation accounting beautiful bookstore
   calculator clever engaged engineer enough
   handsome refrigerator opposite socks interested
   strawberry backgammon anniversary confused
   dangerous entertainment exhausted impossible
   overweight temperature vacation scissors
   accommodation appointment decrease development
   earthquake environment brand environment necessary
   luggage responsible ambassador circumstance
   congratulate frequent'.split()
   return bank[random.randint(0,len(bank))]

def main():
   game = Hangman(rand _ word())
   while not game.hangman _ over():
      game.print _ game _ status()
      user _ input = input('\nEnter a letter: ')
      game.guess(user _ input)

   game.print _ game _ status()
   if game.hangman _ won():
      print ('\nCongratulations! You have won!!')
   else:
      print ('\nSorry, you have lost.')
      print ('The word was ' + game.word)

   print ('\nGoodbye!\n')

if _ _ name _ _ == " _ _ main _ _ ":
   main()
```

QUIT()

Since this is the last example in our Python code repository, we thought we'd go out with a bang and feature the hangman gallows being drawn with each incorrect guess of the word. Don't worry if it looks misaligned in the text here, this is merely due to the differences between using the Python IDLE editor and pasting the code into a word processor (which formats things differently).

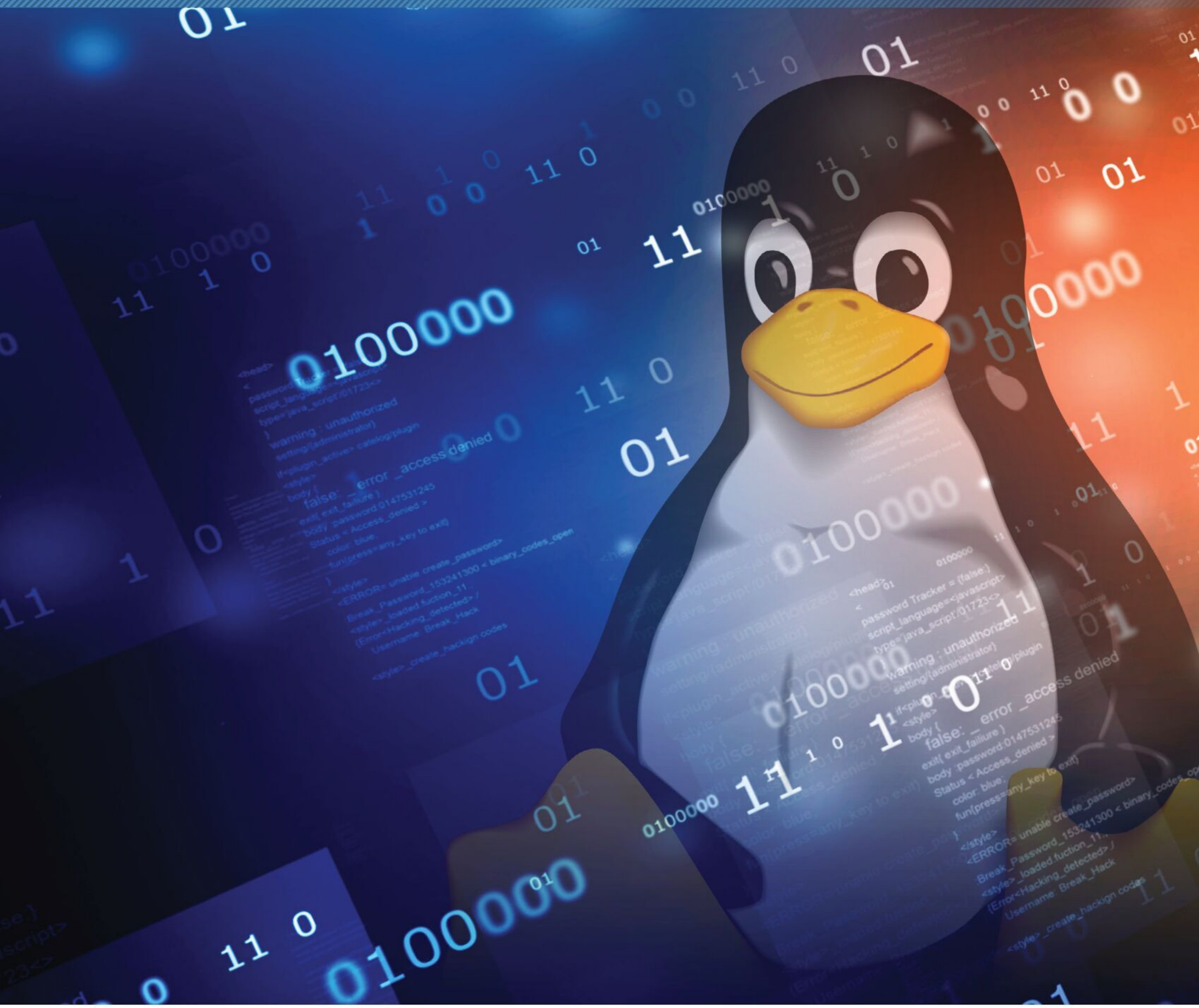
There's plenty you can do to improve, enhance and expand on what we've presented here. You can include a routine that returns an error if the user enters a number or character. You can include extra points for someone who guesses the entire word in one go rather than one letter at a time and you could perhaps add Chopin's Funeral March should you lose the game; or something celebratory if you win.



Consider replacing the bank of words too. They're found under the bank list, and could easily be swapped out for something more difficult. If you download www.github.com/dwyl/english-words you can find a text document with over 466,000 words. Perhaps you could swap the words in the bank to instead read the contents of the text file:

```
def rand _ word():
   with open("/home/pi/Downloads/words.txt", "rt") as f:
      bank=f.readlines()
   return bank[random.randint(0,len(bank))]
```

Understanding Linux



Linux is a remarkably versatile and powerful operating system. It's used throughout the programming and engineering world, in science, space exploration, education, gaming and everything else in between. It's the OS of choice for high-performance servers, it's the backbone of the Internet and it powers the fastest supercomputers in the world.

Knowing how to use Linux, and how it's structured, is key to being able to create better Python content. The Raspberry Pi, for example, uses a Linux-based OS and, as such, makes for an excellent coding platform. Regardless of whether you're using a Pi, like us, or a Linux Mint or Ubuntu, these pages will prove invaluable for your Python learning. Master Linux, master Python, and start engineering your coding future.

138 What is Linux?

140 Using the Filesystem

142 Listing and Moving Files

144 Creating and Deleting Files

146 Create and Remove Directories

148 Copying, Moving and Renaming Files

150 Useful System and Disk Commands

152 Using the Man Pages

154 Editing Text Files

156 Linux Tips and Tricks

158 A-Z of Linux Commands

160 Glossary of Python Terms

What is Linux?

The Raspberry Pi operating system is Raspbian, which is a Linux operating system; but what exactly is Linux? Where did it come from and what does it do? In a world where Windows and macOS have supremacy of the desktop, it's easy to overlook it, but there's more to Linux than you might imagine.

Linux is a surprisingly powerful, fast, secure and capable operating system. It's used as the OS of choice for the Raspberry Pi, in the form of Raspbian OS, as well as in some of the most unlikely places.

Despite only enjoying a 1.96% share (according to netmarketshare.com) of the total desktop operating system market, Linux has a dedicated following of enthusiasts, users and contributors. It was created in 1991 by University of Helsinki student, Linus Torvalds, who had become frustrated with the limitations and licensing of the popular educational system Minix, a miniature version of the Unix operating system, in use at the time.

Unix itself was released in the early '70s, as a multi-tasking, modular-designed operating system originally developed for programmers who needed a stable platform to code on. However, its performance, power and portability meant that it soon became the system of choice for companies and universities where high-end computing tasks were needed.

Torvalds needed a system that could mirror Unix's performance and features, without the licensing cost. Thus was born Linux, the Unix-like operating system which used freely available code from the GNU project. This enabled users around the world to utilise the power of the Unix-like system, completely free of charge, an ethos that still holds today: Linux is free to download, install and use.

Linux is much like any other operating system, such as Windows or macOS in that it manages the computer hardware, provides an interface for the user to access that hardware and comes with programs for productivity, communications, gaming, science, education and more. Linux can be broken up into a number of significant elements:

BOOTLOADER

The bootloader is the software that initialises and boots up your computer. It loads up the various modules the OS uses to begin to access the hardware in the system. You can modify a bootloader to load more than one OS installed on the system.

DAEMONS

Daemons are background services that start as the operating system is booting. These can enable printing, sound, networking and so on. They run unobtrusively rather than under the direct control of the user, often waiting to be activated by an event or condition.

DESKTOP ENVIRONMENTAL

The Desktop Environment, or DE, is the main Graphical User Interface (GUI) that users interact with. It's the desktop, that includes Internet browsers, productivity, games and whatever program or app you're using. There are countless DEs available. Raspbian uses PIXEL.

GRAPHICAL SERVER

This is a module within Linux that provides a graphical output to your monitor. It's referred to as the X server or simply just X. X is an application that manages one or more graphical displays and one or more input devices (keyboard, mouse, etc.) connected to the computer.

KERNEL

The kernel is the core of the system and the single element that is actually called Linux. The Linux kernel manages the computer processor, memory, storage and any peripherals you have attached to your computer. It provides the basic services for all other parts of the OS.

PROGRAMS/APPLICATIONS

With Linux being an open source, free operating system, it also makes use of the tens of thousands of freely available applications. The likes of LibreOffice, GIMP and Python are just the tip of the iceberg.

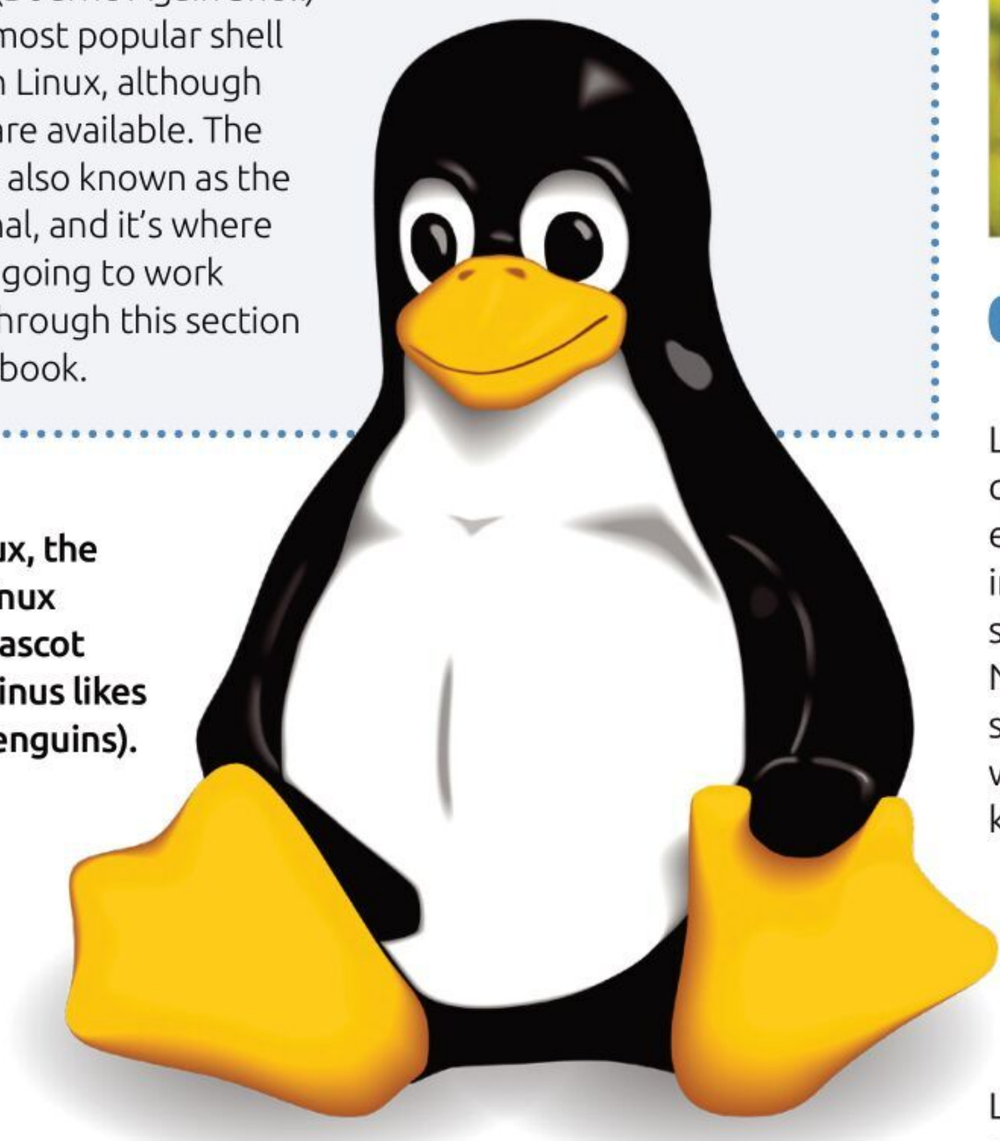
SHELL

The Linux shell is a command-line interface environment that a Linux user can use to enter commands to the OS that directly affect it. Within the shell you can add new users, reboot the system, create and delete files and folders, and much more. BASH (Bourne Again Shell) is the most popular shell used in Linux, although more are available. The shell is also known as the Terminal, and it's where you're going to work from through this section of the book.

Linus Torvalds, the creator of the Linux kernel.

Linux is used throughout the world, in a number of basic and quite unique uses. While it may look radically different from one environment to the next, the actual Linux kernel, can be found in modern smart TVs, in-car entertainment systems and GPS, supercomputers, IoT devices and the Raspberry Pi. It's used by NASA, both in the command centre and on-board the ISS. Linux servers power the backbone of the Internet, along with most of the websites you visit daily. Android utilises components of the Linux kernel, as do set top boxes, games consoles and even your fridge, freezer, oven and washing machine.

Linux isn't just a free to use operating system. It's stable, powerful and fast, easily customised and requires very little maintenance. However, it's more than just performance stats; Linux means freedom from the walled garden approach of other operating systems. It's a lively community of like-minded individuals who want more from their computers without the shackles of price or conformity. Linux means choice.



Tux, the Linux mascot (Linus likes penguins).

Raspbian on the Raspberry Pi, is the Linux distribution of choice.

A Desktop Environment can be as complex or as simple as the user desires.

Using the Filesystem

To master Linux, it's important to understand how the filesystem works. What's more, it's also important to become familiar with the Terminal, or shell. This command line environment may appear daunting at first, but with practise, it soon becomes easy to use.

GETTING AROUND

To drop into the Terminal, click on the fourth icon from the left along the top of the Raspberry Pi desktop, the one with a right-facing arrow and an underscore. This is the shell, or Terminal.

STEP 1 First, you're going to look at directories and the directory path. A directory is the same thing as a folder, however in Linux it's always called a directory. These are placed inside each other using a "/" character. So when you see /home/pi it means the pi directory is inside the home directory. Enter: `clear` and press return to clean the screen. Now enter: `pwd`. This stands for Print Working Directory and displays /home/pi.

```
pi@raspberrypi: ~
File  Edit  Tabs  Help
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $
```

STEP 2 When you log in to your Raspberry Pi, you don't start at the base of the hard drive, known as the 'root' (also known as the topmost directory). Instead you begin inside your user directory, which is named 'pi' by default and is itself in a directory called 'home'. Directories are indicated by the '/' symbol. So, "'/home/pi'" tells you that in the root is a directory called home, and the next "'/'" says that inside "home" is a directory called "pi". That's where you start.

```
pi@raspberrypi ~ $ pwd
/home/pi
pi@raspberrypi ~ $
```

STEP 3 Enter: `ls` to view the contents of the current directory. You should see Desktop, Documents, and Downloads and Scratch in Blue. You may also see other items depending on how much you have used your Raspberry Pi. The colour code is worth knowing: directories are blue while most files are white. As you go on you'll see other colours: executable files (programs) are bright green, archived files are red and so on. Blue and white are the two you need to know to get started.

```
pi@raspberrypi ~ $ pwd
/home/pi
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  exit  indiecity  python_games  Scratch
pi@raspberrypi ~ $
```

STEP 4 Now you're going to move from the pi directory into the Documents directory. Enter: `cd Documents`. Note the capital "D". Linux is case sensitive, which means you have to enter the exact name including correct capitalisation. The cd command stands for change directory. Now enter: `pwd` again to view the directory path. It will display /home/pi/ Documents. Enter: `ls` to view the files inside the Documents directory.

```
pi@raspberrypi ~ $ pwd
/home/pi
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  exit  indiecity  python_games  Scratch
pi@raspberrypi ~ $ cd Documents
pi@raspberrypi ~/Documents $ pwd
/home/pi/Documents
pi@raspberrypi ~/Documents $ ls
Amber  archive.tar  Crypto101.pdf  dog_jump  euro  fizzbang_backup.py  fizzbang.py  mes
pi@raspberrypi ~/Documents $ _
```

STEP 5 How do you get back up to the pi directory? By using a command "cd ..". In Linux two dots means the directory above, also known as the parent directory. Incidentally, a single dot "." is used for the same directory. You never use "cd ." to switch to the same directory but it's worth knowing because some commands need you to specify the current directory.

```
pi@raspberrypi ~/Documents $ pwd
/home/pi/Documents
pi@raspberrypi ~/Documents $ cd ..
pi@raspberrypi ~ $ pwd
/home/pi
pi@raspberrypi ~ $
```

STEP 6 The "ls" and "cd" commands can also be used with more complex paths. Enter: `ls Documents/Pictures` to view the contents of a Pictures directory inside your Documents directory. You can switch to this directory using `cd Documents/Pictures`; use `cd ../..` to move back up two parent directories.

```
pi@raspberrypi ~ $ ls Documents/Pictures
LEGO  LucyHattersley.jpg  raspberry_pi_2_photographs
pi@raspberrypi ~ $ cd Documents/Pictures
pi@raspberrypi ~/Documents/Pictures $ pwd
/home/pi/Documents/Pictures
pi@raspberrypi ~/Documents/Pictures $ cd ../..
pi@raspberrypi ~ $ pwd
/home/pi
pi@raspberrypi ~ $
```

ABSOLUTE VS RELATIVE PATHS

It is important to know the difference between the working directory, root directory and home. There are also two types of path: Absolute and Relative. These are easier to understand than they sound. Let's take a look…

STEP 1 By default, commands like "ls" use the working directory. This is the current directory that you're looking at and is set to your home directory by default (/users/pi). Using "pwd" (Print Working Directory) lets you know what the working directory is, and using "cd" changes the working directory.

```
pi@raspberrypi ~ $ pwd
/home/pi
pi@raspberrypi ~ $
```

STEP 2 The root directory is always '/'. Entering: `ls /` lists the contents of root, and entering: `cd /` switches to the root directory. This is important because there is a difference between "ls Documents/Pictures" and "ls /Documents/Pictures". The first command lists the contents of the Pictures directory in Documents inside the working directory (which, if you are in the home directory, will work).

```
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $ ls Documents/Pictures
BDM-Web-logo-dark1.jpg  David Hayward.jpg  RPi.png
pi@raspberrypi:~ $
```

STEP 3 The second command ("ls /Documents/Pictures") attempts to list the content of Pictures in a directory called Documents inside the root directory (because the path started with '/', which is root). There is typically no Documents directory in root, so you will get a "No such file or directory" error. Starting a path with '/' is known as an "absolute path", while starting without the '/' is known as a "relative path" because it is relative to your working directory.

```
pi@raspberrypi ~ $ ls /
bin  boot  dev  etc  home  lib  lost+found  media  mnt  opt  proc  r
pi@raspberrypi ~ $ ls /Documents/Pictures
ls: cannot access /Documents/Pictures: No such file or directory
pi@raspberrypi ~ $ _
```

STEP 4 There is also an absolute path shortcut to your user directory, and that is the tilde "~" character. Entering: `ls ~` always lists the contents of your home directory, while "cd ~" moves straight to your home directory, no matter what your working directory is. You can also use this shortcut wherever you are: enter: `ls ~/Documents/Pictures` to display the contents of the Pictures.

```
pi@raspberrypi:~ $ cd ~
pi@raspberrypi:~ $ pwd
/home/pi
pi@raspberrypi:~ $ ls ~/Documents/Pictures
BDM-Web-logo-dark1.jpg  David Hayward.jpg  RPi.png
pi@raspberrypi:~ $
```

Listing and Moving Files

Admittedly, using the desktop GUI to list and move files is much easier than using the Terminal and keyboard. However, it's an important skill that you will appreciate as you advance with the Raspberry Pi and Linux.

LOOKING AT FILES

Operating systems are built on files and folders, or directories if you prefer. While you're used to viewing your own files, most operating systems keep other files out of sight. In Raspbian, you have access to every file in the system.

STEP 1 We've already looked at "ls", which lists the files in the working directory, but you are more likely to use a command like "ls –l". The bit after the command (the '-lah') is known as the argument. This is an option that modifies the behaviour of the command.

```
pi@raspberrypi ~ $ ls -l_
```

STEP 2 The "-l" argument lists files and directories in long format. Each file and directory is now on a single line, and before each file is a lot of text. First you'll see lots of letters and dashes, like 'drwxr-xr-x'. Don't worry about these for now; they are known as 'permissions' and we'll come to those later.

```
pi@raspberrypi ~ $ ls -l
total 24
-rw-r--r-- 1 pi pi    0 May 11 20:56 articles.txt
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 Apr 21 14:50 Documents
drwx------ 2 pi pi 4096 Apr 21 15:23 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
-rw-r--r-- 1 pi pi    0 May 11 20:56 names.txt
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Apr 17 12:53 Scratch
pi@raspberrypi ~ $
```

STEP 3 After the permission letters come a single number. This is the number of files in the item. If it's a file then it'll be 1, but if it's a directory it'll be at least 2. This is because each directory contains two hidden files; one with a single dot (.) and one with two dots (..). Directories containing files or other directories will have a higher number.

```
pi@raspberrypi ~ $ ls -l
total 24
-rw-r--r-- 1 pi pi    0 May 11 20:56 articles.txt
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 Apr 21 14:50 Documents
drwx------ 2 pi pi 4096 Apr 21 15:23 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
-rw-r--r-- 1 pi pi    0 May 11 20:56 names.txt
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Apr 17 12:53 Scratch
pi@raspberrypi ~ $
```

STEP 4 Next you'll see the word "pi" listed twice on each line. This refers to the user rather than the name of your computer (your default username is "pi"). The first is the owner of the file, and the second is the group. Typically these will both be the same and you'll see either 'pi' or 'root'. You can enter: `ls -l /` to view the files and directories in the root directory that belong to the root account.

```
pi@raspberrypi ~ $ ls -l
total 28
-rw-r--r-- 1 pi pi    0 May 11 20:56 articles.txt
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 Apr 21 14:50 Documents
drwx------ 2 pi pi 4096 Apr 21 15:23 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
-rw-r--r-- 1 pi pi    0 May 11 20:56 names.txt
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Apr 17 12:53 Scratch
drwxr-xr-x 3 pi pi 4096 May 11 21:15 test
pi@raspberrypi ~ $ ls -l /
total 74
drwxr-xr-x   2 root root  4096 Jan  1  1970 bin
drwxr-xr-x   3 root root  2048 Jan  1  1970 boot
drwxr-xr-x  12 root root  3280 May 11 09:03 dev
drwxr-xr-x 109 root root  4096 May 11 09:03 etc
drwxr-xr-x   3 root root  4096 Jan  1  1970 home
drwxr-xr-x  12 root root  4096 Jan  1  1970 lib
drwx------   2 root root 16384 Feb 15 11:21 lost+found
drwxr-xr-x   3 root root  4096 May 11 07:42 media
drwxr-xr-x   2 root root  4096 Jan 11 00:02 mnt
drwxr-xr-x   6 root root  4096 Jan  1  1970 opt
```

STEP 5 The next number relates to the size of the file, in bytes. In Linux each text file is made up of letters and each letter takes up a byte, so our names.txt file has 37 bytes and 37 characters in the document. Files and directories can be extremely large and hard to determine, so use "ls – lh". The "h" argument humanises the number, making it easier to read.

```
pi@raspberrypi ~ $ ls -l
total 32
-rw-r--r-- 1 pi pi    0 May 11 20:56 articles.txt
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 Apr 21 14:50 Documents
drwx------ 2 pi pi 4096 Apr 21 15:23 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
-rw-r--r-- 1 pi pi   37 May 11 21:27 names.txt
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Apr 17 12:53 Scratch
drwxr-xr-x 3 pi pi 4096 May 11 21:15 test
pi@raspberrypi ~ $ ls -lh
total 32K
-rw-r--r-- 1 pi pi    0 May 11 20:56 articles.txt
drwxr-xr-x 2 pi pi 4.0K Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4.0K Apr 21 14:50 Documents
drwx------ 2 pi pi 4.0K Apr 21 15:23 Downloads
drwxr-xr-x 3 pi pi 4.0K Apr 17 18:48 indiecity
```

STEP 6 Finally, you should be aware that there are many hidden files in Linux. These are listed using the "-a" argument. Hidden files and directories begin with a dot (.), so you should never start a file or directory with a dot, unless you want to hide it. Typically, you can combine all three arguments together into the command '"s –lah".

```
pi@raspberrypi ~ $ ls -lah
total 520K
drwxr-xr-x 33 pi   pi        4.0K May 11 21:14 .
drwxr-xr-x  3 root root      4.0K Jan  1  1970 ..
drwx------  2 pi   pi        4.0K Apr 20 14:31 .aptitude
-rw-r--r--  1 pi   pi           0 May 11 20:56 articles.txt
-rw-------  1 pi   pi        8.7K May 11 09:03 .bash_history
-rw-r--r--  1 pi   pi         220 Feb 15 14:05 .bash_logout
-rw-r--r--  1 pi   pi        3.2K Feb 15 14:05 .bashrc
drwxr-xr-x 10 pi   pi        4.0K Apr 21 17:08 .cache
drwxr-xr-x 20 pi   pi        4.0K Apr 21 13:33 .config
drwx------  3 pi   pi        4.0K Feb 16 14:16 .dbus
drwxr-xr-x  2 pi   pi        4.0K Apr 21 17:55 Desktop
-rw-r--r--  1 pi   pi          35 Apr 17 12:17 .dmrc
drwxr-xr-x  5 pi   pi        4.0K Apr 21 14:50 Documents
drwx------  2 pi   pi        4.0K Apr 21 15:23 Downloads
drwxr-xr-x  2 pi   pi        4.0K Apr 20 13:45 .dreamchess
drwxr-xr-x  2 pi   pi        4.0K Apr 21 18:15 .fontconfig
```

SOME COMMON DIRECTORIES

Now that you know how to view the contents of your hard drive you'll start to notice a lot of directories with names like bin, sbin, var and dev. These are the files and directories that you are kept away from on a Mac, and won't encounter on a Windows PC.

STEP 1 Enter: `ls -lah /` to view all of the files and directories, including the hidden items, in the root directory of your hard drive. Here you will see all the items that make up your Raspbian OS (which is a version of Linux). It's worth taking the time to know some of them.

```
pi@raspberrypi ~ $ ls -lah /
total 82K
drwxr-xr-x  22 root root 4.0K May 11 21:23 .
drwxr-xr-x  22 root root 4.0K May 11 21:23 ..
drwxr-xr-x   2 root root 4.0K Jan  1  1970 bin
drwxr-xr-x   3 root root 2.0K Jan  1  1970 boot
drwxr-xr-x  12 root root 3.3K May 11 09:03 dev
drwxr-xr-x 109 root root 4.0K May 11 09:03 etc
drwxr-xr-x   3 root root 4.0K Jan  1  1970 home
drwxr-xr-x  12 root root 4.0K Jan  1  1970 lib
drwx------   2 root root  16K Feb 15 11:21 lost+found
drwxr-xr-x   3 root root 4.0K May 11 07:42 media
drwxr-xr-x   2 root root 4.0K Jan 11 00:02 mnt
drwxr-xr-x   6 root root 4.0K Jan  1  1970 opt
dr-xr-xr-x  85 root root    0 Jan  1  1970 proc
drwx------   9 root root 4.0K May 11 07:36 root
drwxr-xr-x  10 root root  460 May 11 09:03 run
drwxr-xr-x   2 root root 4.0K Jan  1  1970 sbin
drwxr-xr-x   2 root root 4.0K Jun 20  2012 selinux
```

STEP 2 Bin is a directory that stores binaries. This is the Linux way of saying programs or applications. Sbin is for system binaries, which are the programs that make up your system. Dev contains references to your devices: hard drive, keyboard, mouse and so on. Etc contains your system configuration files.

```
pi@raspberrypi ~ $ ls /bin
bash     bzfgrep      chgrp     dash          domainname  fgconsole  gze
bunzip2  bzgrep       chmod     date          dumpkeys    fgrep      gzi
bzcat    bzip2        chown     dd            echo        findmnt    hos
bzcmp    bzip2recover chvt      df            ed          fuser      ip
bzdiff   bzless       con2fbmap dir           egrep       fusermount kbd
bzegrep  bzmore       cp        dmesg         false       grep       kil
bzexe    cat          cpio      dnsdomainname fbset       gunzip     kmo
pi@raspberrypi ~ $
```

STEP 3 Entering: `ls /home` displays the contents of your home directory, which contains pi; the directory that you start in. So, entering: `ls/home/pi` is the same as just "ls" from the default home directory. This is where you are expected to place most of the documents you create. Don't confuse home with "usr"; the /usr directory is where find you find program tools and libraries.

```
pi@raspberrypi ~ $ ls
articles.txt  Desktop  Documents  Downloads  indiecity  names.txt  python_g
pi@raspberrypi ~ $ ls /home/pi
articles.txt  Desktop  Documents  Downloads  indiecity  names.txt  python_g
pi@raspberrypi ~ $
```

STEP 4 Lib is a directory that contains libraries of code that are referred to by other programs (different programs share files in Lib). "Var" is short for various, which is mostly files used by the system, but you may need to work with items here. Finally there is a directory called "tmp", which is for temporary files; files placed here are on your system for the short term and can be deleted from the system.

```
pi@raspberrypi ~ $ ls /var
backups  cache  lib  local  lock  log  mail  opt  run  spool  swap  tmp  ww
pi@raspberrypi ~ $
```

Creating and Deleting Files

Being able to create and delete a file is an everyday computing skill. However, when using the Linux Terminal, there's an element of care required, chiefly because any deleted files aren't placed in the system recycle bin.

CREATING FILES

Once you learn to recognise the files and directories that make up Raspbian OS, it's time to discover how to make your own. Knowing how to make, edit and delete files and directories is essential if you want to make your own projects.

STEP 1 We're going to create a file using a command called Touch. Touch is an interesting command that reaches out to a file, or directory, and updates it (this changes the system time as if you'd just opened the file). You can see Touch in access using "ls –l" and checking the time next to a directory (such as Scratch).

```
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Apr 17 12:53 Scratch
pi@raspberrypi ~ $ _
```

STEP 2 Now enter: `touch Scratch` and `ls -l` again and notice that the time has changed. It now matches the current time. You might be wondering what this has to do with creating files or directories. Touch has a second, more popular, use, which is to create files.

```
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Apr 17 12:53 Scratch
pi@raspberrypi ~ $ touch Scratch
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
pi@raspberrypi ~ $ _
```

STEP 3 If you try to touch a file that doesn't exist, you create a blank file with that name. Try it now. Type `touch testfile` and `ls -l` to view the files. You'll now have a new file in your home directory called "testfile". Notice that the size of the file is 0, because it has nothing in it.

```
pi@raspberrypi ~ $ touch testfile
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
-rw-r--r-- 1 pi pi    0 May 13 11:10 testfile
pi@raspberrypi ~ $ _
```

STEP 4 A quick word about file names: remember that Linux is case sensitive, so if you now enter: `touch Testfile` (with a capital T), it doesn't update 'testfile'; instead, it creates a second file called 'Testfile'. Enter: `ls -l` to see both files. This is confusing, so most people stick with using lowercase letters at all times.

```
pi@raspberrypi ~ $ touch testfile
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
-rw-r--r-- 1 pi pi    0 May 13 11:08 testfile
pi@raspberrypi ~ $ touch Testfile
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
-rw-r--r-- 1 pi pi    0 May 13 11:08 testfile
-rw-r--r-- 1 pi pi    0 May 13 11:10 Testfile
pi@raspberrypi ~ $ _
```

STEP 5 Another important thing to know is never to use a space in your file names. If you try to enter: `touch test file`, you create a document called "test" and another called "file". Technically there are ways to create files containing a space but you should always use an underscore character ("_") instead of a space, such as "touch test_file".

```
pi@raspberrypi ~ $ touch test file
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
-rw-r--r-- 1 pi pi    0 May 13 11:15 file
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
-rw-r--r-- 1 pi pi    0 May 13 11:15 test
-rw-r--r-- 1 pi pi    0 May 13 11:10 testfile
-rw-r--r-- 1 pi pi    0 May 13 11:12 Testfile
pi@raspberrypi ~ $ _
```

STEP 6 Here are some other files names to avoid: #%&{}\<>*?/$!'":@+`|=. The full stop (.) is used to create an extension to a file; usually used to indicate a file type, such as textfile.txt or compressedfile.zip, and starting a file with a full stop makes it invisible. Don't use full stop in place of a space though; stick to underscores.

```
pi@raspberrypi ~ $ touch don't.use{odd}symbols&in<filenames>or=you'll^confu
```

REMOVING FILES

We've created some files that we don't want, so how do we go about removing them? It turns out that deleting files in your Raspberry Pi is really easy, which may be a problem, so be careful.

STEP 1 Enter: `ls -l` to view the files in your home directory. If you've followed the steps before then you should have three files: "test", "testfile", and "Testfile". We're going to get rid of these items because they were created as an example.

```
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
-rw-r--r-- 1 pi pi    0 May 13 11:15 file
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
-rw-r--r-- 1 pi pi    0 May 13 11:15 test
-rw-r--r-- 1 pi pi    0 May 13 11:10 testfile
-rw-r--r-- 1 pi pi    0 May 13 11:46 Testfile
pi@raspberrypi ~ $
```

STEP 2 To get rid of files you use the "rm" command. Enter: `rm Testfile` to delete the file called "Testfile" (with the uppercase "t"). Enter: `ls -l` and you'll find it's gone. Where is it? It's not in the Trash or Recycle Bin, like on a Mac or Windows PC. It's deleted completely and cannot be recovered. Bear this in mind and always think before deleting files.

```
pi@raspberrypi ~ $ rm Testfile
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Apr 21 17:55 Desktop
drwxr-xr-x 5 pi pi 4096 May 13 10:57 Documents
drwx------ 2 pi pi 4096 May 13 11:01 Downloads
-rw-r--r-- 1 pi pi    0 May 13 11:15 file
drwxr-xr-x 3 pi pi 4096 Apr 17 18:48 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 May 13 11:05 Scratch
-rw-r--r-- 1 pi pi    0 May 13 11:15 test
-rw-r--r-- 1 pi pi    0 May 13 11:10 testfile
pi@raspberrypi ~ $ _
```

STEP 3 We're going to use a wildcard (*) to delete our next two files, but again this is something you really need to do with care. First use "ls" to list the files and make sure it's the one you want to delete. Enter: `ls test*` to view files that match the word "test" and any other characters. The "*" character is called a "wildcard" and it means any characters here.

```
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Desktop
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Documents
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Downloads
-rw-r--r-- 1 pi pi    0 Jul  9 08:37 file
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Scratch
-rw-r--r-- 1 pi pi    0 Jul  9 08:37 test
-rw-r--r-- 1 pi pi    0 Jul  9 08:37 testfile
pi@raspberrypi ~ $ ls test*
test  testfile
pi@raspberrypi ~ $ _
```

STEP 4 We see that "ls test*" matches two files: "test" and "testfile", but not the file called "file". That's because it didn't match the "test" part of "test*". Check carefully over groups of files you want to remove (remember you can't recover them) and replace the "ls" with "rm". Enter: `rm test*` to remove both files. Finally enter: `rm file` to get rid of the confusing file.

```
pi@raspberrypi ~ $ rm test*
pi@raspberrypi ~ $ ls -l
total 24
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Desktop
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Documents
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Downloads
-rw-r--r-- 1 pi pi    0 Jul  9 08:37 file
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 indiecity
drwxrwxr-x 2 pi pi 4096 Jan  1  1970 python_games
drwxr-xr-x 2 pi pi 4096 Jul  9 08:36 Scratch
pi@raspberrypi ~ $ rm file
pi@raspberrypi ~ $
```

Create and Remove Directories

Creating, moving and deleting directories aren't as easy in the Terminal as they are within a desktop interface. You need to tell Linux to move the directories inside other directories, a process known as recursion. Sounds complex but you should quickly get the hang of it.

MANAGING FILES AND DIRECTORIES

Now that you know how to create files, you'll want to learn how to make directories, which are the same thing as folders, as well as move items around. If you are more used to working with a desktop interface, this can take a bit of getting used to.

STEP 1 Enter: `ls` to quickly view all the directories currently in in the home location. Directories are created using the "mkdir" command (make directory). Enter: `mkdir testdir` to create a new directory in your home directory. Enter: `ls` again to see it.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scra
pi@raspberrypi ~ $ mkdir testdir
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scra
pi@raspberrypi ~ $ _
```

STEP 2 The "mkdir" command is different to touch, in that it doesn't update the timestamp if you use it with a directory that already exists. Enter: `mkdir testdir` again and you'll get the error "mkdir: cannot create directory 'testdir: File exists".

```
pi@raspberrypi ~ $ mkdir testdir
mkdir: cannot create directory `testdir': File exists
pi@raspberrypi ~ $ _
```

STEP 3 Like touch, you can create multiple directories at once with the mkdir command. Enter: `mkdir testdir2 testdir3` and enter: `ls`. You'll now find several directories called testdir. Also, like files, you should know this means you can't (and really shouldn't) create directories with spaces. As with files, use an underscore ("_") character instead of a space.

```
pi@raspberrypi ~ $ mkdir testdir2 testdir3
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scra
pi@raspberrypi ~ $ _
```

STEP 4 You can create directories inside of each other using the directory path. Enter: `mkdir Documents/photos` to create a new directory called "photos" inside your documents directory. The directory has to already exist, though, try to enter: `mkdir articles/reports` and you'll get an error because there is no articles directory.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scrat
pi@raspberrypi ~ $ mkdir Documents/photos
pi@raspberrypi ~ $ mkdir articles/reports
mkdir: cannot create directory `articles/reports': No such fi
pi@raspberrypi ~ $
```

STEP 5 To create a directory path you need to pass in the "p" option to mkdir (which stands for "parents"). Options, if you remember, come after the command and start with a '-'. So enter: `mkdir -p articles/reports`. Enter: `ls` to view the articles directory, or "ls articles" to view the reports directory sitting inside.

```
pi@raspberrypi ~ $ mkdir -p articles/reports
```

STEP 6 Now you're starting to get a bit more advanced, we're going to just reiterate something. In Linux the command structure is always: command, option and argument, in that order. The command is the function, next are the options (typically single letters starting with "-") and finally the argument (often a file, or directory structure). It's always command, option then argument.

```
pi@raspberrypi ~ $ ls -l articles
total 4
drwxr-xr-x 2 pi pi 4096 May 13 12:36 reports
pi@raspberrypi ~ $ _
```

GETTING RID OF DIRECTORIES

Deleting directories is pretty easy in Linux, along with files, and this can be a problem. It's too easy to delete entire directories containing files and these are instantly removed, not sent to a trash directory. Tread carefully.

STEP 1 We're going to remove one of the directories we created earlier using the "rmdir" command. Enter: `ls` to view the files and directories in the current directory. We'll start by getting rid of one of the test directories. Enter: `rmdir testdir3` and `ls` again to confirm the directory has been removed.

```
pi@raspberrypi ~ $ ls
articles  Desktop  Documents  Downloads  indiecity  python_ga
pi@raspberrypi ~ $ rmdir testdir3_
```

STEP 2 Now we'll try to get rid of the articles directory (containing the reports directory). Enter: `rmdir articles` and press return. You'll get an error saying "rmdir: failed to remove 'articles': Directory not empty". This is a puzzler; the rmdir command only removes directories that having nothing in them (no files or other directories).

```
pi@raspberrypi ~ $ rmdir articles
rmdir: failed to remove `articles': Directory not empty
pi@raspberrypi ~ $ _
```

STEP 3 To delete a directory containing files or other directories, you return to the "rm" command used to remove files, only now we need to use the "-R" option (which stands for "recursive".) Using "rm –R" removes all the files and directories to whatever you point it at. Enter: `rm -R articles` to remove the articles directory.

```
pi@raspberrypi ~ $ ls
articles  Desktop  Documents  Downloads  indiecity  python_ga
pi@raspberrypi ~ $ rm -R articles
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scrat
pi@raspberrypi ~ $
```

STEP 4 As with multiple files, you can delete multiple directories inside the same directory using the "rm" command with the wildcard character (*). This should be done with care though so use the `-I` option (which stands for "interactive"). This will prompt you before each deletion. Enter: `rm -Ri test*` and press `Y` and `return` to each prompt. It's a good idea to use the `-i` option whenever using the rm command.

```
pi@raspberrypi ~ $ rm -Ri test*
rm: remove directory `testdir'? y
rm: remove directory `testdir2'? y
rm: remove directory `testdir3'? y_
```

Copying, Moving and Renaming Files

Taking command of the Terminal is essential when learning how your Raspberry Pi's operating system works. The copying, moving and renaming of files is equally important, as you'll be doing a lot of this throughout your Pi projects.

USING THE MOVE COMMAND

In Linux, renaming a file is simply moving it from one name to another and copying a file is moving it without deleting the original. Don't panic, it's quite easy to master.

STEP 1 Before we can move anything around, we need to have a few test items in our home directory. Enter: `touch testfile` and `mkdir testdir` to create a test file and test directory in your home directory. Enter: `ls` to check that they are both present.

```
pi@raspberrypi ~ $ touch testfile
pi@raspberrypi ~ $ mkdir testdir
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scra
pi@raspberrypi ~ $
```

STEP 2 Files and directories are moved using the mv command. This is different to the commands we've looked at so far because it has two arguments (remember Linux command line is command, option, argument). The first argument is the source (the file or directory to be moved) and the second is the destination.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scrat
pi@raspberrypi ~ $ mv testfile testdir
```

STEP 3 Enter: `mv testfile testdir` and press return to move the testfile document into the testdir directory. Enter: `ls` to see that it's no longer in the home directory, and `ls testdir` to see the testfile now sitting in the testdir directory. Now enter: `mkdir newparent` to create a new directory.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scrat
pi@raspberrypi ~ $ mv testfile testdir
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scrat
pi@raspberrypi ~ $ ls testdir
testfile
pi@raspberrypi ~ $
```

STEP 4 Directories with files are moved in the same way. Enter: `mv testdir newparent` to move the testdir directory inside the newparent directory. Let's move into the directory to find the file. Enter: `cd /newparent/testdir` and enter: `ls` to view the testfile sitting inside the directory.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  python_games  Scra
pi@raspberrypi ~ $ mkdir newparent
pi@raspberrypi ~ $ mv testdir newparent
pi@raspberrypi ~ $ cd newparent/testdir
pi@raspberrypi ~/newparent/testdir $ ls
testfile
pi@raspberrypi ~/newparent/testdir $
```

STEP 5 Files and directories can be moved up using the double dot ("..") as an argument. Enter: `ls -la` to view your testfile and the single and double dot files. The single dot is the current directory and the double dot is the parent directory. Enter: `mv testfile ..` to move the testfile up into the newparent directory. Enter: `cd ..` to move up to the parent directory.

```
pi@raspberrypi ~ $ cd newparent/testdir
pi@raspberrypi ~/newparent/testdir $ ls
testfile
pi@raspberrypi ~/newparent/testdir $ mv testfile ..
pi@raspberrypi ~/newparent/testdir $ cd
```

STEP 6 You can also move files using longer paths. Enter: `cd ~` to return to the home directory and `mv newparent/testfile newparent/testdir/testfile` to move the testfile from its current location back inside the testdir directory. Enter: `ls newparent/testdir` to view the file back in its current directory.

```
pi@raspberrypi ~/newparent $ cd ~
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  newparent  python
pi@raspberrypi ~ $ mv newparent/testfile newparent/testdir/
pi@raspberrypi ~ $ ls newparent/testdir
testfile
pi@raspberrypi ~ $ _
```

RENAMING FILES AND DIRECTORIES

The mv command isn't used just to move files; it also serves the purpose of renaming files (effectively it moves it from its old name to a new name). Let's see how to use mv to rename items.

STEP 1 Let's start by making a new test file called "names". Enter: `touch testfile` and then `ls` to make sure the testfile is present. We're going to turn this into a file that contains the names of some people. So let's call it something more appropriate, like "names".

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  newparent  python_
pi@raspberrypi ~ $ mv testfile names
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  names  newparent
pi@raspberrypi ~ $
```

STEP 2 Enter: `mv testfile names` and `ls`. Now we can see the new "names" file in our directory. The mv command can also be used to rename directories. We should still have our newparent directory in our home directory. Enter: `mv newparent people` to rename the newparent directory. Enter: `ls` to view it.

```
pi@raspberrypi ~ $ touch testfile
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  newparent  python_
pi@raspberrypi ~ $ mv newparent people
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  people  python_gam
pi@raspberrypi ~ $
```

STEP 3 You can rename directories inside other directories using paths. Let's rename the testdir directory, which is now inside the people directory. Enter: `mv names/testdir names/friends`. Now enter: `mv names people/friends` to move the names file inside the friends directory.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  names  people  pyth
pi@raspberrypi ~ $ mv people/testdir people/friends
```

STEP 4 It is easy to overwrite files using the mv command, so if you have files with the same name use the "-n" option, which stands for "no overwrite". Enter: `touch testfile` to create a new file and `mv -n testfile people/friends`. There's no error report though, enter: `ls` and you'll find testfile still there.

```
pi@raspberrypi ~ $ touch testfile
pi@raspberrypi ~ $ mv -n testfile people/friends
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  people  python_gam
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  people  python_gam
pi@raspberrypi ~ $ ls people/friends
names  testfile
pi@raspberrypi ~ $
```

Useful System and Disk Commands

Understanding these core Linux commands will enable you to not only master the inner workings of your Raspberry Pi but also to transfer those skills to other Linux distros, such as Ubuntu or Linux Mint.

LOTS OF LINUX

Linux is a huge and versatile command line language and there are hundreds of commands you can learn and use. Here are a few that can help you get more from your Raspberry Pi.

STEP 1

The Raspberry Pi is a great little computer, so let's start by getting some information. Enter: `cat /proc/cpuinfo` to view some details on your Raspberry Pi processors. If you have a Raspberry Pi 3 you will see four processors, along with the model name and other info.

```
pi@raspberrypi ~ $ cat /proc/cpuinfo
processor       : 0
model name      : ARMv7 Processor rev 5 (v7l)
BogoMIPS        : 38.40
Features        : half thumb fastmult vfp edsp neon vfpv3 tls vfpv4 idiva idivt vfpd32 lpae ev
CPU implementer : 0x41
CPU architecture: 7
CPU variant     : 0x0
CPU part        : 0xc07
CPU revision    : 5

processor       : 1
model name      : ARMv7 Processor rev 5 (v7l)
BogoMIPS        : 38.40
Features        : half thumb fastmult vfp edsp neon vfpv3 tls vfpv4 idiva idivt vfpd32 lpae ev
CPU implementer : 0x41
CPU architecture: 7
CPU variant     : 0x0
CPU part        : 0xc07
CPU revision    : 5

processor       : 2
model name      : ARMv7 Processor rev 5 (v7l)
BogoMIPS        : 38.40
Features        : half thumb fastmult vfp edsp neon vfpv3 tls vfpv4 idiva idivt vfpd32 lpae ev
CPU implementer : 0x41
CPU architecture: 7
CPU variant     : 0x0
CPU part        : 0xc07
```

STEP 2

Remember that cat is used to list the contents of a text file, which is what cpuinfo is. There are other text files with system info available. Try "cat /proc/meminfo" to get information about your memory, "cat /proc/partitions" for information about your SD card, and "cat /proc/version" shows which version of Raspberry Pi you are using.

```
pi@raspberrypi ~ $ cat /proc/meminfo
MemTotal:         884304 kB
MemFree:          784576 kB
MemAvailable:     834088 kB
Buffers:           11660 kB
Cached:            56340 kB
SwapCached:            0 kB
Active:            49148 kB
Inactive:          30072 kB
Active(anon):      11256 kB
Inactive(anon):      228 kB
Active(file):      37892 kB
Inactive(file):    29844 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:        102396 kB
SwapFree:         102396 kB
Dirty:                36 kB
Writeback:             0 kB
AnonPages:         11132 kB
Mapped:             7464 kB
Shmem:               260 kB
Slab:              10384 kB
SReclaimable:       4512 kB
SUnreclaim:         5872 kB
KernelStack:         672 kB
PageTables:          564 kB
NFS_Unstable:          0 kB
Bounce:                0 kB
WritebackTmp:          0 kB
CommitLimit:      544548 kB
Committed_AS:      43712 kB
VmallocTotal:    1171456 kB
VmallocUsed:        3880 kB
VmallocChunk:     922360 kB
pi@raspberrypi ~ $ cat /proc/partitions
major minor  #blocks  name

 179        0    7761920 mmcblk0
 179        1     835890 mmcblk0p1
 179        2          1 mmcblk0p2
```

STEP 3

Enter: `uname` to view the name of the operating system's kernel, this is the element that sits between the interface and hardware. Just as you would suspect, the response from the command is Linux, as Raspbian is a Linux distro, which in itself is based on another Linux distro called Debian. While it may sound complicated, it actually demonstrates how versatile Linux is.

```
pi@raspberrypi ~ $ uname
Linux
pi@raspberrypi ~ $
```

STEP 4

Enter: `uname -a` to view some more detailed information. Here you'll see the kernel name, hostname and kernel version (3.18.7-v7 on ours). If you have a Raspberry Pi 2 you'll see SMP (symmetric multiprocessing), followed by the system date, CPU architecture and operating system (GNU/Linux).

```
pi@raspberrypi ~ $ uname
Linux
pi@raspberrypi ~ $ uname -a
Linux raspberrypi 3.18.7-v7+ #755 SMP PREEMPT Thu Feb 12 17
pi@raspberrypi ~ $ _
```

STEP 5 Enter: `vcgencmd measure_temp` to view the current operating system temperature of your Raspberry Pi. Enter: `vcgencmd get_mem arm` to view the RAM available, and vcgencmd `get_mem gpu` to view the memory available to the graphics chip. Finally try ls usb to view a list of attached USB devices.

```
pi@raspberrypi ~ $ vcgencmd measure_temp
temp=36.9'C
pi@raspberrypi ~ $ vcgencmd get_mem arm
arm=880M
pi@raspberrypi ~ $ vcgencmd get_mem gpu
gpu=128M
pi@raspberrypi ~ $ lsusb
Bus 001 Device 002: ID 0424:9514 Standard Microsystems Corp.
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 001 Device 003: ID 0424:ec00 Standard Microsystems Corp.
Bus 001 Device 004: ID 04d9:1503 Holtek Semiconductor, Inc. Shortboard Lefty
Bus 001 Device 005: ID 1a40:0101 Terminus Technology Inc. 4-Port HUB
Bus 001 Device 006: ID 276d:1105
pi@raspberrypi ~ $
```

STEP 6 One command you might be wondering about is how to switch off or restart your Raspberry Pi from the command line. Don't just hit the power switch. Enter: `sudo showdown -h` now to shut down the Raspberry Pi (the "-h" option stands for "halt"), or enter: `sudo shutdown -r` now to restart your Raspberry Pi.

```
pi@raspberrypi ~ $ sudo shutdown -r now

Broadcast message from root@raspberrypi (tty1) (Thu May 14 12:20:29 2015):
The system is going down for reboot NOW!
-
```

DISK COMMANDS

Learn the two commands that enable you to view your disk space and the files on it: df (disk free space) and du (disk usage). With these two commands you can view the file usage on your SD card.

STEP 1 Start by entering: `df` in the command line. It returns a list of the volumes contained on your SD card. You might be wondering what a volume is. It's best to think of your SD card as the drive. This contains partitions, which is where you split one drive to act like two or more drives. And each partition can contain volumes, which are storage spaces.

```
pi@raspberrypi ~ $ df
Filesystem     1K-blocks    Used Available Use% Mounted on
rootfs           6581636 3484164   2740096  56% /
/dev/root        6581636 3484164   2740096  56% /
devtmpfs          437856       0    437856   0% /dev
tmpfs              88432     260     88172   1% /run
tmpfs               5120       0      5120   0% /run/lock
tmpfs             176860       0    176860   0% /run/shm
/dev/mmcblk0p5     60479   14536     45943  25% /boot
pi@raspberrypi ~ $
```

STEP 2 Enter: `df -h` to get the list in human readable form. The first two lines should read "rootfs" and "/dev/root" and have matching Size, Used, Avail and Use% listings. This is the main drive, and is an indication of how much space you have used, and have free, on your Raspbian OS. The other volumes are for booting and initialising devices (you can ignore these for now).

```
pi@raspberrypi ~ $ du -h | less
22M     ./.minecraft/games/com.mojang/minecraftWorlds/world
22M     ./.minecraft/games/com.mojang/minecraftWorlds
22M     ./.minecraft/games/com.mojang
22M     ./.minecraft/games
4.0K    ./.pulse
16K     ./.config/gedit
8.0K    ./.config/libfm
1.4M    ./.config/epiphany/adblock
1.5M    ./.config/epiphany
8.0K    ./.config/lxsession/LXDE-pi
12K     ./.config/lxsession
8.0K    ./.config/dconf
8.0K    ./.config/rncbc.org
8.0K    ./.config/lxterminal
8.0K    ./.config/uk.ac.cam.cl
8.0K    ./.config/IndieCity
```

STEP 3 Now enter: `du`. You should see lots of text fly up the screen. This is the disk usage for the files contained in your home directory and their sub-directories. As with df, it is better to use du with the "-h" option to humanise the output. If you want to slow down the output, you'll also need to pipe it through less. Enter: `df -h | less` to view the files and their respective usage one page at a time.

```
pi@raspberrypi ~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
rootfs          6.3G  3.4G  2.7G  56% /
/dev/root       6.3G  3.4G  2.7G  56% /
devtmpfs        428M     0  428M   0% /dev
tmpfs            87M  260K   87M   1% /run
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs           173M     0  173M   0% /run/shm
/dev/mmcblk0p5   60M   15M   45M  25% /boot
pi@raspberrypi ~ $
```

STEP 4 You don't typically enter: du on its own; most of the time you want to view the disk usage of a specific directory. Enter: `du -h python_games` to view how much space the python_games directory (installed alongside Raspbian) takes up. It should be 1.8M. If you want a more comprehensive breakdown of the files contained, use the "-a" option (all). Enter: `du -ha python_games` to view all the files contained and their disk usage.

```
pi@raspberrypi ~ $ ls
Desktop  Documents  Downloads  indiecity  people  python_games  Scratch  testfile
pi@raspberrypi ~ $ du -h python_games
1.8M    python_games
pi@raspberrypi ~ $ du -ha python_games
12K     python_games/RedSelector.png
12K     python_games/4row_board.png
12K     python_games/Star.png
28K     python_games/4row_humanwinner.png
12K     python_games/Wall_Block_Tall.png
8.0K    python_games/princess.png
12K     python_games/Selector.png
8.0K    python_games/4row_black.png
4.0K    python_games/catanimation.py
20K     python_games/flippy.py
36K     python_games/match3.wav
24K     python_games/starpusher.py
```

Using the Man Pages

Linux comes with man (manual) pages that explain each command and show you all the options you can use. Once you get the hang of reading the man pages, you'll be able to find and do just about anything in Linux.

HEY, MAN!

The man pages are one of the best features of Linux, and as a built-in tool it's invaluable for both beginner and senior level Linux administrators. Let's see how it works.

STEP 1

Linux has a built-in manual, known as man for short. Using the man command you can obtain information on all the Linux commands we've talked about. Simply enter: `man` and the name of the command you want to learn more about. Start by entering: `man ls` in the command line.

```
pi@raspberrypi ~ $ man ls
```

STEP 2

The man pages are a bit more detailed than you might be used to. First you have a name, which tells you what the command is called; in this case "list directory contents" and then the synopsis shows you how it works. In this case: "ls [OPTION].. [FILE..]". So you enter: `ls` followed by options (such as `-la`) and the file or directory to list.

```
LS(1)

NAME
       ls - list directory contents

SYNOPSIS
       ls [OPTION]... [FILE]...

DESCRIPTION
       List information about the FILEs (the current directory by default).  Sort entries alphabetic

       Mandatory arguments to long options are mandatory for short options too.

       -a, --all
              do not ignore entries starting with .

       -A, --almost-all
              do not list implied . and ..

       --author
              with -l, print the author of each file

       -b, --escape
              print C-style escapes for nongraphic characters

       --block-size=SIZE
              scale sizes by SIZE before printing them.  E.g., `--block-size=M' prints sizes in unit

       -B, --ignore-backups
              do not list implied entries ending with ~

       -c     with -lt: sort by, and show, ctime (time of last modification of file status informati

       -C     list entries by columns

       --color[=WHEN]
              colorize the output.  WHEN defaults to `always' or can be `never' or `auto'.  More inf

       -d, --directory
              list directory entries instead of contents, and do not dereference symbolic links

       -D, --dired
              generate output designed for Emacs' dired mode

       -f     do not sort, enable -aU, disable -ls --color

       -F, --classify
              append indicator (one of */=>@|) to entries

       --file-type
              likewise, except do not append '*'

       --format=WORD
              across -x, commas -m, horizontal -x, long -l, single-column -1, verbose -l, vertical -

       --full-time
              like -l --time-style=full-iso

 Manual page ls(1) line 1 (press h for help or q to quit)
```

STEP 3

Most commands are pretty easy to figure out how to use, so what you spend most of the time in the man pages is looking under the Description. Here you will see all the options and the letters used to activate them. Most man pages are longer than a single page, so press any key, such as the space bar, to move to the next page of content.

```
-g     like -l, but do not list owner

--group-directories-first
       group directories before files.

       augment with a --sort option, but any use of --sort=none (-U) disables grouping

-G, --no-group
       in a long listing, don't print group names

-h, --human-readable
       with -l, print sizes in human readable format (e.g., 1K 234M 2G)

--si   likewise, but use powers of 1000 not 1024

-H, --dereference-command-line
       follow symbolic links listed on the command line

--dereference-command-line-symlink-to-dir
       follow each command line symbolic link that points to a directory

--hide=PATTERN
       do not list implied entries matching shell PATTERN (overridden by -a or -A)

--indicator-style=WORD
       append indicator with style WORD to entry names: none (default), slash (-p), file-type (--file-

-i, --inode
       print the index number of each file

-I, --ignore=PATTERN
       do not list implied entries matching shell PATTERN
```

STEP 4

Press the H key while looking at a man page to view the commands you can use to control the view. This is called the Summary of Less Commands (the less command is something we'll come to when we look at editing text). For now realise that you can move back and forward with Z and W. Press Q to quit this help screen and return to the man page.

```
                    SUMMARY OF LESS COMMANDS

      Commands marked with * may be preceded by a number, N.
      Notes in parentheses indicate the behavior if N is given.

  h  H                 Display this help.
  q  :q  Q  :Q  ZZ     Exit.
 ---------------------------------------------------------------------------

                           MOVING

  e  ^E  j  ^N  CR  *  Forward  one line   (or N lines).
  y  ^Y  k  ^K  ^P  *  Backward one line   (or N lines).
  f  ^F  ^V  SPACE  *  Forward  one window (or N lines).
  b  ^B  ESC-v      *  Backward one window (or N lines).
  z                 *  Forward  one window (and set window to N).
  w                 *  Backward one window (and set window to N).
  ESC-SPACE         *  Forward  one window, but don't stop at end-of-file.
  d  ^D             *  Forward  one half-window (and set half-window to N).
  u  ^U             *  Backward one half-window (and set half-window to N).
  ESC-)  RightArrow *  Left  one half screen width (or N positions).
  ESC-(  LeftArrow  *  Right one half screen width (or N positions).
  F                    Forward forever; like "tail -f".
  r  ^R  ^L            Repaint screen.
  R                    Repaint screen, discarding buffered input.
        ---------------------------------------------------
        Default "window" is the screen height.
        Default "half-window" is half of the screen height.
 ---------------------------------------------------------------------------

                          SEARCHING

  /pattern          *  Search forward for (N-th) matching line.
```

STEP 5 Scroll to the bottom of the man page to discover more information. Typically you will find the author's name and information on reporting bugs, including web links that can be useful for more information. Press Q to exit the man page and return to the command line.

```
        assume tab stops at each COLS instead of 8
  -u    with -lt: sort by, and show, access time with -l: show access time and sort by name otherwise:
  -U    do not sort; list entries in directory order
  -v    natural sort of (version) numbers within text

  -w, --width=COLS
        assume screen width instead of current value

  -x    list entries by lines instead of by columns

  -X    sort alphabetically by entry extension

  -Z, --context
        print any SELinux security context of each file

  -1    list one file per line

  --help display this help and exit

  --version
        output version information and exit

  SIZE may be (or may be an integer optionally followed by) one of following: KB 1000, K 1024, MB 1000*

  Using color to distinguish file types is disabled both by default and with --color=never.  With --col
  ment variable can change the settings.  Use the dircolors command to set it.

Exit status:
```

STEP 6 The man command can be used for just about every command you use in Linux. You can even enter: man man to get information on using the man tool. From now on, whenever you come across a new command in this book, such as "nano" or "chmod", take time to enter: `man nano` or `man chmod` and read the instructions.

```
MAN(1)                                                                                          Manu

NAME
       man - an interface to the on-line reference manuals

SYNOPSIS
       man  [-C  file] [-d] [-D] [--warnings[=warnings]] [-R encoding] [-L locale] [-m system[,...]] [-
       [-r prompt] [-7] [-E encoding] [--no-hyphenation] [--no-justification] [-p string] [-t] [-T[devi
       man -k [apropos options] regexp ...
       man -K [-w|-W] [-S list] [-i|-I] [--regex] [section] term ...
       man -f [whatis options] page ...
       man -l [-C file] [-d] [-D] [--warnings[=warnings]] [-R encoding] [-L locale] [-P pager] [-r prom
       man -w|-W [-C file] [-d] [-D] page ...
       man -c [-C file] [-d] [-D] page ...
       man [-hV]

DESCRIPTION
       man is the system's manual pager. Each page argument given to man is normally the name of a prog
       section,  if  provided,  will  direct man to look only in that section of the manual.  The defau
       page found, even if page exists in several sections.

       The table below shows the section numbers of the manual followed by the types of pages they cont

       1   Executable programs or shell commands
       2   System calls (functions provided by the kernel)
       3   Library calls (functions within program libraries)
       4   Special files (usually found in /dev)
       5   File formats and conventions eg /etc/passwd
       6   Games
```

USING MAN OPTIONS

Because man doesn't change anything, like mv or mkdir, it is tempting not to see it as a command. But it is, and like all other commands it has options. These can be very handy to learn.

STEP 1 Entering: `man man` enables you to view some of the options, but sometimes you'll just want a quick overview. Fortunately man has a built-in help option that quickly lists the options. Press Q if you're in a man page and enter: `man -h` at the command line.

```
                              print physical location of cat file(s)

  -c, --catman                used by catman to reformat out of date cat pages
  -H, --recode=ENCODING       output source page encoded in ENCODING

Finding manual pages:
  -L, --locale=LOCALE         define the locale for this particular man search
  -m, --systems=SYSTEM        use manual pages from other systems
  -M, --manpath=PATH          set search path for manual pages to PATH

  -S, -s, --sections=LIST     use colon separated section list

  -e, --extension=EXTENSION   limit search to extension type EXTENSION

  -i, --ignore-case           look for pages case-insensitively (default)
  -I, --match-case            look for pages case-sensitively

      --regex                 show all pages matching regex
      --wildcard              show all pages matching wildcard

      --names-only            make --regex and --wildcard match page names only,
                              not descriptions

  -a, --all                   find all matching manual pages
  -u, --update                force a cache consistency check

      --no-subpages           don't try subpages, e.g. 'man foo bar' => 'man
                              foo-bar'

Controlling formatted output:
  -P, --pager=PAGER           use program PAGER to display output
  -r, --prompt=STRING         provide the `less' pager with a prompt

  -7, --ascii                 display ASCII translation of certain latin1 chars
  -E, --encoding=ENCODING     use selected output encoding
      --no-hyphenation, --nh  turn off hyphenation
      --no-justification,                                 --nj   turn off justification
  -p, --preprocessor=STRING   STRING indicates which preprocessors to run:
                              e - [n]eqn, p - pic, t - tbl,
g - grap, r - refer, v - vgrind

  -t, --troff                 use groff to format pages
  -T, --troff-device[=DEVICE]   use groff with selected device

  -H, --html[=BROWSER]        use www-browser or BROWSER to display HTML output
  -X, --gxditview[=RESOLUTION]   use groff and display through gxditview
                              (X11):
                              -X = -TX75, -X100 = -TX100, -X100-12 = -TX100-12

  -Z, --ditroff               use groff and force it to produce ditroff

  -?, --help                  give this help list
      --usage                 give a short usage message
  -V, --version               print program version

Mandatory or optional arguments to long options are also mandatory or optional
for any corresponding short options.

Report bugs to c.watson@debian.org.
pi@raspberrypi ~ $
```

STEP 2 If you're fast you may have noticed the start of the text flew up off the page. This is because the "man –h" option doesn't use the less command by default (less is what enables you to move down text one screen at a time). We'll look into pipes ("|") later on, but for now just use "man -h | less" to read long text one page at a time.

```
pi@raspberrypi ~ $ man -h | less
```

STEP 3 One of the most powerful man options is the -k option, which is for "apropos". This enables you to search a wider range of man pages than the exact command. Enter: `man -k directory` to view all of the man pages relating to directories "(man -k directory | less" to view one page at a time). Here you'll find commands like "ls", "mkdir" and "cd" along with their description.

```
fchdir (2)           - change working directory
fchmodat (2)         - change permissions of a file relative to a directory file descriptor
fchownat (2)         - change ownership of a file relative to a directory file descriptor
fdopendir (3)        - open a directory
find (1)             - search for files in a directory hierarchy
fstatat (2)          - get file status relative to a directory file descriptor
fstatat64 (2)        - get file status relative to a directory file descriptor
futimesat (2)        - change timestamps of a file relative to a directory file descriptor
get_current_dir_name (2) - get current working directory
get_current_dir_name (3) - get current working directory
getcwd (2)           - get current working directory
getcwd (3)           - get current working directory
getdents (2)         - get directory entries
getdents64 (2)       - get directory entries
getdirentries (3)    - get directory entries in a file system-independent format
getwd (3)            - get current working directory
git-clone (1)        - Clone a repository into a new directory
git-mv (1)           - Move or rename a file, a directory, or a symlink
git-stash (1)        - Stash the changes in a dirty working directory away
helptags (1)         - generate the help tags file for directory
linkat (2)           - create a file link relative to directory file descriptors
lookup_dcookie (2)   - return a directory entry's path
ls (1)               - list directory contents
mkdir (2)            - create a directory
mkdirat (2)          - create a directory relative to a directory file descriptor
mkdtemp (3)          - create a unique temporary directory
mkfifoat (3)         - make a FIFO (named pipe) relative to a directory file descriptor
mkfontdir (1)        - create an index of X font files in a directory
mklost+found (8)     - create a lost+found directory on a mounted Linux second extended file system
mknodat (2)          - create a special or ordinary file relative to a directory file descriptor
mktemp (1)           - create a temporary file or directory
modprobe.d (5)       - Configuration directory for modprobe
mountpoint (1)       - see if a directory is a mountpoint
nidfind (1)          - search for files in a directory hierarchy
openat (2)           - open a file relative to a directory file descriptor
opendir (3)          - open a directory
pam_mkhomedir (8)    - PAM module to create users home directory
pwd (1)              - print name of current/working directory
pwdx (1)             - report current working directory of a process
readdir (2)          - read directory entry
readdir (3)          - read a directory
readdir_r (3)        - read a directory
readlinkat (2)       - read value of a symbolic link relative to a directory file descriptor
remove (3)           - remove a file or directory
renameat (2)         - rename a file relative to directory file descriptors
rewinddir (3)        - reset directory stream
rmdir (2)            - delete a directory
run-parts (8)        - run scripts or programs in a directory
scandir (3)          - scan a directory for matching entries
scandirat (3)        - scan a directory relative to a directory file descriptor
seekdir (3)          - set the position of the next readdir() call in the directory stream.
setxattr (1)         - Set or get ACLs on an NT file or directory names
symlinkat (2)        - create a symbolic link relative to a directory file descriptor
telldir (3)          - return current location in directory stream
unlinkat (2)         - remove a directory entry relative to a directory file descriptor
update-info-dir (8)  - update or create index file from all installed info files in directory
vdir (1)             - list directory contents
versionsort (3)      - scan a directory for matching entries
```

STEP 4 Entering the man page for all the commands you come across can be a little long-winded, although ultimately productive. If you simply want to know what a command does you can read just the description using the "whatis" command. Enter: `whatis pwd` to read the description of the "pwd" command ("print name of current/working directory").

```
pi@raspberrypi ~ $ whatis pwd
pwd (1)              - print name of current/working directory
pi@raspberrypi ~ $
```

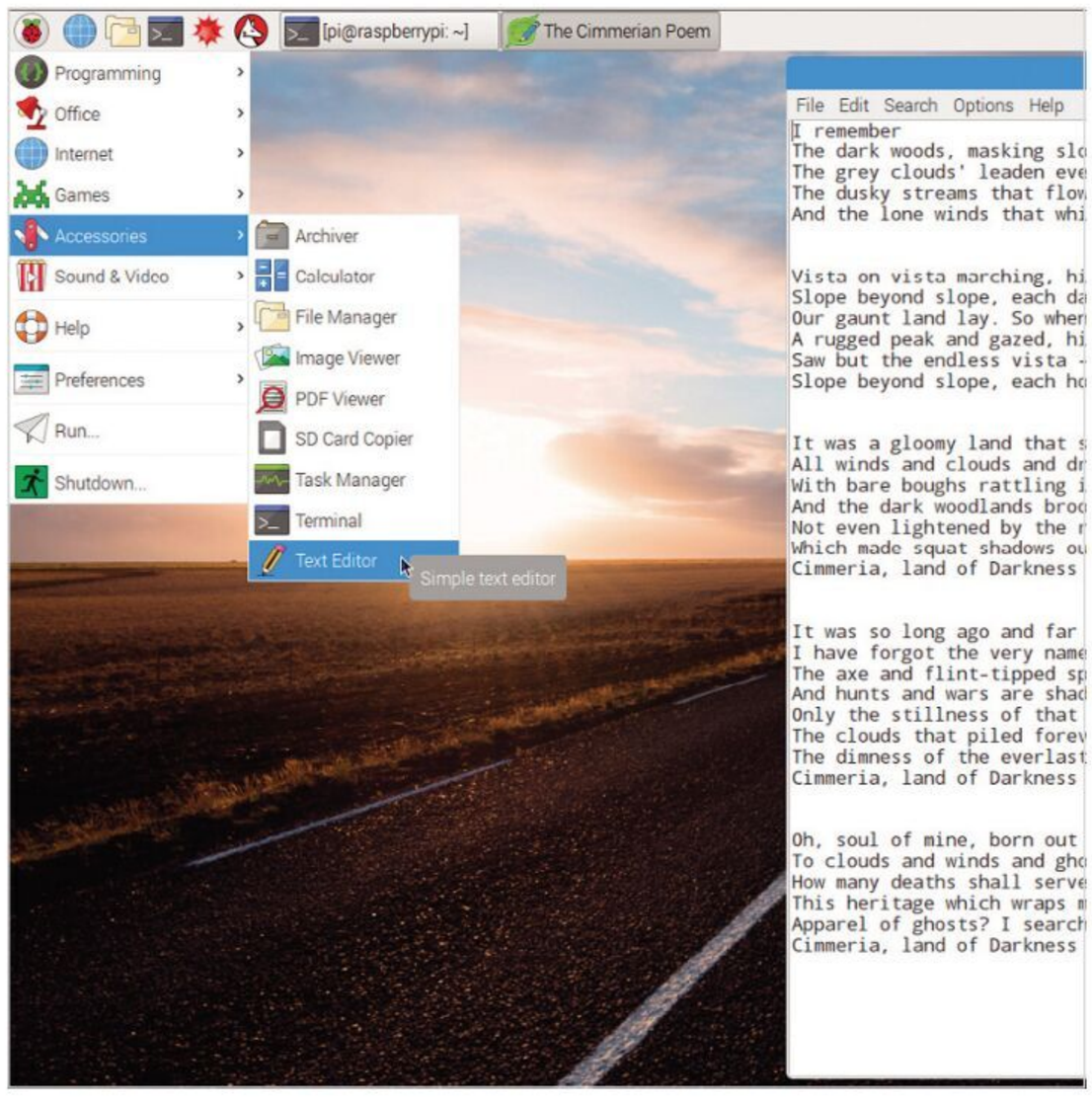
Editing Text Files

A text file in Linux can be anything from a simple set of instructions on how to use an app, to some complex Python, C++ or other programming language code. Text files can be used for scripting, automated executable files, as well as configuration files too.

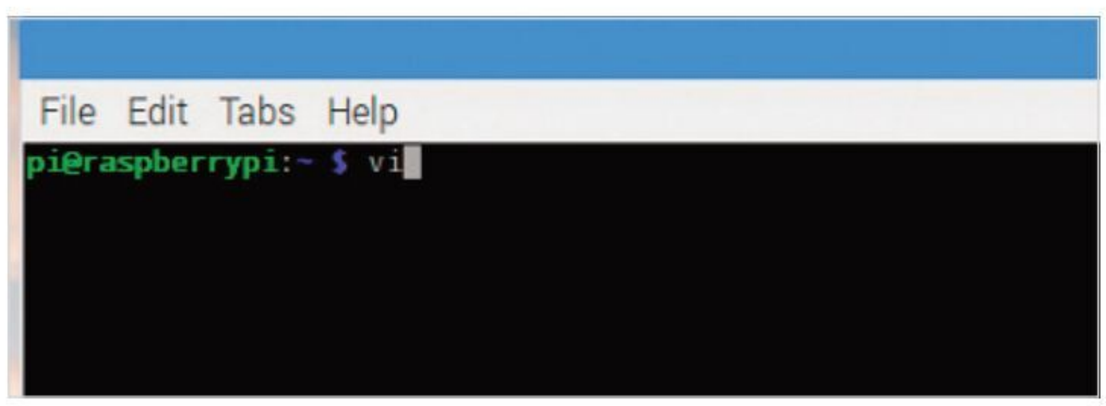
THE JOY OF TEXT

To be able to edit or create a text file, you need a good text editor. Linux has many but here are some in action on the Raspberry Pi.

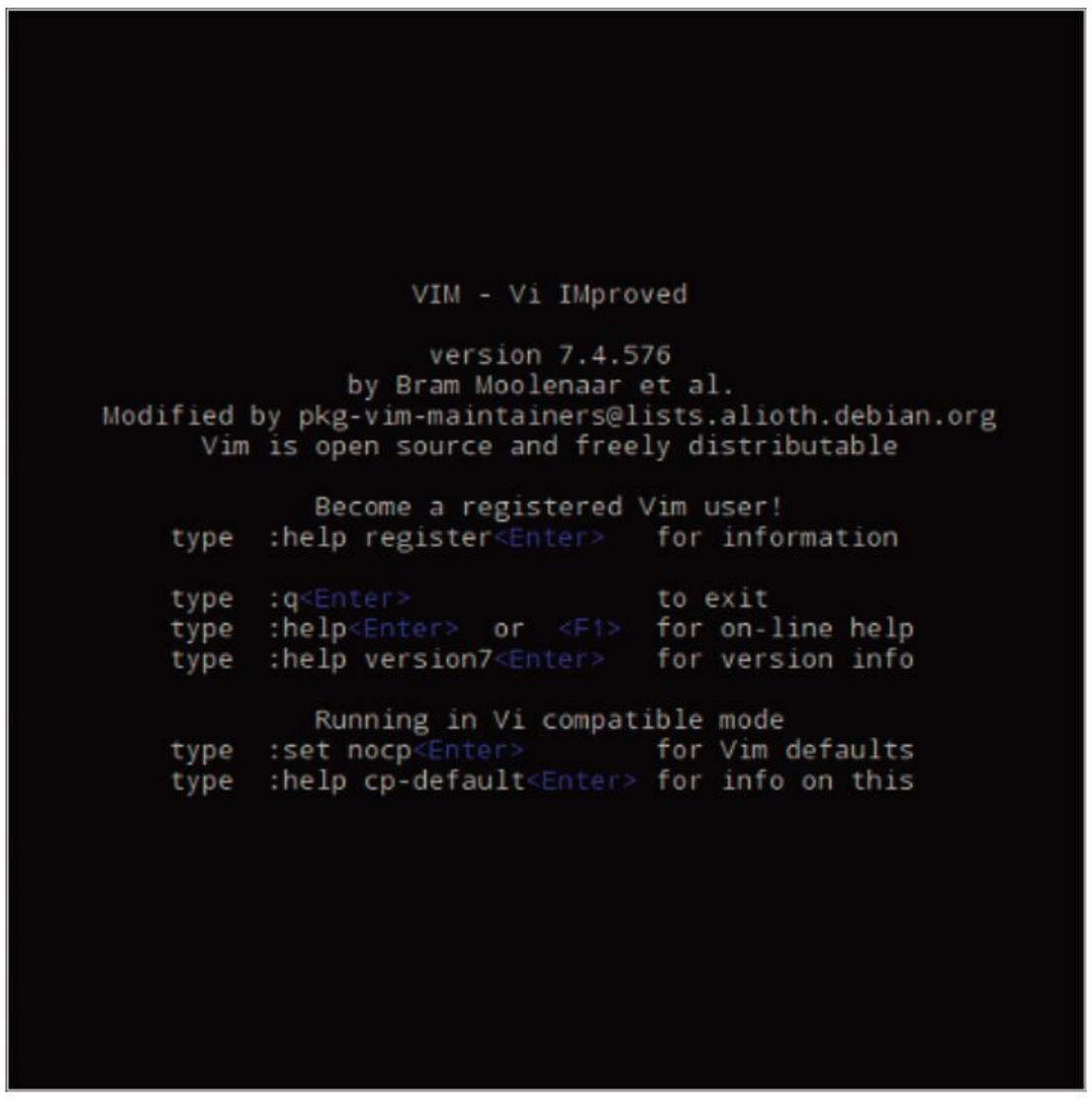
STEP 1 The first text editor for the Raspberry Pi is the default desktop environment app: Leafpad. To use, you can either double-click an existing text file or click the Raspberry Pi menu icon (in the top left of the desktop) and from the Accessories menu, choose Text Editor.



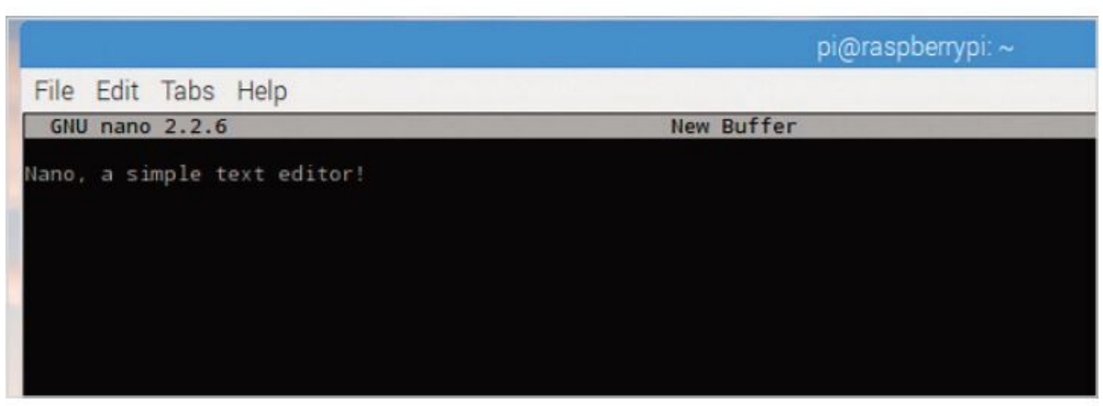
STEP 2 From the Terminal there are even more options, although using the correct command, you can launch any of the desktop apps via the Terminal. One of the simplest, and a classic text editor that's carried over from the Unix days, is vi. In the Terminal, enter: `vi`.



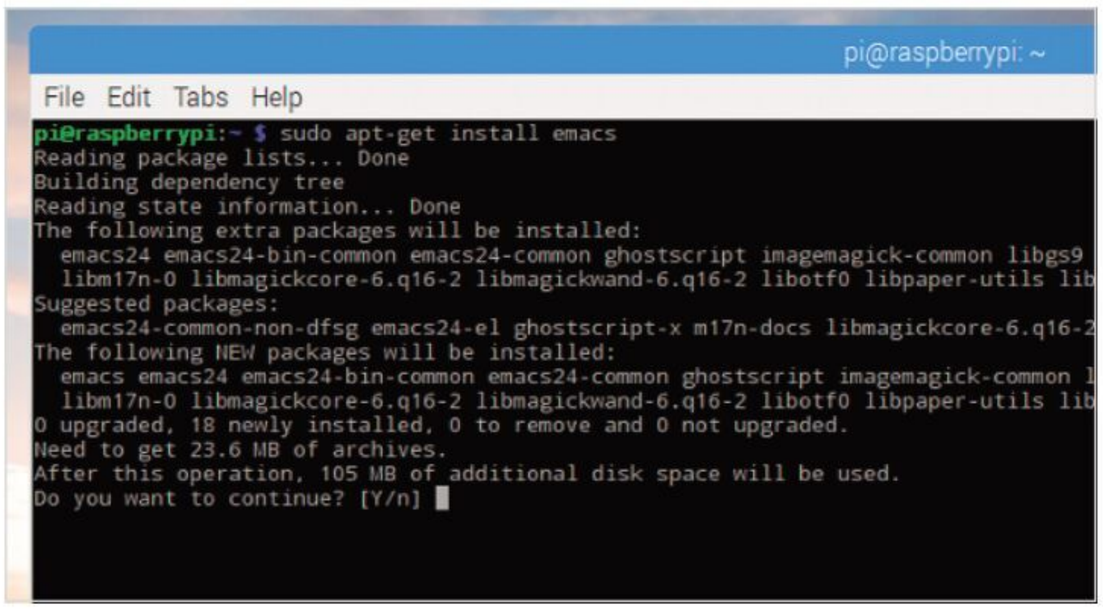
STEP 3 Vi is the original Unix command but in this case it launches VIM, the new Linux version of Vi. Although simple looking, Vi is considered, even by today's standards, to be one of the most widely used text editors, There's a lot you can do with it, so check out the man pages for more Vi information.



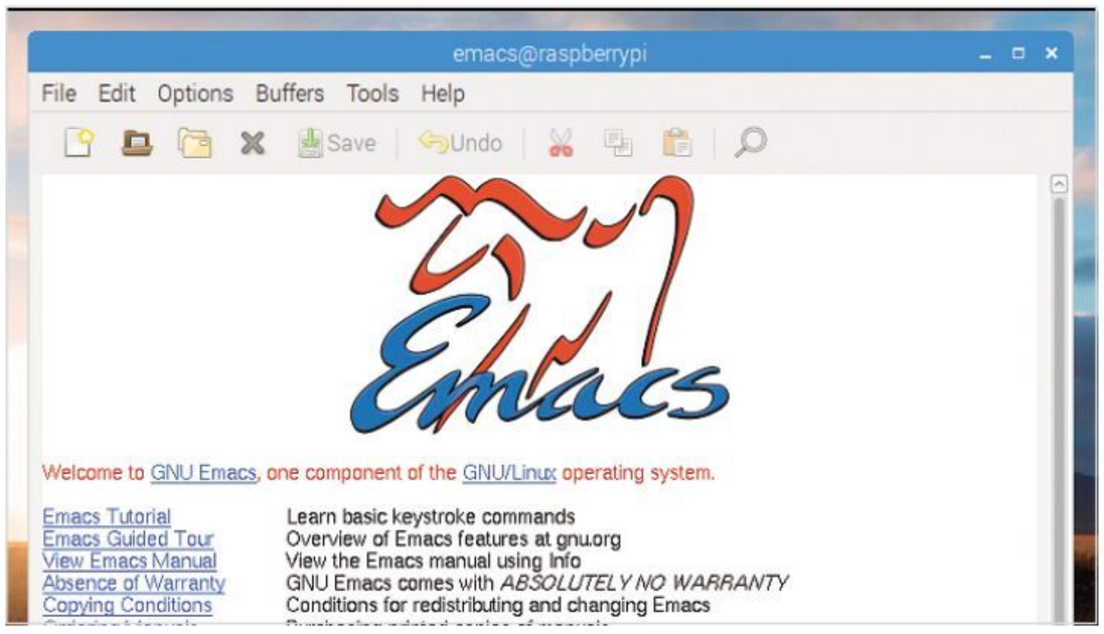
STEP 4 Nano is another favourite, and simple, text editor available for Linux. Enter: `nano` into the Terminal to launch it. You can use Nano for editing code, creating scripts or writing your own help files. To exit Nano, press Ctrl + X, followed by Y to save the file or N to exit without saving.



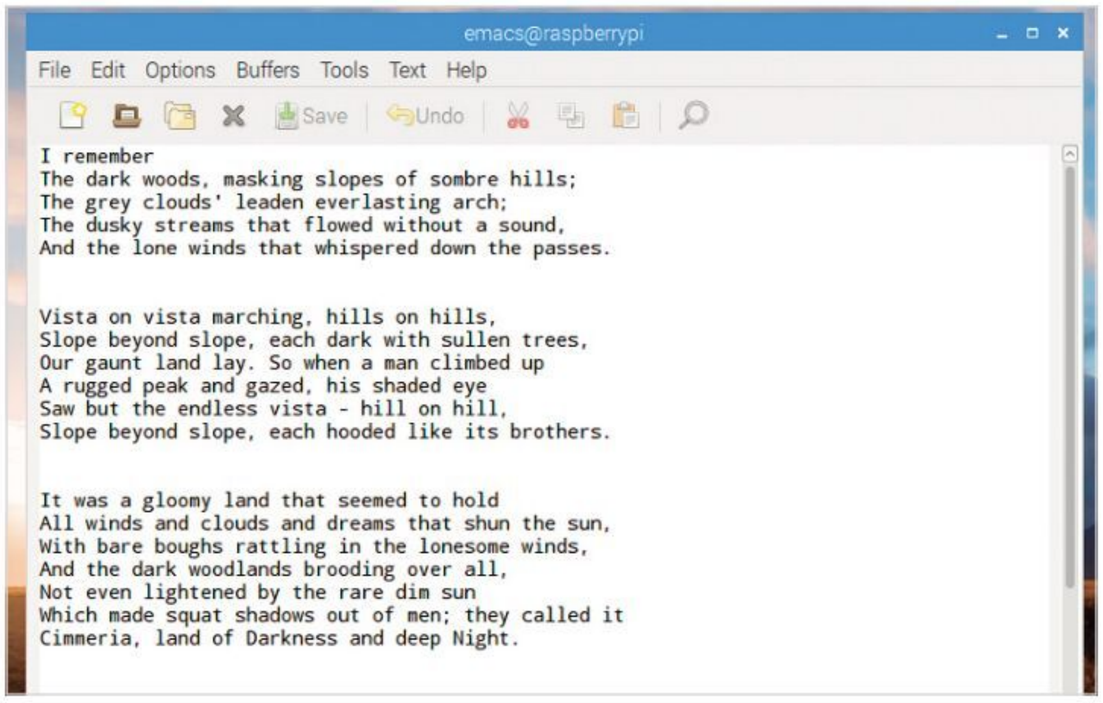
STEP 5 Emacs, or GNU Emacs, is an extensible and customisable, self-documenting, real-time display editor. It's a fantastic text editor and one that's worth getting used to as soon as you can. Sadly, it's not installed on the Pi by default, so you'll need to install it. In the Terminal, enter: `sudo apt-get install emacs`



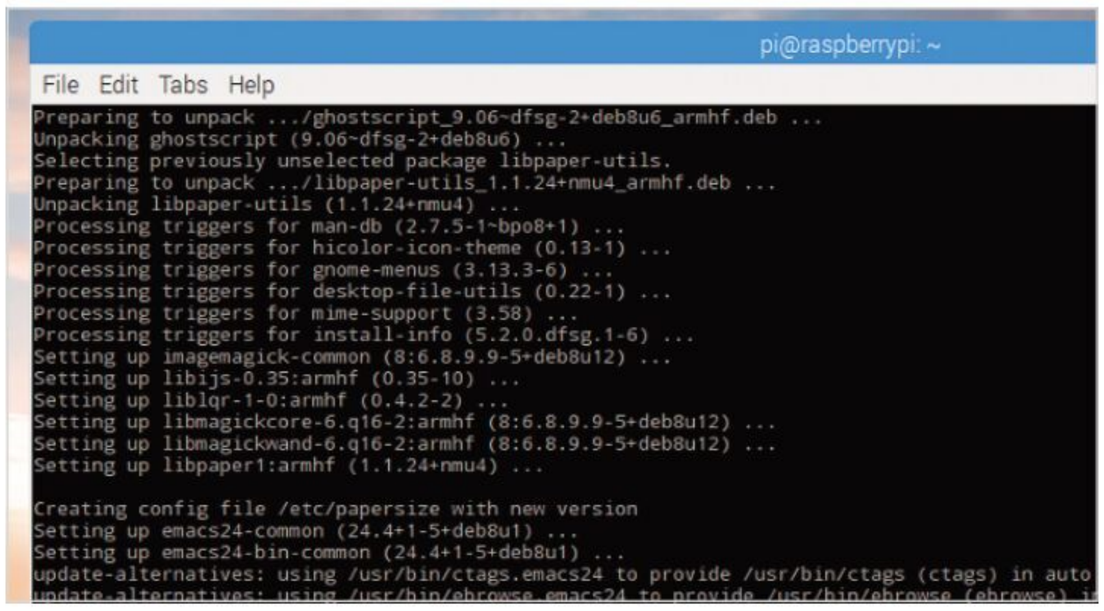
STEP 6 The previous command contacts the Debian (Raspbian is based on a Debian Linux distribution) repositories and pulls down the information needed to install Emacs. When the Pi asks to continue with the installation, press Y. This installs the latest version and when it's done, you'll be back to the command prompt.



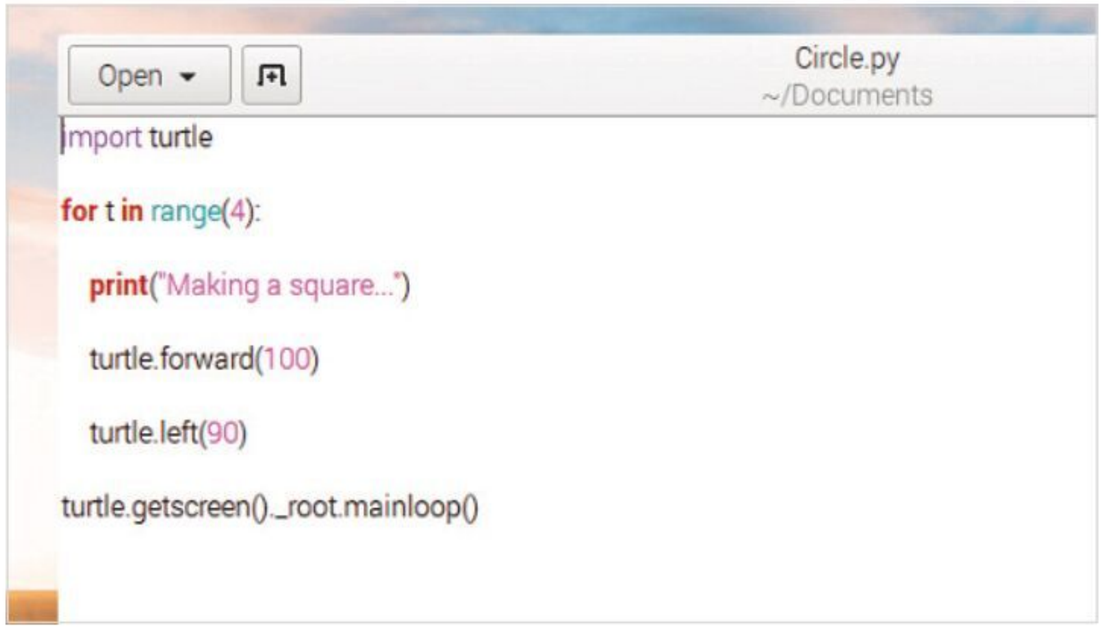
STEP 7 Once the installation is complete, enter: `emacs` into the Terminal. The Emacs splash screen opens in a new window, offering a tutorial (which we recommend you run through) and a guided tour amongst other information.



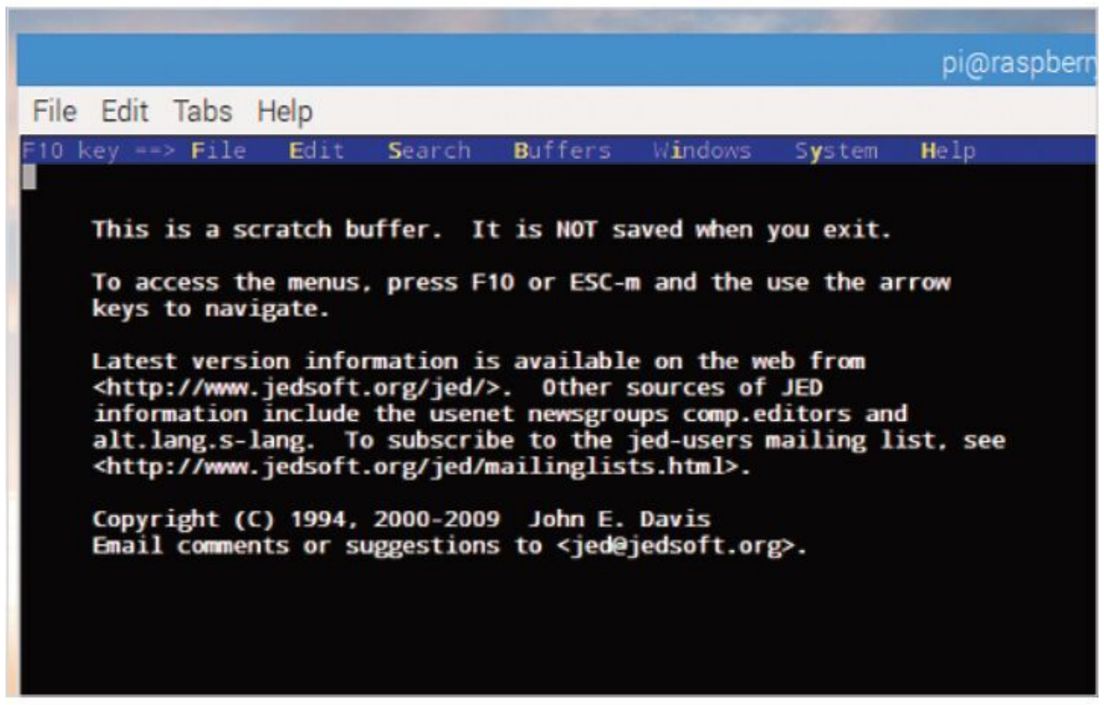
STEP 8 Emacs can offer an uncomplicated view of your text file or one with a plethora of information regarding the structure of the file in question; it's up to you to work out your own preference. There's also a hidden text adventure in Emacs, which we cover later in this book, why not see if you can find it without our help.



STEP 9 Gedit is another excellent text editor for Linux. Again, it's not installed by default on the Raspberry Pi; however, by entering: `sudo apt-get install gedit` and accepting the installation, the program can be on the Pi in a matter of seconds. Once it's installed, use `gedit` in the Terminal to launch it. Gedit is a great text editor for coding.



STEP 10 Finally, Jed is an Emacs-like, cross-platform text editor that's lightweight and comes with a wealth of features. To install it, enter: `sudo apt-get install jed`. Accept the installation and when it's complete, use: `jed` to launch.



Linux Tips and Tricks

The Linux Terminal, you'll no doubt agree, is an exceptional environment and with a few extra apps installed along with a smidgen of command knowledge, incredible and often quite strange things can be accomplished.

TAKING COMMAND

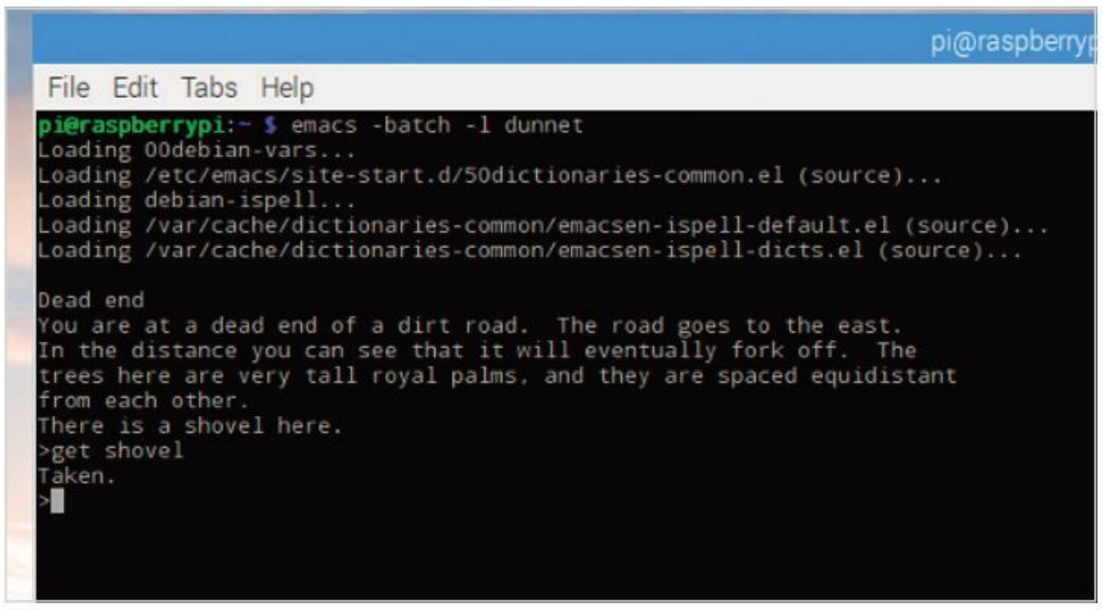
There are countless Linux tips, secrets, hacks and tricks out there. Some are very old, originating from Linux's Unix heritage, while others are recent additions to Linux lore. Here are our ten favourite tips and tricks.

EASTER EGGS

Emacs text editor, is a great piece of software but did you know it also contains a hidden Easter Egg? With Emacs installed (sudo apt-get install emacs24), drop to a Terminal session and enter:

```
emacs -batch -l dunnet
```

Dunnet is a text adventure written by Ron Schnell in 1982, and hidden in Emacs since 1994.



TERMINAL BROWSING

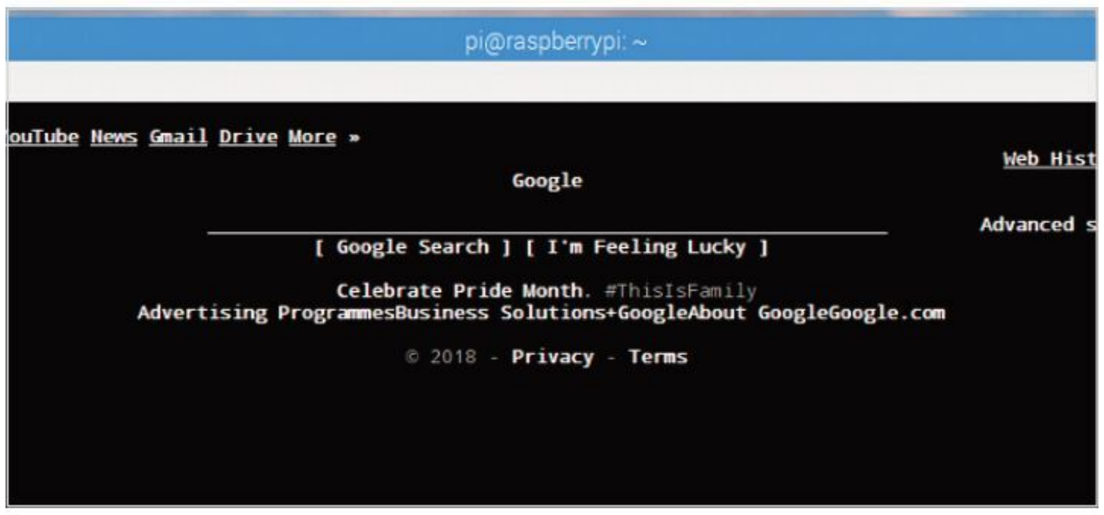
Ever fancied being able to browse the Internet from the Terminal? While not particularly useful, it is a fascinating thing to behold. To do so, enter:

```
sudo apt-get install elinks
```

Then:

```
elinks
```

Enter the website you want to visit.



MOON BUGGY

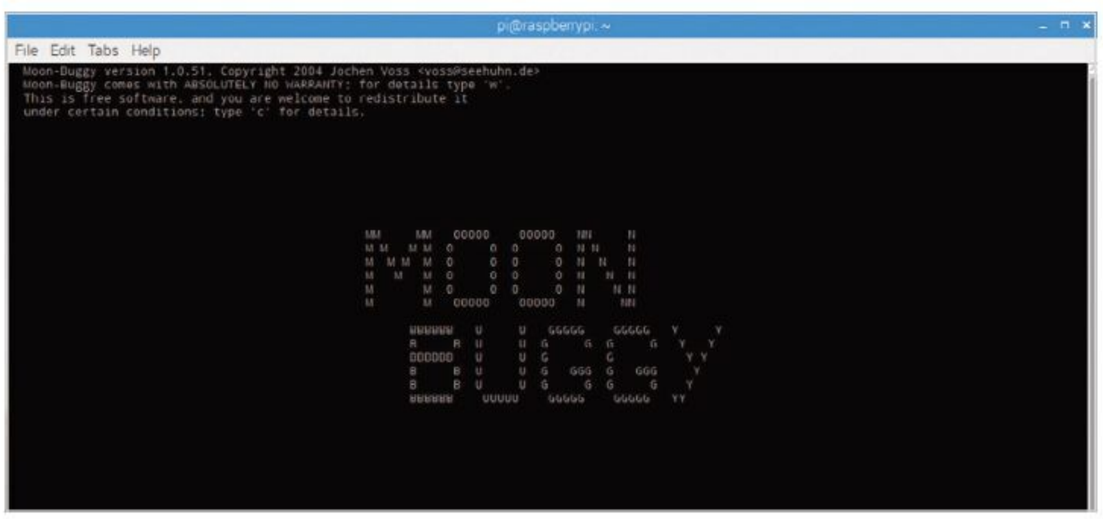
Based on the classic 1982 arcade game, Moon Patrol, Moon Buggy appeared on home computers in 1985 amid much praise. It's a cracking Atari game available in the Linux Terminal by entering:

```
sudo apt-get install moon-buggy
```

Then:

```
moon-buggy
```

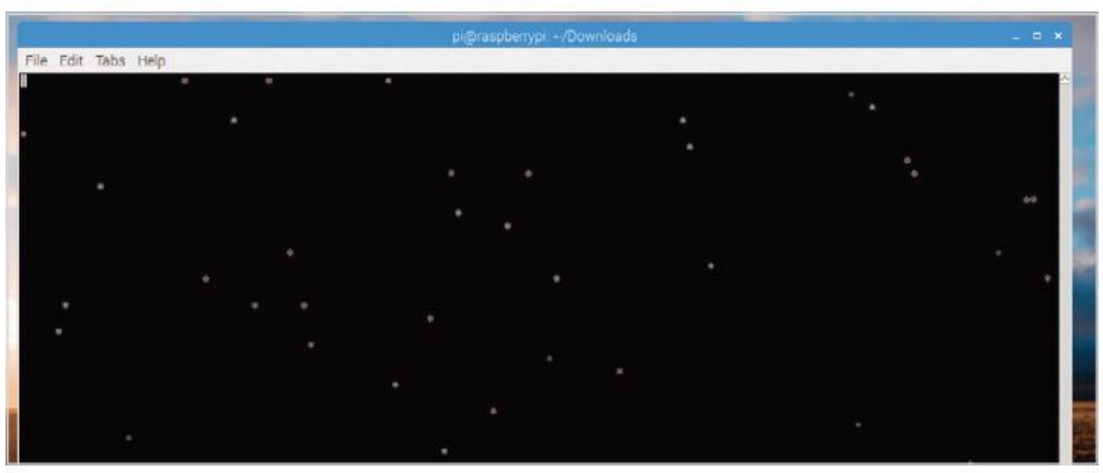
Enjoy.



LET IT SNOW

Snowing in the Terminal console isn't something you come across every day. If you're interested, however, enter:

```
wget
https://gist.githubusercontent.com/sontek/1505483/raw/7d024716ea57e69fb52632fee09f42753361c4a2/snowjob.sh
chmod +x snowjob.sh
./snowjob.sh
```

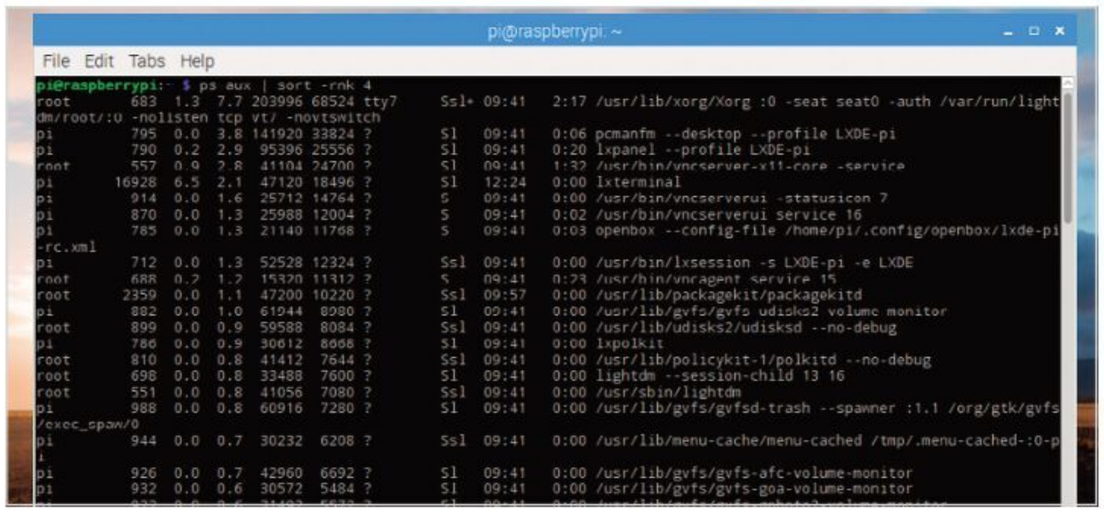


MEMORY HOGS

Memory Hogs – If you need to see which apps are consuming the most memory on your Raspberry Pi, simple enter:

```
ps aux | sort -rnk 4
```

This sorts the output by system memory use.

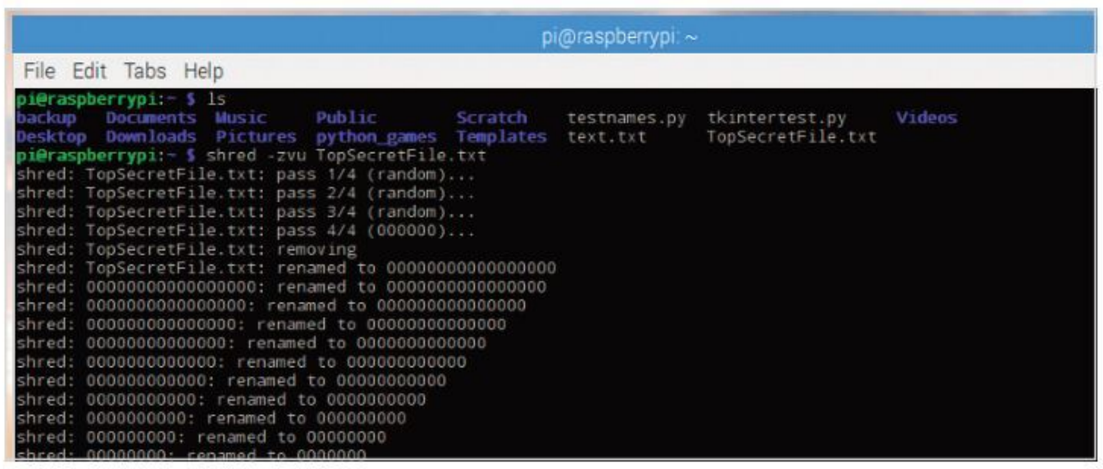


SHREDDER

When you delete a file, there's still a chance of someone with the right software being able to retrieve it. However, files can be securely and permanently deleted using Shred:

```
shred -zvu NAMEOFFILE.txt
```

Replace NAMEOFFILE with the name of the file to delete.

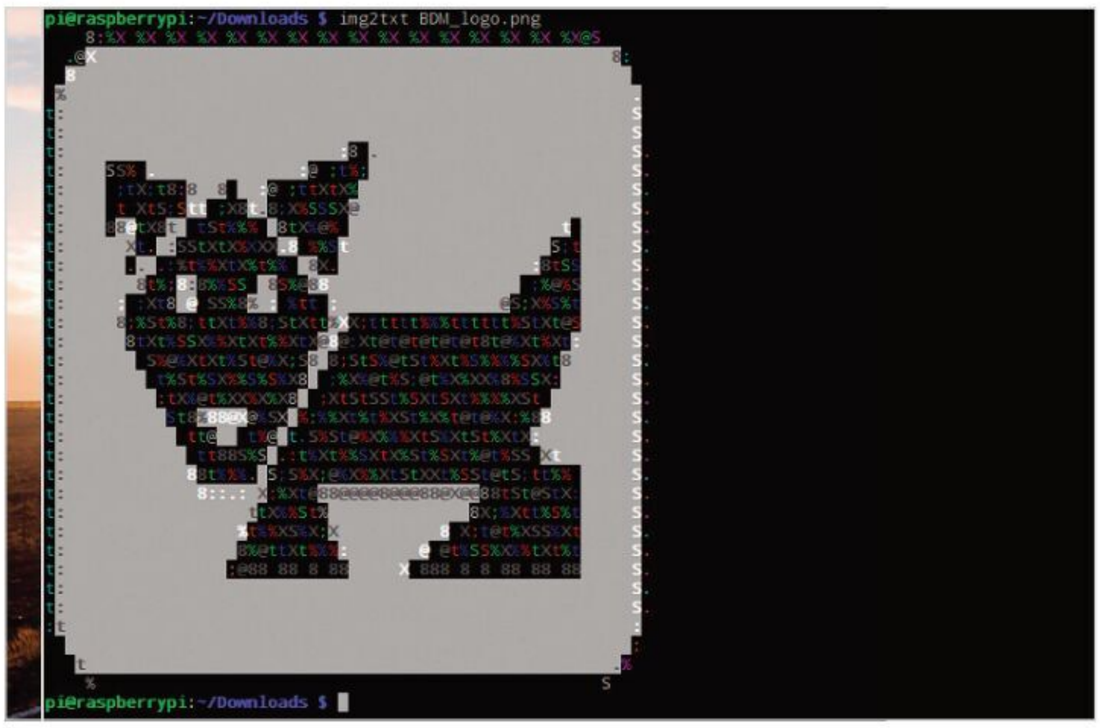


ASCII ART

ASCII art can be quite striking when applied to some images. However, it's often difficult to get just right. You can create some great ASCII art from the images you already have on the Raspberry Pi by using img2txt:

```
img2txt NAMEOFIMAGEFILE.png
```

Replace NAMEOFIMAGEFILE with the actual name of the image file on your system.



BBS

Back in the days of dial-up connections, the online world was made up of Bulletin Board Systems. These remote servers provided hangouts for users to chat, swap code, play games and more. Using Telnet in Linux, you can still connect to some active BBSes:

```
telnet battlestarbbs.dyndns.org
```

There are countless operational BBSes available; check out **www.telnetbbsguide.com/bbs/list/detail/** for more.

DIRECTORY TREES

If you want to create an entire directory (or folder) tree with a single command, you can use:

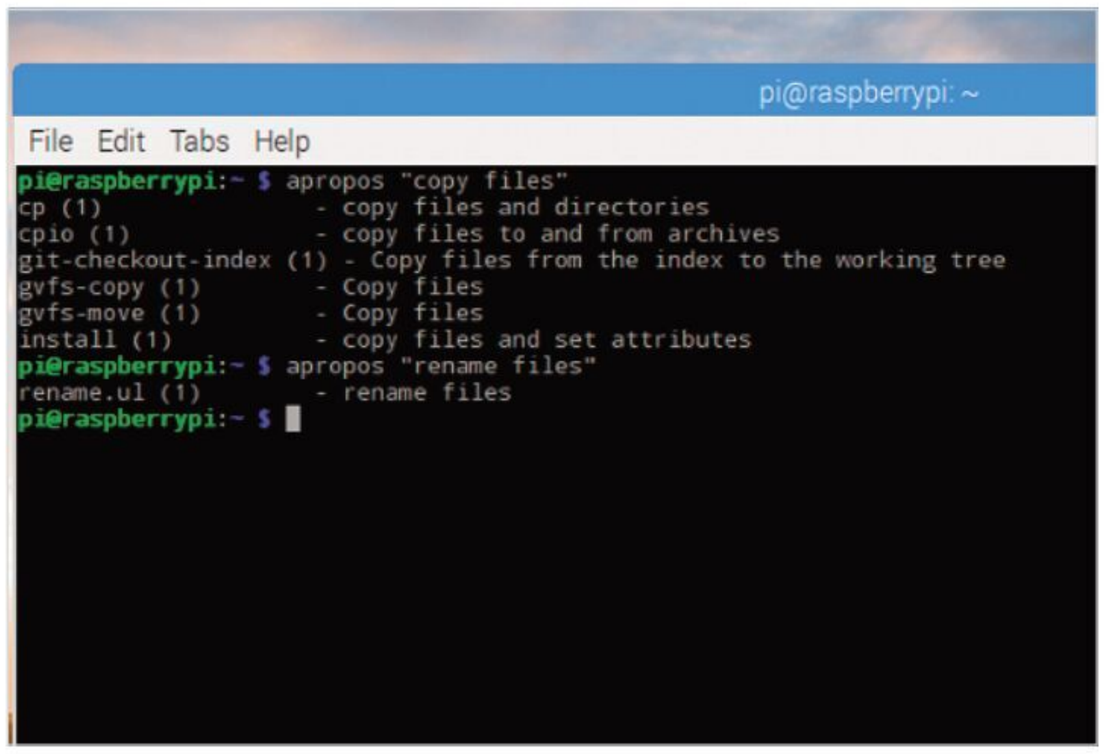
```
mkdir -p New-Dir/
{subfolder1,subfolder2,subfolder3,subfolder4}
```

This creates a New-Dir with four sub folders within.

FORGOTTEN COMMANDS

It's not easy trying to remember all the available Linux commands. Thankfully, you can use apropos to help. Simply use it with a description of the command:

```
apropos "copy files"
apropos "rename files"
```



A-Z of Linux Commands

There are literally thousands of Linux commands, so while this is not a complete A-Z, it does contain many of the commands you will most likely need. You will probably find that you end up using a smaller set of commands over and over again but having an overall knowledge is still very useful.

A

adduser	Add a new user
arch	Print machine architecture
awk	Find and replace text within file(s)

B

bc	An arbitrary precision calculator language

C

cat	Concatenate files and print on the standard output
chdir	Change working directory
chgrp	Change the group ownership of files
chroot	Change root directory
cksum	Print CRC checksum and byte counts
cmp	Compare two files
comm	Compare two sorted files line by line
cp	Copy one or more files to another location
crontab	Schedule a command to run at a later time
csplit	Split a file into context-determined pieces
cut	Divide a file into several parts

D

date	Display or change the date & time
dc	Desk calculator
dd	Data Dump, convert and copy a file
diff	Display the differences between two files
dirname	Convert a full path name to just a path
du	Estimate file space usage

E

echo	Display message on screen
ed	A line oriented text editor (edlin)
egrep	Search file(s) for lines that match an extended expression
env	Display, set or remove environment variables
expand	Convert tabs to spaces
expr	Evaluate expressions

F

factor	Print prime factors
fdisk	Partition table manipulator for Linux
fgrep	Search file(s) for lines that match a fixed string
find	Search for files that meet a desired criteria
fmt	Reformat paragraph text
fold	Wrap text to fit a specified width
format	Format disks or tapes
fsck	Filesystem consistency check and repair

G

gawk	Find and Replace text within file(s)
grep	Search file(s) for lines that match a given pattern
groups	Print group names a user is in
gzip	Compress or decompress named file(s)

H

head	Output the first part of file(s)
hostname	Print or set system name

I

id	Print user and group ids
info	Help info
install	Copy files and set attributes

J

join	Join lines on a common field

K

kill	Stop a process from running

L

less	Display output one screen at a time
ln	Make links between files
locate	Find files

logname	Print current login name
lpc	Line printer control program
lpr	Off line print
lprm	Remove jobs from the print queue

M

man	See Help manual
mkdir	Create new folder(s)
mkfifo	Make FIFOs (named pipes)
mknod	Make block or character special files
more	Display output one screen at a time
mount	Mount a file system

N

nice	Set the priority of a command or job
nl	Number lines and write files
nohup	Run a command immune to hangups

P

passwd	Modify a user password
paste	Merge lines of files
pathchk	Check file name portability
pr	Convert text files for printing
printcap	Printer capability database
printenv	Print environment variables
printf	Format and print data

Q

quota	Display disk usage and limits
quotacheck	Scan a file system for disk usage
quotactl	Set disk quotas

R

ram	Ram disk device
rcp	Copy files between two machines
rm	Remove files
rmdir	Remove folder(s)
rpm	Remote Package Manager
rsync	Remote file copy (synchronise file trees)

S

screen	Terminal window manager
sdiff	Merge two files interactively
select	Accept keyboard input
seq	Print numeric sequences
shutdown	Shutdown or restart Linux
sleep	Delay for a specified time
sort	Sort text files
split	Split a file into fixed-size pieces
SSH	Connects to a remote host computer as a specified user, using secure encrypted protocols.
su	Substitute user identity
sudo	Execute a command as another user, primarily as the Root level, administrator user.
sum	Print a checksum for a file
symlink	Make a new name for a file
sync	Synchronise data on disk with memory

T

tac	Concatenate and write files in reverse
tail	Output the last part of files
tar	Tape Archiver
tee	Redirect output to multiple files
test	Evaluate a conditional expression
time	Measure Program Resource Use
touch	Change file timestamps
top	List processes running on the system
traceroute	Trace Route to Host
tr	Translate, squeeze and or delete characters
tsort	Topological sort

U

umount	Unmount a device
unexpand	Convert spaces to tabs
uniq	Uniquify files
units	Convert units from one scale to another
unshar	Unpack shell archive scripts
useradd	Create new user account
usermod	Modify user account
users	List users currently logged in

V

vdir	Verbosely list directory contents (`ls -l -b')

W

watch	Execute or display a program periodically
wc	Print byte, word, and line counts
whereis	Report all known instances of a command
which	Locate a program file in the user's path
who	Print all usernames currently logged in
whoami	Print the current user id and name

X

xargs	Execute utility, passing constructed argument list(s)

Y

yes	Print a string until interrupted

Glossary of Python Terms

Just like most technology, Python contains many confusing words and acronyms. Here then, for your own sanity, is a handy glossary to help you keep on top of what's being said when the conversation turns to Python programming.

Argument
The detailed extra information used by Python to perform more detailed commands. Can also be used in the command prompt to specify a certain runtime event.

Block
Used to describe a section or sections of code that are grouped together.

Break
A command that can be used to exit a for or while loop. For example, if a key is pressed to quit the program, Break will exit the loop.

Class
A class provides a means of bundling data and functionality together. They are used to encapsulate variables and functions into a single entity.

Comments
A comment is a section of real world wording inserted by the programmer to help document what's going on in the code. They can be single line or multi-line and are defined by a # or '''.

Debian
A Linux-based distro or distribution that forms the Debian Project. This environment offers the user a friendly and stable GUI to interact with along with Terminal commands and other forms of system level administration.

Def
Used to define a function or method in Python.

Dictionaries
A dictionary in Python is a data structure that consists of key and value pairs.

Distro
Also Distribution, an operating system that uses the Linux Kernel as its core but offers something different in its presentation to the end user.

Editor
An individual program, or a part of the graphical version of Python, that enables the user to enter code ready for execution.

Exceptions
Used as a means of breaking from the normal flow of a code block in order to handle any potential errors or exceptional conditions within the program.

Expression
Essentially, Python code that produces a value of something.

Float
An immutable floating point number used in Python.

Function
Used in Python to define a sequence of statements that can be called or referenced at any time by the programmer.

GitHub
A web-based version control and collaboration portal designed for software developers to better manage source code.

Global Variable
A variable that is useable anywhere in the program.

Graphics
The use of visual interaction with a program, game or operating system. Designed to make it easier for the user to manage the program in question.

GUI
Graphical User Interface. The interface which most modern operating systems use to enable the user to interact with the core programming of the system. A friendly, easy to use graphical desktop environment.

High-Level Language
A programming language that's designed to be easy for people to read.

IDLE
Stands for Integrated Development Environment or Integrated Development and Learning Environment.

Immutable
Something that cannot be changed after it is created.

Import
Used in Python to include modules together with all the accompanying code, functions and variables they contain.

Indentation
Python uses indentation to delimit blocks of code. The indents are four spaces apart, and are often created automatically after a colon is used in the code.

Integer
A number data type that must be a whole number and not a decimal.

Interactive Shell
The Python Shell, which is displayed whenever you launch the graphical version of Python.

Kernel
The core of an operating system, which handles data processing, memory allocation, input and output, and processes information between the hardware and programs.

Linux
An open source operating system that's modelled on UNIX. Developed in 1991 by Finnish student Linus Torvalds.

Lists
A Python data type that contains collections of values, which can be of any type and can readily be modified.

Local Variable
A variable that's defined inside a function and is only useable inside that function.

Loop
A piece of code that repeats itself until a certain condition is met. Loops can encase the entire code or just sections of it.

Module
A Python file that contains various functions that can be used within another program to further extend the effectiveness of the code.

Operating System
Also OS. The program that's loaded into the computer after the initial boot sequence has completed. The OS manages all the other programs, graphical user interface (GUI), input and output and physical hardware interactions with the user.

Output
Data that is sent from the program to a screen, printer or other external peripheral.

PIP
Pip Installs Packages. A package management system used to install and manage modules and other software written in Python.

Print
A function used to display the output of something to the screen.

Prompt
The element of Python, or the Command Line, where the user enters their commands. In Python it's represented as >>> in the interactive shell.

Pygame
A Python module that's designed for writing games. It includes graphics and sound libraries and was first developed in October 2000.

Python
An awesome programming language that's easy to learn and use, whilst still being powerful enough to enjoy.

Random
A Python module that implements a pseudo-random character generator using the Mersenne Twister PRNG.

Range
A function that used to return a list of integers, defined by the arguments passed through it.

Root
The bottom level user account used by the system itself. Root is the overall system administrator and can go anywhere, and do anything, on the system.

Sets
Sets are a collection of unordered but unique data types.

Strings
Strings can store characters that can be modified. The contents of a string are alphanumerical and can be enclosed by either single or double quote marks.

Terminal
Also Console or Shell. The command line interface to the operating system, namely Linux, but also available in macOS. From there you can execute code and navigate the filesystem.

Tkinter
A Python module designed to interact with the graphical environment, specifically the tk-GUI (Tool Kit Graphical User Interface).

Try
A try block allows exceptions to be raised, so any errors can be caught and handled according to the programmer's instructions.

Tuples
An immutable Python data type that contains an ordered set of either letters or numbers.

UNIX
A multitasking, multiuser operating system designed in the '70s at the Bell Labs Research Centre. Written in C and assembly language

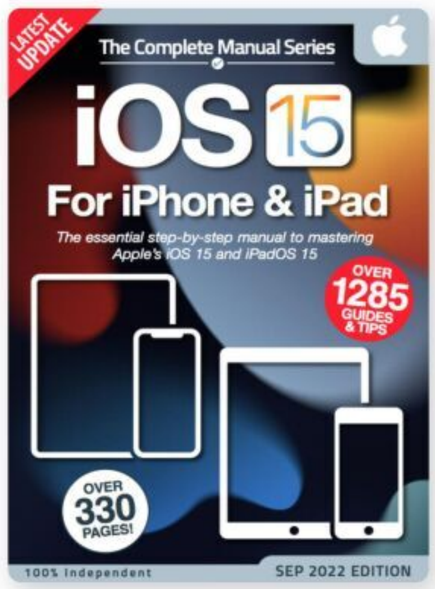
Variables
A data item that has been assigned a storage location in the computer's memory.

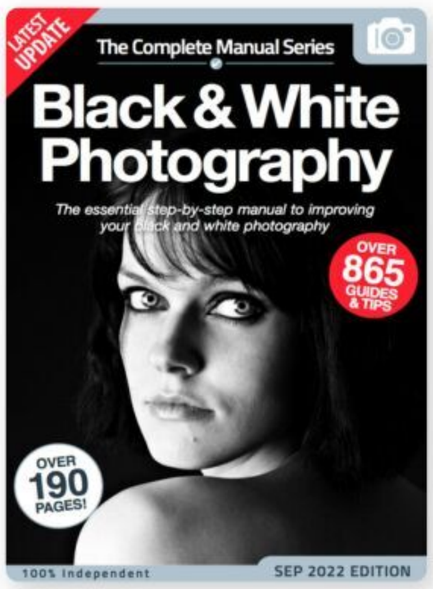
X
Also X11 or X-windows. The graphical desktop used in Linux-based systems, combining visual enhancements and tools to manage the core operating system.

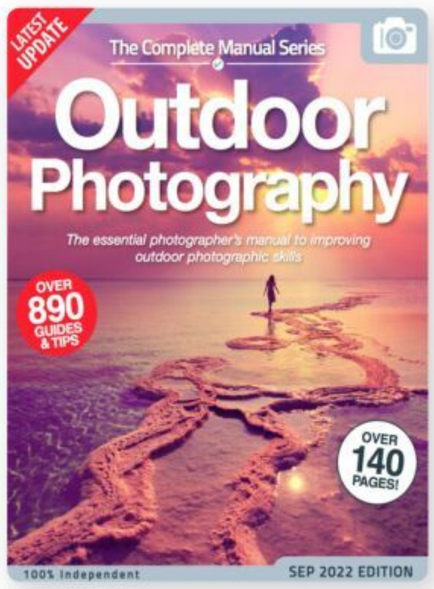
Zen of Python
When you enter: `import this` into the IDLE, the Zen of Python is displayed.

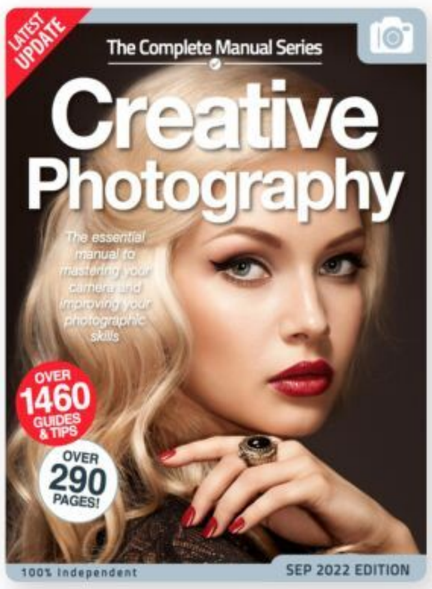
Read More

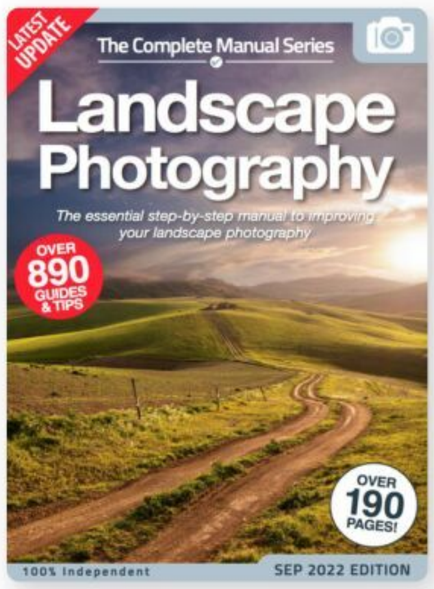
The Complete Manual Series

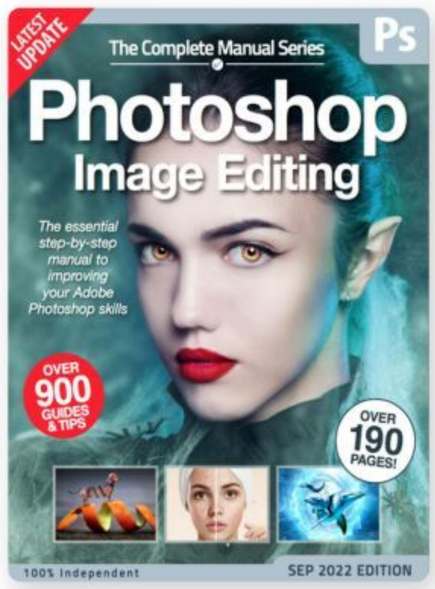


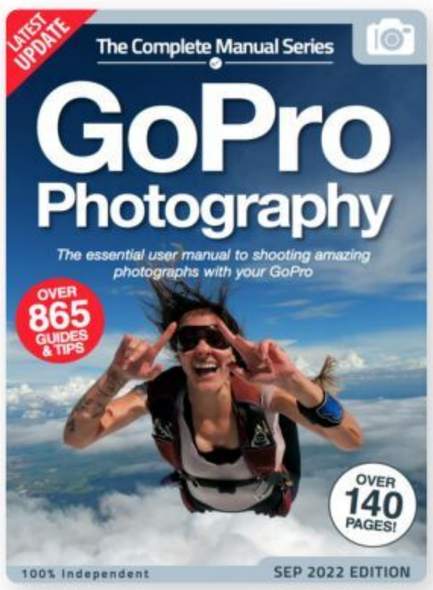


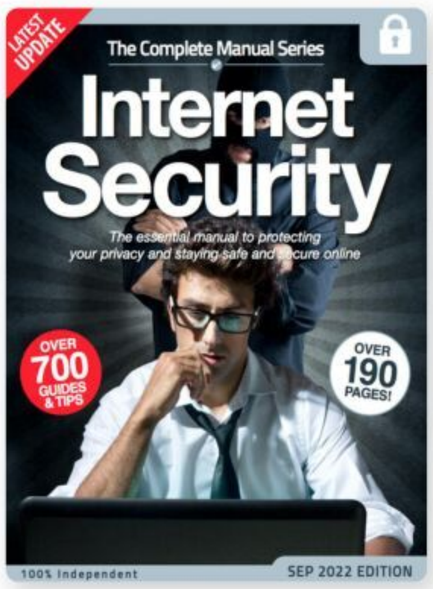


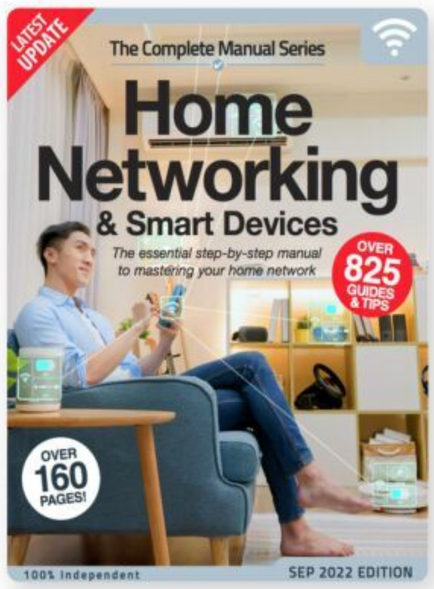


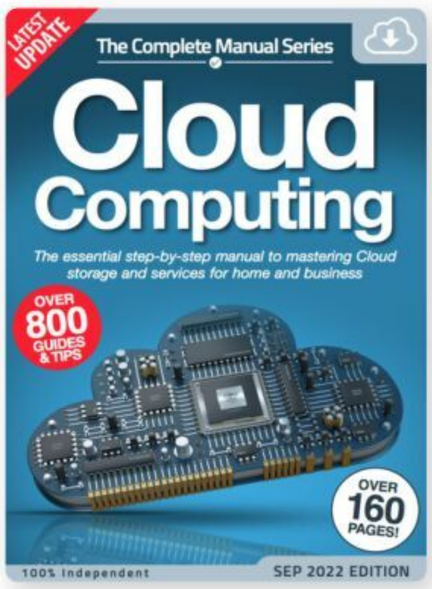


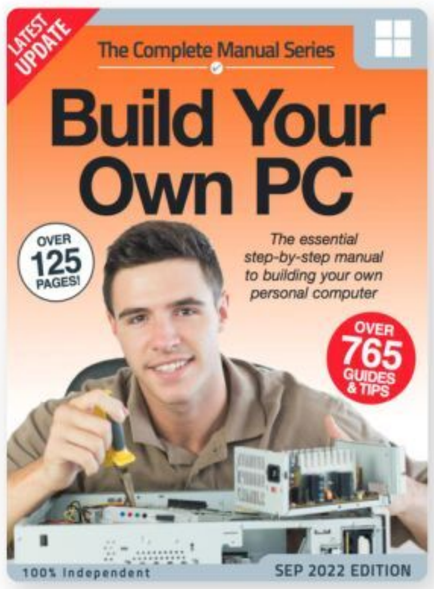


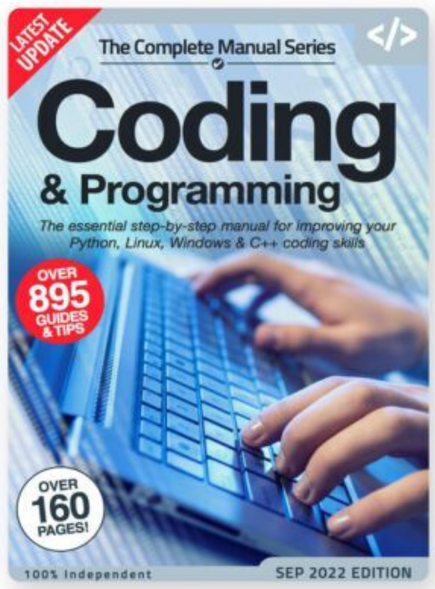




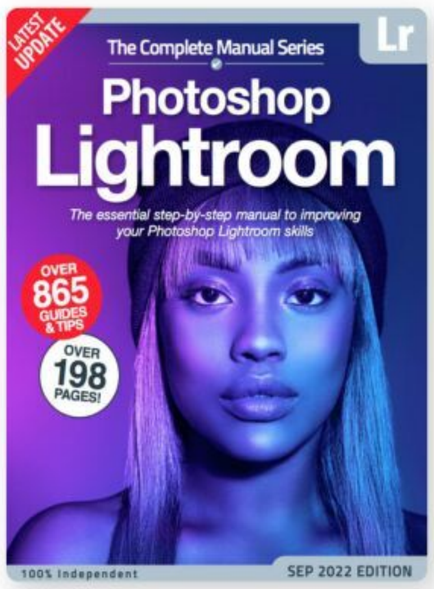


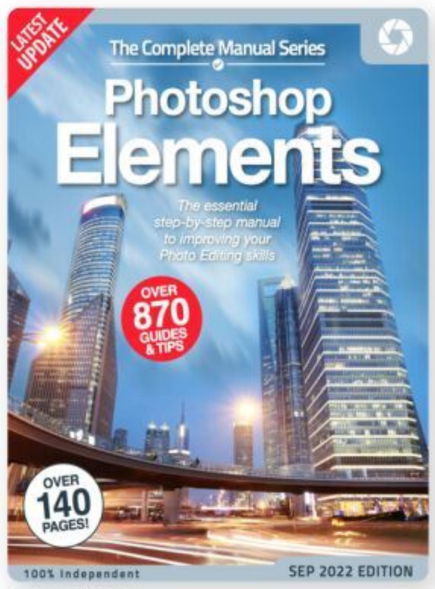


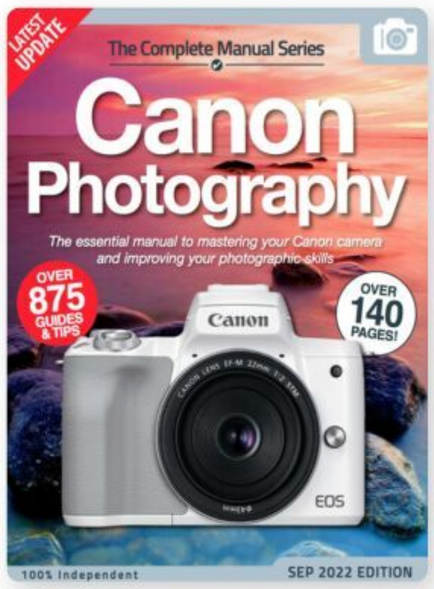


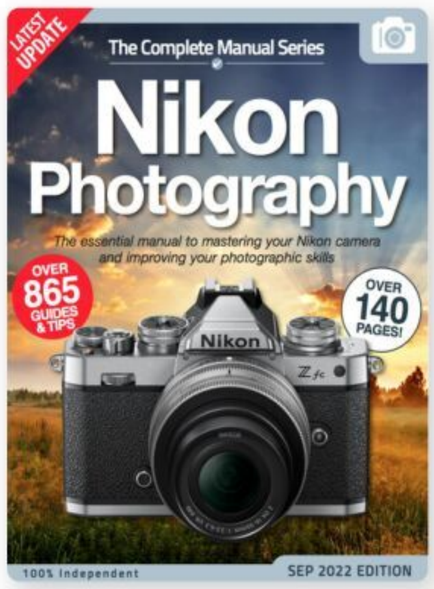


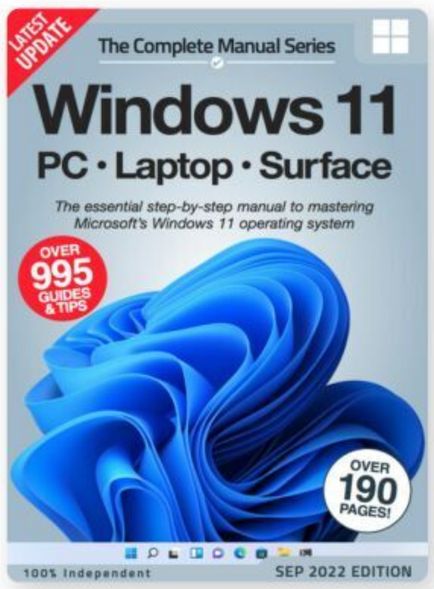
Available on Readly

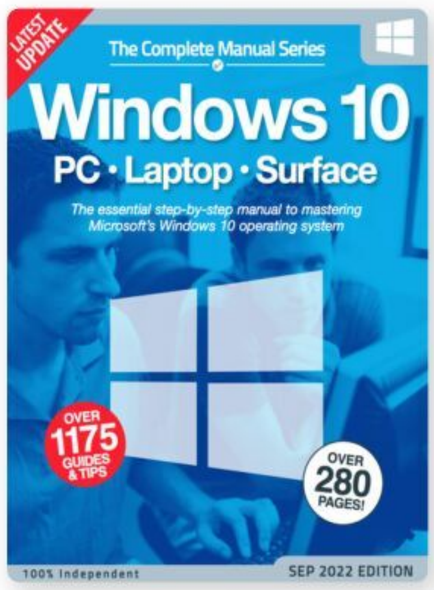


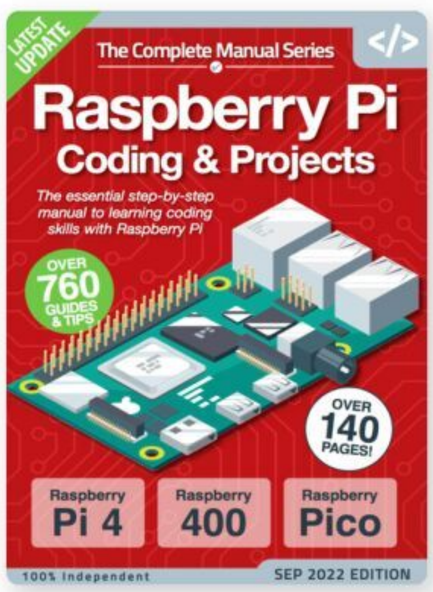


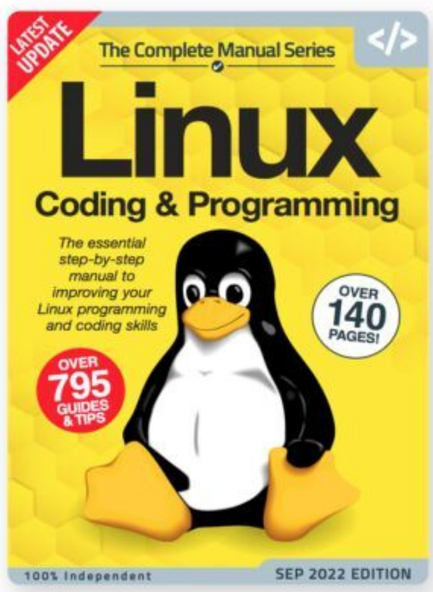


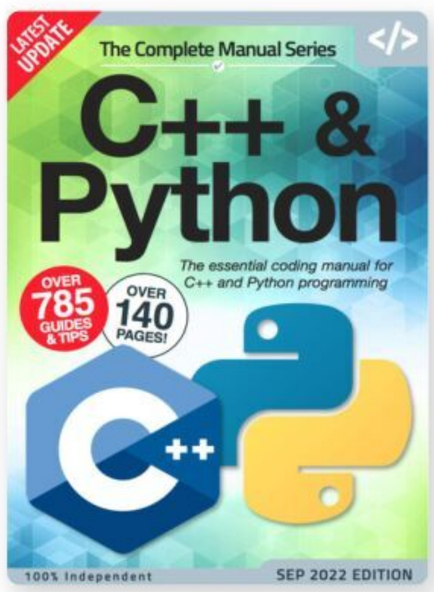












www.pclpublications.com

Want to master your PC?

Then don't miss our NEW Windows PC & Laptop magazine on Readly now!

Click our handy link to read now: https://bit.ly/3y7gwFG

The Complete Manual Series:
Python Coding & Programming
15 | ISBN: 978-1-914404-60-3
Published by: Papercut Limited
Digital distribution by: Readly, Zinio & Pocketmags

© 2022 Papercut Limited All rights reserved. No part of this publication may be reproduced in any form, stored in a retrieval system or integrated into any other publication, database or commercial programs without the express written permission of the publisher. Under no circumstances should this publication and its contents be resold, loaned out or used in any form by way of trade without the publisher's written permission. While we pride ourselves on the quality of the information we provide, Papercut Limited reserves the right not to be held responsible for any mistakes or inaccuracies found within the text of this publication. Due to the nature of the tech industry, the publisher cannot guarantee that all apps and software will work on every version of device. It remains the purchaser's sole responsibility to determine the suitability of this book and its content for whatever purpose. We advise all potential buyers to check listing prior to purchase for confirmation of actual content. All editorial opinion herein is that of the reviewer - as an individual - and is not representative of the publisher or any of its affiliates. Therefore the publisher holds no responsibility in regard to editorial opinion and content. This is an independent publication and as such does not necessarily reflect the views or opinions of the manufacturers or hardware and software, applications or products contained within. This publication is not endorsed or associated in any way with Python, The Linux Foundation, The Raspberry Pi Foundation, ARM Holding, Canonical Ltd, Debian Project, Linux Mint, Microsoft, Lenovo, Dell, Hewlett-Packard, Apple and Samsung or any associate or affiliate company. All copyrights, trademarks and registered trademarks for the respective companies are acknowledged. Relevant graphic imagery reproduced with courtesy of Lenovo, Hewlett- Packard, Dell, Microsoft, Samsung, Linux Mint, NASA, and Apple. Additional images contained within this publication are reproduced under licence from Shutterstock. Any images reproduced on the front cover are solely for design purposes and are not representative of content.
Prices, international availability, ratings, titles and content are subject to change. All information was correct at time of publication. Some content may have been previously published in other volumes or titles.

Papercut Limited
Registered in England & Wales No: 04308513

ADVERTISING – For our latest media packs please contact:
Richard Rowe - richard@tandemmedia.co.uk
Will Smith - will@tandemmedia.co.uk
INTERNATIONAL LICENSING – Papercut Limited has many great publications and all are available for licensing worldwide.
For more information email: jgale@pclpublications.com