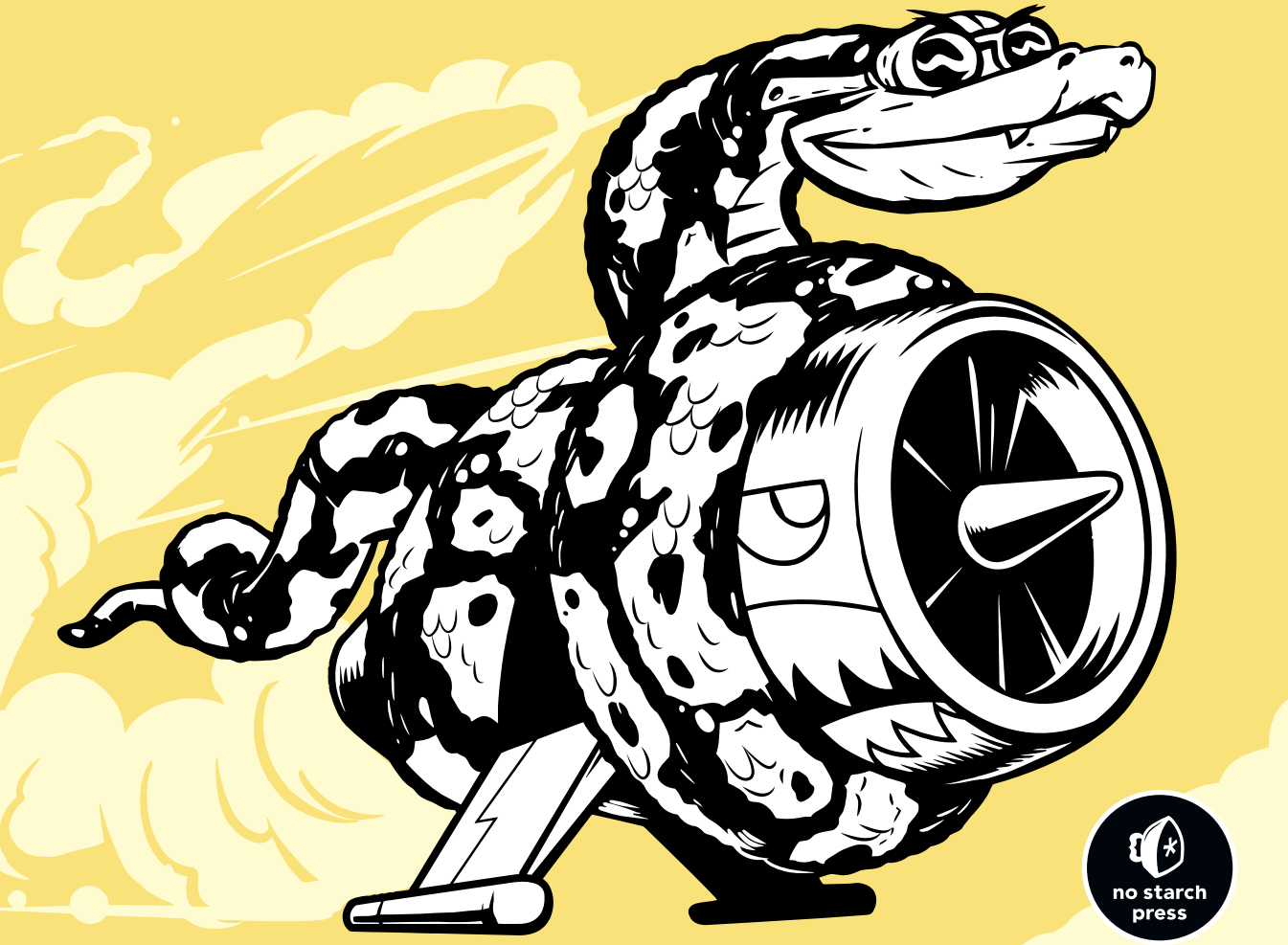
PYTHON CRASH COURSE

A HANDS-ON, PROJECT-BASED INTRODUCTION TO PROGRAMMING

ERIC MATTHES



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by Eric Matthes

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About the Author

Eric Matthes is a high school science and math teacher living in Alaska, where he teaches an introductory Python course. He has been writing programs since he was five years old. Eric currently focuses on writing software that addresses inefficiencies in education and brings the benefits of open source software to the field of education. In his spare time he enjoys climbing mountains and spending time with his family.

About the Technical Reviewer

Kenneth Love has been a Python programmer and teacher for many years. He has given talks and tutorials at conferences, done professional trainings, been a Python and Django freelancer, and now teaches for an online education company. Kenneth is also the co-creator of the django-braces package, which provides several handy mixins for Django's class-based views. You can keep up with him on Twitter at @kennethlove.

For my father, who always made time to
answer my questions about programming,
and for Ever, who is just beginning to ask me
his questions

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I'd like to thank Kenneth Love, the technical reviewer for *Python Crash Course*. I met Kenneth at PyCon one year, and his enthusiasm for the language and the Python community has been a constant source of professional inspiration ever since. Kenneth went beyond simple fact-checking and reviewed the book with the goal of helping beginning programmers develop a solid understanding of the Python language and programming in general. That said, any inaccuracies that remain are completely my own.

I'd like to thank my father for introducing me to programming at a young age and for not being afraid that I'd break his equipment. I'd like to thank my wife, Erin, for supporting and encouraging me through the writing of this book, and I'd like to thank my son, Ever, whose curiosity inspires me every single day.

INTRODUCTION

Every programmer has a story about how they learned to write their first program. I started learning as a child when my father was working for Digital Equipment Corporation, one of the pioneering companies of the modern computing era. I wrote my first program on a kit computer my dad had assembled in our basement. The computer consisted of nothing more than a bare motherboard connected to a keyboard without a case, and it had a bare cathode ray tube for a monitor. My initial program was a simple number guessing game, which looked something like this:

```
I'm thinking of a number! Try to guess the number I'm thinking of: 25
Too low! Guess again: 50
Too high! Guess again: 42
That's it! Would you like to play again? (yes/no) no
Thanks for playing!
```

I'll always remember how satisfied I felt watching my family play a game that I created and that worked as I intended it to.

That early experience had a lasting impact. There is real satisfaction in building something with a purpose, something that solves a problem. The software I write now meets a more significant need than my childhood efforts, but the sense of satisfaction I get from creating a program that works is still largely the same.

Who Is This Book For?

The goal of this book is to bring you up to speed with Python as quickly as possible so you can build programs that work—games, data visualizations, and web applications—while developing a foundation in programming that will serve you well for the rest of your life. *Python Crash Course* is written for people of any age who have never programmed in Python before or have never programmed at all. If you want to learn the basics of programming quickly so you can focus on interesting projects, and you like to test your understanding of new concepts by solving meaningful problems, this book is for you. *Python Crash Course* is also perfect for middle school and high school teachers who want to offer their students a project-based introduction to programming.

What Can You Expect to Learn?

The purpose of this book is to make you a good programmer in general and a good Python programmer in particular. You'll learn efficiently and adopt good habits as I provide you with a solid foundation in general programming concepts. After working your way through *Python Crash Course*, you should be ready to move on to more advanced Python techniques, and your next programming language will be even easier to grasp.

In the first part of this book you'll learn basic programming concepts you need to know to write Python programs. These concepts are the same as those you'd learn when starting out in almost any programming language. You'll learn about different kinds of data and the ways you can store data in lists and dictionaries within your programs. You'll learn to build collections of data and work through those collections in efficient ways. You'll learn to use `while` and `if` loops to test for certain conditions so you can run specific sections of code while those conditions are true and run other sections when they're not—a technique that greatly helps to automate processes.

You'll learn to accept input from users to make your programs interactive and to keep your programs running as long as the user is active. You'll explore how to write functions to make parts of your program reusable, so you only have to write blocks of code that perform certain

actions once, which you can then use as many times as you like. You'll then extend this concept to more complicated behavior with classes, making fairly simple programs respond to a variety of situations. You'll learn to write programs that handle common errors gracefully. After working through each of these basic concepts, you'll write a few short programs that solve some well-defined problems. Finally, you'll take your first step toward intermediate programming by learning how to write tests for your code so you can develop your programs further without worrying about introducing bugs. All the information in Part I will prepare you for taking on larger, more complex projects.

In Part II you'll apply what you learned in Part I to three projects. You can do any or all of these projects in whichever order works best for you. In the first project (Chapters 12–14) you'll create a Space Invaders–style shooting game called Alien Invasion, which consists of levels of increasing difficulty. After you've completed this project, you should be well on your way to being able to develop your own 2D games.

The second project (Chapters 15–17) introduces you to data visualization. Data scientists aim to make sense of the vast amount of information available to them through a variety of visualization techniques. You'll work with data sets that you generate through code, data sets downloaded from online sources, and data sets your programs download automatically. After you've completed this project, you'll be able to write programs that sift through large data sets and make visual representations of that stored information.

In the third project (Chapters 18–20) you'll build a small web application called Learning Log. This project allows you to keep a journal of ideas and concepts you've learned about a specific topic. You'll be able to keep separate logs for different topics and allow others to create an account and start their own journals. You'll also learn how to deploy your project so anyone can access it online from anywhere.

Why Python?

Every year I consider whether to continue using Python or whether to move on to a different language—perhaps one that's newer to the programming world. But I continue to focus on Python for many reasons. Python is an incredibly efficient language: your programs will do more in fewer lines of code than many other languages would require. Python's syntax will also help you write "clean" code. Your code will be easy to read, easy to debug, and easy to extend and build upon compared to other languages.

People use Python for many purposes: to make games, build web applications, solve business problems, and develop internal tools at all kinds of interesting companies. Python is also used heavily in scientific fields for academic research and applied work.

One of the most important reasons I continue to use Python is because of the Python community, which includes an incredibly diverse and welcoming group of people. Community is essential to programmers because programming isn't a solitary pursuit. Most of us, even the most experienced programmers, need to ask advice from others who have already solved similar problems. Having a well-connected and supportive community is critical in helping you solve problems, and the Python community is fully supportive of people like you who are learning Python as your first programming language.

Python is a great language to learn, so let's get started!

PART I

BASICS

Part I of this book teaches you the basic concepts you'll need to write Python programs. Many of these concepts are common to all programming languages, so they'll be useful throughout your life as a programmer.

In **Chapter 1** you'll install Python on your computer and run your first program, which prints the message *Hello world!* to the screen.

In **Chapter 2** you'll learn to store information in variables and work with text and numerical values.

Chapters 3 and **4** introduce lists. Lists can store as much information as you want in one variable, allowing you to work with that data efficiently. You'll be able to work with hundreds, thousands, and even millions of values in just a few lines of code.

In **Chapter 5** you'll use `if` statements to write code that responds one way if certain conditions are true, and responds in a different way if those conditions are not true.

Chapter 6 shows you how to use Python's dictionaries, which let you make connections between different pieces of information. Like lists, dictionaries can contain as much information as you need to store.

In **Chapter 7** you'll learn how to accept input from users to make your programs interactive. You'll also learn about `while` loops, which run blocks of code repeatedly as long as certain conditions remain true.

In **Chapter 8** you'll write functions, which are named blocks of code that perform a specific task and can be run whenever you need them.

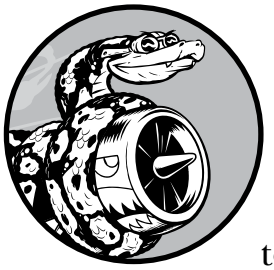
Chapter 9 introduces classes, which allow you to model real-world objects, such as dogs, cats, people, cars, rockets, and much more, so your code can represent anything real or abstract.

Chapter 10 shows you how to work with files and handle errors so your programs won't crash unexpectedly. You'll store data before your program closes, and read the data back in when the program runs again. You'll learn about Python's exceptions, which allow you to anticipate errors, and make your programs handle those errors gracefully.

In **Chapter 11** you'll learn to write tests for your code to check that your programs work the way you intend them to. As a result, you'll be able to expand your programs without worrying about introducing new bugs. Testing your code is one of the first skills that will help you transition from beginner to intermediate programmer.

1

GETTING STARTED



In this chapter you'll run your first Python program, *hello_world.py*. First, you'll need to check whether Python is installed on your computer; if it isn't, you'll install it. You'll also install a text editor to work with your Python programs. Text editors recognize Python code and highlight sections as you write, making it easy to understand the structure of your code.

Setting Up Your Programming Environment

Python differs slightly on different operating systems, so you'll need to keep a few considerations in mind. Here, we'll look at the two major versions of Python currently in use and outline the steps to set up Python on your system.

Python 2 and Python 3

Today, two versions of Python are available: Python 2 and the newer Python 3. Every programming language evolves as new ideas and technologies emerge, and the developers of Python have continually made the language more versatile and powerful. Most changes are incremental and hardly noticeable, but in some cases code written for Python 2 may not run properly on systems with Python 3 installed. Throughout this book I'll point out areas of significant difference between Python 2 and Python 3, so whichever version you use, you'll be able to follow the instructions.

If both versions are installed on your system or if you need to install Python, use Python 3. If Python 2 is the only version on your system and you'd rather jump into writing code instead of installing Python, you can start with Python 2. But the sooner you upgrade to using Python 3 the better, so you'll be working with the most recent version.

Running Snippets of Python Code

Python comes with an interpreter that runs in a terminal window, allowing you to try bits of Python without having to save and run an entire program.

Throughout this book, you'll see snippets that look like this:

```
❶ >>> print("Hello Python interpreter!")
Hello Python interpreter!
```

The text in bold is what you'll type in and then execute by pressing ENTER. Most of the examples in the book are small, self-contained programs that you'll run from your editor, because that's how you'll write most of your code. But sometimes basic concepts will be shown in a series of snippets run through a Python terminal session to demonstrate isolated concepts more efficiently. Any time you see the three angle brackets in a code listing ❶, you're looking at the output of a terminal session. We'll try coding in the interpreter for your system in a moment.

Hello World!

A long-held belief in the programming world has been that printing a *Hello world!* message to the screen as your first program in a new language will bring you luck.

In Python, you can write the *Hello World* program in one line:

```
print("Hello world!")
```

Such a simple program serves a very real purpose. If it runs correctly on your system, any Python program you write should work as well. We'll look at writing this program on your particular system in just a moment.

Python on Different Operating Systems

Python is a cross-platform programming language, which means it runs on all the major operating systems. Any Python program you write should run on any modern computer that has Python installed. However, the methods for setting up Python on different operating systems vary slightly.

In this section you'll learn how to set up Python and run the *Hello World* program on your own system. You'll first check whether Python is installed on your system and install it if it's not. Then you'll install a simple text editor and save an empty Python file called *hello_world.py*. Finally, you'll run the *Hello World* program and troubleshoot anything that didn't work. I'll walk you through this process for each operating system, so you'll have a beginner-friendly Python programming environment.

Python on Linux

Linux systems are designed for programming, so Python is already installed on most Linux computers. The people who write and maintain Linux expect you to do your own programming at some point and encourage you to do so. For this reason there's very little you have to install and very few settings you have to change to start programming.

Checking Your Version of Python

Open a terminal window by running the Terminal application on your system (in Ubuntu, you can press CTRL-ALT-T). To find out whether Python is installed, enter **`python`** with a lowercase *p*. You should see output telling you which version of Python is installed and a >>> prompt where you can start entering Python commands, like this:

```
$ python
Python 2.7.6 (default, Mar 22 2014, 22:59:38)
[GCC 4.8.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

This output tells you that Python 2.7.6 is currently the default version of Python installed on this computer. When you've seen this output, press CTRL-D or enter `exit()` to leave the Python prompt and return to a terminal prompt.

To check for Python 3, you might have to specify that version; so even if the output displayed Python 2.7 as the default version, try the command `python3`:

```
$ python3
Python 3.5.0 (default, Sep 17 2015, 13:05:18)
[GCC 4.8.4] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

This output means you also have Python 3 installed, so you'll be able to use either version. Whenever you see the `python` command in this book, enter `python3` instead. Most Linux distributions have Python already installed, but if for some reason yours didn't or if your system came with Python 2 and you want to install Python 3, refer to Appendix A.

Installing a Text Editor

Geany is a simple text editor: it's easy to install, will let you run almost all your programs directly from the editor instead of through a terminal, uses syntax highlighting to color your code, and runs your code in a terminal window so you'll get used to using terminals. Appendix B provides information on other text editors, but I recommend using Geany unless you have a good reason to use a different editor.

You can install Geany in one line on most Linux systems:

```
$ sudo apt-get install geany
```

If this doesn't work, see the instructions at *http://geany.org/Download/ThirdPartyPackages/*.

Running the Hello World Program

To start your first program, open Geany. Press the Super key (often called the Windows key) and search for Geany on your system. Make a shortcut by dragging the icon to your taskbar or desktop. Then make a folder somewhere on your system for your projects and call it *python_work*. (It's best to use lowercase letters and underscores for spaces in file and folder names because these are Python naming conventions.) Go back to Geany and save an empty Python file (**File ▸ Save As**) called *hello_world.py* in your *python_work* folder. The extension *.py* tells Geany your file will contain a Python program. It also tells Geany how to run your program and highlight the text in a helpful way.

After you've saved your file, enter the following line:

```
print("Hello Python world!")
```

If multiple versions of Python are installed on your system, you need to make sure Geany is configured to use the correct version. Go to **Build ▸ Set Build Commands**. You should see the words *Compile* and *Execute* with a command next to each. Geany assumes the correct command for each is `python`, but if your system uses the `python3` command, you'll need to change this.

If the command `python3` worked in a terminal session, change the Compile and Execute commands so Geany will use the Python 3 interpreter. Your Compile command should look like this:

```
python3 -m py_compile "%f"
```

You need to type this command exactly as it's shown. Make sure the spaces and capitalization match what is shown here.

Your Execute command should look like this:

```
python3 "%f"
```

Again, make sure the spacing and capitalization match what is shown here. Figure 1-1 shows how these commands should look in Geany's configuration menu.

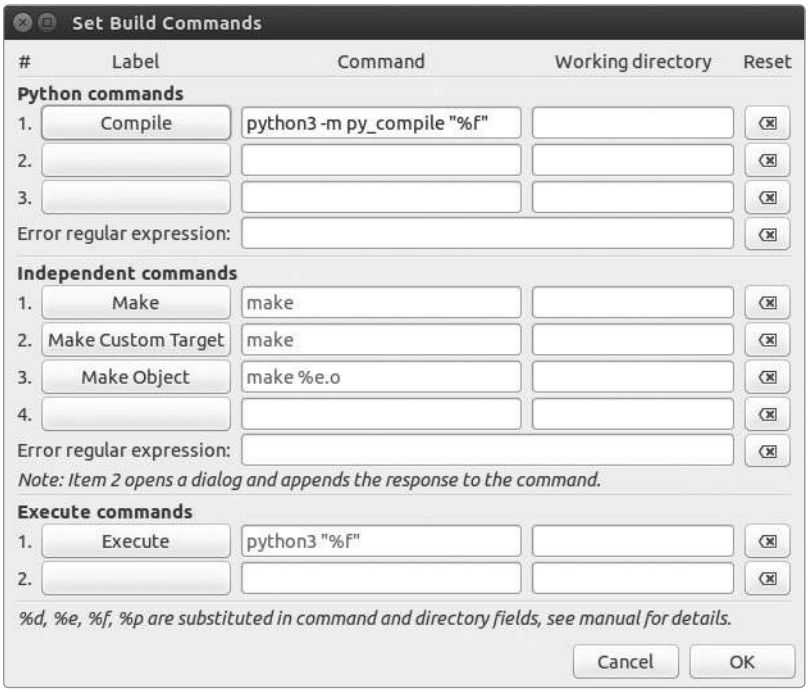


Figure 1-1: Here, Geany is configured to use Python 3 on Linux.

Now run *hello_world.py* by selecting **Build ▸ Execute** in the menu, by clicking the Execute icon (which shows a set of gears), or by pressing F5. A terminal window should pop up with the following output:

```
Hello Python world!

------------------
(program exited with code: 0)
Press return to continue
```

If you don't see this, check every character on the line you entered. Did you accidentally capitalize `print`? Did you forget one or both of the quotation marks or parentheses? Programming languages expect very specific syntax, and if you don't provide that, you'll get errors. If you can't get the program to run, see "Troubleshooting Installation Issues" on page 15.

Running Python in a Terminal Session

You can try running snippets of Python code by opening a terminal and typing `python` or `python3`, as you did when checking your version. Do this again, but this time enter the following line in the terminal session:

```
>>> print("Hello Python interpreter!")
Hello Python interpreter!
>>>
```

You should see your message printed directly in the current terminal window. Remember that you can close the Python interpreter by pressing CTRL-D or by typing the command `exit()`.

Python on OS X

Python is already installed on most OS X systems. Once you know Python is installed, you'll need to install a text editor and make sure it's configured correctly.

Checking Whether Python Is Installed

Open a terminal window by going to **Applications ▸ Utilities ▸ Terminal**. You can also press COMMAND-spacebar, type **`terminal`**, and then press ENTER. To find out whether Python is installed, enter **`python`** with a lowercase *p*. You should see output telling you which version of Python is installed on your system and a >>> prompt where you can start entering Python commands, like this:

```
$ python
Python 2.7.5 (default, Mar  9 2014, 22:15:05)
[GCC  4.2.1 Compatible Apple LLVM 5.0 (clang-500.0.68)] on darwin
Type "help", "copyright", "credits", or "license" for more information.
>>>
```

This output tells you that Python 2.7.5 is currently the default version installed on this computer. When you've seen this output, press CTRL-D or enter `exit()` to leave the Python prompt and return to a terminal prompt.

To check for Python 3, try the command `python3`. You might get an error message, but if the output shows you have Python 3 installed, you'll be able to use Python 3 without having to install it. If `python3` works on your system, whenever you see the `python` command in this book, make sure you use `python3` instead. If for some reason your system didn't come with Python or if you only have Python 2 and you want to install Python 3 now, see Appendix A.

Running Python in a Terminal Session

You can try running snippets of Python code by opening a terminal and typing `python` or `python3`, as you did when checking your version. Do this again, but this time enter the following line in the terminal session:

```
>>> print("Hello Python interpreter!")
Hello Python interpreter!
>>>
```

You should see your message printed directly in the current terminal window. Remember that you can close the Python interpreter by pressing CTRL-D or by typing the command `exit()`.

Installing a Text Editor

Sublime Text is a simple text editor: it's easy to install on OS X, will let you run almost all of your programs directly from the editor instead of through a terminal, uses syntax highlighting to color your code, and runs your code in a terminal session embedded in the Sublime Text window to make it easy to see the output. Appendix B provides information on other text editors, but I recommend using Sublime Text unless you have a good reason to use a different editor.

You can download an installer for Sublime Text from *http://sublimetext.com/3*. Click the download link and look for an installer for OS X. Sublime Text has a very liberal licensing policy: you can use the editor for free as long as you want, but the author requests that you purchase a license if you like it and want continual use. After the installer has been downloaded, open it and then drag the Sublime Text icon into your *Applications* folder.

Configuring Sublime Text for Python 3

If you use a command other than `python` to start a Python terminal session, you'll need to configure Sublime Text so it knows where to find the correct version of Python on your system. Issue the following command to find out the full path to your Python interpreter:

```
$ type -a python3
python3 is /usr/local/bin/python3
```

Now open Sublime Text, and go to **Tools ▸ Build System ▸ New Build System**, which will open a new configuration file for you. Delete what you see and enter the following:

Python3.sublime-build

```
{
    "cmd": ["/usr/local/bin/python3", "-u", "$file"],
}
```

This code tells Sublime Text to use your system's `python3` command when running the currently open file. Make sure you use the path you found when issuing the command `type -a python3` in the previous step. Save the file as *Python3.sublime-build* in the default directory that Sublime Text opens when you choose Save.

Running the Hello World Program

To start your first program, launch Sublime Text by opening the *Applications* folder and double-clicking the Sublime Text icon. You can also press COMMAND-spacebar and enter **`sublime text`** in the search bar that pops up.

Make a folder called *python_work* somewhere on your system for your projects. (It's best to use lowercase letters and underscores for spaces in file and folder names, because these are Python naming conventions.) Save an empty Python file (**File ▸ Save As**) called *hello_world.py* in your *python_work* folder. The extension *.py* tells Sublime Text that your file will contain a Python program and tells it how to run your program and highlight the text in a helpful way.

After you've saved your file, enter the following line:

```
print("Hello Python world!")
```

If the command `python` works on your system, you can run your program by selecting **Tools ▸ Build** in the menu or by pressing CTRL-B. If you configured Sublime Text to use a command other than `python`, select **Tools ▸ Build System** and then select **Python 3**. This sets Python 3 as the default version of Python, and you'll be able to select **Tools ▸ Build** or just press COMMAND-B to run your programs from now on.

A terminal screen should appear at the bottom of the Sublime Text window, showing the following output:

```
Hello Python world!
[Finished in 0.1s]
```

If you don't see this, check every character on the line you entered. Did you accidentally capitalize `print`? Did you forget one or both of the quotation marks or parentheses? Programming languages expect very specific syntax, and if you don't provide that, you'll get errors. If you can't get the program to run, see "Troubleshooting Installation Issues" on page 15.

Python on Windows

Windows doesn't always come with Python, so you'll probably need to download and install it, and then download and install a text editor.

Installing Python

First, check whether Python is installed on your system. Open a command window by entering **command** into the Start menu or by holding down the SHIFT key while right-clicking on your desktop and selecting **Open command window here**. In the terminal window, enter **python** in lowercase. If you get a Python prompt (>>>), Python is installed on your system. However, you'll probably see an error message telling you that `python` is not a recognized command.

In that case, download a Python installer for Windows. Go to *http://python.org/downloads/*. You should see two buttons, one for downloading Python 3 and one for downloading Python 2. Click the Python 3 button, which should automatically start downloading the correct installer for your system. After you've downloaded the file, run the installer. Make sure you check the option Add Python to PATH, which will make it easier to configure your system correctly. Figure 1-2 shows this option checked.

Figure 1-2: Make sure you check the box labeled Add Python to PATH.

Starting a Python Terminal Session

Setting up your text editor will be straightforward if you first set up your system to run Python in a terminal session. Open a command window and enter **python** in lowercase. If you get a Python prompt (>>>), Windows has found the version of Python you just installed:

```
C:\> python
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 22:15:05) [MSC v.1900 32 bit
(Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

If this worked, you can move on to the next section, "Running Python in a Terminal Session."

However, you may see output that looks more like this:

```
C:\> python
'python' is not recognized as an internal or external command, operable
program or batch file.
```

In this case you need to tell Windows how to find the Python version you just installed. Your system's `python` command is usually saved in your *C* drive, so open Windows Explorer and open your *C* drive. Look for a folder starting with the name *Python*, open that folder, and find the *python* file (in lowercase). For example, I have a *Python35* folder with a file named *python* inside it, so the path to the `python` command on my system is *C:\Python35\python*. Otherwise, enter **`python`** into the search box in Windows Explorer to show you exactly where the `python` command is stored on your system.

When you think you know the path, test it by entering that path into a terminal window. Open a command window and enter the full path you just found:

```
C:\> C:\Python35\python
Python 3.5.0 (v3.5.0:374f501f4567, Sep 13 2015, 22:15:05) [MSC v.1900 32 bit
(Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

If this worked, you know how to access Python on your system.

Running Python in a Terminal Session

Enter the following line in your Python session, and make sure you see the output *Hello Python world!*

```
>>> print("Hello Python world!")
Hello Python world!
>>>
```

Any time you want to run a snippet of Python code, open a command window and start a Python terminal session. To close the terminal session, press CTRL-Z and then press ENTER, or enter the command `exit()`.

Installing a Text Editor

Geany is a simple text editor: it's easy to install, will let you run almost all of your programs directly from the editor instead of through a terminal, uses syntax highlighting to color your code, and runs your code in a terminal window so you'll get used to using terminals. Appendix B provides information on other text editors, but I recommend using Geany unless you have a good reason to use a different editor.

You can download a Windows installer for Geany from *http://geany.org/*. Click **Releases** under the Download menu, and look for the *geany-1.25_setup.exe* installer or something similar. Run the installer and accept all the defaults.

To start your first program, open Geany: press the Windows key and search for Geany on your system. You should make a shortcut by dragging the icon to your taskbar or desktop. Make a folder called *python_work* somewhere on your system for your projects. (It's best to use lowercase letters and underscores for spaces in file and folder names, because these are Python naming conventions.) Go back to Geany and save an empty Python file (**File ▸ Save As**) called *hello_world.py* in your *python_work* folder. The extension *.py* tells Geany that your file will contain a Python program. It also tells Geany how to run your program and to highlight the text in a helpful way.

After you've saved your file, type the following line:

```
print("Hello Python world!")
```

If the command `python` worked on your system, you won't have to configure Geany; skip the next section and move on to "Running the Hello World Program" on page 14. If you needed to enter a path like *C:\Python35\python* to start a Python interpreter, follow the directions in the next section to configure Geany for your system.

Configuring Geany

To configure Geany, go to **Build ▸ Set Build Commands**. You should see the words *Compile* and *Execute* with a command next to each. The Compile and Execute commands start with `python` in lowercase, but Geany doesn't know where your system stored the `python` command. You need to add the path you used in the terminal session.

In the Compile and Execute commands, add the drive your `python` command is on and the folder where the `python` command is stored. Your Compile command should look something like this:

```
C:\Python35\python -m py_compile "%f"
```

Your path might be a little different, but make sure the spaces and capitalization match what is shown here.

Your Execute command should look something like this:

```
C:\Python35\python "%f"
```

Again, make sure the spacing and capitalization in your Execute command matches what is shown here. Figure 1-3 shows how these commands should look in Geany's configuration menu.

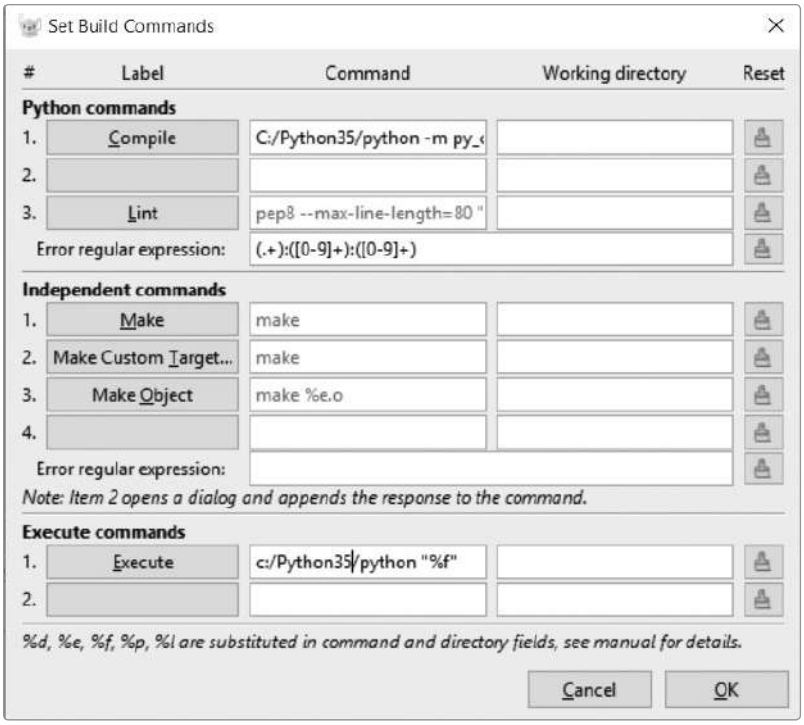


Figure 1-3: Here, Geany is configured to use Python 3 on Windows.

After you've set these commands correctly, click **OK**.

Running the Hello World Program

You should now be able to run your program successfully. Run *hello_world.py* by selecting **Build ▸ Execute** in the menu, by clicking the Execute icon (which shows a set of gears), or by pressing F5. A terminal window should pop up with the following output:

```
Hello Python world!

------------------
(program exited with code: 0)
Press return to continue
```

If you don't see this, check every character on the line you entered. Did you accidentally capitalize `print`? Did you forget one or both of the quotation marks or parentheses? Programming languages expect very specific syntax, and if you don't provide that, you'll get errors. If you can't get the program to run, see the next section for help.

Troubleshooting Installation Issues

Hopefully, setting up your programming environment was successful, but if you've been unable to run *hello_world.py*, here are a few remedies you can try:

- When a program contains a significant error, Python displays a *traceback*. Python looks through the file and tries to report the problem. The traceback might give you a clue as to what issue is preventing the program from running.
- Step away from your computer, take a short break, and then try again. Remember that syntax is very important in programming, so even a missing colon, a mismatched quotation mark, or mismatched parentheses can prevent a program from running properly. Reread the relevant parts of this chapter, look over what you've done, and see if you can find the mistake.
- Start over again. You probably don't need to uninstall anything, but it might make sense to delete your *hello_world.py* file and create it again from scratch.
- Ask someone else to follow the steps in this chapter, on your computer or a different one, and watch what they do carefully. You might have missed one small step that someone else happens to catch.
- Find someone who knows Python and ask them to help you get set up. If you ask around, you might find that you know someone who uses Python.
- The setup instructions in this chapter are also available online, through *https://www.nostarch.com/pythoncrashcourse/*. The online version of these instructions may work better for you.
- Ask for help online. Appendix C provides a number of resources and areas online, like forums and live chat sites, where you can ask for solutions from people who've already worked through the issue you're currently facing.

Don't worry about bothering experienced programmers. Every programmer has been stuck at some point, and most programmers are happy to help you set up your system correctly. As long as you can state clearly what you're trying to do, what you've already tried, and the results you're getting, there's a good chance someone will be able to help you. As mentioned in the Introduction, the Python community is very beginner friendly.

Python should run well on any modern computer, so find a way to ask for help if you're having trouble so far. Early issues can be frustrating, but they're well worth sorting out. Once you get *hello_world.py* running, you can start to learn Python, and your programming work will become more interesting and satisfying.

Running Python Programs from a Terminal

Most of the programs you write in your text editor you'll run directly from the editor, but sometimes it's useful to run programs from a terminal instead. For example, you might want to run an existing program without opening it for editing.

You can do this on any system with Python installed if you know how to access the directory where you've stored your program file. To try this, make sure you've saved the *hello_world.py* file in the *python_work* folder on your desktop.

On Linux and OS X

Running a Python program from a terminal session is the same on Linux and OS X. The terminal command `cd`, for *change directory*, is used to navigate through your file system in a terminal session. The command `ls`, for *list*, shows you all the nonhidden files that exist in the current directory.

Open a new terminal window and issue the following commands to run *hello_world.py*:

```
❶ ~$ cd Desktop/python_work/
❷ ~/Desktop/python_work$ ls
  hello_world.py
❸ ~/Desktop/python_work$ python hello_world.py
  Hello Python world!
```

At ❶ we use the `cd` command to navigate to the *python_work* folder, which is in the *Desktop* folder. Next, we use the `ls` command to make sure *hello_world.py* is in this folder ❷. Then, we run the file using the command `python hello_world.py` ❸.

It's that simple. You just use the `python` (or `python3`) command to run Python programs.

On Windows

The terminal command `cd`, for *change directory*, is used to navigate through your file system in a command window. The command `dir`, for *directory*, shows you all the files that exist in the current directory.

Open a new terminal window and issue the following commands to run *hello_world.py*:

```
❶ C:\> cd Desktop\python_work
❷ C:\Desktop\python_work> dir
  hello_world.py
❸ C:\Desktop\python_work> python hello_world.py
  Hello Python world!
```

At ❶ we use the `cd` command to navigate to the *python_work* folder, which is in the *Desktop* folder. Next, we use the `dir` command to make sure *hello_world.py* is in this folder ❷. Then, we run the file using the command `python hello_world.py` ❸.

If you haven't configured your system to use the simple command `python`, you may need to use the longer version of this command:

```
C:\$ cd Desktop\python_work
C:\Desktop\python_work$ dir
hello_world.py
C:\Desktop\python_work$ C:\Python35\python hello_world.py
Hello Python world!
```

Most of your programs will run fine directly from your editor, but as your work becomes more complex, you might write programs that you'll need to run from a terminal.

TRY IT YOURSELF

The exercises in this chapter are exploratory in nature. Starting in Chapter 2, the challenges you'll solve will be based on what you've learned.

1-1. python.org: Explore the Python home page (*http://python.org/*) to find topics that interest you. As you become familiar with Python, different parts of the site will be more useful to you.

1-2. Hello World Typos: Open the *hello_world.py* file you just created. Make a typo somewhere in the line and run the program again. Can you make a typo that generates an error? Can you make sense of the error message? Can you make a typo that doesn't generate an error? Why do you think it didn't make an error?

1-3. Infinite Skills: If you had infinite programming skills, what would you build? You're about to learn how to program. If you have an end goal in mind, you'll have an immediate use for your new skills; now is a great time to draft descriptions of what you'd like to create. It's a good habit to keep an "ideas" notebook that you can refer to whenever you want to start a new project. Take a few minutes now to describe three programs you'd like to create.

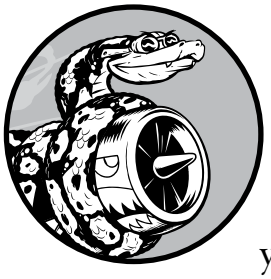
Summary

In this chapter you learned a bit about Python in general, and you installed Python to your system if it wasn't already there. You also installed a text editor to make it easier to write Python code. You learned to run snippets of Python code in a terminal session, and you ran your first actual program, *hello_world.py*. You probably learned a bit about troubleshooting as well.

In the next chapter you'll learn about the different kinds of data you can work with in your Python programs, and you'll learn to use variables as well.

2

VARIABLES AND SIMPLE DATA TYPES



In this chapter you'll learn about the different kinds of data you can work with in your Python programs. You'll also learn how to store your data in variables and how to use those variables in your programs.

What Really Happens When You Run hello_world.py

Let's take a closer look at what Python does when you run *hello_world.py*. As it turns out, Python does a fair amount of work, even when it runs a simple program:

hello_world.py

```
print("Hello Python world!")
```

When you run this code, you should see this output:

```
Hello Python world!
```

When you run the file *hello_world.py*, the ending *.py* indicates that the file is a Python program. Your editor then runs the file through the *Python interpreter,* which reads through the program and determines what each word in the program means. For example, when the interpreter sees the word `print`, it prints to the screen whatever is inside the parentheses.

As you write your programs, your editor highlights different parts of your program in different ways. For example, it recognizes that `print` is the name of a function and displays that word in blue. It recognizes that "Hello Python world!" is not Python code and displays that phrase in orange. This feature is called *syntax highlighting* and is quite useful as you start to write your own programs.

Variables

Let's try using a variable in *hello_world.py*. Add a new line at the beginning of the file, and modify the second line:

```
message = "Hello Python world!"
print(message)
```

Run this program to see what happens. You should see the same output you saw previously:

```
Hello Python world!
```

We've added a *variable* named `message`. Every variable holds a *value*, which is the information associated with that variable. In this case the value is the text "Hello Python world!"

Adding a variable makes a little more work for the Python interpreter. When it processes the first line, it associates the text "Hello Python world!" with the variable `message`. When it reaches the second line, it prints the value associated with `message` to the screen.

Let's expand on this program by modifying *hello_world.py* to print a second message. Add a blank line to *hello_world.py*, and then add two new lines of code:

```
message = "Hello Python world!"
print(message)

message = "Hello Python Crash Course world!"
print(message)
```

Now when you run *hello_world.py*, you should see two lines of output:

```
Hello Python world!
Hello Python Crash Course world!
```

You can change the value of a variable in your program at any time, and Python will always keep track of its current value.

Naming and Using Variables

When you're using variables in Python, you need to adhere to a few rules and guidelines. Breaking some of these rules will cause errors; other guidelines just help you write code that's easier to read and understand. Be sure to keep the following variable rules in mind:

- Variable names can contain only letters, numbers, and underscores. They can start with a letter or an underscore, but not with a number. For instance, you can call a variable *message_1* but not *1_message*.
- Spaces are not allowed in variable names, but underscores can be used to separate words in variable names. For example, *greeting_message* works, but *greeting message* will cause errors.
- Avoid using Python keywords and function names as variable names; that is, do not use words that Python has reserved for a particular programmatic purpose, such as the word `print`. (See "Python Keywords and Built-in Functions" on page 489.)
- Variable names should be short but descriptive. For example, *name* is better than *n*, *student_name* is better than *s_n*, and *name_length* is better than *length_of_persons_name*.
- Be careful when using the lowercase letter *l* and the uppercase letter *O* because they could be confused with the numbers *1* and *0*.

It can take some practice to learn how to create good variable names, especially as your programs become more interesting and complicated. As you write more programs and start to read through other people's code, you'll get better at coming up with meaningful names.

NOTE *The Python variables you're using at this point should be lowercase. You won't get errors if you use uppercase letters, but it's a good idea to avoid using them for now.*

Avoiding Name Errors When Using Variables

Every programmer makes mistakes, and most make mistakes every day. Although good programmers might create errors, they also know how to respond to those errors efficiently. Let's look at an error you're likely to make early on and learn how to fix it.

We'll write some code that generates an error on purpose. Enter the following code, including the misspelled word *mesage* shown in bold:

```
message = "Hello Python Crash Course reader!"
print(mesage)
```

When an error occurs in your program, the Python interpreter does its best to help you figure out where the problem is. The interpreter provides a traceback when a program cannot run successfully. A *traceback* is a record of where the interpreter ran into trouble when trying to execute your code. Here's an example of the traceback that Python provides after you've accidentally misspelled a variable's name:

```
Traceback (most recent call last):
❶  File "hello_world.py", line 2, in <module>
❷    print(mesage)
❸ NameError: name 'mesage' is not defined
```

The output at ❶ reports that an error occurs in line 2 of the file *hello_world.py*. The interpreter shows this line to help us spot the error quickly ❷ and tells us what kind of error it found ❸. In this case it found a *name error* and reports that the variable being printed, `mesage`, has not been defined. Python can't identify the variable name provided. A name error usually means we either forgot to set a variable's value before using it, or we made a spelling mistake when entering the variable's name.

Of course, in this example we omitted the letter *s* in the variable name `message` in the second line. The Python interpreter doesn't spellcheck your code, but it does ensure that variable names are spelled consistently. For example, watch what happens when we spell *message* incorrectly in another place in the code as well:

```
mesage = "Hello Python Crash Course reader!"
print(mesage)
```

In this case, the program runs successfully!

```
Hello Python Crash Course reader!
```

Computers are strict, but they disregard good and bad spelling. As a result, you don't need to consider English spelling and grammar rules when you're trying to create variable names and writing code.

Many programming errors are simple, single-character typos in one line of a program. If you're spending a long time searching for one of these errors, know that you're in good company. Many experienced and talented programmers spend hours hunting down these kinds of tiny errors. Try to laugh about it and move on, knowing it will happen frequently throughout your programming life.

NOTE *The best way to understand new programming concepts is to try using them in your programs. If you get stuck while working on an exercise in this book, try doing something else for a while. If you're still stuck, review the relevant part of that chapter. If you still need help, see the suggestions in Appendix C.*

TRY IT YOURSELF

Write a separate program to accomplish each of these exercises. Save each program with a filename that follows standard Python conventions, using lowercase letters and underscores, such as *simple_message.py* and *simple_messages.py*.

2-1. Simple Message: Store a message in a variable, and then print that message.

2-2. Simple Messages: Store a message in a variable, and print that message. Then change the value of your variable to a new message, and print the new message.

Strings

Because most programs define and gather some sort of data, and then do something useful with it, it helps to classify different types of data. The first data type we'll look at is the string. Strings are quite simple at first glance, but you can use them in many different ways.

A *string* is simply a series of characters. Anything inside quotes is considered a string in Python, and you can use single or double quotes around your strings like this:

```
"This is a string."
'This is also a string.'
```

This flexibility allows you to use quotes and apostrophes within your strings:

```
'I told my friend, "Python is my favorite language!"'
"The language 'Python' is named after Monty Python, not the snake."
"One of Python's strengths is its diverse and supportive community."
```

Let's explore some of the ways you can use strings.

Changing Case in a String with Methods

One of the simplest tasks you can do with strings is change the case of the words in a string. Look at the following code, and try to determine what's happening:

name.py

```
name = "ada lovelace"
print(name.title())
```

Save this file as *name.py*, and then run it. You should see this output:

```
Ada Lovelace
```

In this example, the lowercase string `"ada lovelace"` is stored in the variable `name`. The method `title()` appears after the variable in the `print()` statement. A *method* is an action that Python can perform on a piece of data. The dot (`.`) after `name` in `name.title()` tells Python to make the `title()` method act on the variable `name`. Every method is followed by a set of parentheses, because methods often need additional information to do their work. That information is provided inside the parentheses. The `title()` function doesn't need any additional information, so its parentheses are empty.

`title()` displays each word in titlecase, where each word begins with a capital letter. This is useful because you'll often want to think of a name as a piece of information. For example, you might want your program to recognize the input values `Ada`, `ADA`, and `ada` as the same name, and display all of them as `Ada`.

Several other useful methods are available for dealing with case as well. For example, you can change a string to all uppercase or all lowercase letters like this:

```
name = "Ada Lovelace"
print(name.upper())
print(name.lower())
```

This will display the following:

```
ADA LOVELACE
ada lovelace
```

The `lower()` method is particularly useful for storing data. Many times you won't want to trust the capitalization that your users provide, so you'll convert strings to lowercase before storing them. Then when you want to display the information, you'll use the case that makes the most sense for each string.

Combining or Concatenating Strings

It's often useful to combine strings. For example, you might want to store a first name and a last name in separate variables, and then combine them when you want to display someone's full name:

```
first_name = "ada"
last_name = "lovelace"
❶ full_name = first_name + " " + last_name

print(full_name)
```

Python uses the plus symbol (+) to combine strings. In this example, we use + to create a full name by combining a `first_name`, a space, and a `last_name` ❶, giving this result:

```
ada lovelace
```

This method of combining strings is called *concatenation*. You can use concatenation to compose complete messages using the information you've stored in a variable. Let's look at an example:

```
first_name = "ada"
last_name = "lovelace"
full_name = first_name + " " + last_name

❶ print("Hello, " + full_name.title() + "!")
```

Here, the full name is used at ❶ in a sentence that greets the user, and the `title()` method is used to format the name appropriately. This code returns a simple but nicely formatted greeting:

```
Hello, Ada Lovelace!
```

You can use concatenation to compose a message and then store the entire message in a variable:

```
first_name = "ada"
last_name = "lovelace"
full_name = first_name + " " + last_name

❶ message = "Hello, " + full_name.title() + "!"
❷ print(message)
```

This code displays the message "Hello, Ada Lovelace!" as well, but storing the message in a variable at ❶ makes the final `print` statement at ❷ much simpler.

Adding Whitespace to Strings with Tabs or Newlines

In programming, *whitespace* refers to any nonprinting character, such as spaces, tabs, and end-of-line symbols. You can use whitespace to organize your output so it's easier for users to read.

To add a tab to your text, use the character combination `\t` as shown at ❶:

```
>>> print("Python")
Python
❶ >>> print("\tPython")
    Python
```

To add a newline in a string, use the character combination `\n`:

```
>>> print("Languages:\nPython\nC\nJavaScript")
Languages:
Python
C
JavaScript
```

You can also combine tabs and newlines in a single string. The string `"\n\t"` tells Python to move to a new line, and start the next line with a tab. The following example shows how you can use a one-line string to generate four lines of output:

```
>>> print("Languages:\n\tPython\n\tC\n\tJavaScript")
Languages:
    Python
    C
    JavaScript
```

Newlines and tabs will be very useful in the next two chapters when you start to produce many lines of output from just a few lines of code.

Stripping Whitespace

Extra whitespace can be confusing in your programs. To programmers `'python'` and `'python '` look pretty much the same. But to a program, they are two different strings. Python detects the extra space in `'python '` and considers it significant unless you tell it otherwise.

It's important to think about whitespace, because often you'll want to compare two strings to determine whether they are the same. For example, one important instance might involve checking people's usernames when they log in to a website. Extra whitespace can be confusing in much simpler situations as well. Fortunately, Python makes it easy to eliminate extraneous whitespace from data that people enter.

Python can look for extra whitespace on the right and left sides of a string. To ensure that no whitespace exists at the right end of a string, use the `rstrip()` method.

```
❶ >>> favorite_language = 'python '
❷ >>> favorite_language
  'python '
❸ >>> favorite_language.rstrip()
  'python'
❹ >>> favorite_language
  'python '
```

The value stored in `favorite_language` at ❶ contains extra whitespace at the end of the string. When you ask Python for this value in a terminal session, you can see the space at the end of the value ❷. When the `rstrip()` method acts on the variable `favorite_language` at ❸, this extra space is removed. However, it is only removed temporarily. If you ask for the value of `favorite_language` again, you can see that the string looks the same as when it was entered, including the extra whitespace ❹.

To remove the whitespace from the string permanently, you have to store the stripped value back into the variable:

```
  >>> favorite_language = 'python '
❶ >>> favorite_language = favorite_language.rstrip()
  >>> favorite_language
  'python'
```

To remove the whitespace from the string, you strip the whitespace from the right side of the string and then store that value back in the original variable, as shown at ❶. Changing a variable's value and then storing the new value back in the original variable is done often in programming. This is how a variable's value can change as a program is executed or in response to user input.

You can also strip whitespace from the left side of a string using the `lstrip()` method or strip whitespace from both sides at once using `strip()`:

```
❶ >>> favorite_language = ' python '
❷ >>> favorite_language.rstrip()
  ' python'
❸ >>> favorite_language.lstrip()
  'python '
❹ >>> favorite_language.strip()
  'python'
```

In this example, we start with a value that has whitespace at the beginning and the end ❶. We then remove the extra space from the right side at ❷, from the left side at ❸, and from both sides at ❹. Experimenting with these stripping functions can help you become familiar with manipulating strings. In the real world, these stripping functions are used most often to clean up user input before it's stored in a program.

Avoiding Syntax Errors with Strings

One kind of error that you might see with some regularity is a syntax error. A *syntax error* occurs when Python doesn't recognize a section of your program as valid Python code. For example, if you use an apostrophe within single quotes, you'll produce an error. This happens because Python interprets everything between the first single quote and the apostrophe as a string. It then tries to interpret the rest of the text as Python code, which causes errors.

Here's how to use single and double quotes correctly. Save this program as *apostrophe.py* and then run it:

apostrophe.py

```
message = "One of Python's strengths is its diverse community."
print(message)
```

The apostrophe appears inside a set of double quotes, so the Python interpreter has no trouble reading the string correctly:

```
One of Python's strengths is its diverse community.
```

However, if you use single quotes, Python can't identify where the string should end:

```
message = 'One of Python's strengths is its diverse community.'
print(message)
```

You'll see the following output:

```
  File "apostrophe.py", line 1
    message = 'One of Python's strengths is its diverse community.'
                             ^❶
SyntaxError: invalid syntax
```

In the output you can see that the error occurs at ❶ right after the second single quote. This *syntax error* indicates that the interpreter doesn't recognize something in the code as valid Python code. Errors can come from a variety of sources, and I'll point out some common ones as they arise. You might see syntax errors often as you learn to write proper Python code. Syntax errors are also the least specific kind of error, so they can be difficult and frustrating to identify and correct. If you get stuck on a particularly stubborn error, see the suggestions in Appendix C.

NOTE *Your editor's syntax highlighting feature should help you spot some syntax errors quickly as you write your programs. If you see Python code highlighted as if it's English or English highlighted as if it's Python code, you probably have a mismatched quotation mark somewhere in your file.*

Printing in Python 2

The `print` statement has a slightly different syntax in Python 2:

```
>>> python2.7
>>> print "Hello Python 2.7 world!"
Hello Python 2.7 world!
```

Parentheses are not needed around the phrase you want to print in Python 2. Technically, `print` is a function in Python 3, which is why it needs parentheses. Some Python 2 `print` statements do include parentheses, but the behavior can be a little different than what you'll see in Python 3. Basically, when you're looking at code written in Python 2, expect to see some `print` statements with parentheses and some without.

TRY IT YOURSELF

Save each of the following exercises as a separate file with a name like *name_cases.py*. If you get stuck, take a break or see the suggestions in Appendix C.

2-3. Personal Message: Store a person's name in a variable, and print a message to that person. Your message should be simple, such as, "Hello Eric, would you like to learn some Python today?"

2-4. Name Cases: Store a person's name in a variable, and then print that person's name in lowercase, uppercase, and titlecase.

2-5. Famous Quote: Find a quote from a famous person you admire. Print the quote and the name of its author. Your output should look something like the following, including the quotation marks:

> *Albert Einstein once said, "A person who never made a mistake never tried anything new."*

2-6. Famous Quote 2: Repeat Exercise 2-5, but this time store the famous person's name in a variable called `famous_person`. Then compose your message and store it in a new variable called `message`. Print your message.

2-7. Stripping Names: Store a person's name, and include some whitespace characters at the beginning and end of the name. Make sure you use each character combination, `"\t"` and `"\n"`, at least once.

Print the name once, so the whitespace around the name is displayed. Then print the name using each of the three stripping functions, `lstrip()`, `rstrip()`, and `strip()`.

Numbers

Numbers are used quite often in programming to keep score in games, represent data in visualizations, store information in web applications, and so on. Python treats numbers in several different ways, depending on how they are being used. Let's first look at how Python manages integers, because they are the simplest to work with.

Integers

You can add (+), subtract (-), multiply (*), and divide (/) integers in Python.

```
>>> 2 + 3
5
>>> 3 - 2
1
>>> 2 * 3
6
>>> 3 / 2
1.5
```

In a terminal session, Python simply returns the result of the operation. Python uses two multiplication symbols to represent exponents:

```
>>> 3 ** 2
9
>>> 3 ** 3
27
>>> 10 ** 6
1000000
```

Python supports the order of operations too, so you can use multiple operations in one expression. You can also use parentheses to modify the order of operations so Python can evaluate your expression in the order you specify. For example:

```
>>> 2 + 3*4
14
>>> (2 + 3) * 4
20
```

The spacing in these examples has no effect on how Python evaluates the expressions; it simply helps you more quickly spot the operations that have priority when you're reading through the code.

Floats

Python calls any number with a decimal point a *float*. This term is used in most programming languages, and it refers to the fact that a decimal point can appear at any position in a number. Every programming language must

be carefully designed to properly manage decimal numbers so numbers behave appropriately no matter where the decimal point appears.

For the most part, you can use decimals without worrying about how they behave. Simply enter the numbers you want to use, and Python will most likely do what you expect:

```
>>> 0.1 + 0.1
0.2
>>> 0.2 + 0.2
0.4
>>> 2 * 0.1
0.2
>>> 2 * 0.2
0.4
```

But be aware that you can sometimes get an arbitrary number of decimal places in your answer:

```
>>> 0.2 + 0.1
0.30000000000000004
>>> 3 * 0.1
0.30000000000000004
```

This happens in all languages and is of little concern. Python tries to find a way to represent the result as precisely as possible, which is sometimes difficult given how computers have to represent numbers internally. Just ignore the extra decimal places for now; you'll learn ways to deal with the extra places when you need to in the projects in Part II.

Avoiding Type Errors with the str() Function

Often, you'll want to use a variable's value within a message. For example, say you want to wish someone a happy birthday. You might write code like this:

birthday.py

```
age = 23
message = "Happy " + age + "rd Birthday!"

print(message)
```

You might expect this code to print the simple birthday greeting, `Happy 23rd birthday!` But if you run this code, you'll see that it generates an error:

```
Traceback (most recent call last):
  File "birthday.py", line 2, in <module>
    message = "Happy " + age + "rd Birthday!"
❶ TypeError: Can't convert 'int' object to str implicitly
```

This is a *type error*. It means Python can't recognize the kind of information you're using. In this example Python sees at ❶ that you're using a variable that has an integer value (`int`), but it's not sure how to interpret that

value. Python knows that the variable could represent either the numerical value 23 or the characters *2* and *3*. When you use integers within strings like this, you need to specify explicitly that you want Python to use the integer as a string of characters. You can do this by wrapping the variable in the `str()` function, which tells Python to represent non-string values as strings:

```
age = 23
message = "Happy " + str(age) + "rd Birthday!"

print(message)
```

Python now knows that you want to convert the numerical value 23 to a string and display the characters `2` and `3` as part of the birthday message. Now you get the message you were expecting, without any errors:

```
Happy 23rd Birthday!
```

Working with numbers in Python is straightforward most of the time. If you're getting unexpected results, check whether Python is interpreting your numbers the way you want it to, either as a numerical value or as a string value.

Integers in Python 2

Python 2 returns a slightly different result when you divide two integers:

```
>>> python2.7
>>> 3 / 2
1
```

Instead of `1.5`, Python returns `1`. Division of integers in Python 2 results in an integer with the remainder truncated. Note that the result is not a rounded integer; the remainder is simply omitted.

To avoid this behavior in Python 2, make sure that at least one of the numbers is a float. By doing so, the result will be a float as well:

```
>>> 3 / 2
1
>>> 3.0 / 2
1.5
>>> 3 / 2.0
1.5
>>> 3.0 / 2.0
1.5
```

This division behavior is a common source of confusion when people who are used to Python 3 start using Python 2, or vice versa. If you use or create code that mixes integers and floats, watch out for irregular behavior.

TRY IT YOURSELF

2-8. Number Eight: Write addition, subtraction, multiplication, and division operations that each result in the number 8. Be sure to enclose your operations in `print` statements to see the results. You should create four lines that look like this:

```
print(5 + 3)
```

Your output should simply be four lines with the number 8 appearing once on each line.

2-9. Favorite Number: Store your favorite number in a variable. Then, using that variable, create a message that reveals your favorite number. Print that message.

Comments

Comments are an extremely useful feature in most programming languages. Everything you've written in your programs so far is Python code. As your programs become longer and more complicated, you should add notes within your programs that describe your overall approach to the problem you're solving. A *comment* allows you to write notes in English within your programs.

How Do You Write Comments?

In Python, the hash mark (#) indicates a comment. Anything following a hash mark in your code is ignored by the Python interpreter. For example:

comment.py

```
# Say hello to everyone.
print("Hello Python people!")
```

Python ignores the first line and executes the second line.

```
Hello Python people!
```

What Kind of Comments Should You Write?

The main reason to write comments is to explain what your code is supposed to do and how you are making it work. When you're in the middle of working on a project, you understand how all of the pieces fit together. But when you return to a project after some time away, you'll likely have forgotten some of the details. You can always study your code for a while and figure out how segments were supposed to work, but writing good comments can save you time by summarizing your overall approach in clear English.

If you want to become a professional programmer or collaborate with other programmers, you should write meaningful comments. Today, most software is written collaboratively, whether by a group of employees at one company or a group of people working together on an open source project. Skilled programmers expect to see comments in code, so it's best to start adding descriptive comments to your programs now. Writing clear, concise comments in your code is one of the most beneficial habits you can form as a new programmer.

When you're determining whether to write a comment, ask yourself if you had to consider several approaches before coming up with a reasonable way to make something work; if so, write a comment about your solution. It's much easier to delete extra comments later on than it is to go back and write comments for a sparsely commented program. From now on, I'll use comments in examples throughout this book to help explain sections of code.

TRY IT YOURSELF

2-10. Adding Comments: Choose two of the programs you've written, and add at least one comment to each. If you don't have anything specific to write because your programs are too simple at this point, just add your name and the current date at the top of each program file. Then write one sentence describing what the program does.

The Zen of Python

For a long time, the programming language Perl was the mainstay of the Internet. Most interactive websites in the early days were powered by Perl scripts. The Perl community's motto at the time was, "There's more than one way to do it." People liked this mind-set for a while, because the flexibility written into the language made it possible to solve most problems in a variety of ways. This approach was acceptable while working on your own projects, but eventually people realized that the emphasis on flexibility made it difficult to maintain large projects over long periods of time. It was difficult, tedious, and time-consuming to review code and try to figure out what someone else was thinking when they were solving a complex problem.

Experienced Python programmers will encourage you to avoid complexity and aim for simplicity whenever possible. The Python community's philosophy is contained in "The Zen of Python" by Tim Peters. You can access this brief set of principles for writing good Python code by entering `import this` into your interpreter. I won't reproduce the entire "Zen of

Python" here, but I'll share a few lines to help you understand why they should be important to you as a beginning Python programmer.

```
>>> import this
The Zen of Python, by Tim Peters

Beautiful is better than ugly.
```

Python programmers embrace the notion that code can be beautiful and elegant. In programming, people solve problems. Programmers have always respected well-designed, efficient, and even beautiful solutions to problems. As you learn more about Python and use it to write more code, someone might look over your shoulder one day and say, "Wow, that's some beautiful code!"

```
Simple is better than complex.
```

If you have a choice between a simple and a complex solution, and both work, use the simple solution. Your code will be easier to maintain, and it will be easier for you and others to build on that code later on.

```
Complex is better than complicated.
```

Real life is messy, and sometimes a simple solution to a problem is unattainable. In that case, use the simplest solution that works.

```
Readability counts.
```

Even when your code is complex, aim to make it readable. When you're working on a project that involves complex coding, focus on writing informative comments for that code.

```
There should be one-- and preferably only one --obvious way to do it.
```

If two Python programmers are asked to solve the same problem, they should come up with fairly compatible solutions. This is not to say there's no room for creativity in programming. On the contrary! But much of programming consists of using small, common approaches to simple situations within a larger, more creative project. The nuts and bolts of your programs should make sense to other Python programmers.

```
Now is better than never.
```

You could spend the rest of your life learning all the intricacies of Python and of programming in general, but then you'd never complete any projects. Don't try to write perfect code; write code that works, and then decide whether to improve your code for that project or move on to something new.

As you continue to the next chapter and start digging into more involved topics, try to keep this philosophy of simplicity and clarity in mind. Experienced programmers will respect your code more and will be happy to give you feedback and collaborate with you on interesting projects.

TRY IT YOURSELF

2-11. Zen of Python: Enter `import this` into a Python terminal session and skim through the additional principles.

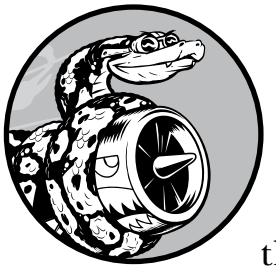
Summary

In this chapter you learned to work with variables. You learned to use descriptive variable names and how to resolve name errors and syntax errors when they arise. You learned what strings are and how to display strings using lowercase, uppercase, and titlecase. You started using whitespace to organize output neatly, and you learned to strip unneeded whitespace from different parts of a string. You started working with integers and floats, and you read about some unexpected behavior to watch out for when working with numerical data. You also learned to write explanatory comments to make your code easier for you and others to read. Finally, you read about the philosophy of keeping your code as simple as possible, whenever possible.

In Chapter 3 you'll learn to store collections of information in variables called *lists*. You'll learn to work through a list, manipulating any information in that list.

3

INTRODUCING LISTS



In this chapter and the next you'll learn what lists are and how to start working with the elements in a list. Lists allow you to store sets of information in one place, whether you have just a few items or millions of items. Lists are one of Python's most powerful features readily accessible to new programmers, and they tie together many important concepts in programming.

What Is a List?

A *list* is a collection of items in a particular order. You can make a list that includes the letters of the alphabet, the digits from 0–9, or the names of all the people in your family. You can put anything you want into a list, and

the items in your list don't have to be related in any particular way. Because a list usually contains more than one element, it's a good idea to make the name of your list plural, such as `letters`, `digits`, or `names`.

In Python, square brackets ([]) indicate a list, and individual elements in the list are separated by commas. Here's a simple example of a list that contains a few kinds of bicycles:

bicycles.py

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles)
```

If you ask Python to print a list, Python returns its representation of the list, including the square brackets:

```
['trek', 'cannondale', 'redline', 'specialized']
```

Because this isn't the output you want your users to see, let's learn how to access the individual items in a list.

Accessing Elements in a List

Lists are ordered collections, so you can access any element in a list by telling Python the position, or *index*, of the item desired. To access an element in a list, write the name of the list followed by the index of the item enclosed in square brackets.

For example, let's pull out the first bicycle in the list `bicycles`:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
❶ print(bicycles[0])
```

The syntax for this is shown at ❶. When we ask for a single item from a list, Python returns just that element without square brackets or quotation marks:

```
trek
```

This is the result you want your users to see—clean, neatly formatted output.

You can also use the string methods from Chapter 2 on any element in a list. For example, you can format the element `'trek'` more neatly by using the `title()` method:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[0].title())
```

This example produces the same output as the preceding example except `'Trek'` is capitalized.

Index Positions Start at 0, Not 1

Python considers the first item in a list to be at position 0, not position 1. This is true of most programming languages, and the reason has to do with how the list operations are implemented at a lower level. If you're receiving unexpected results, determine whether you are making a simple off-by-one error.

The second item in a list has an index of 1. Using this simple counting system, you can get any element you want from a list by subtracting one from its position in the list. For instance, to access the fourth item in a list, you request the item at index 3.

The following asks for the bicycles at index `1` and index `3`:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[1])
print(bicycles[3])
```

This code returns the second and fourth bicycles in the list:

```
cannondale
specialized
```

Python has a special syntax for accessing the last element in a list. By asking for the item at index `-1`, Python always returns the last item in the list:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[-1])
```

This code returns the value `'specialized'`. This syntax is quite useful, because you'll often want to access the last items in a list without knowing exactly how long the list is. This convention extends to other negative index values as well. The index `-2` returns the second item from the end of the list, the index `-3` returns the third item from the end, and so forth.

Using Individual Values from a List

You can use individual values from a list just as you would any other variable. For example, you can use concatenation to create a message based on a value from a list.

Let's try pulling the first bicycle from the list and composing a message using that value.

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
❶ message = "My first bicycle was a " + bicycles[0].title() + "."

print(message)
```

At ❶, we build a sentence using the value at `bicycles[0]` and store it in the variable `message`. The output is a simple sentence about the first bicycle in the list:

```
My first bicycle was a Trek.
```

TRY IT YOURSELF

Try these short programs to get some firsthand experience with Python's lists. You might want to create a new folder for each chapter's exercises to keep them organized.

3-1. Names: Store the names of a few of your friends in a list called `names`. Print each person's name by accessing each element in the list, one at a time.

3-2. Greetings: Start with the list you used in Exercise 3-1, but instead of just printing each person's name, print a message to them. The text of each message should be the same, but each message should be personalized with the person's name.

3-3. Your Own List: Think of your favorite mode of transportation, such as a motorcycle or a car, and make a list that stores several examples. Use your list to print a series of statements about these items, such as "I would like to own a Honda motorcycle."

Changing, Adding, and Removing Elements

Most lists you create will be dynamic, meaning you'll build a list and then add and remove elements from it as your program runs its course. For example, you might create a game in which a player has to shoot aliens out of the sky. You could store the initial set of aliens in a list and then remove an alien from the list each time one is shot down. Each time a new alien appears on the screen, you add it to the list. Your list of aliens will decrease and increase in length throughout the course of the game.

Modifying Elements in a List

The syntax for modifying an element is similar to the syntax for accessing an element in a list. To change an element, use the name of the list followed by the index of the element you want to change, and then provide the new value you want that item to have.

For example, let's say we have a list of motorcycles, and the first item in the list is `'honda'`. How would we change the value of this first item?

motorcycles.py

```
❶ motorcycles = ['honda', 'yamaha', 'suzuki']
  print(motorcycles)

❷ motorcycles[0] = 'ducati'
  print(motorcycles)
```

The code at ❶ defines the original list, with `'honda'` as the first element. The code at ❷ changes the value of the first item to `'ducati'`. The output shows that the first item has indeed been changed, and the rest of the list stays the same:

```
['honda', 'yamaha', 'suzuki']
['ducati', 'yamaha', 'suzuki']
```

You can change the value of any item in a list, not just the first item.

Adding Elements to a List

You might want to add a new element to a list for many reasons. For example, you might want to make new aliens appear in a game, add new data to a visualization, or add new registered users to a website you've built. Python provides several ways to add new data to existing lists.

Appending Elements to the End of a List

The simplest way to add a new element to a list is to *append* the item to the list. When you append an item to a list, the new element is added to the end of the list. Using the same list we had in the previous example, we'll add the new element `'ducati'` to the end of the list:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

❶ motorcycles.append('ducati')
  print(motorcycles)
```

The `append()` method at ❶ adds `'ducati'` to the end of the list without affecting any of the other elements in the list:

```
['honda', 'yamaha', 'suzuki']
['honda', 'yamaha', 'suzuki', 'ducati']
```

The `append()` method makes it easy to build lists dynamically. For example, you can start with an empty list and then add items to the list using a series of `append()` statements. Using an empty list, let's add the elements `'honda'`, `'yamaha'`, and `'suzuki'` to the list:

```
motorcycles = []

motorcycles.append('honda')
motorcycles.append('yamaha')
motorcycles.append('suzuki')

print(motorcycles)
```

The resulting list looks exactly the same as the lists in the previous examples:

```
['honda', 'yamaha', 'suzuki']
```

Building lists this way is very common, because you often won't know the data your users want to store in a program until after the program is running. To put your users in control, start by defining an empty list that will hold the users' values. Then append each new value provided to the list you just created.

Inserting Elements into a List

You can add a new element at any position in your list by using the `insert()` method. You do this by specifying the index of the new element and the value of the new item.

```
motorcycles = ['honda', 'yamaha', 'suzuki']

❶ motorcycles.insert(0, 'ducati')
  print(motorcycles)
```

In this example, the code at ❶ inserts the value `'ducati'` at the beginning of the list. The `insert()` method opens a space at position `0` and stores the value `'ducati'` at that location. This operation shifts every other value in the list one position to the right:

```
['ducati', 'honda', 'yamaha', 'suzuki']
```

Removing Elements from a List

Often, you'll want to remove an item or a set of items from a list. For example, when a player shoots down an alien from the sky, you'll most likely want to remove it from the list of active aliens. Or when a user

decides to cancel their account on a web application you created, you'll want to remove that user from the list of active users. You can remove an item according to its position in the list or according to its value.

Removing an Item Using the del Statement

If you know the position of the item you want to remove from a list, you can use the `del` statement.

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

❶ del motorcycles[0]
print(motorcycles)
```

The code at ❶ uses `del` to remove the first item, `'honda'`, from the list of motorcycles:

```
['honda', 'yamaha', 'suzuki']
['yamaha', 'suzuki']
```

You can remove an item from any position in a list using the `del` statement if you know its index. For example, here's how to remove the second item, `'yamaha'`, in the list:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

del motorcycles[1]
print(motorcycles)
```

The second motorcycle is deleted from the list:

```
['honda', 'yamaha', 'suzuki']
['honda', 'suzuki']
```

In both examples, you can no longer access the value that was removed from the list after the `del` statement is used.

Removing an Item Using the pop() Method

Sometimes you'll want to use the value of an item after you remove it from a list. For example, you might want to get the *x* and *y* position of an alien that was just shot down, so you can draw an explosion at that position. In a web application, you might want to remove a user from a list of active members and then add that user to a list of inactive members.

The `pop()` method removes the last item in a list, but it lets you work with that item after removing it. The term *pop* comes from thinking of a list as a stack of items and popping one item off the top of the stack. In this analogy, the top of a stack corresponds to the end of a list.

Let's pop a motorcycle from the list of motorcycles:

```
❶ motorcycles = ['honda', 'yamaha', 'suzuki']
  print(motorcycles)

❷ popped_motorcycle = motorcycles.pop()
❸ print(motorcycles)
❹ print(popped_motorcycle)
```

We start by defining and printing the list `motorcycles` at ❶. At ❷ we pop a value from the list and store that value in the variable `popped_motorcycle`. We print the list at ❸ to show that a value has been removed from the list. Then we print the popped value at ❹ to prove that we still have access to the value that was removed.

The output shows that the value `'suzuki'` was removed from the end of the list and is now stored in the variable `popped_motorcycle`:

```
['honda', 'yamaha', 'suzuki']
['honda', 'yamaha']
suzuki
```

How might this `pop()` method be useful? Imagine that the motorcycles in the list are stored in chronological order according to when we owned them. If this is the case, we can use the `pop()` method to print a statement about the last motorcycle we bought:

```
motorcycles = ['honda', 'yamaha', 'suzuki']

last_owned = motorcycles.pop()
print("The last motorcycle I owned was a " + last_owned.title() + ".")
```

The output is a simple sentence about the most recent motorcycle we owned:

```
The last motorcycle I owned was a Suzuki.
```

Popping Items from any Position in a List

You can actually use `pop()` to remove an item in a list at any position by including the index of the item you want to remove in parentheses.

```
motorcycles = ['honda', 'yamaha', 'suzuki']

❶ first_owned = motorcycles.pop(0)
❷ print('The first motorcycle I owned was a ' + first_owned.title() + '.')
```

We start by popping the first motorcycle in the list at ❶, and then we print a message about that motorcycle at ❷. The output is a simple sentence describing the first motorcycle I ever owned:

```
The first motorcycle I owned was a Honda.
```

Remember that each time you use `pop()`, the item you work with is no longer stored in the list.

If you're unsure whether to use the `del` statement or the `pop()` method, here's a simple way to decide: when you want to delete an item from a list and not use that item in any way, use the `del` statement; if you want to use an item as you remove it, use the `pop()` method.

Removing an Item by Value

Sometimes you won't know the position of the value you want to remove from a list. If you only know the value of the item you want to remove, you can use the `remove()` method.

For example, let's say we want to remove the value `'ducati'` from the list of motorcycles.

```
motorcycles = ['honda', 'yamaha', 'suzuki', 'ducati']
print(motorcycles)

❶ motorcycles.remove('ducati')
print(motorcycles)
```

The code at ❶ tells Python to figure out where `'ducati'` appears in the list and remove that element:

```
['honda', 'yamaha', 'suzuki', 'ducati']
['honda', 'yamaha', 'suzuki']
```

You can also use the `remove()` method to work with a value that's being removed from a list. Let's remove the value `'ducati'` and print a reason for removing it from the list:

```
❶ motorcycles = ['honda', 'yamaha', 'suzuki', 'ducati']
print(motorcycles)

❷ too_expensive = 'ducati'
❸ motorcycles.remove(too_expensive)
print(motorcycles)
❹ print("\nA " + too_expensive.title() + " is too expensive for me.")
```

After defining the list at ❶, we store the value `'ducati'` in a variable called `too_expensive` ❷. We then use this variable to tell Python which value

to remove from the list at ❸. At ❹ the value `'ducati'` has been removed from the list but is still stored in the variable `too_expensive`, allowing us to print a statement about why we removed `'ducati'` from the list of motorcycles:

```
['honda', 'yamaha', 'suzuki', 'ducati']
['honda', 'yamaha', 'suzuki']

A Ducati is too expensive for me.
```

NOTE *The `remove()` method deletes only the first occurrence of the value you specify. If there's a possibility the value appears more than once in the list, you'll need to use a loop to determine if all occurrences of the value have been removed. You'll learn how to do this in Chapter 7.*

TRY IT YOURSELF

The following exercises are a bit more complex than those in Chapter 2, but they give you an opportunity to use lists in all of the ways described.

3-4. Guest List: If you could invite anyone, living or deceased, to dinner, who would you invite? Make a list that includes at least three people you'd like to invite to dinner. Then use your list to print a message to each person, inviting them to dinner.

3-5. Changing Guest List: You just heard that one of your guests can't make the dinner, so you need to send out a new set of invitations. You'll have to think of someone else to invite.

- Start with your program from Exercise 3-4. Add a `print` statement at the end of your program stating the name of the guest who can't make it.
- Modify your list, replacing the name of the guest who can't make it with the name of the new person you are inviting.
- Print a second set of invitation messages, one for each person who is still in your list.

3-6. More Guests: You just found a bigger dinner table, so now more space is available. Think of three more guests to invite to dinner.

- Start with your program from Exercise 3-4 or Exercise 3-5. Add a `print` statement to the end of your program informing people that you found a bigger dinner table.
- Use `insert()` to add one new guest to the beginning of your list.
- Use `insert()` to add one new guest to the middle of your list.
- Use `append()` to add one new guest to the end of your list.
- Print a new set of invitation messages, one for each person in your list.

3-7. Shrinking Guest List: You just found out that your new dinner table won't arrive in time for the dinner, and you have space for only two guests.

- Start with your program from Exercise 3-6. Add a new line that prints a message saying that you can invite only two people for dinner.
- Use `pop()` to remove guests from your list one at a time until only two names remain in your list. Each time you pop a name from your list, print a message to that person letting them know you're sorry you can't invite them to dinner.
- Print a message to each of the two people still on your list, letting them know they're still invited.
- Use `del` to remove the last two names from your list, so you have an empty list. Print your list to make sure you actually have an empty list at the end of your program.

Organizing a List

Often, your lists will be created in an unpredictable order, because you can't always control the order in which your users provide their data. Although this is unavoidable in most circumstances, you'll frequently want to present your information in a particular order. Sometimes you'll want to preserve the original order of your list, and other times you'll want to change the original order. Python provides a number of different ways to organize your lists, depending on the situation.

Sorting a List Permanently with the sort() Method

Python's `sort()` method makes it relatively easy to sort a list. Imagine we have a list of cars and want to change the order of the list to store them alphabetically. To keep the task simple, let's assume that all the values in the list are lowercase.

cars.py

```
cars = ['bmw', 'audi', 'toyota', 'subaru']
❶ cars.sort()
print(cars)
```

The `sort()` method, shown at ❶, changes the order of the list permanently. The cars are now in alphabetical order, and we can never revert to the original order:

```
['audi', 'bmw', 'subaru', 'toyota']
```

You can also sort this list in reverse alphabetical order by passing the argument `reverse=True` to the `sort()` method. The following example sorts the list of cars in reverse alphabetical order:

```
cars = ['bmw', 'audi', 'toyota', 'subaru']
cars.sort(reverse=True)
print(cars)
```

Again, the order of the list is permanently changed:

```
['toyota', 'subaru', 'bmw', 'audi']
```

Sorting a List Temporarily with the sorted() Function

To maintain the original order of a list but present it in a sorted order, you can use the `sorted()` function. The `sorted()` function lets you display your list in a particular order but doesn't affect the actual order of the list.

Let's try this function on the list of cars.

```
cars = ['bmw', 'audi', 'toyota', 'subaru']

❶ print("Here is the original list:")
  print(cars)

❷ print("\nHere is the sorted list:")
  print(sorted(cars))

❸ print("\nHere is the original list again:")
  print(cars)
```

We first print the list in its original order at ❶ and then in alphabetical order at ❷. After the list is displayed in the new order, we show that the list is still stored in its original order at ❸.

```
Here is the original list:
['bmw', 'audi', 'toyota', 'subaru']

Here is the sorted list:
['audi', 'bmw', 'subaru', 'toyota']

❹ Here is the original list again:
['bmw', 'audi', 'toyota', 'subaru']
```

Notice that the list still exists in its original order at ❹ after the `sorted()` function has been used. The `sorted()` function can also accept a `reverse=True` argument if you want to display a list in reverse alphabetical order.

NOTE *Sorting a list alphabetically is a bit more complicated when all the values are not in lowercase. There are several ways to interpret capital letters when you're deciding on a sort order, and specifying the exact order can be more complex than we want to deal with at this time. However, most approaches to sorting will build directly on what you learned in this section.*

Printing a List in Reverse Order

To reverse the original order of a list, you can use the `reverse()` method. If we originally stored the list of cars in chronological order according to when we owned them, we could easily rearrange the list into reverse chronological order:

```
cars = ['bmw', 'audi', 'toyota', 'subaru']
print(cars)

cars.reverse()
print(cars)
```

Notice that `reverse()` doesn't sort backward alphabetically; it simply reverses the order of the list:

```
['bmw', 'audi', 'toyota', 'subaru']
['subaru', 'toyota', 'audi', 'bmw']
```

The `reverse()` method changes the order of a list permanently, but you can revert to the original order anytime by applying `reverse()` to the same list a second time.

Finding the Length of a List

You can quickly find the length of a list by using the `len()` function. The list in this example has four items, so its length is `4`:

```
>>> cars = ['bmw', 'audi', 'toyota', 'subaru']
>>> len(cars)
4
```

You'll find `len()` useful when you need to identify the number of aliens that still need to be shot down in a game, determine the amount of data you have to manage in a visualization, or figure out the number of registered users on a website, among other tasks.

NOTE *Python counts the items in a list starting with one, so you shouldn't run into any off-by-one errors when determining the length of a list.*

TRY IT YOURSELF

3-8. Seeing the World: Think of at least five places in the world you'd like to visit.

- Store the locations in a list. Make sure the list is not in alphabetical order.
- Print your list in its original order. Don't worry about printing the list neatly, just print it as a raw Python list.
- Use `sorted()` to print your list in alphabetical order without modifying the actual list.
- Show that your list is still in its original order by printing it.
- Use `sorted()` to print your list in reverse alphabetical order without changing the order of the original list.
- Show that your list is still in its original order by printing it again.
- Use `reverse()` to change the order of your list. Print the list to show that its order has changed.
- Use `reverse()` to change the order of your list again. Print the list to show it's back to its original order.
- Use `sort()` to change your list so it's stored in alphabetical order. Print the list to show that its order has been changed.
- Use `sort()` to change your list so it's stored in reverse alphabetical order. Print the list to show that its order has changed.

3-9. Dinner Guests: Working with one of the programs from Exercises 3-4 through 3-7 (page 46), use `len()` to print a message indicating the number of people you are inviting to dinner.

3-10. Every Function: Think of something you could store in a list. For example, you could make a list of mountains, rivers, countries, cities, languages, or anything else you'd like. Write a program that creates a list containing these items and then uses each function introduced in this chapter at least once.

Avoiding Index Errors When Working with Lists

One type of error is common to see when you're working with lists for the first time. Let's say you have a list with three items, and you ask for the fourth item:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles[3])
```

This example results in an *index error*:

```
Traceback (most recent call last):
  File "motorcycles.py", line 3, in <module>
    print(motorcycles[3])
IndexError: list index out of range
```

Python attempts to give you the item at index 3. But when it searches the list, no item in `motorcycles` has an index of 3. Because of the off-by-one nature of indexing in lists, this error is typical. People think the third item is item number 3, because they start counting at 1. But in Python the third item is number 2, because it starts indexing at 0.

An index error means Python can't figure out the index you requested. If an index error occurs in your program, try adjusting the index you're asking for by one. Then run the program again to see if the results are correct.

Keep in mind that whenever you want to access the last item in a list you use the index `-1`. This will always work, even if your list has changed size since the last time you accessed it:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles[-1])
```

The index `-1` always returns the last item in a list, in this case the value `'suzuki'`:

```
'suzuki'
```

The only time this approach will cause an error is when you request the last item from an empty list:

```
motorcycles = []
print(motorcycles[-1])
```

No items are in `motorcycles`, so Python returns another index error:

```
Traceback (most recent call last):
  File "motorcyles.py", line 3, in <module>
    print(motorcycles[-1])
IndexError: list index out of range
```

NOTE *If an index error occurs and you can't figure out how to resolve it, try printing your list or just printing the length of your list. Your list might look much different than you thought it did, especially if it has been managed dynamically by your program. Seeing the actual list, or the exact number of items in your list, can help you sort out such logical errors.*

TRY IT YOURSELF

3-11. Intentional Error: If you haven't received an index error in one of your programs yet, try to make one happen. Change an index in one of your programs to produce an index error. Make sure you correct the error before closing the program.

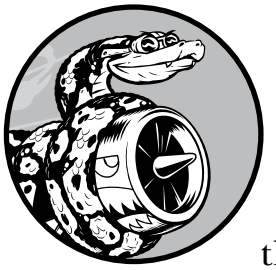
Summary

In this chapter you learned what lists are and how to work with the individual items in a list. You learned how to define a list and how to add and remove elements. You learned to sort lists permanently and temporarily for display purposes. You also learned how to find the length of a list and how to avoid index errors when you're working with lists.

In Chapter 4 you'll learn how to work with items in a list more efficiently. By looping through each item in a list using just a few lines of code you'll be able to work efficiently, even when your list contains thousands or millions of items.

4

WORKING WITH LISTS



In Chapter 3 you learned how to make a simple list, and you learned to work with the individual elements in a list. In this chapter you'll learn how to *loop* through an entire list using just a few lines of code regardless of how long the list is. Looping allows you to take the same action, or set of actions, with every item in a list. As a result, you'll be able to work efficiently with lists of any length, including those with thousands or even millions of items.

Looping Through an Entire List

You'll often want to run through all entries in a list, performing the same task with each item. For example, in a game you might want to move every element on the screen by the same amount, or in a list of numbers you might want to perform the same statistical operation on every element. Or perhaps you'll want to display each headline from a list of articles on a website. When you want to do the same action with every item in a list, you can use Python's `for` loop.

Let's say we have a list of magicians' names, and we want to print out each name in the list. We could do this by retrieving each name from the list individually, but this approach could cause several problems. For one, it would be repetitive to do this with a long list of names. Also, we'd have to change our code each time the list's length changed. A `for` loop avoids both of these issues by letting Python manage these issues internally.

Let's use a `for` loop to print out each name in a list of magicians:

magicians.py

```
❶ magicians = ['alice', 'david', 'carolina']
❷ for magician in magicians:
❸     print(magician)
```

We begin by defining a list at ❶, just as we did in Chapter 3. At ❷, we define a `for` loop. This line tells Python to pull a name from the list `magicians`, and store it in the variable `magician`. At ❸ we tell Python to print the name that was just stored in `magician`. Python then repeats lines ❷ and ❸, once for each name in the list. It might help to read this code as "For every magician in the list of magicians, print the magician's name." The output is a simple printout of each name in the list:

```
alice
david
carolina
```

A Closer Look at Looping

The concept of looping is important because it's one of the most common ways a computer automates repetitive tasks. For example, in a simple loop like we used in *magicians.py*, Python initially reads the first line of the loop:

```
for magician in magicians:
```

This line tells Python to retrieve the first value from the list `magicians` and store it in the variable `magician`. This first value is `'alice'`. Python then reads the next line:

```
    print(magician)
```

Python prints the current value of `magician`, which is still `'alice'`. Because the list contains more values, Python returns to the first line of the loop:

```
for magician in magicians:
```

Python retrieves the next name in the list, `'david'`, and stores that value in `magician`. Python then executes the line:

```
    print(magician)
```

Python prints the current value of `magician` again, which is now `'david'`. Python repeats the entire loop once more with the last value in the list, `'carolina'`. Because no more values are in the list, Python moves on to the next line in the program. In this case nothing comes after the `for` loop, so the program simply ends.

When you're using loops for the first time, keep in mind that the set of steps is repeated once for each item in the list, no matter how many items are in the list. If you have a million items in your list, Python repeats these steps a million times—and usually very quickly.

Also keep in mind when writing your own `for` loops that you can choose any name you want for the temporary variable that holds each value in the list. However, it's helpful to choose a meaningful name that represents a single item from the list. For example, here's a good way to start a `for` loop for a list of cats, a list of dogs, and a general list of items:

```
for cat in cats:
for dog in dogs:
for item in list_of_items:
```

These naming conventions can help you follow the action being done on each item within a `for` loop. Using singular and plural names can help you identify whether a section of code is working with a single element from the list or the entire list.

Doing More Work Within a for Loop

You can do just about anything with each item in a `for` loop. Let's build on the previous example by printing a message to each magician, telling them that they performed a great trick:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
❶    print(magician.title() + ", that was a great trick!")
```

The only difference in this code is at ❶ where we compose a message to each magician, starting with that magician's name. The first time through the loop the value of magician is `'alice'`, so Python starts the first message with the name `'Alice'`. The second time through the message will begin with `'David'`, and the third time through the message will begin with `'Carolina'`.

The output shows a personalized message for each magician in the list:

```
Alice, that was a great trick!
David, that was a great trick!
Carolina, that was a great trick!
```

You can also write as many lines of code as you like in the `for` loop. Every indented line following the line `for magician in magicians` is considered *inside the loop*, and each indented line is executed once for each

value in the list. Therefore, you can do as much work as you like with each value in the list.

Let's add a second line to our message, telling each magician that we're looking forward to their next trick:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(magician.title() + ", that was a great trick!")
❶   print("I can't wait to see your next trick, " + magician.title() + ".\n")
```

Because we have indented both `print` statements, each line will be executed once for every magician in the list. The newline (`"\n"`) in the second `print` statement ❶ inserts a blank line after each pass through the loop. This creates a set of messages that are neatly grouped for each person in the list:

```
Alice, that was a great trick!
I can't wait to see your next trick, Alice.

David, that was a great trick!
I can't wait to see your next trick, David.

Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.
```

You can use as many lines as you like in your `for` loops. In practice you'll often find it useful to do a number of different operations with each item in a list when you use a `for` loop.

Doing Something After a for Loop

What happens once a `for` loop has finished executing? Usually, you'll want to summarize a block of output or move on to other work that your program must accomplish.

Any lines of code after the `for` loop that are not indented are executed once without repetition. Let's write a thank you to the group of magicians as a whole, thanking them for putting on an excellent show. To display this group message after all of the individual messages have been printed, we place the thank you message after the `for` loop without indentation:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(magician.title() + ", that was a great trick!")
    print("I can't wait to see your next trick, " + magician.title() + ".\n")

❶ print("Thank you, everyone. That was a great magic show!")
```

The first two `print` statements are repeated once for each magician in the list, as you saw earlier. However, because the line at ❶ is not indented, it's printed only once:

```
Alice, that was a great trick!
I can't wait to see your next trick, Alice.

David, that was a great trick!
I can't wait to see your next trick, David.

Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.

Thank you, everyone. That was a great magic show!
```

When you're processing data using a `for` loop, you'll find that this is a good way to summarize an operation that was performed on an entire data set. For example, you might use a `for` loop to initialize a game by running through a list of characters and displaying each character on the screen. You might then write an unindented block after this loop that displays a Play Now button after all the characters have been drawn to the screen.

Avoiding Indentation Errors

Python uses indentation to determine when one line of code is connected to the line above it. In the previous examples, the lines that printed messages to individual magicians were part of the `for` loop because they were indented. Python's use of indentation makes code very easy to read. Basically, it uses whitespace to force you to write neatly formatted code with a clear visual structure. In longer Python programs, you'll notice blocks of code indented at a few different levels. These indentation levels help you gain a general sense of the overall program's organization.

As you begin to write code that relies on proper indentation, you'll need to watch for a few common *indentation errors*. For example, people sometimes indent blocks of code that don't need to be indented or forget to indent blocks that need to be indented. Seeing examples of these errors now will help you avoid them in the future and correct them when they do appear in your own programs.

Let's examine some of the more common indentation errors.

Forgetting to Indent

Always indent the line after the `for` statement in a loop. If you forget, Python will remind you:

magicians.py

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
❶ print(magician)
```

The print statement at ❶ should be indented, but it's not. When Python expects an indented block and doesn't find one, it lets you know which line it had a problem with.

```
  File "magicians.py", line 3
    print(magician)
        ^
IndentationError: expected an indented block
```

You can usually resolve this kind of indentation error by indenting the line or lines immediately after the for statement.

Forgetting to Indent Additional Lines

Sometimes your loop will run without any errors but won't produce the expected result. This can happen when you're trying to do several tasks in a loop and you forget to indent some of its lines.

For example, this is what happens when we forget to indent the second line in the loop that tells each magician we're looking forward to their next trick:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(magician.title() + ", that was a great trick!")
❶ print("I can't wait to see your next trick, " + magician.title() + ".\n")
```

The print statement at ❶ is supposed to be indented, but because Python finds at least one indented line after the for statement, it doesn't report an error. As a result, the first print statement is executed once for each name in the list because it is indented. The second print statement is not indented, so it is executed only once after the loop has finished running. Because the final value of magician is 'carolina', she is the only one who receives the "looking forward to the next trick" message:

```
Alice, that was a great trick!
David, that was a great trick!
Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.
```

This is a *logical error*. The syntax is valid Python code, but the code does not produce the desired result because a problem occurs in its logic. If you expect to see a certain action repeated once for each item in a list and it's executed only once, determine whether you need to simply indent a line or a group of lines.

Indenting Unnecessarily

If you accidentally indent a line that doesn't need to be indented, Python informs you about the unexpected indent:

hello_world.py

```
message = "Hello Python world!"
    print(message)
```

❶

We don't need to indent the `print` statement at ❶, because it doesn't *belong* to the line above it; hence, Python reports that error:

```
  File "hello_world.py", line 2
    print(message)
    ^
IndentationError: unexpected indent
```

You can avoid unexpected indentation errors by indenting only when you have a specific reason to do so. In the programs you're writing at this point, the only lines you should indent are the actions you want to repeat for each item in a `for` loop.

Indenting Unnecessarily After the Loop

If you accidentally indent code that should run after a loop has finished, that code will be repeated once for each item in the list. Sometimes this prompts Python to report an error, but often you'll receive a simple logical error.

For example, let's see what happens when we accidentally indent the line that thanked the magicians as a group for putting on a good show:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(magician.title() + ", that was a great trick!")
    print("I can't wait to see your next trick, " + magician.title() + ".\n")

    print("Thank you everyone, that was a great magic show!")
```

❶

Because the line at ❶ is indented, it's printed once for each person in the list, as you can see at ❷:

```
Alice, that was a great trick!
I can't wait to see your next trick, Alice.

❷ Thank you everyone, that was a great magic show!
David, that was a great trick!
I can't wait to see your next trick, David.

❷ Thank you everyone, that was a great magic show!
Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.

❷ Thank you everyone, that was a great magic show!
```

This is another logical error, similar to the one in "Forgetting to Indent Additional Lines" on page 58. Because Python doesn't know what you're trying to accomplish with your code, it will run all code that is written in valid syntax. If an action is repeated many times when it should be executed only once, determine whether you just need to unindent the code for that action.

Forgetting the Colon

The colon at the end of a `for` statement tells Python to interpret the next line as the start of a loop.

```
magicians = ['alice', 'david', 'carolina']
❶ for magician in magicians
    print(magician)
```

If you accidentally forget the colon, as shown at ❶, you'll get a syntax error because Python doesn't know what you're trying to do. Although this is an easy error to fix, it's not always an easy error to find. You'd be surprised by the amount of time programmers spend hunting down single-character errors like this. Such errors are difficult to find because we often just see what we expect to see.

TRY IT YOURSELF

4-1. Pizzas: Think of at least three kinds of your favorite pizza. Store these pizza names in a list, and then use a `for` loop to print the name of each pizza.

- Modify your `for` loop to print a sentence using the name of the pizza instead of printing just the name of the pizza. For each pizza you should have one line of output containing a simple statement like *I like pepperoni pizza.*
- Add a line at the end of your program, outside the `for` loop, that states how much you like pizza. The output should consist of three or more lines about the kinds of pizza you like and then an additional sentence, such as *I really love pizza!*

4-2. Animals: Think of at least three different animals that have a common characteristic. Store the names of these animals in a list, and then use a `for` loop to print out the name of each animal.

- Modify your program to print a statement about each animal, such as *A dog would make a great pet.*
- Add a line at the end of your program stating what these animals have in common. You could print a sentence such as *Any of these animals would make a great pet!*

Making Numerical Lists

Many reasons exist to store a set of numbers. For example, you'll need to keep track of the positions of each character in a game, and you might want to keep track of a player's high scores as well. In data visualizations, you'll almost always work with sets of numbers, such as temperatures, distances, population sizes, or latitude and longitude values, among other types of numerical sets.

Lists are ideal for storing sets of numbers, and Python provides a number of tools to help you work efficiently with lists of numbers. Once you understand how to use these tools effectively, your code will work well even when your lists contain millions of items.

Using the range() Function

Python's `range()` function makes it easy to generate a series of numbers. For example, you can use the `range()` function to print a series of numbers like this:

numbers.py

```
for value in range(1,5):
    print(value)
```

Although this code looks like it should print the numbers from 1 to 5, it doesn't print the number 5:

```
1
2
3
4
```

In this example, `range()` prints only the numbers 1 through 4. This is another result of the off-by-one behavior you'll see often in programming languages. The `range()` function causes Python to start counting at the first value you give it, and it stops when it reaches the second value you provide. Because it stops at that second value, the output never contains the end value, which would have been 5 in this case.

To print the numbers from 1 to 5, you would use `range(1,6)`:

```
for value in range(1,6):
    print(value)
```

This time the output starts at 1 and ends at 5:

```
1
2
3
4
5
```

If your output is different than what you expect when you're using `range()`, try adjusting your end value by 1.

Using range() to Make a List of Numbers

If you want to make a list of numbers, you can convert the results of `range()` directly into a list using the `list()` function. When you wrap `list()` around a call to the `range()` function, the output will be a list of numbers.

In the example in the previous section, we simply printed out a series of numbers. We can use `list()` to convert that same set of numbers into a list:

```
numbers = list(range(1,6))
print(numbers)
```

And this is the result:

```
[1, 2, 3, 4, 5]
```

We can also use the `range()` function to tell Python to skip numbers in a given range. For example, here's how we would list the even numbers between 1 and 10:

even_numbers.py

```
even_numbers = list(range(2,11,2))
print(even_numbers)
```

In this example, the `range()` function starts with the value 2 and then adds 2 to that value. It adds 2 repeatedly until it reaches or passes the end value, 11, and produces this result:

```
[2, 4, 6, 8, 10]
```

You can create almost any set of numbers you want to using the `range()` function. For example, consider how you might make a list of the first 10 square numbers (that is, the square of each integer from 1 through 10). In Python, two asterisks (**) represent exponents. Here's how you might put the first 10 square numbers into a list:

squares.py

```
❶ squares = []
❷ for value in range(1,11):
❸     square = value**2
❹     squares.append(square)

❺ print(squares)
```

We start with an empty list called `squares` at ❶. At ❷, we tell Python to loop through each value from 1 to 10 using the `range()` function. Inside the loop, the current value is raised to the second power and stored in the

variable `square` at ❸. At ❹, each new value of `square` is appended to the list `squares`. Finally, when the loop has finished running, the list of squares is printed at ❺:

```
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
```

To write this code more concisely, omit the temporary variable `square` and append each new value directly to the list:

```
squares = []
for value in range(1,11):
❶     squares.append(value**2)

print(squares)
```

The code at ❶ does the same work as the lines at ❸ and ❹ in *squares.py*. Each value in the loop is raised to the second power and then immediately appended to the list of squares.

You can use either of these two approaches when you're making more complex lists. Sometimes using a temporary variable makes your code easier to read; other times it makes the code unnecessarily long. Focus first on writing code that you understand clearly, which does what you want it to do. Then look for more efficient approaches as you review your code.

Simple Statistics with a List of Numbers

A few Python functions are specific to lists of numbers. For example, you can easily find the minimum, maximum, and sum of a list of numbers:

```
>>> digits = [1, 2, 3, 4, 5, 6, 7, 8, 9, 0]
>>> min(digits)
0
>>> max(digits)
9
>>> sum(digits)
45
```

NOTE *The examples in this section use short lists of numbers in order to fit easily on the page. They would work just as well if your list contained a million or more numbers.*

List Comprehensions

The approach described earlier for generating the list `squares` consisted of using three or four lines of code. A *list comprehension* allows you to generate this same list in just one line of code. A list comprehension combines the `for` loop and the creation of new elements into one line, and automatically appends each new element. List comprehensions are not always presented to beginners, but I have included them here because you'll most likely see them as soon as you start looking at other people's code.

The following example builds the same list of square numbers you saw earlier but uses a list comprehension:

squares.py

```
squares = [value**2 for value in range(1,11)]
print(squares)
```

To use this syntax, begin with a descriptive name for the list, such as `squares`. Next, open a set of square brackets and define the expression for the values you want to store in the new list. In this example the expression is `value**2`, which raises the value to the second power. Then, write a `for` loop to generate the numbers you want to feed into the expression, and close the square brackets. The `for` loop in this example is `for value in range(1,11)`, which feeds the values 1 through 10 into the expression `value**2`. Notice that no colon is used at the end of the `for` statement.

The result is the same list of square numbers you saw earlier:

```
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
```

It takes practice to write your own list comprehensions, but you'll find them worthwhile once you become comfortable creating ordinary lists. When you're writing three or four lines of code to generate lists and it begins to feel repetitive, consider writing your own list comprehensions.

TRY IT YOURSELF

4-3. Counting to Twenty: Use a `for` loop to print the numbers from 1 to 20, inclusive.

4-4. One Million: Make a list of the numbers from one to one million, and then use a `for` loop to print the numbers. (If the output is taking too long, stop it by pressing CTRL-C or by closing the output window.)

4-5. Summing a Million: Make a list of the numbers from one to one million, and then use `min()` and `max()` to make sure your list actually starts at one and ends at one million. Also, use the `sum()` function to see how quickly Python can add a million numbers.

4-6. Odd Numbers: Use the third argument of the `range()` function to make a list of the odd numbers from 1 to 20. Use a `for` loop to print each number.

4-7. Threes: Make a list of the multiples of 3 from 3 to 30. Use a `for` loop to print the numbers in your list.

4-8. Cubes: A number raised to the third power is called a *cube*. For example, the cube of 2 is written as `2**3` in Python. Make a list of the first 10 cubes (that is, the cube of each integer from 1 through 10), and use a `for` loop to print out the value of each cube.

4-9. Cube Comprehension: Use a list comprehension to generate a list of the first 10 cubes.

Working with Part of a List

In Chapter 3 you learned how to access single elements in a list, and in this chapter you've been learning how to work through all the elements in a list. You can also work with a specific group of items in a list, which Python calls a *slice*.

Slicing a List

To make a slice, you specify the index of the first and last elements you want to work with. As with the `range()` function, Python stops one item before the second index you specify. To output the first three elements in a list, you would request indices `0` through `3`, which would return elements `0`, `1`, and `2`.

The following example involves a list of players on a team:

players.py

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
❶ print(players[0:3])
```

The code at ❶ prints a slice of this list, which includes just the first three players. The output retains the structure of the list and includes the first three players in the list:

```
['charles', 'martina', 'michael']
```

You can generate any subset of a list. For example, if you want the second, third, and fourth items in a list, you would start the slice at index `1` and end at index `4`:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[1:4])
```

This time the slice starts with `'martina'` and ends with `'florence'`:

```
['martina', 'michael', 'florence']
```

If you omit the first index in a slice, Python automatically starts your slice at the beginning of the list:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[:4])
```

Without a starting index, Python starts at the beginning of the list:

```
['charles', 'martina', 'michael', 'florence']
```

A similar syntax works if you want a slice that includes the end of a list. For example, if you want all items from the third item through the last item, you can start with index `2` and omit the second index:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[2:])
```

Python returns all items from the third item through the end of the list:

```
['michael', 'florence', 'eli']
```

This syntax allows you to output all of the elements from any point in your list to the end regardless of the length of the list. Recall that a negative index returns an element a certain distance from the end of a list; therefore, you can output any slice from the end of a list. For example, if we want to output the last three players on the roster, we can use the slice `players[-3:]`:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[-3:])
```

This prints the names of the last three players and would continue to work as the list of players changes in size.

Looping Through a Slice

You can use a slice in a `for` loop if you want to loop through a subset of the elements in a list. In the next example we loop through the first three players and print their names as part of a simple roster:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']

print("Here are the first three players on my team:")
❶ for player in players[:3]:
    print(player.title())
```

Instead of looping through the entire list of players at ❶, Python loops through only the first three names:

```
Here are the first three players on my team:
Charles
Martina
Michael
```

Slices are very useful in a number of situations. For instance, when you're creating a game, you could add a player's final score to a list every time that player finishes playing. You could then get a player's top three scores by sorting the list in decreasing order and taking a slice that includes just the first three scores. When you're working with data, you can use slices to process

your data in chunks of a specific size. Or, when you're building a web application, you could use slices to display information in a series of pages with an appropriate amount of information on each page.

Copying a List

Often, you'll want to start with an existing list and make an entirely new list based on the first one. Let's explore how copying a list works and examine one situation in which copying a list is useful.

To copy a list, you can make a slice that includes the entire original list by omitting the first index and the second index (`[:]`). This tells Python to make a slice that starts at the first item and ends with the last item, producing a copy of the entire list.

For example, imagine we have a list of our favorite foods and want to make a separate list of foods that a friend likes. This friend likes everything in our list so far, so we can create their list by copying ours:

foods.py

```
❶ my_foods = ['pizza', 'falafel', 'carrot cake']
❷ friend_foods = my_foods[:]

print("My favorite foods are:")
print(my_foods)

print("\nMy friend's favorite foods are:")
print(friend_foods)
```

At ❶ we make a list of the foods we like called `my_foods`. At ❷ we make a new list called `friend_foods`. We make a copy of `my_foods` by asking for a slice of `my_foods` without specifying any indices and store the copy in `friend_foods`. When we print each list, we see that they both contain the same foods:

```
My favorite foods are:
['pizza', 'falafel', 'carrot cake']

My friend's favorite foods are:
['pizza', 'falafel', 'carrot cake']
```

To prove that we actually have two separate lists, we'll add a new food to each list and show that each list keeps track of the appropriate person's favorite foods:

```
my_foods = ['pizza', 'falafel', 'carrot cake']
❶ friend_foods = my_foods[:]

❷ my_foods.append('cannoli')
❸ friend_foods.append('ice cream')

print("My favorite foods are:")
print(my_foods)
```