LEARNING MADE EASY

3rd Edition

Raspberry Pi®

for dummies®
A Wiley Brand

Connect the Raspberry Pi and install the OS

Learn Programming with Scratch® and Python®

Create electronics projects connected to the GPIO port

Sean McManus
Mike Cook

Raspberry Pi®

3rd Edition

by Sean McManus and Mike Cook

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Raspberry Pi® For Dummies®, 3rd Edition

Published by: **John Wiley & Sons, Inc.,** 111 River Street, Hoboken, NJ 07030-5774, www.wiley.com

Published simultaneously in Canada

Library of Congress Control Number: 2017950656

ISBN: 978-1-119-41200-7; 978-1-119-41202-1 (ebk); 978-1-119-41201-4 (ebk)

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Contents at a Glance

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Introduction

The Raspberry Pi is at the forefront of the maker movement, where people make their own inventions using a mixture of traditional craft skills and modern coding and electronics knowledge. It's also given more and more people access to a computer that provides a gateway into programming, electronics, and the world of Linux — the technically powerful (and free) rival to Windows and Mac OS. As a supercheap computer, the Raspberry Pi is also being pressed into service in media centers and as a family computer for games, music, photo editing, and word processing.

Although the Raspberry Pi presents new opportunities to everyone, it can also be a daunting prospect. It comes as a bare circuit board, so to do anything with it, you need to add an operating system on an SD or microSD card and connect it up to a screen, mouse, and keyboard. To get started, you need to learn a few basics of Linux, or at least get acquainted with PIXEL, the graphical desktop. You might be a geek who relishes learning new technologies, or you might be someone who wants a new family computer to use with the children. In either case, *Raspberry Pi For Dummies,* 3rd Edition, helps you get started with your Raspberry Pi and teaches you about some of the many fun and inspiring things you can do with it.

About This Book

Raspberry Pi For Dummies, 3rd Edition, provides a concise and clear introduction to the terminology, technology, and techniques that you need to get the most from your Pi. With this book as your guide, you'll learn how to

- Connect your Raspberry Pi.
- Change its settings so that it works optimally for you.
- Discover and install great free software you can use on your Raspberry Pi.
- Use the desktop environment to run programs, manage files, surf the web, and view photos.
- Use the Linux command line to manage your Raspberry Pi and its files.
- Use the Raspberry Pi as a productivity tool.

- Edit photos.
- Play music and video.
- Create animations and arcade games with the child-friendly Scratch programming language.
- Write your own games and other programs using the Python programming language.
- Compose music by programming with Sonic Pi.
- Get started with electronics, from an introduction to soldering to the design and creation of electronic projects controlled by the Raspberry Pi.

Incidentally, within this book, you may note that some web addresses break across two lines of text. If you're reading this book in print and want to visit one of these web pages, simply key in the web address exactly as it's noted in the text, pretending as though the line break doesn't exist. If you're reading this as an ebook, you've got it easy — just click or tap the web address to be taken directly to the web page.

Why You Need This Book

After you shake the Raspberry Pi out of the little electrostatic bag it comes in, what next?

This book answers that question. It enables you to get your Raspberry Pi up and running and also introduces you to some of the great things you can do with it, through satisfying practical projects. With this book as your companion, you can write games and other programs and create your own electronic gadgets, all with no prior programming knowledge.

The Raspberry Pi is most likely a bit different compared to other computers you've used, so this book also helps you to do some of the things on your Pi that you expect of every computer, such as play music and edit documents.

You can learn a lot of this through trial and error, of course, but that can be a frustrating way to spend your time. Using this book as a reference, you can more quickly start using your Raspberry Pi, whatever you plan to do with it.

Foolish Assumptions

Raspberry Pi For Dummies, 3rd Edition, is written for beginners, by which we mean people who have never used a similar computer. However, we do have to make a few assumptions in writing this book, because we wouldn't have enough space for all its cool projects if we had to start by explaining what a mouse is! Here are our assumptions:

- **You are familiar with other computers, such as Windows or Apple computers.** In particular, we assume that you're familiar with using windows, icons, and the keyboard and mouse, and that you know the basics of using your computer for things like browsing the Internet, writing letters, or copying files.
- **The Raspberry Pi is not your only computer.** At times, you'll need to have access to another computer — for example, to create your SD or microSD card for the Pi. (See Chapter 2.) When it comes to networking, we assume you already have a router set up with an Internet connection and a spare port that you can plug the Raspberry Pi into.
- **The Raspberry Pi is your first Linux-based computer.** If you're a Linux ninja, this book still gives you a solid reference on the Raspberry Pi and the version of Linux it uses, but no prior Linux knowledge is required.
- **You share our excitement.** The Raspberry Pi can open up a world of possibilities to you!

Other than these assumptions, we hope this book is approachable for everyone. The Raspberry Pi is being adopted in classrooms and youth groups, and this book is a useful resource for teachers and students. The Raspberry Pi is also finding its way into many homes, where people of all ages (from children to adults) are using it for education and entertainment.

Icons Used in This Book

If you've read other *For Dummies* books, you know that they use icons in the margin to call attention to particularly important or useful ideas in the text. In this book, we use four such icons:


TIP

The Tip icon highlights expert shortcuts or simple ideas that can make life easier for you.

Arguably, the whole book talks about technical stuff, but this icon highlights something that's *particularly* technical. We've tried to avoid unnecessary jargon and complexity, but some background information can give you a better understanding of what you're doing, and sometimes we do need to get quite techy, given the sophistication of the projects you're doing. Paragraphs highlighted with this icon might be worth rereading, to make sure you understand, or you might decide that you don't need to know that much detail. It's up to you!

Although we'd like to think that reading this book is an unforgettable experience, we've highlighted some points that you might want to particularly commit to memory. They're either important takeaways, or they're fundamental to the project you're working on.

As you would do on the road, slow down when you see a Warning icon. It highlights an area where things could go wrong.

Beyond the Book

In addition to what you're reading right now, this book comes with a free access-anywhere Cheat Sheet with tips on installing software and using Scratch. To get this Cheat Sheet, simply go to `www.dummies.com` and type **Raspberry Pi Dummies Cheat Sheet** in the Search box.

Also be sure to check out this book's companion website (`www.dummies.com/extras/raspberrypi3e`), where you can download the code listings that appear throughout this book, as well as two bonus appendices (one on The GPIO on the Raspberry Pi and one on the RISC OS) as well as a bonus chapter on Mathematica, a mathematical program.

Both of us maintain our own personal websites too, which contain some additional information on the Raspberry Pi. Mike's is at `www.thebox.myzen.co.uk/Raspberry/Punnet.html`, and Sean's is at `www.sean.co.uk`.

Where to Go from Here

It's up to you how you read this book. It's been organized to take you on a journey from acquiring and setting up your Raspberry Pi to learning the software that comes with it, and from writing your own programs to finally creating your own

electronics projects. Some chapters build on knowledge gained in earlier chapters, especially the sections on Scratch and Python — and all of Part 5.

We understand, though, that some projects or topics might interest you more than others, and you might need help in some areas right now. When a chapter assumes knowledge from elsewhere, we include cross-references to help you quickly find what you might have missed. We also include some signposts to future chapters, so you can skip ahead to a later chapter if it provides the quickest answer for you.

If you haven't set up your Pi yet, start with Part 1. If you have your Pi up and running, Part 2 shows you how to use the software on it. Part 3 covers productivity, creativity, and entertainment software. To flex your programming muscles, perhaps for the first time, read Part 4. You can learn Scratch, Python, or Sonic Pi here, and feel free to start with any one of those languages. The Python chapters provide a good foundation for Part 5, where you can start building your own electronics projects.

1 Setting Up Your Raspberry Pi

IN THIS PART . . .

Get to know the Raspberry Pi and what other equipment you will need to be able to use it.

Download the Linux operating system and prepare an SD or MicroSD card for use on your Raspberry Pi.

Connect your Raspberry Pi to the power, USB hub, keyboard, mouse, and screen.

Install and test the Raspberry Pi Camera Module.

Change the settings on your Raspberry Pi.

IN THIS CHAPTER

- Getting up close and personal with the Raspberry Pi
- Taking stock of your Raspberry Pi
- Determining its limitations
- Purchasing your very own Raspberry Pi
- Figuring out what else you need

Chapter 1
Introducing the Raspberry Pi

The Raspberry Pi is perhaps the most inspiring computer available today. Although most of the computing devices being used (including phones, tablets, and game consoles) are designed to stop people from tinkering with them, the Raspberry Pi is exactly the opposite. From the moment you see its shiny green circuit board, it invites you to prod it, play with it, and create with it. It comes with the tools you need to start creating your own software (or *programming*), and you can connect your own electronic inventions to it. It's cheap enough that if you break it, it won't break the bank, so you can experiment with confidence.

Lots of people are fired up about its potential, and they're discovering exciting new ways to use it. Dave Akerman (`www.daveakerman.com`) and friends attached one to a weather balloon and sent it nearly 40 kilometers high to take pictures of the Earth from near space using a webcam. (You can read about Dave's ballooning project in Chapter 20.)

Professor Simon Cox and his team at the University of Southampton connected 64 Raspberry Pi boards to build an experimental supercomputer, held together by Lego bricks. In the supercomputer (see Figure 1-1), the Raspberry Pis work together to solve a single problem. The project has been able to cut the cost of a

supercomputer from millions of dollars to thousands or even hundreds of dollars, making supercomputing much more accessible to schools and students. Others have also experimented with combining the processing power of multiple Pis. There's even an off-the-shelf kit you can use to combine four Raspberry Pi Zeros with a full-size Raspberry Pi (the Cluster HAT from Pimoroni) so that you can experiment with running programs across multiple Pis at the same time.

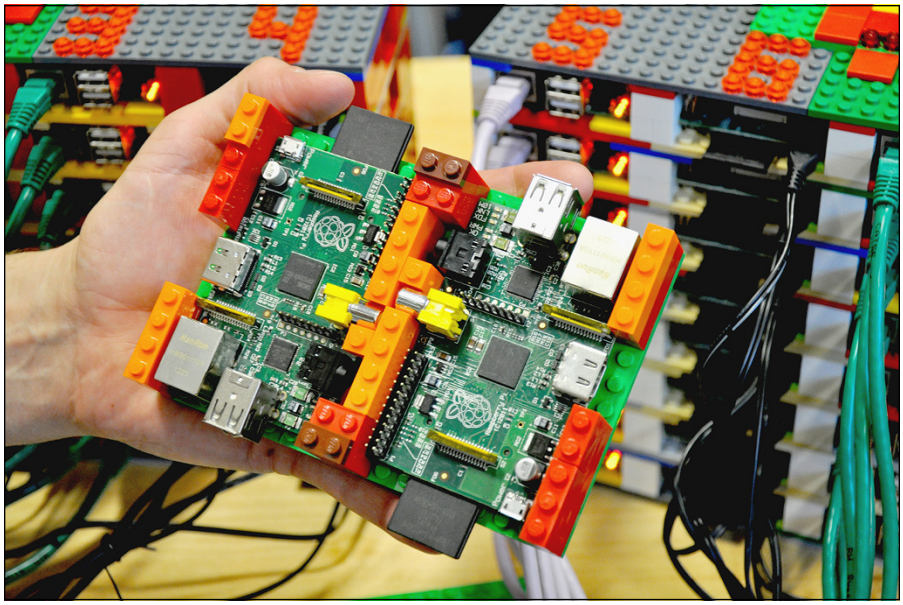

FIGURE 1-1: Two of the Raspberry Pi boards used in the University of Southampton's supercomputer, with the rest of the supercomputer in the background.

Courtesy of Simon Cox and Glenn Harris, University of Southampton.

The Pi is also being used to make weather stations, fitness gadgets, gaming devices, audiobook players, electric skateboards, and much more, as you discover in Chapter 20.

Although those projects are grabbing headlines, another story is less visible but more important: the thousands of people of all ages who are taking their first steps in computer science, thanks to the Raspberry Pi.

Both of the authors of this book used computers in the 1980s, when the notion of a home computer first became a reality. Back then, computers were less friendly than they are today. When you switched them on, you were faced with a flashing cursor and had to type something in to get it to do anything. As a result, though, a whole generation grew up knowing at least a little bit about how to give the computer commands, and how to create programs for it. As computers started to use mice and windows, people didn't need those skills any more, and they lost touch with them.

Eben Upton, designer of the Raspberry Pi, noticed the slide in skill levels when he was working at Cambridge University's computer laboratory in 2006. Students applying to study computer science started to have less experience with programming than students of the past did. Upton and his university colleagues hatched the idea of creating a computer that would come supplied with all the tools needed to program it — and would sell for a target price of $25 (about £20). It had to be able to do other interesting things, too, so that people were drawn to use it, and it had to be robust enough to survive being pushed in and out of school bags hundreds of times.

That idea started a six-year journey that led to the Raspberry Pi you probably have on your desk you as you read this book. It was released in February 2012, and sold half a million units by the end of the quarter. By July 2017, there were more than 14 million Raspberry Pis in homes, schools and workplaces, 10 million of them made in the UK. It is, by a large margin, the best-selling British computer of all time.

Getting Familiar with the Raspberry Pi

When your Raspberry Pi arrives, you'll see that it's a circuit board, with components and sockets stuck on it, as shown in Figure 1-2. In an age when most computing devices are sleek and shiny boxes, the spiky Pi, with tiny codes printed in white all over it, seems alien. That's a big part of its appeal, though: Many of the cases you can buy for the Raspberry Pi are transparent because people love the look of it.

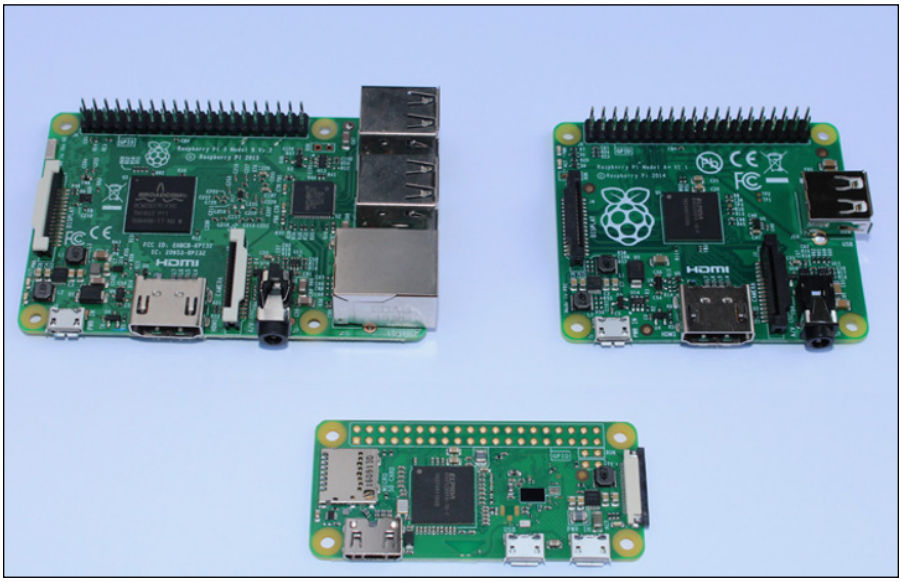

FIGURE 1-2: The Raspberry Pi 3 Model B (top left), Model A+ (top right), and Pi Zero W (bottom).

Over the years, the Raspberry Pi has evolved, increasing its memory, improving its performance, and adding features. So which one should you get? Here's an overview designed to help you decide:

- **Raspberry Pi 3 Model B:** The third generation of the Raspberry Pi, it represents the best all-round Raspberry Pi at the time of writing. According to the Raspberry Pi Foundation, it is 50 to 60 percent faster than the previous model, and ten times faster than the original Raspberry Pi. It includes 1GB of memory, four USB ports, built-in Wi-Fi and Bluetooth, and an Ethernet port for a wired Internet connection. It has 40 General Purpose Input/Output (GPIO) pins, which you can use to connect to your own electronics projects. Like previous Pi models, it's about the size of a credit card. As with any current Raspberry Pi, it uses a MicroSD card for storage. If you're not sure which model to get and your budget allows, get this one. It represents the fastest performance, and offers the best experience on the desktop. Its price is around $35 (about £30).

  It's called the Model B, incidentally, as a tribute to the BBC Microcomputer that was popular in the U.K. in the 1980s. It's sobering to think that the BBC Micro cost about ten times the price of a Raspberry Pi, which, thanks to 35 years of progress in computer science, has more than 7,800 times more memory.

- **Raspberry Pi 1 Model A+:** A cut-down model, it is ideal for projects that need lower power consumption — typically battery-based projects. It is suitable for robots and projects in remote locations, where a wired electricity supply isn't viable and batteries must be used instead. It does not have an Ethernet socket, and only has one USB port, although you can connect it to a USB hub to use more devices simultaneously. It does have the full complement of 40 GPIO pins, though, so you should find that your projects and add-ons work with it. Like the Model B, it includes an audio output (headphones-style) socket. This model has 512MB of memory and a price of $20 (or £20). The Model A+ is slightly shorter on the long side than the Raspberry Pi 3, measuring 6.5 centimeters by 5.5 centimeters.

- **Raspberry Pi Zero:** The Raspberry Pi Foundation astounded everyone when it gave this computer away with the print edition of its magazine *The MagPi.* The Raspberry Pi Zero measures 6.5 centimeters by 3 centimeters, is extremely lightweight, and has 512MB of memory and one Micro USB port. If you want to use the GPIO, you'll need to solder or affix your own pins, available separately. (You can read about adding GPIO pins to the Pi Zero in Chapter 16.) You'll also need a converter for the Mini HDMI socket, and for the Micro USB socket, so you should expect to spend a bit more than the price of the Pi (and have a bit more complexity in your setup). Billed as the $5 computer, the Raspberry Pi Zero has at times been difficult to get hold of, which is perhaps not surprising given the phenomenal demand for it.

- **Raspberry Pi Zero W:** Released in February 2017, the Raspberry Pi Zero W added Wi-Fi and Bluetooth, and compatibility with the Raspberry Pi Camera Module. The Pi Zero W costs around $10 (or about £10). If you're happy to solder your own GPIO pins, or you don't need them, the Raspberry Pi Zero or Zero W represents a great entry point to the Raspberry Pi family. After the Raspberry Pi Model 3, the Pi Zero W is our recommended best buy.

Of course, the older Raspberry Pis are still out there. Recent models usually remain in production while there is demand, and you can buy secondhand versions online from websites such as eBay. Generally speaking, the newer the model, the faster its performance. Memory upgrades have made a difference, as well as the use of more powerful processors, as the Pi has evolved. There are plenty of uses for the Pi that don't need especially fast performance, though, so you might find that an older Pi is perfect for your project. The older models are described in this list:

- **Raspberry Pi 1 Model B with 256MB memory:** Although it's called Model B, this was the first Raspberry Pi to be released, in February 2012. The Raspberry Pi Model B features an Ethernet connection for the Internet and two USB ports. It uses an SD card for storage.
- **Raspberry Pi 1 Model B with 512MB memory:** Released in October 2012, the Raspberry Pi Model B had twice the memory capacity. This improved the speed of some software, especially applications that used images heavily.
- **Raspberry Pi 1 Model A:** The Model A, released in February 2013, is a stripped-down version of the Model B. It has just one USB port and doesn't have an Ethernet port for connecting to the Internet. It has 256MB of memory.
- **Raspberry Pi 1 Model B+:** The Model B+, released in July 2014, has been described by the Raspberry Pi Foundation as "the final evolution of the original Raspberry Pi." It runs all the same software as the previous versions of the Raspberry Pi, but it has four USB ports, more GPIO pins for connecting electronics projects to the Pi, and lower power consumption and better audio than the Model B. In common with the Model B, it has 512MB of memory. Although all previous versions use SD cards for data storage, the Model B+ introduced the smaller MicroSD cards, which are now standard on the Raspberry Pi.
- **Raspberry Pi 2 Model B:** Launched in February 2015, this model doubled the memory on the Model B+ to 1GB. It increased performance, compared to the Model B+, while retaining its physical features. Over the years the Pi's performance has been improved through new software releases as well as updates to the hardware. The Pi 2 represents an immediately noticeable speed-up, compared to the Model B+.

REMEMBER

If you're using anything earlier than the Model B+, you'll need full-size SD cards (not MicroSD) for storage, and you'll only have 26 GPIO pins to play with. Current add-ons are unlikely to be compatible with the early boards, so check their requirements before you buy.

In this book, we offer guidance on older models where possible but will assume you're using at least a Model B+ for the projects. For best performance, we recommend using a current model, if possible.

You'll also see the Raspberry Pi Compute Module in the online stores alongside the Raspberry Pi, but this is something quite different. It's aimed at engineers creating industrial applications (known as embedded systems) or products based on Raspberry Pi technology. We only mention it here in case you wonder what it is: It's not covered further in this book, and it's almost certainly not what you want to buy for your first Raspberry Pi.

TECHNICAL STUFF

The Raspberry Pi was made possible in part by the advances in mobile computer chips that have happened in recent years. At its heart is a Broadcom chip (BCM2835, BCM2836, or BCM2837) that contains an ARM central processing unit (CPU) and a Videocore IV graphics processing unit (GPU). The CPU and GPU share the memory between them. The GPU is powerful enough to be able to handle Blu-ray quality video playback.

Instead of running Windows or Mac OS, the Raspberry Pi uses an operating system called Linux. It's a leading example of open source, a completely different philosophy to the commercial software industry. Rather than being created within the heavily guarded walls of a company, with its design treated as a trade secret, Linux is built by companies and expert volunteers working together. Anyone is free to inspect and modify the source code (a bit like the recipe) that makes it work. You don't have to pay to use Linux, and you're allowed to share it with other people, too.

You probably won't be able to run the software you have on your other computers on your Raspberry Pi. It won't run Windows or Mac software, and not all Linux software works on the Raspberry Pi. But a lot of Linux software that is compatible with the Raspberry Pi is available and is free of charge.

Figuring Out What You Can Do with a Raspberry Pi

The Raspberry Pi is a fully featured computer, and you can do almost anything with it that you can do with a desktop computer.