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2nd Edition

Raspberry Pi®

FOR DUMMIES®

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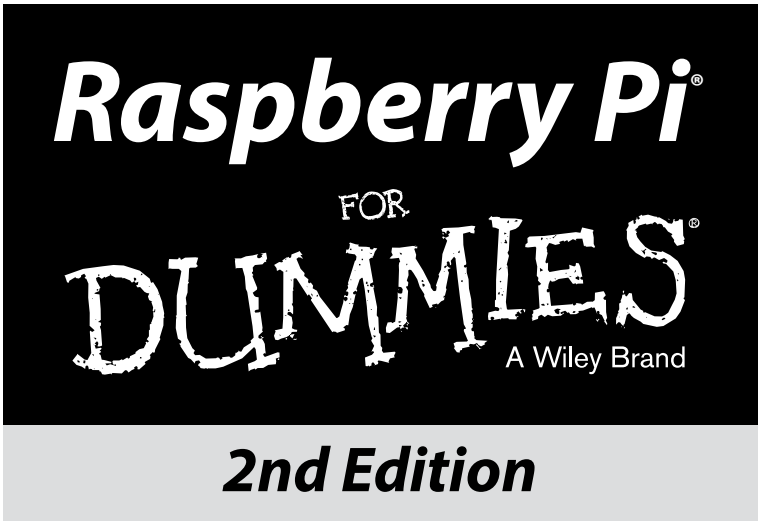
Learn to:

- Connect the Raspberry Pi and install the OS
- Learn programming with Scratch® and Python®
- Create electronics projects connected to the Raspberry Pi's GPIO port
- Make virtual worlds in Minecraft® and computer music with Sonic Pi

Sean McManus
Mike Cook



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by Sean McManus and Mike Cook

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Raspberry Pi® For Dummies®, 2nd Edition

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Introduction

In recent years, computer education has focused largely on office skills, and not on understanding how computers work, or how you can use them to create new programs and inventions. The Raspberry Pi redresses the balance. It can be used for games, music, photo editing, and word processing, like any computer. But it can do so much more, providing a gateway into programming, electronics, and the mysterious world of Linux, the technically powerful (and free) rival to Windows and Mac OS.

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'll 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 LXDE, 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,* 2nd Edition, helps you to 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, 2nd Edition, provides a concise and clear introduction to the terminology, technology, and techniques that you need to get the most from your Pi. With the book as your guide, you'll learn how to

- Connect your Raspberry Pi.
- Change its settings so 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 your files, surf the web, and view your 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 sophisticated electronic games, 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 e-book, 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 without any 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 playing music and editing 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, 2nd Edition, is written for beginners, by which we mean people who have never used a similar computer before. However, we do have to make a few assumptions in writing this book because we wouldn't have enough space for all the 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 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 at the world of possibilities that the Raspberry Pi can open up to you!

Other than those 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 adult) 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:

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

Arguably, the whole book is 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. Sections 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 take-aways, or they are fundamental to the project you're working on.

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

Beyond the Book

- **Cheat Sheet:** This book's Cheat Sheet can be found online at `www.dummies.com/cheatsheet/raspberrypi`. See the Cheat Sheet for tips on installing software and using Scratch.
- **Dummies.com online articles:** Companion articles to this book's content can be found online at `www.dummies.com/extras/raspberrypi`. The topics range from handy Linux commands to programming languages available on the Raspberry Pi.
- **Updates:** If this book has any updates after printing, they will be posted to `www.dummies.com/extras/raspberrypi`.
- **Downloadable code and bonus chapter:** Also at `www.dummies.com/extras/raspberrypi`, you can download the code listings that appear throughout this book, 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` 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, through learning the software that comes with it, to writing your own programs, and finally creating your own electronics projects. Some chapters build on knowledge gained in earlier chapters, especially the sections on Scratch, Python, and all of Part V.

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 too, 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 I. If you have your Pi up and running, Part II shows you how to use the software on it. Part III covers productivity, creativity, and entertainment software. To flex your programming muscles, perhaps for the first time, read Part IV. 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 V, where you can start building your own electronics projects.

Part I

Getting Started with the Raspberry Pi

Visit www.dummies.com/extras/raspberrypi for great Dummies content online.

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 flash it to an SD card.
- Connect your Raspberry Pi to the power, USB hub, keyboard, mouse, and screen.
- Use Raspi-config to change the settings on your Raspberry Pi.

Chapter 1

Introducing the Raspberry Pi

In This Chapter

- Getting familiar with the Raspberry Pi
- Figuring out what you can do with a Raspberry Pi
- Determining its limitations
- Getting your hands on a Raspberry Pi
- Deciding what else you need

The Raspberry Pi is perhaps the most inspiring computer available today. Although most of the computing devices we use (including phones, tablets, and games consoles) are designed to stop us 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 making 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's not going to 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 together. Dave Akerman (`www.daveakerman.com`) and friends attached one to a weather balloon and sent it nearly 40 kilometers above the earth to take pictures of earth from near space using a webcam.

Professor Simon Cox and his team at the University of Southampton connected 64 Raspberry Pi boards to build an experimental supercomputer, held together with 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.

The Pi is also being used to make synthesizers, robots, gaming devices, audiobook players, home automation controls, and much more, as you discover in Chapter 20.

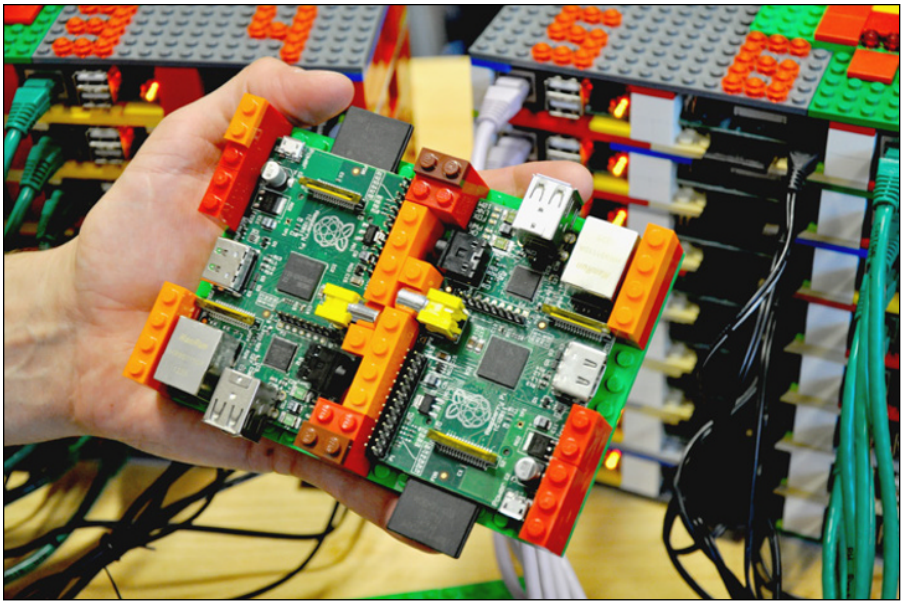

Figure 1-1: Two of the Raspberry Pi boards used in the University of Southampton's supercomputer, with the rest of the supercomputer in the background.

Courtesy of Simon Cox and Glenn Harris, University of Southampton

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 became friendlier, and we started to use mice and windows, we didn't need those skills any more, and we 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 with all the tools needed to program it, and would sell for a target price of $25 (£15). It had to be able to do other interesting things too so that people were drawn to use it, and 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 the time the Model B+ launched in July 2014, there were about three million Raspberry Pis in homes, schools, and workplaces.

Getting Familiar with the Raspberry Pi

When your Raspberry Pi arrives, you'll see it's a circuit board, about the size of a credit card, 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. It's a big part of its appeal, though: Most of the cases you can buy for the Raspberry Pi are transparent because people love the look of it.

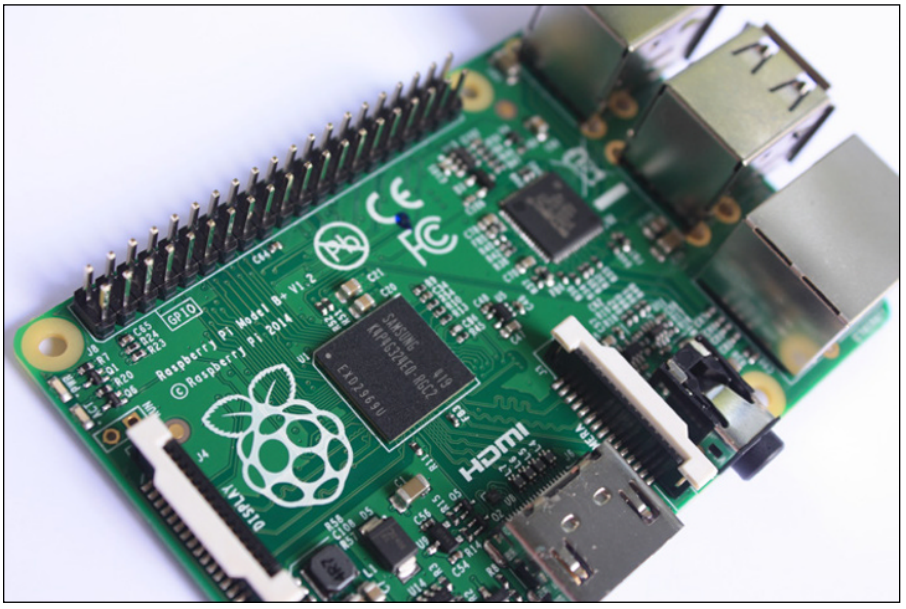

Figure 1-2: Up close with the Raspberry Pi.

There are several different versions of the Raspberry Pi:

- **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. This 256MB version is no longer in production. It's called the Model B, incidentally, as a tribute to the BBC Microcomputer that was popular in the UK 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 30 years of progress in computer science, has more than 8,000 times more memory.

- **Model B with 512MB memory:** Released from 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. Although the Model B has been superseded by the Model B+, the Raspberry Pi Foundation has said it will keep the Model B in production for as long as there is demand for it.
- **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. Because it requires about a third of the power of the Model B, the Model A is ideal for robots and projects in remote locations, where a wired electricity supply isn't viable and batteries must be used instead.
- **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+ uses the smaller MicroSD cards.
- **Compute Module:** You'll see it in the online stores alongside the Raspberry Pi, but the Raspberry Pi Compute Module is something quite different. It's aimed at engineers creating industrial applications (known as *embedded systems*) or products based on Raspberry Pi technology. At the time of writing, products in development based on it include a media center and a handheld camera. 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.

So, which version should you get? Our advice would be to get the Model B+ unless you have a specific application in mind that requires low power, in which case get a Model A. There's one caveat: If you want to use add-on components that connect to your Raspberry Pi, beware of compatibility problems. Because there are more GPIO pins on the Model B+, add-ons designed for the Model A or Model B might not fit the Model B+, and vice versa.

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 BCM2835 chip 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. Instead of 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.

When you switch it on, it has a text prompt (see Chapter 5), but you can use a graphical windows desktop to start and manage programs. You can use it for browsing the Internet (see Chapter 4), word processing and spreadsheets (see Chapter 6), or for editing photos (see Chapter 7). You can use it for playing back music or video (see Chapter 8), or for playing games. You can use the built-in software to write your own music, too (see Chapter 14). It's the perfect tool for homework, but it's also a useful computer for writing letters, managing your accounts, and paying bills online.

The Raspberry Pi is at its best, however, when it's being used to learn how computers work, and how you can create your own programs or electronics projects using them. It comes with Scratch (see Chapter 9), which enables people of all ages to create their own animations and games, while learning some of the core concepts of computer programming along the way.

It also comes with Python (see Chapter 11), a professional programming language used by YouTube, Google, and Industrial Light & Magic (the special effects gurus for the *Star Wars* films), among many others.

It has a General Purpose Input/Output (GPIO) port on it that you can use to connect up your own circuits to the Raspberry Pi, so you can use your Raspberry Pi to control other devices and to receive and interpret signals from them. In Part V, we show you how to build some electronic games controlled by the Raspberry Pi.

Determining Its Limitations

For something that costs so little, the Raspberry Pi is amazingly powerful, but it does have some limitations. Although you probably use it as a desktop computer, its power is closer to a mobile device (like a tablet) than a modern desktop PC.

By way of example, the Raspberry Pi Foundation says the Pi's overall performance is comparable with a PC using a 300 MHz Pentium 2 processor, which you might have bought in the mid to late nineties, except that the Raspberry Pi has much better graphics. The memory of the Raspberry Pi is more limited than you're probably used to, with just 512MB or 256MB available. You can't expand that with extra memory in the way you can a desktop PC.

The graphics capabilities lag behind today's market somewhat too: The Raspberry Pi Foundation says the Pi's graphics are roughly the same as the original Xbox games console, which was released ten years ago.

Both the Pentium 2 PC and the original Xbox were fine machines, of course, for their time. They're just not as snappy as we're used to, and that's where you might experience some problems. You might find that the Pi can't keep up with the demands of some modern software and that some programs don't run fast enough to be useful on it. However, it's easy to find programs, try them, and remove them if they're no good (see Chapter 5), and plenty of programs for work and play run well on the Raspberry Pi (see Chapter 19).

If you already have another computer, the Raspberry Pi is unlikely to usurp it as your main machine. But the Pi gives you the freedom to try lots of things you probably wouldn't dare to try, or wouldn't know how to try, with your main PC.

Getting Your Hands on a Raspberry Pi

The Raspberry Pi was created by the Raspberry Pi Foundation, a charity registered in the UK. The charity's six trustees funded the manufacture of the first large batch themselves, but it sold out rapidly so it quickly became clear that they needed something that would scale better.