IN THIS CHAPTER

- Getting up close and personal with the Raspberry Pi
- Taking stock of your Raspberry Pi
- 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. 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. Some models are cheap enough that breaking them won't break the bank, so you can experiment with confidence.

Lots of people are fired up about the Raspberry Pi's 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.

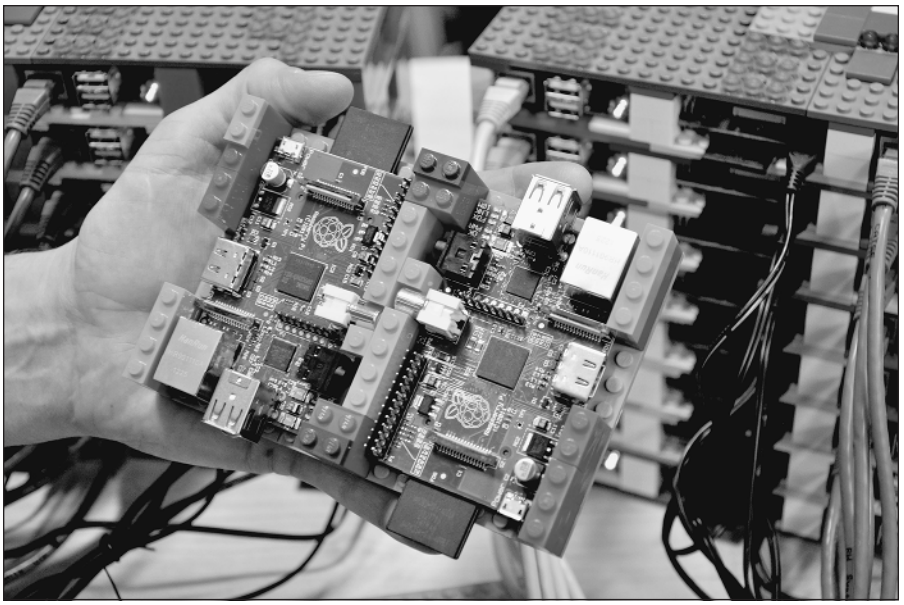

FIGURE 1-1: Two of the Raspberry Pi boards used in the University of Southampton's supercomputer, with the rest of the supercomputer in the background.

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

The Pi is also being used to make fitness gadgets, gaming devices, 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. More than 30 million Raspberry Pi computers have now been sold. It is, by a large margin, the best-selling British computer of all time.

Introducing the Raspberry Pi Range

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 4 Model B

This model is 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.

The Raspberry Pi 4 is the latest Raspberry Pi board. It features the following:

- Up to 8GB of memory
- Four USB ports (two USB 2 ports and two higher-speed USB 3 ports)
- Built-in Wi-Fi and Bluetooth and a Gigabit Ethernet port for a wired Internet or network connection
- A headphones-style audio-out socket
- 40 general-purpose input/output (GPIO) pins, which you can use to connect your own electronics projects or specially designed add-ons (see Chapter 21)

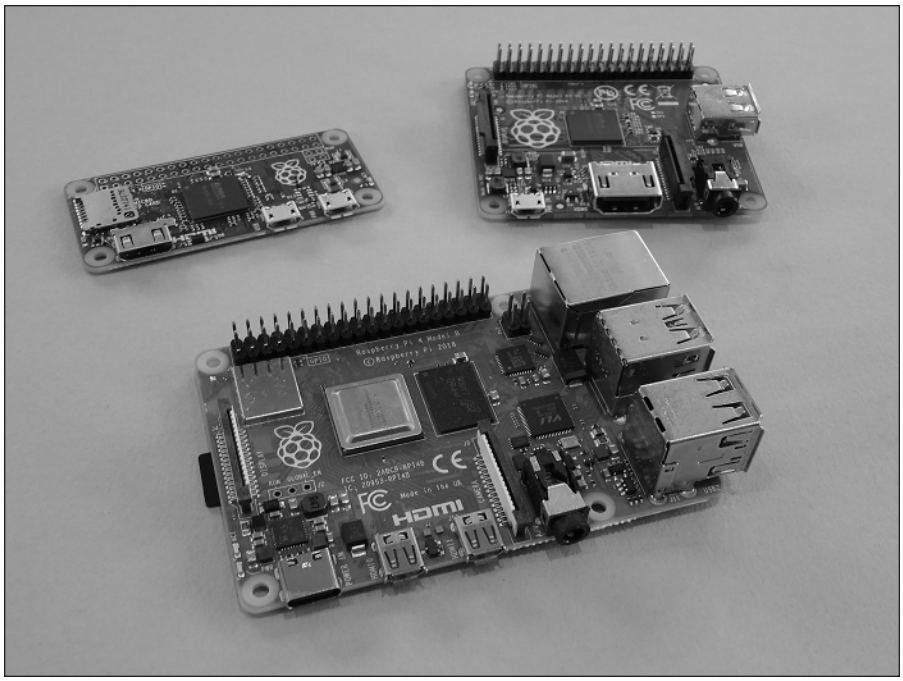

FIGURE 1-2: The Raspberry Pi 4 Model B (center), Model A+ (top right), and Pi Zero W (top left).

- Support for two monitors at resolutions of up to 4K
- Compatibility with the Raspberry Pi Camera Module
- Power over Ethernet (PoE) support when used with the Raspberry Pi PoE HAT, which enables you to use your Ethernet cable for both networking and powering your Pi

Like previous Pi models, the Raspberry Pi 4 is about the size of a deck of cards. As with any current Raspberry Pi, it uses a microSD card for storage. Its price is around $35 for 2GB of memory or $75 for 8GB of memory.

The Raspberry Pi Desktop Kit is also available, which includes the accessories you'll need, except for the monitor.

The Raspberry Pi 4 is our recommendation for the most powerful budget-friendly Raspberry Pi. You may be able to use it with your own keyboard and mouse to save money. The GPIO pins are great for electronics projects.

TECHNICAL STUFF

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 40 years of progress in computer science, has more than 15,600 times more memory.

Raspberry Pi 400

The Raspberry Pi 400 (see Figure 1-3) takes even more inspiration from the classic computers of the '80s by building the Raspberry Pi 4 computer into a computer keyboard. It makes the whole setup much more compact, because you don't have the separate Pi unit on the table, with a cable going to the keyboard.

FIGURE 1-3: The Raspberry Pi 400 hides the computer inside the keyboard.

There are performance improvements, too. The Raspberry Pi 400 is faster than the Raspberry Pi 4, and it's designed with passive cooling built in.

The Raspberry Pi 400 is a white keyboard, with all the sockets on the back of it. It features the following:

- 4GB of memory.
- Three external USB ports (one USB 2 port and two higher-speed USB 3 ports). This is fewer than the four ports you get on a Raspberry Pi 4. The fourth port is used to connect the keyboard inside the case.
- Built-in Wi-Fi and Bluetooth and a Gigabit Ethernet port for a wired Internet or network connection.

- 40 GPIO pins, but these are on the back of the case, not on the top surface. You'll need to use an extension cable or board to use the pins easily and to use add-on boards (see Chapter 21). Although add-on boards can be connected directly, few will work well because their top surface will face away from you.
- Support for two monitors at resolutions of up to 4K.
- No compatibility with the Raspberry Pi Camera Module. You can use a USB camera, as you can on any Raspberry Pi computer.

There is no audio out socket, so you'll need to pass audio through your monitor.

The Raspberry Pi 400 costs $70. The Raspberry Pi 400 Personal Computer Kit adds the accessories you'll need, except for the monitor. The Raspberry Pi 400 is a fantastic value, but it's more expensive than the bare board. We recommend the Raspberry Pi 400 if your budget will bear it and you plan to use the Raspberry Pi as a desktop computer. For electronics projects, we find the bare board easier to use.


TIP

The official Raspberry Pi keyboard and the Raspberry Pi 400 look the same. If you have both on your desk, put a sticker on one of them; otherwise, you'll waste time trying to use the wrong one!

Raspberry Pi 3 Model A+

The Model A+ is a cut-down bare-board Raspberry Pi. It's useful 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 features the following:

- 512MB of memory
- One USB 2 port
- Built-in Wi-Fi and Bluetooth
- A headphones-style audio-out socket
- 40 GPIO pins
- Compatibility with the Raspberry Pi Camera Module

This model has a price of $20. The Model A+ is slightly shorter on the long side than the Raspberry Pi 3, measuring 2½ inches by 2 inches.

Raspberry Pi Zero

The Raspberry Pi Foundation astounded everyone when it gave the Raspberry Pi Zero computer away with the print edition of its magazine *The MagPi.* We'd seen cover-mounted CDs and even tapes long ago, but never a computer before.

There are three models: Raspberry Pi Zero, Raspberry Pi Zero W (adding wireless networking), and Raspberry Pi Zero WH (adding wireless networking and GPIO pins).

The Raspberry Pi Zero family features the following:

- A lightweight, smaller board measuring just 2½ inches by 1 inch.
- A single-core 1 GHz processor. This is less powerful than the bigger boards. The Model B and A+ are quad-core, which means there are four processing units inside the chip that can all work at the same time. The quad-core processors run at a higher frequency, too. Here, you get a single core running at a lower frequency.
- 512MB of memory.
- One Micro USB port.
- Built-in Wi-Fi and Bluetooth, only on the Raspberry Pi Zero W and Zero WH.
- 40 GPIO pins, only on the Raspberry Pi Zero WH. On other models, you can solder your own pins.
- Compatibility with the Raspberry Pi Camera Module, only on the Raspberry Pi Zero W and Zero WH.

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.

The Raspberry Pi Zero is great for compact electronics projects that don't need the performance of a Model B or Model A+.

Older models

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. If you want to support the Raspberry Pi Foundation while buying cheaper, secondhand boards, you can donate to the foundation online.

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+.

- **Raspberry Pi 3 Model B:** Launched in February 2016, this model has a new 64-bit processor, which means it can handle data in bigger chunks than the previous 32-bit processor. The Raspberry Pi 3 Model B is 50 percent to 60 percent faster than the Raspberry Pi 2 Model B when working in 32-bit mode.
- **Raspberry Pi 3 Model B+:** Launched in March 2018, this model has a faster processor and improved networking speeds. It introduced support for PoE, which enables the Raspberry Pi to be powered through the Ethernet cable. You'll need to add the Raspberry Pi PoE HAT accessory.

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.

Many of the projects in this book will work on older Raspberry Pi models (indeed, they first appeared in previous editions of this book when those models were the latest thing). But for best performance, we recommend using a current model, if possible.

WHAT'S THE RASPBERRY PI COMPUTE MODULE?

You'll also see the Raspberry Pi Compute Module in the online stores alongside the Raspberry Pi, but this is something quite different.

The Compute Module, or C for short, is designed for industrial use and intended to be built into a product you're manufacturing. The modules tend to follow the release of the main Raspberry Pi models. There are also light versions available that correspond to the Model A of the Raspberry Pi. They're built on a SODIMM board, which is what is sometimes used for PC memory modules. You're supposed to design your own board to plug the Compute Module into, but a development kit is available with a C module and an example motherboard containing all the normal plug-in connectors (see `www.raspberrypi.org/products/compute-module-development-kit-2`). Note, however, that this is an expensive way to buy what is otherwise a normal Raspberry Pi. Currently, the Raspberry Pi Compute Module 4 is the latest one, but the dev kit uses the Compute Module 3.

We only mention the Compute Module 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.

RASPBERRY PI PICO: A MICROCONTROLLER, NOT A COMPUTER

The Raspberry Pi Pico is a radical new departure for the Raspberry Pi Foundation. Whereas previous devices were general-purpose computers, Raspberry Pi Pico is a microcontroller. A microcontroller is usually built into a device that does one job, such as a heating system or a microwave oven.

You can use the Raspberry Pi Pico for your electronics projects. You program it by connecting it to a computer. It's similar to the Arduino, which you might have heard of, but the Pico uses the Raspberry Pi Foundation's own custom chip.

The big advantage of a microcontroller is that there is no operating system to get in the way of things, so you can get precise control over the signals coming from its pins. This is important for things like audio generation and motor/servo control.

The Raspberry Pi Pico can be programmed using either MicroPython or C, which are both programming languages. (A programming language is a way of giving instructions to a computer or computing device – Part 4 introduces you to some programming languages). MicroPython is a version of Python optimized for running on microcontrollers. There are a few differences in some instructions, but MicroPython mostly looks the same as Python. You can program a Pico using Thonny, a Python programming tool available in Raspberry Pi OS. You get the option of saving your code into the Pico's memory or your computer. Any code saved into a file called `main.py` will run automatically when power is applied to the Pico, independently of whether you have a computer attached.

Programming a Pico in C, however, is not for the fainthearted. It requires a long process to prepare the C code for compiling or the use of a complex piece of software. We expect it to get easier, but at the moment we would recommend MicroPython instead.

The Raspberry Pi Pico is extremely cheap: It costs just $4, and it doesn't need an additional microSD card for storage.

You can find more information on the Raspberry Pi Pico in Chapter 17, but our focus in this book is on the Raspberry Pi computers and not the microcontroller. When we say "the Raspberry Pi," we're referring to the computers.

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.

Instead of running Windows or macOS, 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.

The Raspberry Pi has a graphical windows desktop to start and manage programs (see Chapter 4) as well as a shell for accepting text commands (see Chapter 5). You can use it for browsing the Internet (see Chapter 4), for 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 (see Chapter 19). 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), a visual programming language that 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 GPIO pins 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 5, we show you how to build some electronic projects controlled by the Raspberry Pi. In Chapter 21, we show you some add-ons you can connect to the GPIO pins.

Getting Your Hands on a Raspberry Pi

One of the great things about the Raspberry Pi is that it's established a community of businesses that have created products for it, or have shared in its success by selling it. You can now buy the Raspberry Pi from a wide range of electronics companies for hobbyists. Global retailers include Pimoroni (`www.pimoroni.com`), The Pi Hut (`https://thepihut.com`), and Adafruit (`www.adafruit.com`). It's also available from the Raspberry Pi's distributors, RS Components (`www.rs-components.com`) and Element14 (`www.element14.com`).

You might also be able to buy it from your local computer or electronics store, although you'll probably find it's only available as part of a kit there. Shops often bundle the Raspberry Pi with other items you need to use it. It can be convenient to get everything at once, but it might not represent the cheapest way to get started.

Determining What Else You Need

The creators of Raspberry Pi have stripped costs to the bone to enable you to own a fully featured computer for less than $35, so you'll need to scavenge or buy a few other bits and pieces in order to use your Pi. We say *scavenge* because the things you need are exactly the kind of things many people have lying around their house or garage already, or can easily pick up from friends or neighbors. In particular, if you're using a Raspberry Pi as your second computer, you probably have most of the peripherals you need.

WARNING

Not all devices are compatible. In particular, incompatible USB hubs, keyboards, and mice can cause problems that are hard to diagnose. USB hubs that feed power back into your Raspberry Pi through the Pi's USB port (known as *backpowering*) could potentially cause damage to the Raspberry Pi if they feed in too much power.

A list of compatible and incompatible devices is maintained at `https://elinux.org/RPi_VerifiedPeripherals`, and you can check online reviews to see whether others have experienced difficulties using a particular device with the Raspberry Pi.

TIP

If you're buying new devices, you can minimize the risk by buying recommended devices from Raspberry Pi retailers.

In any case, you should set a little bit of money aside to spend on accessories. The Raspberry Pi is inexpensive, but buying a keyboard, mouse, USB hub, and cables

can easily double or triple your costs, and you may have to resort to that if what you have on hand turns out not to be compatible.

The following sections offer a roundup of what else you may need.

Essentials

There are a few things that are essential to get your Raspberry Pi up and running:

- **Monitor:** The Raspberry Pi has a high-definition video feed and uses an HDMI (high-definition multimedia interface) or Micro HDMI connection for it. If your monitor has an HDMI socket, you can connect the Raspberry Pi directly to it. If your monitor does not support HDMI, it probably has a DVI socket, and you can get a simple and cheap converter that enables you to connect an HDMI cable to it. Older VGA (video graphics array) monitors require a device to convert the HDMI signal into a VGA one. If you're thinking of buying a converter, check online first to see whether it works with the Raspberry Pi. A lot of cheap cables are just cables, when what you need is a device that converts the signal from HDMI format to VGA, not one that just fits into the sockets on the screen and your Raspberry Pi. These converters can be quite expensive, so Gert van Loo has designed a device that uses the Raspberry Pi's GPIO pins to connect to a VGA monitor. He's published the design specs so that anyone can build one, and sell it if they want to, too. Take a look at eBay if you need one, and you might well find what you need. For more information, check out `https://github.com/fenlogic/vga666`. (If your monitor is connected using a blue plug and the connector has three rows of five pins in it, it's probably a VGA monitor.)
- **TV:** You can connect your Raspberry Pi to a high-definition TV using the HDMI socket and should experience a crisp picture. If you have an old television in the garage, you can also press it into service for your Raspberry Pi. The Pi can send a composite video signal, so it can use a TV as its display. When we tried this, it worked but the text lacked definition, which made it difficult to read. You'll need to get a cable with the right connector to fit your Pi: The original Model A and Model B have a dedicated RCA video socket, but current models use the headphone socket for RCA video output, too.
- **USB keyboard and mouse:** The Raspberry Pi only supports wired USB keyboards and mice. If you're still using ones with PS/2 connectors (round rather than flat), you may be able to use a PS/2 to USB adapter. Official Raspberry Pi keyboards and mice are available with an attractive white and red design. You can use Bluetooth devices, but you'll need to use a wired keyboard and mouse to set them up.

TIP

When the Raspberry Pi behaves unpredictably, it can be because the keyboard is drawing too much power, so avoid keyboards with too many flashing lights and features.

- **SD card or microSD card:** The Raspberry Pi doesn't have a hard drive built into it, so it uses a microSD card (current models) or SD card (older models, earlier than the Model B+) as its main storage. You probably have some SD cards that you use for your digital camera, although you might need to get a higher-capacity one. We recommend a 16GB card as a minimum for Raspberry Pi OS, but you can use a 4GB card if you use a media center operating system (OS) like LibreELEC (see Chapter 8 for a guide to LibreELEC). SD and microSD cards have different class numbers that indicate how fast you can copy information to and from them. You will be fine with a Class 6 or higher. If you buy an official Raspberry Pi kit, it includes a microSD card with Raspberry Pi OS already installed on it.

  Note: In this book, when we say microSD card, we also mean SD card if that's what you're using. If we're talking about something that's different for SD cards, we tell you.

- **SD or microSD card writer:** Many PCs today have a slot for SD or microSD cards, so you can easily copy photos from your camera to your computer. If yours doesn't, you might want to consider getting an SD or microSD card writer to connect to your computer. You can use it to copy software to an SD card for use with your Raspberry Pi, but you won't be able to use it to copy files from your Raspberry Pi to a Windows computer. You can also use the card writer to create a backup copy of your Raspberry Pi's files and software. (You can read about making back-ups in Chapter 4.)

- **Power supply:** To power your Raspberry Pi, you need to use a 5V power supply. The Raspberry Pi 4 and Raspberry Pi 400 use a USB-C connector, and earlier models use a USB-C Micro USB connector. Although you may have mobile phone and tablet chargers that fit, many of them can't deliver enough current (up to 2,500 milliamperes for a Raspberry Pi 3 Model A+, and up to 3,000 milliamperes for Raspberry Pi 4), which can make the Raspberry Pi perform unreliably. It's worth checking to see whether you have a 5V charger that may do the job (it should say on it how much current it provides), but for best results, we recommend buying a compatible charger from the same company that you buy your Raspberry Pi from. There is an official Raspberry Pi 4 power supply available, which has plug styles for the United States, Canada, United Kingdom, Australia, New Zealand, Europe, India, and China.

  Don't try to power the Pi by connecting its power port to the USB port on your PC with a cable, because your computer probably can't provide enough power for your Pi. You can also power the Pi through the GPIO pins, but you could damage the Raspberry Pi if there is a spike in current or the wrong voltage is applied. If you want to provide power through the GPIO pins, a

safer approach is to use a hardware-attached-on-top (HAT) device designed to sit on the GPIO pins and provide the consistent power you need while protecting the Pi underneath. For portable applications, you can power the Raspberry Pi using a battery pack designed for mobile phone charging. The Raspberry Pi Foundation advises that you should only use batteries to power your Raspberry Pi if you know what you're doing, because there's a risk of damaging your Raspberry Pi. There is an official Raspberry Pi PoE HAT if you want to power your Pi through an Ethernet cable.

For more details on the power requirements of various Raspberry Pi models, consult the FAQ at `www.raspberrypi.org/documentation/faqs`.

- **Cables:** You'll need cables to connect it all up, too. In particular, you need an HDMI cable (if you're using an HDMI or DVI monitor), an HDMI-to-DVI adapter (if you're using a DVI monitor), an RCA cable (if you're connecting to an older TV), an audio cable (if you're connecting the audio jack to your stereo), and an Ethernet cable (for networking on models with an Ethernet port). The Raspberry Pi 4 and 400 use Micro HDMI connections, so you'll need a cable that connects Micro HDMI to (normal) HDMI for your monitor, or an adapter. Note that the Raspberry Pi 2 and later (including Raspberry Pi 4) send the RCA video signal through a 3.5mm jack (headphone socket). Earlier models had a dedicated RCA socket. You need a different cable, depending on which version of the Pi's design you have, if you plan to use RCA. If you have a Raspberry Pi Zero, you'll need a converter for the Mini HDMI socket and for the Micro USB socket (see Figure 1-4). You can get these cables from an electrical components retailer, and you may be able to buy them at the same time as you buy your Raspberry Pi. Any other cables you need (for example, to connect to PC speakers or a USB hub) should come with those devices.

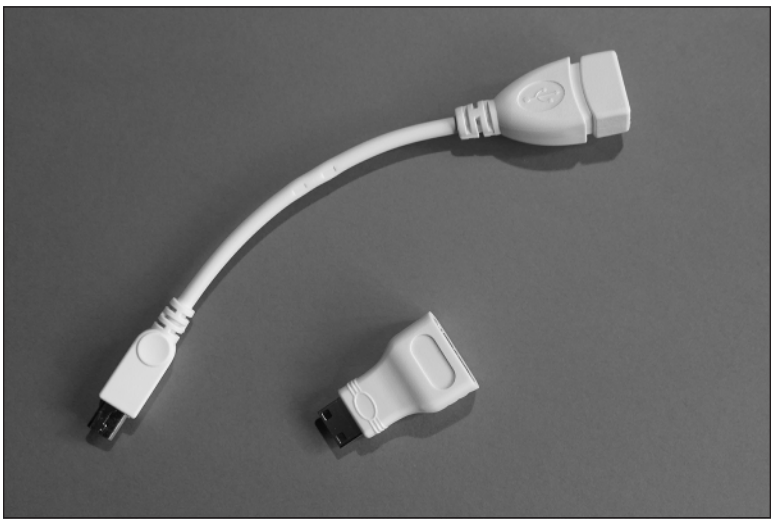

FIGURE 1-4: The Micro USB–to–USB converter cable and the Mini HDMI–to–HDMI converter for the Raspberry Pi Zero.

Optional extras

There are a few additional items you may want to get for your Raspberry Pi. They can make your Raspberry Pi easier to use and enable new applications.

- **USB hub:** The Raspberry Pi has one, two, or four USB sockets (depending on the model you get). Consider using a powered USB hub, for two reasons. Firstly (and especially if you have a Model A, A+, B, or Zero), you're going to want to connect other devices to your Pi at the same time as your keyboard and mouse, which need two sockets. And secondly, a USB hub provides external power to your devices and minimizes the likelihood of experiencing problems using your Raspberry Pi, especially if connecting relatively power-intensive devices such as hard drives. Make sure your USB hub has its own power source, independent of the Raspberry Pi.
- **External hard drive:** If you want lots of storage, perhaps so that you can use your music or video collection with the Raspberry Pi, you can connect an external hard drive to it over USB. You'll need to connect your hard drive through a powered USB hub, or use a hard drive that has its own external power source.
- **Raspberry Pi Camera:** The Raspberry Pi has stimulated entrepreneurs to create all kinds of add-ons for it, but the Camera Module is a product that originated at the Raspberry Pi Foundation. This fixed-focus camera can be used to shoot HD video and take still photos. The standard camera has 8-megapixel resolution, and the Raspberry Pi High Quality Camera offers 12-megapixel resolution. There is also a version of the standard camera without an infrared filter (the PiNoIR Camera), which can be used for wildlife photography at night or weird special effects by day.
- **Speakers:** Raspberry Pis (excluding the Pi 400) have a standard audio out socket, compatible with headphones and PC speakers that use a 3.5mm audio jack. You can plug headphones directly into it, or use the audio jack to connect to speakers, a stereo, or a TV. If you're using a TV or stereo for sound, you can get a cable that connects the 3.5mm audio jack and the audio input(s) on your television or stereo. You won't always need speakers: If you're using an HDMI connection, the audio is sent to the screen with the video signal, so you won't need separate speakers. If you're using a DVI monitor, you can get an HDMI-to-DVI adapter that includes audio extraction, so you can connect the audio separately. Some adapters can also convert from HDMI to VGA, with sound extracted separately.
- **Case:** It's safe to operate your Raspberry Pi as is, but many people prefer to protect it from spills and precariously stacked desk clutter by getting a case for it. The Pibow Coupe (`https://shop.pimoroni.com/collections/pibow`) is one of the most attractively designed cases, assembled from layers

of colored plastic (see Figure 1-5). It's designed by Paul Beech, who designed the Raspberry Pi logo. There are also official red-and-white cases for current Raspberry Pi models. The case for the Pi Zero includes three different tops, so you can either seal it, leave a camera hole, or have access to the GPIO pins. You don't have to buy a case, though. You can go without or make your own using cardboard or Lego bricks. Whatever case you go with, make sure you can still access the GPIO pins so that you can experiment with connecting your Pi to electronic circuits and try the projects in Part 5 of this book.

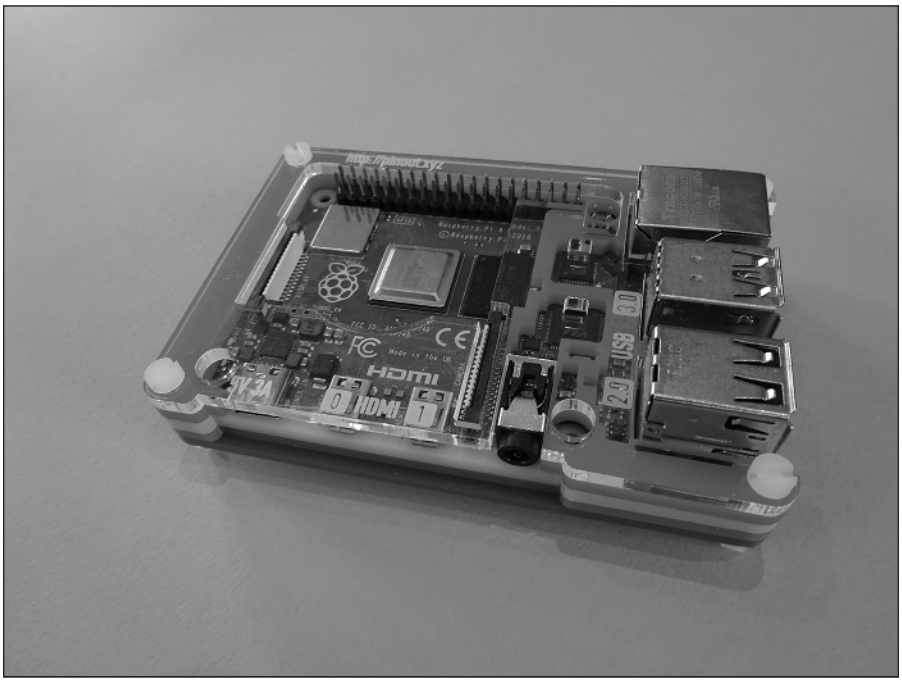

FIGURE 1-5: The Pibow Coupe case on the Raspberry Pi 4.

» **Raspberry Pi 4 Case Fan:** If you're really pushing the performance of your Raspberry Pi 4, you might find it gets a bit hot. The Raspberry Pi 4 Case Fan (see Figure 1-6) is an official accessory that fits inside the official Raspberry Pi case. It connects to your GPIO pins, and the fan spins to keep air flowing through the case. It's useful for power users, but most people won't need one.

FIGURE 1-6: The Raspberry Pi 4 Case Fan.