

# Chapter 1

## Meet the Raspberry Pi

**YOUR RASPBERRY PI** board is a miniature marvel, packing considerable computing power into a footprint no larger than a credit card. It's capable of some amazing feats, but you need to know a few things before you plunge head first into the bramble patch.

---

If you're eager to get started, skip to the next chapter to find out how to connect your Raspberry Pi to a display, keyboard, and mouse; install an operating system; and jump straight into using the Pi.

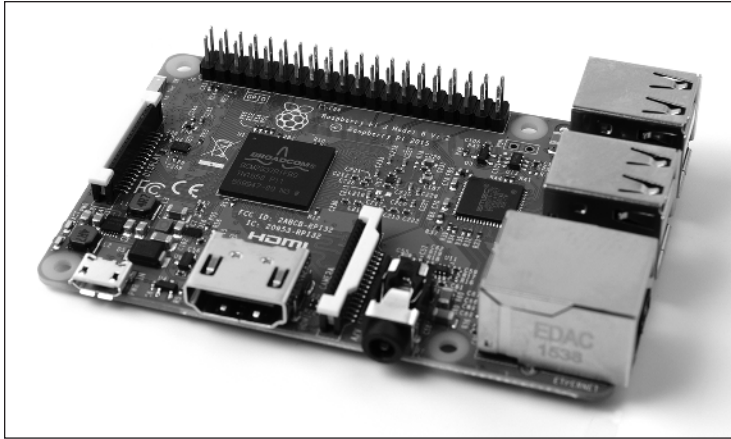
---

**TIP**

### A Trip Around the Board

Since its launch as a mere two models, the Raspberry Pi family has expanded considerably. The current range consists of five mainstream models: the Raspberry Pi Model A+, Raspberry Pi Model B+, Raspberry Pi 2, Raspberry Pi 3 (see Figure 1-1), and Raspberry Pi Zero. Aside from the Zero, which is a cut-down model designed specifically for the lowest-possible cost and minimum board footprint, all models share a roughly similar design differing only in features such as the number of USB ports, presence or absence of network ports, and the power of their processor. The range also has a sixth, less-common, member: the Raspberry Pi Compute Module; designed for industrial use in customised carrier boards, the Compute Module runs the same software as its mainstream stable mates, but is otherwise beyond the scope of this book.

If you are the owner of an original-model Raspberry Pi, either the Model B or cut-down Model A, congratulations: you have a collector's item on your hands. The majority of the material in this book is entirely applicable to your boards, though there are some differences, including an inability to use add-ons adhering to the Hardware Attached on Top (HAT) standard, as described in Chapter 16, "Add-On Hardware". If you find yourself needing features missing from your early board, consider retiring it and picking up a Model A+, Model B+, or faster Raspberry Pi 2 or 3; if you're on a budget, look at the cheaper Raspberry Pi Zero.



**FIGURE 1-1:** The Raspberry Pi 3

In the rough centre of all Raspberry Pi boards is a square *semiconductor*, more commonly known as an integrated circuit or chip. This is the *system-on-chip (SoC) module*, which provides the Pi with its general-purpose processing, graphics rendering, and input/output capabilities. Depending on the model, this may be the original Broadcom BCM2835, the faster quad-core BCM2836, or the more powerful still 64-bit BCM2837. In the case of the Model A+, B+, and Zero, stacked on top of that chip is another semiconductor which provides the Pi with *memory* for temporary storage of data while it's running programs; on the Raspberry Pi 2 and 3, this chip is instead located on the underside of the board. This type of memory is known as *random access memory (RAM)*, because the computer can read from or write to any part of the memory at any time. RAM is *volatile*, meaning that anything stored in the memory is lost when the Pi loses power or is switched off.

Below the SoC are the Pi's video outputs. The wide silver connector is a *High-Definition Multimedia Interface (HDMI)* port, the same type of connector found on media players and many satellite and cable set-top boxes. When connected to a modern TV or monitor, the HDMI port provides high-resolution video and digital audio. A *composite video* port, which is designed for connection to older TVs that don't have an HDMI socket, is provided as part of the black and silver *3.5 mm AV jack* to the right of the HDMI socket. The video quality is lower than is available via HDMI, and only lower-quality analogue audio can be used. You'll need a *3.5 mm AV adapter cable* to use the composite video output, but you can use the analogue audio output with any standard 3.5 mm stereo audio cable.

The Raspberry Pi Zero has a somewhat different layout. In place of a full-size HDMI socket is a *mini-HDMI socket*, which requires a mini-HDMI to HDMI cable or adapter to connect to a TV or monitor. The Pi Zero also lacks the 3.5 mm AV jack of the larger Pi models; there is no

analogue audio output by default, and composite video is available only by soldering a cable or RCA jack to the two empty holes on the upper left of the board marked *TV*.

The pins to the top left of the Pi compose the *general-purpose input/output (GPIO) header*, which you can use to connect the Pi to other hardware. The most common use for this port is to connect an *add-on board*. An example, the Sense HAT, is described in Chapter 16. The GPIO port is extremely powerful, but it's fragile. When handling the Pi, always avoid touching these pins, and never connect anything to them while the Pi is switched on.

The plastic and metal connector below the GPIO port is the *Display Serial Interface (DSI)* port, which is used to connect digitally driven flat-panel display systems. These are rarely used because the HDMI port is more flexible, though the official Raspberry Pi touchscreen accessory is one of the few displays to make use of the port. A second plastic and metal connector, found to the right of the HDMI port, is the *Camera Serial Interface (CSI)* port, which provides a high-speed connection to the Raspberry Pi Camera Module. For more details on the CSI port, see Chapter 15, "The Raspberry Pi Camera Module".

The Pi Zero, again, has a different layout: there is no DSI port available on this model of Pi, and a compact CSI port is used in place of the full-size version found on the larger Pi models. This compact CSI port requires the use of an adapter cable or board to connect to the Raspberry Pi Camera Module. Older revisions of the Pi Zero have no CSI port at all and cannot use the Camera Module as a result.

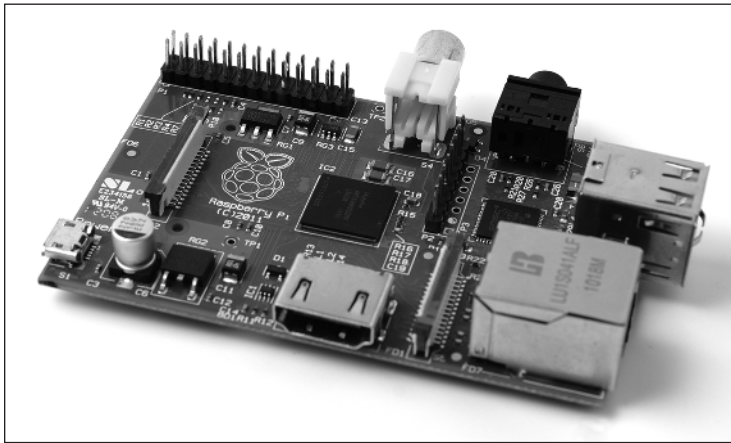
At the very bottom left of the board is the Pi's *power socket*. This is a *micro-USB* socket, the same type found on most modern smartphones and tablets. Connecting a micro-USB cable to a suitable power adapter, detailed in Chapter 2, "Getting Started with the Raspberry Pi", switches the Raspberry Pi on. Unlike a desktop or laptop computer, the Pi doesn't have a power switch and will start immediately when power is connected. For the Raspberry Pi Zero, the power socket is found on the far right of the board rather than the far left.

On the underside of the Raspberry Pi board on the left-hand side is a *micro-SD card slot*. A Secure Digital (SD) memory card provides storage for the operating system, programs, data and other files, and is *non-volatile*. Unlike the volatile RAM, it will retain its information even when power is lost. In Chapter 2, you'll learn how to prepare an SD card for use with the Pi, including installing an operating system in a process known as *flashing*. The Pi Zero has the micro-SD card slot on the top side of the board, rather than the underside.

The right-hand edge of the Pi will have different connectors depending on which model of Raspberry Pi you have; these models are described in more detail in the following pages. The board also includes one or more *light-emitting diodes* which provide visual feedback as to the status of the board: whether it is powered, whether it has a network connection, whether it is actively accessing the micro-SD card, and so forth.

## Model A/B

The original Raspberry Pi models launched were known as the Model A and the Model B (see Figure 1-2). Both had the same Broadcom BCM2835 SoC at their heart, but differed in specification: the Model A had 256 MB of RAM, a single USB port, and no networking capabilities; the Model B had either 256 MB or 512 MB of RAM depending on when it was purchased, two USB ports, and a 10/100 wired network port.



**FIGURE 1-2:** The Raspberry Pi Model B board

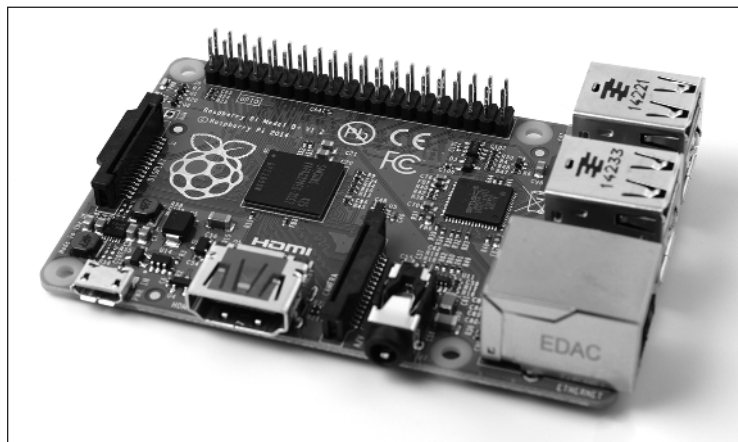
These models are immediately recognisable due to the smaller than normal GPIO port, which has only 26 pins compared to a modern Pi’s larger 40-pin port. Both models also use full-size SD cards for storage, rather than the compact micro-SD cards of newer models. No longer manufactured, Raspberry Pi Model As and Bs are nevertheless still compatible with the majority of software designed for newer models but cannot use add-on hardware based on the HAT standard, as described in Chapter 16.

If you have a Raspberry Pi Model A or Model B, you can follow most of the material in this book without difficulty; simply pay close attention to sections such as Chapter 14, “The GPIO Port”, to ensure that you’re not relying on information written with newer models in mind when wiring hardware directly into the Pi.

## Model A+/B+

The original Model A and B proved popular, but were quickly replaced with a new board design known as the Plus. Split into the Model A+ and Model B+ (see Figure 1-3), these

revisions introduced the now-standard 40-pin GPIO header while also improving various other features; they did not, however, change from the BCM2835 SoC, meaning there is no appreciable difference in performance between the Plus variants and the older non-Plus models.



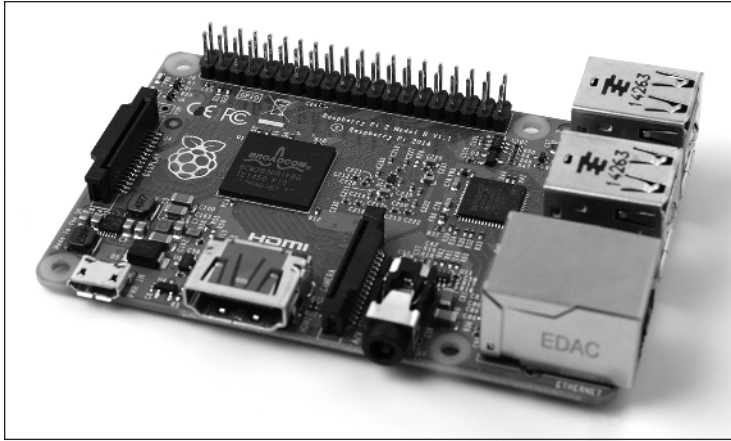
**FIGURE 1-3:** The Raspberry Pi Model B+ board

The hardware split between the Model A+ and Model B+ is similar to that of the Model A and Model B: the A+, which has a smaller footprint than the Model A, has either 256 MB or 512 MB of memory depending on when it was purchased, a single USB port, and no network capabilities; the Model B+ has 512 MB of memory, four USB ports, and a 10/100 wired network port.

The Raspberry Pi Model A+ and Model B+ are compatible with all software and devices mentioned in this book, and use the same GPIO layout as the newer-model Pi variants. If you currently own a Model A+ or Model B+, the only reason you may have to upgrade is to improve performance, gain additional memory, or enjoy built-in wireless capabilities.

## Raspberry Pi 2

While the Plus and prior boards all used the same BCM2835 SoC, the Raspberry Pi 2 (see Figure 1-4) was the first to feature a brand new processor: the BCM2836 SoC. Featuring four processor cores to the original's lone core, the BCM2836 offers anything between four and eight times the performance of its predecessor—making everything from word processing to compiling code run faster. The board also boasts 1 GB (1024 MB) of RAM, double the maximum previously available, making multitasking and memory-intensive applications smoother and more responsive.



**FIGURE 1-4:** The Raspberry Pi 2 board

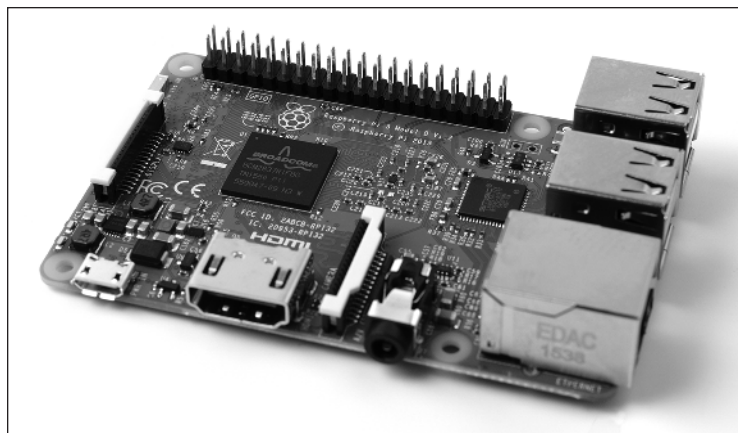
Layout-wise, however, little has changed from the Model B+. The Raspberry Pi 2 features the same 40-pin GPIO header, four USB ports, 10/100 wired network port, and all other ports. If you have a case or add-on device which works with a Model B+, it will also work just fine with the Raspberry Pi 2—but may run considerably faster!

The Raspberry Pi 2 boasts wider software compatibility than its predecessors: as well as Raspbian, the recommended Raspberry Pi operating system, the Pi 2 can run operating systems such as Ubuntu and Windows 10 IoT Core not available for the older models.

## Raspberry Pi 3

The latest model of Raspberry Pi to launch, the Raspberry Pi 3 (see Figure 1-5) builds on its predecessors with yet another new processor: the Broadcom BCM2837. The first to feature 64-bit, rather than 32-bit, support, the BCM2837 is significantly faster than the BCM2836 found in the Pi 2, which itself was a major upgrade from the BCM2835 of the original and Plus lineups. The Pi 3 is also the first model to get built-in wireless support, featuring a radio capable of connecting to 2.4 GHz Wi-Fi networks and Bluetooth devices.

As with the Raspberry Pi 2, though, little has changed with the layout: you'll find the same 40-pin GPIO header, four USB ports, 10/100 wired network port, and all other ports as with the previous models. The only wrinkle for compatibility is a minor change in the way the board communicates with certain add-on hardware; if you're unsure whether a device is compatible with the Raspberry Pi 3, contact the manufacturer or vendor before buying to ensure that software has been written with the change in mind.



**FIGURE 1-5:** The Raspberry Pi 3 board

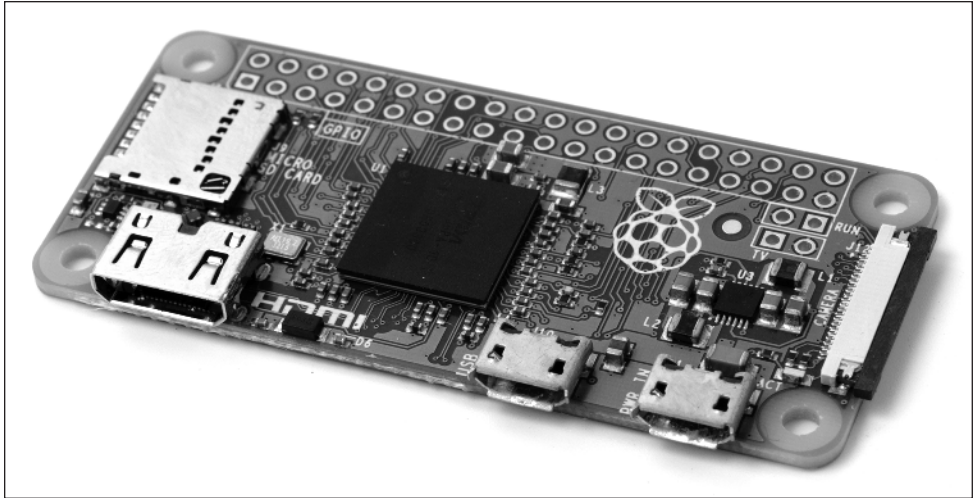
A major advantage of the Raspberry Pi 3, beyond the improved performance and built-in wireless capabilities, is the 64-bit processor. Although little software exists to take advantage of this at present, a move to 64 bit promises to offer increased software compatibility, security, and performance over the 32-bit code the Raspberry Pi family runs today.

## Raspberry Pi Zero

The Raspberry Pi Zero (see Figure 1-6) holds two accolades: it's by far the smallest Raspberry Pi, and it's by far the cheapest. Despite its size—roughly equivalent to a couple of sticks of chewing gum stacked one on top of the other—it loses little: the Pi Zero includes the same BCM2835 SoC and 512 MB of RAM as the Raspberry Pi Model B+, running at a slightly faster speed for improved performance.

Caveats apply to the use of the Pi Zero, however. Even compared to the Model A+, it's cut down: the single micro-USB port and mini-HDMI port both require adapters before they can be connected to standard peripherals; the 3.5 mm AV jack is missing; there's no DSI port, and the CSI port requires an adapter; and the GPIO header, although present, requires pins to be purchased and soldered into place before it can be used.

If you are a Raspberry Pi beginner, the Pi Zero is not the best choice of starter board. When you're more experienced and are looking to add Pi-powered intelligence to embedded projects—especially where size, cost, and power draw are concerns—the Pi Zero should be the first board on your mind.



**FIGURE 1-6:** The Raspberry Pi Zero board

## A Bit of Background

Before heading into Chapter 2, it's a good idea to familiarise yourself with some background details of the Pi and its creation. While the Pi is usable as a general-purpose computer, capable of performing the same tasks as any desktop, laptop, or server—albeit more slowly—it is designed as a *single-board computer* aimed at hobbyists and educational use, and as such differs from a “normal” computer in a couple of important ways.

## ARM Versus x86

The processor at the heart of the Raspberry Pi system is a Broadcom BCM283x-series SoC multimedia processor. This means that the vast majority of the system's components, including its central and graphics processing units along with the audio and communications hardware, are built onto that single component at the centre of the board.

It's not just this SoC design that makes the BCM283x family different from the processor found in your desktop or laptop, however. It also uses a different *instruction set architecture (ISA)*, known as ARM.

Developed by Acorn Computers back in the late 1980s, the ARM architecture is a relatively uncommon sight in the desktop world. Where it excels, however, is in mobile devices. The phone in your pocket almost certainly has at least one ARM-based processing core hidden inside. Its combination of a simple *reduced instruction set computing (RISC)* architecture and low power draw make it the perfect choice over desktop chips with high power demands and *complex instruction set computing (CISC)* architectures.

The ARM-based BCM283x family is the secret to the Raspberry Pi's capacity to operate on just the 5V power supply provided via the onboard micro-USB port. It's also the reason why you won't find any metal heat sinks on the device: the chip's low power draw directly translates into very little wasted heat, even during complicated processing tasks.

It does mean, however, that the Raspberry Pi isn't compatible with traditional PC software. The majority of software for desktops and laptops are built with the x86 instruction set architecture in mind, as found in processors from the likes of AMD, Intel, and VIA. As a result, it won't run on the ARM-based Raspberry Pi.

The BCM2835 found in the Model A, Model B, Model A+, Model B+, Pi Zero, and Compute Module uses a generation of ARM's processor design known as *ARM11*, which in turn is designed around a version of the instruction set architecture known as ARMv6. The BCM2836 found in the Raspberry Pi 2 uses the newer ARMv7 instruction set architecture, giving it higher performance and compatibility with a broader array of operating systems. The BCM2837 found in the Raspberry Pi 3, finally, uses the 64-bit ARMv8 architecture, boosting performance still further and opening the door to supporting native 64-bit code in the future.

It is true that most software you'd find on a desktop or laptop computer is written with x86 rather than ARM in mind, but that's not to say you're going to be restricted in your choices. As you'll discover later in the book, plenty of software is available even for the older ARMv6 instruction set, and as the Raspberry Pi's popularity continues to grow, availability will only increase. In this book, you'll also learn how to create your own software for the Pi, even if you don't have experience with programming.

## Windows Versus Linux

Another important difference between the Raspberry Pi and your desktop or laptop, other than the size and price, is the operating system—the software that enables you to control the computer.

The majority of desktop and laptop computers available today run one of two operating systems: Microsoft Windows or Apple OS X. Both platforms are *closed source*, created in a secretive environment using proprietary techniques.

These operating systems are known as closed source because of the nature of their *source code*, the computer-language recipe that tells the system what to do. In closed source software, this recipe is a closely guarded secret. Users are able to obtain the finished software but never to see how it's made.

The Raspberry Pi, by contrast, is designed primarily to run an operating system called *GNU/Linux*—hereafter referred to simply as Linux. Unlike Windows or OS X, Linux is *open source*, so you can download the source code for the entire operating system and make whatever changes you desire. Nothing is hidden, and all changes are made in full view of the public. This open source development ethos has allowed Linux to be altered quickly to run on the Raspberry Pi. At the time of writing, several versions of Linux—known as *distributions*—have been ported to the Raspberry Pi, including Raspbian and Arch Linux. For the newer models, additional operating systems are available—even a variant of Windows 10 designed for embedded computing projects, a rare example of a closed source operating system being made available on the Raspberry Pi.

The different Linux distributions cater to different needs, but they all have something in common: they're all open source. They're also all, by and large, compatible with each other—software written on a Debian system will usually operate perfectly well on Arch Linux, and vice versa.

Linux isn't exclusive to the Raspberry Pi. Hundreds of different distributions are available for desktops, laptops, and even mobile devices. Even Google's popular Android platform is developed on top of a Linux core. If you find that you enjoy using Linux on the Raspberry Pi, you might want to consider adding it to other computing devices you use as well. It will happily coexist with your current operating system, allowing you to enjoy the benefits of both while giving you a familiar environment when your Pi is unavailable.

As with the difference between ARM and x86, there's a key point to make about the practical difference between Windows and OS X and Linux: software written specifically for Windows or OS X won't run on Linux. Thankfully, there are plenty of compatible alternatives for the overwhelming majority of common software products. Better still, the majority are free to use and as open source as the operating system itself, and can even be installed on both Windows and OS X to provide a familiar experience across all three platforms.