Third Edition
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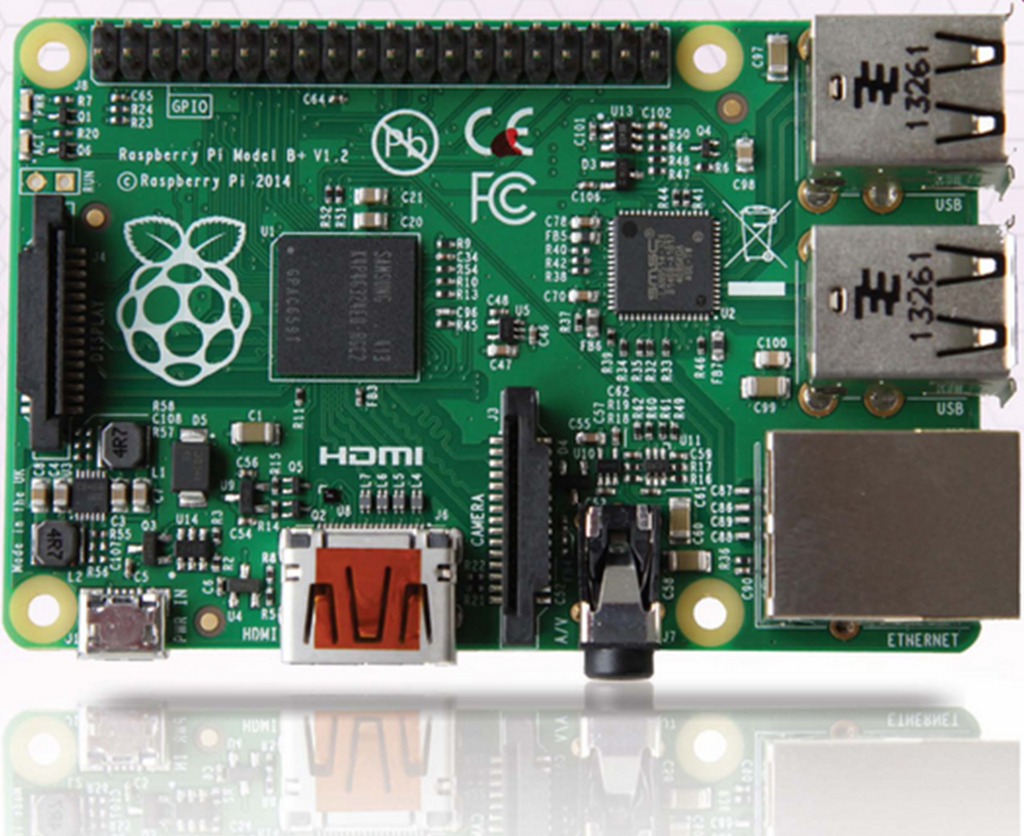


# Raspberry Pi®
## User Guide

**Eben Upton**
Co-creator of the Raspberry Pi
**Gareth Halfacree**

WILEY

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# User Guide

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*For Liz, who made it all possible.*

*—Eben*

*For my father, the enthusiastic past, and my daughter, the exciting future.*

*—Gareth*

# Contents

# Introduction

**"CHILDREN TODAY ARE** digital natives", said a man I got talking to at a fireworks party. "I don't understand why you're making this thing. My kids know more about setting up our PC than I do."

I asked him if they could program, to which he replied: "Why would they want to? The computers do all the stuff they need for them already, don't they? Isn't that the point?"

As it happens, plenty of kids today aren't digital natives. We have yet to meet any of these imagined wild digital children, swinging from ropes of twisted-pair cable and chanting war songs in nicely parsed Python. In the Raspberry Pi Foundation's educational outreach work, we do meet a lot of kids whose entire interaction with technology is limited to closed platforms with graphical user interfaces (GUIs) that they use to play movies, do a spot of word-processed homework and play games. They can browse the web, upload pictures and video, and even design web pages. (They're often better at setting the satellite TV box than Mum or Dad, too.) It's a useful toolset, but it's shockingly incomplete, and in a country where 20 percent of households still don't have a computer in the home, even this toolset is not available to all children.

Despite the most fervent wishes of my new acquaintance at the fireworks party, computers don't program themselves. We need an industry full of skilled engineers to keep technology moving forward, and we need young people to be taking those jobs to fill the pipeline as older engineers retire and leave the industry. But there's much more to teaching a skill like programmatic thinking than breeding a new generation of coders and hardware hackers. Being able to structure your creative thoughts and tasks in complex, non-linear ways is a learned talent, and one that has huge benefits for everyone who acquires it, from historians to designers, lawyers and chemists.

## Programming Is Fun!

It's enormous, rewarding, creative fun. You can create gorgeous intricacies, as well as (much more gorgeous, in my opinion) clever, devastatingly quick and deceptively simple-looking routes through, under and over obstacles. You can make stuff that'll have other people looking on jealously, and that'll make you feel wonderfully smug all afternoon. In my day job, where I design the sort of silicon chips that we use in the Raspberry Pi as a processor and work on the low-level software that runs on them, I basically get paid to sit around all day playing. What could be better than equipping people to be able to spend a lifetime doing that?

It's not even as if we're coming from a position where children don't want to get involved in the computer industry. A big kick up the backside came a few years ago, when we were moving quite slowly on the Raspberry Pi project. All the development work on Raspberry Pi was done in the spare evenings and weekends of the Foundation's trustees and volunteers—we're a charity, so the trustees aren't paid by the Foundation, and we all have full-time jobs to pay the bills. This meant that, occasionally, motivation was hard to come by when all I wanted to do in the evening was slump in front of the *Arrested Development* boxed set with a glass of wine. One evening, when not slumping, I was talking to a neighbour's nephew about the subjects he was taking for his General Certificate of Secondary Education (GCSE, the British system of public examinations taken in various subjects from the age of about 16), and I asked him what he wanted to do for a living later on.

"I want to write computer games", he said.

"Awesome. What sort of computer do you have at home? I've got some programming books you might be interested in."

"A Wii and an Xbox."

On talking with him a bit more, it became clear that this perfectly smart kid had never done any real programming at all; that there wasn't any machine that he could program in the house; and that his information and communication technology (ICT) classes—where he shared a computer and was taught about web page design, using spreadsheets and word processing—hadn't really equipped him to use a computer even in the barest sense. But computer games were a passion for him (and there's nothing peculiar about wanting to work on something you're passionate about). So that was what he was hoping the GCSE subjects he'd chosen would enable him to do. He certainly had the artistic skills that the games industry looks for, and his maths and science marks weren't bad. But his schooling had skirted around any programming—there were no Computing options on his syllabus, just more of the same ICT classes, with its emphasis on end users rather than programming. And his home interactions with computing meant that he stood a vanishingly small chance of acquiring the skills he needed in order to do what he really wanted to do with his life.

This is the sort of situation I want to see the back of, where potential and enthusiasm is squandered to no purpose. Now, obviously, I'm not monomaniacal enough to imagine that simply making the Raspberry Pi is enough to effect all the changes that are needed. But I do believe that it can act as a catalyst. We're already seeing big changes in the UK schools' curriculum, where Computing is arriving on the syllabus this year and ICT is being entirely reshaped, and we've seen a massive change in awareness of a gap in our educational and cultural provision for kids just in the short time since the Raspberry Pi was launched.

Too many of the computing devices a child will interact with daily are so locked down that they can't be used creatively as a tool—even though computing *is* a creative subject. Try using your iPhone to act as the brains of a robot, or getting your PS3 to play a game you've written. Sure, you can program the home PC, but there are significant barriers in doing that which a lot of children don't overcome: the need to download special software, and having the sort of parents who aren't worried about you breaking something that they don't know how to fix. And plenty of kids aren't even aware that doing such a thing as programming the home PC is possible. They think of the PC as a machine with nice clicky icons that give you an easy way to do the things you need to do so you don't need to think much. It comes in a sealed box, which Mum and Dad use to do the banking and which will cost lots of money to replace if something goes wrong!

The Raspberry Pi is cheap enough to buy with a few weeks' pocket money, and you probably have all the equipment you need to make it work: a TV, an SD card that can come from an old camera, a mobile phone charger, a keyboard and a mouse. It's not shared with the family; it belongs to the kid; and it's small enough to put in a pocket and take to a friend's house. If something goes wrong, it's no big deal—you just swap out a new SD card and your Raspberry Pi is factory-new again. And all the tools, environments and learning materials that you need to get started on the long, smooth curve to learning how to program your Raspberry Pi are right there, waiting for you as soon as you turn it on.

## A Bit of History

I started work on a tiny, affordable, bare-bones computer in 2006, when I was a Director of Studies in Computer Science at Cambridge University. I'd received a degree at the University Computer Lab as well as studying for a PhD while teaching there, and over that period, I'd noticed a distinct decline in the skillset of the young people who were applying to read Computer Science at the Lab. From a position in the mid-1990s, when 17-year-olds wanting to read Computer Science had come to the University with a grounding in several computer languages, knew a bit about hardware hacking, and often even worked in assembly language, we gradually found ourselves in a position where, by 2005, those kids were arriving having done some HTML—with a bit of PHP and Cascading Style Sheets if you were lucky. They were still fearsomely clever kids with lots of potential, but their experience with computers was entirely different from what we'd been seeing before.

The Computer Science course at Cambridge includes about 60 weeks of lecture and seminar time over three years. If you're using the whole first year to bring students up to speed, it's harder to get them to a position where they can start a PhD or go into industry over the next two years. The best undergraduates—the ones who performed the best at the end of their three-year course—were the ones who weren't just programming when they'd been told to for their weekly assignment or for a class project. They were the ones who were programming in their spare time. So the initial idea behind the Raspberry Pi was a very parochial one with a very tight (and pretty unambitious) focus: I wanted to make a tool to get the small number of applicants to this small university course a kick start. My colleagues and I imagined we'd hand out these devices to schoolkids at open days, and if they came to Cambridge for an interview a few months later, we'd ask what they'd done with the free computer we'd given them. Those who had done something interesting would be the ones that we'd be interested in having in the program. We thought maybe we'd make a few hundred of these devices, or best case, a lifetime production run of a few thousand.

Of course, once work was seriously underway on the project, it became obvious that there was a lot more we could address with a cheap little computer like this. What we started with is a long way indeed from the Raspberry Pi you see today. I began by soldering up the longest piece of breadboard you can buy at Maplin with an Atmel chip at our kitchen table, and the first crude prototypes used cheap microcontroller chips to drive a standard-definition TV set directly. With only 512 K of RAM, and a few MIPS of processing power, these prototypes were very similar in performance to the original 8-bit microcomputers. It was hard to imagine these machines capturing the imaginations of kids used to modern games consoles and iPads.

There had been discussions at the University Computer Lab about the general state of computer education, and when I left the Lab for a non-academic job in the industry, I noticed that I was seeing the same issues in young job applicants as I'd been seeing at the University. So I got together with my colleagues Dr Rob Mullins and Professor Alan Mycroft (two colleagues from the Computer Lab), Jack Lang (who lectures in entrepreneurship at the University), Pete Lomas (a hardware guru) and David Braben (a Cambridge games industry leading light with an invaluable address book), and over beers (and, in Jack's case, cheese and wine), we set up the Raspberry Pi Foundation—a little charity with big ideas.

## Why "Raspberry Pi"?

We get asked a lot where the name "Raspberry Pi" came from. Bits of the name came from different trustees. It's one of the very few successful bits of design by committee I've seen, and to be honest, I hated it at first. (I have since come to love the name, because it works really well—but it took a bit of getting used to since I'd been calling the project the "ABC Micro" in my head for years.) It's "Raspberry" because there's a long tradition of fruit names in computer companies (besides the obvious, there are the old Tangerine and Apricot computers—and we like to think of the Acorn as a fruit as well). "Pi" is a mangling of "Python", which we thought early on in development would be the only programming language available on a much less powerful platform than the Raspberry Pi we ended up with. As it happens, we still recommend Python as our favourite language for learning and development, but there is a world of other language options you can explore on the Raspberry Pi too.

In my new role as a chip architect at Broadcom, a big semiconductor company, I had access to inexpensive but high-performing hardware produced by the company with the intention of being used in very high-end mobile phones—the sort with the HD video and the 14-megapixel cameras. I was amazed by the difference between the chips you could buy for $10 as a small developer, and what you could buy as a cell-phone manufacturer for roughly the same amount of money: general purpose processing, 3D graphics, video and memory bundled into a single BGA package the size of a fingernail. These microchips consume very little power, and have big capabilities. They are especially good at multimedia, and were already being used by set-top box companies to play high-definition video. A chip like this seemed the obvious next step for the shape the Raspberry Pi was taking, so I worked on taping out a low-cost variant that had an ARM microprocessor on board and could handle the processing grunt we needed.

We felt it was important to have a way to get kids enthusiastic about using a Raspberry Pi even if they didn't feel very enthusiastic about programming. In the 1980s, if you wanted to play a computer game, you had to boot up a box that went "bing" and fed you a command prompt. It required typing a little bit of code just to get started, and most users didn't ever go beyond that—but some did, and got beguiled into learning how to program by that little bit of interaction. We realised that the Raspberry Pi could work as a very capable, very tiny, very cheap modern media centre, so we emphasised that capability to suck in the unwary—with the hope that they'd pick up some programming while they're at it.

After about five years' hard grind, we had created a very cute prototype board, about the size of a thumb drive. We included a permanent camera module on top of the board to demonstrate the sort of peripherals that can easily be added (there was no camera when we launched because it brought the price up too much, but we've now made a separate, cheap camera module available for photography projects), and brought it along to a number of meetings with the BBC's R&D department. Those of us who grew up in the UK in the 1980s had learned a lot about 8-bit computing from the BBC Microcomputer and the ecosystem that had grown up around it—with BBC-produced books, magazines and TV programmes—so I'd hoped that they might be interested in developing the Raspberry Pi further. But as it turned out, something has changed since we were kids: various competition laws in the UK and the EU meant that "the Beeb" couldn't become involved in the way we'd hoped. In a last-ditch attempt to get *something* organised with them, we ditched the R&D department idea and David (he of the giant address book) organised a meeting with Rory Cellan-Jones, a senior tech journalist, in May 2011. Rory didn't hold out much hope for partnership with the BBC, but he did ask if he could take a video of the little prototype board with his phone, to put on his blog.

The next morning, Rory's video had gone viral, and I realised that we had accidentally promised the world that we'd make everybody a $25 computer.

While Rory went off to write another blog post on exactly what it is that makes a video go viral, we went off to put our thinking caps on. That original, thumb-drive-sized prototype didn't fit the bill: with the camera included as standard, it was way too expensive to meet the cost model we'd suggested (the $25 figure came from my statement to the BBC that the Raspberry Pi should cost around the same as a text book, and is a splendid demonstration of the fact that I had no idea how much text books cost these days), and the tiny prototype model didn't have enough room around its periphery for all the ports we needed to make it as useable as we wanted it to be. So we spent a year working on engineering the board to lower cost as much as possible while retaining all the features we wanted (engineering cost down is a harder job than you might think), and to get the Raspberry Pi as useable as possible for people who might not be able to afford much in the way of peripherals.

We knew we wanted the Raspberry Pi to be used with TVs at home, just like the ZX Spectrum in the 1980s, saving the user the cost of a monitor. But not everybody has access to an HDMI television, so we added a composite port to make the Raspberry Pi work with an old cathode-ray television instead since SD cards are cheap and easy to find. We decided against microSD as the storage medium, because the little fingernail-sized cards are so flimsy in the hands of children and so easy to lose. And we went through several iterations of power supply, ending up with a micro USB cable. Recently, micro USB became the standard charger cable for mobile telephones across the EU (and it's becoming the standard everywhere), which means the cables are becoming more and more ubiquitous, and in many cases, people already have them at home.

By the end of 2011, with a projected February release date, it was becoming obvious to us that things were moving faster, and demand was higher, than we were ever going to be able to cope with. The initial launch was always aimed at developers, with the educational launch planned for later in 2012. We had a small number of very dedicated volunteers, but we needed the wider Linux community to help us prepare a software stack and iron out any early-life niggles with the board before releasing into the educational market. We had enough capital in the Foundation to buy the parts for and build 10,000 Raspberry Pis over a period of a month or so, and we thought that the people in the community who would be interested in an early board would come to around that number. Fortunately and unfortunately, we'd been really successful in building a big online community around the device, and interest wasn't limited to the UK, or to the educational market. Ten thousand was looking less and less realistic.

## Our Community

The Raspberry Pi community is one of the things we're proudest of. We started with a very bare-bones blog at `www.raspberrypi.org` just after Rory's May 2011 video, and put up a forum on the same website shortly after that. That forum now has more than 60,000 members—between them they've contributed more than half a million posts of wit and wisdom about the Raspberry Pi. If there's any question, no matter how abstruse, that you want to ask about the Raspberry Pi or about programming in general, someone there will have the answer (if it's not in this book, you'll find it in the forums).

Part of my job at Raspberry Pi involves giving talks to hacker groups, computing conferences, teachers, programming collectives and the like, and there's always someone in the audience who has talked to me or to my wife Liz (who runs the community) on the Raspberry Pi website—and some of these people have become good friends of ours. The Raspberry Pi website gets more than one request every single second of the day.

There are now hundreds of fan sites out there. There's also a fan magazine called *The MagPi* (a free download from `www.themagpi.com`), which is produced monthly by community members, with type-in listings, lots of articles, project guides, tutorials and more. Type-in games in magazines and books provided an easy route into programming for me—my earliest programming experience with the BBC Micro was of modifying a type-in helicopter game to add enemies and pick-ups.

We blog something interesting about the device at `www.raspberrypi.org` at least once every day. Come and join in the conversation!

There were 100,000 people on our mailing list wanting a Raspberry Pi—and they all put an order in on day one! Not surprisingly, this brought up a few issues.

First off, there are the inevitable paper cuts you're going to get boxing up 100,000 little computers and mailing them out—and the fact was that we had absolutely no money to hire people to do this for us. We didn't have a warehouse—we had Jack's garage. There was no way we could raise the money to build 100,000 units at once—we'd envisaged making them in batches of 2,000 every couple of weeks, which, with this level of interest, was going to take so long that the thing would be obsolete before we managed to fulfil all the orders. Clearly, manufacturing and distribution were something we were going to have to give up on and hand over to somebody else who already had the infrastructure and capital to do that, so we got in touch with element14 and RS Components, both UK microelectronics suppliers with worldwide businesses, and contracted with them to do the actual manufacture and distribution side of things worldwide so we could concentrate on development and the Raspberry Pi Foundation's charitable goals.

Demand on the first day was still so large that RS and element14's websites both crashed for most of the day—at one point in the day, element14 were getting seven orders a second, and for a couple of hours on February 29, Google showed more searches were made worldwide for "Raspberry Pi" than were made for "Lady Gaga". We made and sold more than a million Raspberry Pis in the first year of business, making Raspberry Pi the fastest-growing computer company in the world, ever. Things aren't slowing down: we make more than 100,000 Pis every month and have sold more than 3 million in well under three years, with no hint of a slowdown. If we'd stuck with our original plans, we'd have made 100 or so of these devices for University open days, and that would have been it.

**NOTE** The first production Pis were made in Chinese factories, but in 2012 we managed to repatriate all of the production to the UK. Your Raspberry Pi is now made in South Wales, in an area of the country with a proud manufacturing heritage, but few remaining factories. Amazingly, it costs us the same to manufacture in Wales as it did in China, and we're able to do that manufacture without a language or cultural barrier, and with the ability to jump in the car and be on the factory floor in a few hours if necessary.

There is nothing that affects the blood pressure quite like accidentally ending up running a large computer company!

## So What Can You Do with the Raspberry Pi?

This book explores a number of things you can do with your Raspberry Pi, from controlling hardware with Python, to using it as a media centre, setting up camera projects, or building games in Scratch. The beauty of the Raspberry Pi is that it's just a very tiny general-purpose computer (which may be a little slower than you're used to for some desktop applications, but much better at some other stuff than a regular PC), so you can do anything you could do on a regular computer with it. In addition, the Raspberry Pi has powerful multimedia and 3D graphics capabilities, so it has the potential to be used as a games platform, and we very much hope to see more people starting to write games for it.

We think physical computing—building systems using sensors, motors, lights and micro-controllers—is something that gets overlooked in favour of pure software projects in a lot of instances, and it's a shame, because physical computing is *massive fun*. To the extent that there was any children's computing movement when we began this project, it was a physical computing movement. The LOGO turtles that represented physical computing when we were kids are now fighting robots, quadcopters or parent-sensing bedroom doors, and we love it. However, the lack of General Purpose Input/Output (GPIO) on home PCs is a real handicap for many people getting started with robotics projects. The Raspberry Pi exposes GPIO so you can get to work straight away.

I keep being surprised by ideas the community comes up with which wouldn't have crossed my mind in a thousand years: the Australian school meteor-tracking project; the Boreatton Scouts in the UK and their robot, which is controlled via an electroencephalography headset (the world's first robot controlled by Scouting brain waves); the family who are building a robot vacuum cleaner; Manuel, the talking Christmas moose. And I'm a real space cadet, so reading about the people sending Raspberry Pis into near-earth orbit on rockets and balloons gives me goosebumps.

In the first edition of this book, I said that success for us would be another 1,000 people every year taking up Computer Science at the university level in the UK. That would not only be beneficial for the country, the software and hardware industries, and the economy; but it would be even more beneficial for every one of those 1,000 people, who, I hope, will discover that there's a whole world of possibilities and a great deal of fun to be had out there. We've gotten greedy now: I'd like to see that sort of statistic replicated in many more countries across the developed world, and to see something similar starting to happen in the developing world. We've been immensely proud to see Raspberry Pi labs spring up in the most unlikely places, like a village lab in a part of Cameroon with no electricity network where the Pis run off solar power, generators and batteries, or a school high in the mountains in Bhutan.

Building a robot when you're a kid can take you to places you never imagined—I know because it happened to me!

—Eben Upton

# Part I

# The Board

# 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.

**TIP**

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.

## A Trip Around the Board

The Raspberry Pi is currently available as two different models, known as the Model A and the Model B. While there are differences, with the Model A sacrificing some functionality in order to reduce its cost and power requirements, both share plenty of similarities that you find out about in this chapter. Figure 1-1 shows a Raspberry Pi Model B Revision 2, the most common board type. Its layout is shared between the original Model B Revision 1 and the cheaper Model A; the latest Model B+ uses an altered layout discussed later in this chapter.

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 Broadcom BCM2835 *system-on-chip (SoC) module*, which provides the Pi with its general-purpose processing, graphics rendering and input/output capabilities. 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. 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.

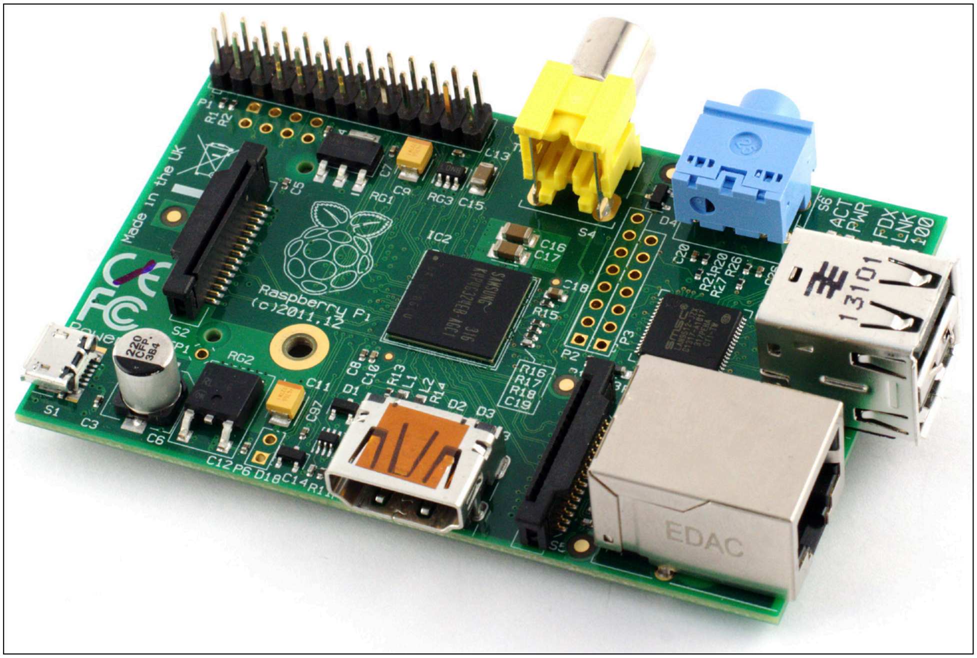


**FIGURE 1-1:** The Raspberry Pi Model B Revision 2 board

Above and below the SoC are the Pi's video outputs. The silver (bottom) 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. The yellow (top) connector is a *composite video* port, which is designed for connection to older TVs that don't have an HDMI socket. The video quality is lower than is available via HDMI, and there's no audio; instead, audio is provided as an analogue signal on the *3.5mm audio jack* to the right of the composite video socket.

The pins to the top-left of the Pi compose the *general-purpose input-output (GPIO) header*, which can be used to connect the Pi to other hardware. The most common use for this port is to connect an *add-on board*. A selection of these boards is described in Chapter 17, "Add-On Boards". 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 except by professional embedded developers because the HDMI port is more flexible.

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 or other Pi-compatible CSI-connected camera system. For more details on the CSI port, see Chapter 16, "The Raspberry Pi Camera Module".

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.

On the underside of the Raspberry Pi board on the left-hand side is an *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 right-hand edge of the Pi will have different connectors depending on which model of Raspberry Pi you have, the Model A or the Model B. Above these is a series of *Light Emitting Diodes (LEDs)*, the left-most two of which—marked ACT and PWR and providing SD card activity notification and power notification, respectively—are present on all boards.

## Model A

The least expensive Raspberry Pi, the Model A shown in Figure 1-2, is designed to be affordable yet flexible. As well as costing less than the Model B, the Model A draws less power and is a good choice for projects that use solar, wind or battery power. Although the Model A's BCM2835 SoC is just as powerful as the one found on the Model B, it comes with half the memory, at 256MB. This is an important consideration when deciding which model to buy, because it can make more complex applications run slowly—in particular, those applications that turn the Pi into a *server,* as described in Chapter 10, "The Pi as a Web Server".

The Model A has only a single port on its right-hand edge, a *Universal Serial Bus (USB)* port. This is the same type of port found on desktop and laptop computers, and allows the Pi to be connected to almost any USB-compatible peripheral. Most commonly, the USB port is used to connect a keyboard for interacting with the Pi. If you also want to use a mouse at the same time, you'll need to buy a *USB hub* to add more ports to the Model A, or alternatively, a keyboard with built-in mouse functionality.

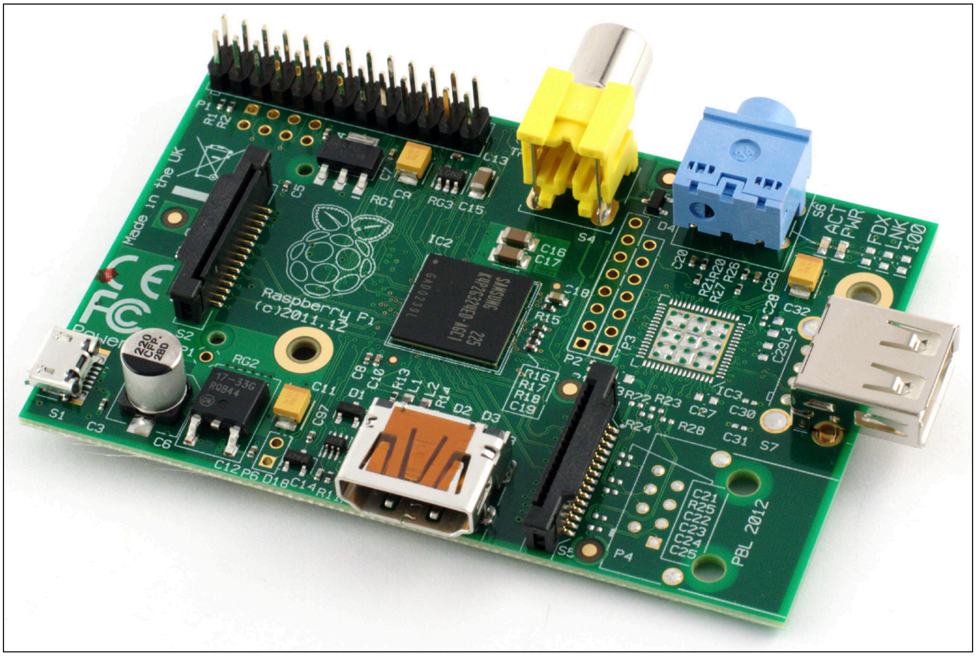


**FIGURE 1-2:** The Raspberry Pi Model A board

## Model B

The Raspberry Pi Model B shown in Figure 1-3 is more expensive than the Model A, but it comes with considerable advantages. Internally, it includes twice the memory, at 512MB, while externally there are additional ports not available on the lower-cost model. For many users, the Model B is a worthwhile investment. Only those with particular requirements of low weight, space or power draw should consider the Model A for general-purpose use.

The Model B has either two or four USB ports on the right-hand edge of the board, primarily to provide connectivity for a keyboard and mouse along with other USB peripherals. Additionally, the Model B includes an *Ethernet* port for connecting the Pi to a wired network, which allows the Pi to access the Internet and allows other devices on the network to access the Pi—providing, that is, that they know the username and password or that the Pi has been set up as a server, as described in Chapter 10.

## Model B+

The Raspberry Pi Model B+, shown in Figure 1-4, is the latest version of the board developed by the Raspberry Pi Foundation. It was created to address issues with the existing Model B Revision 2 design and has a dramatically different layout than any of the previously released Raspberry Pi models.