Raspberry Pi

The **Raspberry Pi** is a series of small [single-board computers](https://en.wikipedia.org/wiki/Single-board_computer) developed in the United Kingdom by the [Raspberry Pi Foundation](https://en.wikipedia.org/wiki/Raspberry_Pi_Foundation)to promote the teaching of basic [computer science](https://en.wikipedia.org/wiki/Computer_science) in schools and in [developing countries](https://en.wikipedia.org/wiki/Developing_countries).[4 The original model became far more popular than anticipated, selling outside its [target market](https://en.wikipedia.org/wiki/Target_market) for uses such as [robotics](https://en.wikipedia.org/wiki/Robotics). It does not include peripherals (such as [keyboards](https://en.wikipedia.org/wiki/Keyboard_(computing)), [mice](https://en.wikipedia.org/wiki/Mouse_(computing)) and [cases](https://en.wikipedia.org/wiki/Computer_case)). However, some accessories have been included in several official and unofficial bundles.

According to the Raspberry Pi Foundation, over 5 million Raspberry Pis were sold by February 2015, making it the best-selling [British computer](https://en.wikipedia.org/wiki/British_computer).[[8]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-8) By November 2016 they had sold 11 million units,[9] and 12.5m by March 2017, making it the third best-selling "general purpose computer". In July 2017, sales reached nearly 15 million.

## Overview

Several generations of Raspberry Pis have been released. All models feature a [Broadcom](https://en.wikipedia.org/wiki/Broadcom) [system on a chip](https://en.wikipedia.org/wiki/System_on_a_chip) (SoC) with an integrated [ARM](https://en.wikipedia.org/wiki/ARM_architecture" \o "ARM architecture)compatible [central processing unit](https://en.wikipedia.org/wiki/Central_processing_unit) (CPU) and [on-chip graphics processing unit](https://en.wikipedia.org/wiki/Graphics_processing_unit#Integrated_graphics) (GPU).

Processor speed ranges from 700 MHz to 1.2 GHz for the Pi 3; on-board memory ranges from 256 MB to 1 GB RAM. [Secure Digital](https://en.wikipedia.org/wiki/Secure_Digital) (SD) cards are used to store the operating system and program memory in either SDHC or MicroSDHC sizes. The boards have one to four USB ports. For video output, [HDMI](https://en.wikipedia.org/wiki/HDMI) and [composite video](https://en.wikipedia.org/wiki/Composite_video) are supported, with a standard 3.5 mm phono jack for audio output. Lower-level output is provided by a number of GPIO pins which support common protocols like [I²C](https://en.wikipedia.org/wiki/I%C2%B2C). The B-models have an [8P8C](https://en.wikipedia.org/wiki/8P8C) [Ethernet](https://en.wikipedia.org/wiki/Ethernet) port and the Pi 3 and Pi Zero W have on-board Wi-Fi 802.11n and [Bluetooth](https://en.wikipedia.org/wiki/Bluetooth). Prices range from US$5 to $35.

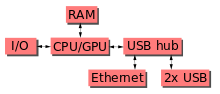
The first generation (**Raspberry Pi 1 Model B**) was released in February 2012, followed by the simpler and cheaper **Model A**. In 2014, the Foundation released a board with an improved design, **Raspberry Pi 1 Model B+**. These boards are approximately credit-card sized and represent the standard *mainline* form-factor. Improved A+ and B+ models were released a year later. A ["Compute Module"](https://en.wikipedia.org/wiki/Raspberry_Pi#Compute_module) was released in April 2014 for embedded applications. The **Raspberry Pi 2** which added more RAM was released in February 2015.

A **Raspberry Pi Zero** with smaller size and reduced [input/output](https://en.wikipedia.org/wiki/Input/output) (I/O) and [general-purpose input/output](https://en.wikipedia.org/wiki/General-purpose_input/output) (GPIO) capabilities was released in November 2015 for US$5. **Raspberry Pi 3 Model B** was released in February 2016 and has on-board [WiFi](https://en.wikipedia.org/wiki/Wi-Fi" \o "Wi-Fi), [Bluetooth](https://en.wikipedia.org/wiki/Bluetooth) and USB boot capabilitiesBy 2017, it became the newest mainline Raspberry Pi. On 28 February 2017, the **Raspberry Pi Zero W** was launched, a version of the Zero with Wi-Fi and Bluetooth capabilities, for US$10On 12 January 2018, the **Raspberry Pi Zero WH** was launched, the same version of the Zero W with pre-soldered GPIO headers.[[17]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-17)

The organisation behind the Raspberry Pi consists of two arms. The first two models were developed by the Raspberry Pi Foundation. After the Pi Model B was released, the Foundation set up Raspberry Pi Trading, with Eben Upton as CEO, to develop the third model, the B+. Raspberry Pi Trading is responsible for developing the technology while the Foundation is an educational charity to promote the teaching of basic computer science in schools and in developing countries.

The Foundation provides [Raspbian](https://en.wikipedia.org/wiki/Raspbian" \o "Raspbian), a Debian-based [Linux distribution](https://en.wikipedia.org/wiki/Linux_distribution) for download, as well as third-party [Ubuntu](https://en.wikipedia.org/wiki/Ubuntu_(operating_system)" \o "Ubuntu (operating system)), [Windows 10 IoT Core](https://en.wikipedia.org/wiki/Windows_10_IoT_Core), [RISC OS](https://en.wikipedia.org/wiki/RISC_OS), and specialised [media centre](https://en.wikipedia.org/wiki/OpenELEC)distributions.[[18]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-raspberrypi_downloads-18) It promotes [Python](https://en.wikipedia.org/wiki/Python_(programming_language)) and [Scratch](https://en.wikipedia.org/wiki/Scratch_(programming_language)) as the main programming language, with support for many other languages.[[19]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-19) The default [firmware](https://en.wikipedia.org/wiki/Firmware) is [closed source](https://en.wikipedia.org/wiki/Closed_source), while an unofficial [open source](https://en.wikipedia.org/wiki/Open_source) is available

The Raspberry Pi hardware has evolved through several versions that feature variations in memory capacity and peripheral-device support.

[](https://en.wikipedia.org/wiki/File:Raspberrypi_block_function_v01.svg)

This block diagram depicts Models A, B, A+, and B+. Model A, A+, and the Pi Zero lack the [Ethernet](https://en.wikipedia.org/wiki/Ethernet) and [USB](https://en.wikipedia.org/wiki/USB) hub components. The Ethernet adapter is internally connected to an additional USB port. In Model A, A+, and the Pi Zero, the USB port is connected directly to the [system on a chip](https://en.wikipedia.org/wiki/System_on_a_chip) (SoC). On the Pi 1 Model B+ and later models the USB/Ethernet chip contains a five-point USB hub, of which four ports are available, while the Pi 1 Model B only provides two. On the Pi Zero, the USB port is also connected directly to the SoC, but it uses a micro USB (OTG) port.

### Processor

The [Broadcom](https://en.wikipedia.org/wiki/Broadcom) BCM2835 SoC used in the first generation Raspberry Pi is somewhat equivalent to the chip used in first modern generation [smartphones](https://en.wikipedia.org/wiki/Smartphone" \o "Smartphone) (its CPU is an older [ARMv6](https://en.wikipedia.org/wiki/ARM11) architecture),[[23]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-Broadcom-BCM2835-Website-23) which includes a 700 [MHz](https://en.wikipedia.org/wiki/Hertz) [ARM11](https://en.wikipedia.org/wiki/ARM11)76JZF-S processor, [VideoCore](https://en.wikipedia.org/wiki/VideoCore" \o "VideoCore)IV [graphics processing unit](https://en.wikipedia.org/wiki/Graphics_processing_unit) (GPU),[[24]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-grandmax_brose_2012-24) and RAM. It has a level 1 (L1) [cache](https://en.wikipedia.org/wiki/CPU_cache) of 16 [KB](https://en.wikipedia.org/wiki/Kibibyte) and a level 2 (L2) cache of 128 KB. The level 2 cache is used primarily by the GPU. The SoC is [stacked](https://en.wikipedia.org/wiki/Package_on_package) underneath the RAM chip, so only its edge is visible.

The earlier V1.1 model of the Raspberry Pi 2 used a Broadcom BCM2836 SoC with a 900 MHz 32-bit quad-core [ARM Cortex-A7](https://en.wikipedia.org/wiki/ARM_Cortex-A7) processor, with 256 KB shared L2 cache. The Raspberry Pi 2 V1.2 was upgraded to a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core [ARM Cortex-A53](https://en.wikipedia.org/wiki/ARM_Cortex-A53) processor, the same SoC which is used on the Raspberry Pi 3, but underclocked (by default) to the same 900 MHz CPU clock speed as the V1.1. The BCM2836 SoC is no longer in production (as of late 2016).

The Raspberry Pi 3 uses a Broadcom BCM2837 SoC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, with 512 KB shared L2 cache

#### Performance

The Raspberry Pi 3, with a quad-core [ARM Cortex-A53](https://en.wikipedia.org/wiki/ARM_Cortex-A53) processor, is described as 10 times the performance of a Raspberry Pi 1. This was suggested to be highly dependent upon task [threading](https://en.wikipedia.org/wiki/Thread_(computing)) and [instruction set](https://en.wikipedia.org/wiki/Instruction_set) use. Benchmarks showed the Raspberry Pi 3 to be approximately 80% faster than the Raspberry Pi 2 in parallelised tasks.

Raspberry Pi 2 V1.1 included a quad-core Cortex-A7 CPU running at 900 MHz and 1 GB RAM. It was described as 4–6 times more powerful than its predecessor. The GPU was identical to the original. In parallelised benchmarks, the Raspberry Pi 2 V1.1 could be up to 14 times faster than a Raspberry Pi 1 Model B+.

While operating at 700 MHz by default, the first generation Raspberry Pi provided a real-world performance roughly equivalent to 0.041 [GFLOPS](https://en.wikipedia.org/wiki/FLOPS). On the [CPU](https://en.wikipedia.org/wiki/Central_processing_unit) level the performance is similar to a 300 MHz [Pentium II](https://en.wikipedia.org/wiki/Pentium_II) of 1997–99. The GPU provides 1 [Gpixel](https://en.wikipedia.org/wiki/Gpixel" \o "Gpixel)/s or 1.5 [Gtexel](https://en.wikipedia.org/wiki/Texel_(graphics)" \o "Texel (graphics))/s of graphics processing or 24 GFLOPS of general purpose computing performance. The graphical capabilities of the Raspberry Pi are roughly equivalent to the performance of the [Xbox](https://en.wikipedia.org/wiki/Xbox_(console)) of 2001.

#### Overclocking

Most Raspberry Pi chips could be [overclocked](https://en.wikipedia.org/wiki/Overclocking" \o "Overclocking) to 800 MHz, and some to 1000 MHz. There are reports the Raspberry Pi 2 can be similarly overclocked, in extreme cases, even to 1500 MHz (discarding all safety features and over-voltage limitations). In the [Raspbian](https://en.wikipedia.org/wiki/Raspberry_Pi" \l "Software) [Linux distro](https://en.wikipedia.org/wiki/Linux_distro) the overclocking options on [boot](https://en.wikipedia.org/wiki/Booting) can be done by a software command running "sudo raspi-config" without voiding the warranty. In those cases the Pi automatically shuts the overclocking down if the chip reaches 85 °C (185 °F), but it is possible to override automatic over-voltage and overclocking settings (voiding the warranty); an appropriately sized [heat sink](https://en.wikipedia.org/wiki/Heat_sink) is needed to protect the chip from serious overheating.

Newer versions of the firmware contain the option to choose between five overclock ("turbo") presets that when used, attempt to maximise the performance of the SoC without impairing the lifetime of the board. This is done by monitoring the core temperature of the chip, the CPU load, and dynamically adjusting clock speeds and the core voltage. When the demand is low on the CPU or it is running too hot the performance is throttled, but if the CPU has much to do and the chip's temperature is acceptable, performance is temporarily increased with clock speeds of up to 1 GHz depending on the individual board and on which of the turbo settings is used.

The seven overclock presets are:

* none; 700 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 [overvolting](https://en.wikipedia.org/wiki/Overvolting" \o "Overvolting)
* modest; 800 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolting,
* medium; 900 MHz ARM, 250 MHz core, 450 MHz SDRAM, 2 overvolting,
* high; 950 MHz ARM, 250 MHz core, 450 MHz SDRAM, 6 overvolting,
* turbo; 1000 MHz ARM, 500 MHz core, 600 MHz SDRAM, 6 overvolting,
* Pi 2; 1000 MHz ARM, 500 MHz core, 500 MHz SDRAM, 2 overvolting,
* Pi 3; 1100 MHz ARM, 550 MHz core, 500 MHz SDRAM, 6 overvolting. In system information CPU speed will appear as 1200 MHz. When in idle speed lowers to 600 MHz.

In the highest (*turbo*) preset the SDRAM clock was originally 500 MHz, but this was later changed to 600 MHz because 500 MHz sometimes causes SD card corruption. Simultaneously in *high* mode the core clock speed was lowered from 450 to 250 MHz, and in *medium* mode from 333 to 250 MHz.

The Raspberry Pi Zero runs at 1 GHz.

The CPU on the first and second generation Raspberry Pi board did not require cooling, such as a heat sink or [fan](https://en.wikipedia.org/wiki/Computer_fan), even when overclocking|overclocked, but the Raspberry Pi 3 may generate more heat when overclocked

### RAM

On the older beta Model B boards, 128 MB was allocated by default to the GPU, leaving 128 MB for the CPU. On the first 256 MB release Model B (and Model A), three different splits were possible. The default split was 192 MB (RAM for CPU), which should be sufficient for standalone 1080p video decoding, or for simple 3D, but probably not for both together. 224 MB was for Linux only, with only a 1080p [framebuffer](https://en.wikipedia.org/wiki/Framebuffer" \o "Framebuffer), and was likely to fail for any video or 3D. 128 MB was for heavy 3D, possibly also with video decoding (e.g. XBMC) Comparatively the [Nokia 701](https://en.wikipedia.org/wiki/Nokia_701) uses 128 MB for the Broadcom VideoCore IV

For the later Model B with 512 MB RAM initially there were new standard memory split files released( arm256\_start.elf, arm384\_start.elf, arm496\_start.elf) for 256 MB, 384 MB and 496 MB CPU RAM (and 256 MB, 128 MB and 16 MB video RAM). But a week or so later the RPF released a new version of start.elf that could read a new entry in config.txt (gpu\_mem=xx) and could dynamically assign an amount of RAM (from 16 to 256 MB in 8 MB steps) to the GPU, so the older method of memory splits became obsolete, and a single start.elf worked the same for 256 and 512 MB Raspberry Pis

The Raspberry Pi 2 and the Raspberry Pi 3 have 1 GB of RAM.[[41]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-41)[[42]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-42) The Raspberry Pi Zero and Zero W have 512 MB of RAM.

### Networking

The Model A, A+ and Pi Zero have no Ethernet circuitry and are commonly connected to a network using an external user-supplied USB Ethernet or [Wi-Fi](https://en.wikipedia.org/wiki/Wi-Fi) adapter. On the Model B and B+ the Ethernet port is provided by a built-in USB Ethernet adapter using the SMSC LAN9514 chip.[[43]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-SMSC-LAN9514-specs-43) The Raspberry Pi 3 and Pi Zero W (wireless) are equipped with 2.4 GHz WiFi [802.11n](https://en.wikipedia.org/wiki/IEEE_802.11n-2009) (150 Mbit/s) and [Bluetooth 4.1](https://en.wikipedia.org/wiki/Bluetooth_4.1) (24 Mbit/s) based on Broadcom BCM43438 [FullMAC](https://en.wikipedia.org/wiki/Wireless_network_interface_controller" \l "FULLMAC" \o "Wireless network interface controller) chip with no official support for [Monitor mode](https://en.wikipedia.org/wiki/Monitor_mode) but implemented through unofficial firmware patching[[44]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-44) and the Pi 3 also has a 10/100 Ethernet port.

### Peripherals

The Raspberry Pi may be operated with any generic [USB computer keyboard](https://en.wikipedia.org/wiki/USB_computer_keyboard) and [mouse](https://en.wikipedia.org/wiki/Mouse_(computing)).[[45]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-VerifiedPeripheralList-45) It may also be used with USB storage, USB to MIDI converters, and *virtually* any other device/component with USB capabilities.

Other peripherals can be attached through the various pins and connectors on the surface of the Raspberry Pi.

### Video

The early Raspberry Pi 1 Model A, with an HDMI port and a standard RCA composite video port for older displays

The video controller can generate standard modern TV resolutions, such as HD and [Full HD](https://en.wikipedia.org/wiki/Full_HD), and higher or lower monitor resolutions as well as older NTSC or PAL standard CRT TV resolutions. As shipped (i.e., without custom overclocking) it can support these resolutions: 640×350 [EGA](https://en.wikipedia.org/wiki/Enhanced_Graphics_Adapter); 640×480 [VGA](https://en.wikipedia.org/wiki/Video_Graphics_Array); 800×600 [SVGA](https://en.wikipedia.org/wiki/Super_video_graphics_array); 1024×768 [XGA](https://en.wikipedia.org/wiki/XGA); 1280×720 [720p](https://en.wikipedia.org/wiki/720p) [HDTV](https://en.wikipedia.org/wiki/High-definition_television#High-definition_display_resolutions); 1280×768 [WXGA](https://en.wikipedia.org/wiki/Graphic_display_resolutions#WXGA) variant; 1280×800 [WXGA](https://en.wikipedia.org/wiki/Graphic_display_resolutions#WXGA) variant; 1280×1024 [SXGA](https://en.wikipedia.org/wiki/SXGA); 1366×768 [WXGA](https://en.wikipedia.org/wiki/Graphic_display_resolutions#WXGA) variant; 1400×1050 [SXGA+](https://en.wikipedia.org/wiki/SXGA%2B); 1600×1200 [UXGA](https://en.wikipedia.org/wiki/UXGA); 1680×1050 [WXGA+](https://en.wikipedia.org/wiki/WXGA%2B); 1920×1080 [1080p](https://en.wikipedia.org/wiki/1080p) [HDTV](https://en.wikipedia.org/wiki/High-definition_television#High-definition_display_resolutions); 1920×1200 [WUXGA](https://en.wikipedia.org/wiki/WUXGA).[[47]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-video-47)

Higher resolutions, such as, up to 2048×1152, may work or even 3840×2160 at 15 Hz (too low a frame rate for convincing video). Note also that allowing the highest resolutions does not imply that the GPU can decode video formats at those; in fact, the Pis are known to not work reliably for [H.265](https://en.wikipedia.org/wiki/H.265) (at those high resolutions), commonly used for very high resolutions (most formats, commonly used, up to Full HD, do work).

Although the Raspberry Pi 3 does not have H.265 decoding hardware, the CPU is more powerful than its predecessors, potentially fast enough to allow the decoding of H.265-encoded videos in software.[[51]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-51) The GPU in the Raspberry Pi 3 runs at higher clock frequencies of 300 MHz or 400 MHz, compared to previous versions which ran at 250 MHz.

### Real-time clock[[edit](https://en.wikipedia.org/w/index.php?title=Raspberry_Pi&action=edit&section=10" \o "Edit section: Real-time clock)]

None of the current Raspberry Pi models have a built-in [real-time clock](https://en.wikipedia.org/wiki/Real-time_clock), so they are unable to keep track of the time of day independently. As a workaround, a program running on the Pi can retrieve the time from a [network time server](https://en.wikipedia.org/wiki/Network_Time_Protocol) or from user input at boot time, thus knowing the time while powered on. To provide consistency of time for the [file system](https://en.wikipedia.org/wiki/File_system), the Pi does automatically save the time it has on shutdown, and re-installs that time at boot.

A real-time hardware clock with battery backup, such as the DS1307, may be added (often via the [I²C](https://en.wikipedia.org/wiki/I%C2%B2C) interface).

### General purpose input-output (GPIO) connector[[edit](https://en.wikipedia.org/w/index.php?title=Raspberry_Pi&action=edit&section=16)]

Raspberry Pi 1 Models A+ and B+, Pi 2 Model B, Pi 3 Model B and Pi Zero (and Zero W) GPIO J8 have a 40-pin pinout Raspberry Pi 1 Models A and B have only the first 26 pins



### Accessories

* Gertboard – A Raspberry Pi Foundation sanctioned device, designed for educational purposes, that expands the Raspberry Pi's GPIO pins to allow interface with and control of LEDs, switches, analogue signals, sensors and other devices. It also includes an optional [Arduino](https://en.wikipedia.org/wiki/Arduino" \o "Arduino) compatible controller to interface with the Pi.
* Camera – On 14 May 2013, the foundation and the distributors RS Components & Premier Farnell/Element 14 launched the Raspberry Pi camera board alongside a firmware update to accommodate it The camera board is shipped with a [flexible flat cable](https://en.wikipedia.org/wiki/Flexible_flat_cable) that plugs into the [CSI](https://en.wikipedia.org/wiki/Camera_Serial_Interface) connector which is located between the Ethernet and HDMI ports. In Raspbian, the user must enable the use of the camera board by running Raspi-config and selecting the camera option. The cost of the camera module is €20 in Europe (9 September 2013).[[97]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-farnellcam-97) It can produce [1080p](https://en.wikipedia.org/wiki/1080p), [720p](https://en.wikipedia.org/wiki/720p) and [640x480p](https://en.wikipedia.org/wiki/480p) video. The dimensions are 25 mm × 20 mm × 9 mm.[[97]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-farnellcam-97) In May 2016, v2 of the camera came out, and is an 8 megapixel camera.
* Infrared Camera – In October 2013, the foundation announced that they would begin producing a camera module without an infrared filter, called the Pi NoIR.
* Official Display – On 8 September 2015, The foundation and the distributors RS Components & Premier Farnell/Element 14 launched the Raspberry Pi Touch Display
* HAT (Hardware Attached on Top) expansion boards – Together with the Model B+, inspired by the [Arduino shield](https://en.wikipedia.org/wiki/Arduino" \l "Shields" \o "Arduino) boards, the interface for HAT boards was devised by the Raspberry Pi Foundation. Each HAT board carries a small EEPROM (typically a CAT24C32WI-GT3containing the relevant details of the board,[]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-101) so that the Raspberry Pi's OS is informed of the HAT, and the technical details of it, relevant to the OS using the HATMechanical details of a HAT board, that use the four mounting holes in their rectangular formation, are available online

### Operating systems

The Raspberry Pi Foundation recommends the use of [Raspbian](https://en.wikipedia.org/wiki/Raspbian" \o "Raspbian), a [Debian](https://en.wikipedia.org/wiki/Debian" \o "Debian)-based [Linux](https://en.wikipedia.org/wiki/Linux) operating system. Other third-party operating systems available via the official website include [Ubuntu MATE](https://en.wikipedia.org/wiki/Ubuntu_MATE" \o "Ubuntu MATE), [Windows 10 IoT Core](https://en.wikipedia.org/wiki/Windows_10_IoT_Core), [RISC OS](https://en.wikipedia.org/wiki/RISC_OS) and specialised distributions for the [Kodi](https://en.wikipedia.org/wiki/Kodi_(software)" \o "Kodi (software))media centre and classroom management.[[105]](https://en.wikipedia.org/wiki/Raspberry_Pi#cite_note-105)

Many other operating systems can also run on the Raspberry Pi