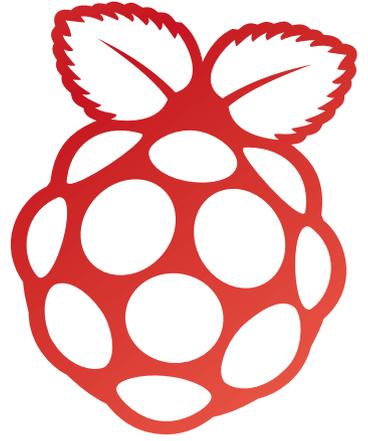


**NEW!** RASPBERRY PI 400

# *The* **MagPi**



Issue 100 | December 2020 | [magpi.cc](http://magpi.cc)

The official Raspberry Pi magazine

**SPECIAL  
EDITION**

# 100

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## RASPBERRY PI MOMENTS

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The greatest Raspberry Pi projects, people,  
and events from 100 issues!



100TH ISSUE



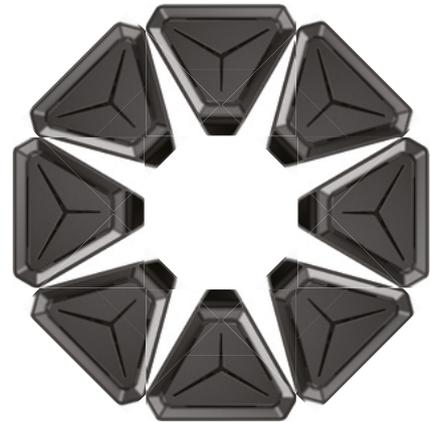
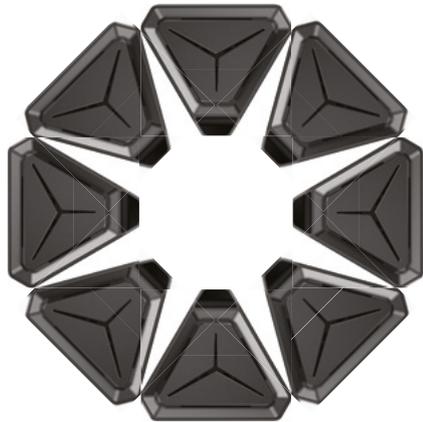
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# The *MagPi* issue



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# WELCOME

## to *The MagPi* 100

**Wow! It feels good to be 100 magazines young.** And what a rollercoaster 100 issues it's been, especially during the past few months.

A magazine hitting 100 is special at any time. But at this moment in time, it's truly incredible, and we just can't thank you, the readers, enough. Every month *The MagPi* team put out the very best issue possible, and I couldn't be prouder of them or the magazine we make.

This month, the team sat down and thought of all the things that happened in the last eight years. There was no shortage of events to choose from: from starting as a fanzine, to covering Raspberry Pi computers in space. The result is 100 moments in *The MagPi* (page 32).

Being part of the Raspberry Pi community is a humbling experience. Some of the smartest, funniest, and quirkiest people have made incredible things with our favourite computer. Thank you for sharing your builds with us, and long may *The MagPi* continue.

**Lucy Hattersley** Editor

*PS. The big thing that happened this month is Raspberry Pi 400 (page 68). It's wonderful. The future is bright for Raspberry Pi.*



EDITOR

**Lucy Hattersley**

Lucy is editor of *The MagPi* and this month she bought a sit-stand desk to work on the bounce and practise her dance moves. She's currently having a sit-down.

@LucyHattersley



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► Issue 100 ► December 2020

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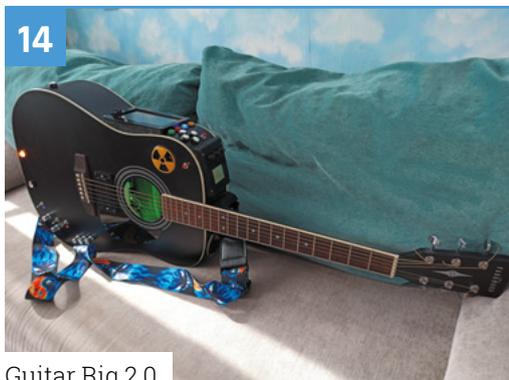
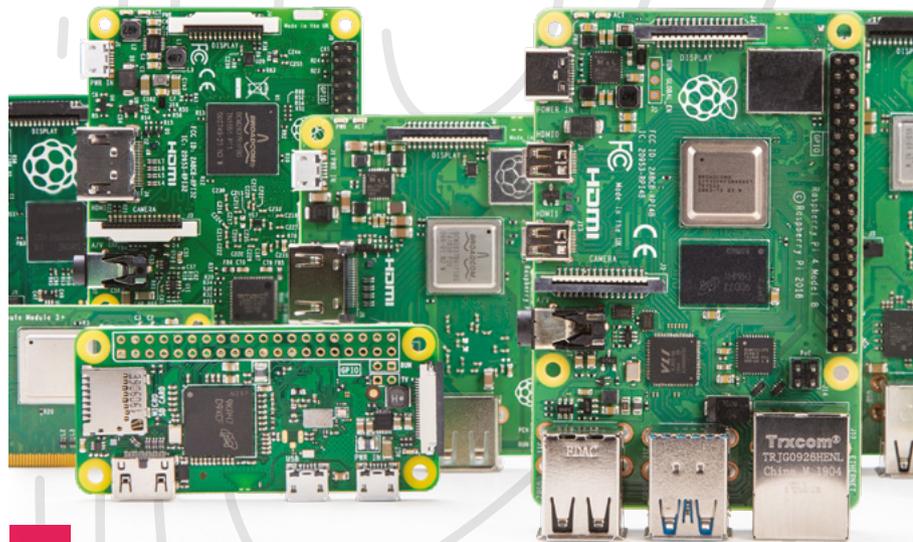
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Guitar Rig 2.0

Becca Cam SLR Camera

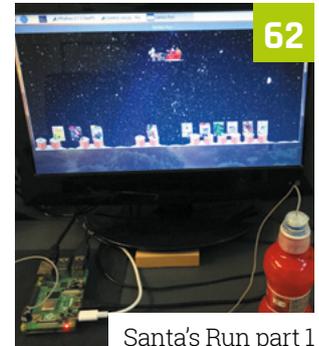
**DISCLAIMER:** Some of the tools and techniques shown in The MagPi magazine are dangerous unless used with skill, experience, and appropriate personal protection equipment. While we attempt to guide the reader, ultimately you are responsible for your own safety and understanding the limits of yourself and your equipment. Children should be supervised. Raspberry Pi (Trading) Ltd does not accept responsibility for any injuries, damage to equipment, or costs incurred from projects, tutorials or suggestions in The MagPi magazine. Laws and regulations covering many of the topics in The MagPi magazine are different between countries, and are always subject to change. You are responsible for understanding the requirements in your jurisdiction and ensuring that you comply with them. Some manufacturers place limits on the use of their hardware which some projects or suggestions in The MagPi magazine may go beyond. It is your responsibility to understand the manufacturer's limits.

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Build a handheld console



Santa's Run part 1

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Raspberry Pi 400



Argon ONE M.2

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Amit Rana interview

# WIN

# AN AMAZING SELECTION OF RASPBERRY PI KIT

50

# Power armour for your Raspberry Pi 4



5-hour internal battery



UPS-style soft shutdown system prevents SD card corruption



USB-C Power Delivery specification at 15V for faster battery charging



Full access to Raspberry Pi's GPIO pins & ports



Mini OLED screen & programmable buttons



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monitor

## A versatile 11.6" touchscreen monitor for pi-top and Raspberry Pi.

Code and create using the touch of your finger with the pi-top FHD Touch Display. Sleek and light, it is compatible with a wide array of devices, including the Raspberry Pi and pi-top [4].

Connect it to your Raspberry Pi or pi-top [4] to turn it into a tablet, add a visual display for your maker projects, or add the pi-top Bluetooth Keyboard to use it as a laptop. It's the perfect Christmas gift present for makers!

**pi-top FHD Touch Display - £179.95 / \$189.95**

Raspberry Pi is a trademark of the Raspberry Pi Foundation.  
\*Not photoshopped. We really did make a pi-top drone!

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# ExoMy 3D-Printed Mars Rover

With a goal of making space robotics accessible for everyone, two European Space Agency engineers have lofty ideals. They tell **Rosie Hattersley** how Raspberry Pi fits in



**MAKER**  
**Maximilian Ehrhardt and Miro Voellmy**

Robotic engineers Maximilian Ehrhardt and Miro Voellmy work at the European Space Agency's Planetary Robotics Laboratory in the Netherlands. As well as developing ExoMy, they enjoy bouldering and making music.

[magpi.cc/exomyinsta](https://magpi.cc/exomyinsta)

[magpi.cc/exomytwitter](https://magpi.cc/exomytwitter)

**W**hy should space engineers have all the fun? Wouldn't it be amazing to design a space robot that could be built and assembled by a hobbyist? Such was the thinking behind ExoMy, a Mars rover that can be built for as little as \$250.

The terrain on Mars is notoriously difficult, so any vehicle intent on exploring the Red Planet needs to be pretty hardy. Something small and agile, powered by a dependable yet powerful on-board computer, is likely to fare best against such unforgiving terrain. Something, perhaps, like a Raspberry Pi.

"The rover is inspired by the ExoMars rover Rosalind Franklin, and features its most characteristic design features (drill, solar panels, wheels)," explain ExoMy's makers Maximilian Ehrhardt and Miro Voellmy from the ESA's Planetary Robotics Laboratory. "Its triple bogie locomotion suspension and six steerable wheels

allow for locomotion in very rough terrain and [also mean it's able to traverse] obstacles larger than the size of the wheel." Better yet, ExoMy can be controlled using a gamepad or a web interface where the video stream from its on-board Raspberry Pi camera is also displayed.

Raspberry Pi 4 Model B is the ExoMy's main board computer, receiving driving commands via the web interface. Raspberry Pi "converts them into motor positions and velocity, which are sent via I2C to the PWM motor board to make the rover move," reveals Miro.

### Small and perfectly formed

Max and Miro chose Raspberry Pi for ExoMy because it "allows the use of a full-fledged operating system and provides a wide variety of GPIO pins and a great camera interface." They were also attracted by its low cost, worldwide availability – important given their ambition to

t = 0 s



t = 1 s



t = 2 s



t = 3 s



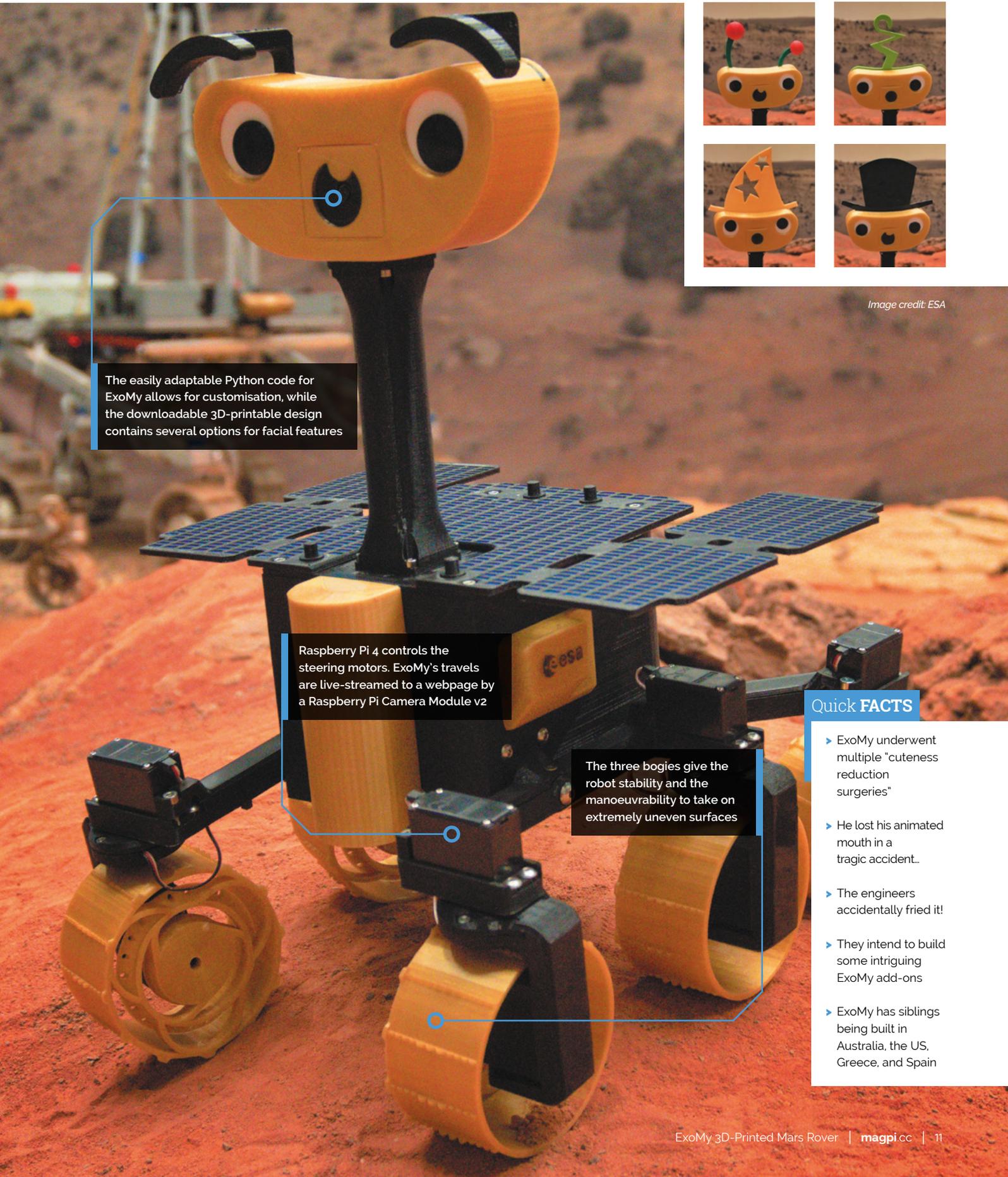
t = 4 s



t = 5 s



▶ The assembled Mars rover tackles some challenging terrain



The easily adaptable Python code for ExoMy allows for customisation, while the downloadable 3D-printable design contains several options for facial features

Raspberry Pi 4 controls the steering motors. ExoMy's travels are live-streamed to a webpage by a Raspberry Pi Camera Module v2

The three bogies give the robot stability and the manoeuvrability to take on extremely uneven surfaces

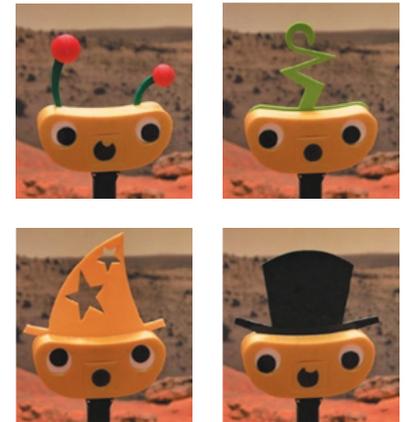


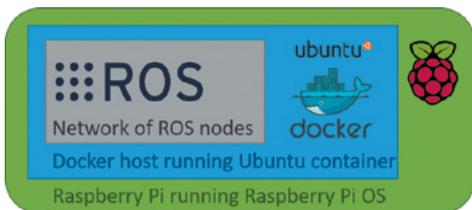
Image credit: ESA

#### Quick FACTS

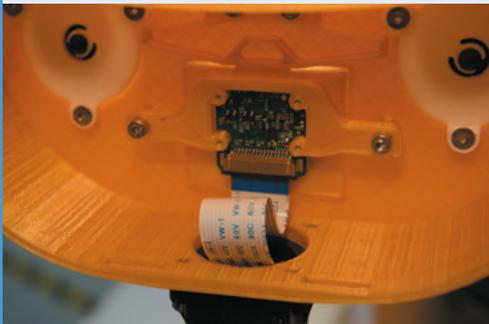
- ▶ ExoMy underwent multiple "cuteness reduction surgeries"
- ▶ He lost his animated mouth in a tragic accident..
- ▶ The engineers accidentally fried it!
- ▶ They intend to build some intriguing ExoMy add-ons
- ▶ ExoMy has siblings being built in Australia, the US, Greece, and Spain

## Make an ExoMy

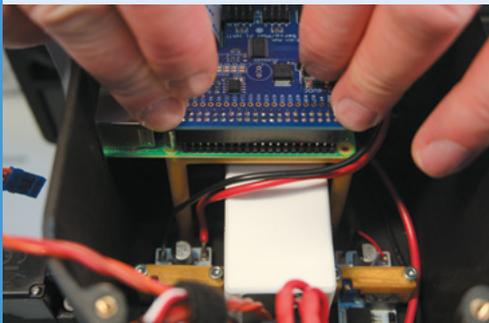
View the components list at [magpi.cc/exomywiki](https://magpi.cc/exomywiki). You will need a Raspberry Pi 4, Camera Module v2, and a way to 3D-print the parts. Help and ideas can be found at [magpi.cc/exomydiscord](https://magpi.cc/exomydiscord).



**01** Follow the setup instructions at [magpi.cc/exomysoftware](https://magpi.cc/exomysoftware). This includes the Docker file containing the full software installation.



**02** Assemble the robot shell and screw the Raspberry Pi Camera Module into place. Install your Raspberry Pi 4 and connect it up.



**03** Connect up the power and the PWM Servo HAT. This fits over the top of Raspberry Pi.



▲ The rover is made from 3D-printed parts and readily available servo motors and screws, plus a Raspberry Pi 4 and Camera Module v2

make space robotics more accessible – and the large community surrounding it. “ROS (Robot Operating System) support meant we could use a lot of available open-source software and ensure that ExoMy stays very modular,” says Miro.

Both engineers had used Raspberry Pi in projects before. Miro used Raspberry Pi to control a spherical robot at the Automation and Robotics Laboratory at ESA that floats on air, and which simulates satellites and spacecraft control algorithms.

Max, meanwhile, worked on a sounding rocket project at university for which he created a Raspberry Pi telemetry logging HAT.

“ Everyone interested in building ExoMy can easily order, install, and use it. They can even use the same software tools as in the Planetary Robotics Laboratory ”

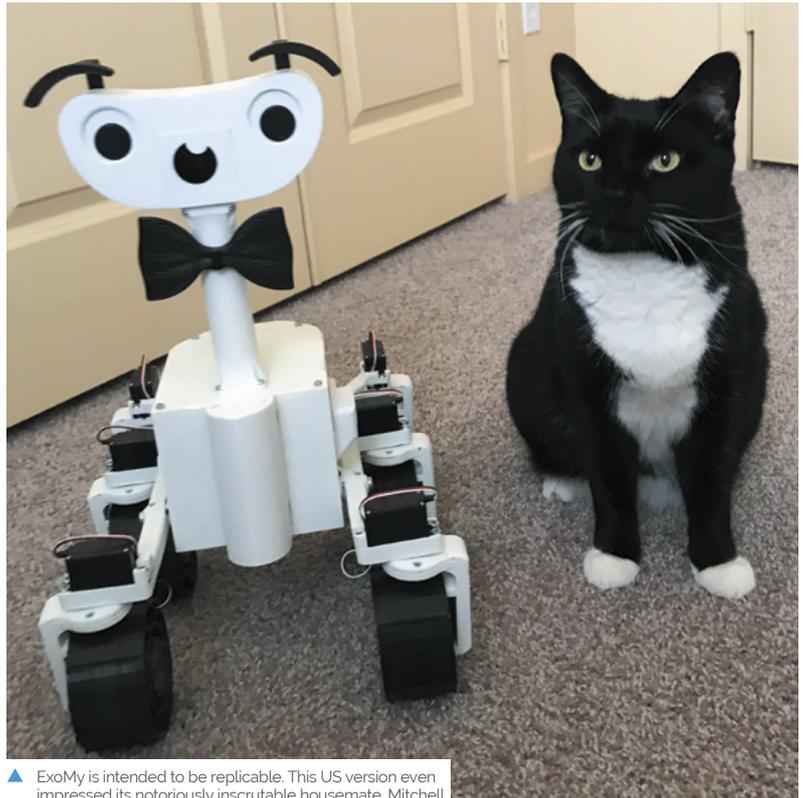
### Building blocks

Although other open-source rovers exist (notably Sawppy and JPL), these had customised metal housings and are far more expensive than the \$250 to \$500 required to build your own ExoMy. A well-received prototype had been produced by trainees in 2018, but it was rather costly and had reliability issues. At the start of 2020, Miro and Max set out to design a reliable and reproducible version that was also far more affordable. They designed all the mechanical parts at the Planetary Robotics Laboratory and 3D-printed them, which took approximately two weeks. Assembly required another two days. The electronics and screws all came from commercial suppliers.

“The idea was that everyone interested in building ExoMy can easily order, install, and use it. They can even use the same software tools as in the Planetary Robotics Laboratory,” says Max. “We try to use as much open-source software as possible,” adds Miro. “ExoMy is, however, designed in SolidWorks, which is unfortunately not free.”

Details of both the hardware and the freely available software used can be found at [magpi.cc/exomygit](http://magpi.cc/exomygit).

Max and Miro encourage others to give it a try and advocate using Docker, since it reduces the need to repeat installations and “allows for a repeatable and reliable software environment.” Discussing your design challenges with someone, getting a second opinion, and inviting different views of a problem generally leads to the best solutions, they advise. You can find out more about ExoMy by joining on Discord: [magpi.cc/exomydiscord](http://magpi.cc/exomydiscord). [M](#)



▲ ExoMy is intended to be replicable. This US version even impressed its notoriously inscrutable housemate, Mitchell

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# Guitar Rig 2.0

Muiota Betarho's pitch-perfect electric guitar project certainly strikes the right tone, as **David Crookes** discovers



**Muiota Betarho**

MAKER

Muiota Betarho is a software developer from Russia. His hobbies include inventing, sound design, 3D printing, DIY electronics, travelling and, of course, the guitar. "I have also visited the North Pole," he says.

[magpi.cc/muiotayt](http://magpi.cc/muiotayt)

**W**ant to hear about a project that truly rocks? Then give it up for Muiota Betarho and his amazing electric guitar. Converted from an acoustic strummer, it's been infused with a humbucker, an LCD display, an amplifier with speakers, an FX processor, and internal LEDs that flash during play. And if that already sounds good, then listen up: this beauty is also powered by a Raspberry Pi computer.

Muiota got the idea while he was enjoying a short break in the countryside. "We like to take a guitar and sing songs, but we were lacking the appropriate accompaniment," he says. "Since we found it was impossible to take heavy musical equipment with us, I began to work on the concept for the first Guitar Rig." It's now on its second, more refined version, boasting an improved design and new automation features.

## Plucking up the courage

"I had explored different travelling guitars before making my own, but none seemed totally convenient," Muiota explains. "Furthermore, the second version of my handmade guitar is

▼ Alexander Zolotov's SunVox ([magpi.cc/sunvox](http://magpi.cc/sunvox)) is a popular, powerful portable music studio which allows for the creation of songs



equipped with lights which are turned on in sync with the rhythm or input signal. This feature adds to the show and I do not know anybody having a similar one."

**“**To be honest, I am still shocked by SunVox's potential **”**

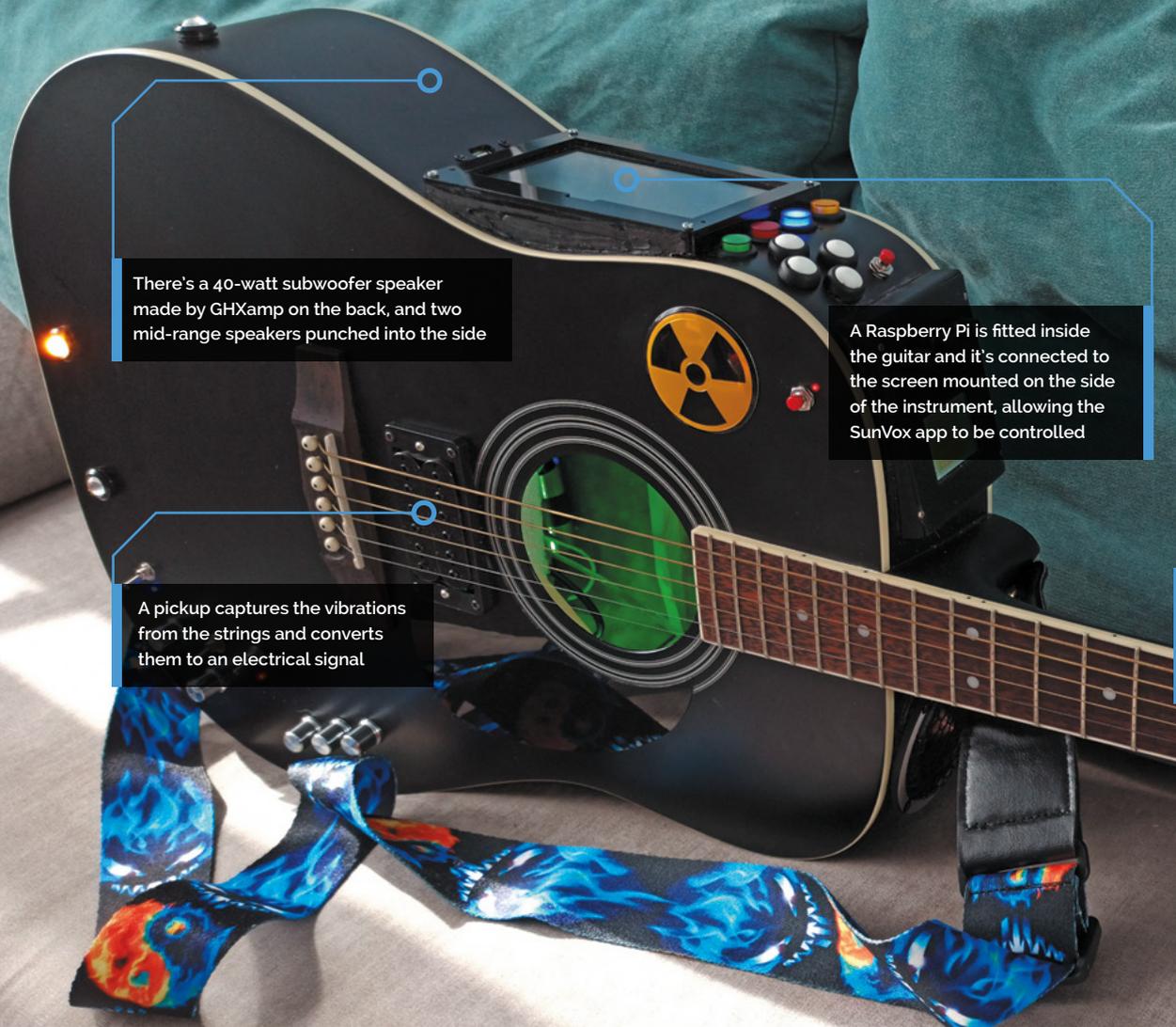
The project involved cutting into an acoustic guitar while using the copious amount of space inside to house the various components. A Raspberry Pi 4 is used for the complicated task of digital signal processing and Muiota has installed the music creation app SunVox, a fast modular synthesiser with pattern-based sequencer.

"It has low system requirements and it is adapted for use on small screens," he notes, having linked a Raspberry Pi computer to a screen that sits in full view on the guitar's side. "To be honest, I am still shocked by SunVox's potential and it's free." He says the guitar is able to compose a custom backing track and make use of bass and special effects.

"I can switch guitar effects during a song, play with parallel synthesiser parts, use effects such



▲ High energy consumption was solved by using a high-power Li-ion battery



There's a 40-watt subwoofer speaker made by GHXamp on the back, and two mid-range speakers punched into the side

A Raspberry Pi is fitted inside the guitar and it's connected to the screen mounted on the side of the instrument, allowing the SunVox app to be controlled

A pickup captures the vibrations from the strings and converts them to an electrical signal

#### Quick FACTS

- ▶ It uses a standard acoustic guitar
- ▶ Flashing LED lights react to the sound
- ▶ A built-in synth provides accompaniment
- ▶ A recorder is also built-in
- ▶ It cost around £400 and took two months to make

as an input equaliser and plug in an external foot-switch. The guitar has eight digital inputs and outputs.”

### Play it again

The guitar also includes a built-in microphone input and there's an HDMI output for synced background video effects. “The LEDs are timed to the sound and can sync with the beats,” says Muiota. “It's a complicated build, for sure.”

Yet he tells us that he didn't find it especially difficult: “The main challenges I faced were the struggle with the ground loop, screening of the digital part of the whole system, search of the most appropriate components' location, tightening the bolts inside the guitar, and 3D model design for some components.”

He was more frightened of spoiling the build in the final steps but, now it's complete, he's reaping the benefits. “I've used a Li-ion battery and the charge is enough for five to six hours,” he says. “It means I can play a long concert using the guitar.” And that is music to our ears. [M](#)



▲ To avoid overheating, Muiota needed to cool Raspberry Pi

# Becca Cam

## Raspberry Pi SLR camera

Upcycling projects often catch *The MagPi* writers' eyes. This camera build by a novice Raspberry Pi user particularly impressed **Rosie Hattersley**



**Becca Farsace**

MAKER

Becca worked as a studio equipment technician at Vox Media before becoming a video host and reviewer. Beccam Cam is her first Raspberry Pi project.

[beccafarsace.com](http://beccafarsace.com)

**V**ideographer Becca Farsace knew her way around cameras, but had never used a Raspberry Pi before deciding to build the Becca Cam, an SLR based around one. She didn't let lack of experience deter her, preferring to learn the necessary skills as she went.

Becca approached her first ever Raspberry Pi project with "absolutely zero background in computer science," but had heard about Raspberry Pi's High Quality Camera as she reports on camera launches for work. When New York City went into lockdown, she was tasked with creating camera content without being able to go anywhere and capture the world. "That's when my inner Victor Frankenstein was born," she says. "What if I built a camera instead of reporting on everyone else's?"

She had several film cameras but "no desire to pay to run film through them." Instead, Becca pondered

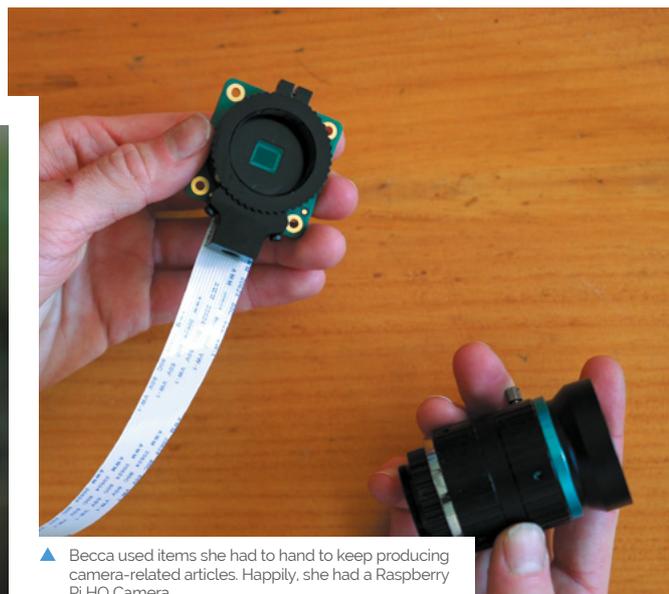
whether she could retrofit one with a digital camera and use it without the film developing cost. Handily, the Raspberry Pi Foundation had sent her a High Quality Camera to review.

### Learning by doing

Becca began with an old toy camera, C-mount lenses, a Raspberry Pi 4, and a Raspberry Pi HQ Camera. "The goal was to use the camera hardware as a case and as optics, but hide Raspberry Pi and the camera module inside of it," she says. With no programming experience, she relied on code she found at the Raspberry Pi Camera Guild and several forums for guidance. "Lack of knowledge was the



▲ This upcycling project offers the ideal excuse for anyone who's ever wanted to take apart a camera. Raspberry Pi 4 is the ideal size to fit inside the SLR case



▲ Becca used items she had to hand to keep producing camera-related articles. Happily, she had a Raspberry Pi HQ Camera

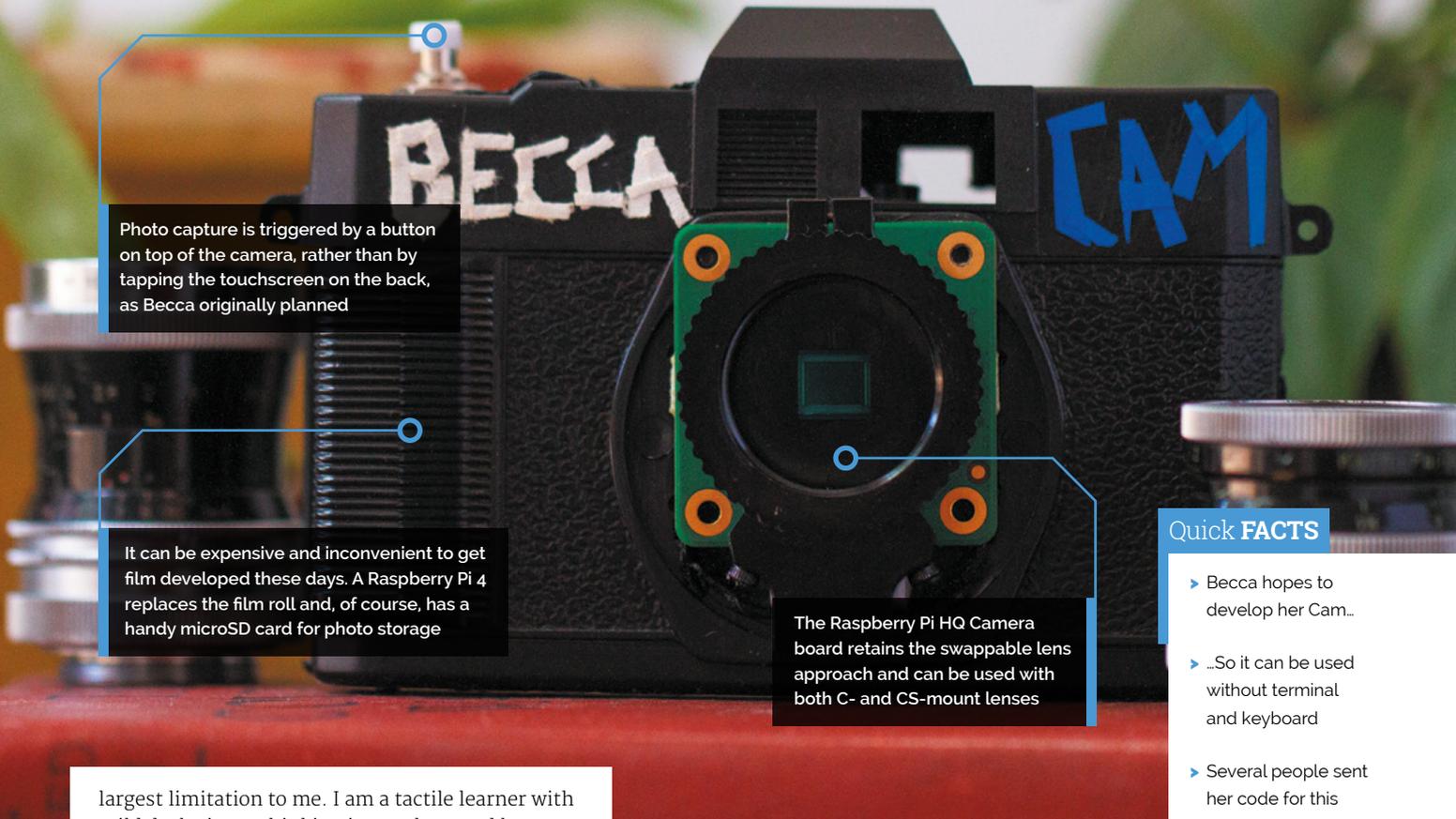


Photo capture is triggered by a button on top of the camera, rather than by tapping the touchscreen on the back, as Becca originally planned

It can be expensive and inconvenient to get film developed these days. A Raspberry Pi 4 replaces the film roll and, of course, has a handy microSD card for photo storage

The Raspberry Pi HQ Camera board retains the swappable lens approach and can be used with both C- and CS-mount lenses

#### Quick FACTS

- ▶ Becca hopes to develop her Cam...
- ▶ ..So it can be used without terminal and keyboard
- ▶ Several people sent her code for this
- ▶ View a photo gallery at [magpi.cc/cameragallery](https://magpi.cc/cameragallery)
- ▶ Try a kaleidoscope lens adapter: [magpi.cc/kalfilter](https://magpi.cc/kalfilter)

largest limitation to me. I am a tactile learner with mild dyslexia, so thinking in numbers and letters was not always an enjoyable experience,” she explains. Nonetheless, she persevered, taking her time whenever she had to enter code, and paying close attention to a similar project by Nick Poole from SparkFun ([magpi.cc/vintagecam](https://magpi.cc/vintagecam)).

“What if I built a camera instead of reporting on everyone else's?”

“Originally I thought I could create a digital button to trigger my capture, on a 4-inch touchscreen. When that wasn't working, I remembered that Nick had used a microswitch as a trigger and decided to go that route as well,” she says.

### Build better, Bec

Becca details the process of building her camera on YouTube: [magpi.cc/beccacamyt](https://magpi.cc/beccacamyt). She started with the software, to make sure she could get the camera to take photos. She then put Raspberry Pi 4 into the camera body, before going out and about using it to troubleshoot any issues. “Wow, it sounds so straightforward when you type it like that, but there were hiccups at almost every step.”

If you're thinking of your own Raspberry Pi project, Becca advises: “The best lesson I learned

was find someone who knows a bit more than you so when you are falling on your face, they can swoop in and save you!”

She already plans to take her own advice. New York's transit authority released an API for its trains a while back. “When I am feeling up to another Raspberry Pi project, I would really like to make a train time display for my local train that I could put by my door. That way I would know the perfect time to leave the house!”

▼ Breaking apart a vintage camera is both terrifying and so utterly fun, says Becca





# Interactive Storytelling Radio



A Cold War-era radio is at the centre of a Raspberry Pi-based adventure game. **Rosie Hattersley** follows the clues

MAKER

## 8 Bits and a Byte

Husband and wife team Dane and Nicole learned to program while studying, and soon became enchanted with the magic of making. They love building all kinds of "tremendously terrible tech".

@8bitsandabyte

**B**ack in the 1980s, an innovative form of story, the ‘choose your own adventure’ book, gave readers the chance to become the protagonist and make crucial decisions about where the action led. More recently, the idea has been revived for text-based online adventure games.

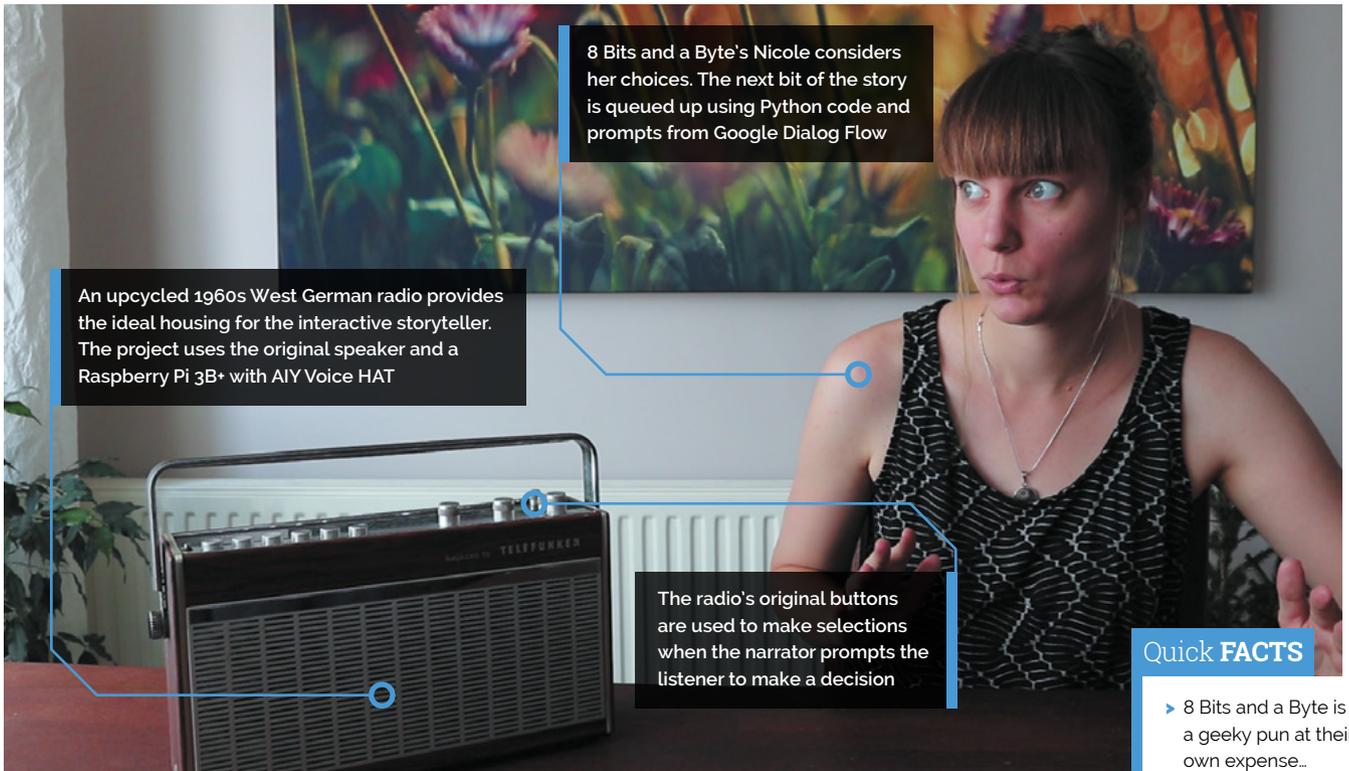
The Interactive Storytelling Radio uses the same idea and asks the listener to decide what happens next. The response prompts the built-in Raspberry Pi to jump to the appropriate bit of the script and narration to continue.

“The aim of the Interactive Storytelling Radio was to recreate the experience of choose your own adventure books, but with voice controls,” explain makers Dane and Nicole, aka 8 Bits and a

Byte. “The radio reads the story to you and when you need to make a decision, you simply say it out loud and the story continues. Raspberry Pi is the control centre of the project, passing the data back and forth to all the separate components, making everything work together.”

An extra thrill is that the radio housing the clever storytelling setup is a Telefunken Bajazzo TS, a West German model dating back to the 1960s and the Cold War era – “hence the story’s spy theme!” explains Nicole. They found the vintage radio for sale in a thrift shop where they live in Brussels, adding to the intrigue.

8 Bits and a Byte is the maker name for husband and wife Dan and Nicole. Having learnt to code while they were studying, they soon encountered



8 Bits and a Byte's Nicole considers her choices. The next bit of the story is queued up using Python code and prompts from Google Dialog Flow

An upcycled 1960s West German radio provides the ideal housing for the interactive storyteller. The project uses the original speaker and a Raspberry Pi 3B+ with AIY Voice HAT

The radio's original buttons are used to make selections when the narrator prompts the listener to make a decision

#### Quick FACTS

- ▶ 8 Bits and a Byte is a geeky pun at their own expense...
- ▶ They are each 4 bits and half a byte!
- ▶ The duo specialise in left-field tech-based builds...
- ▶ Such as Monty the attendance-measuring bot...
- ▶ And the Monty Python-esque Argument Bot

Raspberry Pi and quickly incorporated it into many of their creations. Even though making as a spare time endeavour, they've posted 47 projects in the space of two years! "A Raspberry Pi is a great starting point for any project," says Nicole, modestly downplaying their quirky ideas as "questionable creations".

“ Perhaps because of its quirks, the Interactive Storytelling Radio has caught the imagination of makers online ”

#### Careless talk creates lines

The aim of this particular project was to make "a voice-controllable, interactive, storytelling device." As well as the Telefunken radio's case, they were able to salvage the original speaker and on/off button and to keep the part holding up all the buttons. They still needed a microphone, but most of the rest of the setup was accounted for



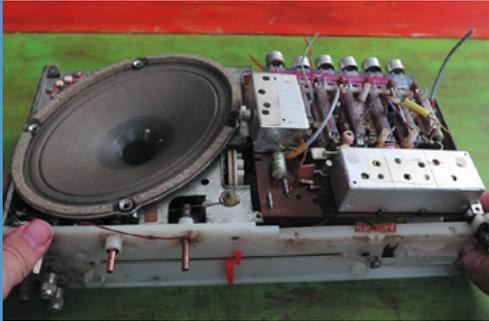
▲ 8 Bits and a Byte routinely put Raspberry Pi to intriguing uses, including doing duty as an Argument Bot



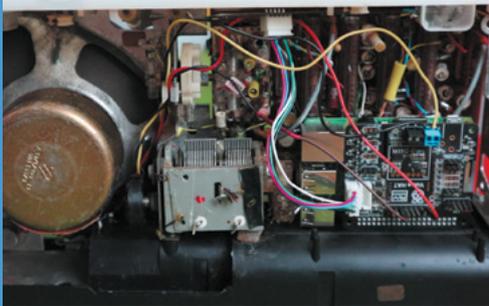
◀ The radio's Cold War era origins suggested the interactive story's theme

## Tell us a story

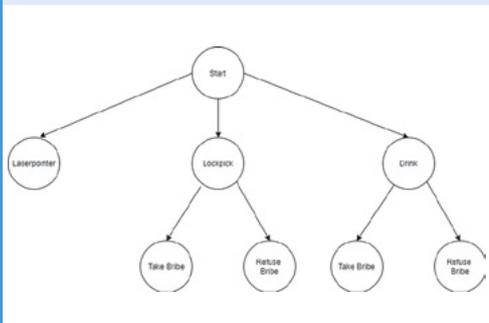
Upcycle a vintage radio to house your interactive storyteller, then get children to decide the outcome of the tale. Full build details at [magpi.cc/storyradiobuild](http://magpi.cc/storyradiobuild).



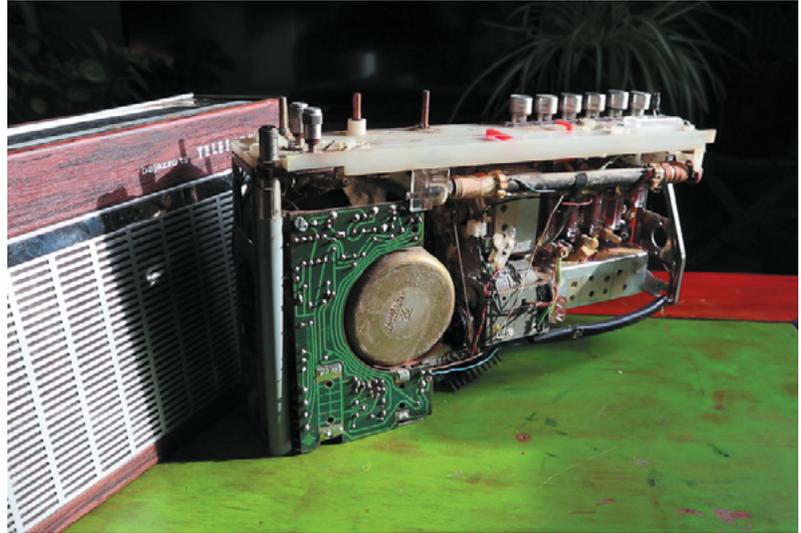
- 01** Carefully disassemble the radio, saving speaker, buttons, dials, and any screws and connectors.



- 02** Insert and wire up your Raspberry Pi, AIY HAT microphone, and either the original radio speaker and buttons, or those from the Google AIY Voice Kit. Carefully solder and reassemble the radio.



- 03** Create or draw a decision tree and then use Google Dialog Flow ([magpi.cc/dialogflowguide](http://magpi.cc/dialogflowguide)) to direct the storyline according to the decisions the user makes.



- ▶ The makers carefully dismantled a vintage radio and reused some of the parts

with a Raspberry Pi 3B+ and Google AIY Voice Kit ([magpi.cc/aiyvoice](http://magpi.cc/aiyvoice)). Helpfully, both these were items the duo had already from previous projects.

Assembly-wise, they followed Google's setup instructions ([magpi.cc/aiyvoicesetup](http://magpi.cc/aiyvoicesetup)), substituting the kit's speaker and button for those from their vintage radio. Testing involved trying out some of the examples listed on the AIY GitHub page ([magpi.cc/aiygithub](http://magpi.cc/aiygithub)).

“ They followed Google's setup instructions, substituting the kit's speaker and button for those from their vintage radio ”

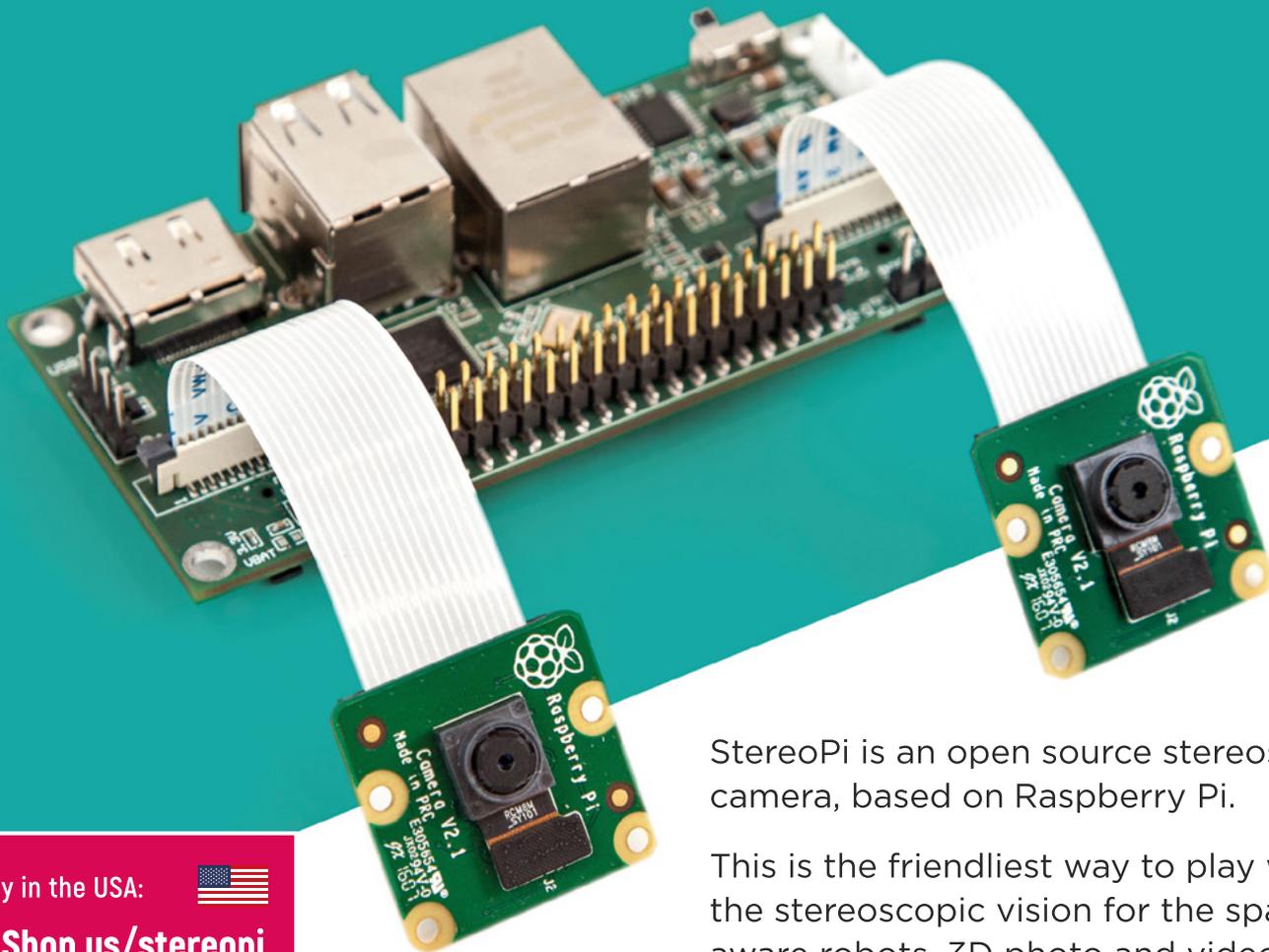
### Adventure time

They now needed to write the storyline – a spy story seemed to be obvious, given the host radio's Cold War origins – and a decision tree to plot the flow. After seeing it recommended in the AIY Voice Kit guide, they used Google



- ▶ Dane and Nicole's Historic Voicebot project lets you chat with your favourite person from the past!

# Do you know HOW ROBOTS SEE?



StereoPi is an open source stereoscopic camera, based on Raspberry Pi.

This is the friendliest way to play with the stereoscopic vision for the spatially aware robots, 3D photo and video!

Buy in the USA:



[PiShop.us/stereopi](http://PiShop.us/stereopi)

Buy in Canada:



[BuyaPi.ca/stereopi](http://BuyaPi.ca/stereopi)



RASPBERRY PI INSIDE



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SUPPORT



OPEN SOURCE



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## LinuxGizmos.com

"The StereoPi can capture, save, livestream, and process real-time stereoscopic video and images for robotics, AR/VR, computer vision, drone instrumentation, and panoramic video."

## MickMake

"With it you can do things like, stream stereoscopic 3D video to YouTube, build real-time depth maps using OpenCV, create panoramics using Hugin and even a 3rd person view of real life. Cool."

## Raspberry Pi Blog

"There are some excellent community efforts too, of which our current favourite is this nifty dual camera board."

## Hackster News

"You can hook this up to YouTube, to Oculus Go, you can use it with OpenCV.. I cannot wait to start messing around with these because it's basically a dream come true."

▶ The radio's buttons became response inputs whenever there's a crossroads in the story



Dialog Flow chatbot software. Raspberry Pi runs a Python script which communicates with the AIY HAT, speaker, microphone, Dialog Flow, and Google Cloud.

Unfortunately, Dialog Flow “is not actually made to follow a decision tree!” As a result, one of the ‘features’ of the Interactive Storytelling Radio is the ability to jump between storylines. “For example, if you’ve chosen the lock pick as the answer to the first question, but later in the storyline yell ‘drink’, it will bring you back to the first decision point,” Dane explains cheerfully.

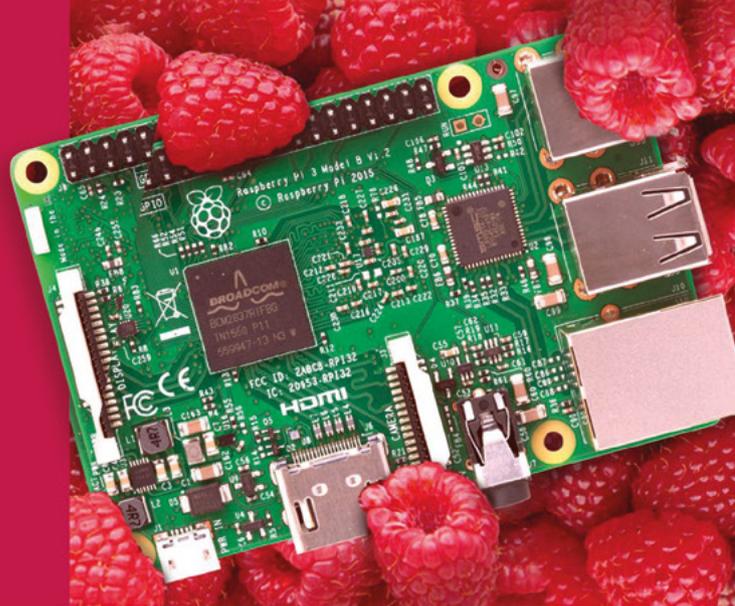
“ One of the ‘features’ of the Interactive Storytelling Radio is the ability to jump between storylines ”

Perhaps because of its quirks, the Interactive Storytelling Radio has caught the imagination of makers online, some of who are building their own to use in teaching and to help with special needs. Magnificent stuff! [M](#)



▲ Another project by the prolific 8 Bits and a Byte generates artworks from online comments

# American Raspberry Pi Shop



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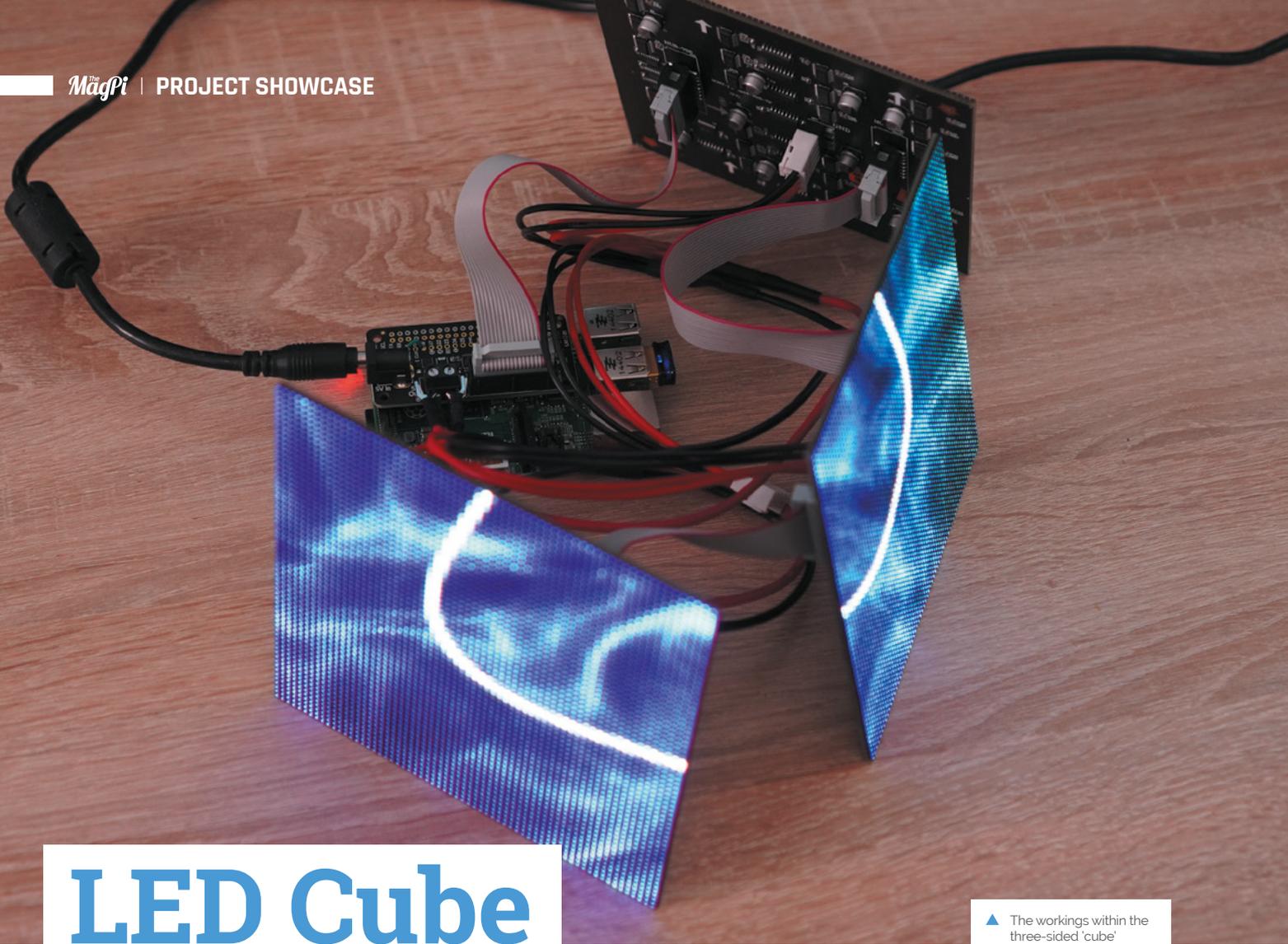


BuyaPi.ca



Raspberry Pi

APPROVED RESELLER



▲ The workings within the three-sided 'cube'

# LED Cube

LED cubes may not be new, but one maker has created a cube with a USP – using it a status monitor for his PC. **Nicola King** sees LEDs in a new light



**Sebastian Staacks**

Sebastian is a physicist and developer of the app 'phyphox' at the RWTH Aachen University (Germany). He is a father of two and presents his hobby projects in his blog.

[there.oughta.be](http://there.oughta.be)

**A**t the end of 2019, when Sebastian Staacks gave a talk at the annual Chaos Communication Congress, he found inspiration from fellow makers and hackers who had created and exhibited their versions of LED cubes. Sebastian left the conference desperate to make his own cube, and initially just envisaged crafting a stationary mood light for his living room, but explains that his plans soon changed. “When it did not get living room clearance from my wife, I turned it into something useful for my office by creating a parametric animation reflecting the status of my [PC’s] CPU”, he says.

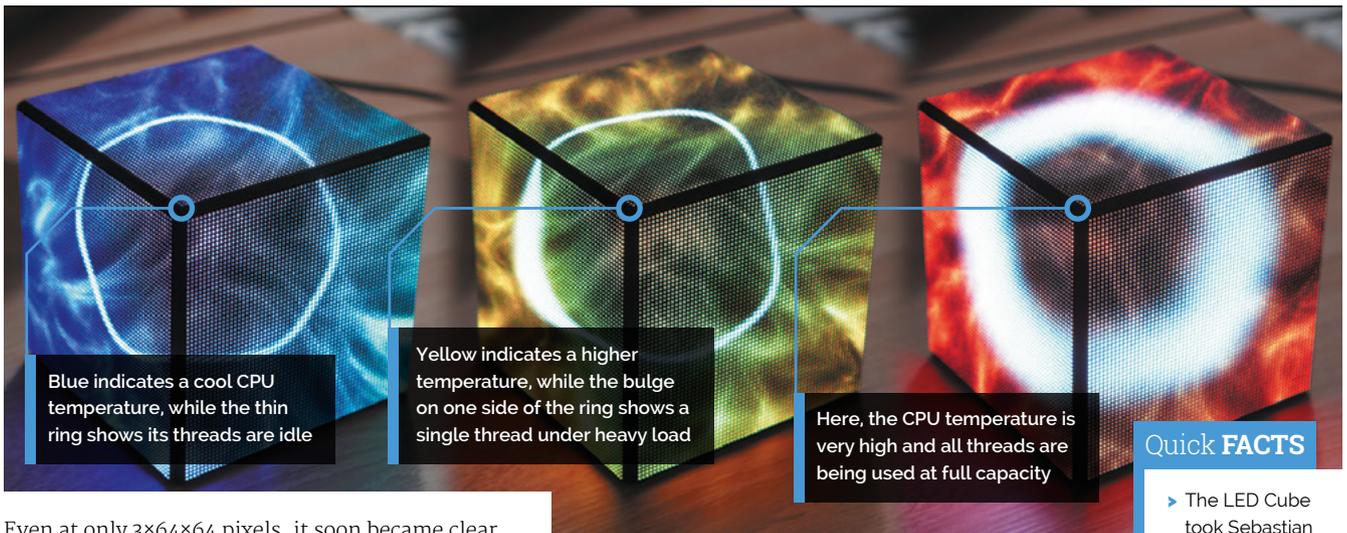
Sebastian spent some time working on the design and aesthetic of the cube, although ‘technically’ it’s not a cube, as he explains: “Since the cube is designed to be stationary and usually only viewed from one side, it is not actually a complete LED cube, but only has three sides with LED matrix panels. Those panels consist of 64×64 RGB LEDs across a side length of 128 mm.

They are held by a 3D-printed frame, which also holds a Raspberry Pi 2 and an LED Matrix Bonnet from Adafruit.”

“ There is a slightly different appeal to it as it has some kind of function ”

## Glorious graphics

Sebastian arranged the three panels so that they are daisy-chained to the Matrix Bonnet, which also distributes the 50 W from the power supply (5V, 10A). This was the more straightforward element of the whole design, as he tells us. “One could say that I mostly put together a few parts that were meant to be assembled just like this. The trickier part was software, because I did not just want simple pixel graphics or a pre-rendered animation.



### Quick FACTS

- ▶ The LED Cube took Sebastian around six months to develop, in his spare time
- ▶ It cost less than €150 (£135) to build
- ▶ The Cube turns on and off automatically with his PC
- ▶ He has a Raspberry Pi 4 running his home automation system with openHAB..
- ▶ And a Raspberry Pi 2 runs his 3D printer

Even at only  $3 \times 64 \times 64$  pixels, it soon became clear that the CPU cannot deal with all the pixels in sequence, but that I had to use OpenGL.”

The glowing visual element of the Cube is stunning, with the background colour determined by his PC’s Ryzen 5 CPU temperature, and the thickness of the ring changing in relation to usage of threads on the CPU. Sebastian achieved these graphics by using OpenGL Shader: “Instead of iterating over each pixel, one writes a fragment shader – a small (and rather limited) piece of code that is executed independently for every single pixel. With this independent execution, every pixel can be done in parallel as much as the hardware supports this. I did not end up with a particle system, but this allows for an animation that covers all pixels and with something going on in every part of the image.”

### Power management

Sebastian had very little fine-tuning to do, once he’d figured out how to use OpenGL. “I had to be careful about the maximum brightness because the

power supply is a bit too weak to handle full white for all LEDs. So, I had to avoid getting too close to a white cube as Raspberry Pi would become unstable at this point,” he reveals.

He also made Raspberry Pi’s file system read-only in order to avoid the possibility of data corruption when unplugging the cube. “This way, I could just cut the power at any time without worrying about file corruption. The cube is now simply plugged into a socket strip which turns off whenever the PC does not draw any power on a controlling socket.”

Sebastian’s colourful creation has garnered much interest from others, which surprised him initially as he was aware that such a cube was not a new concept. “I got extremely positive reactions and a much wider coverage than I expected,” he says. “I think that my presentation in the video was good and that there is a slightly different appeal to it as it has some kind of function, while having very fascinating visuals.” [M](#)



▲ The Cube in action on Sebastian’s desk – an impressive setup

# World's Smallest iMac



**Michael Pick**

MAKER

Michael Pick is a keen photographer and space software engineer. He aims to release one build video each month on his YouTube channel. The Casual Engineer.

[magpi.cc/casualengineer](http://magpi.cc/casualengineer)



## Alert! Cut With Care

Wear safety glasses and gloves when using a rotary tool as a cutter. Clamp the item when cutting. Note that cutting ports on a Raspberry Pi invalidates its warranty.

[magpi.cc/rotarytool](http://magpi.cc/rotarytool)

Michael Pick is so excited to show you his tiny homage to Apple's iconic machine, as **David Crookes** discovers

**T**hey say good things come in small sizes and that's certainly the case with this cute riff on Apple's iconic iMac. Although it doesn't run the macOS operating system, for obvious reasons, it makes use of an image called i Raspbian. Displayed on a 7-inch screen which is fitted within a well-designed, 3D-printed case, it ensures the build has familiar-looking menus, icons, and interfaces. This is a mini Mac that any Apple fan would love to have on their desk.

The brains behind it is Michael Pick, whose attention to detail is mightily impressive. "I got the idea after making my first mini computer, the World's Smallest Gaming PC, and I thought the Apple iMac would make for a fun and interesting build video," he tells us. Before cracking on with the task, though, he spent much time preparing.

"Like all of my builds, I started by modelling all of the components in a 3D CAD program and this allowed me to see and deal with any potential problems before I even started," he explains. "The wiring for this build was rather simple, but if I'm

working on something more complex, a wiring diagram would also come in handy."

## Making the cut

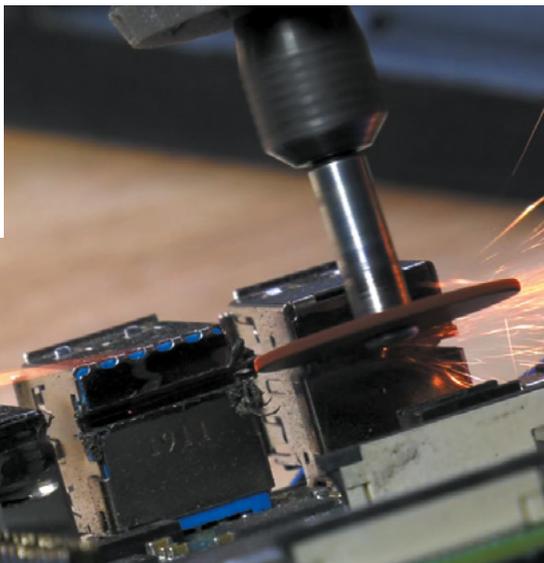
In order to create the smallest possible homage to the iMac, Michael decided to use a Raspberry Pi 4 computer from the beginning. But he was mindful that the resulting machine still needed to be usable, so he opted for a 7-inch screen.

"I knew there were lots of 7-inch displays readily available for Raspberry Pi and I didn't want to go smaller because that would have made it pretty hard to use," he says. The desire for a slim build, however, meant making some amends to his Raspberry Pi 4 to reduce some of its height.

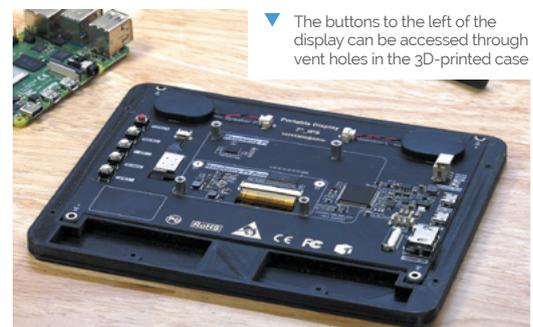
"For this, I needed to break out the rotary tool and the first major modification to Raspberry Pi involved cutting away the top two USB ports, quickly followed by the removal of the Ethernet port," Michael explains, carefully marking where the cuts would go before getting stuck in. "I didn't need these ports, and eliminating them made the final build significantly slimmer. But I had to be careful that I didn't accidentally cut something I wasn't supposed to."

## Another bite

Once Raspberry Pi 4 had been modified, Michael was able to begin the final assembly, painting the 3D-printed parts and using a low-profile ribbon cable to connect the screen to Raspberry Pi while installing i Raspbian as the operating system.



▲ Michael cut the double-stacked USB ports in half and sliced the RJ45 Ethernet connector using a rotary tool



▼ The buttons to the left of the display can be accessed through vent holes in the 3D-printed case

The 3D-printed case has space on the back for a pusher fan, with cool air pushed towards vent holes cut into the side

Raspberry Pi 4 is fixed to the back of the LCD display which draws 5V of power from the computer

Michael primed and painted the case to match the iMac's colour scheme, created a stand, and installed iRaspbian

#### Quick FACTS

- ▶ It uses a 7-inch touchscreen
- ▶ A wireless dongle connects the keyboard
- ▶ Raspberry Pi 4 needed modifying, so be careful!
- ▶ The USB-C power cord needed cutting too
- ▶ Minecraft runs at 1000 fps

“I got very lucky with the release of iRaspbian because it made this project incredibly easy”

“For entertainment purposes, I think iRaspbian suits this project perfectly,” he says. “I got very lucky with the release of iRaspbian because it made this project incredibly easy once I got the hardware sorted out.”

As part of the build, Michael even made a small Apple logo to fit on the front of the case and he stuck to the original colours of black and metal grey. The only part that doesn't quite fit the aesthetic is the keyboard.

“Apple's keyboard is clean and slim and there's nothing that comes close to matching this with current off-the-shelf mini keyboards,” he notes. “I could potentially make a keyboard from scratch, but I didn't have the time. Maybe in the future, this is something I can work on.”

For now, Michael is planning some more mini-computer builds, but he also has plans to take on much larger and complex builds. He's also been able to get some downtime. “I christened my small iMac with a quick game of Minecraft,” he says. [M](#)



▲ Connections for a USB-C power cable and a USB data cable have been created on the underside of the display

# iPourIt

Keeping up with drinks orders can be a challenge, unless you have a Raspberry Pi beer dispenser. **Rosie Hattersley** slakes her thirst



MAKER

**Brett Jones and Darren Nicholson**

Software developer and system engineer. Brett founded iPourIt after spotting a need for self-pour beers. VP of marketing Darren helps bars and restaurants choose a suitable self-pour setup.

[ipouritinc.com](http://ipouritinc.com)

**G**etting served at a busy bar can be a maddening experience, so many of us will sympathise with the story of how iPourIt’s Raspberry Pi self-serve beer dispenser came about. IT engineer Brett Jones was fed up after waiting 15 minutes to get served during a sports game, and was not impressed when the waiter returned some time later to tell him the beer he requested had run out.

The substitute beer was lousy too. “It was time to take things into my own hands,” says Brett, “I could have got my own beer in that time.”

Brett set about creating a self-service beer dispenser in which customers chose and paid for their drinks at their table and then went and helped themselves to it. ID checks and a tab were organised at the counter, a touchscreen terminal is used to select the size and volume, and an RFID wristband is employed to link the drink dispensed to the customer’s account.

The tablet computers iPourit originally used, however, proved a weak link, since their screens needed to be constantly active, which was costly, and they eventually stopped working.

## Let the good times flow

Over the past year iPourit has developed a new type of self-service beer wall with Raspberry Pi at its heart. The iPourit system uses Compute Module 3+ as part of a power-over-Ethernet beer dispenser. The customer gets a highly detailed view of which beers are selling. “Every single controller, every single tap stream on this system is powered and communicated by a managed switch. We put a valve and a meter in the beer line. The network has one Raspberry Pi 4 for every twelve beer lines



▶ The combined RFID reader and touchless tap-key allow for contact-free drinks dispensing



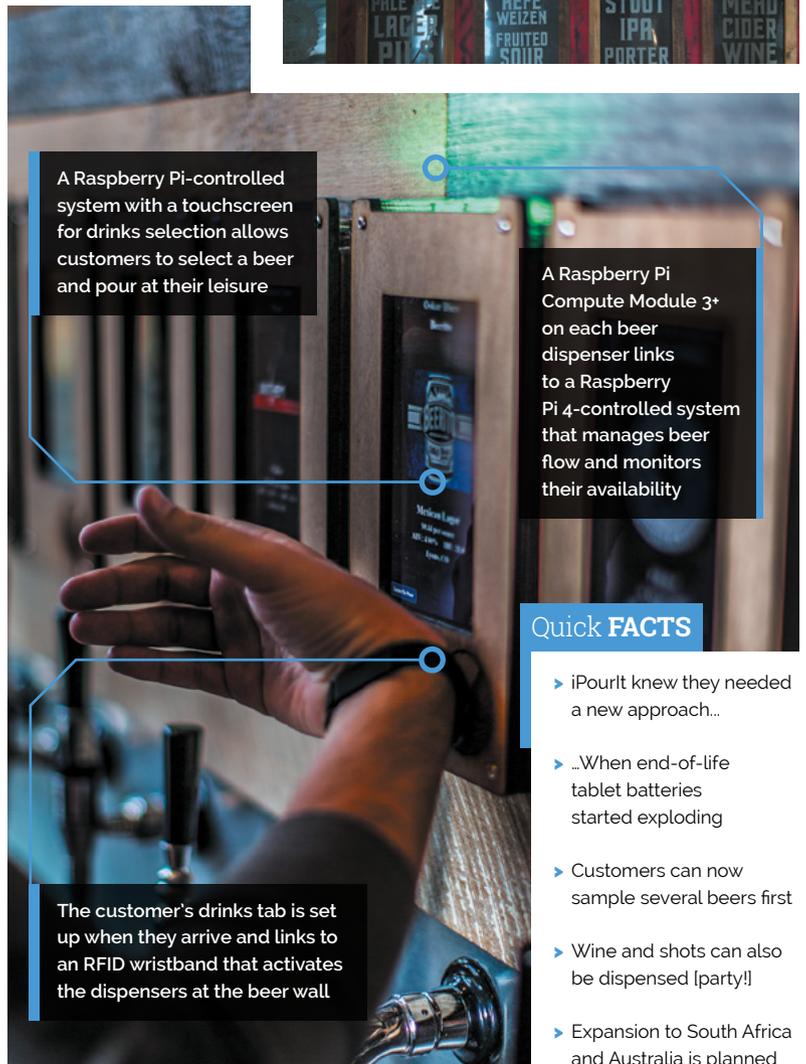
- ◀ Unfamiliar ales are described on the touchscreen display, which has a Compute Module 3+ and RFID reader plugged into the circuit board on the back
- ▼ Each Raspberry Pi 4 controls twelve beer lines, so customers get plenty of choice



which controls and measures them,” enthuses iPourIt CMO Darren Nicholson. Raspberry Pi works with their existing .NET shop setup, which is ideal for any bug fixes and upgrades and meant they didn’t need to start from scratch.

**“ iPourit uses Compute Module 3+ as part of a power-over-Ethernet beer dispenser ”**

The beer wall concept had previously offered a quirky point of difference for venues. With contactless service now the aim of most hospitality venues, the idea has struck a different kind of chord with bars and restaurants. A specially designed RFID tag – controlled by Raspberry Pi, of course – unlocks the pump handle to pour the beer features a hook that allows customers to pull the handle without touching it. [\[1\]](#)



A Raspberry Pi-controlled system with a touchscreen for drinks selection allows customers to select a beer and pour at their leisure

A Raspberry Pi Compute Module 3+ on each beer dispenser links to a Raspberry Pi 4-controlled system that manages beer flow and monitors their availability

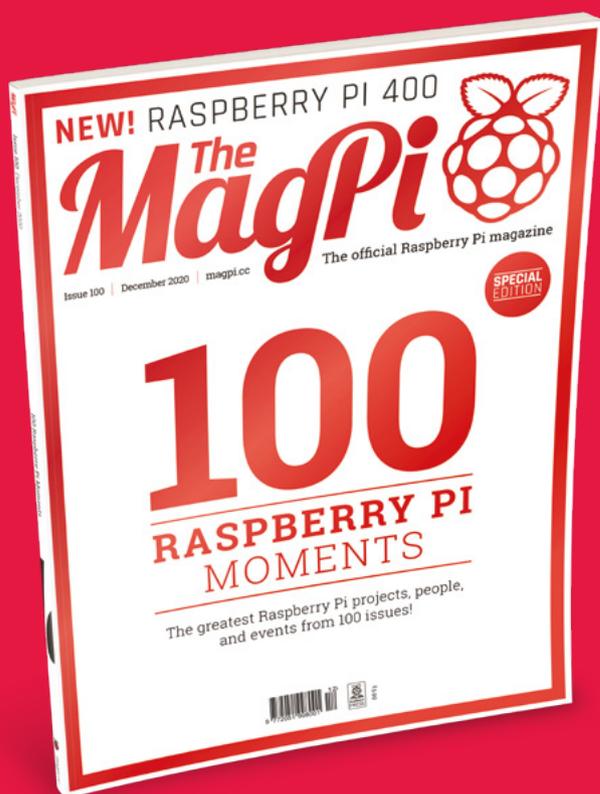
**Quick FACTS**

- ▶ iPourIt knew they needed a new approach...
- ▶ ...When end-of-life tablet batteries started exploding
- ▶ Customers can now sample several beers first
- ▶ Wine and shots can also be dispensed [party!]
- ▶ Expansion to South Africa and Australia is planned

The customer’s drinks tab is set up when they arrive and links to an RFID wristband that activates the dispensers at the beer wall

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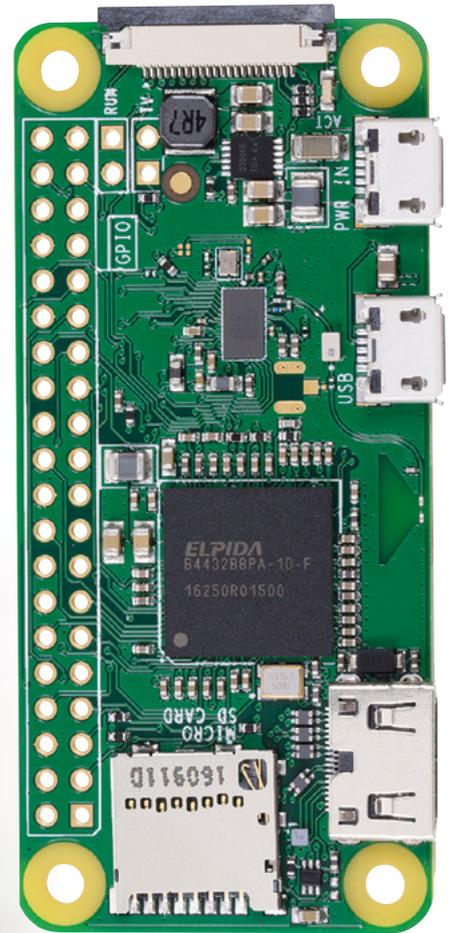
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# 100

## RASPBERRY PI MOMENTS

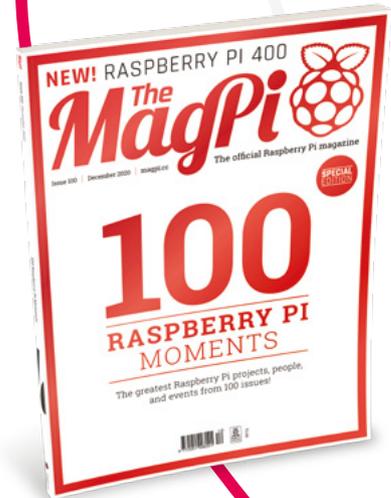
The greatest Raspberry Pi moments, achievements, and events from 100 editions of The MagPi magazine

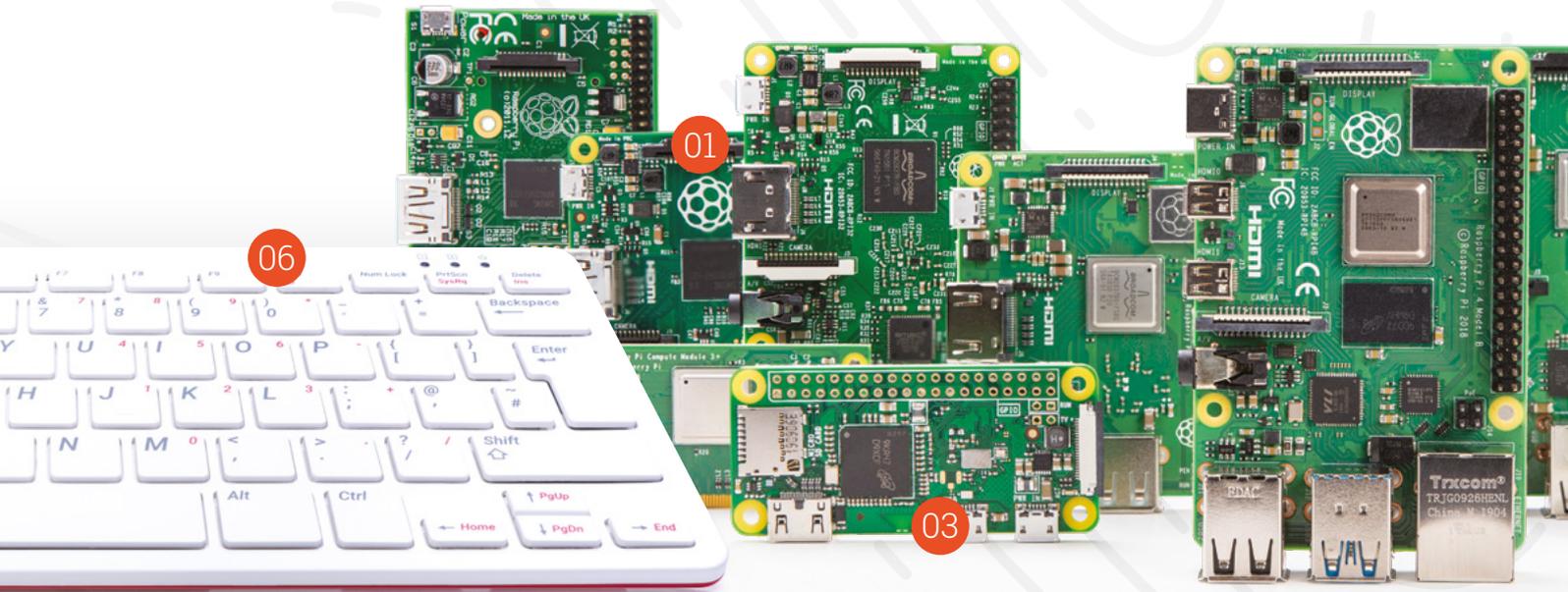
**T**he MagPi magazine has hit 100 issues. An incredible milestone for any magazine, but an especially important one for us.

The MagPi isn't like other magazines. Originally created by the Raspberry Pi community, and backed by Raspberry Pi Publishing. It's the greatest magazine for the world's best computer.

Five years ago, Russell Barnes took over the reins and turned it into the magazine you see today. Then he went on to build a publishing empire at Raspberry Pi Press. Rob, Phil, and Lucy have been looking after the magazine ever since. It's been a wild ride the last 100 issues, both for The MagPi and Raspberry Pi itself.

- 34 Amazing advances in hardware
- 36 The MagPi's amazing achievements
- 38 Influential projects
- 40 Amazing stories from the community
- 42 How Raspberry Pi changed education
- 44 The greatest Raspberry Pi events
- 46 Raspberry Pi in popular culture
- 48 How Raspberry Pi made a difference
- 50 Win something good with our Raspberry Pi give-away





# Amazing achievements for Raspberry Pi hardware

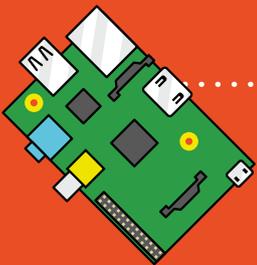
Just what has been achieved with such a tiny computer?

**01 First computer for \$25**  
The launch Raspberry Pi was the Model B at \$35; just under a year later, the Model A was released at just \$25.

**02 First computer for \$5**  
\$25 is cheap, but a computer for just \$5 is incredible. That was how the original Raspberry Pi Zero came to be, and it's still hugely popular.

**03 Printed antenna**  
When Raspberry Pi Zero W came out, we were amazed that the wireless antenna from Raspberry Pi 3 was missing – it had been replaced with one printed into the PCB itself.

**04 Third best-selling computer ever**  
In March 2017, Raspberry Pi sales smashed the 12.5 million mark, making it the third best-selling computer of all time, and definitely the best-selling British computer ever.

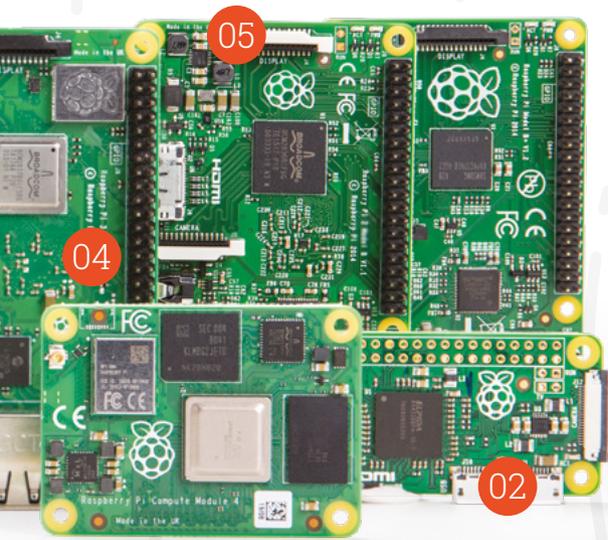


**29/02/2012**  
**11 Raspberry Pi released**

Raspberry Pi Model B, the first Raspberry Pi, is released to the world

**05/05/2012**  
**12 The MagPi #1**

The very first issue of *The MagPi*, then a fanzine, is published by the community



**05 Built in the UK**

While Raspberry Pi computers are sold all over the world, most are manufactured in Pencoed, Wales. Not only is it the best-selling British computer, it's one mostly made in the UK.

**06 Full circle**

Eben Upton often talks about how Raspberry Pi was inspired by the computers of the 1980s, like the BBC Micro and ZX Spectrum. Raspberry Pi 400 is the first version of Raspberry Pi built into a keyboard, much like its spiritual predecessors.

**07 Winner of the MacRobert Award**

The MacRobert Award is an extremely prestigious prize that recognises innovation in engineering in the UK. In 2017, Raspberry Pi's accomplishments were recognised by the MacRobert Award and it ultimately won that year's prize. Dr Dame Sue Ion DBE FEng FRS, Chair of the MacRobert Award judging panel, said of the award: "What sets Raspberry Pi apart is the sheer quality of the innovation, which

has allowed the computer to be used far beyond its original purpose."

**08 Astro Pi**

Getting a Raspberry Pi up to the International Space Station (ISS) may sound simple enough – just chuck it in a rocket, right? Unfortunately, it's a lot more involved, as two Raspberry Pi computers with a Sense HAT and special enclosure went through rigorous testing before being carefully placed in a properly balanced rocket for launch.

These computers are still on the ISS, running experiments programmed by students all over the world in the many Astro Pi missions. Find out more at [astro-pi.org](http://astro-pi.org).



▲ Astronaut Tim Peake with one of the Astro Pi units sent up to the International Space Station. Image credit: ESA

**09 Open-source video drivers**

Raspberry Pi has had two video processors in its lifetime: the VideoCore IV with all the Raspberry Pi models up until Raspberry Pi 3B+, and VideoCore VI on Raspberry Pi 4. VideoCore IV documentation and open-source reference drivers were released in 2014 thanks to the partnership between Raspberry Pi and Broadcom. Currently a conformant open-source OpenGL ES driver exists for VideoCore VI. An open-source Vulkan driver is in development, and very close to being finished.

**10 Eben Upton, CBE**

As you'll see in this feature, Raspberry Pi has broken boundaries on so many levels. Hardware, enthusiast, education, enterprise, even space exploration – the tiny computer has done so many things. It didn't go unnoticed and in 2016, Eben was awarded with a CBE thanks to his services to business and education.



18/07/2012

**13 Raspbian released**

Raspbian would quickly become the official OS of Raspberry Pi

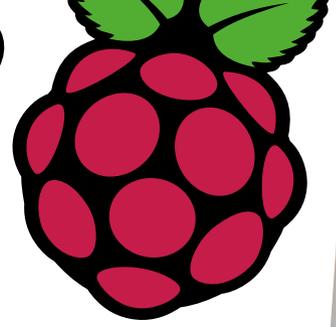


06/09/2012

**14 UK production**

Raspberry Pi is now made in Pencoed, Wales

# The MagPi



Issue 000 | December 2020 | magpi.cc

The official Raspberry Pi magazine

THE MAGPI'S

# AMAZING ACHIEVEMENTS

## 15 COVER-MOUNTED COMPUTER

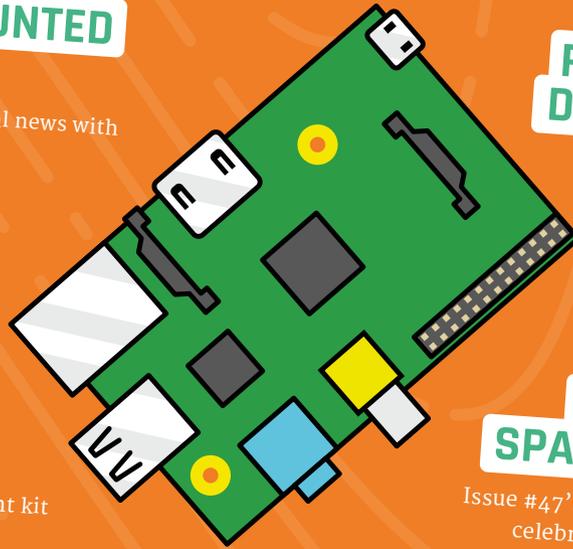
The MagPi #40 made national news with its free Raspberry Pi Zero

## 16 RASPBERRY PI DESKTOP (FOR PC AND MAC)

When Raspberry Pi OS went Intel, we put a copy on the cover

## 17 AIY PROJECTS KIT

We teamed up with Google to give-away a free voice assistant kit

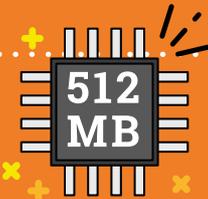


## 18 WE WENT TO SPACE (AND BACK)

Issue #47's free Astro Pi patch & poster celebrated Tim Peake's safe return

## 19 FREE!

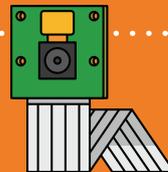
The MagPi has always been available as a free PDF download



15/10/2012

### 26 Memory upgrade

Raspberry Pi Model B now comes with 512MB of RAM, double that of the launch model



14/05/2013

### 27 Camera Module released

The first Raspberry Pi Camera Module is released, making use of the CSI port



**20 Going global**

The *MagPi* magazine has been officially translated into German, French, Hebrew, Italian, and Spanish. And thanks to our open licence, the projects have been translated into many more languages around the world.

**21 Creative Commons**

The *MagPi* is one of the only computer magazines licensed under Creative Commons (CC BY-NC-SA), so it can be shared and remixed. This means you are welcome to share and adapt the content of the magazine as long as you follow the licence terms ([magpi.cc/about](http://magpi.cc/about)).

**22 Since May 2012**

The *MagPi* is almost eight years old now, starting just a month after the launch of the original Raspberry Pi. This is a phenomenal achievement in magazine years.

**23 You heard it here first**

The *MagPi* has had exclusive reveals on Raspberry Pi computers, including the 2, 3, 4, and Raspberry Pi Zero. Every time a new computer

launches, we are the first to know, and have exclusive access to the engineering team who will tell you all about it. See our in-depth coverage of Raspberry Pi 400 in this very issue.

**24 Made by the community**

The first edition of *The MagPi* magazine was created by community members: Jason 'Jaseman' Davies, and Tim 'Meltwater' Cox, along with Ash Stone, and Chris Stagg. You can still download the first 32-page edition for free from our website ([magpi.cc/1](http://magpi.cc/1)).

**25 The birth of Raspberry Pi Press**

After 31 issues, *The MagPi* was brought into the Raspberry Pi fold. This gave the magazine a shot in the arm. Russell Barnes became editor and in issue 36 it became the 100 page print magazine you hold today. This gave Raspberry Pi its own publishing product. Russell turned *The MagPi* into a publishing empire, with magazines such as HackSpace, Wireframe, Hello World, Custom PC, and Digital SLR; plus amazing books like *Code the Classics* and essential guides to all manner of subjects.

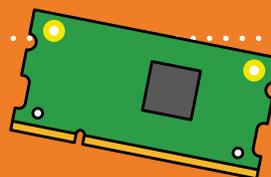


▲ Russell Barnes, Publishing Director of Raspberry Pi Press

06/06/2012

**28 NOOBS released**

The New Out Of the Box Software, NOOBS, makes it easier for new users to set up their Raspberry Pi



07/04/2014

**29 Compute Module**

The original Compute Module releases as embedded computing demand grows

# Influential projects

These are the kinds of projects that bring people to Raspberry Pi

**W**hen you first learnt about Raspberry Pi, we bet you immediately had an idea for a project with it. There are so many awesome projects built with Raspberry Pi, yet some just really stand out and inspire folks.

## 30 Easy media boxes

One of the earlier, very popular uses for Raspberry Pi was as a way to create a media PC or retro gaming machine. With home theatre software like Kodi (then XBMC) available for Raspbian / Raspberry Pi OS, specific OS builds such as Raspbmc and OpenELEC began being released to make it easier to set up. Evolving into OSMC and LibreELEC, home theatre Raspberry Pi builds haven't changed much – they've just got better.

Retro gaming on Raspberry Pi owes a lot to RetroArch and Emulation Station, two pieces

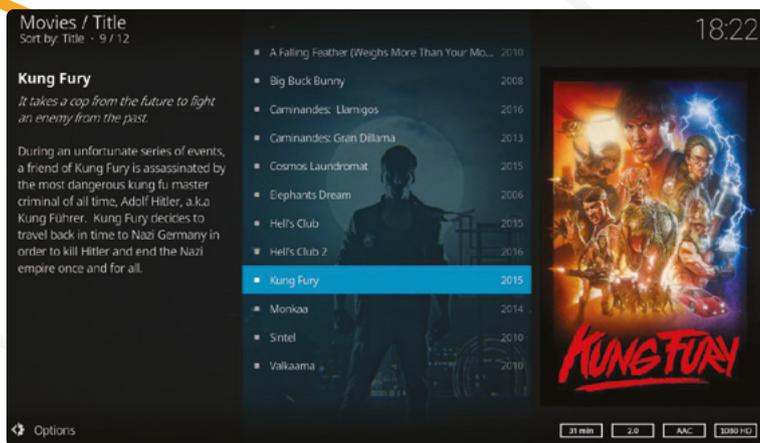
of emulation software that are found in such popular distributions such as RetroPie which very easily and quickly turn a Raspberry Pi into a retro gaming powerhouse. Whether you're building arcade machines, handheld consoles, or simply another way to play old games on your TV, it's never been easier thanks to Raspberry Pi.

## 31 Info panels

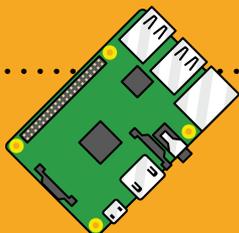
For a while, a couple of years ago, you couldn't go anywhere on the maker side of the internet without seeing Raspberry Pi-powered smart mirrors. You voted to give Michael Teeuw's original Magic Mirror the greatest project ever award in issue 50 for good reason – it combines IoT tech with functional, everyday usage that makes science-fiction reality.

The concept evolved into info panels displaying similar information, albeit in a more condensed format suited for small spaces in kitchens, next to desks, and more.

▼ The simple yet powerful Kodi has changed Raspberry Pi computers worldwide into HTPCs



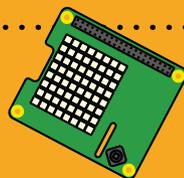
▼ Check on your day while you check yourself out



14/07/2014

## 34 Raspberry Pi Model B+

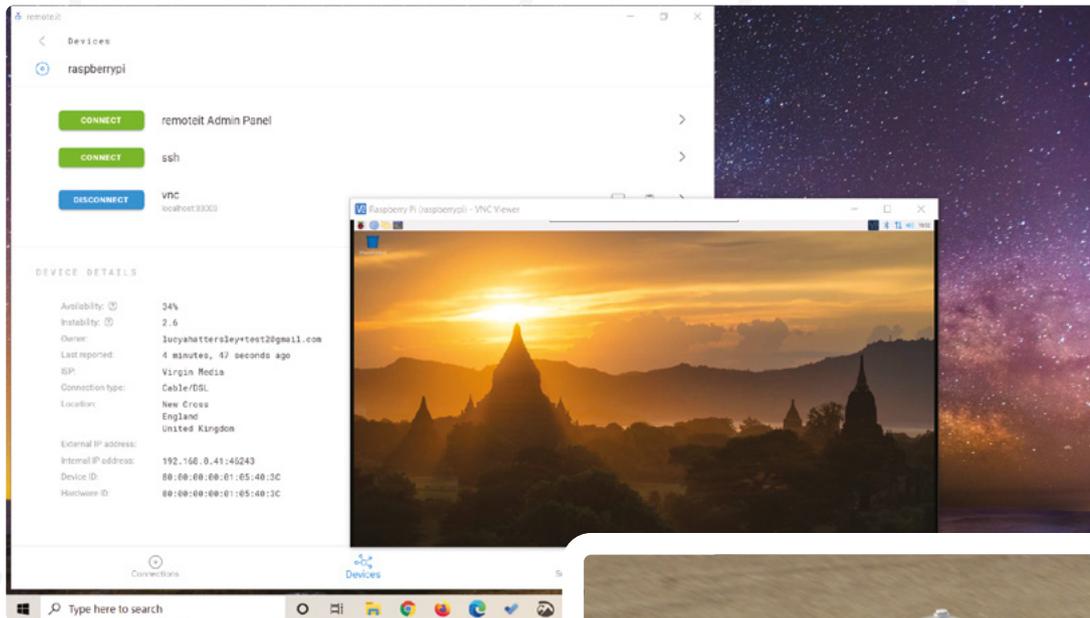
Raspberry Pi Model B+ refreshes the board design, which is still used to this day



31/07/2014

## 35 Raspberry Pi HATs

Now with 40 GPIO pins, the HAT specification is released, resulting in a huge number of add-ons over the years



◀ Dialling in securely from outside your home allows you to access files you may not have while away

### 32 Network helpers

Raspberry Pi is small, unassuming, and can be neatly slot behind many things. This makes it a perfect little computer for adding functionality to your network and we'd be remiss if we didn't talk about the hugely popular and very useful Pi-hole ([pi-hole.net](http://pi-hole.net)).

Privacy and security online is more important than ever, and malicious internet ads are not uncommon. Pi-hole stops ads at the source so they never reach other devices connected to the network, increasing home network security exponentially for the price of a Raspberry Pi.

That's not the only way Raspberry Pi can be used on a network, though – a simple file server / NAS box is a great use for Raspberry Pi, as well as VPN boxes for accessing your files remotely.

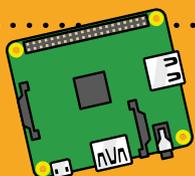
### 33 Robotics revolution

When *Robot Wars* came back a few years ago, it was amazing to think that creating a robot worthy of entry was now accessible to many more people due to an explosion in the popularity of robotics, thanks to Raspberry Pi.



▲ Present at many Raspberry Pi events, the DoodleBorg is a crowd favourite

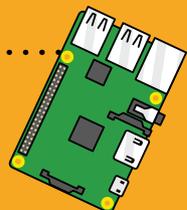
There are several amazing projects and kits, a top ten of which you can find in *The MagPi* issue 94 ([magpi.cc/94](http://magpi.cc/94)). However, there are two we think inspired more than others: the CamJam EduKit 3, the robot starter kit linked with Pi Wars; and PiBorg's incredible DoodleBorg, a giant Raspberry Pi-powered robot powerful enough to pull a caravan. The PiBorg range of kits includes some of the best out there, and DoodleBorg sparked inspiration in many makers.



10/11/2014

### 36 A+ released

This refresh of Raspberry Pi Model A is the first time the form factor has been reduced in size



02/02/2015

### 37 Raspberry Pi 2

Bringing more memory and a quad-core processor, Raspberry Pi 2 is a huge update over the originals

# Community stories

Raspberry Pi is nothing without the community. Here are just some of the stories from the amazing people who are part of it

38



**Mike Cook** @Wee\_Grumphie

I enjoy exhibitions and letting people have a play with projects. I have fond memories of many of them. Like the mother who sat with a child on her lap, jiggling it while she 'ran' on Raspberry Pi racer, the way a small girl controlled the animatronic skull Mulder, and the haematologist who told me the images I got attaching a Raspberry Pi camera to a cheap microscope gave better pictures than the equipment she had to work with. Best of all was the way kids loved creating artwork on the Killido Cam.



39



**Liz Upton** raspberrypi.org

When we started Raspberry Pi, I hoped we'd touch a few thousand kids' lives in a way that made a difference. Every year now, I meet, read about, and receive messages from so many more kids than I ever thought it would be possible to reach. It's a joy, and a huge source of pride.



40



**Tim Richardson** @Geeky\_Tim

I met most of my current friends through the community, starting by helping Michael Horne put up signs at his first two Jams, and joining CamJam as co-organiser. The rest is history, with 20 Jams, five Pi Wars events, and many more since.



41



**Carrie Anne Philbin** @MissPhilbin

My Raspberry Pi journey started as a computing teacher from east London and I initially wanted a device that would help educate my students in computer science. But what I found was a member organisation with a community of people working towards a shared mission, to build, make, educate, and showcase digital making. I have fond memories of visiting Raspberry Jams across the country, seeing what people had made. It's amazing how support from enthusiastic volunteers can help young people achieve outside of formal education!



42



**Ben Nuttall** @ben\_nuttall

The best thing about the Raspberry Pi community is that anyone can contribute. Whether it's designing hardware, building software, organising a Jam, building projects, or creating tutorials, it all helps make a difference. Where would we be without all this global effort from thousands?



43



**Max (pi3g/buyzero.de)** pi3g.com

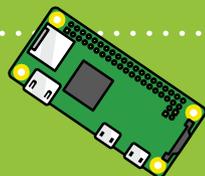
I love connecting and working with people involved with Raspberry Pi: creators, fans, but also people simply using Raspberry Pi! I have been lucky to meet many of them and now consider them my friends. It's inspired me to work on PiCockpit.com with the simple goal of making Raspberry Pi even easier to use.



27/02/2015

## 50 The Official Raspberry Pi Magazine

The MagPi goes official, giving it unprecedented access to Raspberry Pi products



26/11/2015

## 51 Raspberry Pi Zero surprise

Launching on the cover of The MagPi, Raspberry Pi Zero revolutionises microcomputers with a \$5 price tag

44



**Martin Mander** [kyliemander.com](http://kyliemander.com)

The warmth, positivity, and diversity of the community overwhelmed me when I nervously did my first show-and-tell at Raspberry Pi's 3rd Birthday event. It was an amazing day, and introduced me to a friendly group of like-minded individuals I hadn't realised even existed. Since then, I've created and shared another 20 Raspberry Pi projects, and I was lucky enough to bring some of them to the Raspberry Fields event in 2018, a truly inspiring weekend we'll always remember.



45



**Michael Horne** [recantha.co.uk](http://recantha.co.uk)

It's the friendships that I've made that have endured above the technology. Getting to know people like Tim Richardson, Alex Eames, Cat Lamin, Albert Hickey, David Pride, Peter Onion, and Daniel Bull has been a pleasure. Getting Pi Wars up-and-running and having the community help out with judging and marshalling has been wonderful, and helping Raspberry Pi to run two of their Big Birthday Weekends have all been event highlights.



46



**Helene Virolan** [@helenevirolan](https://twitter.com/helenevirolan)

I remember how excited I felt when I received the email from Raspberry Pi announcing I was accepted on the Raspberry Pi Certified Educator programme. Taking part meant a lot to me and I gained new skills. Seeing my daughter having fun in this area made me want to learn more and to share my knowledge. Being part of Picademy meant being part of the Raspberry Pi community of makers, learners, and educators.



47



**Estefannie Explains It All** [magpi.cc/estefannie](http://magpi.cc/estefannie)

Being part of the Raspberry Pi community has been amazing – not just because of being able to collaborate with incredible like-minded people and attend events, but also because of all the friends I've made from around the world! Just recently I got to work with NASA engineers who built a scale model of the ISS that is controlled by a Raspberry Pi (they build the real ISS for their day jobs!). Without being part of the community, I'd have never been able to do that, or film all of my experiences for my channel.



48



**Alex Bate** [@alexjrassic](https://twitter.com/alexjrassic)

Raspberry Pi isn't just a product; it's a key to imagination, to learning, and to building a close family around the world. Yes, OK, that sounds corny, but it's true. From where I sit behind my monitor, talking to you all through the various Raspberry Pi social channels, I get to witness the variety of ways in which the community uses our little green board to explore and improve the world around us. And what a privilege that is.

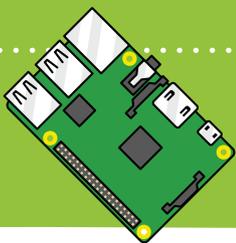


49



**Avey Couloute** [@girlsintocoding](https://twitter.com/girlsintocoding)

Taking part in Coolest Project UK 2018 was amazing. It was an opportunity to see loads of great projects that young CoderDojo, Code Club, and Raspberry Jam goers had been working on. It was also fantastic being able to demonstrate my voice command robot to the public and see some of their faces light up when they interacted with it. I had the added shock and delight when my robot was announced as the winner of the hardware category. The experience was empowering and later helped me to take the leap with my Girls Into Coding idea.



29/02/2016

**52 Raspberry Pi 3**

On Raspberry Pi's birthday, this powerful new model is launched, now with on-board WLAN and Bluetooth



25/04/2016

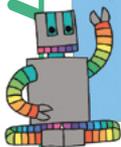
**53 Camera Module V2**

A newer, more powerful Camera Module boasts a huge increase in megapixels

# Educational achievements

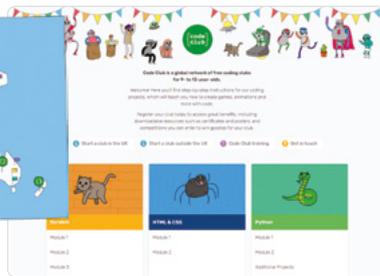
Raspberry Pi revolutionised computer science and education

**R**aspberry Pi was designed with computer science education in mind. In fact, the first Raspberry Pi board was designed specifically to increase the number of students applying to study computer science at Cambridge University. Ever since then, education has been the heart and soul of Raspberry Pi, with the Raspberry Pi Foundation set up as a UK-based charity. The Raspberry Pi Foundation uses Raspberry Pi computers to put the power of computing and digital making into the hands of people all over the world.



## 54 Code Club

In November 2015, Raspberry Pi joined forces with Code Club ([magpi.cc/codeclub](http://magpi.cc/codeclub)). “Raspberry Pi Foundation and Code Club were both created as responses to the collective failure to prepare young people for life and work in a world that is shaped by digital technologies,” said Philip Colligan, Chief Executive of the Raspberry Pi Foundation. Code Club has gone from strength to strength, with its extracurricular computing clubs having been run around the world.



### Creator



### Builder



## 55 Digital Making Curriculum

The Raspberry Pi Foundation has done a lot of work to help educators in the field of computer science, and part of that effort has been creating a digital making curriculum that anyone can access for free. “We have a large and diverse community of people who are interested in digital making,” wrote Carrie Anne Philbin, Director of Educator Support at the Foundation, when the curriculum was introduced. “Some might use the curriculum to help guide and inform their own learning, or perhaps their children’s learning. People who run digital making clubs at schools, community centres, and Raspberry Jams may draw on it for extra guidance on activities that will engage their learners. Some teachers may wish to use the curriculum as inspiration for what to teach their students.” The curriculum focuses on progressive learning over five different concepts: Design, Programming, Physical Computing, Manufacture, and Community and Sharing. You can find out more at [rpf.io/curriculum](http://rpf.io/curriculum).

### Developer



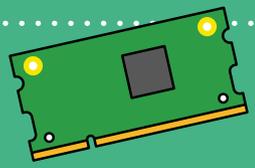
### Maker



29/09/2016

## 58 The MagPi 50

We count down the 50 greatest Raspberry Pi projects, voted for by the community



16/01/2017

## 59 Compute Module 3

Jumping a generation, Compute Module 3 will stay the premier embedded option for nearly four years



Credit: williamsuats.com

## 56 CoderDojo

In 2017 Raspberry Pi Foundation joined forces with the CoderDojo Foundation. CoderDojo is a global network of coding clubs for children from 7 to 17.

The first CoderDojo took place in July 2011, when James Whelton and Bill Liao decided

to share their passion for computing by setting up a club at the National Software Centre in Cork.

The CoderDojo Foundation still runs out of Dublin, supporting the clubs and volunteers with free online resources.

## 57 Issac Computer Science

Raspberry Pi teamed up with the University of Cambridge to launch Issac Computer Science, an online platform for teachers and students of A level computer science ([isaacomputerscience.org](http://isaacomputerscience.org)). Issac Computer Science gives students access to a huge range of online learning materials for the classroom, homework, and revision. The platform's resources are mapped to the A level specifications in England (including the AQA and OCR exam boards).

The project was funded by the Department for Education's National Centre for Computing Education programme (NCCE). NCCE will be giving away 4000 Raspberry Pi kits over the next three years as part of its Student Rewards Programme – see [magpi.cc/helloissac](http://magpi.cc/helloissac).

### Teacher CPD

Sorting and searching, and how to solve a maze



Teacher CPD

When: Mon, 9 Nov 2020, 10:00 – 14:30  
Availability: 13 spaces  
Booking Deadline: Mon, 9 Nov 2020, 9:00

#### Hosts

Andrew French, Associate Professor, Computer Vision Lab, University of Nottingham  
Mercedes Torres Torres, Assistant Professor, Computer Vision Lab, University of Nottingham

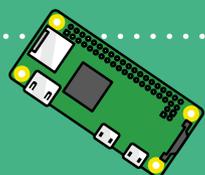
#### Aims

Our event will look at algorithms and Python code to sort and search datasets. You will cover some common sorting algorithms (such as insertion sort, bubble sort, and quick sort). Alongside this, you will look at methods for searching data, such as shortest path methods. To bring it all together, you'll work on code to solve a maze in Python.

#### Teachers will:

- Explore practical code examples of sorting algorithms
- Examine code for a maze solving application to use in the classroom
- Improve their Python skills, including learning about some extra libraries
- Be able to discuss the wider computer science topic with the group
- Also learn how to use the teacher functions on the Issac Computer Science platform

The Masterclasses will be split into two online sessions hosted on Microsoft Teams live.



28/02/2017

## 60 Raspberry Pi Zero W

This important upgrade for Raspberry Pi Zero adds wireless LAN, just in time for the fifth birthday



16/03/2017

## 61 Third best-selling computer

Raspberry Pi sales reach 12.5 million, surpassing the C64 to make it the third best-selling computer ever

# Incredible events

There are several events and programmes that have grown around the work of Raspberry Pi

**T**he community for Raspberry Pi is huge. Not just in terms of makers on YouTube or social media, but also in terms of people that congregate together at Raspberry Jams, Code Clubs, and CoderDojos to learn – and teach – computing.

RASPBERRY  
**JAM**



NUMBER OF  
**JAMS**  
SINCE 2014



**2117**

INDIVIDUAL JAM  
**ORGANISERS**  
SINCE 2014



**867**



**BIGGEST  
BIRTHDAY  
WEEKEND**

TOTAL NUMBER OF  
**BIRTHDAY EVENTS**



## 62 Longest running Raspberry Jam

At the time of writing, #RJam, formerly Preston Raspberry Jam, has had 105 Raspberry Jams. It began running in July 2012, a few short months after Raspberry Pi came out, and was one of the first events to be called 'Raspberry Jam'.

## 63 Birthday Weekend

As Raspberry Pi was originally released on 29 February, it can't have a true birthday each year. That doesn't stop a concerted community effort to celebrate its birthday each year on the weekend nearest to it. They've been running for three years, and occur in over 40 countries around the world.

## 64 Raspberry Fields

In 2018, a huge official Raspberry Pi event was held in Cambridge, taking the Raspberry Jam concept to new heights. With a whole weekend of panels, stalls, and appearances from people from all areas of Raspberry Pi, we hope there'll be another one to go to in the future.

## 65 Pi Wars

CamJam is one of the oldest Raspberry Jams around, and it quickly spawned the annual Pi Wars robot competition. Unlike the battling bots on TV, these robots compete in less destructive events, completing obstacle courses, stopping with precision, and bursting balloons.

04/05/2017

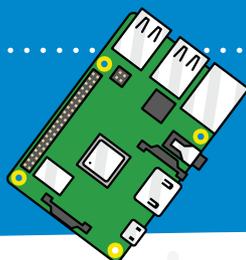
## 72 The MagPi #57

This issue comes with a free kit to build a Google AIY Voice Kit, selling out in shops near instantly

14/03/2018

## 73 Raspberry Pi 3B+

The ultimate evolution of the original model is faster still, and offers network speeds three times quicker



**66 Moonhack**

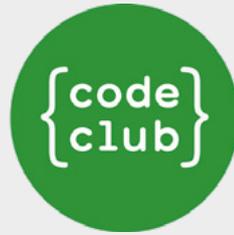
An annual engagement event to get as many young people coding as possible. Creating space-themed projects since 2016, the event organised by Code Club Australia and Telstra keeps breaking records: in 2020, 34,170 kids from 70 countries coded over the week the event was held, smashing the previous record by 10,000.

**67 Shaun the Sheep: Mission to Space**

In association with Studio Canal and Aardman Animations, Code Club members were able to enter a competition for creating the best Scratch animation in honour of *A Shaun the Sheep Movie: Farmageddon*.

**68 FutureLearn training**

You can start a Code Club however you wish, but if you fancy learning how to make it better, Code Club offers a free course on FutureLearn that will help you really make your Code Club special.



{ NUMBER OF }  
**{ CLUBS }**  
**20,000**

**260,000**   
ATTENDEES EACH YEAR



**183** COUNTRIES



NUMBER OF  
**DOJOS**  
**3,800**   
**140** COUNTRIES

  
**76,000**  
ATTENDEES EACH YEAR   
**19,000** VOLUNTEERS

**69 Coolest Projects**

The Foundation now runs three Coolest Projects events: two regional events in the USA and the UK, as well as the International edition, which remains in Dublin, where it originated. Other organisations run their own regional versions under the Coolest Projects licence – including Belgium, Bulgaria, and Malaysia!

**70 Coolest Projects in numbers**

The Coolest Projects events have had a staggering 560 entries this year alone from 775 participants across 39 different countries, with children as young as six taking part.

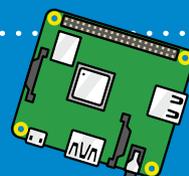
**71 CoderDojo Girls Initiative**

In March 2017, girls only made up 29% of CoderDojo attendees, so the Foundation created the CoderDojo Girls Initiative with the aim of inspiring young girls to learn to code. This includes highlighting female role models so girls can see that they're welcome in the digital making space. By 2019, attendance had risen to 33%.

25/10/2018

**74 The MagPi #75**

Another big issue, this time with 75 of the greatest Raspberry Pi projects voted for by the community



15/11/2018

**75 Raspberry Pi 3A+**

The first new Model A in five years brings the power of Raspberry Pi 3B+ to a much smaller form factor

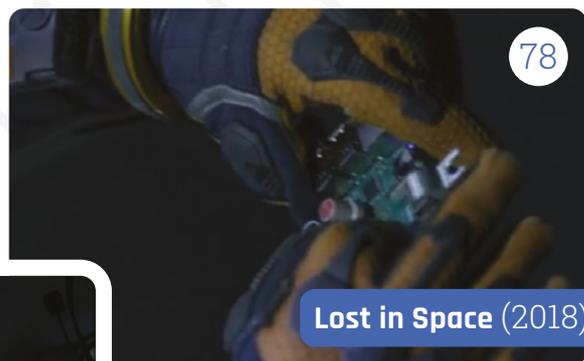
# Redefining computers in pop culture

Raspberry Pi has had a cameo on countless TV shows, movies, and videos. Here are our favourite on-screen Raspberry Pi moments

**R**aspberry Pi bounces on screen in entertainment all the time. Whenever a hacker needs a small computer to open a door, spy on enemies, or just do something techie and futuristic, chances are it's a Raspberry Pi in their hand. "You connect your Raspberry Pi... and Bob's your uncle," as they said in *Mr. Robot*.



77 Election Wipe (2015)



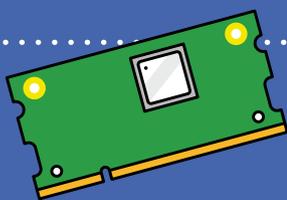
78 Lost in Space (2018)



76 Mr Robot 'eps1.4\_3xpl0its.wmv' (2015)



79 Big Hero 6 (2014)

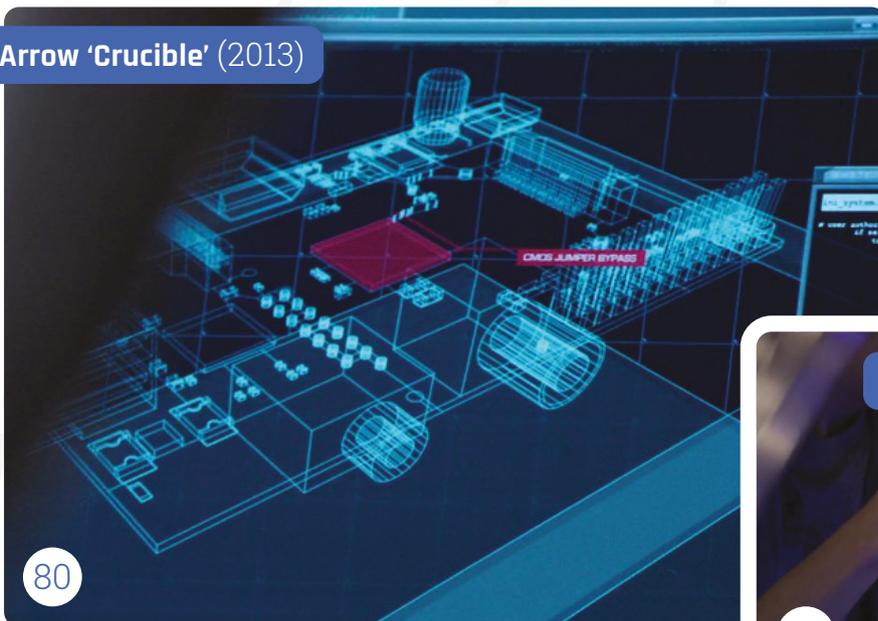


28/01/2019  
**86 Compute Module 3+**  
 The board for deeply embedded systems gets the 3+ treatment



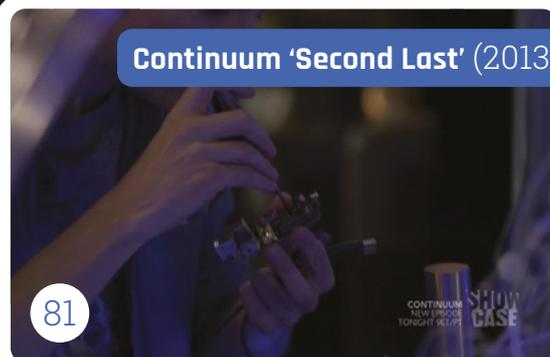
07/02/2019  
**87 Raspberry Pi Store**  
 The first Raspberry Pi retail store is opened in Cambridge, a short walk from the Foundation offices

Arrow 'Crucible' (2013)



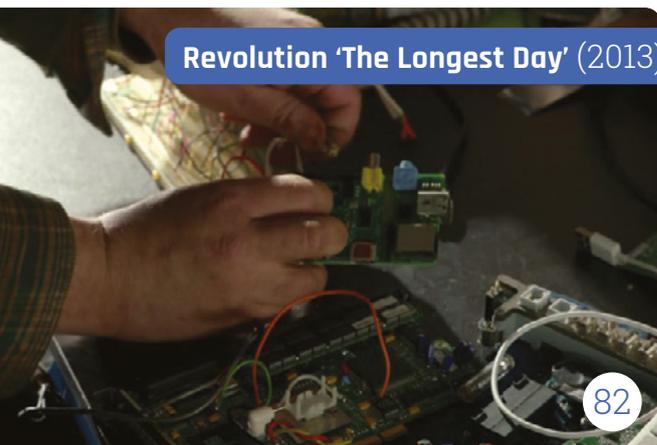
80

Continuum 'Second Last' (2013)



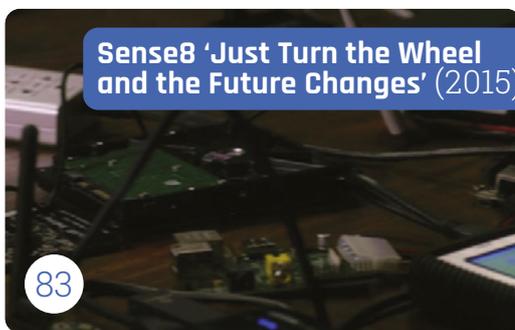
81

Revolution 'The Longest Day' (2013)



82

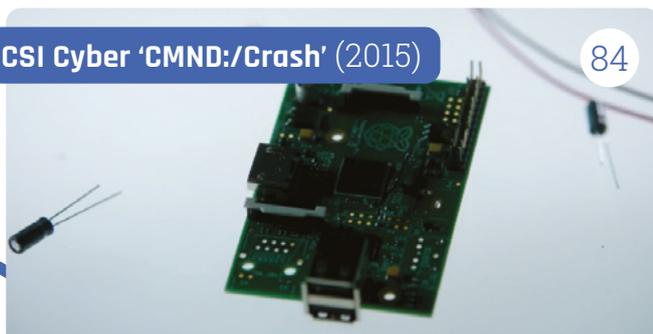
Sense8 'Just Turn the Wheel and the Future Changes' (2015)



83

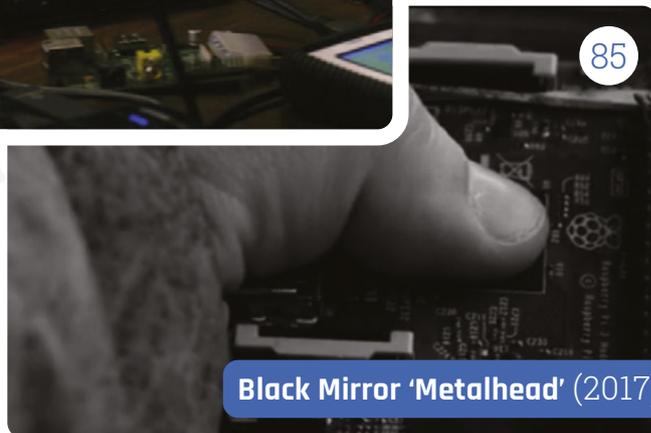
85

CSI Cyber 'CMND:/Crash' (2015)

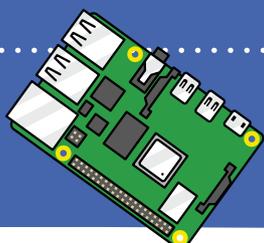


84

Black Mirror 'Metalhead' (2017)



Thanks to RPI Spy for spotting many appearances of Raspberry Pi: [magpi.cc/rpitvshows](http://magpi.cc/rpitvshows).



24/06/2019

**88 Raspberry Pi 4**

With up to 4GB of RAM, USB 3.0, Gigabit Ethernet, and support for dual monitors, this is a huge launch



30/04/2020

**89 High Quality Camera**

The latest version of Raspberry Pi camera allows for interchangeable lenses and incredible photography

# Projects for good

How Raspberry Pi computers and the Foundation are helping people

**R**aspberry Pi was launched in an attempt to get more UK students into computing. Not only did it succeed at that, but the hardware and the Foundation have managed to help people in other ways.

## Direct action

The Raspberry Pi Foundation provides free learning resources for everyone; however, not everyone has access to a computer to learn from at home. The Stay Connected scheme <sup>90</sup> funded by the Bloomfield Trust supplied hundreds of Raspberry Pi Desktop Kits and screens through charities to students most in need, allowing for many who wouldn't have done otherwise to learn from home and connect to their school.

Elsewhere, a need for more medical equipment around the world <sup>91</sup> resulted in many proposals and projects being considered for cheap, easy-to-



- ▲ The full Desktop Kit, including a monitor, made its way to families in need
- ▼ Digital Making at Home live streams and videos were added to the already free content



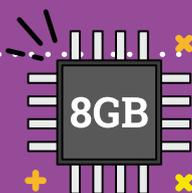
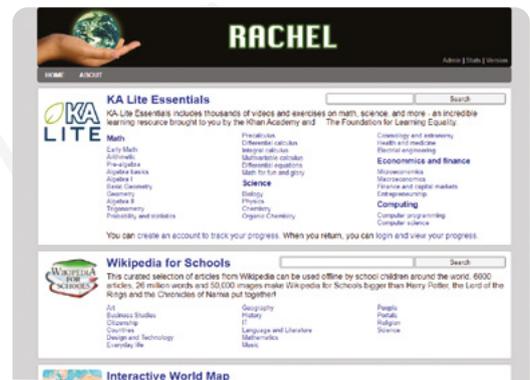
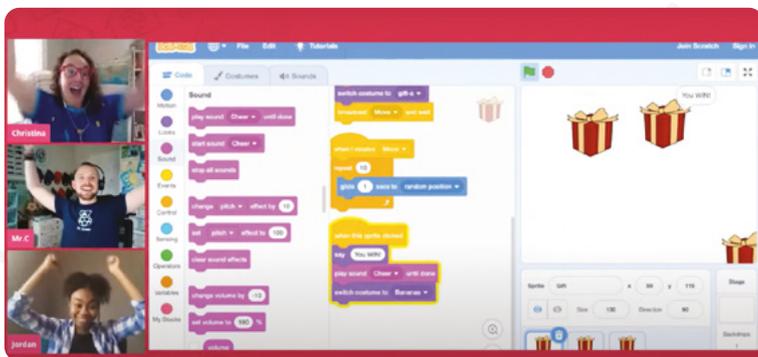
produce machines. Some included Raspberry Pi Zero, with 40,000 sold for ventilator designs.

## Offline learning

While there's no global project or standard to say what an offline internet should contain, some educational projects have tried to condense down enough online content for specific people and load it all onto a Raspberry Pi.

RACHEL-Pi <sup>92</sup> is one such solution. The RACHEL-Pi kit acts as a server, hosting a variety of different educational materials for all kinds of subjects, as well as an offline version of Wikipedia with 6000 articles. There's even medical info for helping others, math lessons from Khan Academy, and much more.

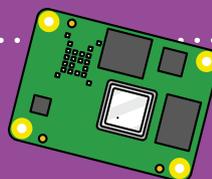
- ▼ The RACHEL sites are available in English, French, and Spanish



28/05/2020

## 97 Raspberry Pi 4 8GB

An upgrade to a massive 8GB, only three months after the 2GB model is reduced to £35



19/10/2020

## 98 Compute Module 4

With a complete redesign, the latest and greatest Compute Module has all the power of Raspberry Pi 4



◀ Ladakh is a desert-like region up a mountain which can easily shut down during the winter

▼ A Raspberry Pi lab in Kuma Adamé, Togo that Dominique Laloux helped create and update



17,000 ft <sup>93</sup> is another great project, bringing computing to schools high up in the Himalayas through a similar method, in an attempt to help children stay in their local communities.

### Education in other countries

The free resources available to people from the Raspberry Pi Projects website are great, but as they're written in English, only a small portion of the world can use them. The Raspberry Pi Foundation has a dedicated translation team <sup>94</sup> and, with help from volunteers around the world, has translated projects into up to 32 other languages. From French and Welsh to Korean and Arabic, there's a ton of projects that students from other countries are able to access.

That's not all: several charitable groups around the world have used Raspberry Pi classrooms <sup>95</sup> to bring computing education to poorer parts of the world. Many African countries and parts of rural India have benefited from these programs, with more countries being helped every day.

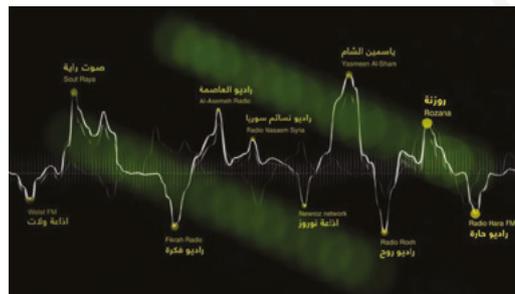


▲ The Pocket FM is far smaller than traditional transmitters, and therefore easy to move into the country and set up

### Pocket FM

The HAM radio community loves Raspberry Pi for amateur radio projects; however, sometimes people need radio for more urgent purposes. In 2016, German group Media in Cooperation and Transition created the Pocket FM <sup>96</sup>, micro radio transmitters with 4–6 km range. These radios allowed Syrians in the middle of a civil war to connect to free media on Syrnet for more reliable news.

Raspberry Pi powered these transmitters, chosen because of how easy it is to upgrade and add components to. Each transmitter is powered by solar power, and Syrnet is still transmitting through them as the war continues into its tenth year.



◀ There are a number of independent radio stations that transmit through Pocket FM



02/11/2020

### <sup>99</sup> Raspberry Pi 400

A throwback to computers of yore, Raspberry Pi 400 is a 4GB Raspberry Pi 4 fitted neatly into an official keyboard

26/11/2020

### <sup>100</sup> The MagPi 100

The MagPi issue 100 is released, celebrating 100 amazing moments in Raspberry Pi history

# WIN A RASPBERRY

## The MagPi 100 competition

We've teamed up with all of our friends from across the community to bring you a bumper competition. We've got prizes galore...



### pi-top [4] DIY Edition and Foundation Kit

This stylish case comes with a battery and small OLED display for powering and using Raspberry Pi on the move. The Foundation kit clips to the bottom and enables easy click-and-connect electronic components.

[magpi.cc/pitop4diy](https://magpi.cc/pitop4diy)

### Argon One cases

The Argon One is one of our favourite cases. With passive and active cooling, a power button for startup and shutdown, and repositioned sockets, it gives Raspberry Pi 4 a desktop style. Argon 40 has ten cases to give away.

[magpi.cc/argonone](https://magpi.cc/argonone)



### NESPi 4 cases

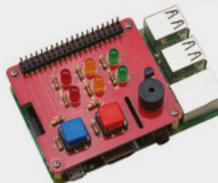
Our friends at The Pi Hut have five of these amazing retro-styled console gaming cases to be won.

[magpi.cc/nesp4](https://magpi.cc/nesp4)

### Jam HATS

We love the Jam HAT. It packs LEDs, buzzers, and buttons onto a simple board on top of Raspberry Pi. It makes starter electronics with Raspberry Pi a lot easier. Thanks to The Pi Hut for five of these cracking HATs.

[magpi.cc/jamhat](https://magpi.cc/jamhat)



### RFID HAT

Read the radio-frequency identification information stored on key fobs and tags with this super new RFID HAT. SB Components has ten to give away.

[magpi.cc/rfidhat](https://magpi.cc/rfidhat)



# PI PRIZE BUNDLE!

## SmartPi Touch 2

This fantastic case is designed for Raspberry Pi screen-based projects and makes a great interface. SmartPi has got ten SmartPi 2 cases to give away. You'll need to bring your own Raspberry Pi and screen, though.

[magpi.cc/smartipi2](http://magpi.cc/smartipi2)



## DAC2Pro

HiFiBerry makes some of our favourite DACs (digital to analogue converters). These super DAC2Pro HATs make it possible to hook Raspberry Pi into hi-fi equipment. HiFiBerry has five to give away.

[magpi.cc/dac2pro](http://magpi.cc/dac2pro)



## MeArm

Enter the wonderful world of robotics engineering with the MeArm robot arm Raspberry Pi kit. MeArm has three of these superb robot arm kits to be won.

[magpi.cc/mearm](http://magpi.cc/mearm)



## GrowPi

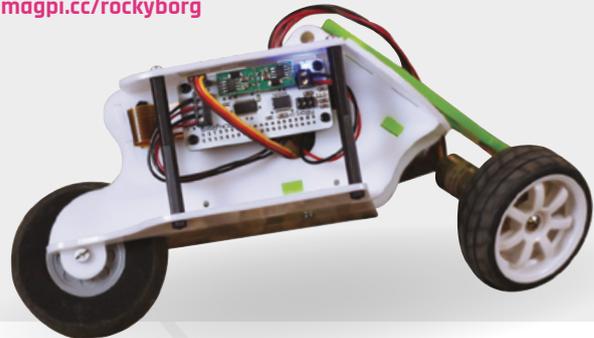
This new Grow HAT from Pimoroni is one for budding green-fingered hackers. It's a compact Raspberry Pi-powered monitoring system designed to help you take the best possible care of your plants. Pimoroni has ten to give away.

[magpi.cc/grow](http://magpi.cc/grow)

## RockyBorg

We love RockyBorg. This three-wheeler by PiBorg is a fast, fun, and nimble robot with two 20 mm 180 rpm metal-gear motors and a powerful metal-gear servo for leaning into corners. PiBorg has two to give away to lucky readers.

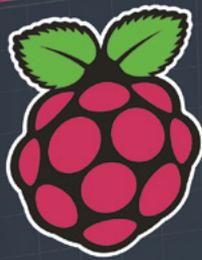
[magpi.cc/rockyborg](http://magpi.cc/rockyborg)



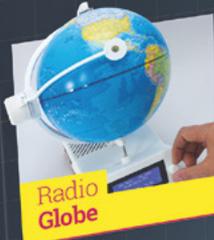
# Enter now: [magpi.cc/win100](http://magpi.cc/win100)

## Terms & Conditions

Competition prizes do not include Raspberry Pi computers; additional components and extra parts may be required to assemble working products. Competition opens on **26 November 2020** and closes on **18 December 2020**. Prizes are offered to participants worldwide aged 13 or over, except employees of the Raspberry Pi Foundation, the prize supplier, their families, or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from The MagPi magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked. This promotion is in no way sponsored, endorsed or administered by, or associated with, Instagram or Facebook.



# THE Official RASPBERRY PI HANDBOOK 2021



Radio Globe



Magic Mirror



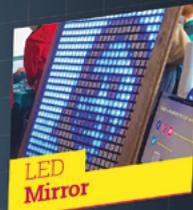
Reachy Robot



Hot Spotter Drone



High Quality Camera



LED Mirror



Dual-screen Instaclock



Introducing RASPBERRY PI 400

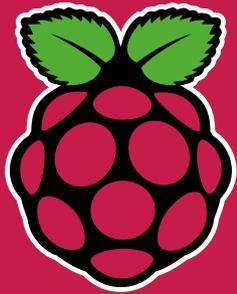
Make amazing things with Raspberry Pi

FROM THE MAKERS OF *MagPi* THE OFFICIAL RASPBERRY PI MAGAZINE

THE OFFICIAL RASPBERRY PI HANDBOOK 2021

Make amazing things with Raspberry Pi

THE *Official*



# RASPBERRY PI HANDBOOK

2021



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- Learn how to code and make with our step-by-step tutorials
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# Build a handheld console



MAKER

## K.G. Orphanides

K.G. is a writer, maker of odd games and software preservation enthusiast. They will fight anyone who claims that piracy is the only thing emulation's good for.

@KGOOrphanides



### Alert! Copyright

Many classic games are protected by copyright. Stick to homebrew and legal ROMs.

[magpi.cc/legalroms](http://magpi.cc/legalroms)

### You'll Need

- Retroflag GPI case (£60) [magpi.cc/gpi](http://magpi.cc/gpi)
- microSD card (8GB+)
- Raspberry Pi Imager [magpi.cc/downloads](http://magpi.cc/downloads)
- Monitor, USB-to-micro USB adapter, keyboard (briefly)
- 3 × AA batteries

Forget the TV, a dedicated handheld is the pinnacle of retro gaming. Whether you play in bed or in the garden, we've got builds for under £100 and under £200

**T**his month, we're going to build handheld consoles powered by two different Raspberry Pi computers, in two different cases. The Retroflag GPI Case for Raspberry Pi Zero, supplied by The Pi Hut, has a total of eight buttons plus a digital pad and a 2.8-inch 320×240 colour screen. It'll run for hours on three AA batteries and is small enough to carry in a generously sized coat pocket.

The PiBoy DMG is more expensive, chunkier, and much more powerful. It has a 3.5-inch 640×480 display, both digital and analogue controls, and a total of ten buttons. You can access all Raspberry Pi 4's USB ports and there's an optional mini-HDMI pass-through. It won't run off AAs, so the full kit ships with a 4500 mAh rechargeable battery.

## Build 1: Raspberry Pi Zero

### 01 Install RetroPie

Use the Raspberry Pi Imager for Windows, Linux, and macOS to download and write RetroPie (RPI 1/ZERO) on a microSD card. 8GB capacity should be fine for our purposes, as none of the systems we'll be emulating involve large files.

Before you install Raspberry Pi Zero in the GPI Case, you connect it to a monitor, a keyboard, and the internet to install Retroflag's safe shutdown script. Insert your microSD card and connect your peripherals. Allow RetroPie to boot, then press **F4** to quit to the command prompt.

### 02 Basic config & safe shutdown

Type `sudo raspi-config`. Now go to Network Options. Go to Wi-Fi and set your country, network name (SSID), and password. In Localization options, Change Keyboard to make sure your

keyboard is properly configured. **TAB** to Finish on the main menu, press **ENTER**, and reboot.

At the command prompt, type `ifconfig` to confirm that your wireless network is connected. Finally, on a single line, type:

```
wget -O - "https://raw.githubusercontent.com/RetroFlag/retroflag-picase/master/install_gpi.sh" | sudo bash
```

This will download and run the safe shutdown installer before restarting Raspberry Pi Zero. Power down and unplug the system.

### 03 Add display support

Return the microSD card to the system you're using to prepare the OS for use. Download the patch zip file from [magpi.cc/gpicasepatch](http://magpi.cc/gpicasepatch) and unzip it.

The readme file includes instructions for Windows and macOS – the latter also applies to Linux operating systems including Raspberry Pi OS.

From the boot partition of your RetroPie disk, copy `config.txt` to the `original_files` directory in the patch's folder and replace it with the one that you'll find in the `patch_files` subdirectory.

Similarly, back up `dpi24.dtbo` from RetroPie's `/boot/overlays` folder to the supplied `overlays` directory, then copy over `dpi24.dtbo` and `pwm-audio-pi-zero.dtbo` from the `patch_files` subdirectory to RetroPie's `overlays` folder.

### 04 Prepare the case

The Retroflag GPI Case comes with a helpful illustrated installation guide, a USB power cable, plus the screwdriver and four screws you'll need to assemble your handheld.



The Retroflag GPI will just about fit in a jeans pocket, so you can play From Below wherever you go



The larger screen size and chunkier dimensions of the PiBoy DMG make it feel like playing a horizontal console despite its vertical form factor

Open the battery compartment at the back and flip the Safe Shutdown switch to the 'on' position. Make sure the main console power switch is in the off position.

Remove the 'cartridge' – actually a Raspberry Pi Zero case – from the slot at the top of the console; turn it so that the sticker's facing you and gently but firmly pull it apart.

Remove the microSD card from Raspberry Pi and the microSD cover from the case.

### 05 Install Raspberry Pi

Place Raspberry Pi loosely into position on the four mounting posts in the shell, with the SD slot facing the gap you removed the cover from.

Connect the micro USB extension ribbon cable from the I/O conversion board that comes installed in shell 2 to Raspberry Pi's USB port (the rightmost – the other one is only for power). Now seat Raspberry Pi into shell 1 and position the I/O board on top of it. Make sure both the posts and GPIO pogo pins are lined up.

Reinsert the microSD cover, clip the cartridge halves back together, and install the supplied screws into the holes on the back to secure it. Open the SD card cover, insert your card, close it, and slide the cartridge back into the main body of the case. Insert three AA batteries.



A micro USB port under the GPI's battery cover can provide USB peripheral connectivity via a powered hub, but reliability varies greatly from hub to hub

### 06 Power up and configure

Flip the power switch at the top right and RetroPie will boot. The GPI Case registers as an Xbox 360 pad, less a few buttons, though left and right buttons are hidden on the back of the case.

Hold any button to start configuration. When you get to a button that doesn't exist, press and hold any button. Skip hotkey configuration and allow RetroPie to auto-configure it as Select when prompted. You'll be able to exit to the menu from games by pressing Start and Select at the same time.

In the front end, tap A to enter the RetroPie menu, scroll to RetroPie Setup, and tap A. Go to Configuration / tools, select Samba, and Install RetroPie Samba share to create a network share so you can easily copy game files over to the console's `~/RetroPie/roms` directory. RetroPie Setup also allows you to install new emulators.

### Top Tip

The right emulator

For improved Raspberry Pi Zero emulation, use lr-picodrive for Mega Drive, lr-pce-fast for PC Engine, and lr-genesis-plus-gx for Master System.

## Top Tip

### Windows required

PiBoy DMG kits coming on sale in November 2020 should have the latest firmware, but future updates ([magpi.cc/piboyfirmware](http://magpi.cc/piboyfirmware)) will require a Windows PC.



► The 'cartridge' that slots into the GPI Case is really a swappable Raspberry Pi Zero case, so you could keep different game collections on separate systems

## You'll Need

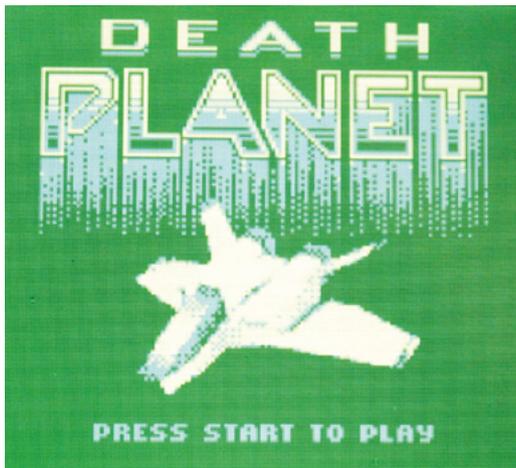
- PiBoy DMG – Full Kit (\$120) [magpi.cc/piboydmg](http://magpi.cc/piboydmg)
- Optional PiBoy DMG HDMI adapter (\$10)
- microSD card (32GB+)
- Raspberry Pi Imager [magpi.cc/downloads](http://magpi.cc/downloads)

## Build 2: Raspberry Pi 4

### 01 Image your microSD card

Experimental Pi has its own fork of RetroPie, tweaked to fully support the handheld's features. Download and extract the operating system image via [magpi.cc/piboydmgimage](http://magpi.cc/piboydmgimage) and flash it to your microSD card using the Raspberry Pi Imager tool.

Alternatively, you can install RetroPie – or any other Raspberry Pi OS / Raspbian-based operating system – but will have to add Experimental Pi's safe shutdown and on-screen display scripts, available at [magpi.cc/piboydmgscripts](http://magpi.cc/piboydmgscripts).



► Even on a backlit colour screen, modern Game Boy games feel right on a handheld

### 02 Chassis preparation

Experimental Pi's illustrated online assembly instructions for the PiBoy DMG are among the best we've seen, so keep them on hand during this build: [magpi.cc/piboydmgbuild](http://magpi.cc/piboydmgbuild). The PiBoy DMG Full Kit comes with the battery, screws, screwdriver, buttons, and blanking plates that you'll need to build it. It's worth adding the HDMI adapter to your order, too.

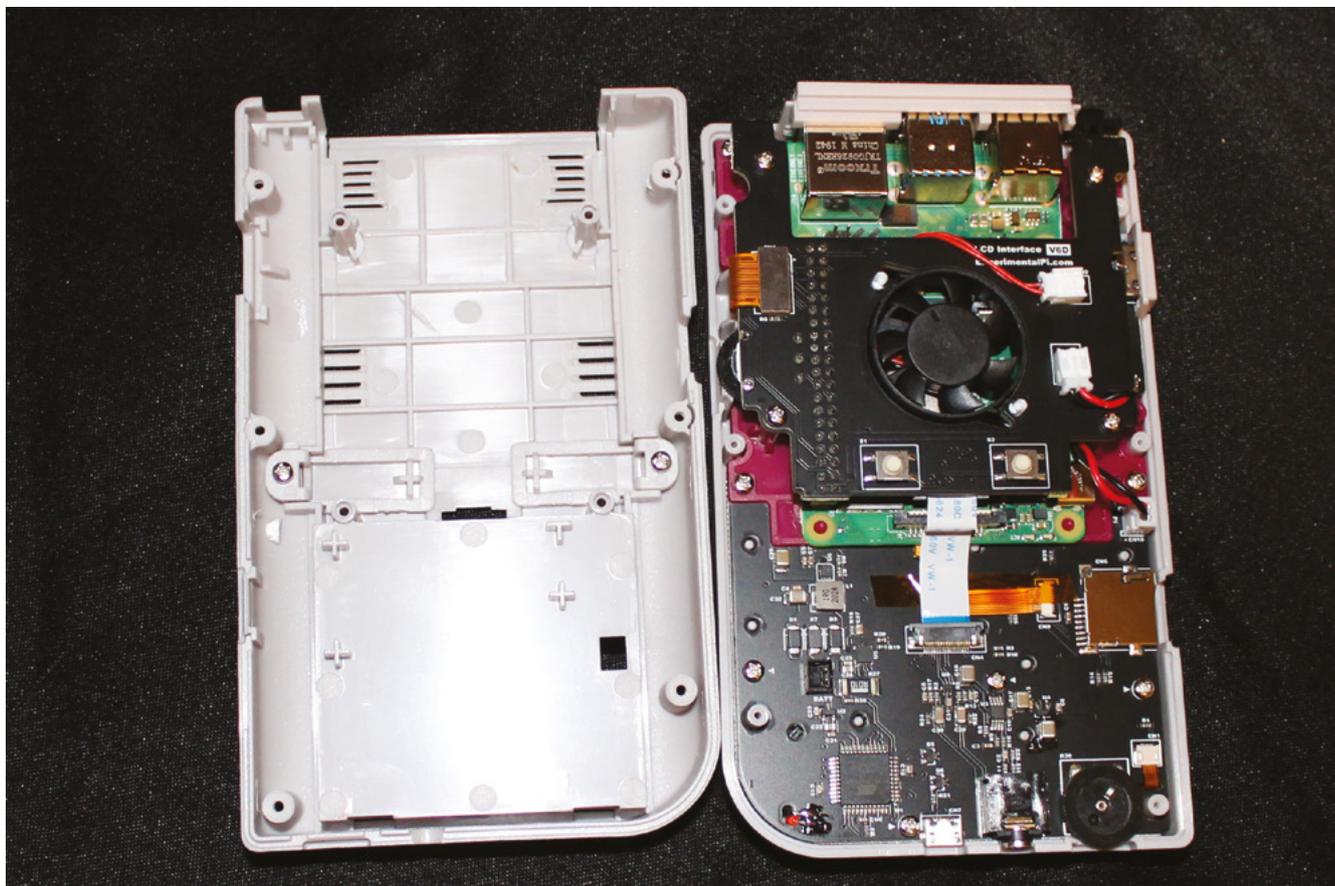
Unscrew the back of the case, and then unscrew and lift off the fan assembly that'll keep Raspberry Pi cool in situ.

“ It's worth enabling Samba for ease of transferring software to the console ”

### 03 Install Raspberry Pi

Slip the supplied faceplate over Raspberry Pi's ports – and, if you're using it, fit the PiBoy HDMI adapter to the rightmost micro-HDMI port and slide its faceplate on.

Gently push the SD card adapter ribbon cable into Raspberry Pi's microSD slot, then lower the computer and HDMI adapter onto the standoffs. Screw the HDMI adapter into position. If you're not going to use this adapter, fit a blanking plate in its place.



## 04 Fit the fan

Add the fan board: making sure that it's lined up with the GPIO, gently seat it into place – a rocking motion works well for this. Make sure all cables are correctly lined up and screw the board down. Line up and gently press into the place the IPS screen cable.

Place the supplied power switch onto the switch on the top right of the board and screw the rear of the case back on. Fit the rechargeable battery – it'll only connect one way round, but there are also polarity markings to help.

## 05 Go wireless

Slide the microSD card you imaged earlier into position and power up. To add wireless networking to our handheld build, mount its microSD hard disk on any other computer. In the top-level `/boot` directory, create a file called `wifikeyfile.txt`. It should contain these lines:

```
ssid="wifi_name"
psk="password"
```

## Handheld homebrew

To help you find the latest games for your favourite classic handhelds, here are six more game collections on indie platform itch.io.

- 👉 [magpi.cc/itchgb](https://magpi.cc/itchgb)
- 👉 [magpi.cc/itchgbc](https://magpi.cc/itchgbc)
- 👉 [magpi.cc/itchgba](https://magpi.cc/itchgba)
- 👉 [magpi.cc/itchlynx](https://magpi.cc/itchlynx)
- 👉 [magpi.cc/itchpsp](https://magpi.cc/itchpsp)
- 👉 [magpi.cc/itchpce](https://magpi.cc/itchpce)

Save the file, unmount the card, return it to your handheld, and boot. From the RetroPie menu, select 'Wifi', then import WiFi credentials from `/boot/wifikeyfile.txt`.

As with the Retroflag build, it's worth enabling Samba for ease of transferring software to the console (see Build 1, Step 6). Transfer your games, and you're ready to play on the move. 📺

▲ The Pi Boy DMG case has a built-in fan, which makes it a little noisy but also means you can overclock it to run demanding games

## Top Tip 👍

### Why HDMI?

Adding the micro-HDMI adapter to the PiBoy DMG means you can connect it to a TV, add a couple of USB controllers, and enjoy classic multiplayer gaming.

# Build a Home Assistant: the light fantastic



PJ Evans

MAKER

PJ is a writer, software engineer, and tinkerer. He just wants to start his coffee machine on the first morning yawn.

@mrpjevens

Play with colour and mood, or go completely disco with Home Assistant's light controls

**L**ast month we got our Home Assistant set up and ready to work. Now it's time to look at home automation's most popular feature; lighting control. Automating lights has never been easier and cheaper. It's also a great way to find out about some of Home Assistant's great features such as scenes or triggers. We're going to use the Ikea Trådfri range in this tutorial, but you can also use other compatible ranges such as Philips Hue. So, let's brighten up our day (and night) without the need for boring light switches.

## 01 Install your smart light system

Like many 'smart' light systems, Trådfri uses direct radio communication using a protocol called ZigBee. To control the lights from a computer, the easiest approach is to add a suitable gateway. These are normally inexpensive and are often cross-compatible (as with Trådfri and Philips Hue). Once installed, the Ikea Trådfri Gateway will allow

not only your smartphone to control lights, but also Home Assistant. Typically they need a wired connection, so it's a good idea to have your Home Assistant Raspberry Pi computer wired on the same network switch for reliability. Follow the supplied instructions and get set up before moving on.

## 02 Pair up your lights

It's far easier to get your new smart light setup running as a closed system first: it makes discovery easier later on. We're going to cover a number of different scenarios, such as an automated porch light and a group of lights that can act as one. These will all need setting up in the Trådfri smartphone app so they are recognised by the gateway. You can also group them if you want to, as that will be helpful later and save some work. Don't feel you have to follow our setup here – you can use a single light or as many as your home can take.

## You'll Need

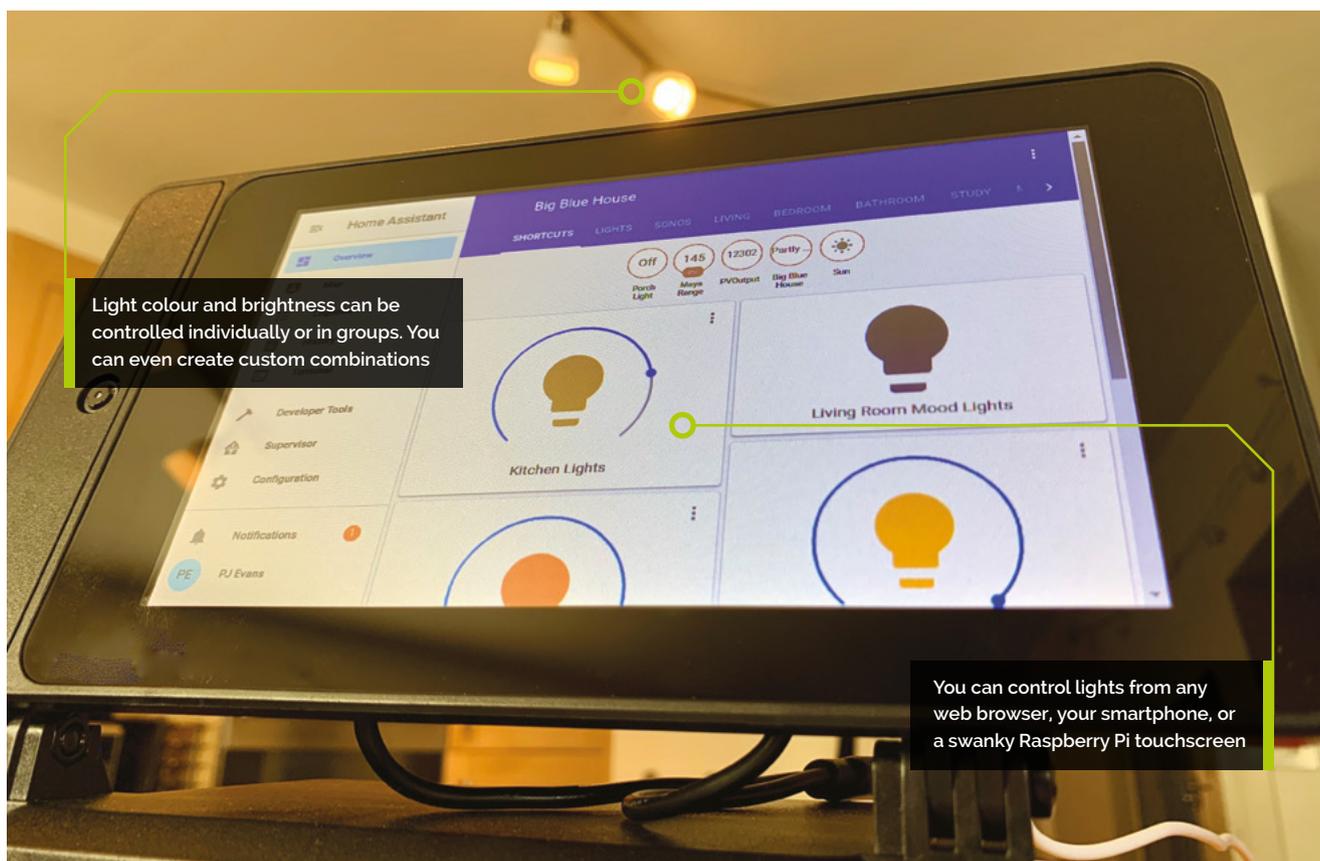
- ▶ Home Assistant setup (see [magpi.cc/99](http://magpi.cc/99))
- ▶ Ikea Trådfri Gateway [magpi.cc/tradfrigateway](http://magpi.cc/tradfrigateway)
- ▶ Ikea Trådfri light bulb(s), e.g. [magpi.cc/tradfrie27](http://magpi.cc/tradfrie27)



▲ The Trådfri system is an affordable entry into smart lighting. Image credit: Ikea

## 03 Integrate!

Once you're happy your smart light gateway is running, log in to Home Assistant and go to Configuration, Server Controls, and then click 'Restart' under Server Management. This will cause Home Assistant to rescan the network for new devices. Luckily, Home Assistant is capable of spotting a Trådfri gateway automatically and you should get a notification that a new integration has been discovered. You can now enable the integration and Home Assistant will automatically



add all your lovely new lights. Each light will be added as a device, something on your systems, and an entity – a single thing that can be controlled.

#### 04 Nice name

Now Home Assistant is aware of your fancy new lights, it's time to make things a bit more friendly. Each light now has an entity code in the system. These are normally in the form of type-dot-name, so as the device type is 'light', you'll see entities such as 'light.tradfri\_bulb\_1' listed under Configuration > Entities. You can click on these to give them more meaningful names and place them in 'areas' such as the kitchen or lounge. Once you're happy with all the names and places, you can add cards to the main control panel.

#### 05 Card-making

Last month, we configured the default dashboard 'Overview' and switched off automatic updates. If you did this, then (surprise!) controls for your new bulbs will already be available. Otherwise, click the three dots in the top-right-hand corner and then 'Configure UI'. Now click

the bottom right '+' to add a new card. Choose the 'Light' card. Chances are, Home Assistant will have picked up your bulb and name. If not, click the arrow to select the entity you need. Click 'Save' to add your new card. You should now be able to tap the card to control your light and the slider to set brightness (if your light supports it).

“ Home Assistant is capable of spotting a Trådfri gateway automatically ”

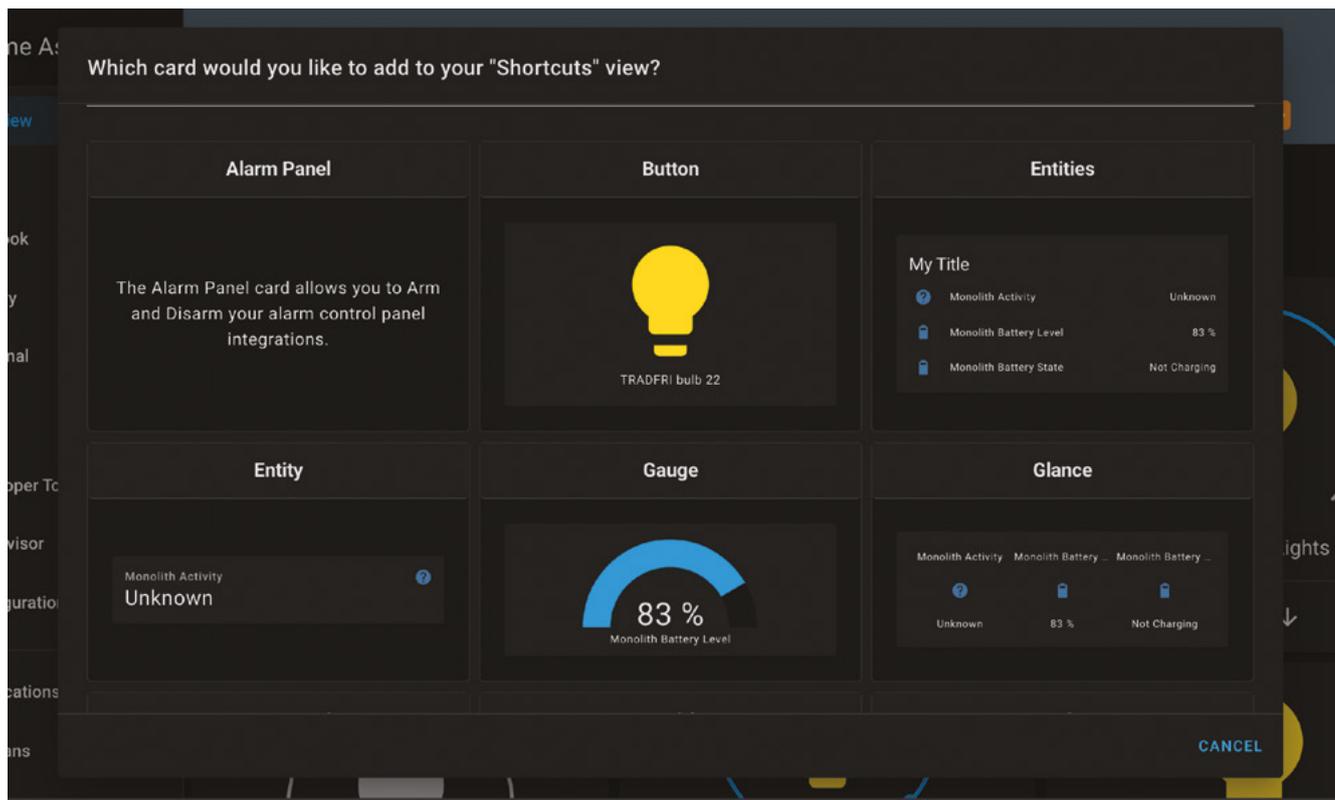
#### 06 Add an add-on

For one of our setups we want many lights to be controllable together, including dimming. This is a bit trickier and not something we can do in the interface – we'll have to edit a configuration file. To do that, we need to get console access and that means installing an add-on. Add-ons extend Home Assistant's core functionality. Click on 'Supervisor', then 'Add-on Store' to see what's available. Search for 'terminal' and install the 'Terminal & SSH' add-on. Once installed, 'Terminal' will appear on your sidebar. Click it to get a command-line prompt. Also, you now have SSH access to your installation if you want.

#### Top Tip

##### Unsupported?

If your favourite device isn't listed as an official integration, get Googling. Home Assistant is an open system and anyone can add to it, so they probably have!

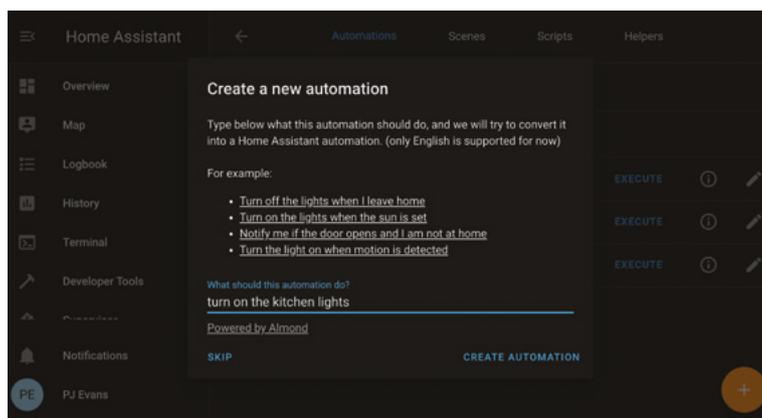


▲ There are a wide range of cards for setting up controls, and you can design your own

▼ Automations can be created with plain language and then customised

## 07 Configure it out

To control our multiple lights with one control, we need to create a single 'virtual' light. This gives us the chance to familiarise ourselves with Home Assistant's configuration files. Click on the Terminal add-on and then enter `cd config`. In this directory are all the configuration files for the system. To make our virtual light, we need to edit **configuration.yaml**. YAML files are text files that use indentation and special characters to convey meaning. The main file is **configuration.yaml**. Any changes made there require Home Assistant to be restarted. Others, such as groups, can be dynamically reloaded from Configuration > Server Controls.



## 08 A little light typing

The virtual light group is a little special, so it has to be created in the main **configuration.yaml**. Edit the configuration file as follows:

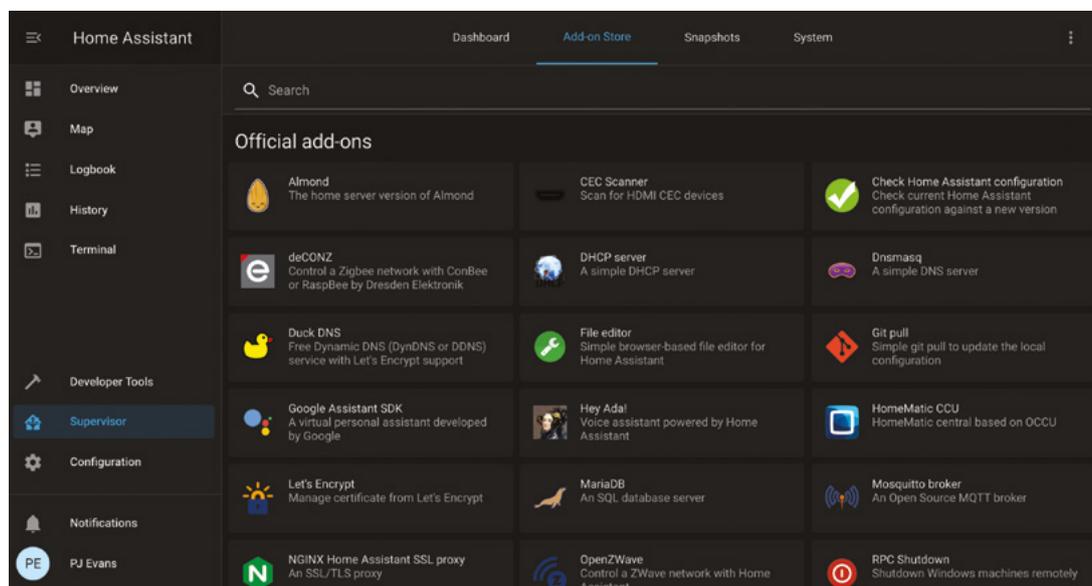
```
nano ~/config/configuration.yaml
```

Now enter in the example shown at the end of the file. You'll need to change the entities to match your installation and, of course, you can change the name to anything you wish. If you add any further groups, you should add them under the existing 'light' section. Save the file with **CTRL+X** and then restart Home Assistant to pick up the changes. You should now be able to add a new card to the dashboard which will use your new bulb and control everything in sync.

```
light:
  - platform: group
    name: Kitchen Lights
    entities:
      - light.tradfri_bulb_1
      - light.tradfri_bulb_2
```

## 09 All in good time

Let's create an automation to switch the kitchen lights off at 11pm. Click 'Configuration'



◀ The add-on store extends your server in all kinds of ways

then ‘Automations’. This is the most powerful area of Home Assistant and we’ll go more in-depth next month. For now, click the ‘+’ icon and, when prompted, enter ‘turn off the kitchen lights’, then ‘create automation’. This will set up a basic automation for you. Go to ‘Triggers’, select a type of ‘Time’, and enter ‘23:00’. Make sure all your lights are selected under ‘Actions’ and then click the save icon (yes, it’s a floppy disk). Now your kitchen lights will switch themselves off every night at 11pm. Can you get them to switch on?

## 10 Triggered

A key part of automations is the ‘trigger’: the event or change that causes an automation to run. Triggers are fed by sensors, devices connected to the system that feed it information, rather than being something it controls. Examples are temperature, humidity, movement (PIR sensors), and buttons. Home Assistant automatically adds the sun (!) as an input and knows when the sun rises and sets, so automations can be triggered. If you have a porch light, this is a simple step and the language parser will accept ‘switch the porch light on when the sun sets’ and configure everything for you. Remember to ask it to switch it off again!

## 11 Setting the scene

Another way of controlling groups is to use ‘Scenes’. You’ll find the scenes editor under Configuration. A ‘scene’ is a group of devices that you would want to group together in a particular

way. For example, you might want a single button that turned off the main light, turned on the mood lights, and started playing music on your smart speaker. This works by adding entities together in a scene and then creating a button in the dashboard to trigger that scene. You can also have the scene triggered using automations; imagine having the lights and music come on when you enter the house by using your smartphone app as a trigger.

“ Imagine having the lights and music come on when you enter the house by using your smartphone app as a trigger ”

## 12 Notifications

Now, it may not be very useful to know that a light has come on, but it does make for an interesting example of how notifications work. Let’s say you wanted an alert when the porch light switches on. You firstly need to add a notification provider to **configuration.yaml**. There’s an example here for one of our favourite services, Pushover.net:

```
notify:
  - name: pushover
    platform: pushover
    api_key: <YOUR API KEY GOES HERE>
    user_key: <YOUR USER KEY GOES HERE>
```

Once added (and with the service restarted), you can add notifications as an action on any automation. There is support for virtually every popular notification system out there. [\[7\]](#)

## Top Tip

### A bit of colour

The Trådfri integration adds fine control over the colour palette available for multicolour bulbs. Just click the three dots on the card to see a colour wheel.

# Santa's Run

Make a crazy Christmas game and guide Santa on his Christmas Eve run, delivering The MagPi magazines



**Mike Cook**

MAKER

Veteran magazine author from the old days, writer of the Body Build series, plus co-author of *Raspberry Pi for Dummies*, *Raspberry Pi Projects*, and *Raspberry Pi Projects for Dummies*.

[magpi.cc/mikecook](http://magpi.cc/mikecook)

**W**ith our 100th issue and Christmas fast approaching (at the rate of one day per day), we thought we could combine the two and develop a game that combines both celebrations. Enter Santa's Run, a game where you control Santa's sleigh to try to drop *The MagPi* magazines down the chimneys of overexcited children of all ages. All played against a night sky which is exactly as it will look on the big night in 2020.

## 01 The game

It's Christmas Eve, ten to midnight in 2020. The moon is waxing gibbous, at a phase of 73%, the constellation of Orion stands as high in the sky as it gets from these latitudes, and Santa is about to make his overhead pass. He is propelled through the sky by a mixture of magic and the energetic shaking of his eager recipients – that's you. His mission is to deliver every single copy of *The MagPi* magazine to the people waiting below. He has two passes to the end of the screen and back. Will he make it, or will some fall into the soggy snow?

## 02 The controller

The hardware controller we are about to build is about as simple as it gets. It consists of a tilt switch mounted in a plastic drinks bottle. This then connects to a GPIO pin on Raspberry Pi, and the rest is software.

We first used tilt switches in *The MagPi* issue 52 ([magpi.cc/52](http://magpi.cc/52)) with the sliders game – coincidentally also a Christmas game, and one of our favourites. But this time we only need one switch. We used a small (140 mm) flip-top drinks bottle from a discount supermarket, and mounted the switch in the top.

## You'll Need

- ▶ A tilt switch  
[magpi.cc/tiltswitch](http://magpi.cc/tiltswitch)
- ▶ One plastic bottle.  
e.g. [magpi.cc/fruityblasts](http://magpi.cc/fruityblasts)
- ▶ Microphone cable (2 metres).  
e.g. [magpi.cc/miccable](http://magpi.cc/miccable)

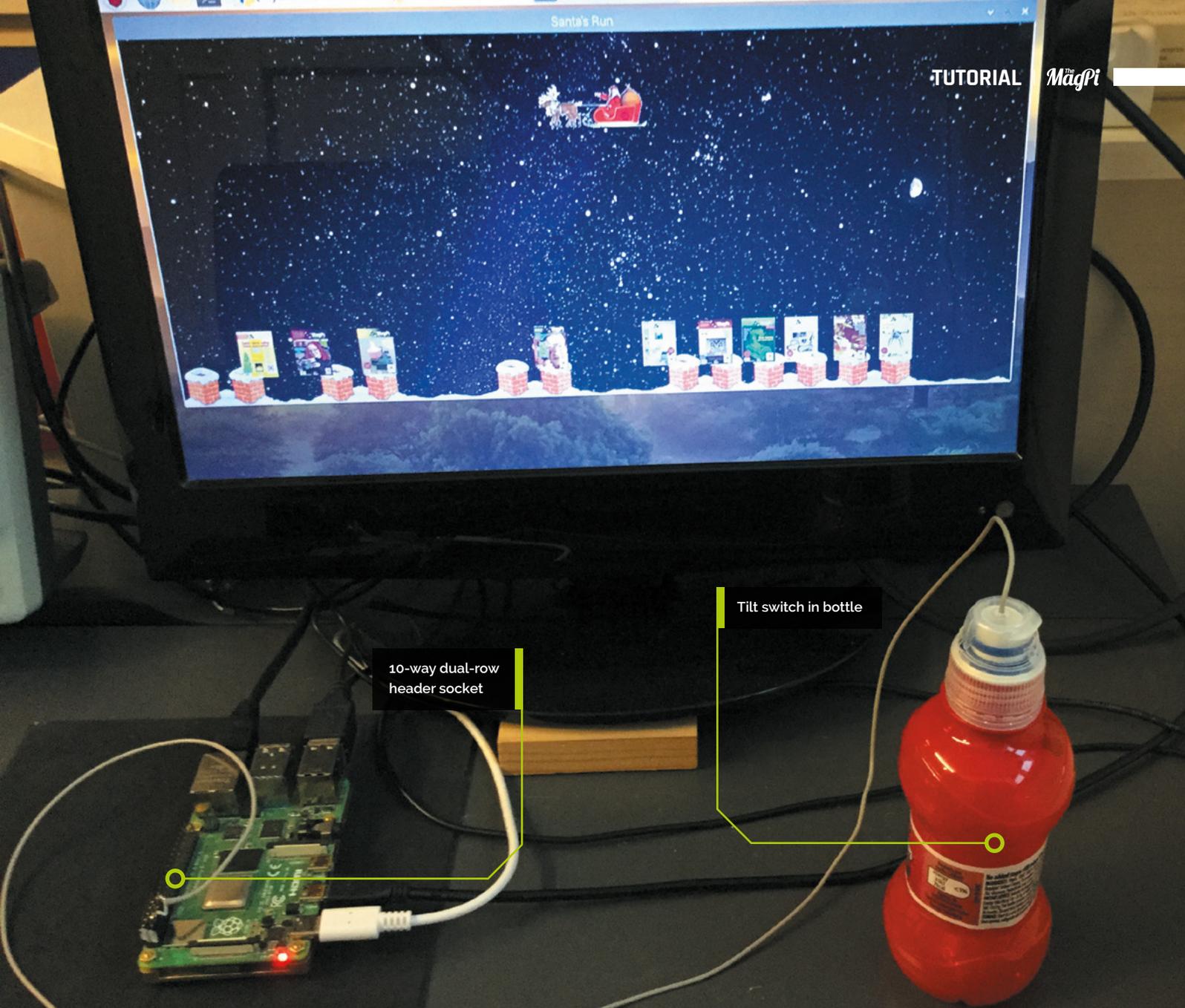
**Figure 1**



▲ **Figure 1** Soldering the tilt switch to the wire

## 03 Make your shaker

We used thin screened microphone wire for the connection; it is only 1.6 mm in diameter. This makes for a nice neat job, but any sort of wire will work. First, we drilled a 2 mm hole in the flip-top cover, and then threaded the wire through. Then we trimmed the wire on the tilt switch down to about 5 mm and soldered a wire on each connector (**Figure 1**). Then we pushed the tilt switch through into the bottle until the wires were below the level of the rim, and flooded the top recess with hot-melt glue, ensuring the tilt switch was vertical, as shown in **Figure 2** (overleaf).



## 04 Connecting to the GPIO pins

To connect the other end of the tilt switch to the GPIO pins, we used a ten-pin dual-row header socket. We connected the wires to pins 2 and 9 of the header socket; this corresponds to ground and GPIO 3, as shown in the photograph in **Figure 3**. We used an I2C pin because of the, already fitted, 1K8 (1.8 kΩ) pull-up resistor to give it good immunity from interference. **Figure 4** shows the physical layout diagram for the whole interface. We then ran a short test program, available on our GitHub page ([magpi.cc/pibakery](https://magpi.cc/pibakery)), to check it worked.

## 05 Graphics

One of the major components of this sort of project is the graphics, so we got them together

“ To connect the other end of the tilt switch to the GPIO pins, we used a ten-pin dual-row header socket ”

before starting on writing any code. We looked around the net for royalty-free Christmas animated GIFs of Santa’s sleigh, and found a good one with seven reindeer. This was too many for our needs, so we used a photo editing package to remove all but the first pair. We split the GIF into its separate frames and started editing: first removing excess reindeers, then making the background transparent, and finally adding a Raspberry Pi logo onto the sides of the sleigh.

## Top Tip

### Santa’s height

During forward motion, Santa’s height will slowly drop until it reaches the level of Rigel.

Figure 2

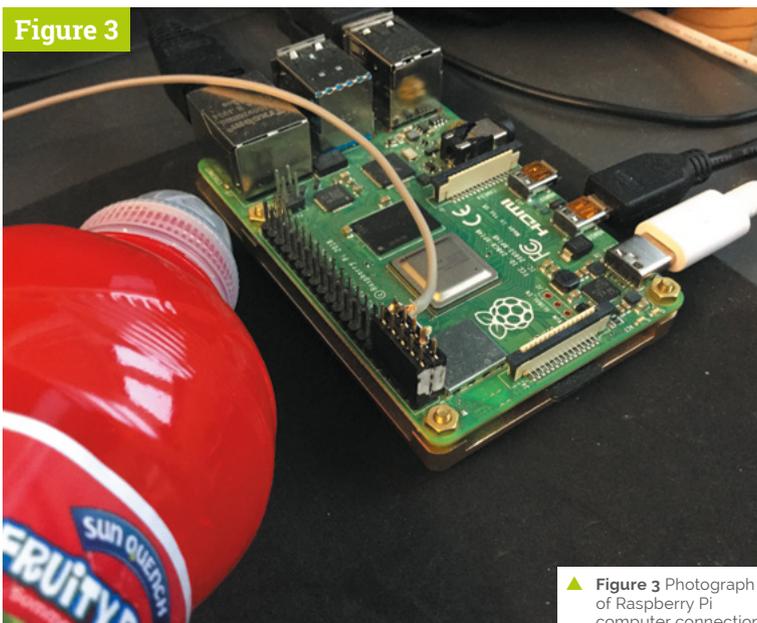


▲ Figure 2 Hot-melt glue fixing the tilt switch

## 06 Your first dashboard

Then we found a chimney and made it a double chimney with a copy and flip of the original clip art. We also did some retouching on the snow line between the chimneys, to make the transition smooth. Most importantly, we made the snow line at either side of the chimneys end at the same height. Finally, we made two lengths of just plain snow: one the same length as the chimneys, and the other half the length. In this way, we could mix and match the graphic elements in the scrolling ground display.

Figure 3



▲ Figure 3 Photograph of Raspberry Pi computer connection

## 07 The MagPi covers

This could have been hard work, going through all the back issues online and taking screen grabs, but fortunately the magazine was planning to put all the covers on the front page of the 100th issue, so they had gathered them together already. We only had to scale them, in our case to 50 pixels wide. The final element was the star-studded background for Santa to ride across, but being very keen on astronomy, we wanted this to be accurate, along with the position and phase of the moon. So we turned to a great open-source planetarium package, Stellarium.

## 08 Stellarium

Stellarium has been around for at least 15 years and is, by now, a very sophisticated product available free for all three major platforms. We used it to look at the sky as it would be on Christmas Eve 2020. While leap years keep the stars in the same place at a specific date from year to year, the moon's position and phase will change. This year the moon is waxing gibbous, at a phase of 73%. 'Waxing' means it is getting fuller day by day, 'gibbous' means it's between half and full, and 'phase' is how much of the moon you can see.

“ We took a bit of poetic licence when it came to the size of the moon ”

## 09 Poetic licence

We took a bit of poetic licence when it came to the size of the moon. When looking at it in the sky, we actually perceive it to be bigger than it really is, so we enlarged the moon to match our perceptions. **Figure 5** shows the negative of the background image we used. It also includes constellation lines and star names – note the position of Rigel in the constellation of Orion, as it is a key point in the game. Stellarium is much more than a simple planetarium and can animate all sorts of events like the analemma of the sun.

## 10 Software

All the software and graphics files can be found on our GitHub page. You use the shaker to propel Santa across the sky, and need to keep

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Figure 5



Figure 6



- ▲ **Figure 5** The night sky used showing constellations and names
- ▲ **Figure 6** Santa in action, delivering one more magazine

shaking to keep him going. When you have positioned him correctly, you press the **SPACE** bar to release a copy of *The MagPi* magazine, which then drops to the ground. The longer it descends, the faster it drops, as the speed increases because of the acceleration due to gravity. The forward speed of the drop, however,

is constant. This adds a bit of realism to what is a big suspension of disbelief.

## 11 The drop

While the magazine is dropping, Santa's forward speed is transferred to vertical speed, allowing you to control his altitude. This is important, because aiming from a low height is easier but you can only drop magazines if the runners on the sleigh are above Rigel. If you attempt a drop and you are at the level of Rigel, you will be whooshed to the top of the screen. If the magazine's bottom-left or bottom-right corner intersects the hidden capture rectangle on each chimney, it sticks there and is considered delivered; if not, then it sinks into the snow and is lost.

## 12 Winning the game

Santa makes two runs across the screen: right to left, then left to right. The objective is to deliver all 100 issues of *The MagPi* magazine. The game stops when either you complete the two runs or you run out of magazines. You get to see the total delivered at the end, along with a round of applause. **Figure 6** shows Santa on his return run adding another magazine to those already delivered.

Next month, in part two, we will look at using two shakers. So get another tilt switch while you are at it, to make more shaking fun. 🎮

## Top Tip

### Santa's forward leap

When a magazine is successfully delivered, Santa jumps forward a bit. This is to prevent you hovering in one place and just lobbing all the magazines into one chimney.

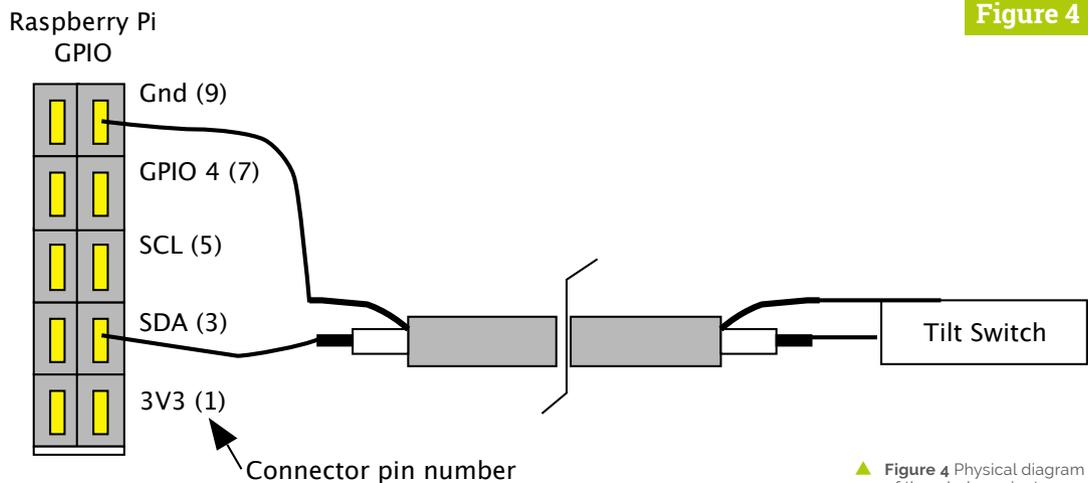
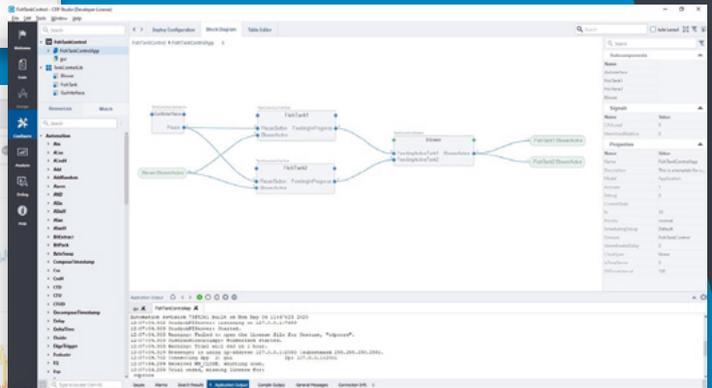
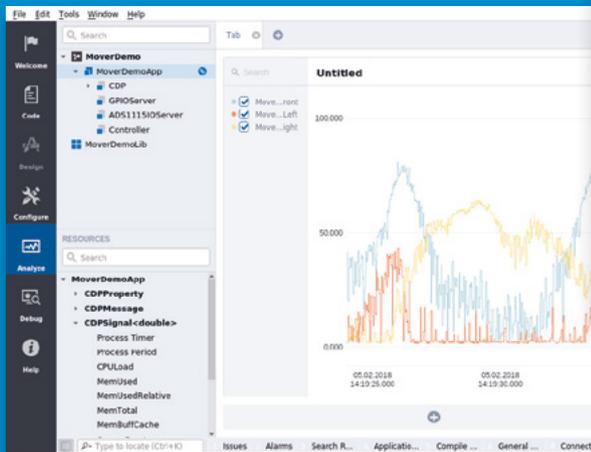
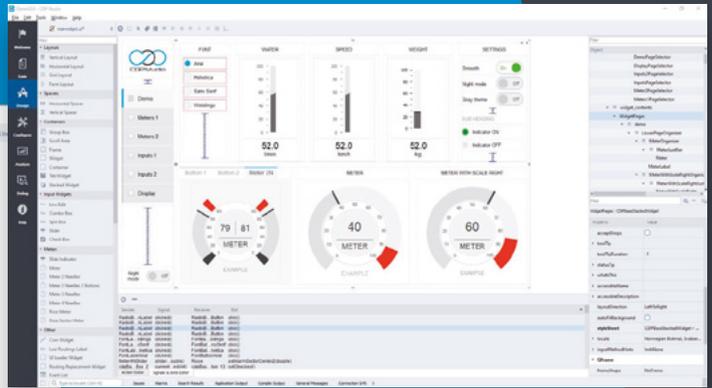
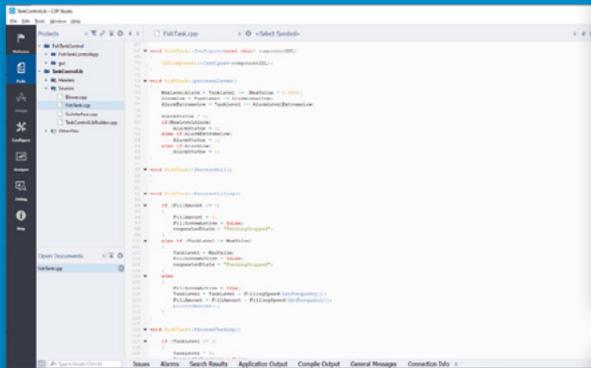


Figure 4

- ▲ **Figure 4** Physical diagram of the whole project

Code



Configure

Analyze

# CDP STUDIO: HOME PROJECTS MADE EASY

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```
print("Hello, World!")
```

# Raspberry Pi

An all-in-one system, **Raspberry Pi 400** is the only desktop you need

**W**hen is a keyboard not a keyboard? When it contains an entire personal computer. On the surface, Raspberry Pi 400 marks a return to the early days of personal computing, when bedroom programmers and office staff plugged all-in-one keyboards directly into their TVs and monitors for everything from gaming to coding.

Raspberry Pi 400 packs a measurable speed boost over Raspberry Pi 4, thanks to a clever passive cooling system which offers enough headroom for a processor jump from 1.5GHz to 1.8GHz.

Join us as we dive into the latest, and most impressive, Raspberry Pi ever made.

▣ Raspberry Pi 400 packs a measurable speed boost over Raspberry Pi 4" ▣



## Personal Computer Kit

You can buy Raspberry Pi 400 on its own, or as part of a Personal Computer Kit bundle with all the accessories you need. Inside the box you'll find:

- ▶ Raspberry Pi 400 computer
- ▶ USB mouse
- ▶ Power supply
- ▶ microSD card
- ▶ HDMI cable
- ▶ Beginner's Guide book

▶ Raspberry Pi 400 computers being built in the Sony factory in Pencoed, Wales. Image credit: Sony UK Technology Centre, [sonypencoed.co.uk](http://sonypencoed.co.uk)



400

## PLACES TO BUY

## UK &amp; Ireland

**Raspberry Pi Store**[magpi.cc/retail-store](http://magpi.cc/retail-store)**OKdo**[okdo.com](http://okdo.com)**The Pi Hut**[thepihut.com](http://thepihut.com)**SB Components**[sb-components.co.uk](http://sb-components.co.uk)**Pimoroni**[pimoroni.com](http://pimoroni.com)

## North America

**OKdo**[okdo.com](http://okdo.com)**Adafruit**[adafruit.com](http://adafruit.com)**Micro Center**[microcenter.com](http://microcenter.com)**PiShop.us**[pishop.us](http://pishop.us)**Vilros**[vilros.com](http://vilros.com)**Canakit**[canakit.com](http://canakit.com)

## Europe

**OKdo**[okdo.com](http://okdo.com)**pi3g**[pi3g.com](http://pi3g.com)**Berrybase**[berrybase.de](http://berrybase.de)**Kubii**[kubii.fr](http://kubii.fr)**Raspishop**[raspishop.de](http://raspishop.de)**BuyZero**[buyzero.de](http://buyzero.de)**Reichelt**[reichelt.de](http://reichelt.de)**Funk24.net**[funk24.net](http://funk24.net)**Totonic**[pi-shop.ch](http://pi-shop.ch)**Welectron**[welectron.com](http://welectron.com)

## Asia

**Cytron**[cytron.io](http://cytron.io)**Hangzhou Junroc**[junroc.com](http://junroc.com)**Seed**[seedstudio.com](http://seedstudio.com)**Beijing iVision**[ivision-tech.world.taobao.com](http://ivision-tech.world.taobao.com)For a full list of approved resellers, please go to [rpf.io/products](http://rpf.io/products)

# Meet Raspberry Pi 400

**O**n the first inspection, Raspberry Pi 400 is deceptively similar to Raspberry Pi keyboard and hub. The rear of Raspberry Pi 400 tells a different story, with an array of sockets and connectors. Inside Raspberry Pi 400 is hardware similar to Raspberry Pi 4, but with a different design to reposition all the connections.

## Specifications

**PRICE:** £65 / \$70 (Raspberry Pi 400), £93.00 / \$100 (Raspberry Pi 400 Personal Computer Kit)

**SoC:** Broadcom BCM2711C0 quad-core ARM Cortex-A72 (ARMv8-A) 64-bit @ 1.8GHz

**GPU:** Broadcom VideoCore VI

**RAM:** 4GB LPDDR4 SDRAM

**NETWORKING:** 2.4GHz and 5GHz 802.11b/g/n/ac wireless LAN, Gigabit Ethernet

**BLUETOOTH:** Bluetooth 5.0, Bluetooth Low Energy (BLE)

**GPIO:** 40-pin GPIO header, populated

**STORAGE:** microSD

**PORTS:** 1× USB Type-C power input, 2× micro-HDMI 2.0, 1× USB 2.0, 2× USB 3.0, 1× RJ45 Ethernet, 1× Kensington locking slot

**COOLING:** Built-in passive heatsink

**DIMENSIONS:** 286 mm × 122 mm × 23.7mm, 385 g

**KEYBOARD LAYOUTS:** UK, US, German, Spanish, French, Italian.



### A GPIO PINS

The 40-pin GPIO header is used to connect Raspberry Pi 400 to electronic devices and to experiment with electronics and coding. Look closely and you'll see PIN1 and PIN40 imprinted on the case next to the first and last pin



### E USB 3.0

Two USB 3.0 sockets can be used to connect devices with fast throughput, such as external storage drives.



### F USB 2.0

A single USB 2.0 socket can be used with the mouse





**B MICRO SD CARD**

This push-click microSD socket acts as the main drive. A 16GB microSD card with Raspberry Pi OS pre-installed is included in the Personal Computer Kit



**C MICRO-HDMI**

Two micro-HDMI connectors are used to connect Raspberry Pi 400 to up to two 4K monitors



**D USB-C POWER**

Raspberry Pi 400 is powered via USB-C using a Raspberry Pi 15.3W USB-C Power Supply (included with the Personal Computer Kit).



**G ETHERNET**

Gigabit Ethernet provides a fast direct network connection



**H KENSINGTON LOCK SOCKET**

Secure Raspberry Pi 400 to a table with the security lock socket



## Using HAT hardware with Raspberry Pi 400

**Raspberry Pi 400 has the same 40-pin GPIO header as all current Raspberry Pi models. Only now it's positioned on the rear of the case.**

You can connect HAT hardware directly to the 40-pin GPIO header, but it will be pointing backwards and up. A ribbon cable can be used to extend the GPIO pins and most will connect to Raspberry Pi 400 and extend with the pins facing upwards. You can pick up ribbon cables from The Pi Hut and other stores for around £3. Here we're using a 40-Pin GPIO Ribbon Cable – Rainbow 150 mm from The Pi Hut ([magpi.cc/ribboncable](https://magpi.cc/ribboncable)).



```
print("Hello, World!")
```

# Inside Raspberry Pi 400

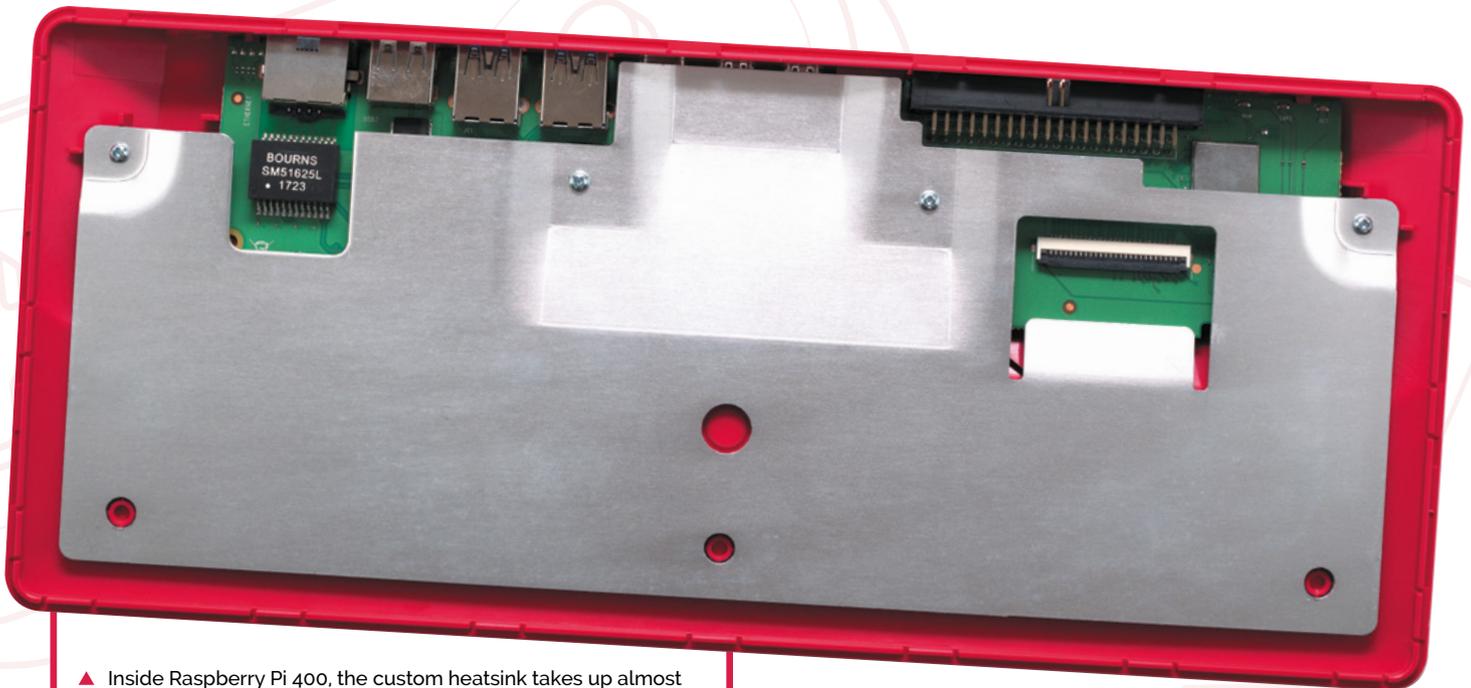
More than a keyboard, **Raspberry Pi 400** packs all the power of Raspberry Pi



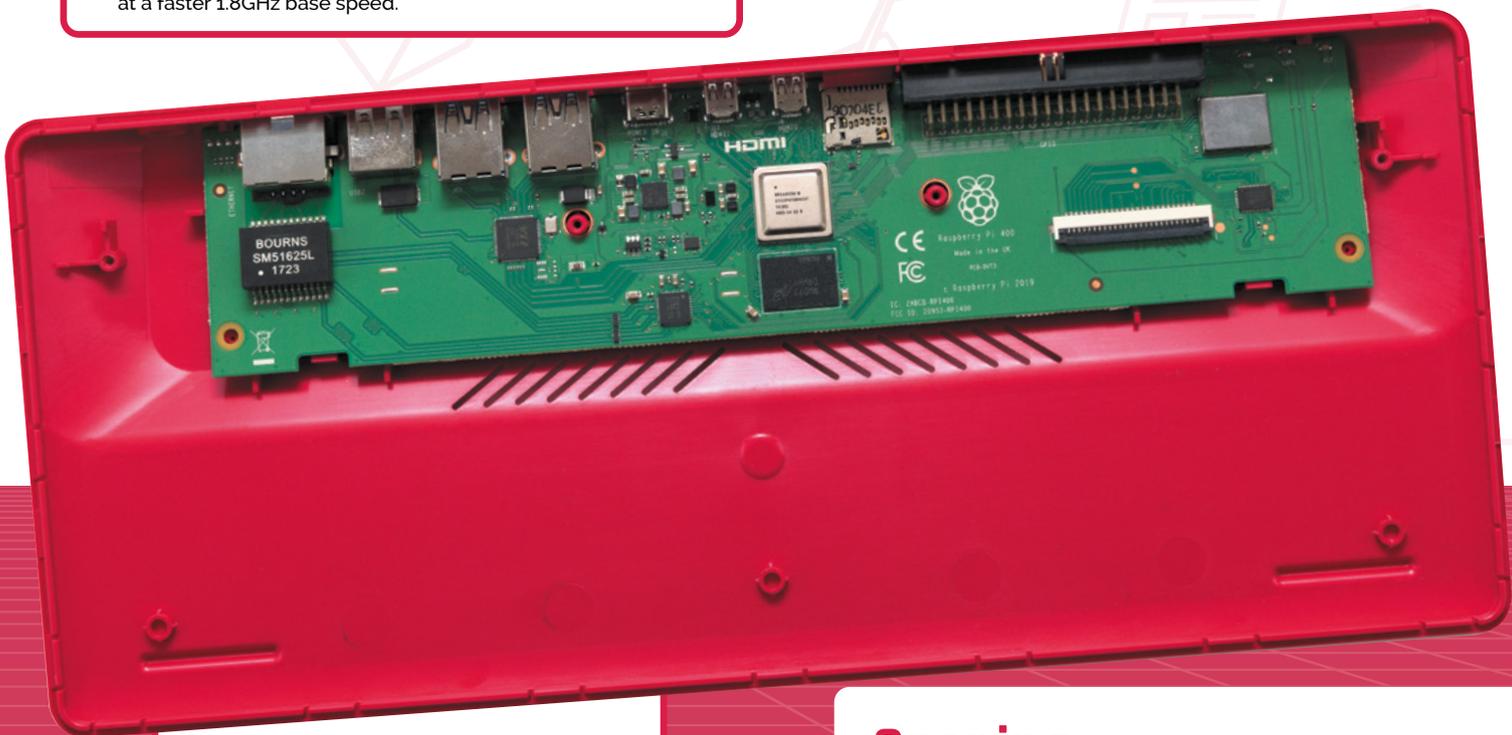
◀ Built entirely into the keyboard, Raspberry Pi 400 keeps clutter to a minimum while simplifying setup – and if you buy the bundled version, it even comes with a Raspberry Pi OS microSD card pre-installed to get you up and running as quickly as possible.



▲ The underside of the case, which clips in place using no screws, includes two ventilated sections to let the built-in heatsink cooling system breathe. A QR Code with the serial number is included in case you ever need to contact support.



▲ Inside Raspberry Pi 400, the custom heatsink takes up almost the entire casing. Connected to the system-on-chip with a thermal pad, the heatsink works silently to keep Raspberry Pi 400 from thermally throttling. This enables the processor to run at a faster 1.8GHz base speed.



▲ Under the heatsink, the printed circuit board uses a very different layout to previous Raspberry Pi models. Long and thin, the board has Ethernet hardware at its left, the USB and HDMI ports, the silver system-on-chip in the middle, the GPIO and keyboard connectors, and ends at the right with the wireless LAN and Bluetooth radio.

## Opening Raspberry Pi 400

**Open your Raspberry Pi 400 carefully!** There are no screws, and it just clips in place all around the four sides of the body. Put a spudger (or plectrum) between the two halves and slide until you feel a clip, then push to release; keep doing it until all clips have been freed and the two halves are apart. Remove the four screws to detach the heatsink.

# Eben Upton and Simon Martin on Raspberry Pi 400

Raspberry Pi Foundation founder **Eben Upton** and principal hardware engineer **Simon Martin** wax lyrical about the new product

“It’s the most exciting product,” Raspberry Pi Foundation founder Eben Upton enthuses of Raspberry Pi 400’s birth. “Every now and then we do a product which brings together everything that we’ve learned, about technology and about business. Raspberry Pi 400 is another one of those summary products.

“I think it’s important to make beautiful things, and it’s just beautiful. It’s designed to be an object of desire. It just looks great.

“It’s faster than Raspberry Pi 4, and it’s thermally a lot better because it’s got more space and there’s some clever passive thermal design. So, although it runs 20% faster, it runs a lot cooler. That’s cool, but really, for me, it’s just the feel of it in your hand, the weight. It just feels like a consumer product, and it’s the first time we’ve ever made anything that’s like that.”



▲ Eben Upton, creator of Raspberry Pi and founder of Raspberry Pi Foundation

## Project Gamma

“I was hired at Raspberry Pi to do just such a product, back in summer 2017,” Raspberry Pi 400 designer Simon Martin explains. “At the time, Raspberry Pi 3 was the thing and I set about making a ‘Raspberry Pi 3 in a keyboard’ product.

“I think it’s important to make beautiful things, and it’s just beautiful”

“The project was called the Commodore 64 Project, and I thought, ‘Well, it’s a bit risky calling something the Commodore 64 Project, because everybody knows what we’re doing!’ So I took the letter C, in C64, and replaced it with Project Gamma, as in alpha, beta, gamma.

## What’s in a name?

“Somebody asked me, ‘Is it named after the Atari 400?’ I mean,” Eben explains, “it’s a nod to the ‘three-digit number that ends in zero’ as a pretty common naming convention with Atari, both 8-bit and 16-bit with the 520, Amiga with various hundreds, Acorn with the Archimedes 305s, 310s, 440s, yeah. It was a pretty common naming convention.

“It is obviously appealing that if, in the far future, we do a Raspberry Pi 5, then a Raspberry Pi 5 version will be called Raspberry Pi 500, which as an Amiga person is quite nice.

“It gives you a natural extension of the name scheme: we can still do plus models, we can still do major revisions, and it preserves the ‘if you don’t know anything about Raspberry Pi, get the largest number you can see’ rule.”



"It was clear it was going to be ready in production after Raspberry Pi 4 was announced, so we decided to move to Raspberry Pi 4. It was February last year I started work on making this Raspberry Pi 4-based Raspberry Pi 400 product."

### Keeping cool

"I spent about six months working on the thermal side of it," Simon continues. "That was the key to getting this thing to be a successful product: to make something that didn't need any external cooling, it was going to deal with it itself. So, I spent a lot of time doing a thermal solution for it, and we came up with this metalwork inside it."

"If you see inside one, there's a metal plate that runs across the entire board and keeps everything cool. I involved some consultants in thermal design, and they said that if the power consumption was, say, under 10 watts, then a passive cooling solution would be possible."

"Sure enough, there were some improvements to power draw that went on with Raspberry Pi 4 before it was announced, getting it down to the sort of 6 to 7 watt level. All of those improvements have kept the power budget to a useful level such that we can overclock Raspberry Pi 400 to 1.8GHz."



▲ Simon Martin, Senior Principal Hardware Engineer at Raspberry Pi and designer of Raspberry Pi 400

## Pi Drop

"We've been doing bits of outreach to help kids who've been sent home from school with no computer," says Eben. "It's a programme called Pi Drop, that the Raspberry Pi Foundation is running."

"Ease of setup is very important to that customer base. It sounds trivial, but getting rid of Raspberry Pi, its case, and the cable between Raspberry Pi and the keyboard, it takes three things off the table."

"There's also much less misconfiguration possibility with Raspberry Pi 400 than there is with Raspberry Pi 4. So we'll be rolling over all of our charitable work from Raspberry Pi 4 to Raspberry Pi 400."

# Benchmarking Raspberry Pi 400

A full-chip redesign, the first in the history of Raspberry Pi, has unlocked new levels of performance

**R**aspberry Pi 400 isn't just an entirely new form factor and Raspberry Pi's first integrated design: it's also the fastest Raspberry Pi model ever released. A large metal heatsink, running almost the entire width of the casing, coupled with a roomier printed circuit board means Raspberry Pi 400's system-on-chip ships clocked at 1.8GHz (one billion eight hundred million cycles per second) – up from Raspberry Pi 4's 1.5GHz.

The additional speed can be felt in everything from web browsing and image editing to running Python programs, and it doesn't come at the cost of compatibility: Raspberry Pi 400 is fully compatible with all software and operating

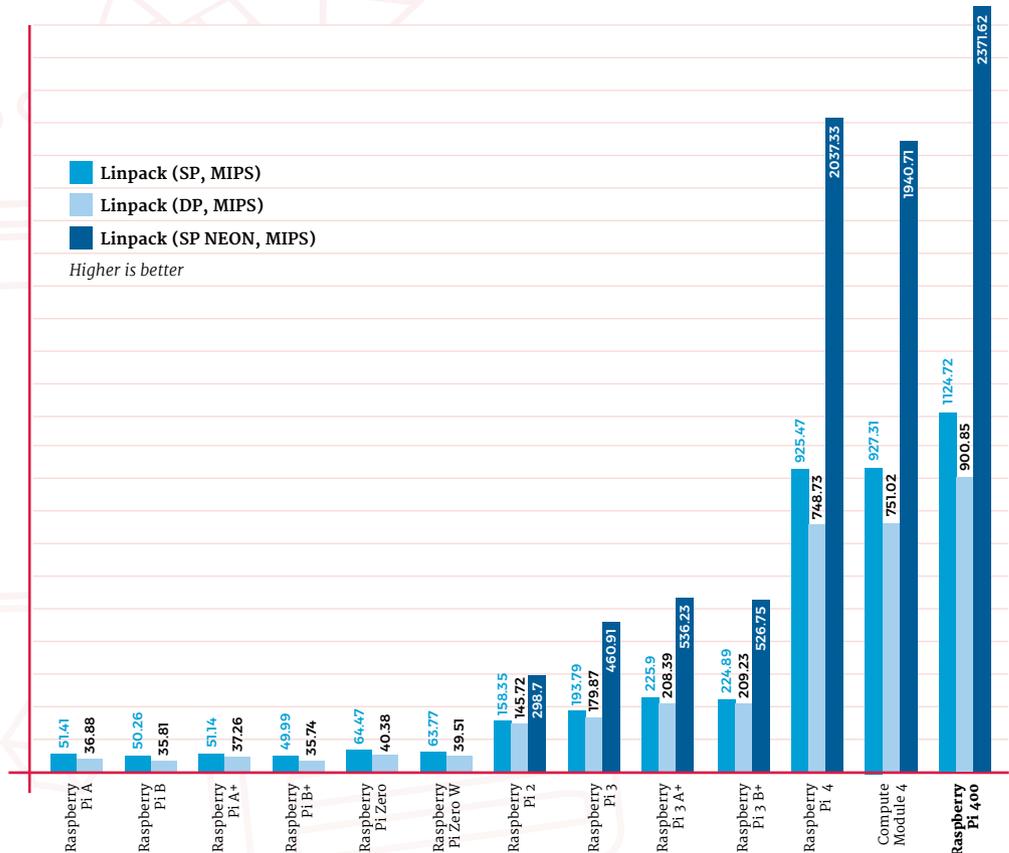
systems which work on Raspberry Pi 4, and older models too.

It can also use less power: while the extra 300MHz means Raspberry Pi 400 draws more electricity than Raspberry Pi 4 under load, it finishes more quickly – and not needing to run an external USB keyboard means it uses less power at idle, too.

For the majority of use-cases, Raspberry Pi 400 is now the machine to beat – but those working on embedded projects will find the more compact Raspberry Pi 4, with its Display Serial Interface (DSI) and Camera Serial Interface (CSI) ports and Power over Ethernet (PoE) capabilities, is still the go-to model.

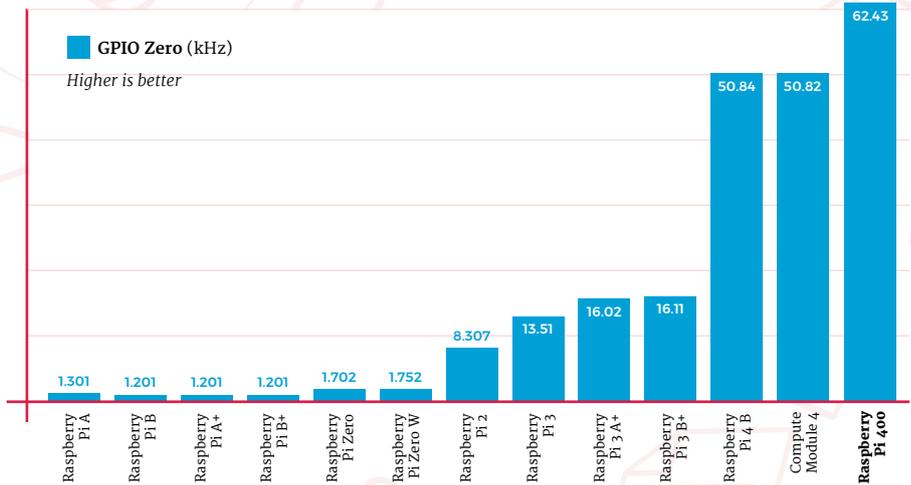
## Linpack

Originally developed for supercomputers, this synthetic benchmark – ported to Raspberry Pi OS by Roy Longbottom – offers a look at best-case performance gains between models. Three versions of the benchmark are compared: Single Precision (SP), Double Precision (DP), and a Single Precision variant which uses the accelerated Arm NEON instructions available since Raspberry Pi 2.



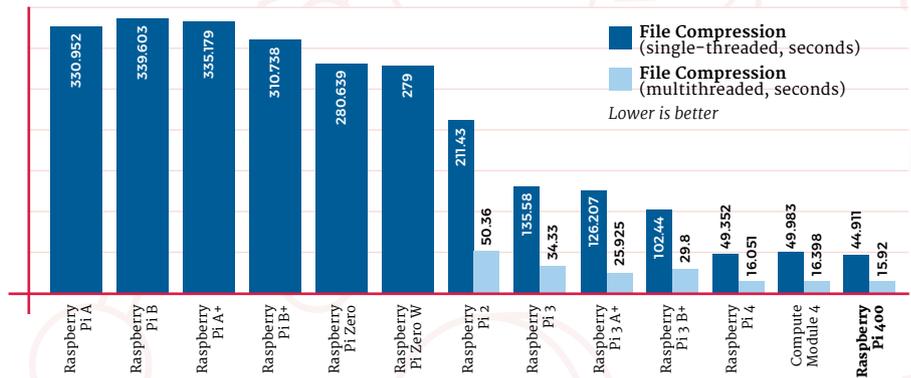
## Python GPIO Zero

This benchmark demonstrates how each model reacts to Python programs in a worst-case scenario: a simple program which does nothing more than toggle a GPIO pin on and off using the GPIO Zero library. The faster the toggle, the faster your Python code can run – or the less time it'll spend waiting on the CPU.



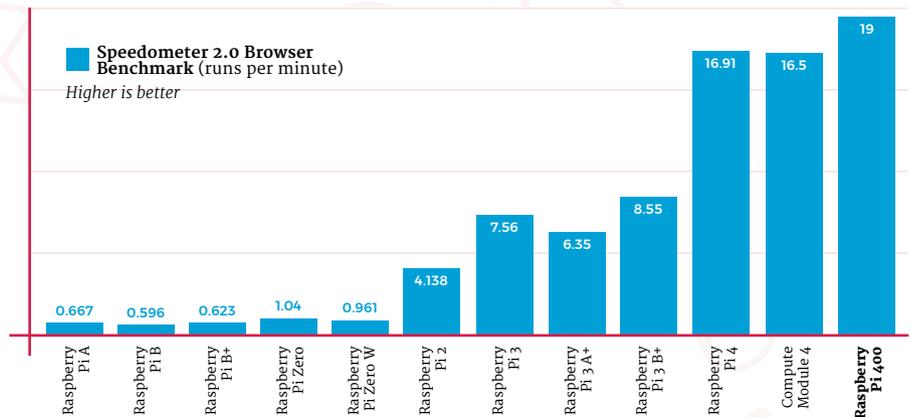
## File Compression

This real-world benchmark takes a 100MB test file and compresses it using the bzip2 algorithm, first using a single processor core and then using all four processor cores in a process known as multithreading. Compression is also affected by storage performance; here, the file is compressed purely in memory for a level playing field.



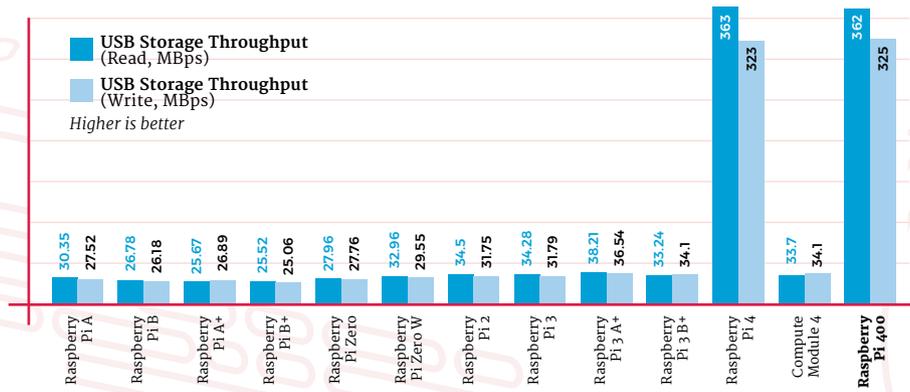
## Speedometer 2.0

Many Raspberry Pi computers are used as desktop workstations, and Raspberry Pi 400 excels in the role. This benchmark tests how well a browser-based application – a simple to-do list – runs on each model, with higher run rates representing a more responsive web app.



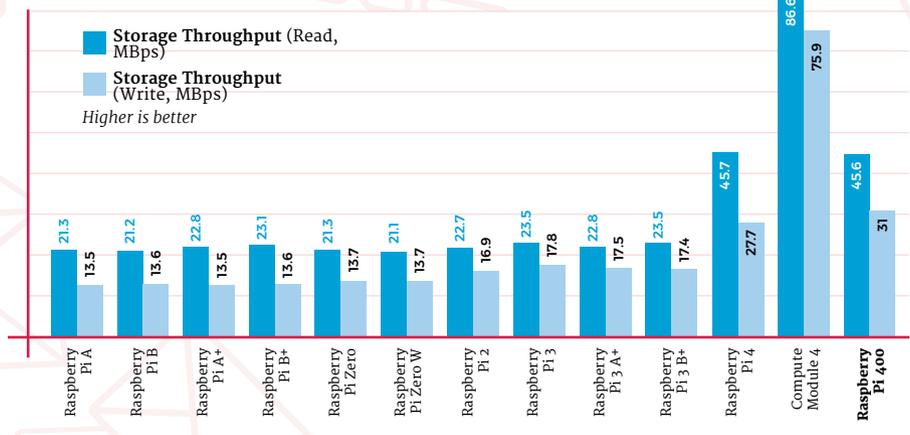
## USB Storage Throughput

Although Raspberry Pi 400 doesn't need a keyboard, that doesn't mean you can't connect peripherals. The two blue-coloured USB 3.0 ports at the back accept the same range of accessories as Raspberry Pi 4, and here are tested to the limit by transferring data to and from a high-performance USB solid-state drive (SSD).



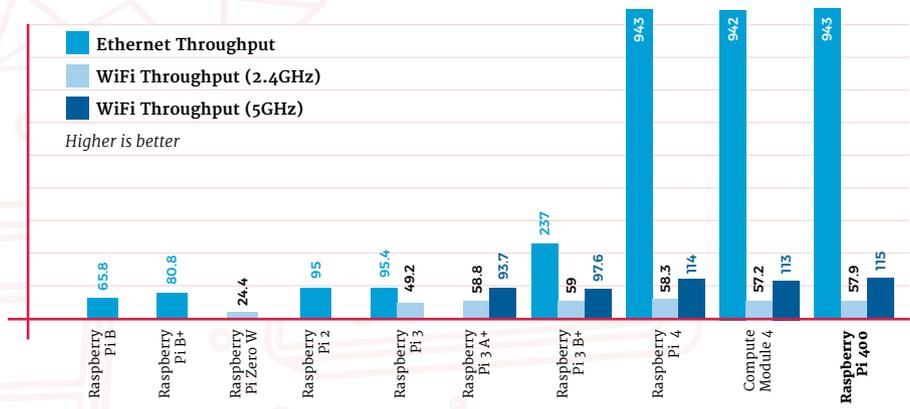
## Storage Throughput

Raspberry Pi 400 benefits from the same switch to Double Data Rate (DDR) operation on its microSD slot as Raspberry Pi 4, boosting how quickly it can load data from and save data to the microSD card as proven by this benchmark – though the eMMC storage on the recently launched Raspberry Pi Compute Module 4 takes the performance crown.



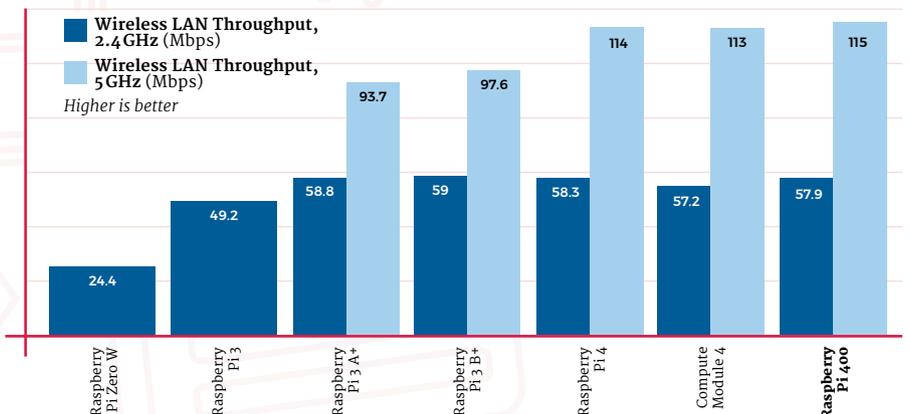
## Ethernet Throughput

For top performance, a wired Ethernet connection always beats wireless. Here data is transferred from a central server to each Raspberry Pi model on test and the speed measured in megabits per second – aiming at the theoretical maximum, never truly reachable, of 1000Mb/s.



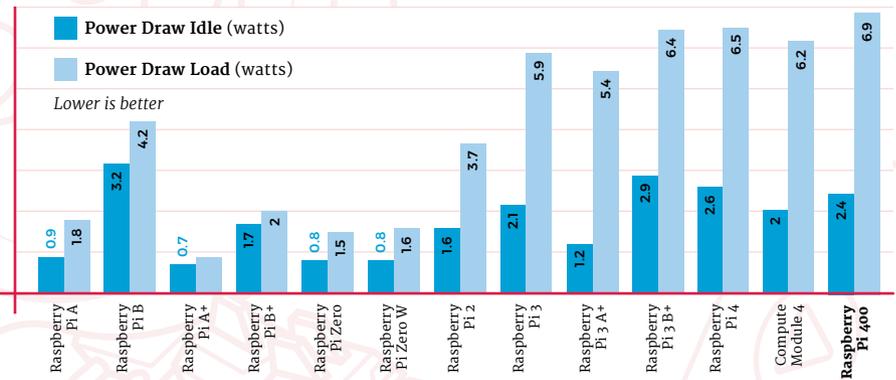
## Wireless LAN Throughput

Wired Ethernet is fast, but wireless is more convenient. Despite the enclosed casing and large metal heatsink, this benchmark – which places each Raspberry Pi on a 2.4GHz and a 5GHz wireless LAN network in turn – proves that Raspberry Pi 400 can keep up with its younger sibling.



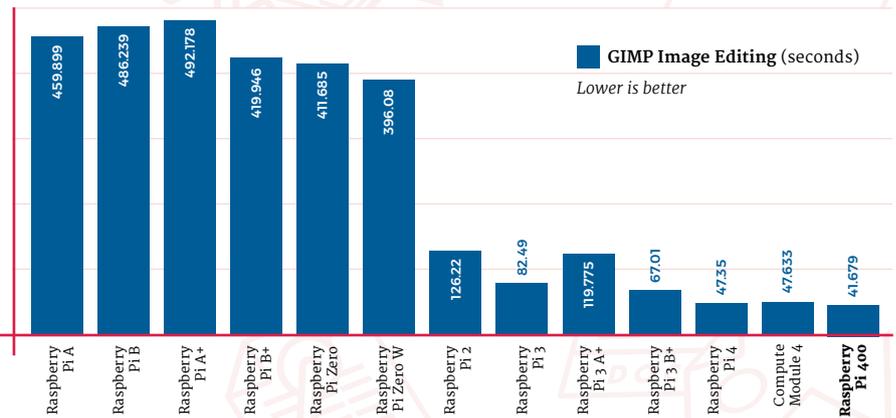
## Power Draw

The less power a computer draws, the better it is for the environment, your electricity bills, and the temperature in your room. Here each Raspberry Pi on test has its power draw measured at idle, sat at Raspberry Pi OS desktop, and under heavy sustained load for a worst-case loaded figure.



## GIMP Image Editing

Image editing is another common real-world use-case for a desktop computer, and in this test each model is given a 4K-resolution image to edit in the popular open-source GIMP image editor. As with the compression benchmark, the file is stored in memory to level the playing field.

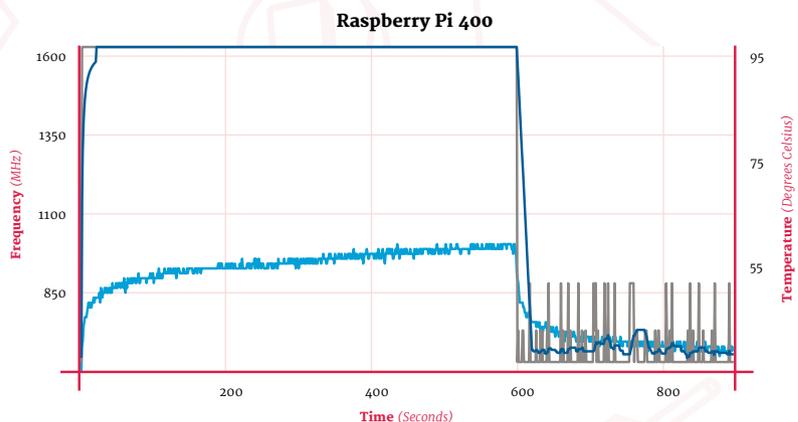
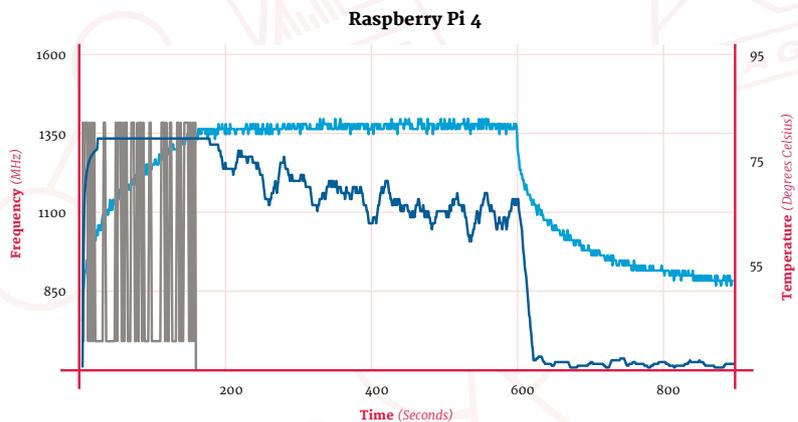


## Thermal Throttling

All computers include a ‘thermal throttle’ which protects the processor from getting too hot by reducing its speed. Here, Raspberry Pi 4 and Raspberry Pi 400 go head-to-head running a torturous worst-case-scenario synthetic benchmark designed to heat the processor as much as possible – and Simon Martin’s heatsink proves its worth.

- CPU Temperature
- CPU Clock
- CPU Clock (Moving Average)

“ Simon Martin’s heatsink proves its worth ”



# Argon ONE M.2

## SPECS

**DRIVE TYPE:**  
M.2 SATA SSD  
with Key-B or  
Key-B&M

**DISPLAY  
PORTS:**  
Dual full-size  
HDMI

**FEATURES:**  
UASP support,  
power  
management,  
active and  
passive cooling

► Argon 40 ► [magpi.cc/argononem2](http://magpi.cc/argononem2) ► £43 / \$45

Add a super-fast M.2 SATA SSD to Raspberry Pi 4 along with dual full-sized HDMI sockets, a power button, and fan cooling. By **Lucy Hattersley**

**T**he Argon ONE M.2 case for Raspberry Pi 4 has been on the radar for many Raspberry Pi power users. We're glad to report that your anticipation has not gone unrewarded.

The marquee addition here is support for an M.2 SATA SSD drive (the blade drives commonly found in laptops). This sits snugly in a bottom compartment and is connected to Raspberry Pi using the USB 3.0 connection (via a U-shaped adapter). It features UASP (USB Attached SCSI Protocol) support to increase performance.

In the spirit of things, we tested it with a Raspberry Pi 4 8GB RAM and Raspberry Pi OS (64-bit) still in beta testing ([magpi.cc/64bitbeta](http://magpi.cc/64bitbeta)).

An internal board repositions the ports to the rear, and converts the micro-HDMI ports of Raspberry Pi 4 to two full-sized HDMI sockets. GPIO remains accessible via a removable flap with a pin guide printed to the side.

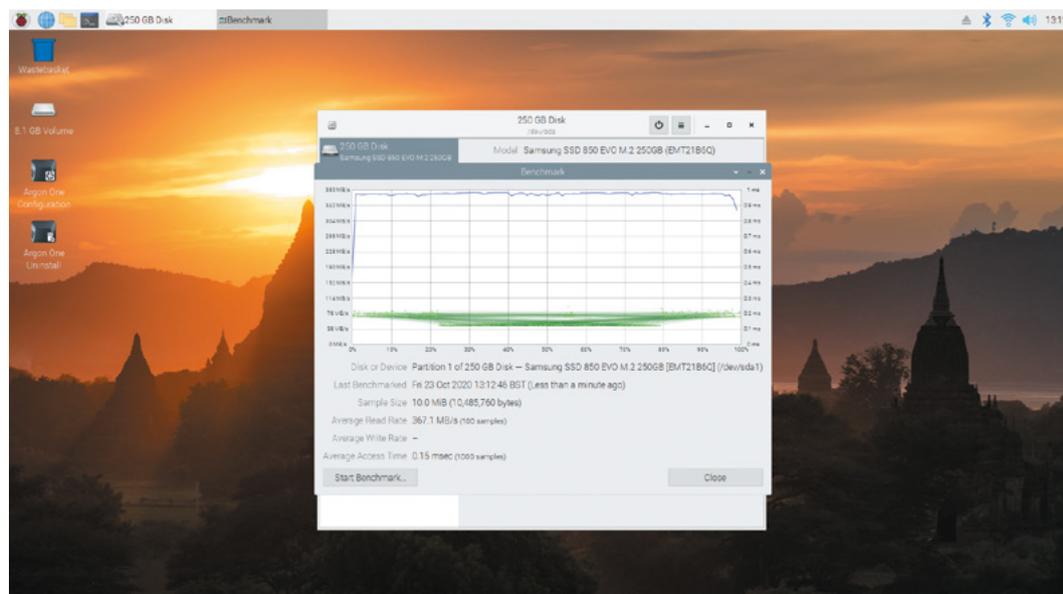
The aluminium alloy lid acts as a heatsink and a 30 mm fan provides active cooling. The fan is controlled via a script provided by Argon 40. Default settings start at 10% power when the CPU temperature is at 55°C, increasing to 55% at 60°C, and 100% at 65°C.

## Putting it together

Your M.2 SATA SSD clips into the lower part of the case and is held in place with a single screw. The two halves are then screwed together and a U-shaped USB adapter is used to bridge the lower part of the case the port on the upper part.

It's an ingenious solution, but you lose a USB 3.0 socket in the final build. More importantly, the microSD card socket is sealed inside the case, requiring disassembly to access it.

Raspberry Pi EEPROM recently provided USB boot support in the default 'critical' firmware,



► Gnome Disk Utility benchmarking the rootfs partition of our SSD



and a recent update (still currently in beta but due soon) improves USB boot performance.

Once booted into Raspberry Pi OS, we installed Imager and used that to flash a clean install of Raspberry Pi OS (64-bit) onto the SSD. Remove the USB thumb drive and Raspberry Pi boots straight from the SSD.

### Benchmarking the Argon M.2

We used a Samsung 850 EVO SSD supplied by our friends at Custom PC magazine ([magpi.cc/custompc](http://magpi.cc/custompc)) and installed Gnome Disks for its benchmarking test.

The M.2 did not disappoint, with an average read rate of 367.1MB/s compared to 45MB/s for our microSD card. That's an 800% speed increase.

**“** You get unrestrained performance with an overclocked Raspberry Pi 4 coupled with an ultra-fast SSD storage solution **”**

Overjoyed with our SSD throughput rate, we set about testing CPU speed and thermal performance (the two are related as Raspberry Pi OS throttles performance if the CPU temperature exceeds 80°C).

We performed a similar test to the one Gareth Halfacree uses when thermal-testing Raspberry Pi boards ([magpi.cc/thermaltesting](http://magpi.cc/thermaltesting)). We ran stressing and glxgears for ten minutes while monitoring CPU speed and temperature recordings, followed by a five-minute cool-down period.

Raspberry Pi remained cool under stress, maxing out at 53°C – not even high enough for the fan to kick in, with the passive case doing all the cooling. We took our Raspberry Pi clock speed up to 1800MHz ([magpi.cc/overclock](http://magpi.cc/overclock)) and, after leaving Raspberry Pi to recover, ran the test again. This time the board got a little more stressed, maxing out at 73°C – enough for the Argon fan to kick in at 100% speed, but below the critical 80°C point where Raspberry Pi OS begins to throttle back the CPU speed.

So at all times you get unrestrained performance with an overclocked Raspberry Pi 4 coupled with an ultra-fast SSD storage solution. If that's not nifty, we don't know what is.

We did also install Ubuntu, but we could not install the scripts for the fan in this case (as it depends on GPIO Zero, [magpi.cc/gpiozero](http://magpi.cc/gpiozero)), so the fan was on permanently. Raspberry Pi OS remains our preferred operating system at any rate.

We spent a delightful couple of days knocking together the scripts for testing in Visual Studio Code and creating graphs of the results in LibreOffice, all while doing browser research and writing up the results. Our Argon ONE M.2 build remained a joy to use throughout. **M**

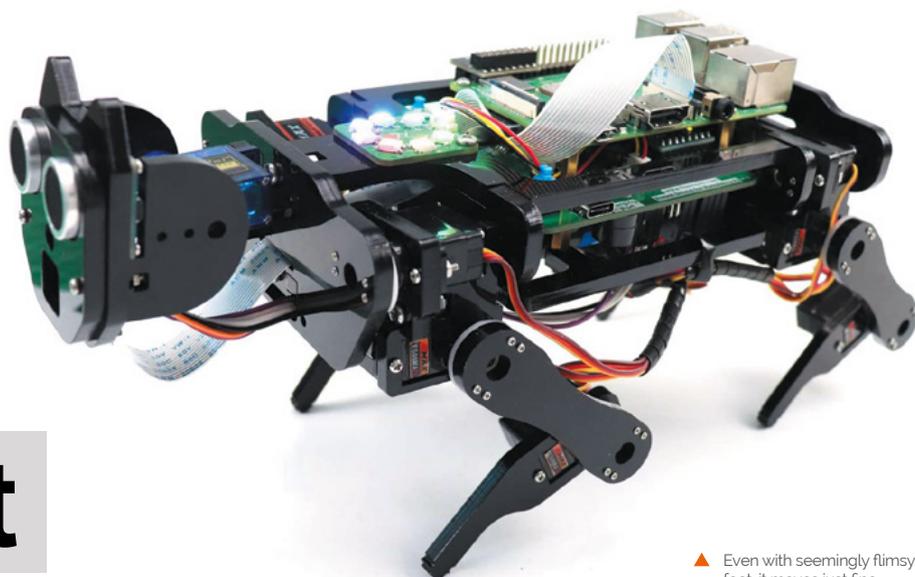
▲ The two halves of the case connect together with a U-shaped USB 3.0 connector bridging the M.2 SSD SATA drive to Raspberry Pi 4

## Verdict

If you want to take Raspberry Pi 4 performance as far as it can go, this is the way to do it.

# 10/10

# Robot Dog Kit



▲ Even with seemingly flimsy feet, it moves just fine

## SPECS

### SERVOs:

12 × ES08MA,  
1 × SG90

### SENSORS:

Ultrasonic distance,  
camera,  
accelerometer,  
gyroscope

### CHASSIS:

Acrylic parts

► Freenove ► [freenove.com](http://freenove.com) ► £120 / \$130

This Raspberry Pi-powered robot kit can do it all, and walk on all four legs. **Rob Zwetsloot** looks to see if it's more than just a gimmick

**U**sually, robot kits that move on limbs come as bipedal, movie-style robots, or six-to-eight-legged spider-bots that are a little too close to their arachnid inspirations.

The Robot Dog Kit from Freenove bucks this trend by walking on four legs, much like the (in)famous Boston Robotics machines.

It's a kit in the truest sense of the word. Coming as several sheets of acrylic and a load of separate sensors and motors, you'll need to build it nearly entirely from scratch. It's not a quick build either, and we spent a few hours putting it together just right as we followed the downloadable PDF manual.

A robot dog kit might just stop at being able to walk forward. With a ton of cleverly placed servos,



▲ The mobile app lets you see what the dog is seeing, as well as fully control its motion

however, it has a huge range of movement. Beyond how it moves, it comes with a suite of sensor types, example code, and smartphone/desktop control apps so that you can learn plenty about robotics.

“ It can be modified to do many things even some of the more established Raspberry Pi robot kits cannot ”

### Smart dog

Once built, the dog has multiple functions: walking, self-balancing, ball tracing, face detection, live video, and ultrasonic ranging. Freenove's GitHub page has a range of code and applications for you to explore ([magpi.cc/robotdoggit](http://magpi.cc/robotdoggit)). You'll also find datasheets and calibration graphs on GitHub.

You'll have to supply a Raspberry Pi and specific (button-top 3.7V 18650) rechargeable batteries – which can be tricky to find in the UK – but this does mean that all the code is very hackable. With computer vision, ultrasonic sensors, gyros, and so on, this Robot Dog can be modified to do many things even some of the more established Raspberry Pi robot kits cannot...

Although we do feel like it looks more like a cat. ■

## Verdict

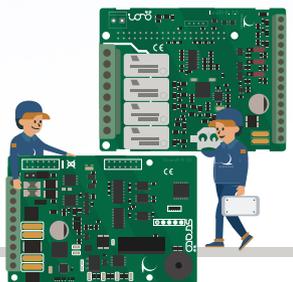
A really great robot kit once you get through the building process, although you will need to supply some extras.

8/10

# Raspberry Pi goes industrial



Long term availability, high reliability and support



## Tailor-made embedded solutions

Our range of Raspberry Pi-based devices is wide. Really wide.  
But what if your project needs something more?  
We can put all of our expertise into your custom OEM design.  
Don't hesitate to contact us to explore every possibility!



Visit our website [www.sferalabs.cc](http://www.sferalabs.cc)



# 10 Amazing:

## Festive projects

Get into the holiday spirit with these incredible Raspberry Pi projects



**Alert!**  
High voltage

Be careful when working with mains electricity.

[magpi.cc/electricalsafety](http://magpi.cc/electricalsafety)

**L**ast issue we showed you how to decorate your home for Christmas. As the season draws near, however, you may be interested in what else you can do to celebrate. Raspberry Pi is used all around the world, so we sought out some alternative holiday projects as well. We hope you're able to have a good time. [M](#)



### ▲ Perpetual Yule Log

#### Eight nights of lights

Burning a yule log is an ancient tradition related to the winter solstice. Not everyone has a fireplace these days, though, so creating a virtual one that both looks nice and won't fill your home with smoke is a great alternative.

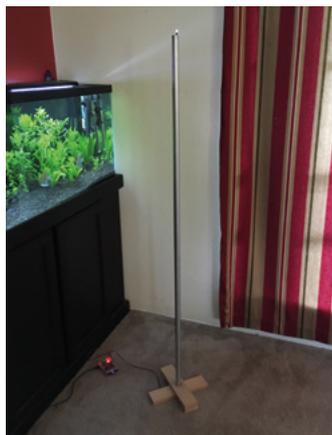
[magpi.cc/yulelog](http://magpi.cc/yulelog)

### ▲ Our Giant Raspberry Pi Menorah

#### Eight nights of lights

Ben Forta could have just had a series of lights that looks like a menorah, but he went one step further and made the flames flicker. He even added an animation whereby the centre candle 'lit' all the other candles as the days went on. Clever!

[magpi.cc/menorah](http://magpi.cc/menorah)



### ◀ IoT Festivus Pole

#### For the rest-of-us

Invented for the sitcom *Seinfeld*, Festivus on 23 December includes a meal, the airing of grievances, feats of strength, and labelling any innocuous happening a Festivus miracle. A Raspberry Pi is connected to the pole and illuminates an LED when someone mentions Festivus on Twitter, causing everyone in the room to yell, "It's a Festivus miracle!"

[magpi.cc/festivus](http://magpi.cc/festivus)

### ► Secret Santa Babbage

#### Covert present organiser

Upgrade your office secret Santa (when people can be in the office again) by having a cute mascot Babbage Bear decide who is gifting whom through the use of technology. A printout is created so that you won't forget names.

[magpi.cc/santababbage](http://magpi.cc/santababbage)





## ▲ Smart gingerbread house

### Electronic sweets

A motorised house you just want to eat... mainly because (most of) it is edible. Stefannie built this with lots of tech running through it, so doors open, lights shine, and marshmallows mysteriously disappear when no one is looking.

[magpi.cc/gingerbread](http://magpi.cc/gingerbread)



## ◀ 2018 Christmas Light Show

### Deck your house

A huge 4000 lights and tree are synced to music outside of this very brightly lit house. It's all controlled by lightshowpi to make the music syncing easy, but be careful if you choose to replicate this – it will require access to a lot of dangerous high voltage wiring.

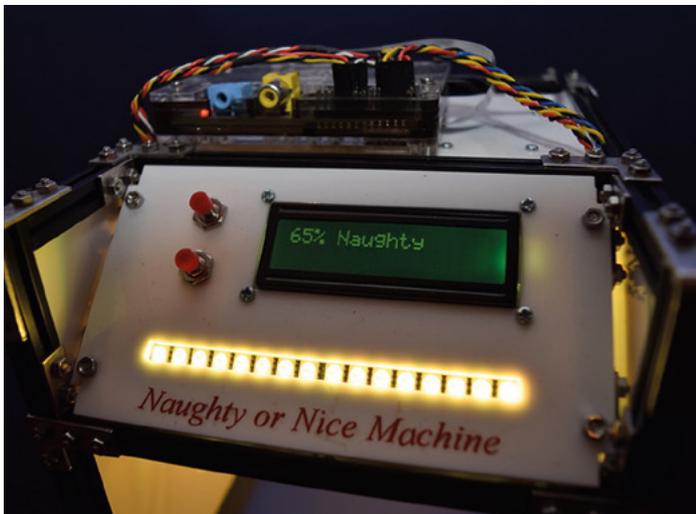
[magpi.cc/2018lightshow](http://magpi.cc/2018lightshow)

## ▼ Naughty or Nice Machine

### Morality checker

This machine will check to see if you're getting presents or coal for Christmas by assessing your hand. According to Brian Corteil, it basically checks how big your hand is, but we believe it's linked to a database at the North Pole.

[magpi.cc/naughtynice](http://magpi.cc/naughtynice)



## ▲ Christmas tree

### Virtually real

Minecraft Pi can interact with Python. Python on Raspberry Pi can control real things. So this digital Christmas tree created in Minecraft can be used to control a corresponding real Christmas tree. Truly a Festivus miracle of tech.

[magpi.cc/minecrafttree](http://magpi.cc/minecrafttree)



## ◀ Ornament

### TV on a tree

Christmas adverts are an interesting beast, with certain ones invoking nostalgia in the right people. It's almost a part of Christmas itself! So why not have them playing throughout the season on your Christmas tree?

[magpi.cc/xmasornament](http://magpi.cc/xmasornament)

## ► LED Christmas Tree

### Smart tree

Smart/IoT Christmas tree lights are great and we've done several tutorials that show you how to make your own – this one goes a bit further and has a video projector that can display your festive faves over your presents.

[magpi.cc/ledxmastree](http://magpi.cc/ledxmastree)



## More Christmas ideas!

Looking for more Christmas inspiration? Check out our feature Holiday Projects for a Festive Home in *The MagPi* #99 ([magpi.cc/99](http://magpi.cc/99)).



# Learn Raspberry Pi OS

Raspberry Pi OS is the official operating system and the brains of Raspberry Pi. It pays to learn to use it. By **Lucy Hattersley**

## Raspberry Pi Help

CREATOR

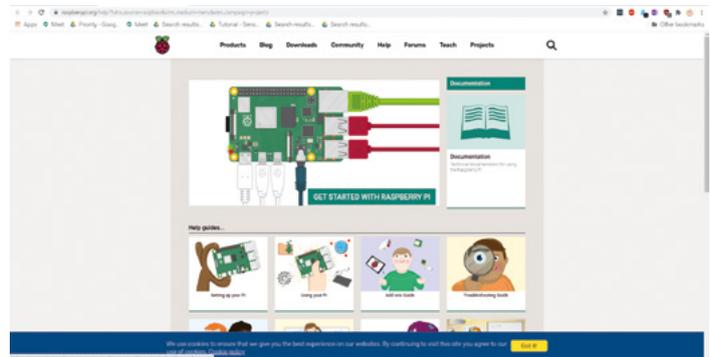
### Raspberry Pi

Price:  
Free  
[raspberrypi.org/help](http://raspberrypi.org/help)

For many people, Raspberry Pi OS is their first taste of a Linux operating system. Don't fret! It's built on top of Debian, and many aspects of it are similar in design and function to Windows and macOS. But Linux is much more fun when learning how computers work.

Your first port of call should be to visit Raspberry Pi's Help section. Click on the Raspberry Pi menu icon at the top left of the screen and choose Help > Get Started. This online course will walk you through the basics of installing software, keeping Raspberry Pi up to date, using the terminal, and configuring Raspberry Pi OS.

After you've finished the course, click on the menu icon, then choose Help > Help. This webpage has more comprehensive information, including Documentation and Troubleshooting. **M**



## Bookmark these

Make sure you keep these websites to hand

### DEBIAN REFERENCE CARD

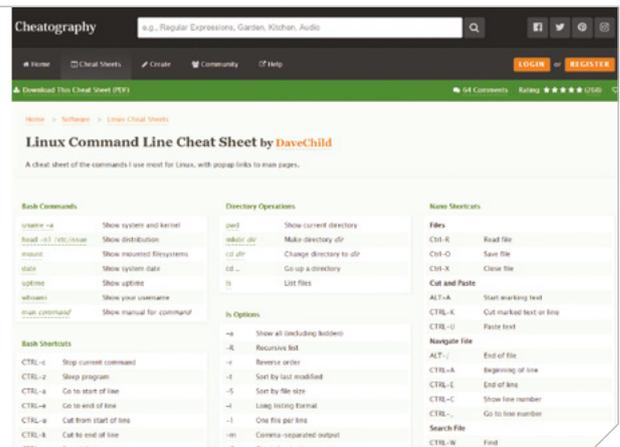
Raspberry Pi OS is a flavour of Debian Linux, so it makes sense to keep the reference card to hand. [magpi.cc/debref](http://magpi.cc/debref)

### LINUX CHEAT SHEET

There are hundreds of cheat sheets for Linux, but this one is our favourite. [magpi.cc/linuxcheatsheet](http://magpi.cc/linuxcheatsheet)

### RASPBERRY PI OS DOCUMENTATION

The official Raspberry Pi OS documentation pages have information on installing, upgrading, and working with Raspberry Pi OS-specific services. It also includes info about terminal applications such as OMXPlayer and raspistill. [magpi.cc/raspberrypi](http://magpi.cc/raspberrypi)



# Understanding Computer Systems

CREATOR

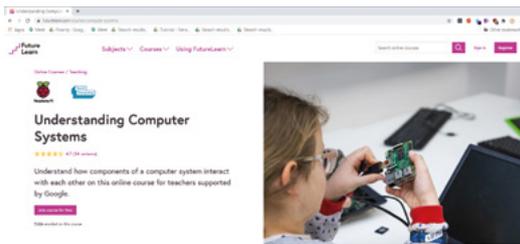
## Raspberry Pi Foundation

Price: Free

[magpi.cc/computersystems](http://magpi.cc/computersystems)

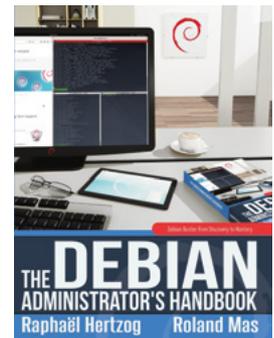
If you want something more in-depth than the **Raspberry Pi Help section**, **FutureLearn has you covered**. Understanding Computer Systems is developed by Raspberry Pi and supported by

Google. This course explains in detail what goes on when you turn on a computer. It covers booting up, hardware and software systems, input and output, and the history and function of operating systems. It's even accredited by CPD Certified so you can prove you've learned the information. There's a follow-up course that covers computer architecture, binary logic, and data processing if you want to get under the hood of computer science. [M](#)



## Further reading on Debian

Read these books to get an understanding of Debian



### THE DEBIAN ADMINISTRATOR'S HANDBOOK

The official source on all things Debian. This book is available as a free download, or you can purchase a print edition copy. [debian-handbook.info](http://debian-handbook.info)

### THE LINUX BIBLE

When we say complete, we mean it. This is the most comprehensive Linux resource around. [magpi.cc/linuxbible](http://magpi.cc/linuxbible)

### LINUX POCKET GUIDE

This comprehensive guide provides critical information in as compact a form as possible. With information sorted by function, it's handy to keep around. [magpi.cc/linuxpocketguide](http://magpi.cc/linuxpocketguide)

# The Official Raspberry Pi Beginner's Guide 4th Edition

CREATOR

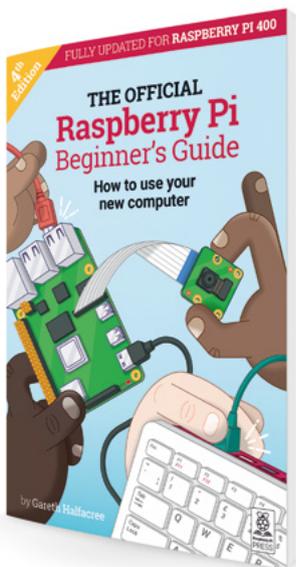
## Gareth Halfacree

Price: £10

[magpi.cc/beginnersguide4](http://magpi.cc/beginnersguide4)

*The Official Raspberry Pi Beginners Guide book has always been a fantastic book.* This official guide has 252 pages of information about Raspberry Pi computing, and the 4th Edition is fully updated for the brand new Raspberry Pi 400. It takes you through

the installation of Raspberry Pi OS, and working with the graphical interface and command-line environment. Plus, this book also features all of those aspects that make Raspberry Pi special: projects, electronic components, using Raspberry Pi GPIO pins, and much more. [M](#)





# Amit Rana

An engineer turned trainer and teacher, Amit transitioned from helping college students to students of all ages

- > Name **Amit Rana** | > Occupation **Trainer and consultant**
- > Community role **Educator** | > url **kitflix.com**

## Amit Rana didn't have the usual path into teaching.

Graduating in 2008 with a master's in Electronic Engineering, he had to wait a year for his job to start. During that time, he started working as a lecturer for an engineering college.

"This developed my interest in the teaching industry," he tells us. "After quitting my job quite early in my career, the first thing I did was to

start a training centre." In the beginning, he was mostly teaching engineering students, training them with practical hands on with microcontrollers and Raspberry Pi.

"Slowly we started conducting training for school students, teaching them how to build robots, how to make apps using App Inventor, Python programming, and Arduino," Amit says. "For a couple of years we also ran a Code Club, which was an activity where we used to visit schools and teach Python and HTML."

## What kind of things do you teach?

I mostly teach Internet of Things, embedded systems and PCB design. I use Raspberry Pi, Azure IoT Hub, AWS IoT Core, AVR / ARM7 microcontrollers, PIC microcontrollers, and EAGLE and KiCad for PCB design.

## How did you find out about Raspberry Pi?

When Raspberry Pi was to be launched, I was getting newsletters from element14 and had read a few posts on social media, so I ordered it first thing when it was launched in India. I still have my first 256MB board with big SD card slot, and it's working just fine.

## What is Kitflix?

Kitflix is an e-learning website which hosts online courses on electronics, embedded systems, IoT, and programming, using recorded self-paced and live online sessions.

## How has Kitflix been received?

As said, I also had a training institute (Vidya Robotics) which is closed now. Kitflix is a brand

▼ Originally, Amit trained older students, but he's since trained schoolchildren





- ◀ Amit's training courses cover IoT with Raspberry Pi and microcontrollers
- ▼ A robot built in a training course – it uses a mix of technology!



we chose for our online course platform which sounds a little catchy. So far, we're doing good: we have more than 17,200 students across 150 countries for our online courses through Kitflix and other partner sites, like Skillshare and Udemy. And we have about 1000 visitors each day to our website.

#### **Any student success stories you can share?**

There are many. Some of them are listed on our home page ([kitflix.com](http://kitflix.com)). Many of my students are now working in a variety of industries across the globe. Many went on for higher education in countries abroad; many are working for elite institutes, like IIT, in India.

“ We have about 1000 visitors each day to our website ”

#### **Anything else you'd like to add?**

I am a person passionate towards spreading the education in electronics, embedded systems, and IoT, which is a field often considered [to be] under the umbrella of IT skills, but still it's excessively big and all-encompassing. My vision is to create a kind of 'Khan Academy' for electronics and programming education. **M**



- ▲ Amit also used to run a Code Club

# This Month in Raspberry Pi

## MagPi Monday

Amazing projects direct from our Twitter!

**E**very Monday we ask the question: have you made something with a Raspberry Pi over the weekend? Every Monday, our followers send us amazing photos and videos of the things they've made.

Here's a selection of some of the awesome things we got sent this month – and remember to follow along at the hashtag #MagPiMonday!! 🍷

01. It's always nice to see people still using the ol' AIY projects kit from issue 57
02. Halloween occurred during the production of this magazine, so we got to see some fun spooky builds
03. We like the simplicity of this Halloween project
04. Jitesh has been updating us with cool videos of their web-controlled robot
05. 3D scanners always seem like dark tech magic, but we appreciate that they're fun to make
06. Upgrading a 26-year-old project is very cool in our book
07. These 3D-printed cases are really nice, and great for specific environments
08. This solar-powered robot remains a mystery to us. What does it do? Is it actually called Solarbot?



**Pierre-yves Baloche**  
@FunkyPiwy

01

Replying to @TheMagPi

Did a time travel trip back to #2017 and brought back a collectible item to upgrade to #2020 needs, following @MrPJEvans latest project idea. Good news is that after some simple code upgrade, it works perfectly!





**Brian Cortell**  
@CannonFodder

02

Replying to @TheMagPi

Bit late to the party, finally finished my Halloween Pumpkin project after 2 years, all running on a Pi Zero :-)

🎃🎃🎃🎃🎃

#MagPiMonday



0:12 1.2K views



**PenguinTutor**  
@penguintutor

03

Replying to @TheMagPi

I've been working on some Halloween pictures for my Raspberry Pi RGB Matrix

It's still work on progress - find out about the project at: [penguintutor.com/projects/rpi-m...](http://penguintutor.com/projects/rpi-m...)

#MagPiMonday #Halloween2020



**Lewis Workshop**  
@LewisWorkshop

05

Replying to @TheMagPi

Well #magpiMonday, it's a Raspberry Pi powered 3D scanner. Just finished soldering it together (except for the lasers, I'll connect those once I've got the motors working properly under python.)



**TGD**  
@TGD\_Consulting

07

Replying to @TheMagPi

I did some 3D printing. The "fall/winter collection" of #3Dprinted bodies for the smart CO2 traffic light are ready.

From only 25,- EUR as #DIY. Code @GitHub. 3D models @Cults3D.

#MagPiMonday #STEM #IOT #CO2Ampel #3dprinting #Maker #mhz19 #esp8266 #RPi

**TGD** @TGD\_Consulting - Oct 31  
Die "Herbst-/Winterkollektion" der 3D-Druck Gehäuse für die smarte #DIY CO2-Ampel sind fertig.

Ab 25,- EUR im Selbstbau. Code @GitHub. 3D-Modelle @Cults3D. Bauanleitung mit MH-Z19 hier:

[forum-raspberrypi.de/forum/thread/4...](http://forum-raspberrypi.de/forum/thread/4...)

#MINT #IOT #CO2Ampel #3dprinting #Maker #esp8266 #KISS #RaspberryPi



**Jitesh Saini**  
@jiteshsaini10

04

Replying to @TheMagPi

Wrote an article on web-based #raspberrypi robot which I made sometime back. All components, including Raspberry Pi & 12 V DC motors, powered through single battery bank. Read it here:- [helloworld.co.in/article/basic-...](http://helloworld.co.in/article/basic-...)



**Mark Cantrill**  
@AstroDesignLtd

06

Replying to @TheMagPi

This w/e i put the finishing touches to my latest camera - combining the Raspberry Pi High Quality Camera with the Pentax body I made as a prototype for my final year uni project back in '94. Lots of lens options :)



**TK**  
@whatuptkhere

08

Replying to @TheMagPi and @six20brownie

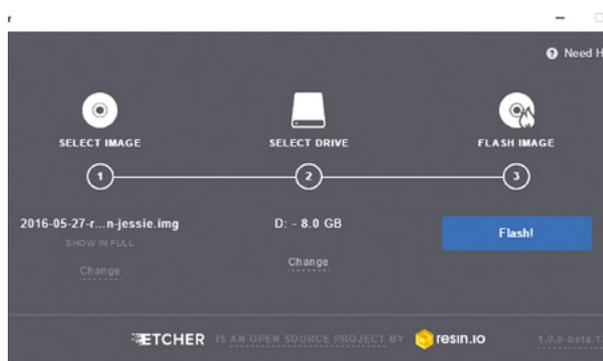
SOLARBOI



# Best of the rest!

A bumper-sized best of the rest section to fit in everything from this month

## RASPBERRY PI IMAGE MANAGER



Benn emailed us about his project called **sdm** ([magpi.cc/sdm](https://magpi.cc/sdm)) which is a tool for creating custom versions of Raspberry Pi OS with all the localisation and security settings you'd want to edit, along with extra software installed.

It requires you to be running Linux, but it will copy relevant location and connection settings from your current system and update the packages on the image. You'll be able to write to a microSD card immediately from here, or you can do more customisation – see the GitHub page for more details.

► [magpi.cc/sdm](https://magpi.cc/sdm)

## RASPBERRY PI VIRTUAL KEYBOARD



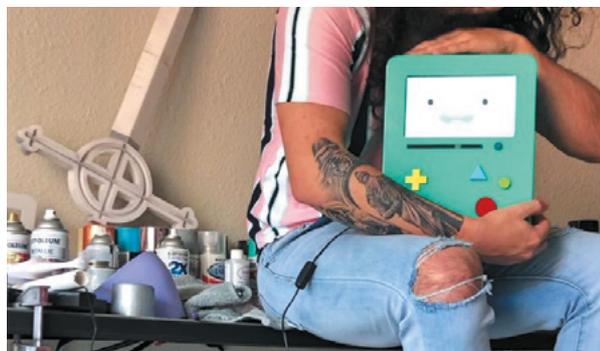
KeyMusician is software that lets you play a virtual (musical instrument) keyboard with your (computer typing) keyboard. Aere emailed us about how they'd been testing it on Raspberry Pi 4 with great results. You can find the full guide here: [magpi.cc/keymusician](https://magpi.cc/keymusician).

"After downloading the KMK Debian package (installer), I installed it using the system default package installer with no problems, along with the normal dependencies," Aere writes. "Running KMK the first time, out-of-the-box, worked fine, with no problems and no audio glitches."

He has some upgrade ideas in the article as well.

► [magpi.cc/keymusician](https://magpi.cc/keymusician)

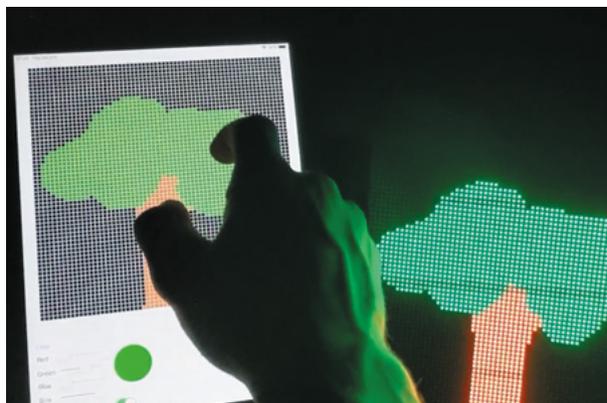
## BMO



This BMO from cartoon *Adventure Time* was 3D-printed and runs on a Raspberry Pi 4! "They currently run the DIY Hue Sync, Audio Sync, and General LED Control of my room," says reddit user [huragok\\_in\\_disguise](https://www.reddit.com/user/huragok_in_disguise).

► [magpi.cc/bmopi](https://magpi.cc/bmopi)

## PAINT WITH LEDS



Using an old iPad, a Raspberry Pi, and an LED matrix, reddit user [Gorse212](https://www.reddit.com/user/Gorse212) created this very cool, interactive painting app.

► [magpi.cc/ledpaint](https://magpi.cc/ledpaint)

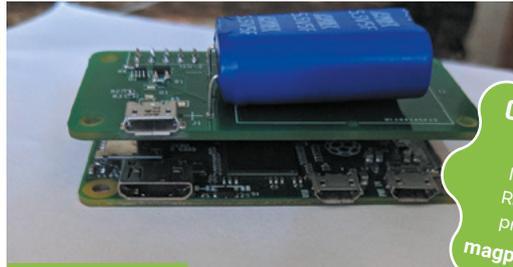
# Crowdfund **this!** Raspberry Pi projects you can crowdfund this month



## Clover drone

This drone is powered by a Raspberry Pi, which means it's extremely hackable and customisable. In fact, that's the angle for this on the Kickstarter campaign, boasting how it can be modified and used for aerial photography and cargo delivery, etc.

► [kck.st/36uEg9c](https://kck.st/36uEg9c)



## PiZ-SuperCap

The 'Cap' part of the title is a multilayered pun: Cap being like HAT and short for capacitor. Very nice. It acts a bit like an uninterruptible power supply so that if your Raspberry Pi Zero loses power, this will keep it going for a bit. 15 seconds, apparently. It can help with reducing microSD card corruption.

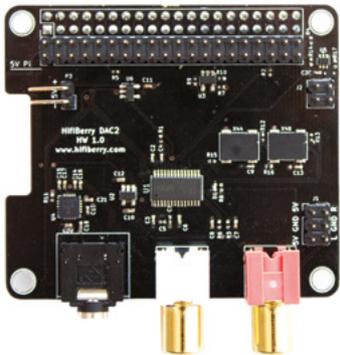
► [kck.st/3oKX9Mb](https://kck.st/3oKX9Mb)

**CROWDFUNDING A PROJECT?**  
If you've launched a Raspberry Pi-related project, let us know!  
[magpi@raspberrypi.com](mailto:magpi@raspberrypi.com)

[www.hifiberry.com](http://www.hifiberry.com)

# PROFESSIONAL OR HIGH END?

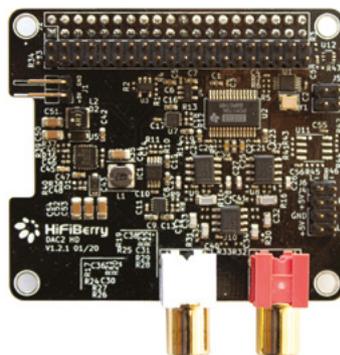
Pick the HiFiBerry DAC for Raspberry Pi, that fits your needs



## HiFiBerry DAC2 Pro

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Headphone output  
Can be equipped with an additional DSP board

DSP add-on board adds digital signal processing capabilities



## HiFiBerry DAC2 HD

Higher dynamic range  
Lower noise floor  
Lower distortion  
Can be equipped with an additional DSP board



# Your Letters



## Multiple shutdown

I saw the letter in the magazine from Jonathan. [Ed – from issue 84.]

This will run "init 0" on everything in \${LIST}:

```
#!/bin/bash
LIST="192.168.1.101 192.168.1.102 ..."
for RPI in ${LIST}
do
    ssh -o StrictHostKeyChecking=no -o
TCPKeepAlive=yes -o ConnectTimeout=10 -l root
${RPI} "init 0;" >&1
done
```

I use a longer version of this to perform all kinds of tasks to update medical practice management systems every week. The key is to have your local SSH public key installed in all of the Raspberry Pis' /root/.ssh/authorized\_keys.

Larry via email

Jonathan was originally asking about running scripts at boot. However, we appreciate getting this letter as telling multiple Raspberry Pi to shut down is something we'll need sooner or later.

If anyone else has any other automated, simple tasks they use, we'd love to hear.

▲ A great solution for those who need a laptop version of Raspberry Pi

## Laptop Pi

I wish to buy a Raspberry Pi system that I can use as a laptop, primarily indoors at home.

I have read much of the documentation and articles on the subject, but would much appreciate your advice on the following points:

I want a Raspberry Pi set up like a laptop, i.e. all-in-one motherboard plus screen, plus keyboard, and plus batteries as one unit.

How can the screen be incorporated into the device so that it works like a laptop, i.e. not as a separate unit, so that I can use Raspberry Pi on my lap?

What is the best battery pack which will integrate into the unit so that I don't have two items to carry instead of one?

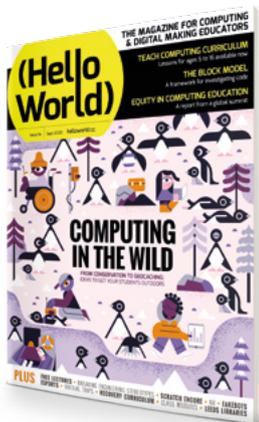
Are there any packages which will fulfil all my above requirements?

Peter via email

There are two options we think fit this best. First of all, our Build a Laptop feature from issue 74 ([magpi.cc/74](http://magpi.cc/74)) has a great guide on creating your own personal laptop using a Raspberry Pi.

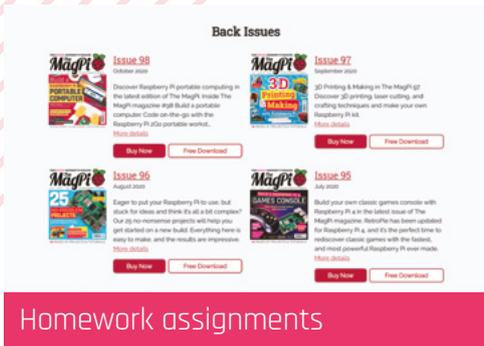
As you've mentioned you're a beginner, though, perhaps a pi-top ([pi-top.com](http://pi-top.com)) might be better suited to your needs – it's an all-in-one laptop solution that comes pre-built, with keyboard, screen, and built-in battery as well. It will allow you to learn all about Raspberry Pi without having to go through extra setup.

▼ If you're an educator who teaches computing, then you may be interested in our sister magazine Hello World ([helloworld.cc](http://helloworld.cc))



## Contact us!

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- Email [magpi@raspberrypi.com](mailto:magpi@raspberrypi.com)
- Online [raspberrypi.org/forums](https://raspberrypi.org/forums)



## Homework assignments

I write homework assignments for schoolchildren and teachers and parents. I recently decided to use Raspberry Pi as my new inspiration for what to write for reading comprehension activities. I decided to purchase a Raspberry Pi 400 and write about my experiences as homework assignments. I just thought I would let you know I am reading past issues, and watching videos, and reading books to prepare for my new computer to arrive.

My dad was a mechanical engineer working for the Department of Defense and I know he did his own wiring for years. So I want to make some projects to give me a glimpse of what he used to do. I took my first programming class at age twelve with my grandma, so I would have a ride to the other side of town. The streets were too busy for me on my bike. Because I took that class and enjoyed it, my dad bought us a family computer that my mom, my brother, and I all used for writing school papers. I also typed out word searches for extra credit in an English class.

All programmers started as children, so it is wonderful you support children using computers for programming and engineering. Thank you for existing. Maybe some more people in the United States of America will join in on the fun to help keep everyone up and running. We are all part of one world. Children and parents are saying the kids don't have enough to do. I have suggested writing journals for daily writing and the Raspberry Pi hobby to keep them busy with educational activities.

**Janine** via email

Janine sent us some examples of questions she sets and they're all excellent. We very much appreciate you spreading Raspberry Pi and our magazine in this way, Janine. Hopefully the free PDFs on the website will help with your students as well!

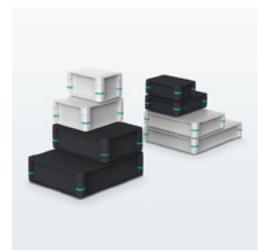


## We've got your electronics covered

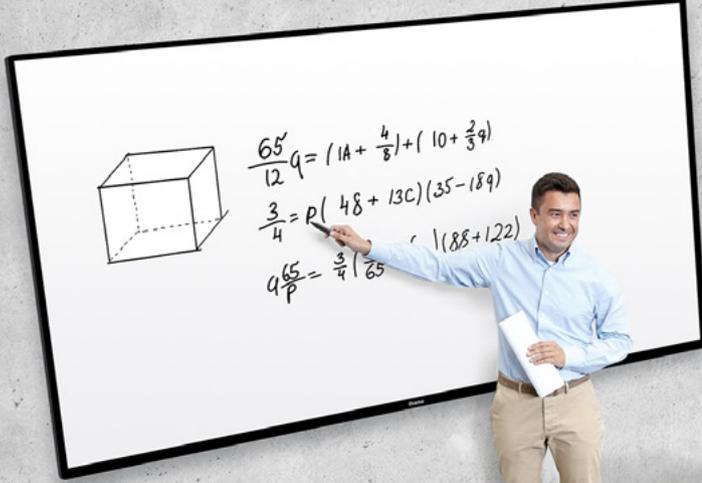
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iiyama's smart 4K touchscreen series ProLite TExx03MIS enables teamwork without a PC. results.

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In order to make the ProLite 03 Series the ideal solution for meeting and classrooms, the most advanced components and features have been combined. The large-format smart displays use infrared 20-point touch technology, which offers a decisive advantage compared to typical film overlays and touch substrates: the display can be operated by several people at the same time and is not subject to wear and tear. Four millimeter thick safety glass doesn't give scratches a chance, regardless of whether it is operated with the fingers or the supplied stylus pens.

In addition, the anti-glare screens score with their razor-sharp 4K display, brilliant colors and an excellent contrast ratio. Even in suboptimal lighting conditions, content remains perfectly legible.

Technical hurdles were eliminated and tailor-made solutions were integrated. Thanks to the WLAN module and iiWare 8.0, you don't even need a PC to work together on a screen. The installed software makes modern teamwork really easy. This includes a digital whiteboard app, web browser, file manager with cloud connection and WPS Office for Microsoft Office files. In addition, via ScreenSharePro, all content from external sources can be transmitted wirelessly to the screen without tangled cables. In short: iiyama's devices of the 03 Series transform classic team meetings and teaching units into interactive sessions that encourage all participants to engage.



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# An education in computing

Raspberry Pi Press Publishing Director, **Russell Barnes**,  
on milestones and recaptured youth...

**A**s a publisher, there's little more satisfying than seeing one of your titles hit triple figures. I'm super-proud of the magazine team, new and old, for this achievement. While what follows could be construed as the life story nobody asked for, I hope my ramblings go some way to explaining why the magazine and this milestone means so much to me.

I was essentially one of the young people that fell through the computer education cracks that Eben often speaks of when recounting the humble beginnings of Raspberry Pi. The situation in my school wasn't completely dire – we had a computer room lined with systems and we had computer classes, just not the right type.

It was all the more frustrating considering my tutor room – where we'd take register and congregate between classes – was that very heaven of classic computers. I'd arrive early most mornings to load *Wolfenstein* from one of my floppy disks, or coax it to beep the *Axel F* tune to the amusement of my peers, among other things.

But while I was trying to reverse-engineer conversational bots, copy code listings, and understand how pokes (cheats) worked in my favourite games between classes, in them I was being taught how to write letters and organise simple data in a spreadsheet.

## Window of opportunity

OK, fast-forward too many years to mention and it turns out that I write letters and organise data in spreadsheets as a full-time gig these

“ I loved this stuff when I was a kid ”

days (so the education system didn't *completely* drop the ball), but my frustration at the time was tangible and – starved of the encouragement my younger self yearned for – my love of code-based computing withered away. My window of opportunity to be pulled into computing – as a child at least – had passed.

But then it happened. One minute I was editing a now defunct Linux and open-source magazine at a now defunct publishing company on the south coast of England, and

the next, Raspberry Pi was just 'there'. That was when the last few of paragraphs of my childhood found their perspective. I *loved* this stuff when I was a kid. As such, Raspberry Pi clicked with me in really quite a profound way. After courting both Eben and Liz to within an inch of my life, a project to reimagine and relaunch a beloved community magazine cropped up.

For me it presented a genuine opportunity to make a computing

magazine that I'd want to read cover-to-cover. And not just old, paunchy me, but the younger, sleeker me too. Not many publishers get that opportunity. Thanks for reading the magazine – here's to another 100 issues of *The MagPi*. 🍷

## AUTHOR Russell Barnes

Russell is the Publishing Director of Raspberry Pi Press, a part-time frustrated racing driver, and full-time frustrating sci-fi bore.

@another\_russell



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