CanaKit Raspberry Pi 3 Ultimate Starter Kit
Model B | 1 GB RAM | 1.2 GHz | Quad-Core CPU

- Learn to Code
- Explore Computing
- Get started with Electronics

Kit Includes Raspberry Pi 3 and...

- Premium Case & Heat Sinks
- 2.5A Power Adapter
- 32 GB Class 10 MicroSD Card
- USB MicroSD Card Reader
- Premium HDMI Cable
- Quick-Start Guide
- GPIO to Breadboard Interface Board
- Ribbon Cable
- Full-Size Breadboard
- Jumpers
- LEDs
- Resistors & Push-Buttons

Available for worldwide shipping at:
WWW.CANAKIT.COM

Raspberry Pi Zero W
Now available at CanaKit!
Welcome

Welcome to the official magazine

We’re always amazed by what the Raspberry Pi community builds using the Pi Zero W (Raspberry Pi’s smallest wireless computer). We’ve seen miniature game consoles, photo frames, magic mirrors (plus other small display projects), drones, tiny robots, and smart devices around the home. The Pi Zero W is small, cheap, sturdy and, crucially, incredibly well engineered. No wonder it’s so popular.

But Raspberry Pi isn’t the only platform out there. Another board that’s often used by digital makers is Arduino. People often think of Pi and Arduino as rivals, but they are very different devices. Raspberry Pi is a computer platform, while Arduino is a microcontroller, ideal for controlling precision elements like servos and DC motors.

Putting the two together creates an unstoppable tag team. You get more done if you stop thinking about which widget is best, and start thinking about how components could work together to get the best result.

That’s why this month we’ve got two incredible features: 10 Pi Zero W Projects, plus Arduino and Pi. Read both features and you’ll be capable of building bigger, better, and bolder projects. Never limit yourself to just one approach, device, or project. The more tools you can use, the better a digital maker you’ll become.

Lucy Hattersley
Editor – The MagPi

Editorial
Editor: Lucy Hattersley
lucy@raspberrypi.org
Features Editor: Rob Zwetsloot
rob@raspberrypi.org
Sub Editors: Rachel Churcher and Phil King

Design
Critical Media: criticalmedia.co.uk
Head of Design: Dougal Matthews
Designers: Lee Allen, Daiva Burnelyte, and Mike Kay
Illustrator: Sam Alder

Publishing
For advertising & licensing:
Head of Publishing: Russell Barnes
russell@raspberrypi.org | +44 (0)7904 766523
Publisher: Liz Upton | CEO: Eben Upton

Subscriptions
Select Publisher Services Ltd
PO Box 6337
Bournemouth
BH1 9EH | +44 (0)1202 586 848

Contributors
Bill Ballard, Alex Bate, Henry Budden,
Chris Bush, Mike Cook, David Crookes, Phil King,
Matt Richardson, Tim Richardson, Richard Smedley,
Daria Tsaregorodtseva, Clive Webster

Contact Us
magpi@raspberrypi.org

Find us online
raspberrypi.org/magpi

This magazine is printed on paper sourced from sustainable forests and the printer operates an environmental management system which has been assessed as conforming to ISO 14001.

The MagPi magazine is published by Raspberry Pi (Trading) Ltd, 30 Station Road, Cambridge, CB1 2JH. The publisher, editor, and contributors accept no responsibility in respect of any omissions or errors relating to goods, products or services referred to or advertised in the magazine. Except where otherwise noted, content in this magazine is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported licence. BY-NC-SA 3.0. ISSN: 2051-9982.
10 PI ZERO PROJECTS YOU MUST MAKE!

- **10 PI 101 - TEXT EDITING GUIDE**  38
  - The best ways to code and edit your config files
- **10 PI 101 - FILE COMPRESSION TIPS**  40
  - Using zips and file archives on a Raspberry Pi
- **MAKE A MIDI SEQUENCER**  42
  - Polyrhythmic sequencing on your Pi
- **WINE TEMPERATURE MONITOR**  45
  - Save your wine when it starts to get warm
- **BUILD A 3D PRINTER WITH PI**  48
  - Make a budget 3D printer with a bit of recycling
- **STREAM SONIC PI ONLINE**  50
  - Share your performances online with MQTT
- **CONTROL HUE LIGHTS WITH PI**  54
  - Phillips Hue lights are great, but let's make them better

IN THE NEWS

PIONEERS WINNERS

Victors from the latest round of Pioneers!

Aiy needs your voice to improve recognition

10 MILLION PIS

Pis made in the UK reach a huge milestone
THE BIG FEATURE

ARBITURINO AND PI
A microcontroller and an SBC – one unstoppable team

YOUR PROJECTS

INTERCOM
Using the AY Projects Voice Kit to upgrade old-school intercoms

REGULARS

NEWS 06
TECHNICAL FAQ 56
BOOK REVIEWS 80
FINAL WORD 98

COMMUNITY

PROJECT THINGS INTERVIEW 82
We talk to Mozilla about their new IoT project

THIS MONTH IN RASPBERRY PI 84
What else happened in the world of Pi this month?

CODE CLUB MEETUP REPORT 88
Educators learn to teach computing to kids

COMMUNITY PROFILE 90
HAB legend Dave Akerman is profiled this month

EVENTS MAP 92
Find an event coming up next month

YOUR LETTERS 94
Burning queries answered by our team

REVIEWS

STRATO PI CAN 74
INKY HAT 75
HYPER PIXEL 76
PI-TOP PULSE 77
CLEVER CARD KIT 78

raspberrypi.org/magpi
The Sony UK Technology Centre (Sony UK TEC) has announced the production of the ten millionth Raspberry Pi made in the UK.

Raspberry Pis were originally made in China, but in 2012 Sony UK TEC was contracted to make 10,000 units. However, a Sony UK TEC spokesperson confirmed that the facility “went on to produce one million [Raspberry Pi boards] in its first year.”

Steve Dalton, Sony UK TEC managing director, said, “The last five years have seen unprecedented growth across our Pencoed facility – something we are understandably proud of.”

The Pencoed facility was chosen, a Sony UK TEC spokesperson explained, “due to the facility’s capacity and innovative automated processes.” Based roughly 13 miles west of Cardiff, the Sony UK TEC facility “has seen staff numbers leap by 200, taking its team of local employees to 540” over the last five years.

Steve added, “Our growth has been intrinsically linked to the success of the Raspberry Pi. This is a significant achievement for everyone involved in its production, especially our devoted Sony Team, The Raspberry Pi Foundation, and distributors Premier Farnell.”

Raspberry Pi co-founder Eben Upton joined Sony UK TEC to celebrate the milestone, saying “when we initially began manufacturing [Raspberry Pis] here at Sony UK TEC, we could never have imagined it would be the soaring success it has become – and for that we are grateful to Sony and our distribution partners.”
Made in Britain... in Japan?
Eben attributes much of the success of the Raspberry Pi to Sony UK TEC’s “unparalleled manufacturing standards, comprising the latest techniques and the very best engineering talent.”

Steve Dalton added that making Raspberry Pis in such volume “has challenged our highly skilled team of engineers and technicians to develop new processes and drive innovation. We were able to support The Raspberry Pi Foundation further by introducing Pi manufacturing to our counterparts in Japan, and there is now a ‘made in Japan’ version of Pi.”

Our growth has been intrinsically linked to the success of the Raspberry Pi

No Raspberry Pi 4 yet, though
Speaking with Beta News (betanews.com) at a separate event, Eben was asked whether we might see a Raspberry Pi Model 4 sometime soon. His response was, “Nope!”

Eben clarified: “I think we gave the impression by launching Pi 2 and Pi 3 a year apart that we were establishing some sort of annual cadence. We’ve said that we think the Raspberry Pi 3 is more of a three-year platform.”

Even that is a very soft timeline, though, as Eben added, “we’re not much more than a year into that (very rough) window yet.”

How many PIs in the world?

<table>
<thead>
<tr>
<th>PIS in Millions</th>
<th>5M</th>
<th>4M</th>
<th>3M</th>
<th>2M</th>
<th>1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model B+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (Model A, A+, Zero, Zero W, Compute Modules)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Minimaker faire at the Institute of Imagination

Fueling kids’ imaginations with a full head of STEAM

London-based charity, the Institute of Imagination (IoI, www.ioi.london) hosted a Mini Maker Faire at its Imagination Lab on 29 July. The event featured activities from retro computing and laser cutting to robot football. We caught up with Corrie Jones, IoI interim marketing manager, after the show. “We’re really happy to have had so many people attend, and to see so many children get so involved in all of the activities,” she told us.

“Our current theme is ‘Teaching Me’, and is all about inventing things that you think will make a positive impact in the future. One child that I spoke to had created a robot that would pick up all the rubbish from the bottom of the ocean. Inventions [like that] show a really high level of thinking about what we need to improve the world.”

Pi-powered robot football

Red Robotics (redrobotics.co.uk) brought some SoccerBotz to make a three-a-side Pi-powered robot football game. “That was brilliant,” remarks Corrie. “I didn’t get to have a go on it myself because it was so busy throughout the day!”

STEAM power

IoI focuses on STEAM learning, adding art and design to science, technology, engineering, and maths. So, “as well as there being science and technology elements,” to IoI events, Corrie says, “the arts and things that [kids] can make and feel really proud of” also feature.

The IoI runs many weekend activities, all aimed at children, families, schools and teachers, and covering everything from film-making to coding and 3D design. Visit ioi.london/whats-on for details, or contact the IoI at hello@ioi.london to bring an ‘Imagination Pod’ to your school.
LOW COST COMPUTING FOR THE NEXT GENERATION

WITH WD PiDrive Compute Centre

ONLY $109.99

Includes custom NOOBS, Raspbian PIXEL, and Raspbian Lite on a bundled SD card. Organize multiple projects in one place with Project Spaces and easily assemble components in a custom enclosure.

Learn more at wd labs.io/mp60a
The Pi Hut (thepihut.com) has released the first full range of cameras designed specifically for the Pi Zero. The cameras are smaller than the standard official Raspberry Pi Camera Modules, and connect directly to the smaller CSI ports of the Zero boards.

The range includes a standard camera, a fish-eye camera, and a NOIR infrared camera. Despite the module’s reduced size of just 11.4×11.4 mm (compared to the 25×23 mm of the standard Module), it still packs a 5MP sensor (compared to the 8MP of the V2 Camera Module).

The Pi Hut’s Jamie Mann tells us, “We sampled a bunch [of camera modules] from various manufacturers, found the best factory for the job and created the ZeroCam brand.”

Jamie explains that the ZeroCams “work with the existing camera code.” He also predicted that we’ll see smaller camera connectors on future models of the Pi: “There are already smaller ones out there... it’ll happen!”

The ZeroCam, ZeroCam FishEye and ZeroCam NOIR cost £15 each from thepihut.com.

---

**Pioneers Winners Announced**

Who ‘Made it Outdoors’ the best?

The winners of the second Pioneers challenge, a digital making program for 11-16 year-olds, have been announced.

The overall theme winner is HH Squared’s Pi Spy project.

Pioneers challenges young people to work together to create a piece of technology addressing a theme, with this cycle’s theme being ‘Make It Outdoors’.

Pioneers organiser Oly Brown says of HH Squared’s project, “We really loved how every member of the team contributed [and] how tech was used to enhance the enjoyment of the outdoors.”

The Pioneers challenge isn’t just about making something, but the process of trying to make something. Coding Doughnuts won the Inspiring Journey prize by explaining all the problems they encountered while trying to build a smart picnic hamper.

Equally, Uniteam’s “great explanation of such a wonderful project” earned it the Best Explanation prize. Watch their YouTube video, Plantz with a Z (magpi.cc/2vfHueC).

Don’t miss the next Pioneers challenge – sign up to the newsletter at magpi.cc/2oMN2rc.
Aiy Projects Needs Your Voice

New open-source project to make voice-based making easier

Google’s new Open Voice Project aims to make Aiy Projects ‘more responsive’ by providing ‘a set of open-source voice keywords to use.’

But the project needs your help: the more people who provide a sample of their voice, the better the speech recognition gets.

“We have around 2,000 recordings of each word so far,” Google engineer Pete Warden tells us, “but the more diversity in accents we can get, the more people the speech detection will work for.” As a Brit abroad, Pete has often found himself having to spoof an American accent to make voice systems work.

The project is only aiming to “enable a very basic voice interface”, Pete reveals, with single-word commands like ‘stop’ or ‘open’.

Pete also confirms that the Open Voice Project will always be open: “We will be releasing the recordings under a Creative Commons BY 4.0 licence,” he discloses.

You can help the project now by turning on your microphone and heading to magpi.cc/2wmo05l.

Now Trending

The stories we shared that flew around the world

Raspberry Pi Desktop Challenge

Can you really use a Raspberry Pi 3 as your main computer? After all, that quad-core 1.2GHz processor and 1GB of RAM should be plenty for office work. Follow the link to see if it’s possible!

Julia Language Now On Pi

Julia, a next-generation coding language for data analysis and scientific research, is now available on the Pi. With the claimed ‘speed of Fortran and ease of Python’, Julia’s a decent choice for hobbyists, too.

Microsoft’s Pi Simulator

Microsoft has launched an online Raspberry Pi simulator. It’s early days, but it could be a useful way to prototype projects without breaking out the breadboard – never mind the soldering iron!
exas-based Petrolog Automation (petrologautomation.com) has created a smart oil well monitor that increases the revenue from each well by a reported $7,000 (roughly £5,300). The smart monitor is based around a Raspberry Pi and a custom-made cellular modem.

The need for a smart meter arises at so-called ‘marginal wells’ (also, we are told, referred to as ‘stripper wells’). As Carlos Labrado, software developer at Petrolog, clarifies: “these wells are low-production wells that are often thought of as not worthy of a POC [Pump Off Condition] controller.”

Carlos explains the benefit of Petrolog’s POC controller: “[It] saves money by not having the well turned on when there is not enough fluid, and not having people going to the well every day. Also, our controller is smart, so it finds the best times to be pumping and thus increases production.”

Carlos tells us that Petrolog chose the Raspberry Pi for version one due to its size, low cost, and features. “Now we keep using it because of the great support community… like resinOS.”

The need for a smart meter arises at so-called ‘marginal wells’ (also, we are told, referred to as ‘stripper wells’). As Carlos Labrado, software developer at Petrolog, clarifies: “these wells are low-production wells that are often thought of as not worthy of a POC [Pump Off Condition] controller.”

Carlos explains the benefit of Petrolog’s POC controller: “[It] saves money by not having the well turned on when there is not enough fluid, and not having people going to the well every day. Also, our controller is smart, so it finds the best times to be pumping and thus increases production.”

Carlos tells us that Petrolog chose the Raspberry Pi for version one due to its size, low cost, and features. “Now we keep using it because of the great support community… like resinOS.”

The Pi embedded in the Petrolog POC controller runs resinOS (resinos.io), a dedicated Internet of Things (IoT) operating system from resin.io. Alison Davis, director of product marketing and strategy, explains, “Because resin.io uses Docker containers to deploy updates, the Petrolog team can change the application running on their oil well monitors as often as they like, without fear of bricking devices.”

“As anybody can get started with resin.io,” Alison tells us, “whether you’re a hobbyist with a few devices at home, or a professional with a fleet of thousands.” She confirms that the free resin.io account accommodates up to five devices.
cott Edenbaum, a recent graduate from the NYC Data Science Academy (nycdatascience.com), has turned a humble Pi Zero into a data crunching, code trialling, data science-ing auxiliary processor.

Wanting to avoid “the potential for security exploits” of installing MySQL on his main development computer, Scott instead used virtualisation software Docker (docker.com) to create standard environments for Python and R (a programming language suited to data science). Scott’s approach avoids the “multiple (possibly conflicting) dependencies” of Python and R, while allowing him to create his sandbox coding and testing environment quickly and easily. Building the environment from scratch each time is “a process that takes 2+ hours on a Raspberry Pi 3”, let alone a modest Pi Zero.

Plug-in processor

“Because the device is so inexpensive, I can see there being a lot of possibility using it for education” Scott tells us, while the standardised environment saves “headaches” such as installing libraries and managing package repositories.

Scott’s project could replace Excel “for some tasks”, while Docker “allows deployment and management of a few devices or hundred, without too much extra work.” He says there are “a lot of interesting cases I haven’t thought of.”

The project is on GitHub at magpi.cc/2uh3guV, and Scott has documented the installation process at magpi.cc/2fmMPdJ.
pi-topOS

The OCR® endorsed pi-topOS (Operating system) platform comes pre-installed on the BGB SD card shipped with every unit. pi-topOS software suite lets you - browse the web, - check emails, - create and edit Microsoft Office compatible files. It includes pi-topCODER and comes with the revolutionary educational game CEEUniverse.

pi-topCODER

pi-topCODER is the interface that allows you to access worksheets and pre-built Raspberry Pi projects. It's the easiest way to tinker or deliver lessons by providing step-by-step guides for computer science and STEAM worksheets.

CEEDuniverse

CEEDuniverse is our educational game. It's a world of fantasy developed in line with the computing curriculum - taking science fiction and transforming it science. It is a FREE massive role-play game carefully crafted by pi-top. The game teaches students to solve computational puzzles, how to code in Python and build physical circuits which interact with the game.

Exploring the planet, the students first encounter 'drag & drop' coding puzzles and move on to writing text based code.
pi-top

The modular build-it-yourself Raspberry Pi powered laptop

- 10 Hour Battery Life
- 13.3” HD Screen
- Modular Components

pi-top

LEARN
PLAY
CREATE

pi-topCEED

The modular all-in-one Raspberry Pi powered desktop

- Adjustable Viewing Angles
- 14” HD Screen
- Modular Components

Worldwide shipping available in green or grey at www.pi-top.com or our distributors. Stay up to date with our latest news by following our social media.
The Pi Zero W is a fantastic piece of kit, and these pages are packed with ideas to inspire your Pi Zero creativity.

Adding wireless internet connectivity to the original Raspberry Pi Zero was at the top of many people’s wish lists when it was first launched. A real computer, amazingly small, with a built-in internet connection – this opens up so many possibilities for amazing projects.

Since its release in February 2017, the Pi Zero W has been used in many amazing builds around the world, so we thought it was about time to highlight some of the exciting things you can do with the newest member of the Raspberry Pi family, and the original Pi Zero as well. Let’s get making!
MINI HDMI
Connect to an HDMI display to create your own media PC or interactive project.

SYSTEM ON A CHIP
This features the same CPU as in the original Raspberry Pi, although it’s clocked a little higher.

WIRELESS CHIP
Connect to a wireless network or Bluetooth with the radio chip on the Pi Zero W.

CAMERA CONNECTOR
The Raspberry Pi Camera Module can be added for photography projects – all you need is an adapter cable.
While you can do a lot of things with the Pi Zero, it’s worth sharing a few tips to help you use it in even more projects. These can be as simple as software tweaks to improve performance and reduce power requirements, or adding hardware to make it easier to integrate into your projects. Here are some of our favourites.

**ATTACH A GPIO HEADER**
Add GPIO pins to your Raspberry Pi Zero

**YOU’LL NEED**
- 40-pin male header
- Soldering iron and solder

**01 GET READY TO SOLDER**
Put the short legs of the 40-pin header through the GPIO holes on the Pi Zero. We like to turn it upside down so the side of the Pi Zero with the header is raised off the floor, giving a perfect view of the pins to solder to the board.

**02 SOLDER THE PINS**
Let your soldering iron heat up and then solder the individual pins. Make sure no solder crosses between the pins or you may short them out. Be careful – soldering irons are extremely hot, so let the solder cool before touching it!

**OR HAMMER HEADERS**
Pimoroni has an excellent solution to adding a GPIO header to the Pi Zero: a special header that can be hammered into the holes with a special kit. You can find out more on Pimoroni’s site: magpi.cc/2lohN2U

**CONVERT THE USB PORT**
Connect USB accessories quickly and easily

A lot of micro USB to USB A converters can be bulky, using wires and full-sized female USB/A ports. A great alternative is to use a micro USB shim, which is only as big as the connector. This allows you to convert the data port while losing minimal space.

**OR**
You can buy HATs and other add-ons to add USB ports to the Pi Zero without making the Pi Zero wider or longer, but these options will more than double its height. If you’re feeling extremely brave, you could try removing the micro USB and soldering on a standard USB A connector, but we don’t recommend it unless you really know what you’re doing.
In Raspberry Pi Configuration (which can be found in Menu > Preferences on the desktop, or by running `sudo raspi-config` in the command line), you can change the boot options. This includes booting to the graphical desktop, as well as auto-login. Turn off Boot to desktop and activate Auto-login, and your Pi will boot up more quickly and free up more computing resources.

**ADD COMPOSITE VIDEO OUT**

Using an old telly? Here’s how to use it as a display for a Pi Zero

- **YOU’LL NEED**
  - Two-pin header
  - 2x female-to-male jumper wires
  - Screw terminal with RCA connector

- **TOP TIP**
  If the video looks wrong, switch the jumper cables over on the Pi Zero

**CONNECT TO WIRELESS ON THE COMMAND LINE**

It’s tricky but doable — here’s how!

1. **GATHER INFORMATION**
   You’ll need to know the SSID and the password of the wireless network. You can run a scan of available wireless networks using `sudo iwlist wlan0 scan`.

2. **CONFIGURATION FILE**
   Open the `wpa_supplicant` file with:
   ```bash
   sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
   ```
   Go to the bottom of the file and enter:
   ```yaml
   network={
     ssid="[Name of network]"
     psk="[Password for network]"
   }
   ```

**SOLDER TO THE PI**

Look to the top right-hand corner of the Pi Zero and you’ll see two holes labelled TV, below the GPIO holes and next to two pins labelled RUN. Put the short ends of the header through the TV holes, flip the Pi over, and solder them on.

**CONNECT THE RCA**

Slot the jumper wires onto the headers, and put the other ends inside the screw terminals of the RCA plug. The Pi Zero should automatically switch to this output when you plug it into a TV.

**TURN OFF BOOT TO DESKTOP**

Improve speed and power efficiency for projects that don’t use a display.

In Raspberry Pi Configuration (which can be found in Menu > Preferences on the desktop, or by running `sudo raspi-config` in the command line), you can change the boot options. This includes booting to the graphical desktop, as well as auto-login. Turn off Boot to desktop and activate Auto-login, and your Pi will boot up more quickly and free up more computing resources.

**TROUBLESHOOTING**

Having trouble with your Pi Zero? Check our previous issue for an exhaustive troubleshooting guide, which includes specific fixes for the Pi Zero: [magpi.cc/magpi60](http://magpi.cc/magpi60)
Extend your router’s range or turn your wired hotel internet into a wireless wonderland

A few years ago, when the Raspberry Pi was fairly new, Adafruit produced an excellent guide to creating something called the Onion Pi. The concept was to take a Raspberry Pi, connect it to the internet, and then connect to the Raspberry Pi via WiFi. Once connected, you could then access the internet, encrypted via the Tor network. You can read the original instructions here: magpi.cc/2vCKTqy.

We’re going to do something a little more straightforward, and remove the Tor functionality. So this will be a simple, tiny, wireless access point.

**YOU’LL NEED**

- Latest version of Raspbian
- USB Ethernet adapter
- An extra wireless dongle (advanced)

**PREPARE THE RASPBERRY PI**

We need a lot of software to get the wireless access point working. First, update your Raspberry Pi with:

```bash
sudo apt-get update
sudo apt-get upgrade
```

Then install:

```bash
sudo apt-get install hostapd bridge-utils
```

You’ll need to turn off some of the new services you’ve just installed using:

```bash
sudo systemctl stop hostapd
```

**BRIDGE THE DEVICES**

This works best with an Ethernet connection, but you should be able to use a wireless connection – with some caveats. We need to bridge the connection between the internet (`eth0`) and the wireless network (`wlan0`).

Edit the DHCP file by first using `sudo nano /etc/dhcpcd.conf` and add `denyinterfaces wlan0` and `denyinterfaces eth0` to the bottom of the file. Save and exit, and then create a bridge with:

```bash
sudo brctl addbr br0
```

Connect the network ports with:

```bash
sudo brctl addif br0 eth0 wlan0
```

**BRIDGE INFORMATION**

Open the network interfaces file with `sudo nano /etc/network/interfaces`, then change the `wlan info` to `manual`.

```bash
allow-hotplug wlan0
iface wlan0 inet manual
```

With that done, add the information for the bridge to the file.

```bash
# Bridge setup
auto br0
iface br0 inet dhcp
bridge_ports eth0 wlan0
```
Now, we need to edit the `hostapd` file to allow another computer to connect to the Raspberry Pi. Open the file with `sudo nano /etc/hostapd/hostapd.conf` and add the following, putting in your own network name and password:

```plaintext
interface=wlan0
bridge=br0
ssid=[Network name]
hw_mode=g
channel=7
wmm_enabled=0
macaddr_acl=0
auth_algs=1
ignore_broadcast_ssid=0
wpa=2
wpa_passphrase=[Password]
wpa_key_mgmt=WPA-PSK
wpa_pairwise=TKIP
rsn_pairwise=CCMP
```

Save the conf file and open another file with `sudo nano /etc/default/hostapd`. In this file we can tell the system where to find the configuration file we edited. Find the line `#DAEMON_CONF` and replace it with:

```plaintext
DAEMON_CONF="/etc/hostapd/hostapd.conf"
```

Save, exit, and then reboot the Raspberry Pi. You should now be able to connect to it from another device.

**Wireless Caveats**

Bridging wireless connections is doable, but it can be tricky. A lot of wireless networks don’t allow auto-connection, or require you to know the password in the first place. If you’re using free WiFi, there may also be a landing page you have to sign into first, which may cause problems for the bridged computer.
RFID-style technology for automation and more

**MAKE A PI BLUETOOTH TAG**

We've seen some great projects that use Bluetooth tags and larger Raspberry Pis. With the Pi Zero W, you can create a smaller tag that slips easily into your pocket. There are many applications that support this, but here's how to get your tag set up.

### 01 INSTALL THE SOFTWARE

Python doesn’t come with a built-in Bluetooth module, so we need to install `pybluez` to our Raspberry Pi. Do a standard `sudo apt-get update` and `sudo apt-get upgrade` before you start. Once that’s done, install the following:

```
sudo apt-get install python-pip
```

This is pip, the Python module installer. It works like `apt-get`, but has a different repository of software. We can then install `pybluez` using:

```
sudo pip install pybluez
```

### 02 TAG ADDRESS

You can use specific Bluetooth tags that send out a signal and MAC address, or you can set an existing device like a PC or phone to transmit its Bluetooth signal, which the Pi can detect. If you’re using a tag, you could carry it with you and leave your Pi Zero at home.

A tag will usually tell you what its MAC address is, but Windows, Android, and iOS all use slightly different methods for other devices. Use Google to look up how to find the Bluetooth MAC address for your device.

### 03 WRITE YOUR CODE

Now you know your MAC address, you can plug it into the tag code listed on this page. The code is simple – it scans the surroundings once every 20 seconds and looks for the specific Bluetooth MAC address. If it finds the correct address, it lets you activate the next stage, whatever you want that to be. With that in place, you can start using this setup to automate your projects!

```
#!/usr/bin/env python
import time
import bluetooth

tag = “ff:ff:ff:ff:ff:ff”

def search():
    devices = bluetooth.discover_devices(duration=5,
                                           lookup_names = True)
    return devices

while True:
    results = search()

    for addr, name in results:
        if addr == tag:
            # perform function
            time.sleep(20)
```

With the Pi Zero W, you can create a smaller tag that slips easily into your pocket.

---

You’ll need

- PyBluez – magpi.cc/1VOuGCy
- Bluetooth tag or another Bluetooth device

BT_TAG.PY  magpi.cc/PiZeroWProjects

September 2017 Feature

raspberrypi.org/magpi

22
HOW TO USE A BLUETOOTH TAG

Creative projects for your Bluetooth tags

ART PROJECTS

In issue 44 we explored an amazing art installation called Lichen Beacons, which used Bluetooth tags to create an interactive display. It’s a wonderful idea, and the concept could be used to activate specific home automation tasks as you walk around your house, or to create a recorded walking tour for a museum: magpi.cc/2tPnw7t

WAKE-ON-LAN

An old favourite, this project sends a magic WoL packet signal to a computer to turn it on when the Bluetooth is detected. We produced a tutorial on this, way back in issue 47—find it at: magpi.cc/2vD7e4e

BLUETOOTH UNLOCK

Using an actuator, a bit of code, and a motor controller attached to the Pi, you can use the tag to unlock a door when you stand near it for a certain amount of time. One less key to carry around with you!
10 AMAZING PI ZERO PROJECTS

Need some inspiration to put your Pi Zero to work? Here are some of the best Pi Zero projects out there!

VOICE CHANGER

magpi.cc/2vEnZfU

KEY PARTS

- Microphone
- Speaker

The Raspberry Pi Zero is great for cosplay, as you can do some pretty complex things with it while secreting it away in a hidden nook of your outfit. Voice amplifiers or distorters are something many cosplayers will consider at some point, depending on their costumes.

We like the simplicity of this version, using a clip-on microphone. The sound is input to and modified by the Pi, before being sent to the attached speaker. This version is used for a Star Wars Mandalorian bounty hunter costume, which is really cool, but the project could be adapted for other cosplay as well.
Videó Jukebox

Popularly known as the Simpsons Shuffler or Simpsons Button, this very simple Pi Zero project features a selection of Simpsons episodes. When you press a button, the Pi Zero plays a random episode. Obviously, you could do this with any media (even music), and all it requires you to do is solder a button to a GPIO pin and load a Python script. For the full Simpsons experience, there’s a 3D-printed case design you can download as well.

If you are choosing Simpsons episodes, we suggest limiting yourself to seasons three to eight. You’ll thank us later.

Pi Zero Power Case

This is a simple but excellent idea: attaching a Raspberry Pi Zero to a USB power adapter so that the form-factor of the computer is the same size as a plug. This can then be used to run a mini server, or even as a travel computer. This version of the project by NODE on YouTube also includes a USB hub, so you can easily connect storage and other peripherals to the Pi Zero.

The video includes a guide on how to build the power supply. Be careful – you’re dealing with mains power! Don’t take any risks with this project.

Digital Free Library

Libraries are great, even in today’s digital world. A quiet workspace – and importantly, free books! While we think of traditional libraries as inhabiting large buildings in town centres, full of resources and slow computers, we’ve also seen cute little libraries spring up in defunct phone boxes and other locations. This project takes the mini library concept one step further, and allows for the easy and free sharing of digital books and other e-publications.

This project comes straight from Adafruit, so there’s a very thorough guide to creating your own digital learning repository. Books can be accessed via a web browser on a PC or a mobile phone, after you’ve connected to the Pi Zero as a wireless access point.
Disney and Lucasfilm might want to push BB-8 as the new coolest sidekick, but we all know that R2-D2 is the best droid in the Star Wars universe. Making your own remote-controlled R2 is an extremely popular maker hobby, so much so that the version of R2 that appears in the new Star Wars films is one of these hobby-builds (magpi.cc/2wAFbAM).

This version is a little more straightforward, and instead of creating a one-to-one replica of the astromech, it’s a mod of a small toy. This makes it much easier to hack using a Pi Zero and some small motors.

It might be a bit tricky to track down that particular R2-D2 toy these days, though...

The magic mirror project is a popular Raspberry Pi project, and while it is usually made using a Raspberry Pi 3, there’s no reason why you couldn’t use a Pi Zero. Especially now that the Pi Zero W has wireless capabilities, so you’ll only need power and HDMI connections to get it working.

If you’ve not seen this project before, it’s actually incredibly easy to make. The carpentry skills required aren’t very sophisticated, and the software part is all taken care of. You just need to run the specific install script and then customise it to your tastes. It’s also very modular, so you can add and remove features very easily.

The back of the cabinet is the same size as the Raspberry Pi Zero, while the front is a little deeper than the board. It uses a tiny 0.96-inch OLED screen, with a resolution of 96×64, perfect for the oldest of arcade games. The buttons are soldered to some custom-made prototype boards, and the case is a custom design in laser-cut acrylic. Adafruit themselves say the design process was more of a challenge than anything else but hey, it would be a cool project to break out at a party.
USB RETRO CONTROLLER

Projects like this are surprisingly easy, and we’ve covered a couple like them in the magazine before: from quick, simple hacks of NES controllers, to installing a rechargeable battery system into a fully enclosed SNES emulator.

All you need to do is find a way to connect the controller’s USB cable to the Pi Zero. You can swap the USB connector for a micro USB connector; you can solder each individual USB wire to the Pi Zero’s USB port if you’re feeling brave; or solder them to the GPIO and make some modifications to the code. RetroPie lets you very quickly and easily configure your Pi Zero to play old games, and from there it’s up to you how you use it.

PI ZERO AIRPLAY SPEAKER

We find that AirPlay doesn’t always work when we want it to, even between Apple devices – but when it does work, it’s seamless and lovely. This project tries to bring the magic of AirPlay to Raspberry Pi with a wireless speaker powered by a Pi Zero. Just throw songs to it and voilà – a portable speaker.

This version of the project features an amazing wooden case that would look at home in a room with other fancy devices, but you could always make an acrylic or 3D-printed case if you prefer.

DASH CAM

The ZeroView is a cool and cheap add-on for the Raspberry Pi Zero that allows you to connect the Pi Zero, via suction cups, to a window. It includes a special mount for the Raspberry Pi Camera Module that means it can film through the window at the same time.

With very little in the way of additional coding and accessories, you can easily turn it into a dash cam for your car, keeping an eye on the road ahead just in case. It could even be used on track days to film your amazing lap-times!
SUBSCRIBE TODAY AND RECEIVE A

FREE PI ZERO W

Subscribe in print for 12 months today and receive:

- A free Pi Zero W (the latest model)
- Free Pi Zero W case with three covers
- Free Camera Module connector
- Free USB and HDMI converter cables

Other benefits:

- Save up to 25% on the price
- Free delivery to your door
- Exclusive Pi offers and discounts
- Get every issue first (before stores)
Pricing

Get six issues:
- £30 (UK)
- £45 (EU)
- $69 (USA)
- £50 (Rest of World)

Subscribe for a year:
- £55 (UK)
- £80 (EU)
- $129 (USA)
- £90 (Rest of World)

Get three issues:
- £12.99 (UK) (Direct Debit)
- $37.50 (US) (quarterly)

How to subscribe:
- magpi.cc/Subs-2 (UK / ROW)
- imsnews.com/magpi (USA)
- Call +44(0)1202 586848 (UK/ROW)
- Call 800 428 3003 (USA)

SUBSCRIPTION FORM

YES! I’d like to subscribe to The MagPi magazine and save money

This subscription is: [ ] For me [ ] A gift for someone*

Mag#61

YOUR DETAILS

Mr [ ] Mrs [ ] Miss [ ] Ms [ ]
First name __________________________________________ Surname ________________________________
Address ........................................................................................................................................
Postcode ................................................ Email .................................................................
Daytime phone ................................................ Mobile ...................................................

*If giving The MagPi as a gift, please complete both your own details (above) and the recipient’s (below).

GIFT RECIPIENT’S DETAILS ONLY

Mr [ ] Mrs [ ] Miss [ ] Ms [ ]
First name __________________________________________ Surname ________________________________
Address ........................................................................................................................................
Postcode ................................................ Email .................................................................

PAYMENT OPTIONS

1 DIRECT DEBIT PAYMENT £12.99 every 3 issues (UK only)

Instruction to your bank or building society to pay by Direct Debit

Please fill in the form and send to: The MagPi, Select Publisher Services Ltd, PO Box 6337, Bournemouth BH1 9EJ

Name and full postal address of your bank or building society:

To: The Manager Bank/building society ________________________________
Address .................................................................................................................................

Name(s) of account holder(s) ..............................................................................................

Branch sort code [ ] [ ] [ ] [ ] [ ] [ ] Account number [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
Reference [ ] [ ] [ ] [ ] [ ] [ ] (Official use only)

Instruct the account holder to pay by Direct Debit

Instruction to your bank or building society

Please pay Select Publisher Services Ltd Direct Debits from the account detailed in this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction to pay and the amount and dates on which to pay it may remain with Select Publisher Services Ltd and, if so, details will be passed electronically to my bank/building society.

Signature ............................................................................................................................... Date [ ] [ ] [ ]

Banks and building societies may not accept Direct Debit instructions for some types of account.

SUBSCRIPTION PRICING WHEN PAYING BY CHEQUE OR CREDIT/DEBIT CARD

6 ISSUES [ ] UK £30 [ ] Europe £45 [ ] Rest of World £50

12 ISSUES [ ] UK £65 [ ] Europe £80 [ ] Rest of World £90

2 CHEQUE

I enclose a cheque for ___________________________ (made payable to Select Publisher Services Ltd)

3 CREDIT/DEBIT CARD [ ] Visa [ ] MasterCard [ ] Maestro [ ] Switch

Card number [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
Expiry date [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
Issue number [ ] (if shown) Security number [ ] [ ] [ ] [ ] (last 3 digits on the back of the card)

Signature ............................................................................................................................... Date [ ] [ ] [ ]

I would like my subscription to begin from issue ___________________________ (month + year)

RETURN THIS FORM TO:

MagPi Magazine Subscriptions, Select Publisher Services Ltd, PO Box 6337, Bournemouth BH1 9EJ

[ ] Please tick this box if you DO NOT want to receive any other information from Select Publisher Services Ltd.

[ ] Please tick this box if you DO NOT want to receive any other information from other companies.

[ ] Please tick this box if you DO NOT want to subscribe to The MagPi newsletter.
When Martin Mander saw The MagPi was giving away a free hardware voice kit from Google in issue 57, he did the sensible thing and rushed off to buy a copy. But after he assembled the components, placed them in the cardboard housing, and pressed the button to activate the Google Assistant to ask a question, he started to think about the future possibilities.

Ironic, then, that he promptly delved into the past. “The family and I enjoy the local car-boot sales and I’m always looking for old, obsolete or broken technology that I can use in projects,” he says, relishing the chance of picking up something from the 1970s and 1980s.

He noticed some intercoms which were in their battered original packaging, and he thought it’d be fun for the kids to be able to chat between their rooms. “They didn’t work, and so I shelved them in the workshop,” Martin continues. “Then the Voice HAT came along and I decided it would be nice to preserve the spirit of these intercoms in a small way.”

Martin’s idea was to fit the Google AIY kit into one of these old units. “I’d followed the instructions in The

Eager to evoke a sense of nostalgia, retro nut Martin Mander decided to place his Google AIY kit inside an old FM wireless intercom

When Martin Mander saw The MagPi was giving away a free hardware voice kit from Google in issue 57, he did the sensible thing and rushed off to buy a copy. But after he assembled the components, placed them in the cardboard housing, and pressed the button to activate the Google Assistant to ask a question, he started to think about the future possibilities.

Ironic, then, that he promptly delved into the past. “The family and I enjoy the local car-boot sales and I’m always looking for old, obsolete or broken technology that I can use in projects,” he says, relishing the chance of picking up something from the 1970s and 1980s.

He noticed some intercoms which were in their battered original packaging, and he thought it’d be fun for the kids to be able to chat between their rooms. “They didn’t work, and so I shelved them in the workshop,” Martin continues. “Then the Voice HAT came along and I decided it would be nice to preserve the spirit of these intercoms in a small way.”

Martin’s idea was to fit the Google AIY kit into one of these old units. “I’d followed the instructions in The

Eager to evoke a sense of nostalgia, retro nut Martin Mander decided to place his Google AIY kit inside an old FM wireless intercom

When Martin Mander saw The MagPi was giving away a free hardware voice kit from Google in issue 57, he did the sensible thing and rushed off to buy a copy. But after he assembled the components, placed them in the cardboard housing, and pressed the button to activate the Google Assistant to ask a question, he started to think about the future possibilities.

Ironic, then, that he promptly delved into the past. “The family and I enjoy the local car-boot sales and I’m always looking for old, obsolete or broken technology that I can use in projects,” he says, relishing the chance of picking up something from the 1970s and 1980s.

He noticed some intercoms which were in their battered original packaging, and he thought it’d be fun for the kids to be able to chat between their rooms. “They didn’t work, and so I shelved them in the workshop,” Martin continues. “Then the Voice HAT came along and I decided it would be nice to preserve the spirit of these intercoms in a small way.”

Martin’s idea was to fit the Google AIY kit into one of these old units. “I’d followed the instructions in The

Eager to evoke a sense of nostalgia, retro nut Martin Mander decided to place his Google AIY kit inside an old FM wireless intercom

When Martin Mander saw The MagPi was giving away a free hardware voice kit from Google in issue 57, he did the sensible thing and rushed off to buy a copy. But after he assembled the components, placed them in the cardboard housing, and pressed the button to activate the Google Assistant to ask a question, he started to think about the future possibilities.

Ironic, then, that he promptly delved into the past. “The family and I enjoy the local car-boot sales and I’m always looking for old, obsolete or broken technology that I can use in projects,” he says, relishing the chance of picking up something from the 1970s and 1980s.

He noticed some intercoms which were in their battered original packaging, and he thought it’d be fun for the kids to be able to chat between their rooms. “They didn’t work, and so I shelved them in the workshop,” Martin continues. “Then the Voice HAT came along and I decided it would be nice to preserve the spirit of these intercoms in a small way.”

Martin’s idea was to fit the Google AIY kit into one of these old units. “I’d followed the instructions in The

Eager to evoke a sense of nostalgia, retro nut Martin Mander decided to place his Google AIY kit inside an old FM wireless intercom

When Martin Mander saw The MagPi was giving away a free hardware voice kit from Google in issue 57, he did the sensible thing and rushed off to buy a copy. But after he assembled the components, placed them in the cardboard housing, and pressed the button to activate the Google Assistant to ask a question, he started to think about the future possibilities.

Ironic, then, that he promptly delved into the past. “The family and I enjoy the local car-boot sales and I’m always looking for old, obsolete or broken technology that I can use in projects,” he says, relishing the chance of picking up something from the 1970s and 1980s.

He noticed some intercoms which were in their battered original packaging, and he thought it’d be fun for the kids to be able to chat between their rooms. “They didn’t work, and so I shelved them in the workshop,” Martin continues. “Then the Voice HAT came along and I decided it would be nice to preserve the spirit of these intercoms in a small way.”

Martin’s idea was to fit the Google AIY kit into one of these old units. “I’d followed the instructions in The
The MagPi to assemble the HAT and get the software up and running on the Pi,” he recalls. With the Pi and HAT running on his desk, he tested some voice commands before getting on with the task of cracking open the old intercom. “There’s always a slight feeling of naughtiness in ignoring the ‘do not open’ warning and seeing what’s inside,” he says. “The great thing about older tech is things tend to be screwed or bolted together, allowing them to come apart nicely, leaving just the case.”

Having made lots of tiny measurements, he was convinced the kit would fit, so he cleaned and spray-painted the front of the case, let it dry, and began bolting the Pi into the case, adding the other components around it. “I set aside the green push–button from the kit, but kept the microswitch and fixed it inside the case alongside the big hinged intercom button.”

Getting the microswitch in exactly the right place was the greatest challenge and it involved lots of trial and error: “Because it was being activated at an angle by the rear of the button, even a couple of millimetres made the difference between the microswitch sticking ‘on’ or there being too much play in the action.”

Martin then removed the LED from its case and soldered in a two-hole component connector to secure it between the Pi’s USB ports, under the original microphone grille. “The kit’s microphone board was just glued into place once I’d drilled holes in the top of the case. Once that was in place, I connected the cables and closed the case.”

Martin is pleased with the result: “The kids have described it as fancy and futuristic, which I’ll happily take.” He has since linked the intercom to his IFTTT account (see ‘A connected home’ box). “This took some configuring,” he concludes, “but thinking up responses for the intercom to read out when the triggers are activated was really good fun.”
"I’m grateful for finishing this project," says maker Eunice Lee as she holds a button while speaking into a large silver microphone. A printout of the sound waves produced by her voice emerges from the device’s thermal printer.

This is a demonstration of Waves, a side project created by Matt Zhang with Eunice Lee and Bomani McClendon, students of design and computer science at Northwestern University in Illinois.

"During our first meeting, we shared some inspiring hardware projects we’d seen, and had a brainstorm session where we drew out lots of wild, funny, and weird project ideas on Post-it notes," recalls Bomani. "Afterwards, we voted on the ideas and filtered them by feasibility, materials cost, and (most importantly) excitement. We chose Waves,

Below Matt Zheng looks pleased with the thermal printout of his answer – we wonder what he’s grateful for!

Quick Facts
- The project took 7-8 hours to make
- A controller script handles subprocesses
- There’s no maximum recording length
- The same amount of paper is used each time
- Build details and code are on GitHub magpi.cc/2vANCvc

Above Two printouts of different responses, both answering the question on the left

Below

WHAT'S YOUR MOTTO?

WHY ARE YOU GRATEFUL FOR TODAY?

MAKE A WISH!

GIVE US YOUR BEST LAUGH

Holding the relevant colour-coded button, the user records their answer

Users choose to answer one of four open-ended questions

The thermal printer plots a waveform of the recorded response
Four push-buttons – one for each question – are placed on a breadboard and connected to the Raspberry Pi’s GPIO pins. The user holds down a button while recording their response.

The four questions are printed on cards with coloured stickers matching the ones next to the push buttons on the device. A cool-looking Blue USB mic records the user’s voice.

A Python script converts the recording of the user’s answer into a graphical waveform to print. “The programming wasn’t too tricky, since we borrowed a lot from open-source Python code,” says Matt. “The plots take up the same amount of paper, no matter how long the recording is, but we have to manually adjust the volume on the microphone, to make sure that the audio doesn’t blow out or disappear entirely.”

The result can also be uploaded to a locally hosted website, which was displayed on a monitor during an annual Design Expo at the university. “The idea for the website was that people could see other people’s sound waves and wonder what was said,” says Eunice. “It was a really fun addition that turned some heads and made people interested in what our project was.”

Eunice was delighted with the overall reaction to Waves: “It was really great to see people’s faces light up when they finished recording and saw their sound waves being printed. [...] The best part was being able to give that to the user and say, ‘You can keep it!’.”
ver since he saw Breakdance: The Movie in 1984, Daniel James wanted to be a DJ. But he soon realised scratching expensive vinyl or carting it from venue to venue is far from ideal. “Unless you are famous enough to have a roadie, large boxes of vinyl are heavy and impractical,” he tells us. There’s also the problem that a lot of music is not being released on analogue vinyl, despite the huge resurgence of interest in the format.

Digital Vinyl Systems (DVS) have long provided an alternative. They allow you to DJ using digital music files and software while letting you benefit from the feel of a turntable. You simply place a special vinyl record on a standard turntable and the system will read the position of the stylus from a timecode. This is used to play back a digital music file at the same point in time – but these systems can be hugely expensive.

Not now. Daniel and his colleague Chris Obbard at 64 Studio put a Raspberry Pi 3 alongside a standard vinyl deck, eliminating the hassle and expense of hooking digital decks to a laptop. They figured that
all you need is a USB stick packed with music files. “As long as there is low latency in both directions of travel, you can make effects such as rubbing the kick drum beats, scratching and backspins sound, feel and look realistic,” Daniel says.

Motivated by a desire to show that low latency applications could work reliably on small and inexpensive ARM devices such as the Pi, Daniel and Chris got to work. They used xwax (xwax.org), an open-source DVS for Linux capable of playing MP3, FLAC, and AAC files, among others. “But because xwax isn’t easy for people new to GNU/Linux to set up the system optimally, we created a ready-made Debian image for the Raspberry Pi that is specialised for this one application,” reveals Daniel. “It means DJs don’t have to go through as many steps to get it running.”

The pair had tested Raspbian images and various kernels with hand-soldered audio hardware to create the inputs and outputs that they needed. “Then we tried a HAT sound card from audioinjector.net and some USB audio interfaces which include phono cartridge preamplifiers. These are needed because the stylus on the record outputs a signal at a very low level, compared to other audio devices.”

The greatest challenge was getting the audio interfaces to work with low latency since many of the known techniques are for PC architecture. “Interrupt tweaking doesn’t work the same way on the ARM architecture, for instance,” Daniel explains, “but switching to newer Linux kernels helped a lot.” The majority of the work involved configuring and scripting various programs to work smoothly together with minimal user input. “Most of the setup is done with shell script, which is easy to hack.”

A screen completed the package. Daniel and Chris decided to use the official Raspberry Pi seven-inch touchscreen. “We wanted something that would be easy to set up,” Daniel continues, “but the Pi Deck works with any compatible screen. If you’re not using a touchscreen, an ordinary mouse can be used to click the buttons. A QWERTY keyboard is useful for searching music titles.”

Since creating the Pi Deck last October, the pair have been excited at the level of positive feedback. Hearing about people using it across the world has been music to their ears. “People appreciate the low latency and stability,” Daniel concludes. “These are the crucial factors for any performance.”
animator by trade, Alonso Martinez wanted to take his maker skills to the next level. He decided to explore the idea of interactivity with robot characters by creating Gertie, Mira and Lumens.

With Gertie, he was able to explore the idea of the ball bounce – a staple in animation school, where students are asked to animate a ball, and the reaction of its surface when it connects with another object. Where Gertie excelled at bouncing, there was still a lack of the emotion and personality that Alonso hoped to achieve.

Alonso learned the majority of his maker skills from internet videos. Mira went through multiple designs before her final egg shape. She charges via a small port on her base. Mira’s small onboard camera can utilize face recognition. Alonso’s next build, Lumens, doubles as a night light.

Mesmerising Mira

Enter Mira. Alonso wanted to create a character that was not only aesthetically pleasing and highly interactive, but also able to explore the science behind how we perceive a character based on its shape and features. Mira’s round form is the result of a study into shape science. Her lack of limbs and sharp edges creates an instantly accessible and pleasing character. And her eyes, with their mini LED screens that blink with their deep, somewhat galactic blue orbs, draw us to her that little bit more.

Mira's blinking eyes are powered by two small LCD screens that run constant animations.

Her shape is the result of an exploration into shape science, and how we perceive certain features.

Mira's recent appearance on the YouTube Tested channel attracted a storm of people desperate to buy their own Mira.
But Mira is more than just a pretty face. Inside her body lies a Raspberry Pi, laden with code. Cover your face, for example, and Mira will recognise the game of peekaboo via her on-board camera, offering up a shocked squeal of excitement when you say “Boo!” and reveal yourself. Sit Mira beside you at a piano and she’ll sing back to you any note that you play, shaking her head like a bird from a classic Disney movie. And while all this interaction is fun and pleasing, Alonso is planning to take the build further.

Robotic evolution
Alonso wants to explore the idea of code evolution through interaction and play. While it’s cute to play with Mira – or her successor Lumens, a mushroom-shaped light that hides under its cap – what if she could do more with the information received? What if, through the unique individuality of the user, the robot created its own, similarly unique personality? While explaining the concept, Alonso touches on Conway’s Game of Life and the concept of cellular automation with code. Could Mira and Lumens build their own code and truly create their own unique identities?

Millimetre-perfect
Stepping back from the mind-blowing concepts of interactive, intelligent robots, the physical build behind Mira and Lumens is equally impressive. As an animator, Alonso is highly skilled in 3D design using the computer animation software, Maya. And it was through Maya that Alonso sculpted his robots, enabling him to recreate the Raspberry Pi and components, and measure his 3D prints to the millimetre. Those blinking eyes that give Mira so much personality come from two ultra-thin screens that slip between the two layers of her body. The space was so tight that Alonso found himself having to sand down solder just to make them fit. And as for the way her ‘head’ moves over several axes? He took the idea of the joystick he’d used as a child to play games and recreated the function using 3D-designed and printed parts.

Mira and her growing family are constantly evolving, and we look forward to seeing how Lumens takes shape moving forward. Hands up who wants their own?

Her lack of limbs and sharp edges creates an instantly accessible and pleasing character

With his latest creation, Lumens, Alonso aims to incorporate the function of a night light into the robot while maintaining the ideas behind Mira.
Editing text documents is a vital skill to learn when using a Raspberry Pi.

**You’ll Need**
- Raspberry Pi
- Raspbian OS

A secret that most computer makers don’t tell you is that underneath all the gloss and shine of modern operating systems, it’s all text. Every menu, every button, and every setting of every program started as a text document somewhere.

In Raspbian, which is based on Debian Linux, you are far more likely to need to edit text files than on computers running MacOS or Windows. This is a great thing. It lets you get under the hood and really see what’s going on.

You may remember the days when computers had text-based interfaces, or you may have only pushed buttons and tapped icons until now. No matter – you will now need to edit text.

There are a lot of different ways to edit text, and everybody has their own favourites. Here were going to look at the two main options: Text Editor (also called Leafpad) and Nano.

**HOW TO:**

**EDIT TEXT FILES**

>STEP-01

**Viewing text**

We’ve downloaded the release notes for the latest version of Raspbian to view and edit. You can get them from magpi.cc/us7N6sk. Right-click and save the file to your Pi folder. Open a Terminal window. Open the File Manager and double-click the release_notes.txt file to view it in Text Editor.
>STEP-02
Using cat
Often you'll be working with text files from the command line. The way to do this is using cat (short for ‘concatenate’). Open the Terminal and enter `cat release_notes.txt`. The text will fly up off the top of the screen. To view the text one page at a time, pipe it through `more` and press SPACE to move one page at a time.

`cat release_notes.txt | more`

>STEP-03
Open text
You can open a text file in Text Editor from the command line using `xdg-open` (this will open a file in its default associated app).

`xdg-open release_notes.txt`

This is a handy compromise between working on the command line and text editing in a friendly graphical environment. It’s the best way to edit text files when you first start.

>STEP-04
Nano
You won’t always have access to the GUI when working in the command line, and you should quickly learn to edit text files without heading to the GUI. The way to do this is using a text editing app called Nano.

`nano release_notes.txt`

>STEP-05
Cut and paste
Nano works just like a word processor – although, without a cursor and interface, you may find it quirky. Move around with the arrows and enter and delete text. You can cut lines of text using `CTRL+K` and paste with `CTRL+U`.

>STEP-06
Save and close
When you’ve finished editing a text file, you save it using the Writeout function. Press `CTRL+O` and enter `Y` to save the file. Use `CTRL+X` to exit and close Nano and return to the command line.
UNCOMPRESSING FILES ON A RASPBERRY PI

How to extract just about any file on your Raspberry Pi

You’ll Need

- Raspberry Pi
- Compressed files

Files downloaded from the internet almost always arrive on your computer as compressed files. Files are often compressed before being made available for transfer. The reduced file sizes are quicker to download, smaller to host, and save money on bandwidth.

Pretty much everybody is familiar with the concept of a compressed file, often called a ‘zipped’ file thanks to the early, and still popular, zip format. Uncompressing, or ‘unzipping’ a compressed file isn’t a complicated task, but there is a baffling array of different compression techniques and files, each requiring its own tool and technique for restoring the file to its former glory.

In this feature we’re going to look at the different compressed file types you’ll come across when using a Raspberry Pi, and how to go about unzipping them.
UNCOMPRESSING FILES ON A RASPBERRY PI

Tutorial

HOW TO: UNCOMPRESS FILES

>STEP-01 Archiver
Your first stop for uncompressing any file on your Raspberry Pi should be to use Archiver (magpi.cc/2wmJWO5). This lightweight desktop app, also known as Xarchiver, is included with Raspbian and can handle 7-zip, arj, bzip2, gzip, rar, lha, lzma, lzop, deb, rpm, tar, and zip archives. Open it using Menu > Accessories > Archiver.

>STEP-02 Open archived files
Choose Archiver > Open or click on the ‘Open an Archive’ icon. Choose a compressed file (typically it’ll be saved in your Downloads folder) and click Open. It may take a while to scan the file, depending on its size. We’re using the RISC OS image from here (magpi.cc/2w2H34Z) as a test.

>STEP-03 Select and view
Typically, you’ll want to extract all the files in a compressed image, but it’s worth knowing that you can select individual files and extract them. You can also double-click on files in the compressed image inside Archiver to view them (handy for ReadMe files).

>STEP-04 Extract
The Extract Files window is straightforward. If all you want are the files, then click Extract and they’ll be saved into the same location (typically Downloads). You can change the Extract To folder, but you won’t have sudo privileges, so stick to directories inside /home/pi/. You can also enter the password to access restricted compressed files. The icon in the bottom-right corner of Archiver will flash green and red while it extracts the files, and solid green when it’s done.

Terminal

You may need to extract files while working from the command line. There’s a range of tools you’ll need — some are installed on the Raspberry Pi and others you’ll need to acquire with apt-get. Here are the commands you need for many popular extension types. Enter man and the file type, such as man tar, to view more information.

File extension: .tar
tar xvf filename.tar

File extensions: .tar.gz, .tgz, .tar.bz
tar xzvf filename.tar.gz

File extension: .gz
 gunzip filename.gz

File extensions: .bz, .bz2
bunzip2 filename.bz2

File extension: .xz
unlzma filename.xz

File extension: .zip
unzip filename.zip

File extension: .7z
sudo apt-get install p7zip-full
7z x filename.7z

File extension: .rar
sudo apt-get install unrar-free
unrar x filename.rar
ack in The MagPi #58 we showed you our Hexome simulator, running on a mobile device and controlling a sequence. It used concentric rings of trigger positions, starting with a ring of six with each subsequent ring having six more trigger positions. Now we take that basic idea, run with it, fall over, pick up the pieces, and assemble it into a universal polyrhythmic sequencer.

The basic concepts are the same, but this project gives us nearly unlimited flexibility. Each ring generates only one note, and those notes can be changed by mapping. However, almost everything else has changed. There are up to six rings in the sequence: each ring can have a maximum of 32 trigger positions, and can be individually muted. The big change is that each ring can have its own individual sound and volume, courtesy of MIDI.

**MIDI connection**

MIDI stands for Musical Interface for Digital Instruments. It is a very old standard, but still as popular as ever. MIDI is a serial interface that sends messages between musical devices, which include instruments (like a keyboard), and sound modules that generate an audio signal. Some devices can combine the two categories in one device – the most popular being sound-generating keyboards. Messages consist of two or three bytes, and cover commands such as Note On and Note Off, as well as other controls, including volume, vibrato, echo, and pitch bend.

A MIDI connection can control 16 different channels, where a channel can range from one voice or sound to a totally separate piece of hardware. Often instruments have a switch that determines the channel they transmit on, and most will default to channel 1.

MIDI runs at the quirky baud rate of 31,250 baud. It is odd by today’s standards, but in the old days it was used because it was simple to generate. A MIDI device can have an input and an output, and, much to the surprise of younger people, an input must be connected to an output. There can also be a MIDI ‘Thru’ (‘through’ in English), which is simply the

---

**You’ll Need**

- MIDI / USB interface lead
- MIDI sound module (any type)

---

**Figure 1**
A block diagram of the complete hardware setup
signal from an MIDI input, passed to an output, allowing one MIDI output to talk to a number of inputs in a chained fashion.

The quirky baud rate is a historic accident. At the time, you would have used a 1 MHz clock for your processor, which you simply divided by two to give 500 kHz. This was fed directly into the UART (serial chip), which required a clock signal of 16 times the baud rate, giving you 31,250 baud. While the Raspberry Pi can’t support that rate directly, it can be helped to do so. Although this was relatively simple on earlier models, the Pi 3 uses the good serial port for Bluetooth, and the second serial port is tied to the clock speed – which can be variable depending on processor demand and temperature. The simplest solution is to bypass the serial port and plug in a USB/MIDI lead. While these used to be expensive, today you can find them for less than £5.

We also chose to use a hardware MIDI sound module for this project. We used the Yamaha MU10, but there are any number of modules that could be used – many available second-hand at bargain prices. There are many other options for this project – see the ‘Taking it further’ section at the end of this article. The basic setup we used is shown in Figure 1.

Why MIDI?

So why use MIDI for this project? Other projects we have worked on involving sound generate that sound by playing samples. Those samples have to be found, recorded and put into the appropriate files. If you want to use more than a handful of different instruments, this is a lot of work. It can also result in an unsatisfactory quality of sound, because you can't control the individual volume, and you can experience audio clipping if too many samples are played at the same time. By using MIDI, we can leave the instrument or voice generation to another piece of hardware or software.

Polyrhythmic sequencer

The original Hexome was based on a hexagonal grid of concentric circles. This gave an inner ring of six positions. Around that was a circle of 12, around that a circle of 18, and so on. This led to a rule that any ring Rn has the number of positions in Rn given by:

\[ R_n = R_{n-1} + 6 \]

...where Rn-1 is the number of keys in the previous ring. With this software, we can base the rings on any number, so that formula becomes:

\[ R_n = R_{n-1} + B \]

...where B is the base number of the innermost ring. This leads to the concept of a Triome, based on three positions on a ring – or a Quadome, Pentome, Heptome or Octome. Each of these models can be set up using this software. Additionally, any number of trigger points can be set up on a ring, up to a maximum of 32. For example, if each ring has the same number of trigger points, you have simply produced a conventional N step sequencer.

The length, or number of steps before repeating, of any particular setup is given by the highest common factor of each of the rings. This is maximised in setups where the rings contain a prime number of trigger points, as this gives a sequence length of the number of trigger points in each ring multiplied together. If you start at two triggers for the smallest ring, this gives a staggering 30,030 steps before a repeat. Starting with a base of three you get even more, at 255,255. At these sequence lengths, the result is indistinguishable from random sounds.
would need a window measuring at least 1100×860 pixels. Each ring is limited to a maximum of 32 trigger points, again due to the physical resolution of the screen. This is despite using the trick of changing the ring width depending on the number of trigger points.

The Code

This code is written in three sections, or tabs: these are Poly, Controls, and Note_Map. In the Poly tab, the line at the start:

`MidiBus.list()`

lists all the MIDI devices that have been recognised by the computer, both as input and output devices. We are only interested in output devices, and it is likely that you will only have one such device plugged in. If so, the line:

`MidiBus(this, 0, 1)`

...which selects the MIDI device to use, will not need to be changed.
BUILD A POLYRHYTHMIC SEQUENCER

The controls

Figure 2 shows the screen, with an explanation of the controls and what they do. In order to fit round the circles, and to minimise the window width required, the controls are scattered around the outermost circle. Most of the controls need repeating for each ring, including the ring length and mute controls. Others apply to the whole instrument, including the speed control, along with the Stop/Start, Reset and Clear commands.

The configuration controls give you some preset rings and trigger position numbers. These can be modified by the ring length controls, but it is a convenient place to start. The instrument controls determine the voices for each ring. On startup, this is set to 0, which is a Grand Piano. For a list of which instruments correspond to each number, see the implementation sheet for your MIDI sound module.

On the lower right-hand side of the screen is the MIDI channel for each ring. These can be set to the same channel to play all the notes with the same voice. Similarly, the Velocity number determines how hard an instrument is ‘struck’. You might like to think of this as a volume control, which in a way it is – but a good sound module will also subtly change the timbre of the sound as the velocity increases.

The note mapping is controlled by the buttons running down the right-hand side of the window. This controls which notes are generated on each ring, as defined in the Note_Map code tab. The top five are arranged in thirds, ascending; whereas the next five are in a pentatonic scale. It is a good idea not to change between these in a single piece, as the resulting key change can be jarring. The lower seven mappings are simple single-note shifts in the key of C major. These settings can easily be changed by altering the code in the Note_Map code tab. Figure 3 shows three different setups for the program.

MIDI channel 9

There is something special about MIDI channel 9. When you use this channel, for each note number you don’t get a change in note pitch, but a different percussive instrument, including cymbals, drums, cowbells, blocks, and whistles. With the same mapping as the pitched notes, it can be pot luck as to which instrument ends up here.

It is possible that as you change some parameters on the fly, you can be left with a hanging note. This is a note where the sound module has received a Note On message, but no corresponding Note Off message. If you get a hanging note and want to reset it, click the Reset control. This sends Note Off messages to all possible notes on all possible channels, a process which takes less than two seconds.

Taking it further

You can extend any program. Despite its flexibility, this one is no exception. The most useful change you could make is to include the ability to save and load the patterns and controls you have created. It is just a matter of saving the appropriate arrays, and restoring them when you load the program. You also might like to have a special set of mapping that kicks in when the percussion channel, channel 9, is selected. You might want to use a soft synth as your sound generator – this could be on another computer, another Pi, or on the same Pi you are using to run the software. The fluidsynth and qsynth combination is popular on the Pi, but there are several MIDI-capable synthesizers out there. You could even investigate routing the output of this sequencer into Sonic Pi.
WINE SAVER:
ROOM TEMPERATURE MONITOR

This project monitors the temperature of a wine storage room hourly, and sends an email when it exceeds an ‘alarm’ or ‘fail’ level

We have a wine storage unit in our garage, and over the last 20 years the compressor has failed twice during extreme heatwaves. We weren’t constantly checking the temperature display, so we had no warning of the impending failures, which would have allowed us to move the wine to an air-conditioned location and have the compressor repaired. This project provides hourly logging of the temperature, and sends warning emails if the temperature exceeds set limits.

Software setup
Download and install the latest version of Raspbian Jessie Lite on your microSD card. Initialise Raspbian with `sudo raspi-config` to the proper international options (time zone, keyboard, wireless country code, etc.), change the default password, and set the host name in advanced options to something like ‘wineroom’. Make sure that you enable both SSH and 1-Wire in the Interface section of raspi-config.

Reboot (otherwise your keyboard settings may not be correct), and set up the wireless by editing the relevant config file: `sudo nano /etc/wpa_supplicant/wpa_supplicant.conf`. Add these lines to the end:

```
network={
  ssid="your ssid"
psk="your password"
  key-mgmt=WPA-PSK
}
```

Be sure to replace "your ssid" and "your password" with the actual values for your network, and keep the quotes. Now reboot again.

Use the `ifconfig` command to see the IPv4 address that you will need to SSH into the Pi later. Write it down (192.168.1.27 or 10.0.0.27 are typical values). Now you should run the usual update and upgrade to the operating system:

```
sudo apt-get update && sudo apt-get upgrade -y
```

Next, install the mail and ssmtp applications:

```
sudo apt-get install ssmtp heirloom-mailx
```

Edit the ssmtp configuration file to point to your Gmail account as shown. Add the text below to the end:

```
network={
  ssid="your ssid"
psk="your password"
  key-mgmt=WPA-PSK
}
```

Add your actual Gmail account details:

```
host="smtp.gmail.com"
user="your email"
pass="your password"
```

Next, add the following lines to your `/etc/default/ssmtp` file:

```
UseLocalDelivery = true
```

Then enable it as the default mail server:

```
sudo update-rc.d ssmtp default
```

Finally, run the test email script:

```
nohup python -m smtpd -n -c DebuggingServer localhost:1025
```

This will send an email to yourself, telling you that it worked.

---

You’ll Need
- Pi Zero W
- 4GB (or larger) microSD card
- Suitable case for the Pi
- Waterproof DS18B20 temperature sensor
- Stacking header
- Gmail account
- Empty wine bottle and a cork that fits it

Note the sensor connections to the header for the GPIO
A temperature sensor is installed in the cork, passing through into the water in the bottle
of the configuration file with `sudo nano /etc/ssmtp/ssmtp.conf`.

```
# Wine Room Monitor settings - for gmail
hostname=wineroom
root=your-mail@gmail.com
mailhub=smtp.gmail.com:587
AuthUser=your gmail name (leave out the @ and stuff after that)
AuthPass=your gmail password (no quotes needed here)
UseSTARTTLS=YES
UseTLS=YES
AuthUser=LOGIN
```

Now save the file and exit. As we will run the monitor program with `crontab`, we must also change the `/etc/ssmtp/revaliases` file or authentication errors will occur. So, `sudo nano /etc/ssmtp/revaliases` and add the following line:

```
root:your-email@gmail.com:smtp.gmail.com:587
```

Now reboot.

### The program

Log back into the Pi. First, create a directory called `wineroom` and move into it:

```
mkdir wineroom
cd wineroom
```

Download the `ds18b20.c` file from GitHub ([magpi.cc/2uBzlR4](magpi.cc/2uBzlR4)) and customise it for your email address and your alarm temperature levels. To compile:

```
gcc ds18b20.c -o ds18b20 -Wall -std=gnu99
```

### Hardware setup

Take the wine bottle cork and cut it to half its length with a hacksaw. Carefully clamp it and use a ¼ inch bit to drill a hole lengthwise through the centre of the cork. Next, push the DS18B20 sensor’s stainless steel through the cork so that it is protruding from the other end – this is why we cut it in half. Wetting the sensor may make insertion easier. Now rinse the wine bottle with hot water and fill it nearly full of water. Wet the cork and push it carefully into the bottle, then put the bottle on its side to check for leaks. You may need to add a bit of silicone to seal around the sensor.

On the stacking header, solder a 4.7 kΩ resistor to Pin 1 and Pin 4. Solder the sensor red wire to Pin 1. Solder the white wire to Pin 4; the black wire to Pin 5.

Now plug the header onto the Raspberry Pi (make sure it’s off!), being careful to get the location of Pin 1 correct. Boot the Pi up, log in, and test it with:

```
5 * * * * /home/pi/wineroom/ds18b20
4 0 1 * * /home/pi/wineroom/logupdate.sh
```

Save the file, then to get the new `crontab` entries working:

```
sudo service cron start
sudo update-rc.d cron defaults
```

Use some Velcro on the bottom of the Raspberry Pi Zero W case to attach it to the cooler unit. If there is no power plug inside the wine cooler, remove a bit of the sealant around the cooler and run a micro USB power cable through. Then replace the sealant to close the system back up, power it up, and let it run!
3D PRINTING
WITH YOUR RASPBERRY PI

Climb on board the 3D printing bandwagon on a budget, using a cheap but powerful printer controller with a Raspberry Pi at its core.

You’ll Need
- 3D printer with updated firmware and USB connection
- Spare microSD card
- WiFi connectivity (USB WiFi dongle if needed)
- Official touchscreen
- Repetier Pro subscription (optional)
- USB webcam (optional)

The rise of 3D printers has seen numerous inexpensive models becoming available in the £100–£150 bracket, but what is the best way to interface with them? A Raspberry Pi, of course! This tutorial will cover the things you need in order to control your already working 3D printer with a Pi, allowing you to have remote access and monitoring capabilities for your printer from anywhere in the world, as well as the ability to start printing, cancel, and tweak the settings mid-print, thanks to our favourite little credit-card–sized computer.

Choosing your printer
If you are not already lucky enough to be the proud owner of a 3D printer, then the first step is to choose one to buy. There are many options on the market, ranging from £100 to upwards of £1,000, with reliability and quality a considerable factor in these price differences. In an attempt to keep the cost of this project low, we opted for a £150 Prusa i3 clone new from eBay. The printer came as a kit and required some adjustments, along with some Googling due to difficult-to-translate instructions.

Even so, this should be easy enough for a complete 3D printing novice.

There are many of these clones available at a similar price online. If you would prefer a branded budget printer, you can buy a Startt printer for £99 from imakr.com. However, it still requires building and adjusting, and has a smaller build volume than the Prusa. For larger amounts of money, the official Prusa 3D printers can be purchased, as well as many others. As this market has grown so rapidly, there are countless options. When buying a 3D printer for use...
with a Raspberry Pi, ensure that the printer has a USB interface and that the firmware is recent.

**Setting up the software**

Once you have built your printer by following the specific instructions, you should be able to print normally, if directly connected to a computer. You’ll soon realise that this is a solution with very limited functionality, as you have to be directly connected to the printer in order to make any changes to it.

To set up the software on your Raspberry Pi, head to [magpi.cc/2vBupZw](magpi.cc/2vBupZw) and download the OS image specified for the Raspberry Pi. Once you have done this, unzip the file and write the image to your microSD card.

If you are using an official touchscreen, connect this to your Pi, as well as a method to connect to a WiFi network if needed. Once the Raspberry Pi is powered on, the touchscreen will display the option to connect to a wireless network, which is vital. Follow the on-screen instructions. If you are not using a touchscreen, you can follow a step-by-step guide to setting up WiFi at [magpi.cc/2vBe739](magpi.cc/2vBe739). Troubleshooting for any problems that may arise while setting up the internet connection and installing the OS can also be found here.

You will then need to set up your printer on the system by inputting the type of printer, as well as its size, shape, and manufacturer. The process is fairly foolproof, and you will be guided through it step-by-step.

**Using Repetier software**

The majority of the following information will mainly apply to those using the official touchscreen to interface with their printer.

Once the internet connection is set up, you will see a menu similar to the one shown in Figure 1. Navigating these menus will allow you to directly control the printer’s motors, as well as viewing network settings and sending emergency stop commands. One of the best features of the software is the fact that you can access the printer remotely via the local network by navigating to the Pi’s IP address on any device connected to the same LAN. This allows you to upload files to the server to be printed, as well as allowing you to view the progress of prints and cancel them. You can also view a live picture feed of the printer if you connect a USB webcam to the Pi.

For a better experience, installing Repetier-Host ([magpi.cc/2vBgs4f](magpi.cc/2vBgs4f)) on a PC will offer a more streamlined process that allows you to slice STL files and upload them directly for printing, as well as offering built-in direct control of your printer without the latency introduced by using a web browser.

**Printing**

As a beginner, it’s easy to feel intimidated by all the different file types and methods for printing a predesigned object, but there are several industry-standard methods that are almost always used.

Most 3D designs from online sites such as thingiverse.com will be in the form of an STL file that contains the actual shape data of the object. In order to print this design, the file will need to be ‘sliced’, which converts the shape into exact instructions for the printer’s movements. Slicers such as Cura can be found online, however, the Repetier-Host software for PC contains a built-in slicer. By slicing the file, the software will generate instructions for printing based on your printer’s exact parameters, including its size and shape. Once the STL file has been sliced, a G-code file will be created, which can be uploaded directly to the printer and run in order to print the object.

![Figure 1](https://via.placeholder.com/150)

*Figure 1* Printer control is also accessible via the internet over a local connection on any device.
Share your live-coding performances with listeners anywhere on the internet using Sonic Pi, some simple Python code, and MQTT.

Originally created as an interactive and fun instructional tool for teaching both programming and music, Sonic Pi is also a very powerful tool for creating sophisticated live performances as well as algorithmic compositions, all by writing code. It’s perfect for people who love to code and love to create music, even if they can’t play an instrument. Best of all, Sonic Pi is included in Raspbian, making it easy to get started with coding your own musical creations on your Raspberry Pi. Wouldn’t it be great if you could share those creations over the internet? In this project, we’ll show you how!

Sharing Sonic Pi compositions

For this project, we will assume that you are at least somewhat familiar with the Sonic Pi GUI and its coding language, and you have at least tried some simple code or played with the many examples included with Sonic Pi. If not, check out the Essentials book, *Code Music with Sonic Pi*, for some excellent beginners tutorials: magpi.cc/1VGIOux.

Our goal for this project is to give you a way to go beyond playing your Sonic Pi compositions for whoever happens to be in the room with you. We’ll show how you can share your Sonic Pi coding creations with your friends, family, and fans over the internet, so they can listen to your musical masterpieces virtually anywhere in the world.

To do that, we have created a couple of simple Python programs that can interface with Sonic Pi, and communicate with each other over the internet, using a lightweight IoT messaging protocol called MQTT.

MQTT is a publish/subscribe messaging transport protocol (in case you are wondering, MQTT originally stood for MQ Telemetry Transport, but is no longer officially an acronym). It was designed to be very lightweight, simple and easy to implement and is most commonly used for communication in machine–to–machine and Internet of Things applications.
The main aspect in the publish/subscribe pattern is the decoupling of publisher and receiver, where the publisher and subscriber don’t know about the existence of one another, don’t have to run at the same time, and are not halted during publishing or receiving. A third component, a broker, is known by both parties: this filters and distributes all incoming messages by subject/topic.

For this project, we have created two Python programs that use the Eclipse Paho MQTT Python client library to implement an MQTT publisher and subscriber. The programs use the public Eclipse IoT MQTT broker at iot.eclipse.org to exchange messages.

The publisher program, `sp-mqtt-publisher.py`, is used to read a file that contains Sonic Pi code, and publish it to the Eclipse IoT MQTT broker. The subscriber program, `sp-mqtt-subscriber.py`, is then used to retrieve the Sonic Pi code from the broker and send it to Sonic Pi for playback.

**Getting started**

To get started, first download the two included Python programs, `sp-mqtt-publisher.py` and `sp-mqtt-subscriber.py`, and save them on your Raspberry Pi.

Next, you will need to install the Python MQTT client library from the Eclipse Paho project. This is easy with the Python package manager, called pip, which is included with Raspbian Jessie. Open a Terminal window on your Raspberry Pi and enter the following command:

```
sudo pip install paho-mqtt
```

Finally, you will need a way to send Sonic Pi code directly to the Sonic Pi synth server, rather than typing it into the Sonic Pi GUI. Currently, there is no built-in capability to play your compositions on Sonic Pi from the command line – although that is apparently planned for Sonic Pi 3. Consequently,
we are using sonic-pi-cli, written by Nick Johnstone (magpi.cc/2vBhoze). This provides a very simple command-line interface, written in Ruby, for interacting with Sonic Pi. Luckily, Ruby also comes as part of the Raspbian Jessie distribution, and sonic-pi-cli should work just fine with it. From the Terminal window, enter the following command:

```
sudo gem install sonic-pi-cli
```

This will install a Ruby script, called sonic_pi, in the `/usr/local/bin` directory on your Raspberry Pi, where it can easily be called from the Python code.

Try it out!

Once you have these components installed, it’s time to try everything out. First, let’s make sure that the sonic_pi Ruby program is working. Start by opening Sonic Pi. Once the Sonic Pi GUI is running, open a Terminal window and enter the following command:

```
sudo gem install sonic-pi-cli
```

Now it’s time to try a simple live-coding performance over the internet

This will install a Ruby script, called sonic_pi, in the `/usr/local/bin` directory on your Raspberry Pi, where it can easily be called from the Python code.

Try it out!

Once you have these components installed, it’s time to try everything out. First, let’s make sure that the sonic_pi Ruby program is working. Start by opening Sonic Pi. Once the Sonic Pi GUI is running, open a Terminal window and enter the following command:

```
sudo gem install sonic-pi-cli
```

You should hear the breakbeat sample loop that is included with Sonic Pi.

With that working, now it’s time to try a simple live-coding performance over the internet, using the two Python programs provided. With Sonic Pi open, copy one of the code examples included with Sonic Pi into a buffer. Then, using the Save button, save the buffer to a file. In the screenshot, we have chosen the tron-bikes example because, well – who doesn’t like the sound of Tron light cycles?

Once the buffer is saved to a file, run the `sp-mqtt-publisher.py` program from a Terminal window. You will need to include two command-line arguments when you run the program. The first specifies the MQTT topic name that you will publish to. Choose something that is simple and likely to be unique. The second argument is the name of the code file in which you saved the buffer from Sonic Pi. For example, you might enter the following command:

```
python sp-mqtt-publisher.py saulpimon tron-bike.txt
```

The publisher program will read the contents of the code file named on the command line, and publish it to the Eclipse IoT MQTT broker under the provided topic name. The publisher program runs an infinite loop, and every ten seconds will re-publish the code
to the MQTT broker. With each iteration of the loop, it will check to see if the code file has been updated and, if so, it will re-read the file before re-publishing, so that the most recent version of the live-coding composition is published to the MQTT broker.

Now, of course, this isn’t much of a live-coding performance without listeners, right? If you have a couple of friends who want to help, you can have them install the required components as described in the ‘Getting started’ section, and run the Python subscriber program, `sp-mqtt-subscriber.py`, to retrieve the published code from the MQTT broker and play it using Sonic Pi on their own Raspberry Pi. Or, if you like, you can run the subscriber program yourself on the same Raspberry Pi that you used to publish the code. To run the subscriber program, first be sure you have installed the Paho MQTT client and the `sonic_pi` Ruby script as described above. Next, open Sonic Pi and run the Python subscriber program, being sure to specify the same topic name that was used with the publisher above as a command-line argument. For example, enter the following command:

```
python sp-mqtt-subscriber.py saulpimon
```

The subscriber program will connect to the Eclipse IoT MQTT broker and retrieve messages that are published to the topic named on the command line. When a message is received, the subscriber program then calls the `sonic_pi` Ruby script, passing the retrieved message as data. The `sonic_pi` Ruby script connects to Sonic Pi and sends it the code, which will then be played. Don’t worry when you don’t see the retrieved code in the Sonic Pi GUI on the Raspberry Pi on which you’re running the subscriber program. The `sonic_pi` Ruby script doesn’t interact with the Sonic Pi GUI at all. Instead, it connects directly to the Sonic Pi synth server to send the code.

You are now ready to start sharing your live-coding masterpieces over the internet. Simply make changes to the Sonic Pi code as you would with any other live-coding performance, and save the buffer to a file as described above. The simple Python programs and MQTT will handle the rest, for you and your faithful listeners!
Learn how to control Philips Hue lights with a Raspberry Pi and the Pimoroni Touch pHAT

We’re all guilty of spending too much time geeking out! GeekyTim is no exception; he spends his time in ‘Hut 8’ (his log cabin in the garden) tinkering with Raspberry Pis, 3D printing, and laser cutting. His wife complains when she has to come out in the rain to call him in!

After buying some Hue lights, he wondered whether they could be controlled with a Pi. Philips provides APIs, and other Python libraries have been developed to access the Bridge. So, he put them all together and created the PiHue – a Raspberry Pi Zero W with Touch pHAT that his family can use to call him in from play...

Setting up
We start by connecting our Pimoroni Touch pHAT to the Pi, burning the Raspbian Jessie Lite image onto an SD card, booting up, and connecting to the same network that the Hue Bridge is on.

We need to install a few prerequisites before downloading the PiHue code, including Python 3, pip, the Touch pHAT library, and the phue library that gives us access to the Hue lights from Python:

```
sudo apt-get update
sudo apt-get install python3 python3-pip git
sudo apt-get install python3-touchphat
sudo pip3 install phue
```

Next, we need to download the PiHue code from GitHub:

```
git clone https://github.com/GeekyTim/PiHue
```

The PiHue code is in the PiHue directory:

```
cd PiHue
```

Configuring PiHue
Each of the Touch pHAT’s six capacitive buttons will have a different function. The Back (left arrow) button turns the lights on and off; four A, B, C and D buttons flash the lights red, yellow, green, and blue respectively; and Enter (right arrow) makes them all bright.

There are two versions of the code:
- `PiHueRoom.py` controls a Room as defined in the Hue app.
- `PiHueLightList.py` controls individual lights in a list.

The Room version works best with a room that contains more than one light, especially if one is coloured and one is dimmable.

We have to edit the code to make some changes for our Hue setup:
- Set the IP address of the Philips Hue: `bridgeip`. We can find this by accessing our router’s IP address list or using a network sniffer tool. The Bridge’s MAC address can be found in the Hue app.
- For `PiHueRoom.py`, set the name of the room to be controlled: `roomname`.
- For `PiHueLightList.py`, change the names of the lights in the Python list: `lights`.

Optionally, we can change the list of Hue xy colours by adding to those already listed under the comment `# Hue 'xy' colours.`
PIHUE: CONTROL PHILIPS HUE LIGHTS

Running on boot
There are a few ways to run Python code when the Raspberry Pi boots. A good method is to use systemd. In this case, we need to create a configuration file (aka a ‘unit’ file) that defines a new systemd service:

```
sudo nano /lib/systemd/system/PiHue.service
```

…and type in the following (replacing `PiHueRoom.py` with `PiHueLightList.py` if required):

```
[Unit]
Description=PiHue Service
After=multi-user.target

[Service]
Type=idle
User=pi
Restart=always
ExecStart=/usr/bin/python3 /home/pi/PiHue/PiHueRoom.py

[Install]
WantedBy=multi-user.target
```

Exit and save using CTRL+X, Y, then ENTER. The permission of the unit file needs to be set to 644:

```
sudo chmod 644 /lib/systemd/system/PiHue.service
```

We need to instruct systemd to start the service during the boot sequence:

```
sudo systemctl daemon-reload
sudo systemctl enable PiHue.service
```

When we reboot the Pi, the PiHue service should run.

Check service status
We can check the status of the PiHue service using:

```
sudo systemctl status PiHue.service
```

The last line should look like:

```
Jul 10 23:26:52 PiHue systemd[1]: Started Start the Touch pHAT Hue controller.
```

Sometimes the Raspberry Pi disconnects from the network, especially when using WiFi. Once disconnected, it will remain disconnected unless the interface is restarted or the Pi is rebooted. That makes this light switch a bit useless. But help is at hand: we can reboot the Pi if it cannot see your home router!

Follow the instructions by Thijs Bernolet on his blog to enable reboot on network loss: magpi.cc/2uC0iny.

We can also change the `alert` patterns in the section following # Alert Patterns. These are Python lists; the first number is how many times to repeat the pattern. The second is the delay between changes – the recommended minimum delay is 0.4 (seconds).

The remaining values are Python dictionaries of the light status changes.

Use any valid Hue status, e.g. `on, bri, xy, ct, sat, hue, transformationtime` (see the Hue API for details: magpi.cc/2vEpXI).

Dimmable lights do not accept any of the colour changes (`xy, ct, sat, hue`), so just change their brightness instead.

We can specify as many changes as we want.

For Light Lists, the status changes are Python dictionaries that contain the changes for each light type (e.g. `Extended color light` and `Dimmable light`). Other light types can be added if you have them (e.g. `Color Light`, `Color Temperature Light`).

There is one special dictionary that is used by the Touch pHAT’s Enter button to set all lights to bright white: `allwhite`. We could redefine this to be a preferred colour and brightness.

Running the code
The line `# b.connect()` must be uncommented the first time the code is run. Just before running it, we must press the Bridge connect button. Run with:

```
python3 PiHueRoom.py
```

…or:

```
python3 PiHueLightList.py
```

The Pi should connect to the Bridge and save the Bridge details in the file `/home/pi/.python_hue`. If we ever need to change the Bridge, we just need to delete this file. We can now re-comment the `b.connect()` line by adding `#` at the front.

Above: It’s alive!

Don’t just use the code as is – why not experiment and make your lights match your own colour schemes?

CONTROL YOUR OWN WORLD!

> PYTHON 3

NAME:
PiHueRoom.py
PiHueLightList.py

DOWNLOAD:
magpi.cc/2vBxtoI

CONTROL PHILIPS HUE LIGHTS

Above: It’s alive!

We can also change the `alert` patterns in the section following # Alert Patterns. These are Python lists; the first number is how many times to repeat the pattern. The second is the delay between changes – the recommended minimum delay is 0.4 (seconds).

The remaining values are Python dictionaries of the light status changes.

Use any valid Hue status, e.g. `on, bri, xy, ct, sat, hue, transformationtime` (see the Hue API for details: magpi.cc/2vEpXI).

Dimmable lights do not accept any of the colour changes (`xy, ct, sat, hue`), so just change their brightness instead.

We can specify as many changes as we want.

For Light Lists, the status changes are Python dictionaries that contain the changes for each light type (e.g. `Extended color light` and `Dimmable light`). Other light types can be added if you have them (e.g. `Color Light`, `Color Temperature Light`).

There is one special dictionary that is used by the Touch pHAT’s Enter button to set all lights to bright white: `allwhite`. We could redefine this to be a preferred colour and brightness.

Running the code
The line `# b.connect()` must be uncommented the first time the code is run. Just before running it, we must press the Bridge connect button. Run with:

```
python3 PiHueRoom.py
```

…or:

```
python3 PiHueLightList.py
```

The Pi should connect to the Bridge and save the Bridge details in the file `/home/pi/.python_hue`. If we ever need to change the Bridge, we just need to delete this file. We can now re-comment the `b.connect()` line by adding `#` at the front.
F.A.Q. YOUR QUESTIONS ANSWERED

FREQUENTLY ASKED QUESTIONS
Your technical hardware and software problems solved...

USING RASPBERRY PIS WITH OTHER DEVICES

WHAT COMPUTERS DOES RASPBERRY PI WORK WITH?

PCs
The Raspberry Pi plays well with PCs (running Windows or Linux) and Macs in the same way any other computer would – you can set it up to view folders and files over the network, and it can read all the files from a PC as long as it is running compatible software.

Smartphones and tablets
Depending on your device, you should be able to connect it to the Raspberry Pi to view the contents of its storage, in the same way that you would plug the device into a PC. Internet tethering over USB can also work, but you will need to look up the specific guides for your devices.

Other Raspberry Pis
As the Raspberry Pi is a fully functional computer, it will interact with another Pi in the same way it would interact with a PC or Mac. Many people use multiple Raspberry Pis in media setups in their homes, with one Pi hosting media files while another Pi plays them on a TV or speakers.

DOES THE RASPBERRY PI WORK WITH MICROCONTROLLERS?

What is a microcontroller?
A microcontroller is a small piece of electronics that, while limited in its function, can be powerful enough to control lights, motors and so on with a bit of programming. The benefit of a microcontroller over a Raspberry Pi is that they typically require less power to run.

Arduino
Popular tools for creating very small computerised projects, Arduinos are cheap and usually use a lot less power than a Raspberry Pi. You can find HATs and another add-ons that enable you to connect a Raspberry Pi with, and even program, an Arduino.

Skip the microcontroller
If power isn’t a problem for you, you can usually perform the tasks a microcontroller could do using the Raspberry Pi. There’s a huge range of HATs and other Pi add-ons that offer extra functionality, such as motor control, environment sensing, and even higher-quality audio output.

NEED A PROBLEM SOLVED?
Email magpi@raspberrypi.org or find us on raspberrypi.org/forums to feature in a future issue.

CONTROLLING ELECTRONICS

Controlling electronics
The Raspberry Pi on its own can control other electronic items if you wire them up correctly to the GPIO pins. The most basic function is to sense and send on and off signals, which could be used to control a game using the buttons on an old video game controller.

Correct components
Not every project can be made using the Raspberry Pi on its own. You may need to use components such as thermometers, microphones, light sensors, and analogue-to-digital converters.

Be careful!
Hacking an existing product may not always work – in fact, you may break it or the Raspberry Pi beyond repair! Make sure you’ve fully researched your project and looked up guides and instructions for similar projects before starting yours.

Above Raspberry Pi can play nicely with microcontrollers
WHAT ARE THE DIFFERENCES BETWEEN MODELS?
The Model A+ has 512MB RAM (as of August 2016: earlier models have 256MB), one USB port, 40 GPIO pins, and no Ethernet port. The Model B+ has 512MB RAM, four USB ports, 40 GPIO pins, and one Ethernet port.

The B+ was superseded by the Pi 2 Model B. The Pi 2 originally used a 900MHz quad-core ARM Cortex-A7 CPU with 1GB RAM. Some recent versions of the Pi 2 (v1.2) now use a 900MHz ARM Cortex-A53 CPU.

The Pi 3 Model B was launched in February 2016. It uses a 1.2GHz 64-bit quad-core ARM Cortex-A53 CPU, has 1GB RAM, integrated 802.11n wireless LAN, and Bluetooth 4.1.

The Pi Zero and Pi Zero W are half the size of a Model A+, with a 1GHz single-core CPU and 512MB RAM, mini-HDMI and USB On-The-Go ports, and a camera connector. The Pi Zero W also has integrated 802.11n wireless LAN and Bluetooth 4.1.

<table>
<thead>
<tr>
<th>Product</th>
<th>SoC</th>
<th>Speed</th>
<th>RAM</th>
<th>USB Ports</th>
<th>Ethernet</th>
<th>Wireless/Bluetooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raspberry Pi Model A+</td>
<td>BCM2835</td>
<td>700MHz</td>
<td>512MB</td>
<td>1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Raspberry Pi Model B+</td>
<td>BCM2835</td>
<td>700MHz</td>
<td>512MB</td>
<td>4</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Raspberry Pi 2 Model B</td>
<td>BCM2836 or BCM2837</td>
<td>900MHz</td>
<td>1GB</td>
<td>4</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Raspberry Pi 3 Model B</td>
<td>BCM2837</td>
<td>1200MHz</td>
<td>1GB</td>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Raspberry Pi Zero</td>
<td>BCM2835</td>
<td>1000MHz</td>
<td>512MB</td>
<td>1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Raspberry Pi Zero W</td>
<td>BCM2835</td>
<td>1000MHz</td>
<td>512MB</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

KEEP MULTIPLE PROJECTS IN ONE PLACE

WD PiDrive Foundation Edition Made for Raspberry Pi

Our custom NOOBS software enables you to install multiple work spaces for up to 5 projects that can all be managed from the WD PiDrive.

---

**USB Flash 64GB**
Includes microSD™ card with starter software
$18.99

**USB Hard Drive 250GB / 375GB**
Includes microSD™ card with starter software and WD PiDrive Cable
Starts at $28.99

Learn more at wdlabs.io/mp60b
BUILD A COMPUTER
FOLLOW MISSIONS
LEARN PROGRAMMING

PIPER COMPUTER KIT
Educational Computer that teaches STEM and Coding

Kids build their first real computer then advance through Piper’s award-winning story-based curriculum and learn physical engineering and electronics in the process.

Special $10 MagPi coupon:
MagPiSummer
only at BuildPiper.com
A STEM SOLUTION FOR SCHOOLS
Teachers all over the world use Piper to inspire kids to program, design, and engineer.

Want to learn how to bring Piper to your school?
buildpiper.com/EDU

THE PIPER EXPERIENCE
BUILD FROM SCRATCH
SOFTWARE-BASED CURRICULUM
CREATE YOUR ELECTRONICS

Supported by Top University Funds
Stanford-StartX Fund
AEF of Princeton University

Available at:
BuildPiper.com
amazon
ToysRus
Barnes&Noble
If you want your next project to break beyond the limits of code and screens, you might want to consider adding an Arduino board to your Raspberry Pi. These simple, cheap controllers come in all shapes and sizes and allow you to easily measure, monitor, and manipulate the physical world.

Arduinos are microcontrollers that make physical computing projects quick and easy to build. Whether you’re flashing LEDs, activating motors, or sensing changes in the real world, an Arduino is worth considering as part of your project.

This tutorial will take you through the first steps of using an Arduino, and provide examples of fun and useful projects to make. Whether you’re building a weather station, constructing a robot, making an alarm for your bedroom, or planning an automatic watering system for the greenhouse, Arduino and Raspberry Pi make a powerful tag team.
**ARDUINO AND RASPBERRY PI**

**ARDUINO UNO**
The Arduino Uno looks like a smaller Raspberry Pi board, but works differently. While the Raspberry Pi is a versatile computer, the Arduino board is a highly focused microcontroller.

**DIGITAL I/O**
The Arduino has 14 digital input/output pins (female header) of which six can be used as PWM (pulse-width modulation) outputs to control devices such as servos, RGB light levels, and other devices that need precision.

**MICROCONTROLLER CHIP**
An ATMega328P microcontroller is used to control the hardware on the Arduino board. It is programmed using the Arduino IDE (accessed via the Raspberry Pi).

**USB TYPE B**
The larger USB Type B connector on the Arduino is used to draw power, and provides a connection between the Raspberry Pi and Arduino.

**ANALOGUE INPUTS**
On the lower half of the Arduino Uno are six analogue input pins (female header). These can be used to read information from devices such as potentiometers and photoresistors.

**QUARTZ CRYSTAL**
A 16MHz quartz crystal chip is included on the board. This helps the Arduino control devices with precision.

**RESET BUTTON**
On one corner of the Arduino board sits a reset button.

**USB TYPE A**
Use one of the USB Type A ports on the Raspberry Pi to provide power to the Arduino. You’ll need a USB Type A to B cable.
Arduinos have specific inputs to receive analogue information from devices such as our PIR motion sensor.

Now you know what an Arduino is, you’ll want to discover how to connect it to a Raspberry Pi and use it. We’re using an Arduino Uno with a Raspberry Pi 3 for this guide, but the steps are similar for all models.

The first step in programming an Arduino board is to install the Arduino IDE (integrated development environment) on your Raspberry Pi. This program checks code and loads it onto the Arduino. Install the latest version of Arduino IDE using `apt`:

```bash
sudo apt-get update && sudo apt-get upgrade
sudo apt-get install arduino
```

Alternatively, open Chrome on your Raspberry Pi, head to magpi.cc/2tPw8ht, and click the Linux ARM link under ‘Download the IDE’. Extract the file to your `/opt` directory, then open a Terminal and run the `install.sh` script to install.

```bash
cd Downloads/
tar -xf arduino-1.8.3-linuxarm.tar.xz
sudo mv arduino-1.8.3 /opt
sudo /opt/arduino-1.8.3/install.sh
```

You will find Arduino IDE under Menu > Programming. Open the app to start programming your Arduino board.

**STOP THE PROGRAM**

Unlike a Raspberry Pi, the Arduino will keep running the same program, even if you unplug or reset the board. The easiest way to stop it running is to open a new blank program and upload it to the board.

**SKETCH YOUR IDEAS**

Arduino programs are called ‘sketches’, and are based on the C programming language. Open the IDE and you’ll see a blank sketch, with the two basic areas for code: `void setup()` and `void loop()`. If you see an empty script, choose File > Examples > 01.Basics > BareMinimum.

As the comments explain, `void setup()` is for code that runs once to set up your electronics properly. The code you type into `void loop()` will repeat from the first line to the last in an endless loop.

To demonstrate, we’ve written a basic sketch that flashes two LEDs when you move your hand over a PIR sensor. Connect the two LEDs and PIR sensor to the Arduino, as shown in the circuit diagram (Figure 1).

Once you’ve wired up the Arduino to the circuit, attach it to one of the Pi’s USB ports; this also enables two-way communication. Use the digital GPIO pins of the Arduino to control the electronics.

Power the Arduino from one of the Pi’s USB ports; this also enables two-way communication.

Use the digital GPIO pins of the Arduino to control the electronics.

Arduinos have specific inputs to receive analogue information from devices such as our PIR motion sensor.

We use the `pinMode` instruction to tell the Arduino which GPIO pins the LEDs are attached to (pins 5 and 6) and that each pin should be treated as an output.

In the `void loop()` section, we tell the Arduino to raise the voltage on these pins to HIGH (5 V) with the

```c
void setup()
{
  pinMode(5, OUTPUT);
  digitalWrite(5, HIGH);
}

void loop()
{
  // PIR sensor read
  if (pir.read() == HIGH)
  {
    digitalWrite(5, LOW);
  }
  else
  {
    digitalWrite(5, HIGH);
  }
}
```
digitalWrite instruction, then to pause for half a second, and then to turn off the LEDs.

Before uploading your sketch to the Arduino, tell the IDE which Arduino board you’re using by opening Tools > Board. Then tell the IDE which port to use to upload your code by opening Tools > Serial Port and selecting /dev/ttyACM0. On version 1.8.3 of the IDE, you need to select the version marked ‘(Arduino/Genuino Uno)’.

Now click Upload to program the Arduino with your sketch. After a few seconds of code-checking and uploading, you should see your LEDs flashing whenever you move your hand over the sensor.

LOOKING AT THE CODE
While not necessary, it’s also good Arduino sketch etiquette to include a description at the start.

At the top of your sketch, type /* and hit ENTER: the IDE will add two more lines. Anything written between the */ and */ will be ignored by the Arduino, but can be read by any humans wanting to understand what your sketch does and how it works.

We’ve used variables for our LEDs, meaning that if we change the GPIO pins they’re attached to, we’ll have fewer edits to make.

We tell the Arduino IDE the type of variable, then the name, and the value. So our LED pins are int led1=5; By replacing all instances of 5 with led1, any changes to our build require only one change to our code.

ADD MOTION
We’ve also added a PIR (passive infrared) motion sensor, as shown in the circuit diagram (Figure 1). We therefore declared the variable int motion = 3 and added this line to void setup():

pinMode(motion, INPUT);

Finally, we added some code to make the motion sensor trigger the LED flashes:

if (digitalRead (motion) == HIGH) {

As with the if statement, this is part of the void loop() section that will run continuously, meaning the motion sensor will be read – or polled – repeatedly for signs of motion.

A final note on coding with Arduino: every line of code must end with either a semicolon or a curly bracket. The IDE will highlight any line of code that suffers an error, and typically it’ll be because the previous line lacks its semicolon terminator.

If you are unfamiliar with the C programming language, there are lots of resources you can find online to learn how to use it.
Now that we can program an Arduino with a Pi, let’s get the two talking to each other.

It is possible to make commands from the Pi (automated or human-activated) affect the sketch loaded onto an Arduino, and for data collected by the Arduino to be sent automatically to the Pi to be processed.

By why would you want to? It’s a fair question, as the Pi has plenty of GPIO headers to attach motors, sensors, LEDs, and other devices – why add the complication and expense of a second board?

The answer lies in the simplicity of an Arduino board. It’s an easily programmable microcontroller with clearly labelled GPIO pins. An Arduino board therefore has very little overhead to prevent it from taking millisecond-accurate readings, and there’s nothing much to go wrong and cause an Arduino to stall or hang.

The Raspberry Pi, meanwhile, has all kinds of hardware and software overheads – from USB controllers and display outputs to wireless connections and a full-blown operating system. All of these can lead to delays or jitters in measurements.

Most Arduino boards have analogue inputs, and can supply a wide range of voltages rather than the 3.3 V or 5 V that a Pi offers. This makes it much easier to connect and code for many electronic components.

### SERIAL COMMUNICATIONS

The standard method of communication between a Pi and an Arduino is serial: it’s robust, simple, quick and easy. Let’s start with the Arduino, turning our basic sketch into an alarm system.

First, re-save the PIRBlink file, renaming it SerialFlashLights. Now, we need to enable serial communication, so we head to the end of the `void setup()` section and add:

```cpp
Serial.begin(9600);
```

Now, the sketch for the Arduino looks like this:

```cpp
//variables
int led1 = 5;
int led2 = 6;
int motion = 3;
int wait = 500; //500ms = 1/2s

void setup() {
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(motion, INPUT);
  Serial.begin(9600);
}

void loop() {
  // put your main code here, to run repeatedly:
  if (digitalRead(motion) == HIGH) {
    if (Serial.available()) {
      flash(Serial.read() - '0'); //Converts Serial message into a number
    }
  }
  delay(5000);
}

void flash(int repetitions) {
  for (int i = 0; i < repetitions; i++) {
    digitalWrite(led1, HIGH);
    digitalWrite(led2, HIGH);
    delay(wait);
    digitalWrite(led1, LOW);
    digitalWrite(led2, LOW);
    delay(wait);
  }
}
```

### Notes

- The Arduino sketch is available on GitHub: https://github.com/adobn/ArduinoAndPi
- The Python script for the Pi is available on GitHub: https://github.com/adobn/ArduinoAndPi
- For more information on serial communication, see the MagPi issue 64.

---

**SerialLightsRespond.ino**

This sketch is available in the MagPi issue 64, and is hosted on GitHub: https://github.com/adobn/ArduinoAndPi

---

**SerialCommunication**

By enabling serial communication, we can easily send data from the Arduino to the Pi, and vice versa. This is a powerful feature, allowing for complex interactions between devices.

---

**SerialResponse**

The Python script for the Pi is essential for receiving and processing data from the Arduino. It’s available on GitHub: https://github.com/adobn/ArduinoAndPi

---

**SerialCommunication**

For more information on serial communication, see the MagPi issue 64.
/* Blinks two LEDs when motion detected and sends serial message to serial_flash_pi_side.py */

//variables
int led1 = 5;
int led2 = 6;
int motion = 3;
int wait = 500; //500ms = 1/2s

void setup() {
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(motion, INPUT);
  Serial.begin(9600);
}

void loop() {
  if (digitalRead(motion) == HIGH) {
    Serial.println("Motion detected!");
    digitalWrite(led1, HIGH);
    digitalWrite(led2, HIGH);
    delay(wait);
    digitalWrite(led1, LOW);
    digitalWrite(led2, LOW);
    delay(wait);
  }
}

Most Arduino boards have analogue inputs, and can supply a wide range of voltages rather than the 3.3 V or 5 V that a Pi offers

The capital S is required (serial.begin() won’t work, so the instruction won’t turn orange), while the number sets the speed. Serial connections are measured in baud, with a typical speed of 9600 baud, or 9,600 bits per second.

Next, we need to set up some way of outputting data from the Arduino over this newly opened serial communication. This is fairly easy: just add the line Serial.println (message); in the void loop() section. The classic message would be hello world, but we can skip straight to something more useful with the line:

Serial.println ("Motion detected!");

We can even test that new code without having to write any code for Pi just yet. Upload the sketch to the Arduino and then click the Serial Monitor button at the top right-hand side. You should see the ‘Motion detected!’ message whenever you wave your hand at the sensor.

**ARDFINO TO PI**

Now we can switch to writing a Python script on the Pi. We’ll use Thonny, the new Python IDE for Raspbian. If you haven’t got Thonny yet, install it with this code:

```
sudo apt-get update & sudo apt-get install thonny
```

Once installed, fire up Thonny. Enter the code from SerialFlashLights.ino into Arduino IDE and serial_flash_lights_pi_side.py into Thonny. Make sure you
upload the code to Arduino first, then run the program in Thonny. Now when you wave your hand, the lights will flash and a message will appear in the Thonny Shell that reads ‘Arduino says: Motion detected!’.

**LOOKING AT SERIAL**

First we import the Python serial library with `import serial`. We then need to define the serial connection with the Arduino:

```python
serialMsg = serial.Serial('/dev/ttyACM0', 9600, timeout = 1)
```

Note that you could use any name rather than `serialMsg`. The first argument is the port that the Arduino uses, the second is the baud rate of the serial connection, and it’s best to specify a timeout to prevent overloading.

Next, we read the serial link with the line `serialMsg.readline()`. However, the serial connection will change the encoding of the Arduino’s message into something unusable. We need to encode the message and strip the extra characters added if we’re to use the Arduino’s readings to trigger an action in our Python script. That’s what the `message` variable does in the `SerialFlashLights.ino` code.

You can replace the mundane `print` line with almost anything you can think of to make any sensor on the Arduino trigger any kind of event. If your Arduino uses

```
import serial

serialMsg = serial.Serial("/dev/ttyACM0", 9600, timeout=1)

while True:
    rawMsg = serialMsg.readline()
    message = (rawMsg.decode().strip())
    if (message == "Motion detected!"): print("Arduino says: Motion detected!")
```

With a bit of practice, you’ll be capable of developing some great projects.
many sensors, use a different serial message for each so that the Python script can tell which action to take.

**PI TO ARDUINO**

Having the Arduino react to inputs from the Raspberry Pi is slightly less complicated. In `SerialLightsRespond.ino` we’ve defined our own function, `flash()`. In the `void loop()` section, the `flash` function’s variable `repetitions` will be replaced by the number received (and converted) from the Pi, meaning the lights will flash according to the number output by the Pi.

In `serial_respond_pi_side.py` we use `serialMsg.write(b'7')` to tell the Arduino to flash the LED lights seven times. The `b` is required to properly encode the message for the Arduino to interpret; whether you send text or numerals, they must be placed within quotes.

Unfortunately, whether you send letters or numbers, they all arrive as characters – even `serialMsg.write(b'1')` will be received as the text character 1 rather than a number.

If you’re sending letters to the Arduino, that’s not a problem. However, if you do want to send numbers – perhaps to tell the Arduino to flash its LED a certain number of times – you need to convert the numerical character into a numerical number using `- 0`, as in our `SerialLightsRespond.ino` code.

When you wave your hand in front of the PIR motion sensor, the LED lights will flash seven times. Adjust the 7 to any number you want in the Python code, and the LED lights will respond accordingly.

**READY TO GO**

You’ve linked an Arduino to a Raspberry Pi and discovered how to control its input/output pins, how to read information from the Arduino, and how to send messages from the Raspberry Pi to the Arduino. With a bit of practice, you’ll be capable of developing some great projects.
PROJECT IDEAS

HAMMOND SMART HOME
For his ‘HAMMOND’ smart home system, Paul Sieradzki used an Arduino Mega to manage everything from motors that roll blinds, temperature sensors and PIR motion sensors, to relays to control power, IR blasters, and RFID readers. There’s a Pi on top to gather weather information, add web access, and manage Alexa-based voice recognition. A second Pi serves video and music.

INTERNET OF LEGO
An entire city, built from Lego and controlled by Arduinos, Raspberry Pis, and bundles of sensors. All the parts interact with each other, with myriad sensors placed around the blocky cityscape to track events within the city and in the real world. The whole connected city is powered by a Raspberry Pi running the Node–RED Internet of Things manager (nodered.org).

GALAGA ARCADE CABINET
Galaga. That 1981 arcade game of champions. While you can play Galaga in your browser (freegalaga.com), nothing beats the look of a light-up arcade cabinet, complete with sticks and giant buttons. In fact, Hamburg’s Alex Weber went even further, rescuing an old CRT television from a skip to connect to a Pi running MAME through RetroPie (retropie.org.uk).

INTERNETOFLEGO.COM
magpi.cc/2vbNDZe

HAMBONDM SMART HOME
magpi.cc/2vb6NPe
PIANO STAIRS
As part of a HackPrinceton hackathon, Bonnie Eisenman created stairs that play a tune. Each step is fitted with a light on one side and a light sensor on the other; when a foot breaks the beam, an Arduino passes the number of the step to a Raspberry Pi, triggering a specific note to be played through a set of speakers.

magpi.cc/2vbAE9T

SMART JUKEBOX
Tijuana Rick (aka Ricardo Cortez) used an Arduino Mega to transform a 1969 Wurlitzer 3100 jukebox into a digital retro music box. He had to go the digital route because, while the jukebox still worked, the previous owner kept all the vinyl records. The Arduino monitors the jukebox buttons, sending a serial output to the Pi, which handles the music playback.

magpi.cc/2vbTbDl

FLIPFRAME
FlipFrame solves the problem of showing a slideshow of mixed-orientation images. Obviously, black bars are insufferable, so Tim Giles uses a Raspberry Pi to analyse his slideshows. If the resolution indicates a landscape image, the Pi tells a motor-governing Arduino to turn the FlipFrame’s 27-inch screen from landscape to portrait mode. It is a sight to behold.

magpi.cc/2vbQ032
Tiny 4WD is a small but powerful robot that you build yourself.

**Coretec Maker Says**

If you cast your mind back to issue 51 of the magazine, you’ll remember a robot on the cover that you could make yourself. Its designer, Brian Corteil, has taken the lessons from making that robot to build an all-new improved version, which you can buy directly from his Coretec website (magpi.cc/Tiny4WD) and from pimoroni.com.

The Tiny 4WD is the end result of this learning process, and is available as a kit that you build yourself. All you need to supply is a Raspberry Pi and a way to power it (a mobile USB battery charger will do the trick). The kit is optimised for a Pi Zero, with specific mounting points on the chassis. However, we tested it using a Raspberry Pi 3 and it worked well.

**Easy build**

The build is fairly quick. There are only three parts to the chassis, and one of these isn’t necessary in its basic state. The box recommends using the build in *The MagPi* as your instructions, but they don’t quite fit this kit. Luckily, there’s a great guide online, linked from the Pimoroni website: magpi.cc/2pXHCu8.

Online instructions aren’t ideal – it would be nice to have printed instructions in the box – but it’s enough to get you started. We managed to get the robot up and running in just under two episodes of *Brooklyn Nine-Nine*, so we’d estimate 30–40 minutes’ build time, but it may take longer depending on your skills with a soldering iron. You’ll need to...
TINY 4WD ROBOT KIT

magpi.cc/Tiny4WD

£55 / $72

solder a 40-pin and a 20-pin header to the Explorer pHAT supplied with the kit, as well as soldering a GPIO header to the Pi Zero. The rest of the setup is easy: install the software on the Pi Zero (running Raspbian) and you’re ready to play!

Flexible control

From here you can use the test scripts to control the robot using a USB controller, or start making it more autonomous. The Pimoroni library for the Explorer pHAT is easy to understand – so, with the docs open and the examples to hand, you can easily start creating your own programs.

Each side of the Tiny 4WD is powered by one of the motor outputs on the pHAT. This means that, for example, both left wheels will always run at the same speed and direction as each other. This makes it easy to turn on the spot, and gives it full power when it’s moving forwards and backwards.

The Tiny 4WD is easy to customise. There are extra inputs and outputs on the board, so you can start adding additional sensors. There’s a camera mount that could be used to attach an ultrasonic sensor, or a Raspberry Pi Camera Module – like the robots in the Formula Pi racing series.

Power choices

Choosing a power supply can be tricky. The idea is to house your power source between the layers of the chassis. However, the narrow gap, partly blocked by the wires to the motors, limits the size of any power supply. You’ll also need to think about power capacity – the motors will be powered from the Pi’s GPIO pins, so your Pi will need more power than you might expect.

Thumbs up

We do like this robot overall. The build quality is great, with a sturdy chassis made from thick acrylic, decent micro motors supplied with the kit, and the inclusion of a great motor controller in the Explorer pHAT. The soldering requirements make it unsuitable for an absolute beginner, but it’d be great as a step up for novices. It could even be used as a base by more advanced robotics users, as you can easily swap out the HAT and use a bigger Pi to add more functionality.

Unfortunately, supplies are limited for this kit, but more units are being made all the time. If you want one, you may just have to be patient. We think it’s worth the wait, though.

Last word

A great little robot kit which could do with some better build instructions. Once it’s built, however, you have a lot of options and plenty of ways to make it your own.

★★★★☆
The main selling point of RasPiO InspiRing is the ability to daisy-chain a variety of LED strips and shapes together to create 2D and even 3D displays. Now headed for general sale following a successful Kickstarter, the range comprises four kits: a strip of eight LEDs (£10/£13), a circle or triangle of 24 LEDs (£20), an NTP Clock kit including Pi Zero (£30), and a pyramid kit featuring three 24-LED triangles (£50).

Although the super-bright APA102c LEDs can be controlled by other devices – including Arduino, ATtiny, and ESP8266 – each kit comes with a pHAT-sized driver board for the Pi, communicating via SPI. Assembly takes around 20 minutes and involves soldering on a 40-pin header, two small female headers, and a socket for a buffer chip. The chip translates the Pi’s voltage to 5 V logic to drive the LEDs. The power supplied by the Pi alone should be enough for most projects, but there’s the option of boosting it with an external 5 V power supply if needed. Jumper wires are supplied for connecting the light strips and shapes to the Pi, along with a couple of optional 10 kΩ resistors (not needed in most cases). There’s also the option of a header for analogue inputs, so you could control your lights with potentiometers, for instance.

Male and female four-pin connectors are supplied for each LED strip and shape, enabling you to daisy-chain units together. Three sets of input/output holes are provided at each end, so you can solder your connectors at various angles: 180°, 90°, or 45°. This offers more flexibility when connecting units to create custom light displays, although you can always just wire directly to the holes if you prefer.

Indeed, that’s what you’ll be doing for the pyramid kit. After assembling the 3D shape from three triangles, held together using pieces of sticky tape, you’ll need to solder bare wires between the input/output holes at each vertex, which is fairly fiddly. Once the hardware is assembled, the software is installed on the Pi with a single command and includes a range of Python examples which can easily be adapted for your own purposes.
he Raspberry Pi has slowly been making its way from the digital hobbyist’s garage into professional manufacturing environments. SferaLabs specialises in smart control systems, and its Strato Pi boards are a great attempt to add commercial-grade hardware to the Raspberry Pi board. There’s a range of different boards available, and we’re looking at the top-of-the range CAN board, which has all the bells and whistles.

Most of the Strato Pi boards accept 9–28 V, while this board uses 9–65 V DC power. A high-quality power supply ensures reliable operation of a Raspberry Pi when it’s being used 24/7. The board has a step-down converter to provide the 3 A continuous output. It also features power surge protection (up to ±500 V, 2 ohms, 1.2/50 μs).

The CAN board also features UPS (uninterruptible power supply). In the event of power loss, it offers enough time to save data and perform a clean shutdown.

Another nifty feature is Hardware Watchdog, which monitors the software running on the Pi. The Strato Pi Can monitors a GPIO 5 heartbeat pin (which takes less than 60 seconds to change state). If it doesn’t see a change, it initiates a shutdown procedure and raises GPIO 12 to HIGH, which can signal to your code that a watchdog timeout has occurred, allowing you to run a script.

On the end of the Pi CAN board is an 11-position terminal block. Power runs into this block, and it provides a CAN (Controller Area Network) bus and RS-485 ports, both of which can be used at the same time. The CAN controller is used in automotive environments, and you can use it to interface with a car’s internal network.

Eight of the GPIO pins are used to control the real-time clock, CAN controller, buzzer, and for power management; but you can still use the remaining pins for pass-through control. You can view circuit diagrams and find usage instructions in the user guide (magpi.cc/2ut7y33) and schematics (magpi.cc/2ut6z34).

A Strato Pi utility is used to control the buzzer, watchdog, and UPS, installed using:

```
sudo wget http://sferalabs.cc/files/strato/strato
```

Lucy Hattersley looks at an industrial solution for Raspberry Pi...
Add a little more colour to your e-Ink display, says Phil King

With the ability to display text and images that remain on screen without using a power supply, e-Ink displays are ideal for saving precious battery life in portable projects. They’re also much easier to view in bright sunlight than conventional screens.

Until now, Pi e-Ink displays have been black and white – but the tri-colour Inky pHAT injects a bright shade of red into the mix. This certainly adds a dash of extra interest to images, such as the logo shown on the display when you unpack your pHAT.

Unlike the rival PaPiRus Zero, the Inky pHAT comes fully assembled, with the e-Ink screen already mounted and connected to the board via a small ribbon cable. This saves fiddling about with a thin and fragile screen, although you still have to take care not to press on it when mounting the pHAT on the Pi’s GPIO pins.

While the Inky pHAT has a Zero form factor, it’ll happily work with any 40-pin Pi model. Communicating via SPI, it only uses six GPIO pins (plus 3 V and 5 V power). If you wanted to locate the screen away from the Pi, however, you’d need to use something like a Black Hat Hack3r (magpi.cc/2fqGy0D).

A single Terminal command installs all the software required. The Python library comes with a few helpful examples, including a calendar and a weather display. There’s a lot of flashing and pulsing as the screen refreshes, the red parts usually appearing last. While the end result looks vibrant, the downside is a much slower refresh time compared with a monochrome e-Ink screen – typically around 15 seconds vs 1 second or less. The badge example takes even longer, but demonstrates the ability for a partial update, adding text (your name) to a background image.

The slow refresh rate makes the Inky pHAT unsuitable for scrolling text, but static text can easily be displayed in any installed TrueType font, using a simple message function in Python. Images are a bit trickier, as you need to prepare them in a special indexed colour mode, and they must also exactly match the size of the display at 212 × 104 pixels.

Related

PAPIRUS ZERO
Available in a range of sizes, this black-and-white eInk display has a far faster refresh rate, plus push-buttons to control what’s shown on screen.

From £27 / $35
magpi.cc/2ou5KTh

Add a little more colour to your e-Ink display, says Phil King

While the Inky pHAT has a Zero form factor, it’ll happily work with any 40-pin Pi model. Communicating via SPI, it only uses six GPIO pins (plus 3 V and 5 V power). If you wanted to locate the screen away from the Pi, however, you’d need to use something like a Black Hat Hack3r (magpi.cc/2fqGy0D).

A single Terminal command installs all the software required. The Python library comes with a few helpful examples, including a calendar and a weather display. There’s a lot of flashing and pulsing as the screen refreshes, the red parts usually appearing last. While the end result looks vibrant, the downside is a much slower refresh time compared with a monochrome e-Ink screen – typically around 15 seconds vs 1 second or less. The badge example takes even longer, but demonstrates the ability for a partial update, adding text (your name) to a background image.

The slow refresh rate makes the Inky pHAT unsuitable for scrolling text, but static text can easily be displayed in any installed TrueType font, using a simple message function in Python. Images are a bit trickier, as you need to prepare them in a special indexed colour mode, and they must also exactly match the size of the display at 212 × 104 pixels.
A high-resolution, high-speed 3.5-inch TFT display for your Raspberry Pi

**Maker Says**

A high-resolution, high-speed 3.5-inch TFT display for your Raspberry Pi

**Pimoroni**

While most small screens connect to the Pi’s HDMI socket, the HyperPixel is a HAT that plugs onto the GPIO pins. It comes pre-assembled, so no soldering is required. On a Pi Zero, it mounts straight on top for a flush fit. For other Pi models, an extra female header is supplied to raise the HyperPixel so it sits on top of the Pi’s USB ports. A rubber foot (to stick to the top of the Ethernet port) and a support bolt are also supplied to provide extra stability.

Before you can use the HyperPixel, you’ll need to install some software. Fortunately, as with most Pimoroni products, you can use a one-line installer command in the Terminal. To enter the command you’ll need to hook the Pi up to another monitor, or access it remotely via SSH. When the software has been installed, the Pi will only display to the HyperPixel, unless you revert the config.txt file.

Once it’s all up and running, you’re sure to be impressed by the HyperPixel’s performance. The 800×480 resolution matches the official Pi 7-inch touchscreen, and with a pixel density of 270 ppi, the HyperPixel beats its rival 3.5-inch screens. The display looks seriously sharp with vibrant colours (18-bit for 262,144 shades) and good viewing angles. There is some occasional colour banding when displaying fine gradients, but it’s hardly noticeable. With a frame rate of 60 fps, videos look superb – although we noticed a tiny bit of distortion at the right-hand edge when streaming YouTube videos (but not when playing those stored locally).

That frame rate is down to the use of DPI (Display Parallel Interface). The downside to this is that the 18-bit colour uses 18 GPIO pins, while the rest are needed for functions including syncing and two-point capacitive touch. I2C and SPI are also disabled. Naturally, this limits the screen’s usefulness for some projects. In addition, if you want to use PWM for fine control of the backlight brightness, you won’t be able to output audio via the Pi’s 3.5 mm jack.

**Last word**

While not suitable for projects requiring GPIO pins, the HyperPixel is ideal for use in a mini media centre, portable retro games console, camcorder (see magpi.cc/2tjrgNq), or as a touchscreen interface. Since the Raspbian desktop is too fiddly to control in miniature, you’ll want to create your own custom GUI. Whatever you use it for, this is a stunning screen.

**Related**

**ADAFRUIT PIFFT PLUS 3.5-INCH**

This 480×320 screen also plugs into the GPIO pins, but only uses eight of them. It has a resistive, rather than capacitive, touch interface.

£45 / $45

magpi.cc/2uf3kxq

**Review HYPERPIXEL**

Vibrant mini screen packs a lot of pixels into a small space – Phil King
Pi-top PULSE

A new multimedia add-on that brings lights and sound to a pi-top or a Raspberry Pi. Rob Zwetsloot takes a look

We love the pi-top range of computers. They provide true PC or laptop conversion kits for the Raspberry Pi, customisable with plug-in modules and aimed at educational users. Usually these add-ons are designed to enhance the experience of using the pi-top, but that’s all changing with their latest and most ambitious add-on, the pi-topPULSE.

It may be ambitious, but it is also very cool. From the top, it’s an unassuming white plastic square. It includes a 7×7 LED display under the plastic, plus a microphone and speaker. The PCB is visible on the underside, but it is lovely and well designed.

On its own, it can be plugged into a pi-top using the special magnetic rails inside the slide-out compartment, but it can also be used as a HAT on the Raspberry Pi. You’ll need to plug in a header to the underside of the PULSE before popping it on the Pi, but it works with Raspbian after installing a single piece of software.

It’s a very tight fit on the Pi. The case barely misses the Ethernet port, and the connectors for the pi-top hang over the board, increasing the footprint of the Pi. As an educational tool it is excellent, with a very robust Python library for creating light displays and games.

The microphone and speaker give you access to other functions. The PULSE acts as a fully integrated speaker for Sonic Pi, and is even optimised for use with Amazon Alexa on the Raspberry Pi. There’s a great demo on the product page that shows how it can be used with Alexa.

It is a little tricky to get your head around the programming, but there are plenty of examples that helped us figure out how to use everything.

All in all, it’s one of the most fun HATs we’ve seen in a while, allowing users to explore many amazing project ideas.

Related

UNICORN HAT HD
With its programmable 16x16 RGB LED display, this is a great HAT that is easy to code and fun to use in a range of projects.

£32 / $41
magpi.cc/UniHATHD

Last word

An amazing idea with great execution — we just wish it was slightly easier to program. With a bit of practice you can create some astounding things with the PULSE.

Rating: 4/5
n this issue of *The MagPi* we have a tutorial on creating an automation system with Bluetooth tags, using the Pi Zero W’s built-in Bluetooth connection to detect Bluetooth signals (page 22). This project is based on the concept of key cards and other contactless RFID technology. Now, thanks to this kit, you can easily create your own Pi-based RFID projects.

This simple, cheap kit allows you to add an RFID reader to a Raspberry Pi. It comes with six RFID-compatible cards and an RFID key fob. Being a Monk Makes kit, it also comes with some other goodies to help you play with your new project, including a push button and an RGB LED. The lovely printed booklet that comes with the kit includes instructions for projects that use the extra goodies, and takes you through the easy Python code needed to set up the reader.

The book starts with some basic projects and finishes off with a special ‘Monopoly’ project, which allows you to assign money to each RFID card and play the game without using stacks of cash. It’s a wonderful little kit, and it’s so easy to use. The projects in the book require absolutely zero soldering – although if you want to make something a little more complex, you can always get your soldering iron out. It doesn’t require much extra software installation either, so we had the reader up and running in no time. Finally, the inclusion of the cards and key fob are very welcome – we already have some ideas for projects using these in the future.

And did we mention that it’s only £15? That’s a bargain any day of the week.

A really fun kit idea from Monk Makes that does a great job of teaching you how to use RFID readers, and inspires you to go out and do much more with the technology.
Strato Pi enhances the Raspberry Pi and the Compute Module with hardware features that make them suitable for use in professional applications where reliability and service continuity are key requirements.

Iono Pi is a versatile I/O module that combines digital and analog standard interfaces with the powerful computing core of the Raspberry Pi.
LEARNING OPENCV 3

Authors: Gary Bradski & Adrian Kaehler
Publisher: O'Reilly
Price: £59.99
ISBN: 978-1491937990
magpi.cc/2hGVLM4

Targeting the C++ API, Kaehler and Bradski’s near 1,000-page work covers every aspect of real-time image processing library OpenCV, as well as some useful insights into computer vision in theory and practice.

VISION AND BRAIN: HOW WE PERCEIVE THE WORLD

Author: Dr James V Stone
Publisher: MIT Press
Price: £23.95
ISBN: 978-0262517737
magpi.cc/2ulRAqA

A computational theory of vision. Dr Stone’s enjoyable and accessible look at the how and why of animal and human vision will give you a fresh perspective on the subject.

RASPBERRY PI IMAGE PROCESSING PROGRAMMING

Author: Ashwin Pajankar
Publisher: Apress
Price: £14.99
ISBN: 978-1484227305
magpi.cc/2umpuj9

Putting it all together on the Pi, a compact but useful introduction to Python-based image capture and processing on the Pi, with pillow, scipy, and matplotlib.

NUMSENSE!

Authors: Annalyn Ng & Kenneth Soo
Publisher: Annalyn Ng & Kenneth Soo
Price: £23.99
ISBN: 978-981110689
magpi.cc/2umfEOg

Data science is everywhere (as is hype about data science), as intelligent analysis of petabytes of new data becomes essential to governments, business, charities, and anyone looking to make intelligent predictions. The field requires strong mathematical skills, but what about people who need to make decisions about data, but who are not statisticians and programmers?

Ng and Soo’s guide to Data Science for the Layman: No Math Added is a clear explanation of ten data analysis algorithms for supervised and unsupervised learning – plus one reinforced learning example – preceded by a basic look at data selection. Each algorithm is illustrated with a well-chosen data example, which is examined with illustrative graphs, clear text, and no mathematics, rounded off with a look at the limitations of the algorithm chosen.

From soccer penalties and obese giraffes, to PageRank and social networks applied to geopolitics and weapons sales, Numsense!’s examples illustrate and illuminate, but the real clarity comes from the direct writing style, and the authors’ understanding of the subject matter. This book is not just for the non-technical reader – any programmer looking to understand data science and machine learning will quickly gain an appreciation of algorithms that other works introduce in a far less digestible form.

VISION AND BRAIN: HOW WE PERCEIVE THE WORLD

A long time in the making (the second edition was released more than a decade ago), the cover refers to this book as ‘a desktop quick reference’ – and it is the place to look up queries about Python, the standard library, and many parts of the Python ecosystem – but the size of this edition (more than 700 pages) is a heavyweight indicator of Python’s growth.

O’Reilly’s venerable nutshell series offers a comprehensive treatment of every topic – in this case Python for programmers coming from other languages, or those with a little Python who need to know more. Coverage is split between the basics (with plenty of detail on alternatives to standard CPython); core Python and the standard library, and a mixture of standard and extension libraries over topics such as databases, numeric processing, and dealing with testing and debugging.

Treatment is always detailed enough to get the job done. Network and web protocols make up the penultimate section; and the book is rounded off with extending, embedding, packaging, and the issues arising between versions 2 and 3 of Python. This may not be the book you’ll use to learn the language, but put it on your shelf and you’ll often reach for it as a reference text throughout the time that you use Python.
In the 1970s and 1980s, newsagents’ shelves were stacked with titles like *Everyday Electronics* and *Practical Wireless*, and amateur electronic hardware knowledge would be applied everywhere from home hi-fi to DIY guitar pedals. A combination of pervasive computing and ready-made hardware devices costing pennies means modern Pi users are far more likely to be familiar with software than hardware. How to catch up on a mix of theory, component knowledge, and dozens of useful circuits?

### ELECTRONICS COOKBOOK

*Author:* Simon Monk  
*Publisher:* O’Reilly  
*Price:* £39.99  
*ISBN:* 978-1491953402  
[link](https://magpi.cc/2z4iUBo)

In the early chapters, to introduce theory and the basics of discrete components, but soon the recipes become mini–projects in themselves, and potential building blocks for all manner of Pi-based constructions. For old hands, it’s nice to have all these circuits collected together – and your old reference books won’t have this one’s Pi and Python recipes.

### KOTLIN IN ACTION

*Authors:* Dmitry Jemerov & Svetlana Isakova  
*Publisher:* Manning  
*Price:* From £20 (Amazon resellers only in the UK)  
*ISBN:* 978-1617293290  
[link](https://magpi.cc/2z4d9jD)

Kotlin is a JVM language from JetBrains, the people behind the IntelliJ IDEA Java IDE. Not the first language to attempt to fix the problems of Java (hello Scala!), but uptake has been swift, and we’ve heard praise for the language even from some notable Pythonistas. Kotlin is touted as a good replacement for Java in Android development – something of additional interest here, with Android Things running on the Pi 3. This book is aimed squarely at Java developers: you don’t need to be a Java expert to benefit from this very effective guide, but non-Java users should wait for a different Kotlin book. Jemerov and Isakova are Kotlin insiders. They make a persuasive case in the ‘What and Why’ chapter, before moving on to the basics of ‘how’ – emphasising the lack of boilerplate in examples such as declaring classes, and showing off the language’s type inference. Classes are expanded in a chapter which highlights the differences from Java in interfaces. Improved function calls, adding methods to Java classes or interfaces, lambdas, and Kotlin’s extensive type system round off the first half’s language introduction. The second half gets you building your own APIs, using higher order functions, and using deeper features such as DSLs.

### ESSENTIAL READING: BEYOND FRAMEWORKS

Frameworks can hinder understanding. Get to know the nuts and bolts of web development.

#### Build your own AngularJS

*Author:* Tero Parviainen  
*Publisher:* Teropa  
*Price:* £15.00  
[link](https://magpi.cc/2zvKuoWA)

A deep dive into the workings of a web framework, guiding you to better skills, and confidence in your knowledge.

#### Modern JavaScript

*Author:* Various  
*Publisher:* Sitepoint  
*Price:* £5 or Sitepoint subscription  
[link](https://magpi.cc/2zvEgH1)

Having trouble keeping up? Sitepoint’s latest anthology is a quick introduction to the most important parts of the JS ecosystem.

#### Go in Practice

*Authors:* Matt Butcher & Matt Farina  
*Publisher:* Manning  
*Price:* £27.99  
*ISBN:* 978-1633430075  
[link](https://magpi.cc/2zvC59Gi)

Pattern-focused guide to the highly concurrent language that could solve your web app problems.

#### Refactoring JavaScript

*Author:* Evan Burchard  
*Publisher:* O’Reilly  
*Price:* £39.99  
*ISBN:* 978-1491964927  
[link](https://magpi.cc/2zvCG9J)

Refactoring and testing will turn bad code to good. Well-written and enjoyable read – strongly recommended.

#### Inclusive Design Patterns

*Author:* Heydon Pickering  
*Publisher:* Smashing Magazine  
*Price:* £27.00  
*ISBN:* 978-3945749432  
[link](https://magpi.cc/2zvJiYp)

Best practices for pages accessible to all users, reconceiving web design as code—not pixel-based. Essential reading.
MOZILLA, IOT, AND THE RASPBERRY PI: AN INTERVIEW

Project Things is a new framework involving Mozilla’s Web of Things, and is now available on the Raspberry Pi. What exactly does this mean?

The maker community was abuzz with excitement when Mozilla announced Project Things last month, so we sat down with Benjamin Francis from the development team to talk about exactly what it means. Here’s what he told us.

Can you explain what Project Things is?
Project Things is an experimental framework of software and services to help developers connect ‘things’ (physical objects in the real world) to the World Wide Web in a safe, secure and interoperable way. The project includes developing a ‘Web of Things’ gateway, which helps bridge existing IoT devices to the web, a collection of cloud services to help manage a large number of IoT devices over a wide geographic area, and a framework of reusable software components to help create IoT devices which directly connect to the Web of Things.

The first piece of the framework we’ve released is an early prototype of an open-source Web of Things gateway. Anyone can download the software image from Mozilla’s website and build their own Web of Things gateway using a Raspberry Pi. The gateway enables users to choose a unique web address for their home without any complex DNS or router configuration, by using a secure tunnelling service provided by Mozilla. The gateway can then be used to monitor and control existing smart home devices like ZigBee and Z-Wave smart plugs and sensors, and access them remotely via a unified web interface.

Our initial demo showed how you can turn smart plugs on and off from a web app. We’re now working with the community to add support for new types of devices and protocols via an adapter add-on system, and developing new components like a rules engine which can be used to define automated rules for how individual ‘things’ interact with each other (e.g. having a light turn on when a sensor detects motion).

Why the Raspberry Pi?
The Raspberry Pi 3 is affordable, easy to get hold of, runs Linux, and has wireless LAN and Bluetooth built in. This makes it an ideal hardware platform for the initial use cases – and the initial audience of DIY hackers and makers we’re targeting with Project Things. We plan to support other hardware platforms in the future too, but the Pi was a great starting point for us.

Do you find it difficult to convey exactly what the IoT is to people?
People have diverse ideas about what the Internet of Things is, and there’s really no single

Above Project Things is easy to set up
MOZILLA, IOT, AND THE RASPBERRY PI: AN INTERVIEW

The gateway enables users to choose a unique web address for their home.

In its infancy, there are no universally agreed standards for how connected devices should communicate. This means that there are lots of proprietary products and platforms available which can’t talk to each other, so it’s easy to get locked into a particular brand or cloud service.

At Mozilla we want to help educate users about the security, privacy, and interoperability issues around new IoT devices, while helping to define new standards for a decentralised Internet of Things which is safe and secure.

What is the Web of Things?
The Web of Things is an effort to take the lessons learned from the World Wide Web and apply them to the Internet of Things. It’s about creating a decentralised Internet of Things by making Things linkable and discoverable on the web, and defining standard data models and APIs (application programming interfaces) to make them interoperable.

To put it simply, it’s about giving Things URLs on the web.

We’re working with the W3C (World Wide Web Consortium) to help define standards for a decentralised Internet of Things, including a standard Web Thing description format to describe Things, and APIs to communicate with them. Project Things is Mozilla’s open-source implementation of those proposed standards, but like all web standards, anyone is free to implement the specifications themselves in the programming language of their choice.

How can people get started?
Go to iot.mozilla.org to download our Things Gateway software image and follow the instructions to flash the image onto an SD card. You can then plug the SD card into your Raspberry Pi, plug in USB dongles for any additional wireless protocols you want to support, then access the gateway via your web browser to set up a secure web address for your home. You can pair devices like ZigBee and Z-Wave smart plugs with the gateway and control them from your browser using the built-in web app.

Project Things is an open-source project and we really encourage community contributions. There are lots of ways you can contribute, such as building your own IoT device which uses the proposed standard Web Thing API (magpi.cc/2vMuYB9), creating an adapter to bridge an existing IoT protocol or device to the web, or hacking Project Things itself to help us develop Mozilla’s Web of Things implementation (github.com/mozilla-iot).

We’re looking forward to seeing what the hacker and maker community can build with this software as it develops, and we’d love to hear about your DIY IoT projects!
THE MONTH IN RASPBERRY PI

Everything else that happened this month in the world of Raspberry Pi

AIY INTERCOMS AND PHONES

For some reason, everyone’s been using their AIY Projects Voice Kits in phones and intercoms this month...

Earlier in this very issue, you’ll have seen an amazing project that uses the AIY kit from issue 57 to hack an old-school intercom and turn it into a digital voice assistant. It’s a wonderful project, and we always love seeing what Martin Mander is going to upcycle next.

Strangely, everyone else has been having the same idea! We saw loads of toy phones, intercoms, and other voice-powered products upgraded using AIY kits. Here are some of our favourites.

Kids’ smartphone
magpi.cc/2vMuSty

This one is a little mean but honestly, we laughed. This Fisher-Price phone is a true classic and we love the idea of giving it a hefty upgrade with AIY. Here’s another

Another intercom?
magpi.cc/2vMSlL7

Already Martin is inspiring other makers. Here’s another intercom voice project in the works, this time using Amazon Alexa. One day we’ll have to run a comparison between the different voice assistant platforms. Perhaps we should have a retro intercom competition to decide it?

Above Martin Mander’s intercom project is retro and lovely
Operator!
magpi.cc/2vN4rE0

More retro upcycling with this old-school phone, upgraded to incorporate an AIY kit. Dial zero to talk to the assistant and get answers to your everyday queries. We have visions of someone picking it up and putting it under their chin to ask for ounce-to-gram conversions while they mix some batter, Nineties style.

Toucan play at that
magpi.cc/2vMA6VP

This one is just fun. It’s noise-activated, and the assistant voice really doesn’t match its appearance. Maybe you could mod it so it has a Gilbert Gottfried voice? It also moves about as it speaks, adding to the Coolness Factor™.

HOW TO GET AN AIY PROJECTS VOICE KIT

Still waiting for an AIY kit? They’re coming, we promise! The best way to find out more is to sign up to our mailing list — that way we can let you know as soon as they go on sale. You can sign up at magpi.cc/Email-me.

JAMS IN PICTURES

Pictures from the past month’s Pi events around the world

Shh! Geniuses at work! I’ve got an AWESOME team! #joustingbot #Picademy @Raspberry_Pi @cortlentz1 @ascollins @Mshaghs

@tmnoc #raspberryjam really creative ideas using the #raspberrypi

PICADEMY USA
Another successful Picademy took place in the USA, with some robo-jousting as part of the event.

THE NATIONAL MUSEUM OF COMPUTING
Some amazing projects were on display at The National Museum of Computing during its Raspberry Jam.

JAPANESE RASPBERRY JAM
Raspberry Pis are truly global! This robot recognises faces, and was shown off at a recent Jam in Japan.
We got a massive Raspbian update this month – here’s what you need to know about the latest Raspbian release

NEW RASPBIAN STRETCH OUT NOW!

The successor to the original version of Raspbian, Jessie brought us a lot of minor upgrades and visual overhauls that are now a normal part of the Raspbian experience. Jessie came out in September 2015, so it’s now time for Raspbian to upgrade to Stretch. The major upgrades this time are happening below the surface, so you shouldn’t notice many differences when you’re using the desktop. What you will find is upgraded software, including Chromium, and Bluetooth audio via ALSA, along with…

SONIC PI 3.0.1

Sonic Pi 3.0 boasts a lot of new features, including:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time State</td>
<td>A powerful new time-based deterministic shared memory system</td>
</tr>
<tr>
<td>MIDI</td>
<td>Support for input and output of MIDI</td>
</tr>
<tr>
<td>OSC</td>
<td>Support for sending and receiving OSC messages on the network</td>
</tr>
<tr>
<td>Live Audio</td>
<td>For getting multiple streams of audio into Sonic Pi</td>
</tr>
<tr>
<td>Multi-channel audio out</td>
<td>For outputting multiple streams of audio</td>
</tr>
<tr>
<td>Audio Buffers</td>
<td>For internal recording of audio, enabling the creation of loopers</td>
</tr>
</tbody>
</table>

SCRATCH 2 SENSE HAT EXTENSION

Scratch was upgraded in the last Jessie release to Scratch 2, and this upgrade gives it the ability to interact with the Sense HAT. Hopefully this will introduce Scratch users to Astro Pi!

Right: Debian releases are named after Toy Story characters. Stretch is an octopus toy from Toy Story 3, about whom you’ve probably forgotten after your heart shattered at the end…

You can read a full guide to the new features of Raspbian Stretch on the Raspberry Pi blog: magpi.cc/2w6uvfF.
KICKSTART THIS!

Raspberry Pi projects you can crowdfund this month

**BOBOP**

[link]

BOBOP is billed as ‘the first smart robot for parents’. It looks a bit like the Mira bot project, featured earlier in this issue, although this one apparently keeps an eye on your kids. According to the creators, it was prototyped heavily with a Raspberry Pi, which is still being used as one of its main computers. You should just have enough time to give it a look before it ends.

**SMARTIPI FLEX**

[link]

This is a neat project. It’s a special case for a Pi Zero and the Raspberry Pi Camera Module, with a flexible arm that holds the camera in a fixed position. It’s a simple but great idea, allowing you to make some really cool camera-based projects. The campaign will have just finished by the time you read this, but hopefully it hit its target and you can pre-order one for yourself!

**BEST OF THE REST**

Here are some other great projects we saw this month

**CNC WOOD BURNER**

This is amazing. A spinning wood burner powered by a Raspberry Pi. It’s cool, and it creates amazing results – everything we like to see in a Raspberry Pi project. It uses a hot wood burner pen rather than a laser, which is probably a lot safer.

**JEEP ACCELEROMETER**

When you have a big 4x4, and you regularly go off-road, you can experience some interesting angles while driving. Reddit user GoHomePortland made a display to track the pitch and roll while taking his Jeep off-road. Pointless? Probably. Cool? Absolutely.

**AUTOMATIC VIDEO WALL**

An incredible feat of engineering, this project uses QR-like codes displayed on multiple different screens, which allow the software to calculate their locations, sizes, overlays, and angles. It then figures out how to piece the screens together into one large screen, and play a single video over all the screens so that it looks right. It’s magic in action.
Traditionally, Code Clubs are places for educators to teach kids about computer science. There are thousands of them around the world and they’ve helped countless students improve their computing skills through fun activities.

In Cambridge, in late July, a different kind of Code Club meeting took place. Volunteers and educators who run Code Clubs, along with prospective Code Club hosts, visited Code Club (and Raspberry Pi) HQ to attend some talks, get to know other Code Club volunteers, and find out how to improve their Code Clubs.

“At the event in Cambridge, everybody had a chance to get hands-on with Code Club projects using pi-tops,” said Sarah Sheerman-Chase, Participation Manager at Code Club. “Peter Onion, who is a volunteer at a club in Essex, demonstrated physical computing with micro:bits. There was also plenty of time for networking, and the opportunity to meet the team, including Mickey Day, the Code Club Coordinator for the East of England, and myself.”
While this was a relatively small event held in a conference room, it was pretty packed and full of excited Code Clubbers wanting to learn more and share their experiences. We saw many people getting to grips with some of the example projects on the pi-tops in the room, while others were wowed by Peter Onion’s computing demos.

A sea of volunteers
We spoke to Anne Worthington, who runs a Code Club at Cambridge Central Library, which has become very popular. “It was a bit slow to begin with,” Anne admitted to us. “Then, as soon as people knew what it was about, we started filling up a waiting list and we managed to satisfy those requests to get on board.”

It began with a taster session, held in partnership with a sister event in Huntingdon. The club eventually started in the middle of the school term with a focus on Scratch and Python.

“Those who had done Scratch could move onto Python,” explained Anne. “The volunteers thought it was a good way of engaging them beyond Scratch. Now we’ve finished this academic year and they’ve all said how much they’ve enjoyed it. The volunteers are doing fantastic work.”

We always hear about Code Clubs being constantly full, and how kids really enjoy them, and Anne’s club was no different. “We’ve had a very successful year, with a full complement of 14 or so children at each session. A bit up and down with holidays and family life, but it was just joyous seeing how much better the children got at the activities. We have similar Code Club activities running in Huntingdon and St Neots, and we’re looking to expand to libraries out in The Fens as well.”

Choose your own adventure
One of the volunteers for the Cambridge Central Library Code Club, Krishna Kumar, helped develop learning resources for the micro:bit, which the club plans to use – a hot topic of discussion at the event.

He also helps out in the Code Club sessions, revealing that their club has a far better gender ratio than the tech workforce as a whole, with girls making up between 35 and 40 percent of their attendees.

He feels the courses have a great deal of choice in them, allowing every participant to create projects based on their own interests.

After munching on some pizza, it was time to head home, but everyone seemed to leave with new ideas and inspirations to start or improve their Code Clubs.
David Akerman

High-altitude balloonist and master of LoRa, Dave likes to send Pis as high as the atmosphere will allow.

Dave

Category: High-altitude balloonist
Day job: HAB enthusiast/software engineer
Website: daveakerman.com
twitter.com/daveake

Dave continues to help others while breaking records and having a good time exploring the atmosphere.

The pinned tweet on Dave Akerman’s Twitter account shows a table displaying the various components needed for a high-altitude balloon (HAB) flight. Batteries, leads, a camera and Raspberry Pi, plus an unusually themed payload. The caption reads ‘The Queen, The Duke of York, and my TARDIS’, and sums up Dave’s maker career in a heartbeat.

Though writing software for industrial automation pays the bills, the majority of Dave’s time is spent in the world of HAB and the ever-growing community that encompasses it. And, while he makes some money sending business-themed balloons to near-space for the likes of Aardman Animations, Confused.com and the BBC, Dave is best known in the Raspberry Pi community for his use of the small computer in every payload, and his work as a tutor alongside the Foundation’s staff at Skycademy events.

Dave has dedicated many hours and many, many more miles to assisting with the Foundation’s Skycademy programme, helping to explore HAB with educators from across the UK. Using a Raspberry Pi and various other pieces of lightweight tech, Dave, and Foundation staff member James Robinson, explored the incorporation of high-altitude ballooning into education. Through Skycademy, educators were able to learn new skills and take them to the classroom, setting off their...
Dave Akerman

HIGHLIGHTS

WHERE NO PI HAS GONE BEFORE
Dave is recognised as being the first person to incorporate a Raspberry Pi into a HAB payload, and continues to break records with the help of the little green board. More recently, he's been able to lighten the load by using the Raspberry Pi Zero.

PI IN THE SKY
When the first Pi made its way to near-space, Dave tore the computer apart in order to meet the weight restriction. The Pi in the Sky board was created to add the extra features needed for the flight. Since then, the HAT has experienced a few changes.

MORPH IN SPACE
One of the many commercial flights Dave has organised featured the classic children's TV character Morph, a creation of the Aardman Animations studio known for Wallace and Gromit. Morph took to the sky twice in his mission to reach near-space, and finally succeeded in 2016.

PI IN THE SKY
When the first Pi made its way to near-space, Dave tore the computer apart in order to meet the weight restriction. The Pi in the Sky board was created to add the extra features needed for the flight. Since then, the HAT has experienced a few changes.

PI IN THE SKY
When the first Pi made its way to near-space, Dave tore the computer apart in order to meet the weight restriction. The Pi in the Sky board was created to add the extra features needed for the flight. Since then, the HAT has experienced a few changes.

As with anyone passionate about a specific hobby, Dave strives to break records on a photographic forum. With a lifelong interest in space thanks to watching the Moon landings as a boy, plus a talent for electronics and photography, it seems a natural progression. Throw in his coding skills from learning to code on a Teletype and it’s no wonder he was ready and eager to take to the skies, so to speak, and capture the curvature of the Earth. What was so great about using the Raspberry Pi was the instant gratification gained when receiving images in real-time as they were taken during the flight. While other devices could operate a camera and store the photographs for later retrieval, Dave was able to transmit them back down to Earth and check the progress of his balloon while attempting to break records with a flight.

High-altitude ballooning isn’t the only part of Dave’s life that incorporates a Raspberry Pi. Having "lost count" of how many Pis he has running tasks, Dave has also created radio receivers for APRS (ham radio data), ADS-B (aircraft tracking), and OGN (gliders), along with a time-lapse camera in his garden, and a few more for tinkering purposes.

Dave’s most recent flight broke a new record. On 13 August 2017, his HAB payload was able to send back the highest images taken by any amateur flight.
RASPBERRY JAM EVENT CALENDAR

Find out what community-organised, Raspberry Pi-themed events are happening near you...

**GUILDFORD RASPBERRY JAM**
*When:* Saturday 16 September  
*Where:* Guildford Library, Guildford, UK
*magpi.cc/2xawKf1*
Learn about Raspberry Pis, get help from others, show off your projects, and meet other Raspberry Pi fans.

**JAMMING IN MARLBOROUGH**
*When:* Saturday 16 & 23 September  
*Where:* Marlborough Library, Marlborough, UK
*magpi.cc/2xa25yq*
Drop in to Marlborough Library on Saturday morning to see Raspberry Pis being used in a variety of ways.

**TECHNO JAM**
*When:* Saturday 9 September  
*Where:* Southport College, Southport, UK
*technojam.uk*
An event for people who are interested in all forms of technology to come together and share their knowledge.

**CORNWALL TECH JAM**
*When:* Saturday 9 September  
*Where:* Cornwall College Camborne, Redruth, UK
*cornwalltechjam.uk*
For all ages and abilities: ask questions and learn about programming in Scratch, Python, Minecraft, and much more.

**RASPBERRY JAM JOBURG**
*When:* Saturday 16 September  
*Where:* Entelect, Johannesburg, South Africa
*magpi.cc/2wgjUv8*
You’ll get the opportunity to demonstrate your Pi project and discuss it with other like-minded Pi enthusiasts.

**HULL RASPBERRY JAM**
*When:* Saturday 9 September  
*Where:* Hull Central Library, Hull, UK
*magpi.cc/2wgjUv8*
There’ll be chances to get hands-on with digital making activities through workshops, and a hackspace area to share projects and give lightning talks.

**FIND OUT ABOUT JAMS**
Want a Raspberry Jam in your area? Want to start one? Email Ben Nuttall about it: ben@raspberrypi.org

**REGULAR EVENTS**

**HIGHLIGHTED EVENTS**
EVENTS

WE’VE HIGHLIGHTED SOME OF THE AREAS IN NEED OF A JAM! CAN YOU HELP OUT?

6 HULL RASPBERRY JAM
Hull, UK

8 RASPBERRY JAM @ PI TOWERS
Cambridge, UK

3 JAMMING IN MARLBOROUGH
Marlborough, UK

1 TECHNO JAM
Southport, UK

7 MANCHESTER RASPBERRY JAM
Manchester, UK

2 GUILDFORD RASPBERRY JAM
Guildford, UK

5 CORNWALL TECH JAM
Redruth, UK

RASPBERRY JAM ADVICE

FINDING VOLUNTEERS

“You’ll find that a lot of the people who attend your first Jam will become your future volunteers”

Mike Horne
Cambridge Raspberry Jam

Every Raspberry Jam is entitled to apply for a Jam starter kit, which includes magazines, printed worksheets, stickers, flyers, and more. Download the book here: magpi.cc/2q9DhFQ.

MANCHESTER RASPBERRY JAM
When: Saturday 9 September
Where: The Shed, Manchester, UK
magpi.cc/2wgeAMp
A very long-running Jam that celebrated its fifth birthday in June of this year, finally back from its summer hiatus.

RASPBERRY JAM @ PI TOWERS
When: Saturday 16 September
Where: Raspberry Pi HQ, Cambridge, UK
magpi.cc/2wgB0xb
A family-friendly event where everyone is welcome, providing coding and digital making activities for children and adults.
YOUR LETTERS

Etcher on Pi

I followed the instructions in the article about how to use Etcher with Raspberry Pi SD cards. However, I am unable to make it work. I used the code below:

```
cd Downloads
chmod a+x Etcher-linux-x64.AppImage
./Etcher-linux-x64.AppImage
```

I get an error and I am unable to make Etcher run. The error is: ‘cannot execute binary file: Exec format error’. Can you help?

CuteCobra

Unfortunately, Etcher doesn’t work on the Raspberry Pi: the packages you can download for Linux are either x86 or x86_64, which are meant to run on a normal PC – in this case a normal PC running Linux.

You can’t burn a downloaded Raspbian image to another SD card on the Raspberry Pi in the same way as using Etcher on a PC. However, with the SD Card Copier tool in Raspbian, you can make a copy of your current SD card to another SD card connected via a USB card reader. The software will guide you through the process.

The article this reader is referring to can be found here: magpi.cc/2fZkyJD.

Maker Faire New York

I see The MagPi attends some events in the UK, such as the birthday parties and Pi Wars. I understand you’re a UK-based magazine. However, I was wondering if your team would be making an appearance at a US Jam or event of some sort? Would love to meet you guys!

Angela L

We don’t exhibit at events often enough, really! It’s fun and great to meet people, but it does take a lot of time. Having said that, if you’re at Maker Faire New York this September, some MagPi team members will be helping out at the Raspberry Pi stall, so if you’re attending you can come and see us. Even if you can’t get to New York, you can usually find some MagPi-related goodies on Raspberry Pi stalls at events across the USA.

GETTING THE Aiy PROJECTS VOICE KIT

We’re still getting emails from a lot of people asking how they can get their hands on issue 57 or the Aiy Projects Voice Kit that came with it. We’re adding a boxout here to remind everyone that the kit will be going on sale on its own soon. To find out when the kits will be available, sign up to our mailing list at magpi.cc/Email-me. That way, we can let you know as soon as we have a date for the release of the kits.
I have just received the latest *The MagPi* #60, and was delighted to find the attached Raspberry Pi Desktop x86 DVD. Unfortunately I then realised I hadn’t bothered adding a DVD drive to my new computer. My intention was to run it in VirtualBox, so ideally I just need an ISO image. Where would the best place be to download the latest version of the ISO image (happy to do so as a torrent)?

Quite a few blogs from last year point to another image but I found a different one that seems to be more up to date.

Is the latest one safe to use? How do I know it’s safe?

Many thanks,
CraigT

For future reference, you can easily find the ISO of the latest x86 Raspberry Pi Desktop build by going to `rpf.io/x86`, set up by Raspberry Pi Community Manager Ben Nuttall. The one you pointed to in the forum thread was the latest version. As a general rule, if they’re hosted on the Raspberry Pi website, they’re safe to use. If they’re beta release or some other form of non-stable release, they will be labelled as such.

FROM THE FORUM: ISO ISSUES

The Raspberry Pi Forum is a hotbed of conversations and problem-solving for the community. Join in via <raspberrypi.org/forums>

A PALM-SIZED PI SERVER

**WD PiDrive Node Zero + Raspberry Pi Zero**

Build your own mini DLNA + Samba file server, wireless mobile storage device, a Pi Music Box with local storage and so much more.

Includes:
- 314GB WD PiDrive, Raspberry Pi Zero, and custom adapter board
- SD card with starter software
- Mini HDMI adapter cable

ONLY $44.95

Learn more at walbs.io/mp60c
START A CODE CLUB IN YOUR SCHOOL!

Code Club is a network of volunteers and educators who run free coding clubs for young people aged 9-13.

Our aim is to inspire the next generation to get excited about computer science and digital making.

“We use Code Club’s fun educational resources to run a weekly after-school club for Year 7 and Year 8 pupils. The students benefit considerably from the extra challenge!”

Karen Dadd, Computing Teacher

- Code Club is free
- Code Club provides step-by-step guides for Scratch, Python, HTML, and Sonic Pi
- Code Club helps children develop skills including logical thinking, creativity, and resilience

We have over 6000 clubs across the UK teaching more than 80,000 young people to code—come and join us!”

Find out more at www.codeclub.org.uk

Code Club is part of the Raspberry Pi Foundation. Registered Charity Number 1129409
WIN!

RASPBERRY PI 3 RETRO GAMING BUNDLES

We’ve got three Raspberry Pi 3 retro gaming bundles up for grabs, worth £65 each.

Not only that, 15 lucky runners-up will get a SNES-style Raspberry Pi game pad.

These great prizes are courtesy of The Pi Hut: thepihut.com

The Raspberry Pi makes the ideal retro gaming console. Pi Hut’s retro gaming bundle has everything you need to build your retro console. It comes with a Raspberry Pi 3 computer, black case, 16GB microSD card, official Raspberry Pi power supply, HDMI cable, and two SNES-style game pads.

Learn more about the retro gaming bundle at magpi.cc/2uY6K9Y

Enter now at magpi.cc/WinSep17

Terms & Conditions

Competition opens on 30 August 2017 and closes on 28 September 2017. Prize is offered to participants world-wide 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. This promotion is in no way sponsored, endorsed or administered by, or associated with, Instagram or Facebook.
When I first joined the maker movement in 2010, microcontrollers such as Arduino were already an indispensable tool for making things with technology. I used Arduino in many of my projects because it was so easy to program, and there was a ton of easy-to-follow examples and community support available. At the time, some of my projects involved operations such as saving data and hosting a web server, which would push any microcontroller of that era to its limits.

Therefore, when maker-friendly single-board computers like Raspberry Pi came onto the scene, I started to think a lot about how their powerful processors would be useful for more advanced projects. Coupled with the on-board general-purpose input and output pins, it meant makers had new tools at their disposal to push the boundaries of what’s possible for their projects.

There’s a lot of overlap in the functionality of a single-board computer and a microcontroller. Both have the ability to run code and interface with electronics. The strength of a single-board computer lies in its ability to do ‘high-level’ tasks, such as running web servers, writing to databases, capturing photos, executing computer vision algorithms, playing audio and video, and so on. Microcontrollers have their strengths as well. For example, they’re good at sending signals with precise timing, which is important for controlling some types of motors or addressable LEDs. Other advantages include their low energy consumption, their quick start-up time, and often they have built-in analogue input capability.

Working together
As a maker, having both microcontrollers and single-board computers in your toolbox means you can accomplish a broader range of projects. Choosing the right type of board based on your project’s needs is an important skill for a maker, but that doesn’t necessarily mean that you’ll choose one or the other. A single-board computer can work well with a microcontroller in a unified project.

A simple serial communications connection between a Raspberry Pi and Arduino means that the two boards can talk to each other and pass data back and forth. For example, if you were making your own pen plotter, you may have a microcontroller controlling the stepper motors which move the pen. The data could be fed to the microcontroller by a single-board computer, which shows a user interface on a screen or via a built-in web server.

The way that the two platforms work together doesn’t stop there. A microcontroller isn’t very useful if you don’t have a computer to write the code and upload it to the board. Luckily, the Arduino’s development environment runs nicely on Raspberry Pi’s Raspbian operating system. So even if your project doesn’t call for anything more than a microcontroller, why not use your Raspberry Pi to program it?

Contrary to what some may believe, microcontrollers and single-board computers aren’t competitors, but partners. While there’s a lot of overlap in the functionality of both types of devices, they’re both great tools to have in your maker toolbox. Their strong interoperability opens up so many possibilities for rather complex projects. When you make with both microcontrollers and single-board computers, the whole is greater than the sum of the parts – and that makes them a powerful pair.
From the makers of the official Raspberry Pi magazine

GET THEM DIGITALLY:

Available on the App Store

GET IT ON Google Play
Kit Includes:

- Raspberry Pi For Dummies Booklet
- Raspberry Pi 3 Board
- Memory Card
- Plastic Case
- 2.5A Power Supply
- HDMI Cable
- Resistors
- LEDs
- Push Button Switches
- Prototyping Breadboard
- Jumper Wires
- Heat Sinks

Available for worldwide shipping at: WWW.CANAKIT.COM

Available in Europe through RS Components

$89.99 US DOLLARS  £69.99 EXCLUDING VAT

Raspberry Pi is a registered trademark of the Raspberry Pi Foundation.
For Dummies and the Dummies Design are trademarks used under license.
For Dummies 2018, Inc. RS is a registered trademark of RS Components Ltd. Canakit is a registered trademark of Canakit Corporation.