COMP 122

Rev 8-12-23

ASSEMBLY Programming on

Raspberry Pi

Dr Jeff Drobman

website → https://www.raspberrypi.org/products/raspberry-pi-4-model-b/

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Drazen Zoric · Follow
Lives in Cork, Ireland ·

Cheap RPi

Quora

Which Raspberry microcontroller is for beginners, or do you recommend for beginners?

For beginner I will suggest to move away from RPI is you have embedded and microcontrollers on mind. But if you plan working with Linux story is different, go for RPI.

For start, as already mentioned, RPI is not a microcontroller it is a quite powerful CPU (multicore) capable of running Linux, not only Linux but also a distro - has graphical user interface.

If planning writing Linux or web apps then buy any RPI, eg RPI 3 or 4. That's cheapest solution to start with Linux.

But, RPI also has two small versions, Zero and Pico.
Zero is quite powerful ARM CPU also running an OS - RPI OS.

On other side RPI Pico is microcontroller based on ARM Cortex M0. There is no OS here and as such is for fully embedded application. Today embedded has changed meaning and is better to call it bare-metal.
Pico has MicroPython which is nice for beginners cause Python works everywhere. Later you could switch to C or C++ and probably other languages. It is cheap and uses USB for connection to PC.
All these makes it very nice beginners platform.

But, there is something else just a bit more expensive but more powerful - ESP32. 10 Eur:

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Cheap RPi

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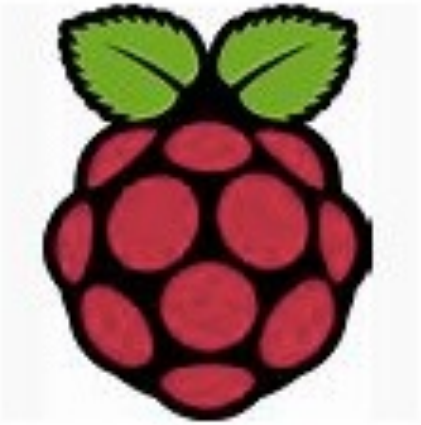
But, there is something else just a bit more expensive but more powerful - ESP32.
10 Eur:

20 Eur with OLED:

Pi Intro

Raspberry Pi

Raspberry Pi 4
Your tiny, dual-display, desktop computer



The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside its target market for uses such as robotics. It does not include peripherals and cases. However, some accessories have been included in several official and unofficial bundles.

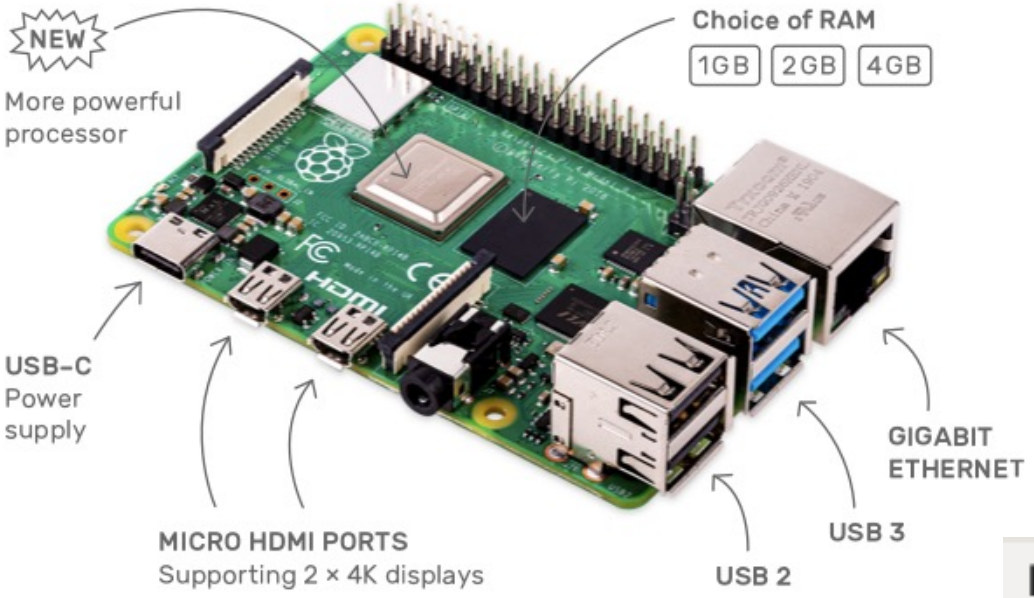
https://www.raspberrypi.org

Raspberry Pi 4

Your tiny, dual-display, desktop computer

Completely upgraded, re-engineered

Faster, more powerful



From **$35**

You'll recognise the price along with the basic shape and size, so you can simply drop your new Raspberry Pi into your old projects for an upgrade; and as always, we've kept all our software backwards-compatible, so what you create on a Raspberry Pi 4 will work on any older models you own too.

RAM	Retail price
1GB	$35
2GB	$45
4GB	$55

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Pi Book

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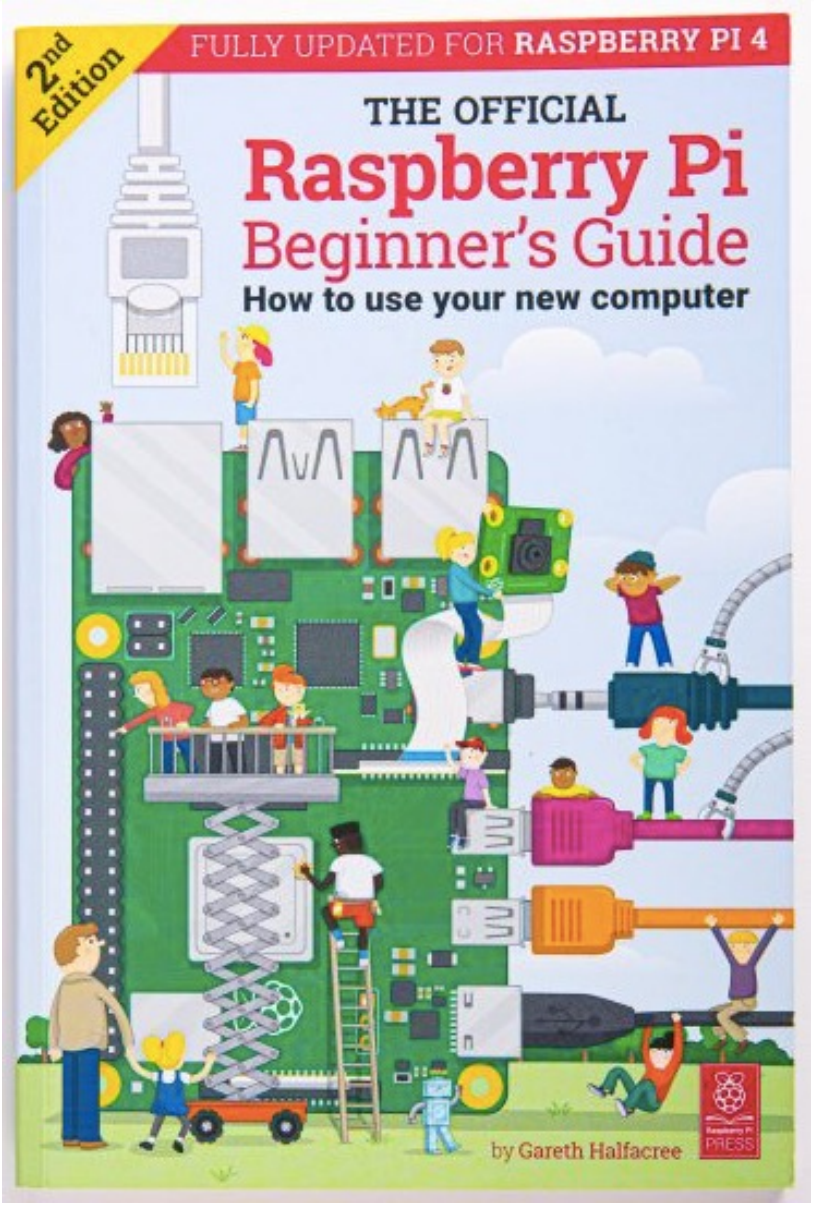

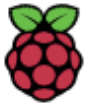

Pi Features

Raspberry Pi 4 Model B

Here are the highlights:

- A 1.5GHz quad-core 64-bit ARM Cortex-A72 CPU (**~3× performance**)
- **1GB, 2GB, or 4GB** of LPDDR4 SDRAM
- Full-throughput **Gigabit Ethernet**
- Dual-band 802.11ac wireless networking
- Bluetooth 5.0
- Two **USB 3.0** and two USB 2.0 ports
- **Dual monitor support**, at resolutions up to 4K
- VideoCore VI graphics, supporting OpenGL ES 3.x
- **4Kp60** hardware decode of HEVC video
- Complete compatibility with earlier Raspberry Pi products

Official Pi Suppliers

Buy Raspberry Pi 4 Model B

CanaKit™

CHICAGO ELECTRONIC DISTRIBUTORS

PiShop.us

Newark element14

adafruit

okdo™
DESIGN THE WORLD

MICRO CENTER
computers & electronics

VILROS

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Ordering Pi + Extras

PiShop.us

Search the store

HOME > * RASPBERRY PI > RASPBERRY PI BOARDS > CURRENT PI BOARDS > RASPBERRY PI 4 MODEL B/1GB

1 GB

Click to zoom in

Raspberry Pi 4 Model B/1GB

Raspberry Pi Foundation

★★★★★ (No reviews yet) Write a Review

$35.00

Brand Raspberry Pi Foundation

SKU: 1GB-9002

Maximum Purchase:150 units

Essential extras:

HighPi Raspberry Pi Case for Pi4

MicroUSB Power Supply with USB-C Adapter

Class 10 microSD Card With Raspbian - 16GB

Pi Add-Ons

Optional

Add-ons for your Raspberry Pi 4

Raspberry Pi 4 Desktop Kit

Full desktop computer kit - just connect to HDMI display(s)

More info >

Raspberry Pi 15.3W USB-C Power Supply

The official and recommended USB-C power supply

More info >

Required

Raspberry Pi 4 Case

The official case for Raspberry Pi 4

More info >

Micro HDMI to Standard HDMI (A/M) 1m Cable

The official Raspberry Pi micro HDMI to HDMI (A/M) cable

More info >

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Pi Power Supply

Raspberry Pi 4 Power Supply

Good, low-cost USB-C power supplies (and USB-C cables) are surprisingly hard to find, as we discovered when sending out prototype units to alpha testers. So we worked with Ktec to develop a suitable 5V/3A power supply; this is priced at $8, and is available in UK (type G), European (type C), North American (type A) and Australian (type I) plug formats.

Power

We've moved from USB micro-B to USB-C for our power connector. This supports an extra 500mA of current, ensuring we have a full 1.2A for downstream USB devices, even under heavy CPU load.

Raspberry Pi 4
Your tiny, dual-display, desktop computer

Pi Video

Video

To accommodate dual display output within the existing board footprint, we've replaced the type-A (full-size) HDMI connector with a pair of type-D (micro) HDMI connectors.

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Pi HDMI Adaptor

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Raspberry Pi 4 micro HDMI Cables

Again, low-cost micro HDMI cables which reliably support the 6Gbps data rate needed for 4Kp60 video can be hard to find. We like the Amazon Basics cable, but we've also sourced a 1m cable, which will be available from our resellers for $5.

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Buying Pi

PiShop.us

Thank you Jeff!

Raspberry Pi 4
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Order Summary Print

2 Items

1 x Raspberry Pi 4 Model B/1GB — $54.90
SKU: 1354 MicroUSB Power Supply with USB-C Adapter
SKU: 1309 Class 10 microSD Card With Raspbian - 16GB

1 x Raspberry Pi 4 Case, Red/White — $5.00

Subtotal	$59.90
Shipping	$7.95
Tax	$0.00
Total (USD)	**$67.85**

Buying Pi

PiShop.us
http://www.pishop.us/

Raspberry Pi 4
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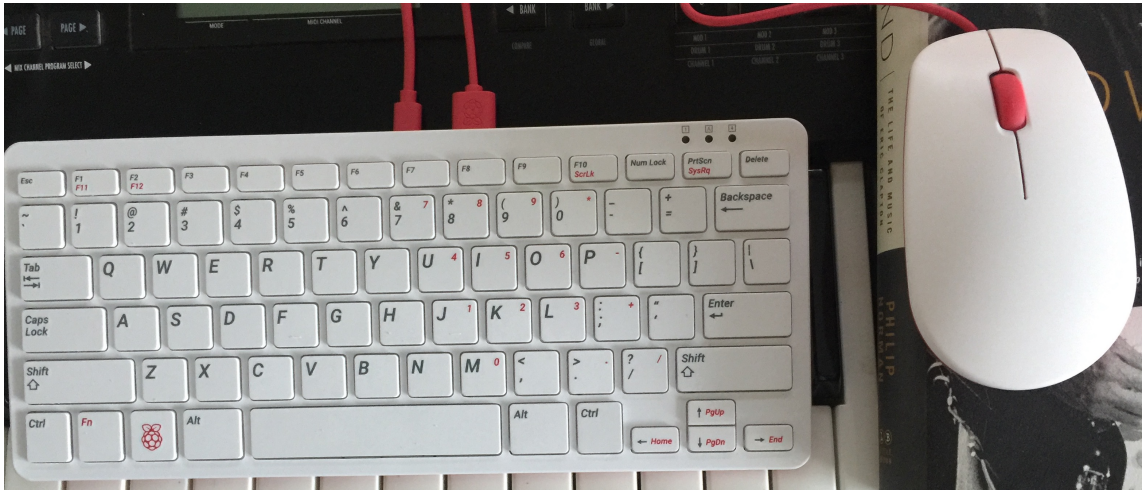
Cart Items	SKU	Qty	Item Price	Item Total
Micro-HDMI to Standard HDMI (A/M), 1m cable	1667	1	$5.00 USD	$5.00 USD
Raspberry Pi Official Keyboard - Red/White	2012	1	$17.00 USD	$17.00 USD
Raspberry Pi Official Mouse - Red/White	2010	1	$8.00 USD	$8.00 USD



Subtotal:	**$30.00 USD**
Shipping:	**$7.95 USD**
Grand Total:	**$37.95 USD**

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My Pi

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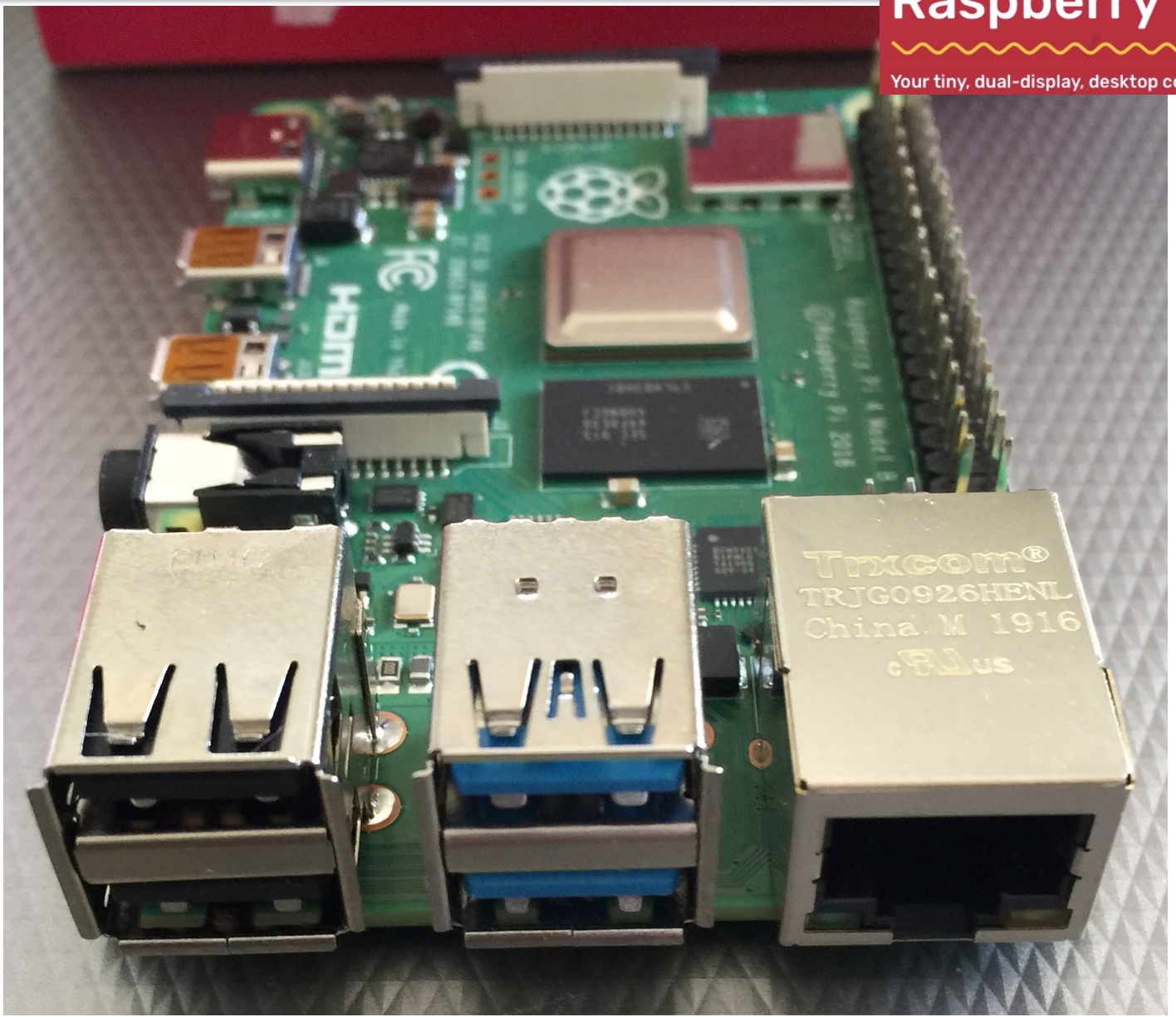

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My Pi

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Pi Kit

Optional

Raspberry Pi 4 Desktop Kit

Bringing all of this together, we're offering a complete Desktop Kit. This is priced at $120, and comprises:

- A 4GB Raspberry Pi 4
- An official case
- An official PSU
- An official mouse and keyboard
- A pair of HDMI cables
- A copy of the updated Beginner's Guide
- A pre-installed 16GB ~~32GB~~ *[oops – Ed.]* microSD card

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Pi 4 Specs

Raspberry Pi 4
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The latest and the most powerful model! Released on June 24, 2019!

The Raspberry Pi 4 Model B is the latest product in the Raspberry Pi range, boasting a 64-bit quad core processor running at 1.5GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 5.0/BLE, true Gigabit Ethernet, and PoE capability via a separate PoE HAT.

The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market.

Specifications:

- 1.5GHz 64-bit quad-core ARM Cortex-A72 CPU (Broadcom 2711)
- **1GB RAM (LPDDR4 SDRAM) - also available in 2GB and 4GB versions!**
- On-board wireless LAN - dual-band 802.11 b/g/n/ac
- On-board Bluetooth 5.0 HS low-energy (BLE)
- 2 x USB 2.0 ports
- 2 x USB 3.0 ports
- True Gigabit Ethernet
- Extended 40-pin GPIO header
- 2x micro HDMI, 4k video
- 4 Pole stereo output and composite video port
- MIPI Camera port (CSI)
- MIPI Display port (DSI)
- microSD format for loading OS & data storage
- 5V/3A DC via USB type C connector
- 5V DC via GPIO
- PoE Enabled
- Multimedia H.265 decode (4kp60), H.254 decode (1080p60), H.254 encode (1080p30), OpenGL ES 1.1, 2.0, 3.0 graphics

IEEE **802.11** WiFi standards

The Ethernet controller on the main SoC is connected to an external Broadcom PHY over a dedicated RGMII link, providing full throughput. USB is provided via an external VLI controller, connected over a single PCI Express Gen 2 lane, and providing a total of 4Gbps of bandwidth, shared between the four ports.

DC power options (3, incl ”PoE”)

Pi 4 Extras

A keyboard and a mouse

To start using your Raspberry Pi, you need a USB keyboard and a USB mouse.

Once you've set your Pi up, you can use a Bluetooth keyboard and mouse, but you'll need a USB keyboard and mouse for the first setup.

A TV or computer screen

To view the Raspbian desktop environment, you need a screen, and a cable to link the screen and the Pi. The screen can be a TV or a computer monitor. If the screen has built-in speakers, the Pi is able to use these to play sound.

HDMI

The Raspberry Pi has a HDMI output port that is compatible with the HDMI port of most modern TVs and computer monitors. Many computer monitors may also have DVI or VGA ports.

Raspberry Pi 4 has two micro HDMI ports, allowing you to connect two separate monitors.

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Pi 4 Power

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Power over Ethernet

From Wikipedia, the free encyclopedia

In this configuration, an Ethernet connection includes power over Ethernet (gray cable looping below), and a PoE splitter provides a separate data cable (gray, looping above) and power cable (black, also looping above) for a wireless access point. The splitter is the silver and black box in the middle between the wiring junction box (left) and the access point (right). The PoE connection eliminates the need for a nearby power outlet. In another common configuration, the access point or other connected device includes internal PoE splitting and the external splitter is not used.

Pinouts [edit]

802.3af Standards A and B from the power sourcing equipment perspective

Pins at switch	T568A color	T568B color	10/100 mode B, DC on spares		10/100 mode A, mixed DC & data		1000 (1 gigabit) mode B, DC & bi-data		1000 (1 gigabit) mode A, DC & bi-data	
Pin 1	White/green stripe	White/orange stripe	Rx +		Rx +	DC +	TxRx A +		TxRx A +	DC +
Pin 2	Green solid	Orange solid	Rx –		Rx –	DC +	TxRx A –		TxRx A –	DC +
Pin 3	White/orange stripe	White/green stripe	Tx +		Tx +	DC –	TxRx B +		TxRx B +	DC –
Pin 4	Blue solid	Blue solid		DC +	Unused		TxRx C +	DC +	TxRx C +	
Pin 5	White/blue stripe	White/blue stripe		DC +	Unused		TxRx C –	DC +	TxRx C –	
Pin 6	Orange solid	Green solid	Tx –		Tx –	DC –	TxRx B –		TxRx B –	DC –
Pin 7	White/brown stripe	White/brown stripe		DC –	Unused		TxRx D +	DC –	TxRx D +	
Pin 8	Brown solid	Brown solid		DC –	Unused		TxRx D –	DC –	TxRx D –	

IEEE **802.3** Ethernet standards

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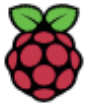

Pi 4 PoE

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Power over Ethernet

From Wikipedia, the free encyclopedia

Power over Ethernet or **PoE** describes any of several standard or ad-hoc systems which pass electric power along with data on twisted pair Ethernet cabling. This allows a single cable to provide both data connection and electric power to devices such as wireless access points, IP cameras, and VoIP phones.

There are several common techniques for transmitting power over Ethernet cabling. Three of them have been standardized by IEEE 802.3 since 2003. These standards are known as *Alternative A*, *Alternative B*, and *4PPoE*. For 10BASE-T and 100BASE-TX, only two of the four signal pairs in typical Cat 5 cable are used. *Alternative B* separates the data and the power conductors, making troubleshooting easier. It also makes full use of all four twisted pairs in a typical Cat 5 cable. The positive voltage runs along pins 4 and 5, and the negative along pins 7 and 8.

Alternative A transports power on the same wires as data for 10 and 100 Mbit/s Ethernet variants. This is similar to the phantom power technique commonly used for powering condenser microphones. Power is transmitted on the data conductors by applying a common voltage to each pair. Because twisted-pair Ethernet uses differential signaling, this does not interfere with data transmission. The common-mode voltage is easily extracted using the center tap of the standard Ethernet pulse transformer. For Gigabit Ethernet and faster, all four pairs are used for data transmission, so both Alternatives A and B transport power on wire pairs also used for data.

4PPoE provides power using all four pairs of a twisted-pair cable. This enables higher power for applications like PTZ cameras, high-performance wireless access points, or even charging laptop batteries.

In addition to standardizing existing practice for spare-pair (*Alternative B*), common-mode data pair power (*Alternative A*) and 4-pair transmission (*4PPoE*), the IEEE PoE standards provide for signaling between the **power sourcing equipment** (PSE) and **powered device** (PD). This signaling allows the presence of a conformant device to be detected by the power source, and allows the device and source to negotiate the amount of power required or available.

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Pi 4 Ports

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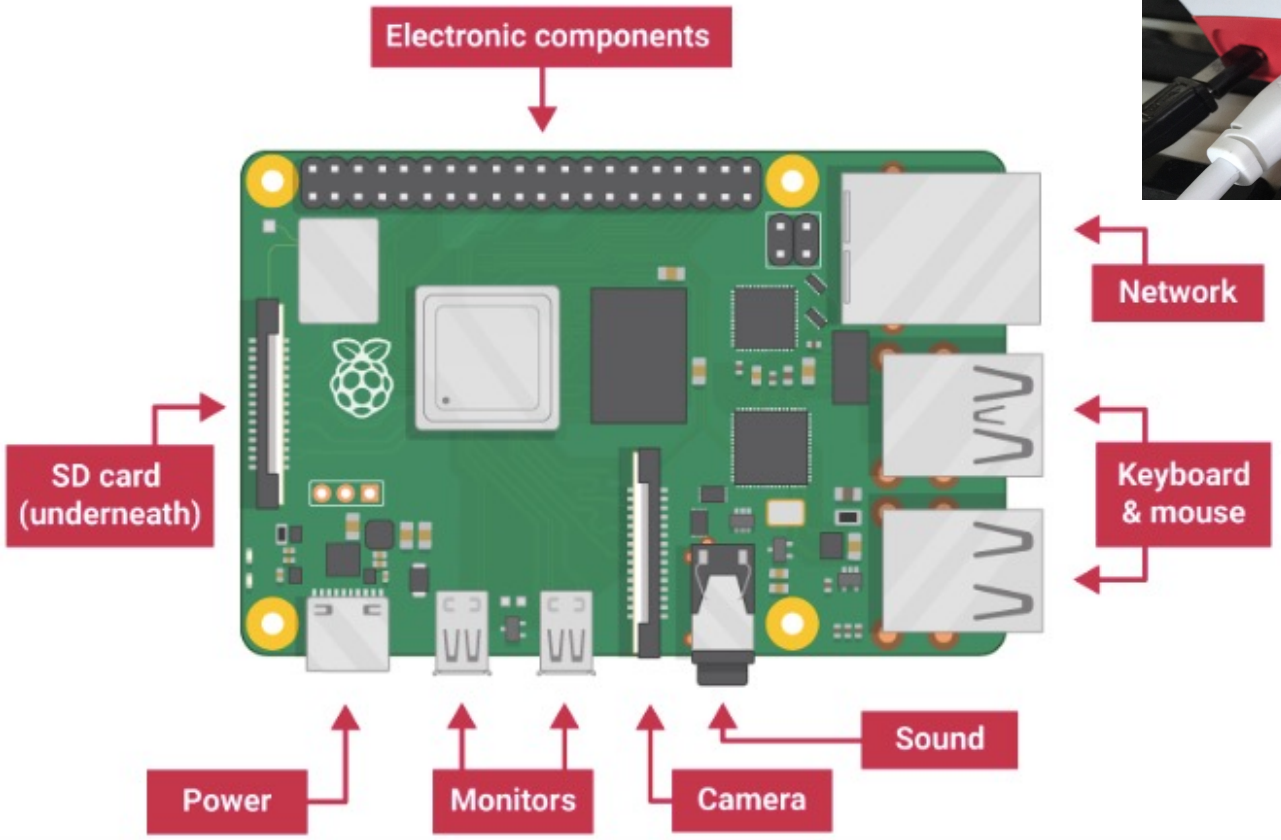
Connect your Raspberry Pi

Now get everything connected to your Raspberry Pi. It's important to do this in the right order, so that all your components are safe.



Pi 4 Ports

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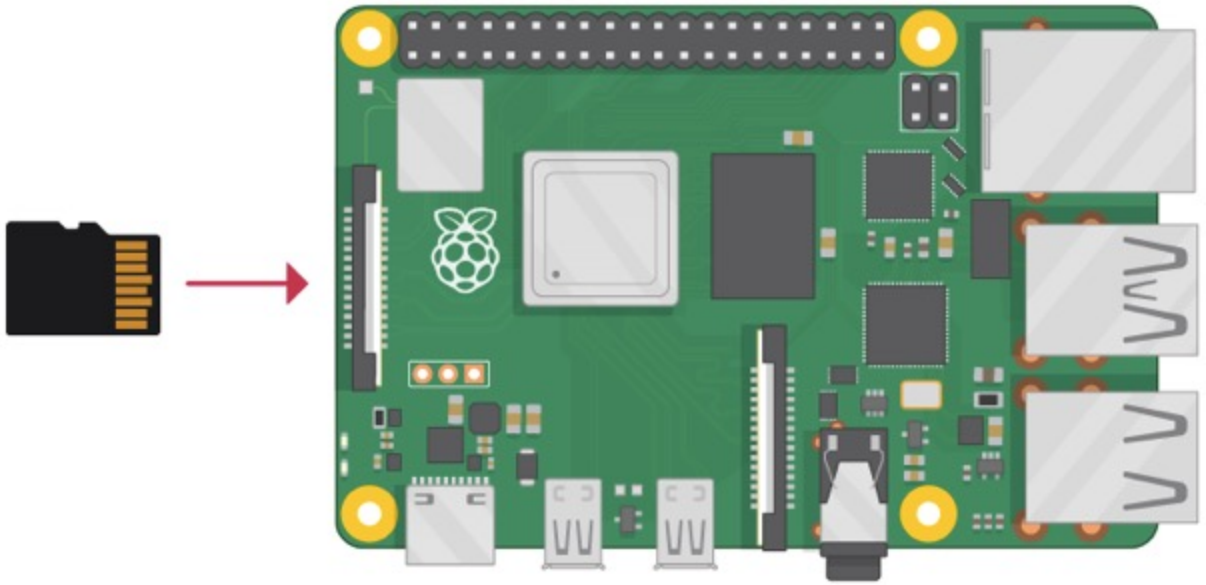
A microSD card

Your Raspberry Pi needs an SD card to store all its files and the Raspbian operating system.



You need a microSD card with a capacity of **at least 8 GB**.

Many sellers supply SD cards for Raspberry Pi that are already set up with Raspbian and ready to go.

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Pi 4 Ports

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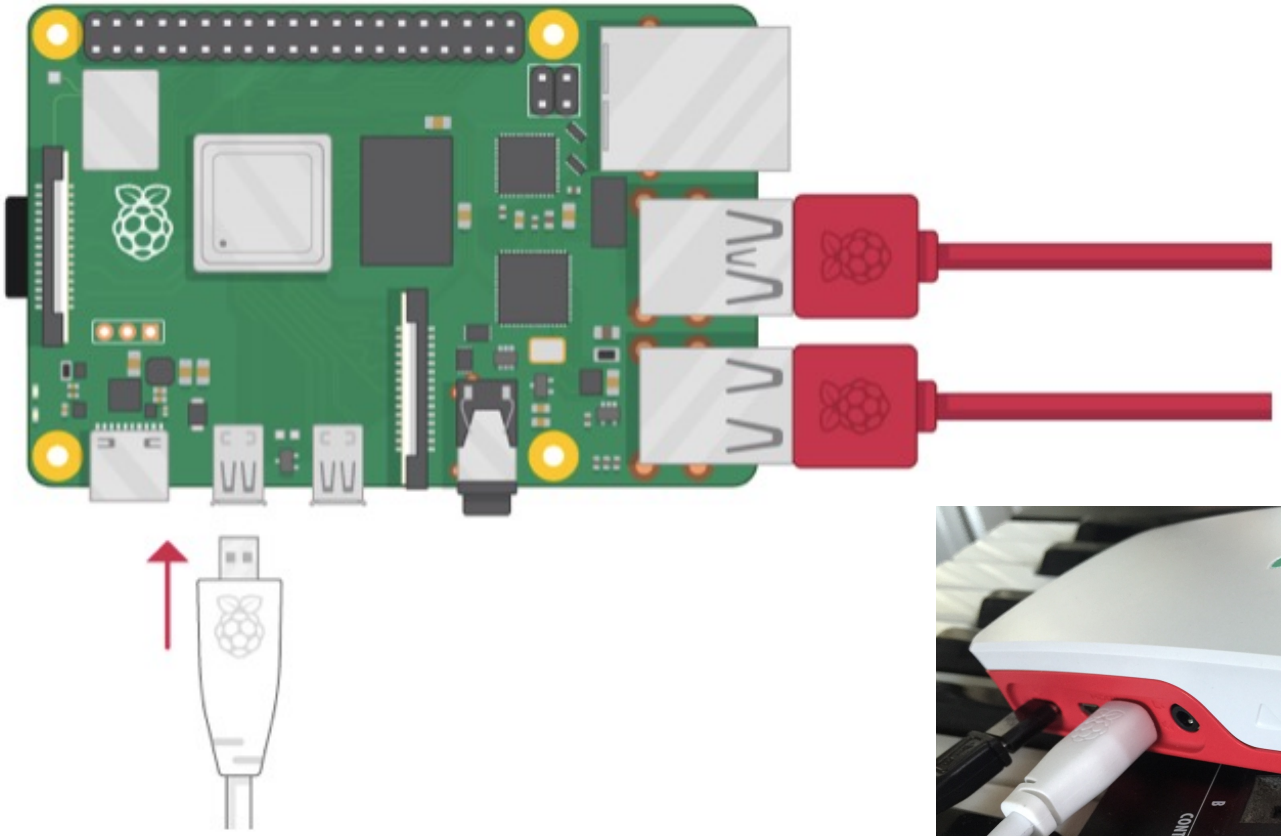
Raspberry Pi 4

Connect your screen to the first of Raspberry Pi 4's HDMI ports, labelled **HDMI0**.



You can connect an optional second screen in the same way.

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Pi 4 Ports

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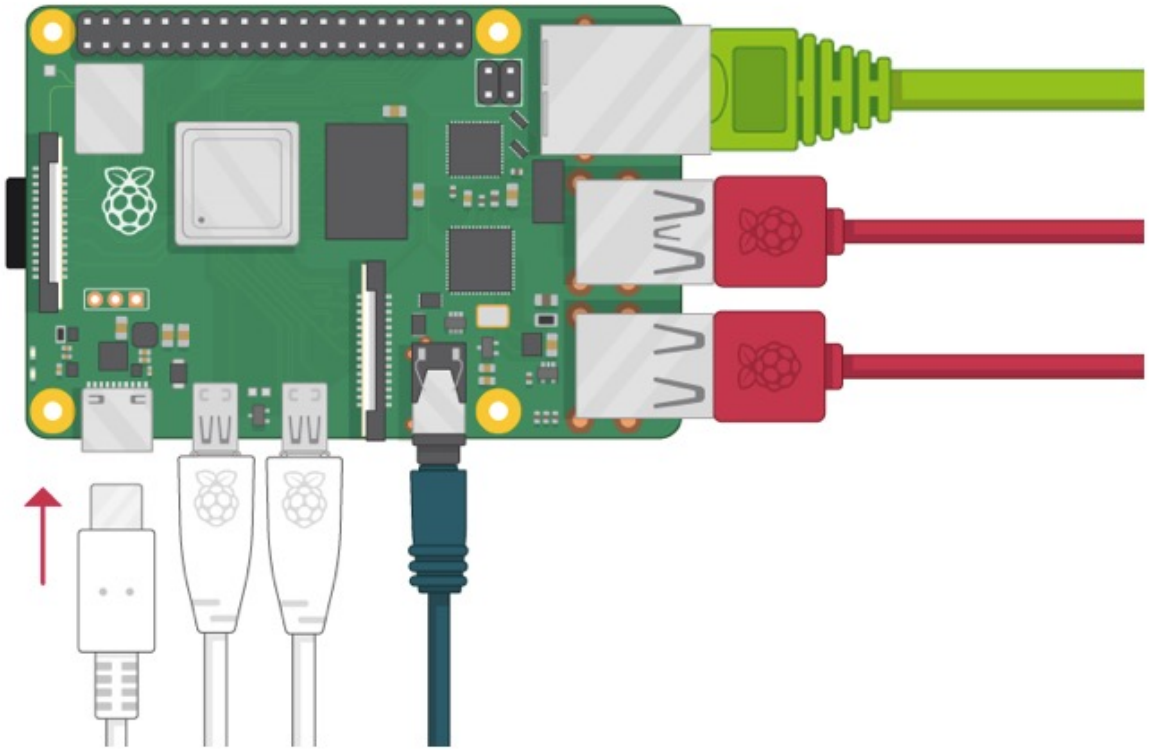
Start up your Raspberry Pi

Your Raspberry Pi doesn't have a power switch: as soon as you connect it to a power outlet, it will turn on.

- Plug the USB power supply into a socket and connect it to your Raspberry Pi's power port.



RPi

NFC/RFID

The HAT is not hard on resources, so you can use many variants of Raspberry Pi

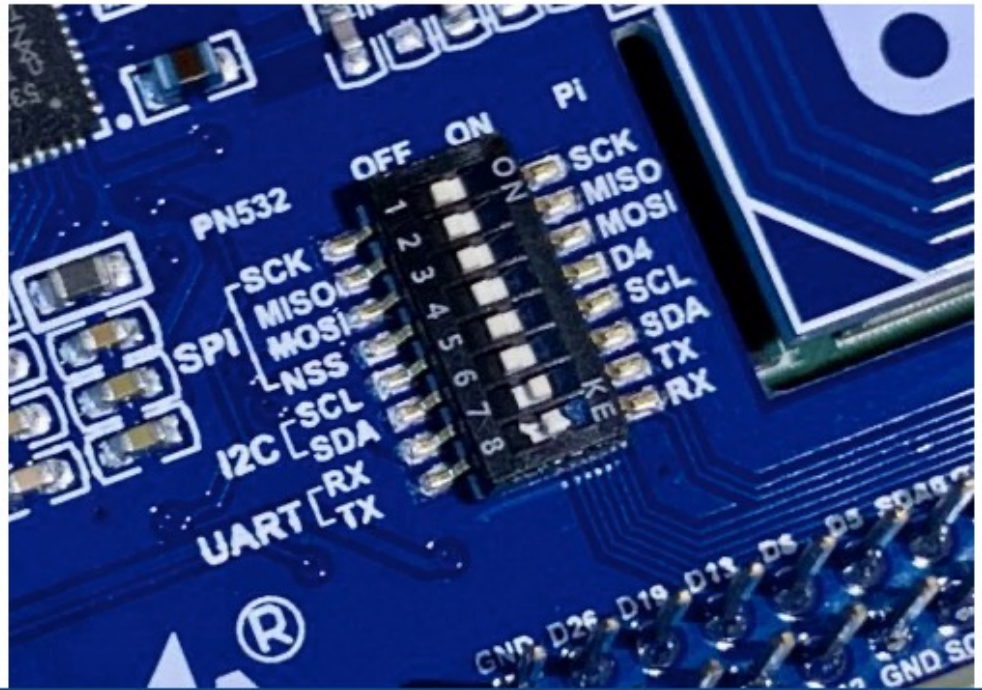
NFC (near-field communication) is based on the RFID (radio-frequency identification) standard. Both allow a device to receive data from a passive token or tag (meaning it doesn't require external power to work). RFID supports a simple ID message that shouts 'I exist', whereas NFC allows for both reading and writing of data.

RPi

Jumpers & Switches

Configure and install the HAT

As mentioned in the previous step, we have a choice of interfaces and swapping between them means changing some physical settings on the NFC HAT itself. Do not do this while the HAT is powered up in any way. Our HAT can be configured for UART/Serial by default but do check on the wiki at hsmag.cc/iHj1XA. The jumpers at I1 and I0 should both be shorting 'L', D16 and D20 should be shorted and on the DIP switch, everything should be off except RX and TX. Check, double-check, attach the HAT to the GPIO, and boot up.



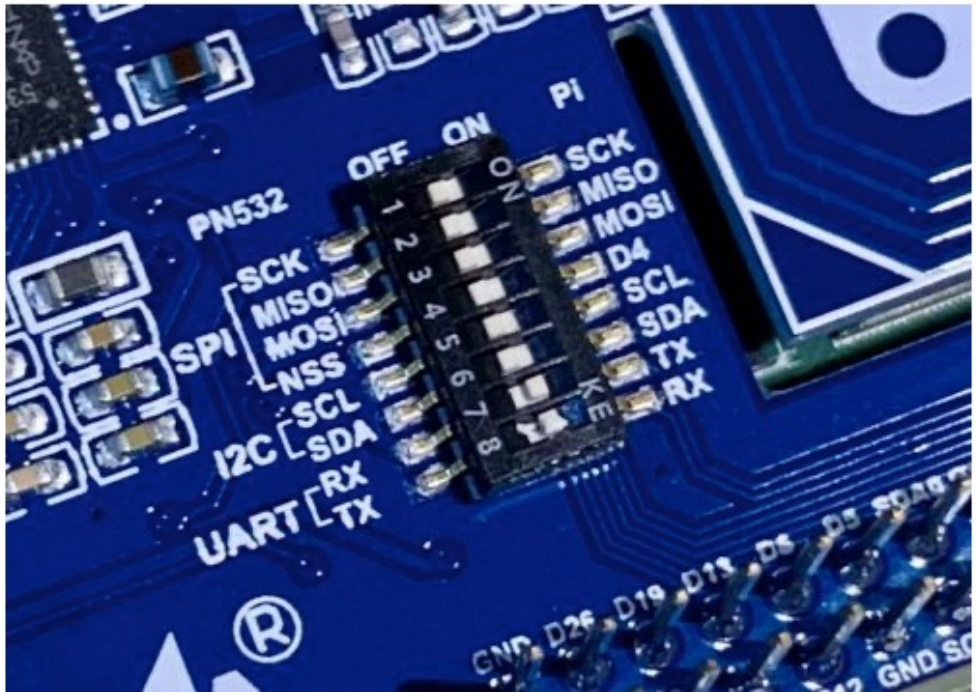
RPi

Serial Ports

I2C, SPI, UART

Enable the serial interface

This NFC HAT is capable of communicating over three different interfaces: I2C, SPI, and UART. We're going with UART as it's the simplest to demonstrate, but you may wish to use the others. Start by running sudo raspi-config, going to 'Interfacing options', and selecting 'Serial Interface'. When asked if you want to log into the console, say 'No'. Then, when asked if you want to enable the serial interface, say 'Yes'. You'll need to reboot now. This will allow the HAT to talk to our Raspberry Pi over the serial interface.



RPi

Download the examples

You can download some examples directly from Waveshare. First, we need to install some dependencies. Run the following at the command line:

```
sudo apt install rpi.gpio p7zip-full python3-pip
pip3 install spidev pyserial
```

Now, download the files and unpack them:

```
cd
wget https://www.waveshare.com/w/upload/6/67/Pn532-nfc-hat-code.7z
7z x Pn532-nfc-hat-code.7z
```

Before you try anything out, you need to edit the example file so that we use UART (see the accompanying code listing).

```
cd ~/raspberrypi/python
nano example_get_uid.py
```

Find the three lines that start `pn532 =` and add a # to the top one (to comment it out). Now remove the # from the line starting `pn532 = PN532_UART`. Save, and exit.

Lab

Software OS

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Pi 4 OS

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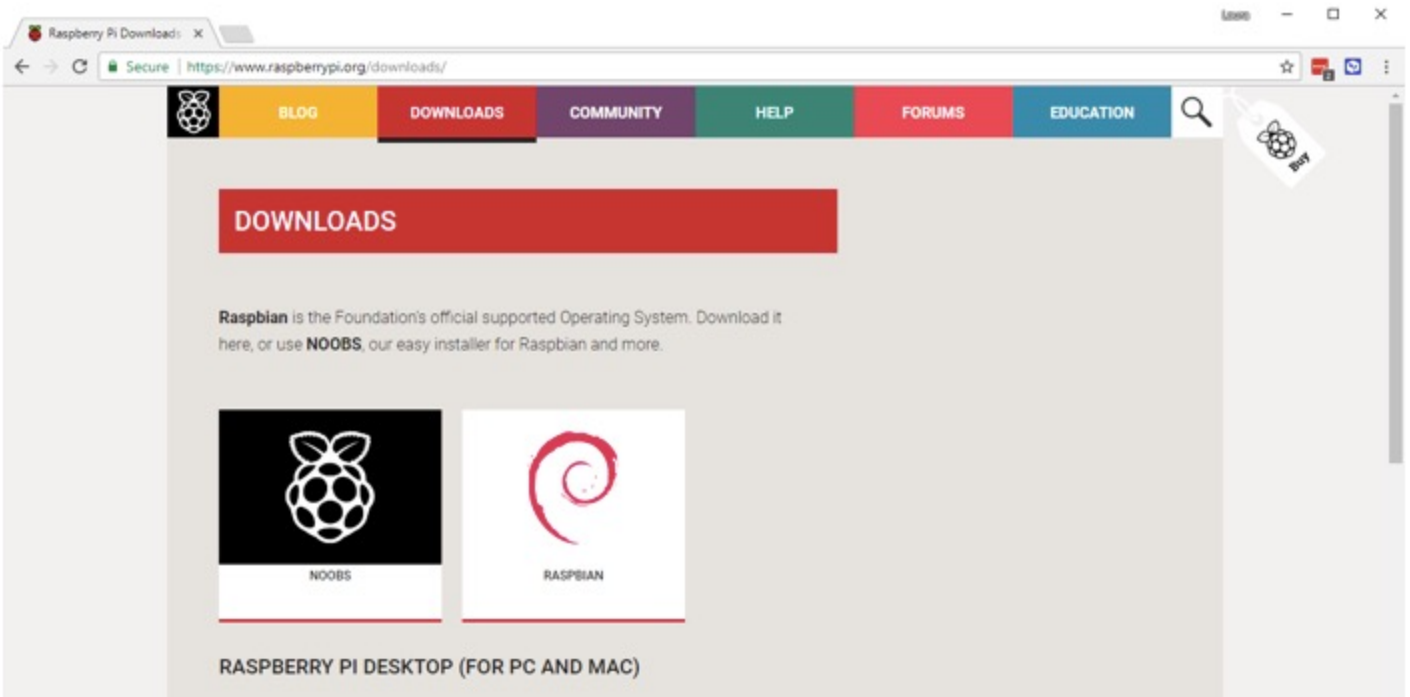
The Raspbian operating system via NOOBS

Using the NOOBS software is the easiest way to install Raspbian on your SD card.

Note: more advanced users looking to install a particular operating system should use this guide to **installing operating system images**.

Download NOOBS

- Visit the **Raspberry Pi downloads page**.



Pi 4 OS

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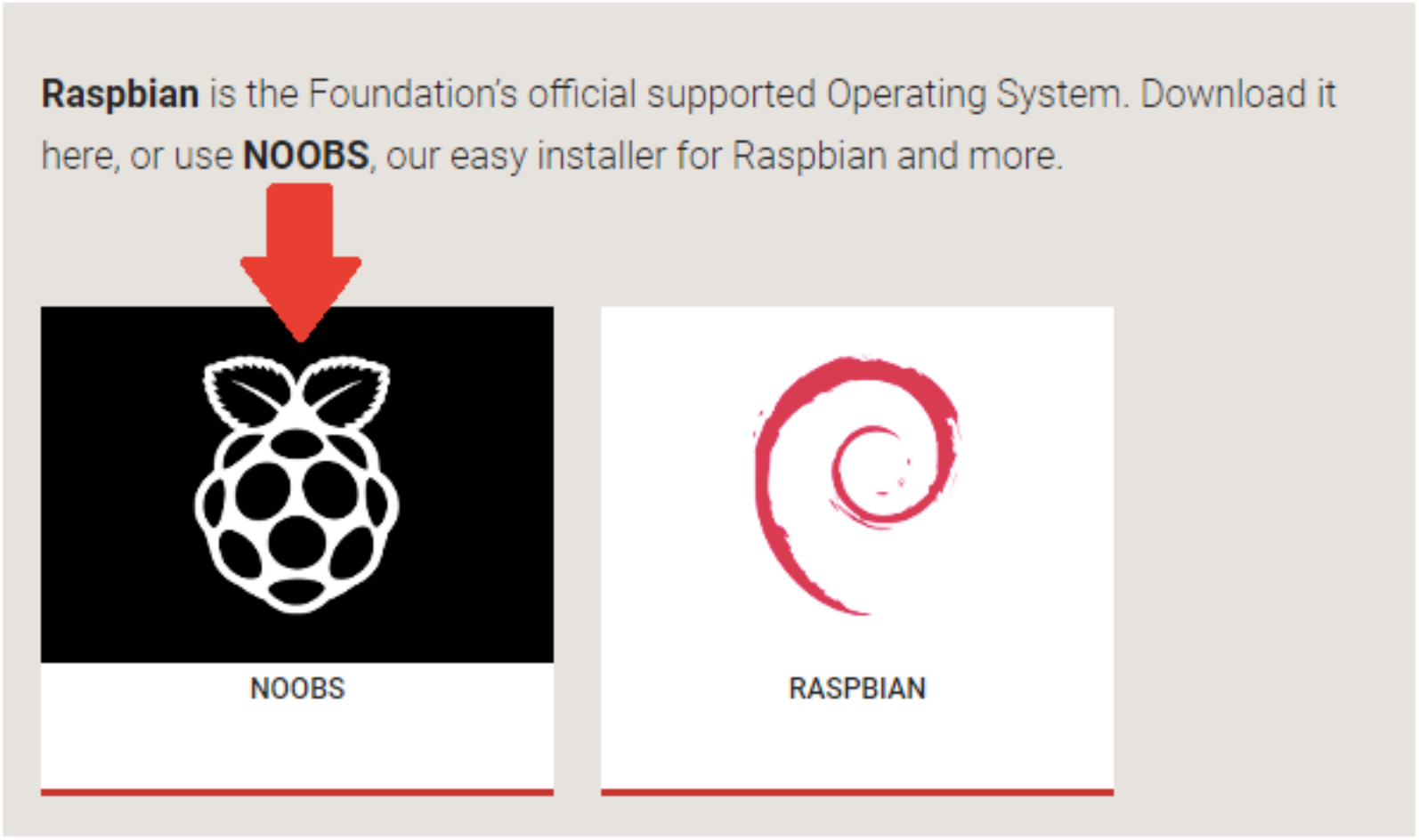
- You should see a box linking to the NOOBS files. Click on the box.



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Pi 4 Setup

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Finish the setup

When you start your Raspberry Pi for the first time, the **Welcome to Raspberry Pi** application will pop up and guide you through the initial setup.

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Pi 4 Desktop

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First-time startup with NOOBS

After a few seconds the Raspbian Desktop will appear.

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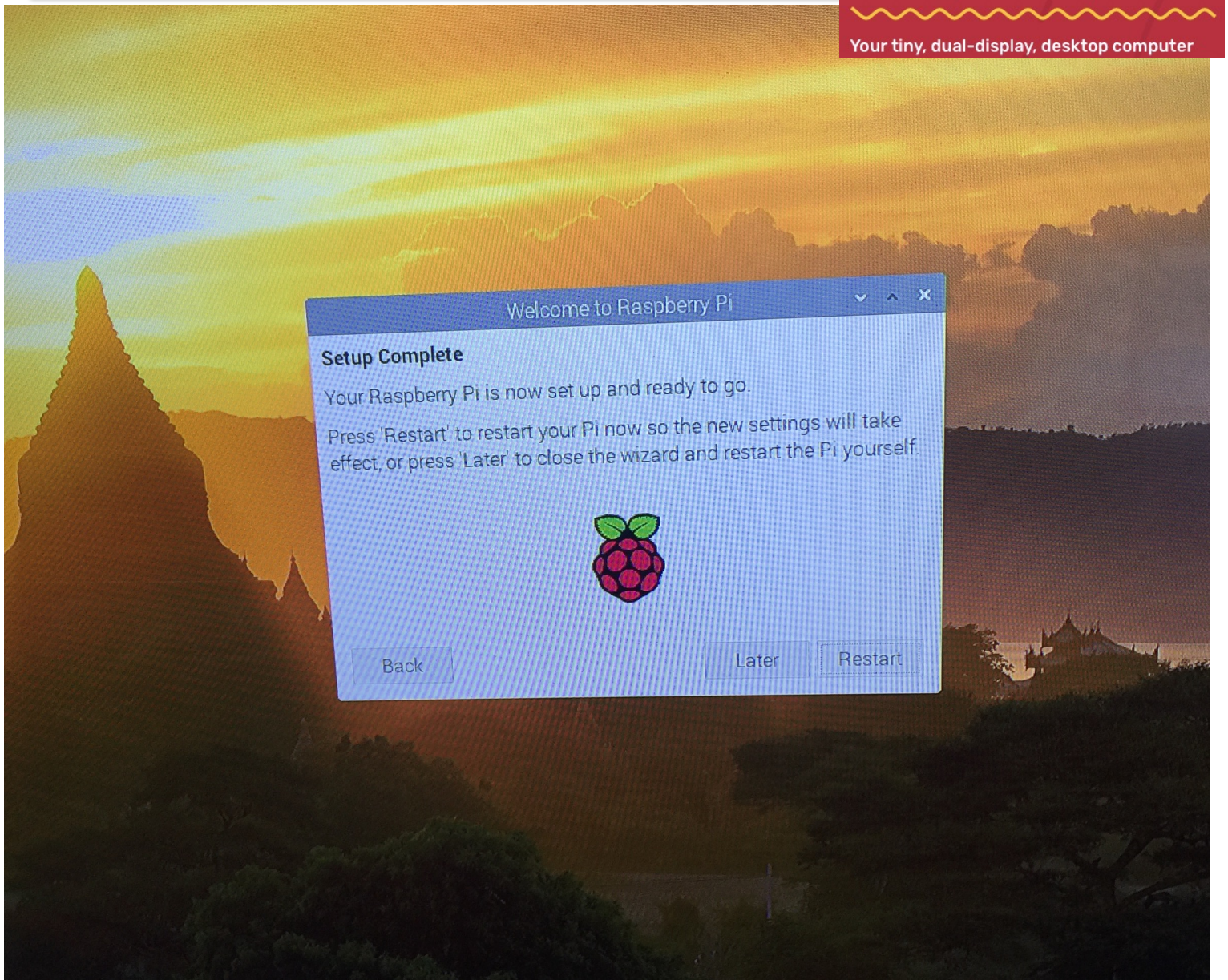
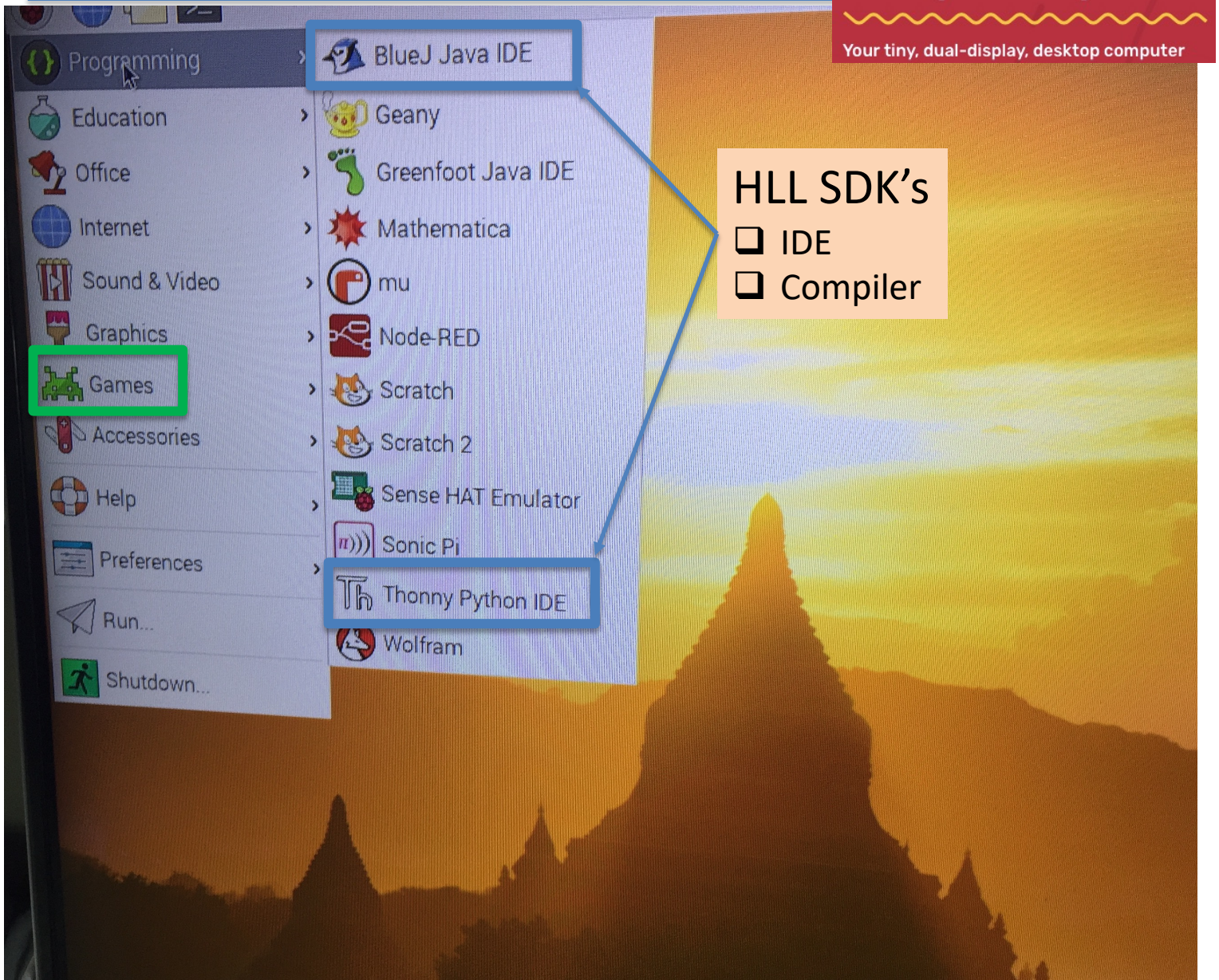
Pi 4 Desktop



Pi 4 Software



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Pi 4 Software

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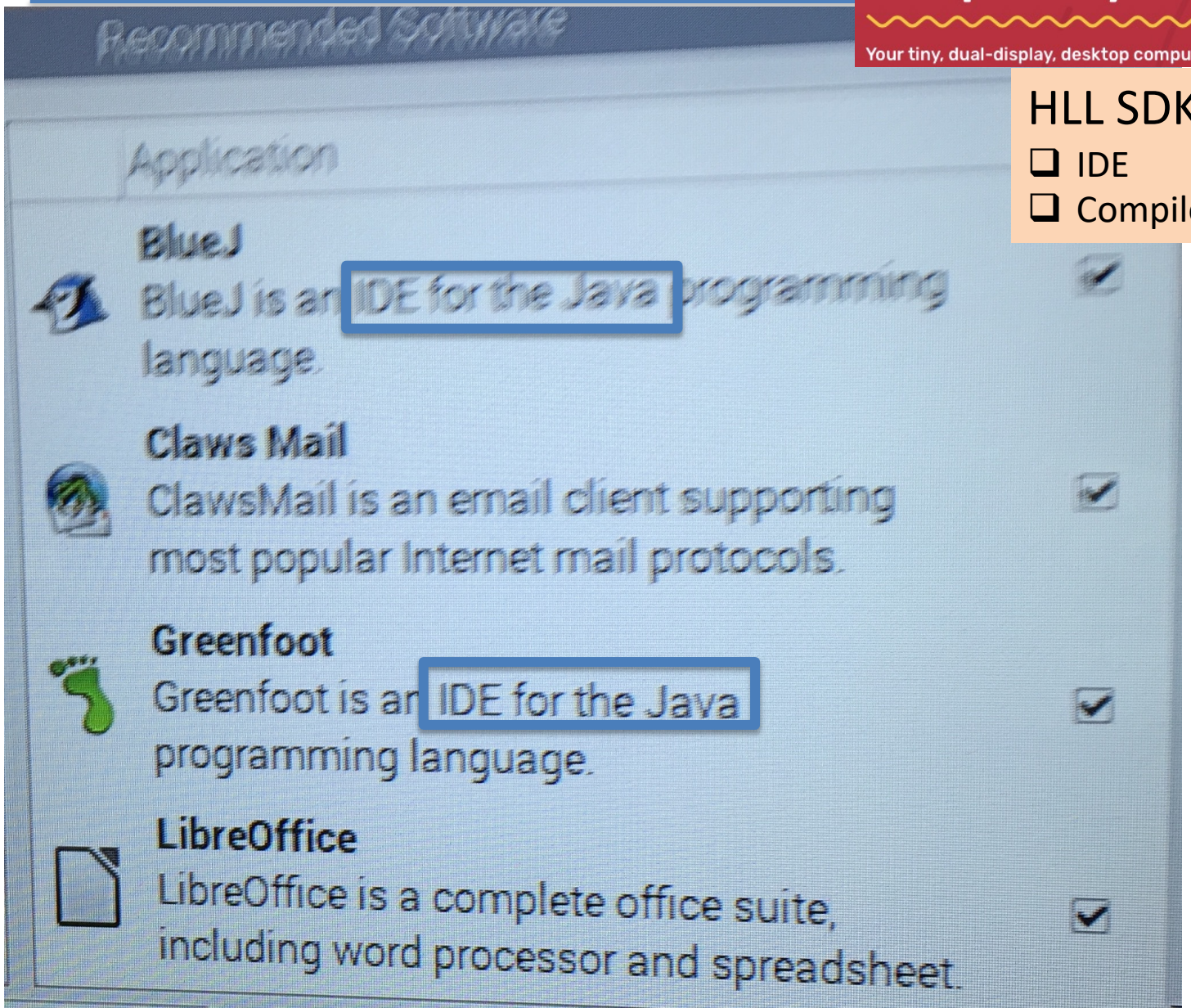
HLL SDK's
- ❑ IDE
- ❑ Compiler



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HLL SDK's
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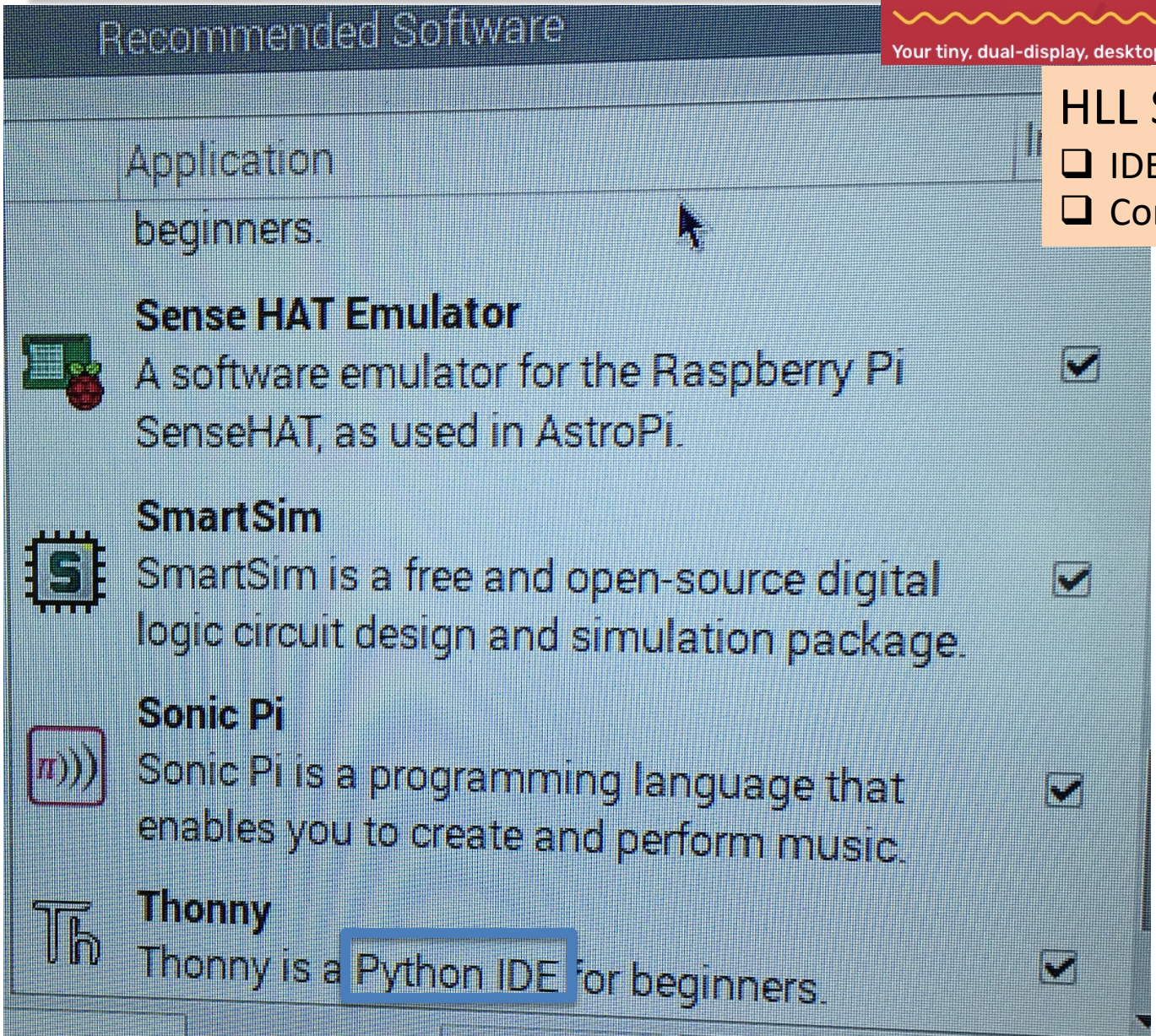

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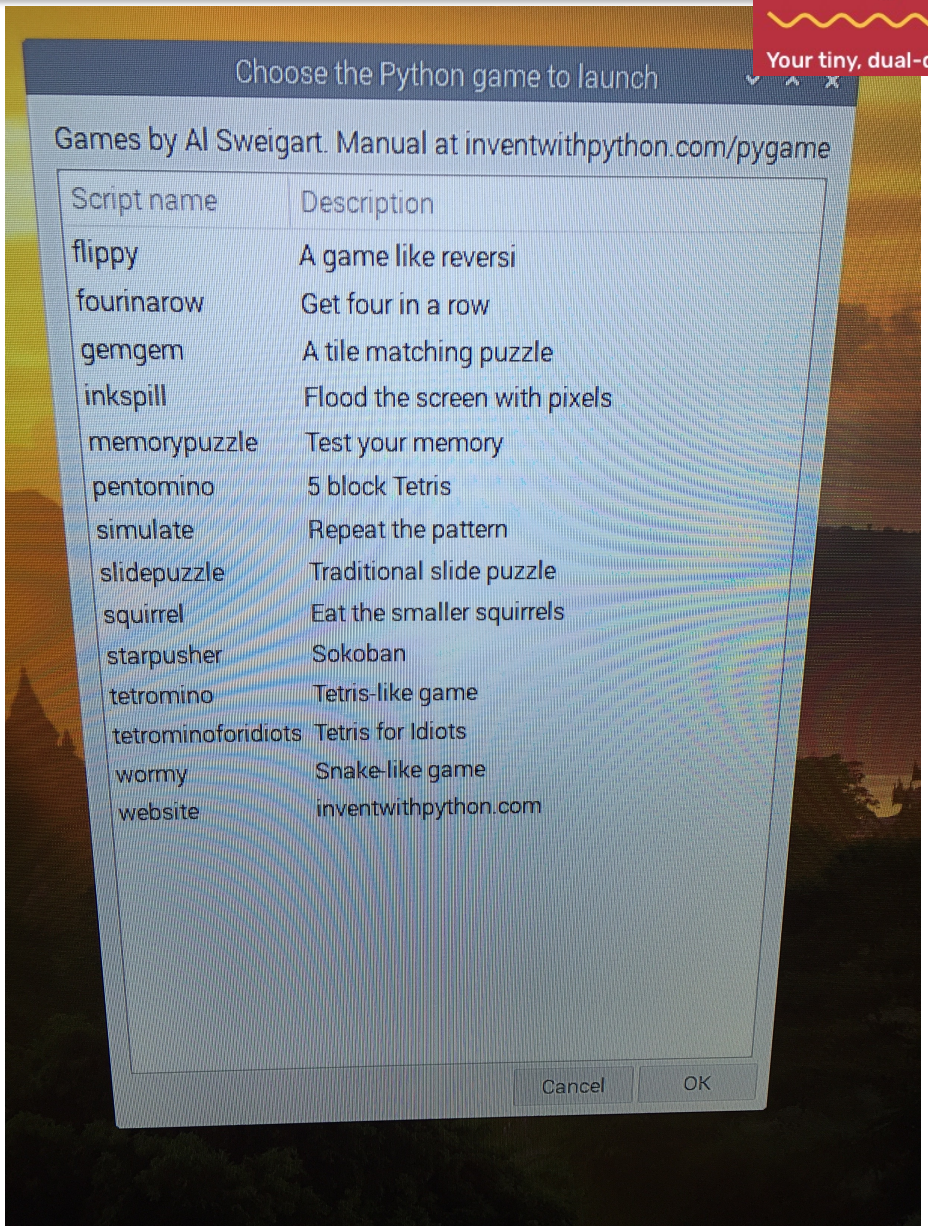
Pi 4 Games



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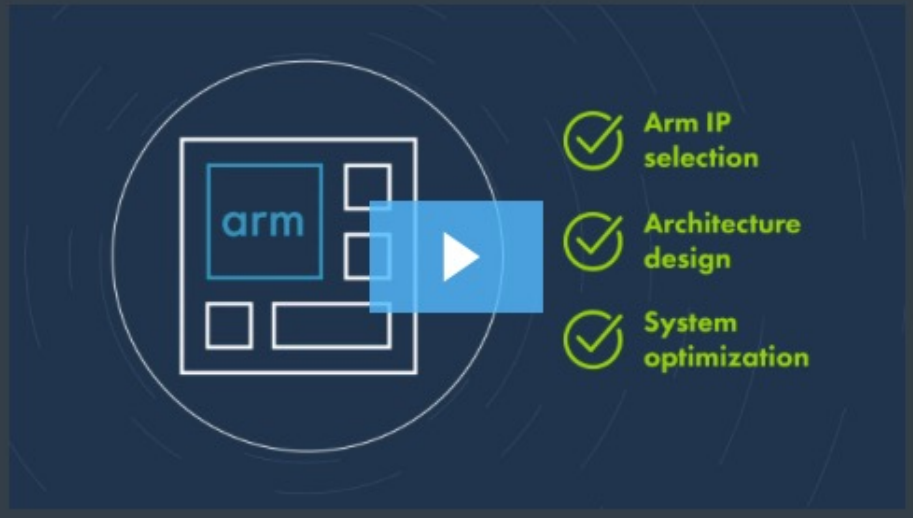
DEVELOPMENT TOOLS AND SOFTWARE

CYCLE MODELS

Simulator



Evaluate Arm IP with Precision

Cycle models are 100% cycle accurate models of Arm IP, compiled directly from RTL. With Cycle Models, users can confidently select and configure Arm IP, make architectural decisions, optimize system performance, and develop bare metal software and low-level firmware before silicon is available.

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Features and Benefits

A Golden IP Performance Reference

100% accurate cycle models of Cortex processors and system IP, including NIC, CCI, CCN, and CMN interconnect. Prove your assumptions before committing to hardware. Analyze complex interconnect behavior, quickly explore design options, and see the impact of hardware/software tradeoffs.

Rapid System Level Debugging

Cycle Models are instrumented to enable fast and detailed debug and analysis of Arm IP whether under software workloads or traffic-based stimulus. Arm debugger integration, and cache coherent memory views are all available to SoC architects, system designers, performance engineers, and

Recommended For You

Unified Software and Hardware Analysis

Software teams can view code, set breakpoints, and examine registers and memories. Hardware teams can examine signals, dump waveforms, and trace execution through the system. All users gain rapid insight from instrumented architectural and microarchitectural registers and a

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Assembly

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Assembly Language

https://www.youtube.com/watch?v=ViNnfoE56V8

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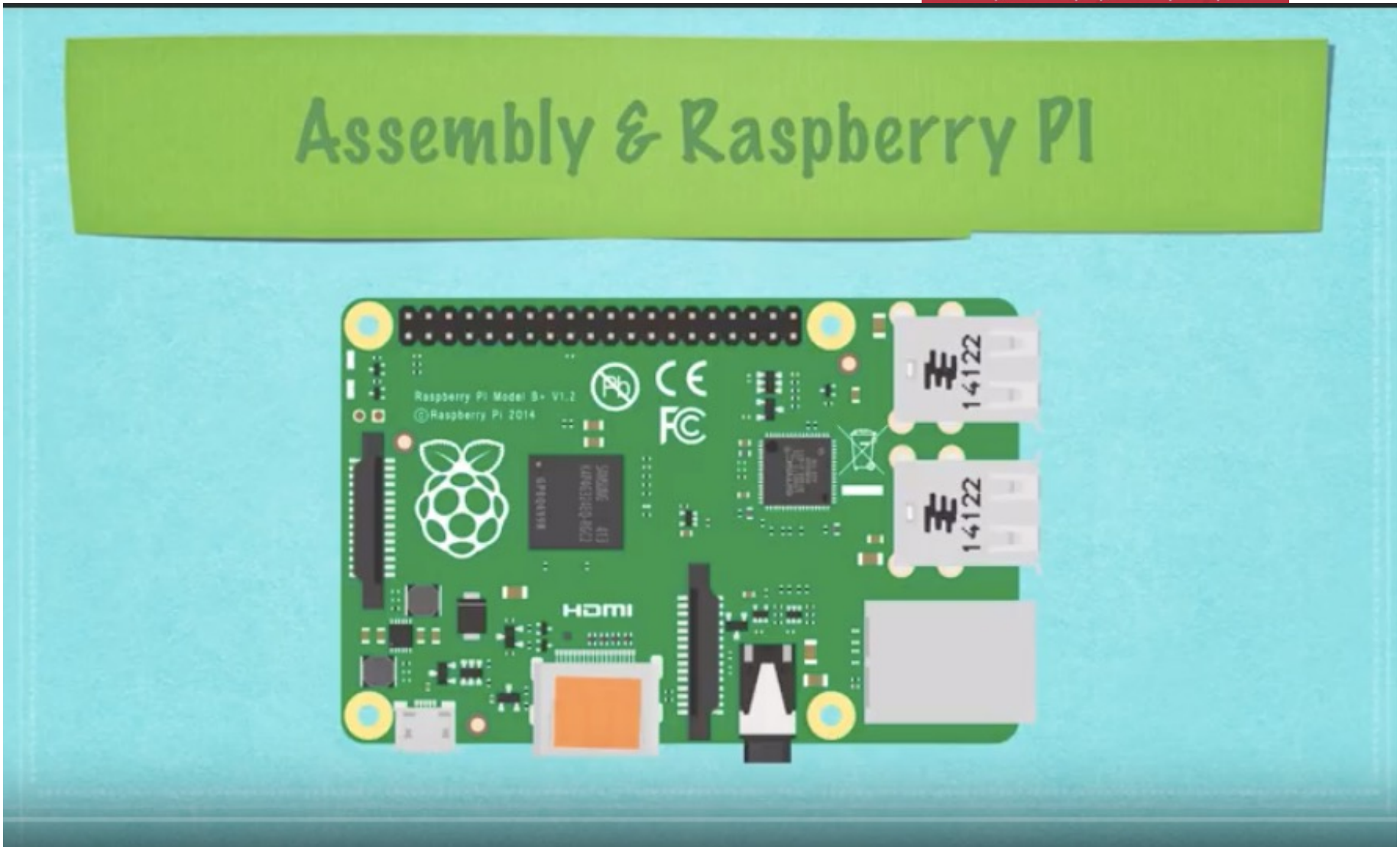

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Assembly Language

https://www.youtube.com/watch?v=ViNnfoE56V8


```
pi@raspberrypi:~/Documents/ASM Projects $ sudo apt-get install vim
```

```
pi@raspberrypi:~/Documents/ASM Projects $ cd ..
pi@raspberrypi:~/Documents $ cd ASM\ Projects
pi@raspberrypi:~/Documents/ASM Projects $ sudo raspi-config expand_rootfs
```

```
pi@raspberrypi:~/Documents/ASM Projects $ cd ..
pi@raspberrypi:~/Documents $ cd ASM\ Projects
pi@raspberrypi:~/Documents/ASM Projects $ vim asmtut
```

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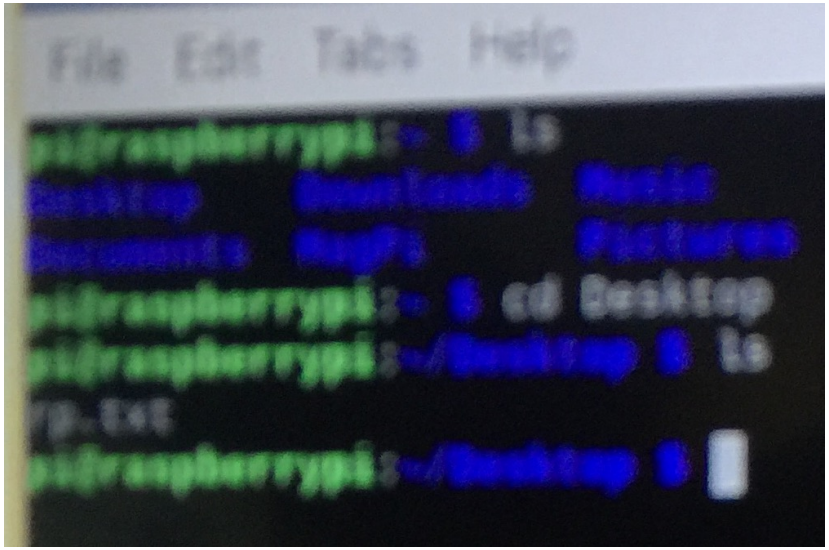
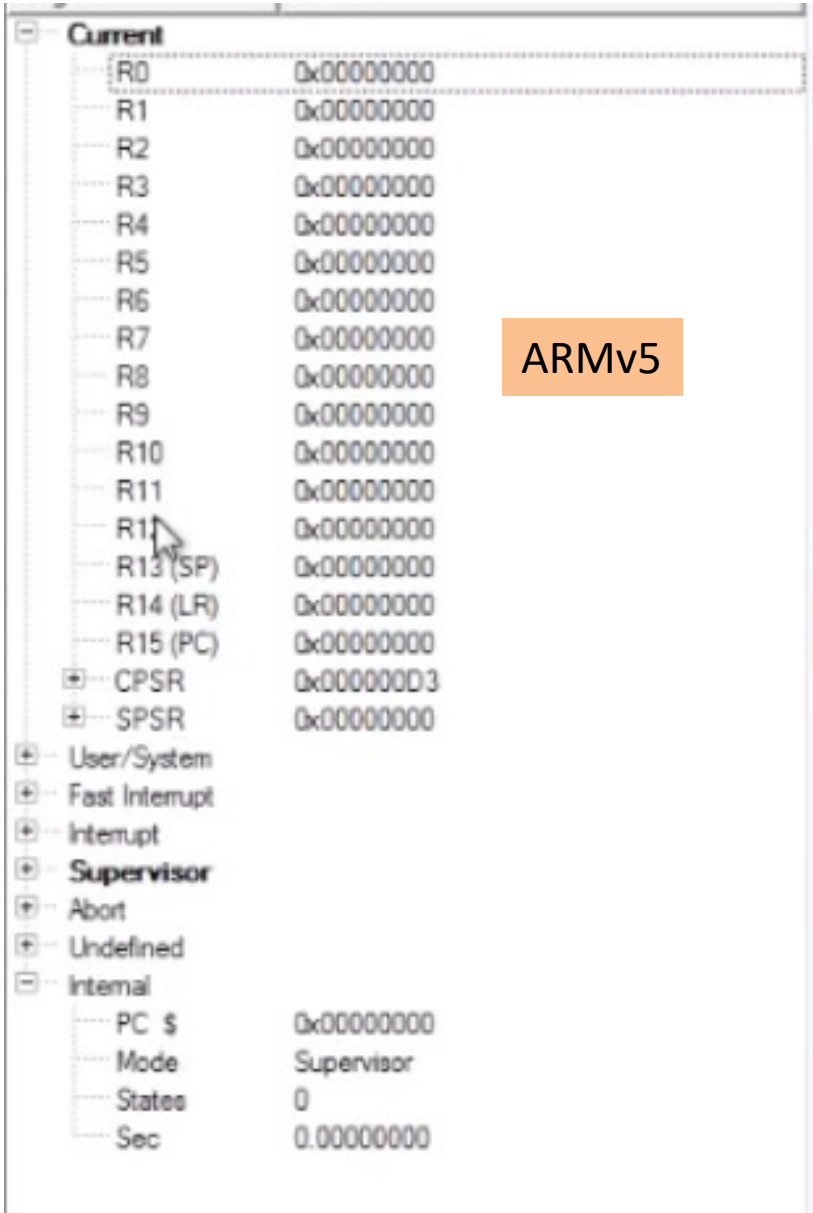
AddTwo.asm

```
; AddTwo.asm - adds two 32-bit integers.
; Chapter 3 example

.386
.model flat,stdcall
.stack 4096
ExitProcess proto,dwExitCode:dword

.code
main proc
    mov eax,5
    add eax,6

    invoke ExitProcess,0
main endp
end main
```



x86: i80386

Assembly Language



ARMv5

```
    8:
0x00000000  E3A0000B  MOV        R0,#0x0000000B
    9: stop    B       stop
0x00000004  EAFFFFFE  B          0x00000004
0x00000008  00000000  ANDEQ      R0,R0,R0
0x0000000C  00000000  ANDEQ      R0,R0,R0
0x00000010  00000000  ANDEQ      R0,R0,R0
0x00000014  00000000  ANDEQ      R0,R0,R0
0x00000018  00000000  ANDEQ      R0,R0,R0
0x0000001C  00000000  ANDEQ      R0,R0,R0
0x00000020  00000000  ANDEQ      R0,R0,R0
0x00000024  00000000  ANDEQ      R0,R0,R0
0x00000028  00000000  ANDEQ      R0,R0,R0
0x0000002C  00000000  ANDEQ      R0,R0,R0
```

firstasm.s

```
1           GLOBAL Reset_Handler
2           AREA Reset, CODE, READONLY
3           ENTRY
4
5 Reset_Handler
6
7           MOV      r0, #11
8
9 stop      B        stop
10
11          END
12
13
14
```

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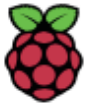
Help

- References
- Books
- Projects



Pi 4 Help

Where to find help

If you're having problems with your Raspberry Pi, there are lots of places you can get help and advice:

- Check out the **help section** and the **troubleshooting guide** on the Raspberry Pi website
- The **Raspberry Pi forum**, including the **Beginners** section, is a great place to ask questions and get support from the Raspberry Pi community
- Call out on Twitter using the hashtag #rpilearn, or submit a question on the **Raspberry Pi Stack Exchange**
- You could also attend a free **Raspberry Jam** community event to talk to people about their experiences and get some first-hand help from fellow Raspberry Pi users

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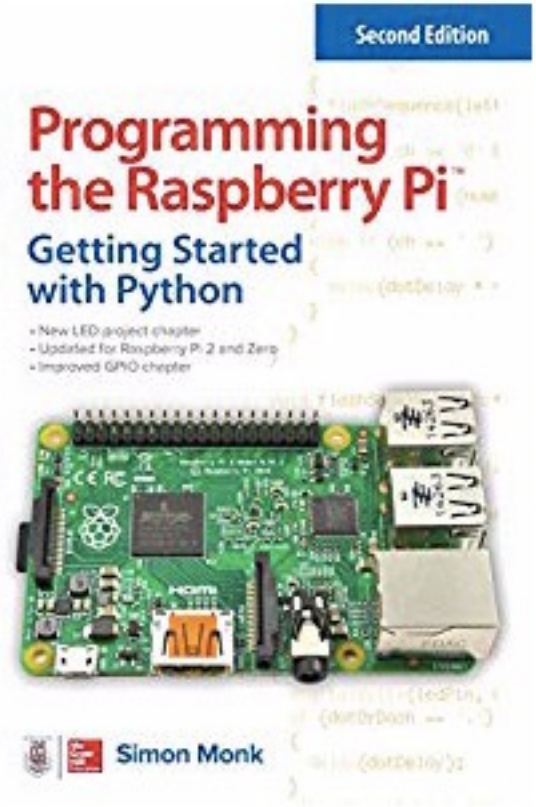

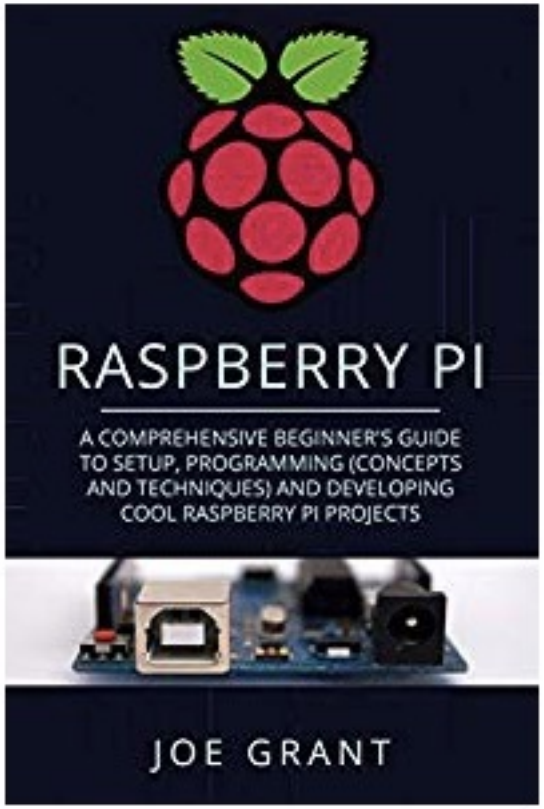

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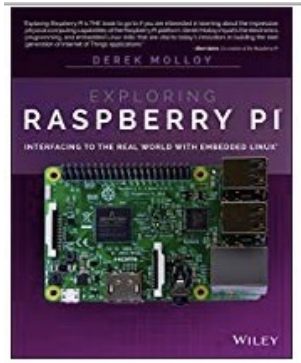

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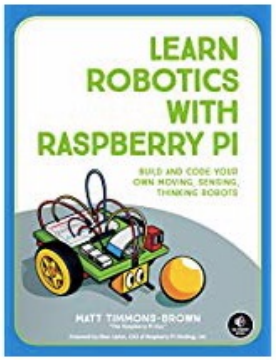

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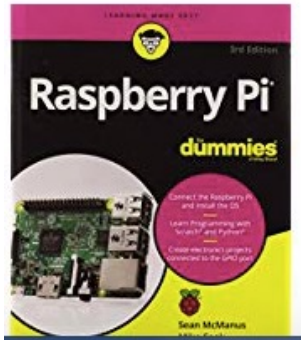

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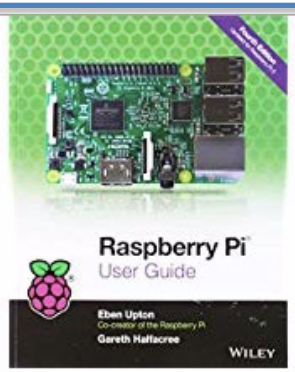

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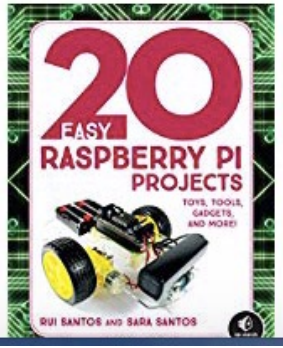

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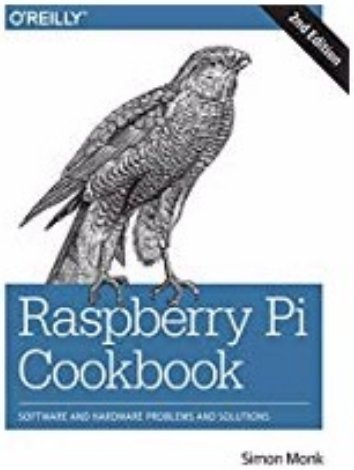

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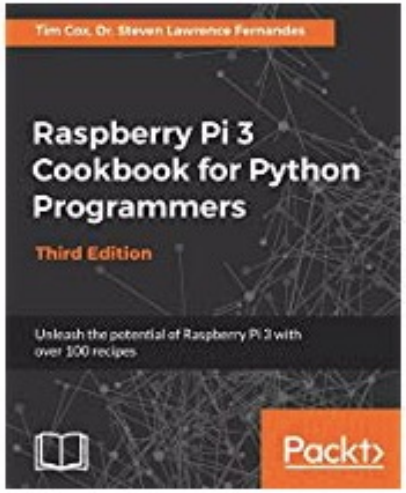

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Scratch 3 Desktop for Raspbian on Raspberry Pi

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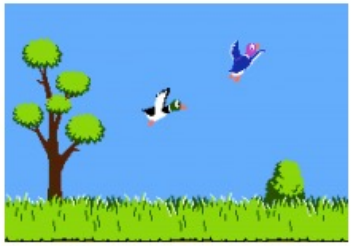

Code your own 2D shooting gallery in Python

(raspberrypi.org)

Use Python and Pygame to create a 2D shooting gallery

Build a Raspberry Pi music box with Sally Le Page

(raspberrypi.org)

Tap tap tap

Real-time train station departure board

(raspberrypi.org)

Never miss a train again...

Build a xylophone-playing robot

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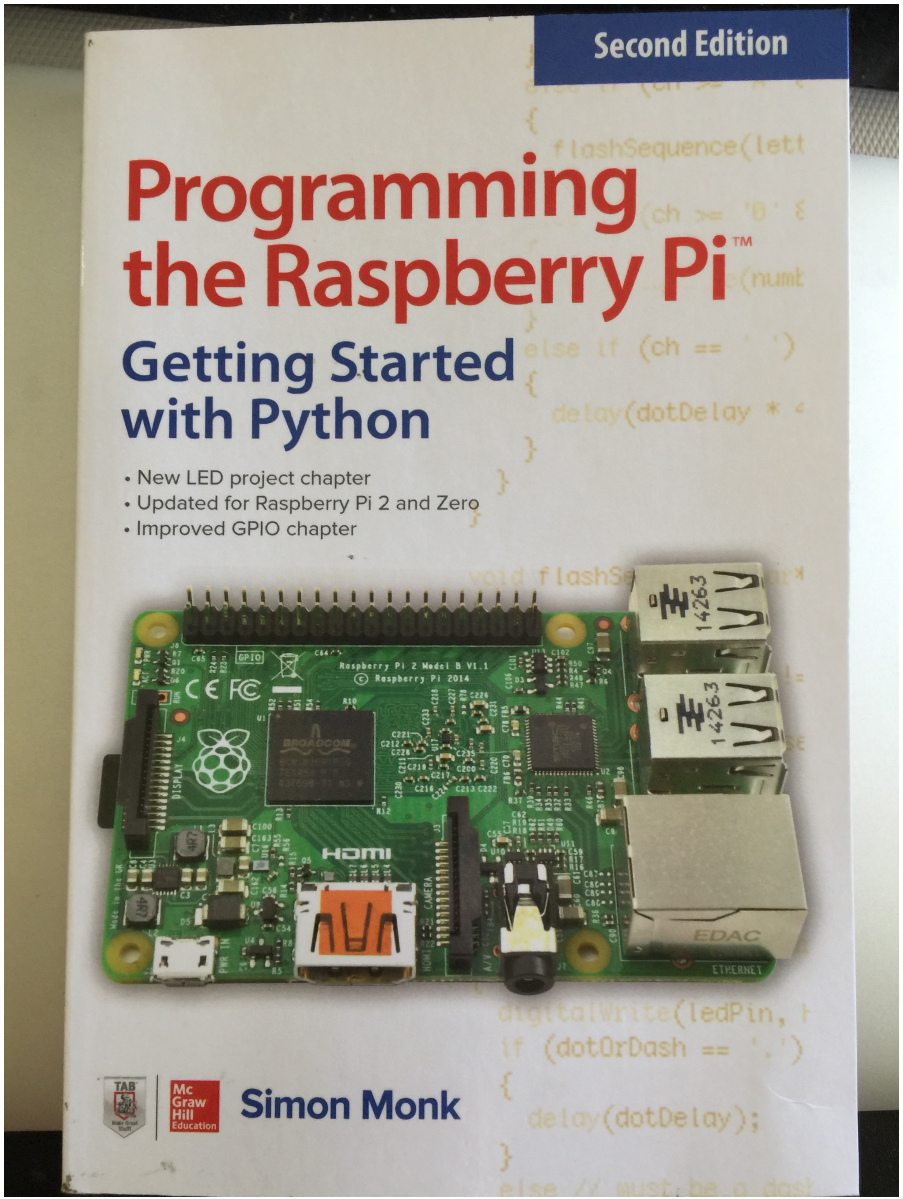

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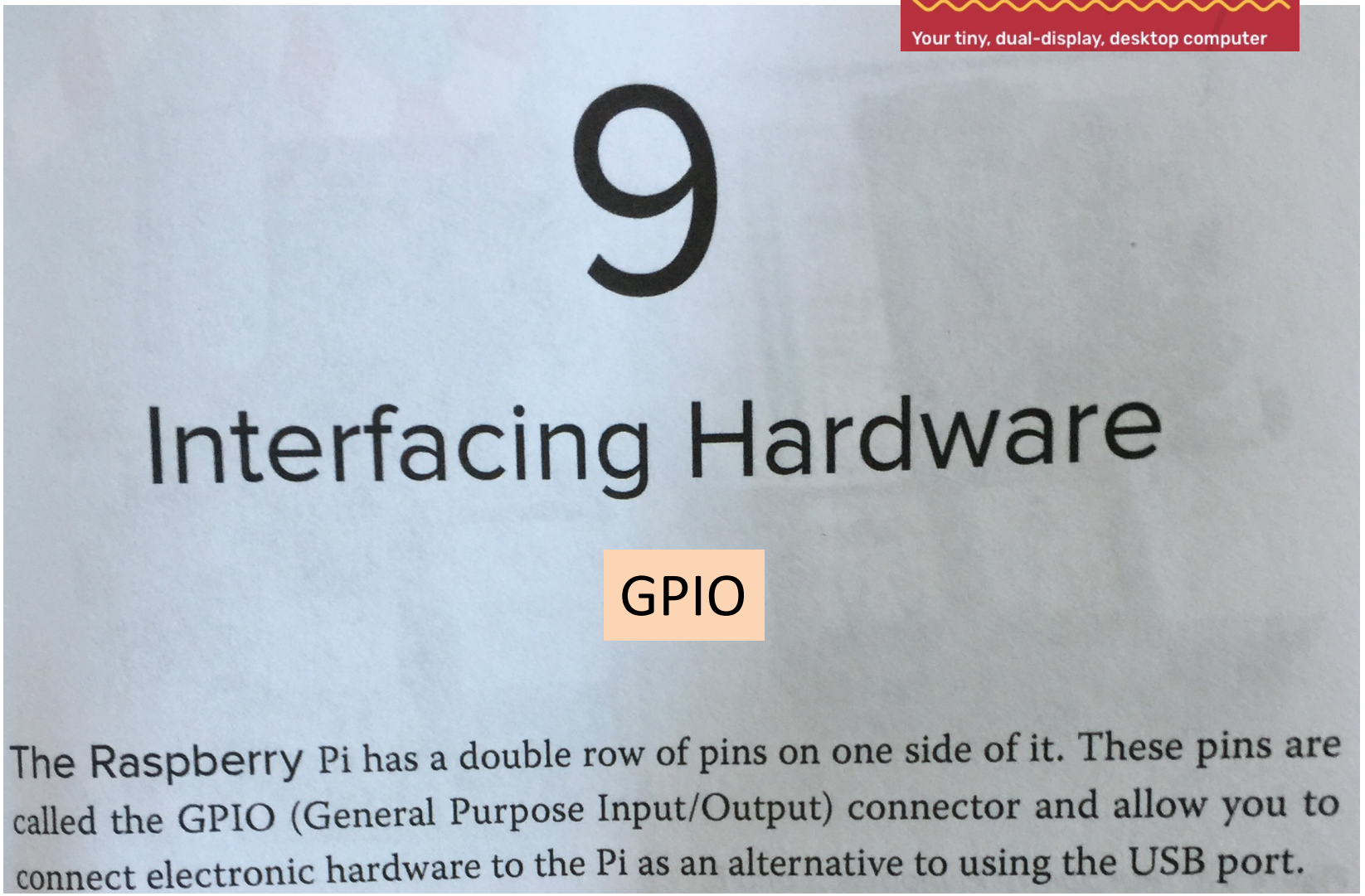

9

Interfacing Hardware

GPIO

The Raspberry Pi has a double row of pins on one side of it. These pins are called the GPIO (General Purpose Input/Output) connector and allow you to connect electronic hardware to the Pi as an alternative to using the USB port.

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GPIO

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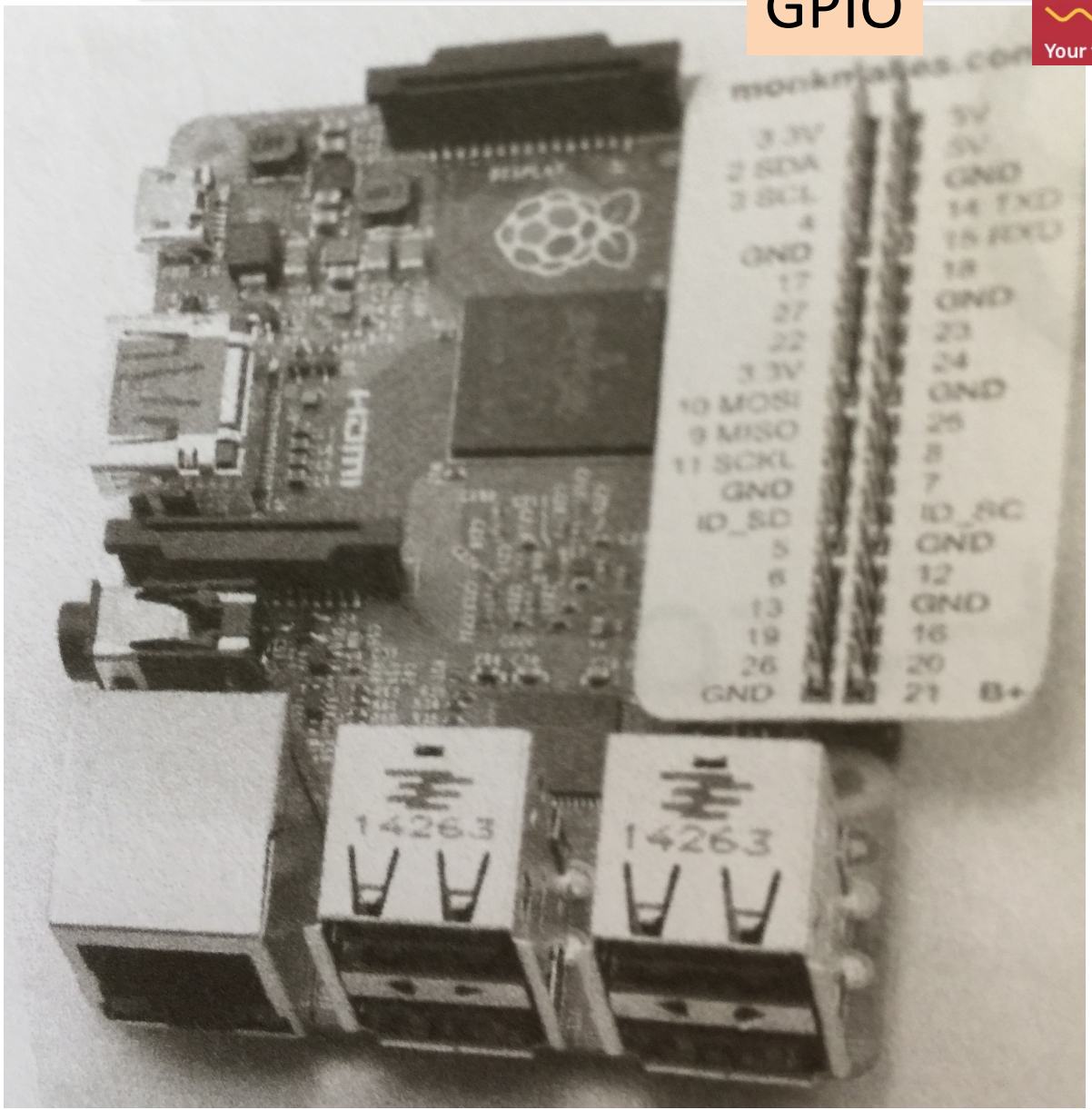

3.3V	☐☐	5V
2 SDA	☐☐	5V
3 SCL	☐☐	GND
4	☐☐	14 TXD
GND	☐☐	15 RXD
17	☐☐	18
27	☐☐	GND
22	☐☐	23
3.3V	☐☐	24
10 MOSI	☐☐	GND
9 MISO	☐☐	25
11 SCKL	☐☐	8
GND	☐☐	7
ID_SD	☐☐	ID_SC
5	☐☐	GND
6	☐☐	12
13	☐☐	GND
19	☐☐	16
26	☐☐	20
GND	☐☐	21

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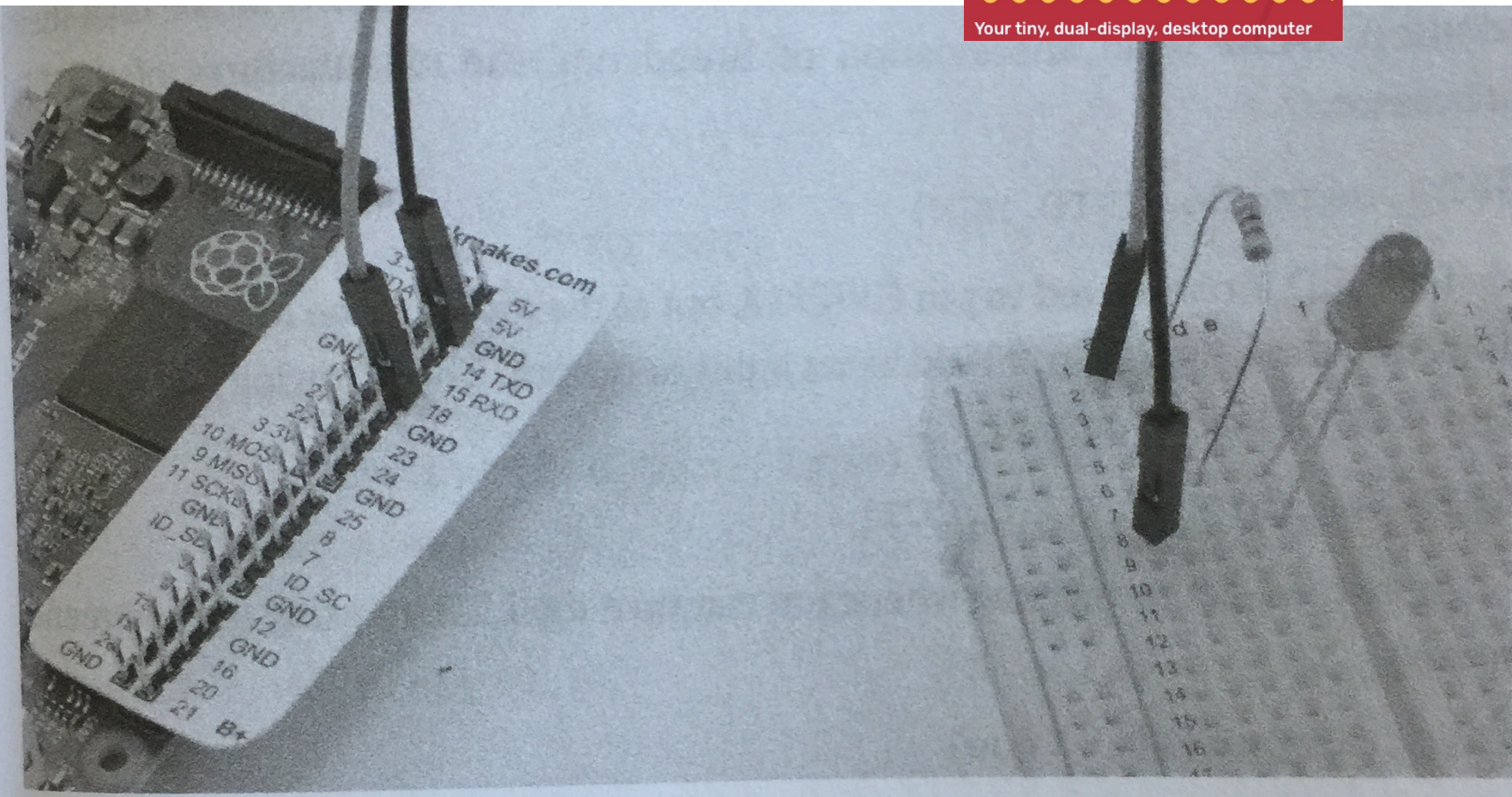

Figure 9-5 *The breadboard and Pi connected.*

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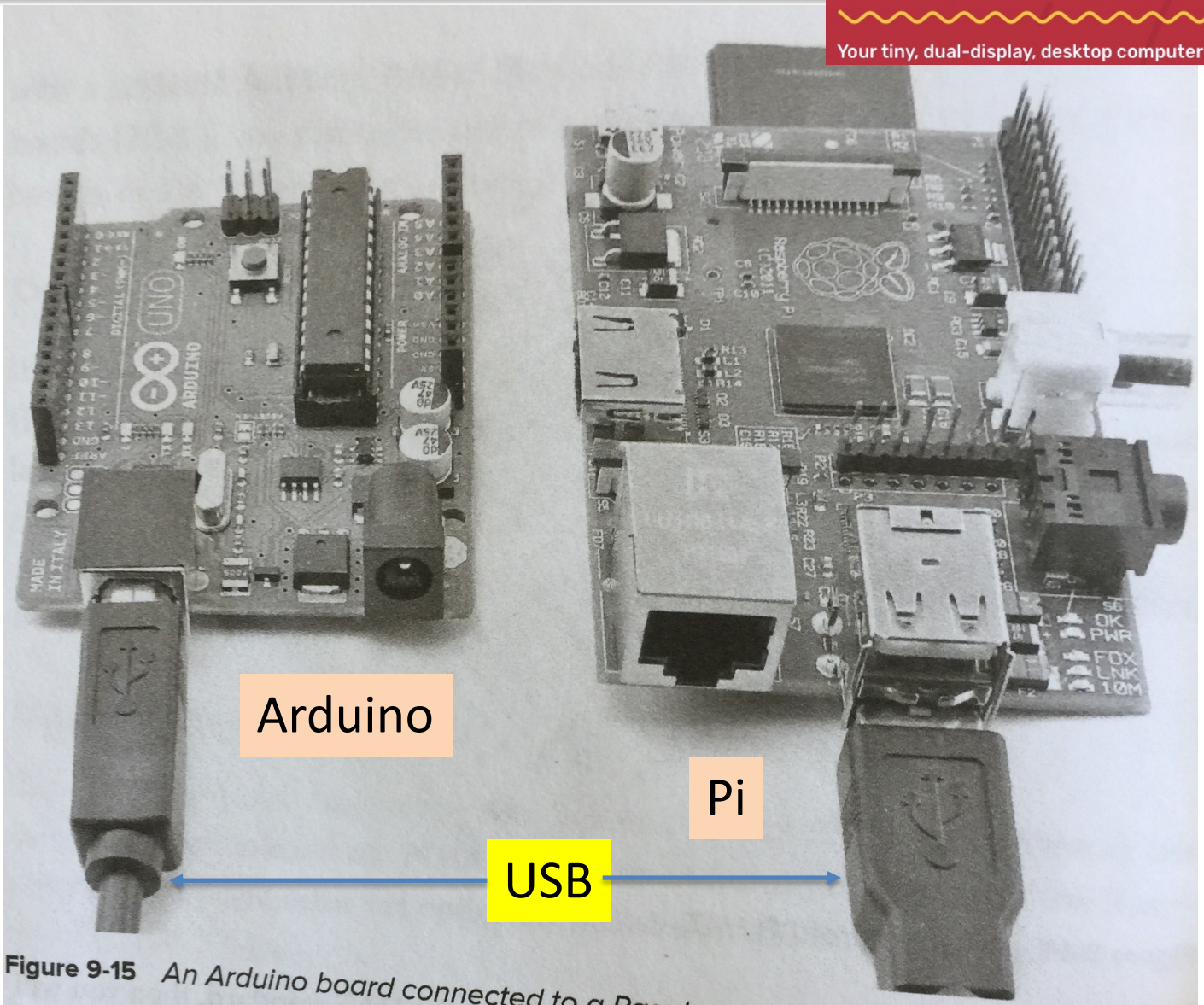

Figure 9-15 *An Arduino board connected to a Raspberry Pi.*

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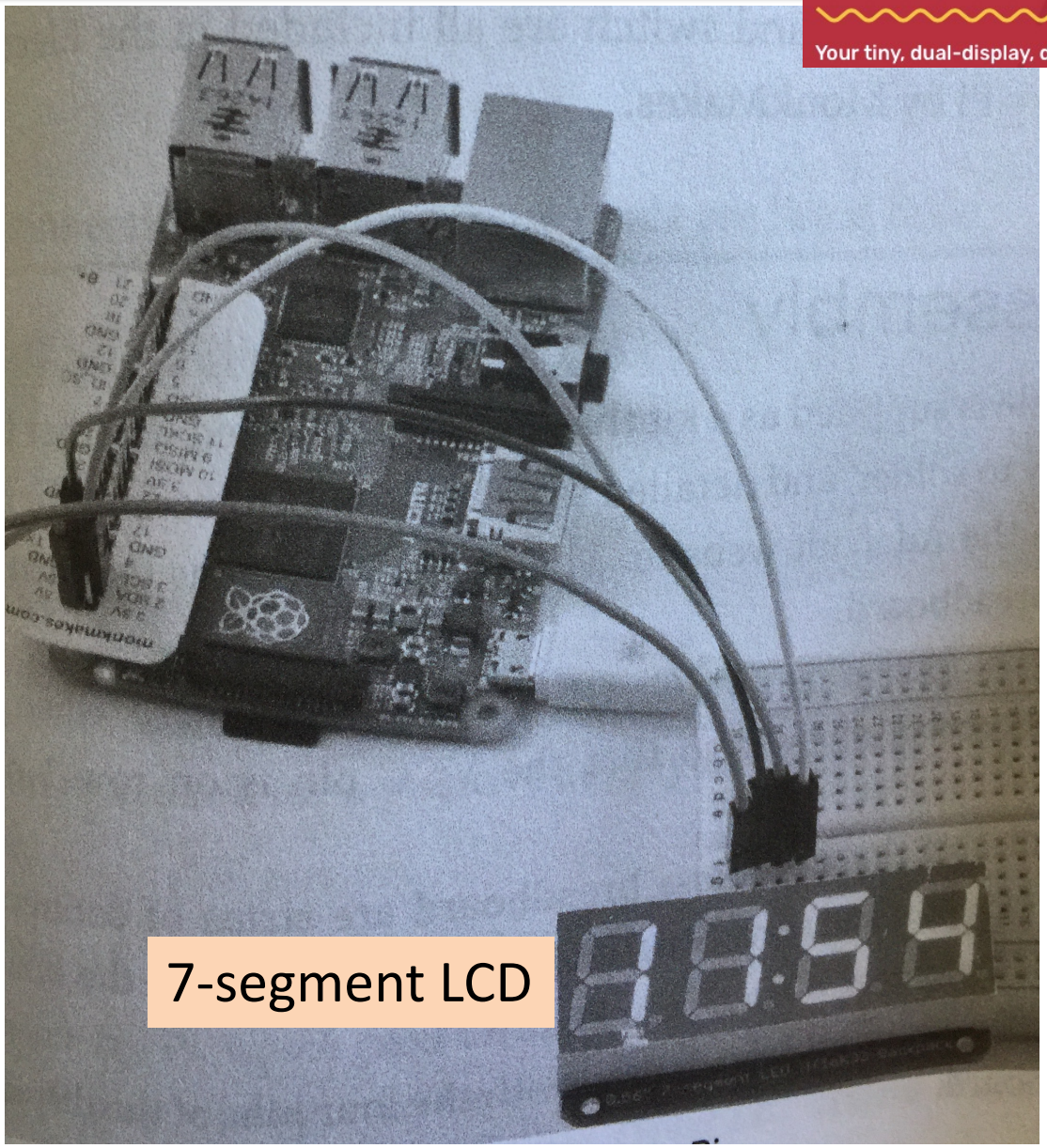

Pi Chips

Raspberry Pi 4
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Raspberry Silicon in the form of RP2040 is on sale now for just $1, and we released an improved PoE HAT, keeping its cost down at the original price of $20. Check out the Raspberry Pi PoE+ HAT below.

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Pi Hat

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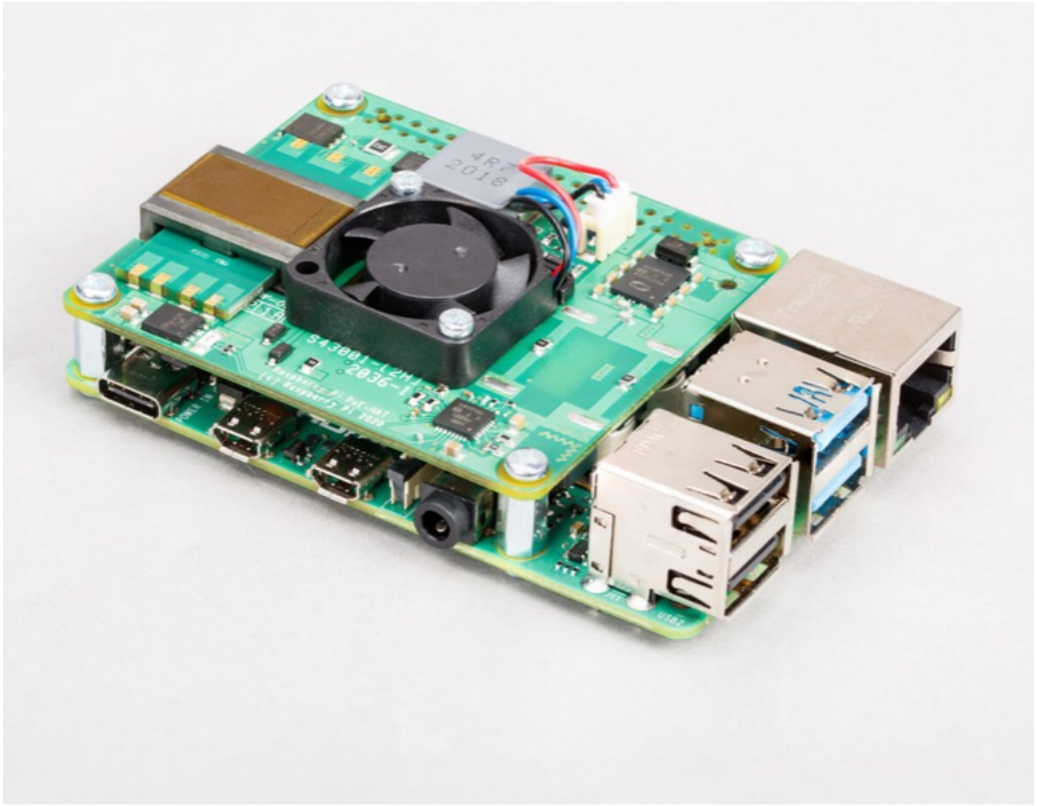
Raspberry Pi 4

Today we're announcing the next generation of our Power over Ethernet (PoE) HAT. Compared to its predecessor, the **Raspberry Pi PoE+ HAT** delivers more power, implementing the 802.3at PoE+ standard; and it runs cooler, thanks to various design improvements. Best of all, we've been able to keep the original affordable price of $20.



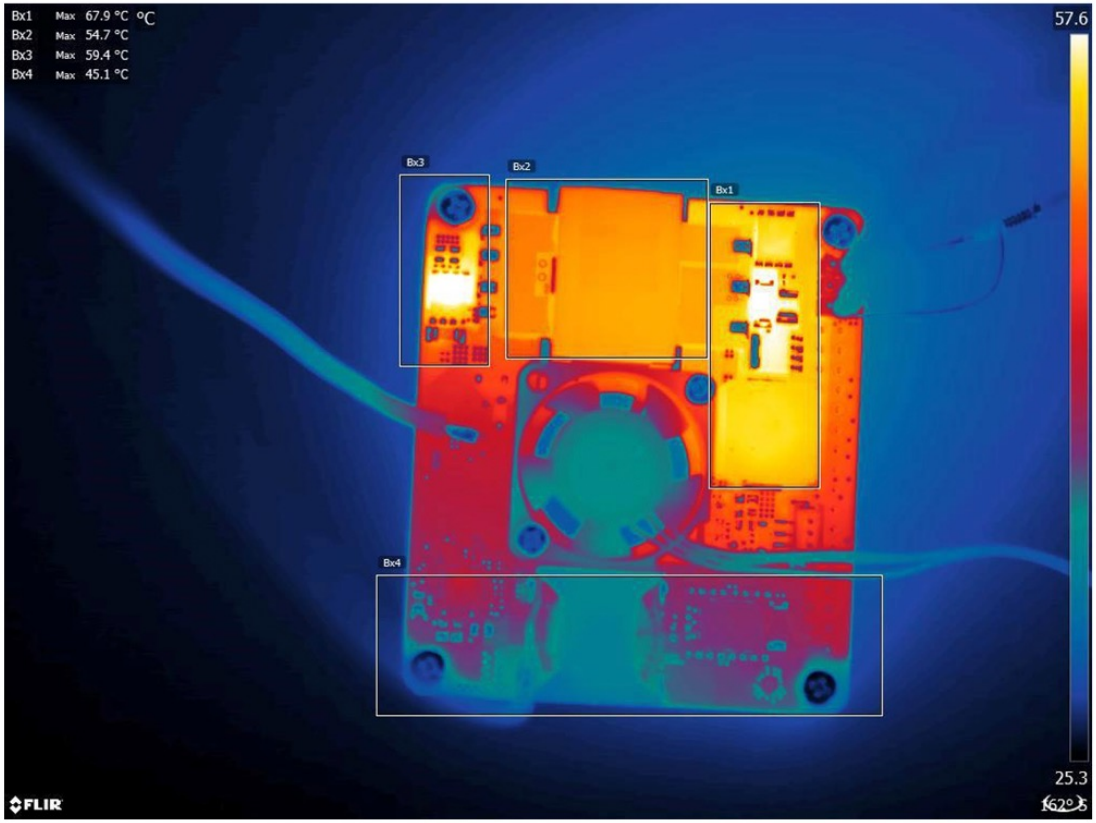
PoE HAT TNG

Pi Hat

Raspberry Pi 4

A better diode rectifier

What else has changed? To reduce heat dissipation we replaced the diode rectifier with an “ideal diode” rectifier, in the form of a Microchip PD70224ILQ device.



Thermal image of PoE+ HAT delivering 2.5A

Pi Train

Raspberry Pi 4

The Motor Channel on YouTube is a great community for miniature railway enthusiasts

What does Raspberry Pi Pico do here?

KushagraK7's Raspberry Pi Pico controls the track voltage to control the speed of the train using pulse-width modulation (PWM). PWM is a method of reducing the average power delivered by an electrical signal. A motor driver powers the locomotive itself.

Pi Train

Raspberry Pi 4

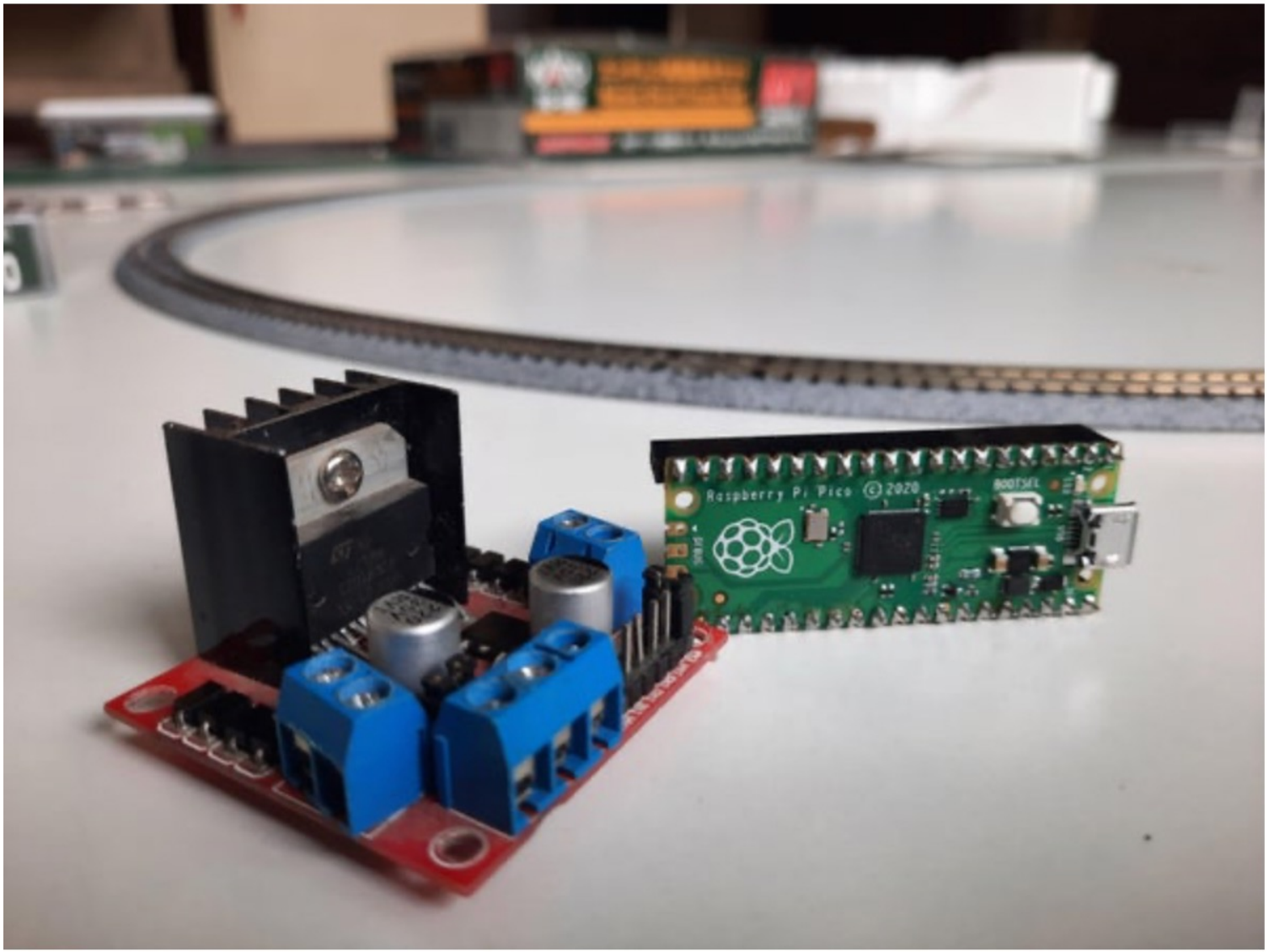


Photo from KushagraK7's Instructable