

010123131

# Software Development Practice I

## Handout #4

<rawat.s@eng.kmutnb.ac.th>

Last Update: 2024-07-09

# Agenda

- Introduction to Raspberry Pi (RPi) SBCs
- OS Support for Raspberry Pi
- Raspberry Pi System Setup
- Raspberry OS Installation Process

# Raspberry Pi SBCs

- **Raspberry Pi** is a series of small **Single-Board Computers** (SBCs).
  - It was developed in the United Kingdom (UK) by the **Raspberry Pi Foundation** (<https://raspberrypi.org/>) to promote teaching of basic Computer Science in schools and in developing countries.
- **Possible Applications:**
  - Use in hobby and DIY applications
  - Use in education and research
  - Use in home automation
  - Use in industrial automation
  - Use in commercial products



Source: <https://www.cam.ac.uk/stories/raspberrypi>

## IMPACT

**775**

young people from

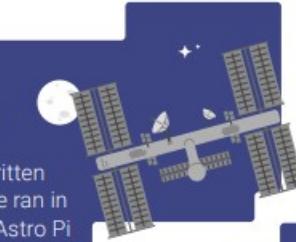
**39 countries**

Showcased projects in our Coolest Projects online gallery



**6559**

programs written by young people ran in space through Astro Pi



**350** people

from 25 countries took part in our research events



OVER  
**1M**

questions answered on our Isaac Computer Science A level platform

**36,000**

subscribers to Hello World



**10,000**

subscribers to our other magazines

**4.9 MILLION**

learners engaged with our online projects

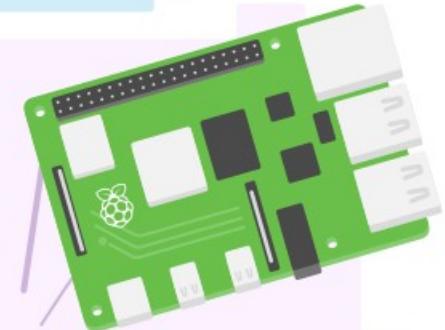


**26k**

teachers from 12,000 schools in England supported through the National Centre for Computing Education

**70,000**

participants in our online courses in 2020



**37.4 MILLION**

Raspberry Pi computers sold to date

**220k** downloads

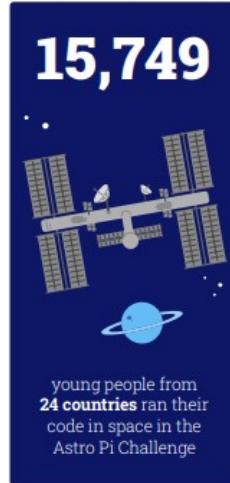
of our Teach Computing Curriculum resources for teachers

**220 SCHOOLS**

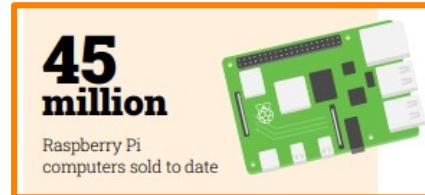
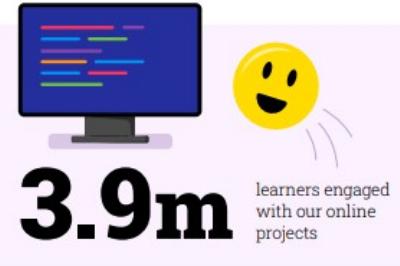
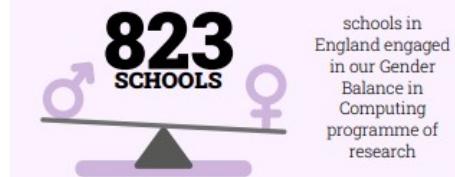
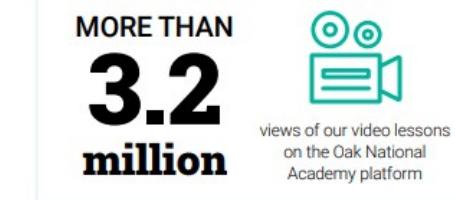
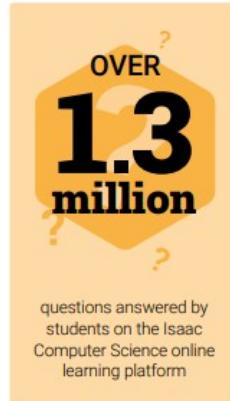
engaged in our research on gender balance in computing



## Our impact in 2021



**1,385**  
young people from  
54 countries showcased  
tech projects in Coolest  
Projects



**1,454 Code Clubs  
& 801 CoderDojos**  
ran in-person sessions



**971**  
attendees at 11 online  
research seminars



**9,885**

schools in England  
downloaded  
resources from the  
Teach Computing  
Curriculum



**31,753**  
subscribers  
to Hello World  
magazine

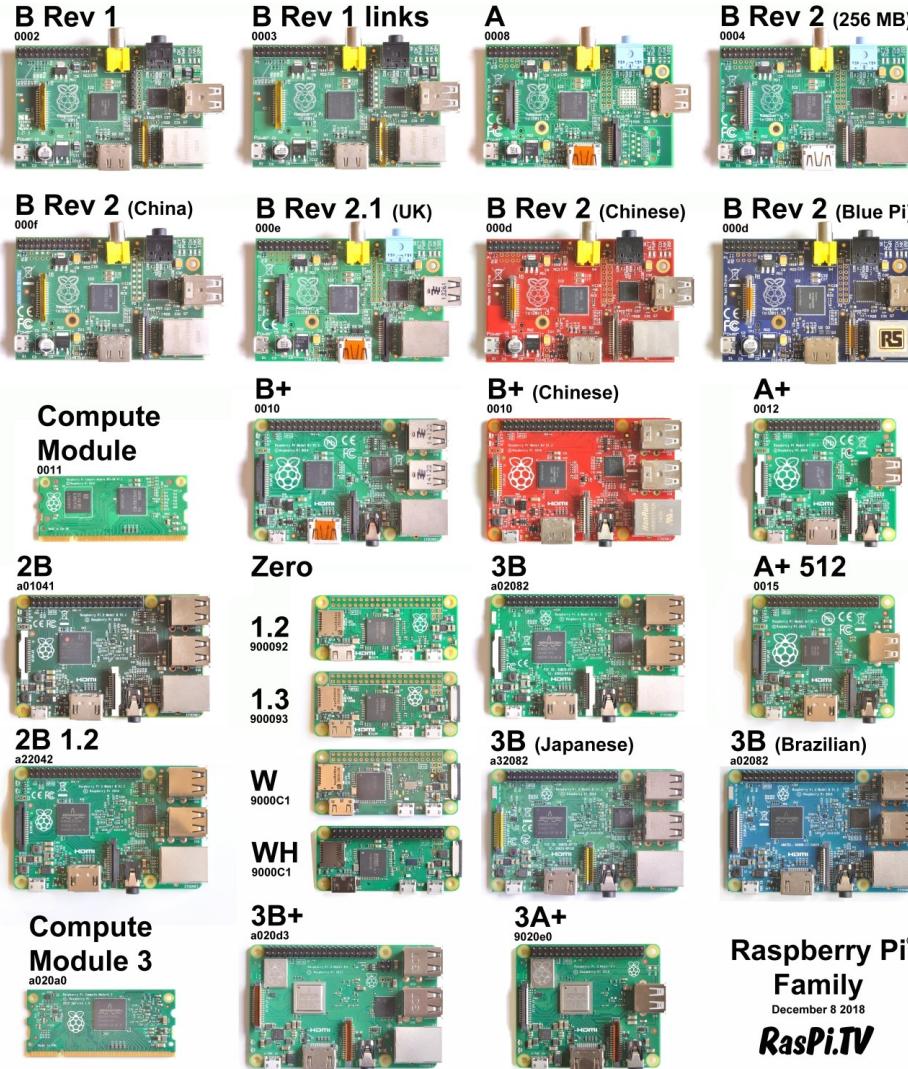


Source: <https://static.raspberrypi.org/files/about/RaspberryPiFoundationAnnualReview2021.pdf>

# Raspberry Pi Models

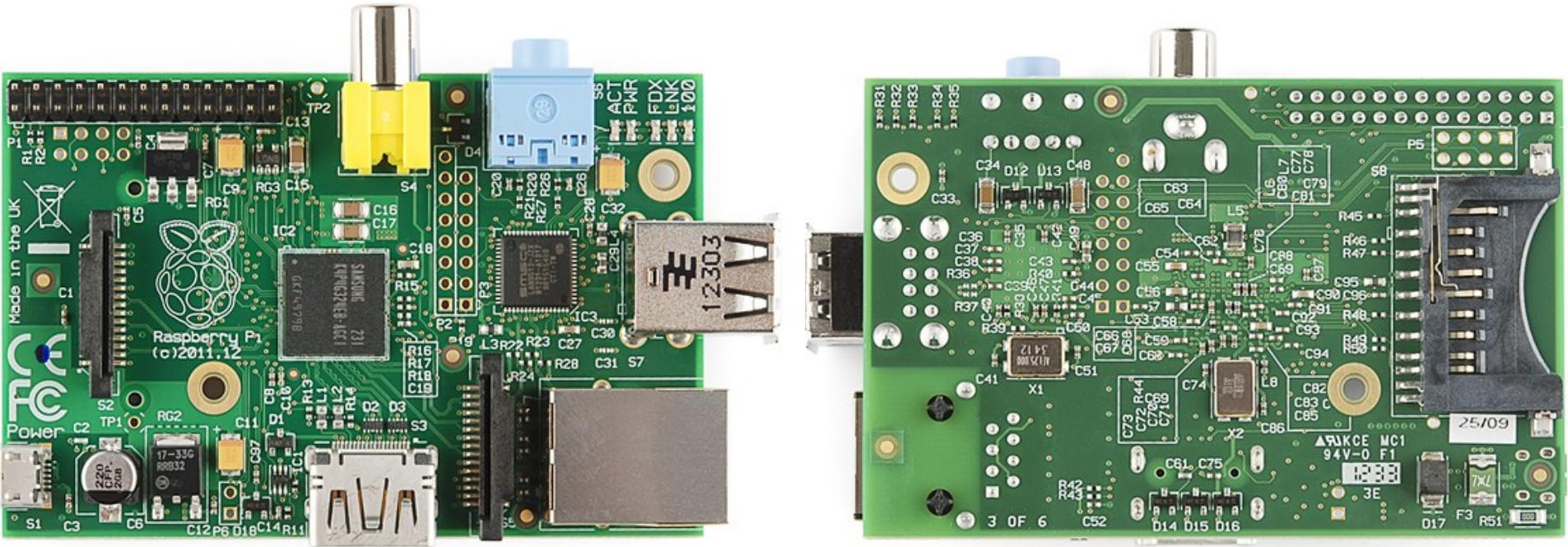
Last Update:  
December 2018

<https://raspi.tv/rpifamily>



Raspberry Pi®  
Family  
December 8 2018  
**RasPi.TV**

# Raspberry Pi 1 Model B



The first-generation Raspberry Pi Model B was released in February 2012.

# Raspberry Pi 1 Model B



## Features

- Broadcom BCM2835 SoC
- ARM1176JZF-S core CPU (**700 MHz**)
- Broadcom VideoCore IV GPU
- RAM: **512 MB**
- 2 x USB2.0 Ports
- Video Out: Composite (PAL / NTSC), HDMI, DSI
- Audio Out: 3.5mm Jack or Audio over HDMI
- Storage: SD/MMC/SDIO
- 10/100 Ethernet (RJ45)
- Peripherals: GPIO, UART, I2C, SPI
- Power: 5V @ 700 mA via MicroUSB or GPIO Pins
- Dimension: 85.60mm x 56mm x 21mm



# SoCs and Raspberry Pi Models

## SoC: BCM2835 SoC: 32-bit ARM1176JZF-S, arm6hf

- Raspberry Pi 1 Models A, A+, B, B+
- Raspberry Pi Zero
- Raspberry Pi Zero W
- Raspberry Pi Compute Module 1

## BCM2836 SoC: Quad-core 32-bit Cortex-A7, armhf

- Raspberry Pi 2 Model B

## BCM2837 SoC: Quad-core 64-bit ARM Cortex A53, 1.2GHz, arm64

- Raspberry Pi 3 Model B
- Raspberry Pi Compute Module 3

Reference: <https://www.raspberrypi.com/documentation/computers/processors.html>

ARM Cortex-A53: <https://developer.arm.com/Processors/Cortex-A53>

## SoCs and Raspberry Pi Models

### **BCM2837B0 SoC: Quad-core 64-bit ARM Cortex A53, 1.4GHz, arm64**

- Raspberry Pi 3 Models A+, B+
- Raspberry Pi Compute Module 3+

### **RP3A0 System-in-Package (SiP)**

**with BCM2710A1: Quad-core 64-bit ARM Cortex A53, 1.5GHz, arm64**

- Raspberry Pi Zero 2

### **BCM2711 SoC: Quad-core 64-bit ARM Cortex A72, 1.5GHz, arm64**

- Raspberry Pi 4 Model B
- Raspberry Pi 400
- Raspberry Pi Compute Module 4 (CM4)

Reference: <https://www.raspberrypi.com/documentation/computers/processors.html>

ARM Cortex A72: <https://developer.arm.com/Processors/Cortex-A72>

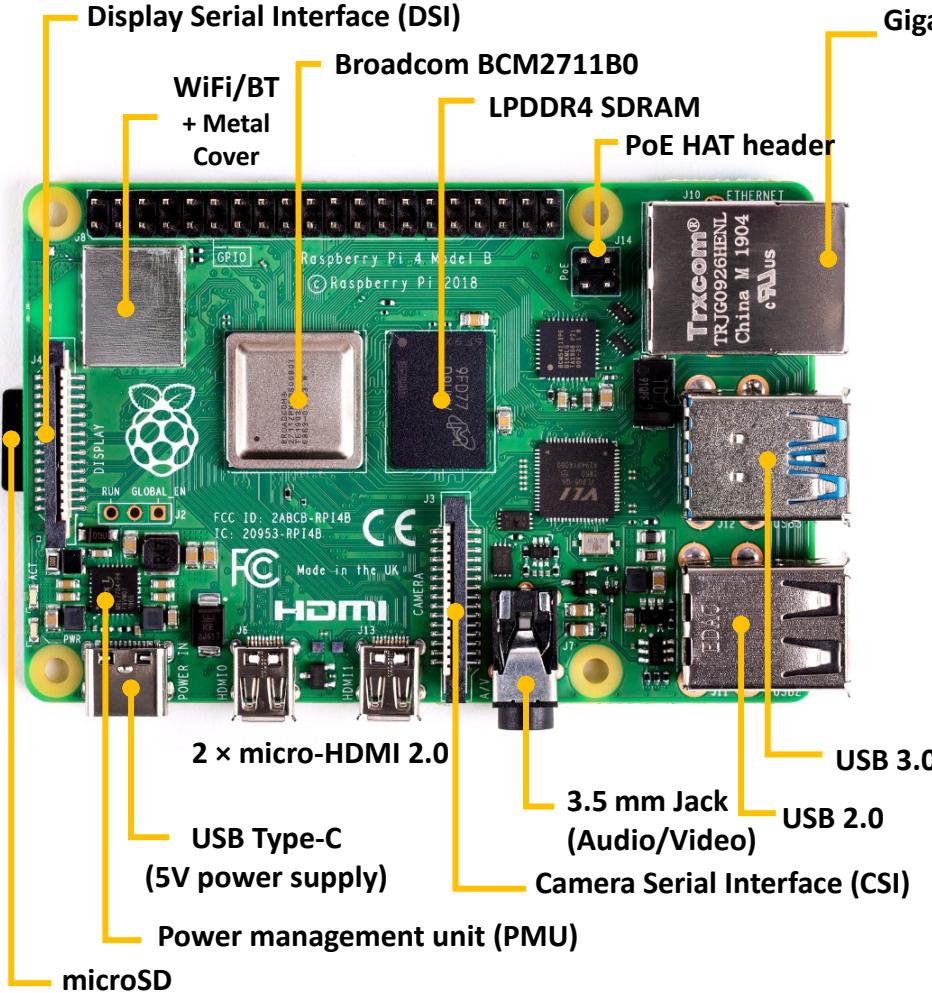
# SoCs and Raspberry Pi Models

Product	Processor	ARM core	Debian/Raspbian ARM port (maximum)	Architecture width
Raspberry Pi 1	BCM2835	ARM1176	arm6hf	32 bit
Raspberry Pi 2	BCM2836	Cortex-A7	armhf	32 bit
Raspberry Pi Zero	BCM2835	ARM1176	arm6hf	32 bit
Raspberry Pi Zero 2	BCM2710	Cortex-A53	arm64	64 bit
Raspberry Pi 3	BCM2710	Cortex-A53	arm64	64 bit
Raspberry Pi 4	BCM2711	Cortex-A72	arm64	64 bit

Source: <https://www.raspberrypi.com/news/raspberry-pi-os-64-bit/>

# Raspberry Pi 4 Model B

The Raspberry Pi 4 Model B was released in June 2019.



## Raspberry Pi 4 specs

- **SoC:** Broadcom BCM2711B0 quad-core A72 (ARMv8-A) 64-bit @ 1.5GHz
- **GPU:** Broadcom VideoCore VI, 500MHz
- **RAM:** 1GB, 2GB, or 4GB LPDDR4 SDRAM
- **WiFi:** 2.4 GHz and 5 GHz 802.11b/g/n/ac
- **Bluetooth:** Bluetooth 5.0, Bluetooth Low Energy (BLE)
- **GPIO:** 40-pin GPIO header, populated
- **Storage:** microSD
- **Ports:** 2× micro-HDMI 2.0, 3.5 mm analog audio-video jack, 2× USB 2.0, 2× USB 3.0, Gigabit Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)
- **Dimensions:** 88 mm × 58 mm × 19.5 mm, 46 g

← → ⌂ th.cytron.io/c-raspberry-pi/c-raspberry-pi-main-board/c-raspberry-pi-4

CATEGORIES HOT DEALS NEW ARRIVALS BEST SELLERS LOCAL WAREHOUSE PROJECTS TUTORIALS INDUSTRY

Home » All Categories » Raspberry Pi Main Board » Raspberry Pi 4

Price Range X ▶

Raspberry Pi 4

Sort By: Popularity Show: 20

Availability ▼

In Stock  
 Out of Stock

Shipped From ▼

Local (5)

Brands ▼

Raspberry Pi (5)

Change Category

> Projects

> Raspberry Pi -

**Raspberry Pi 4**

Out Of Stock

Sort By: Popularity Show: 20

  
★★★★★  
Raspberry Pi 4 Model B 8GB and Kits  
THB3,310.00++  
[Login to Purchase](#)

  
★★★★★  
Raspberry Pi 4 Model B 2GB and Kits  
THB1,990.00++  
[Login to Purchase](#)

  
★★★★★  
Raspberry Pi 4 Model B 1GB and Kits  
THB1,550.00++  
[Login to Purchase](#)

  
★★★★★  
Raspberry Pi 400 Keyboard Computer-US Layout (L...  
THB3,070.00  
[Login to Purchase](#)

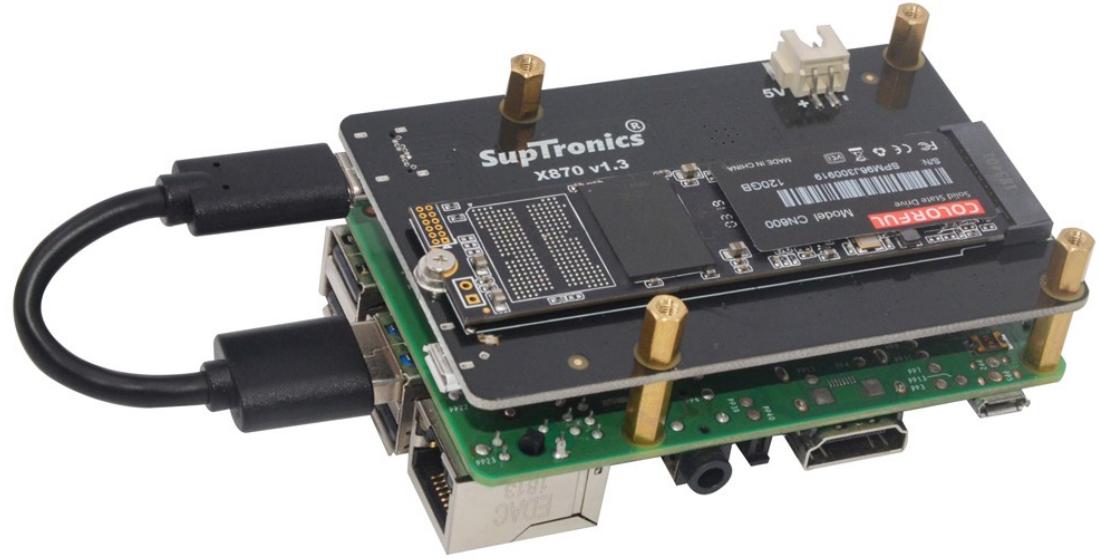
  
★★★★★  
Raspberry Pi 4 Model B 4GB and Kits  
THB2,520.00++  
[Login to Purchase](#)

Showing 1 to 5 of 5 (1 Pages)

The chip shortage situation (due to COVID'19) has affected directly the production and availability of Raspberry Pi 4 boards.

Last access: May 23, 2023

# Raspberry Pi 4 Model B + USB-SSD or NVMe SSD Shield



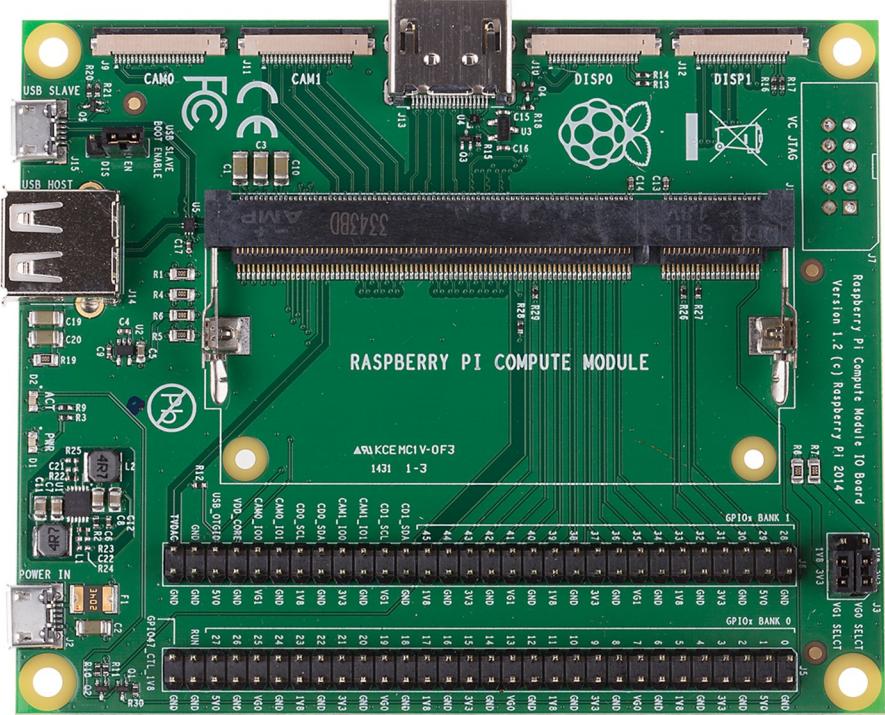
<http://www.suptronics.com/miniPCkits/x870.html>

# Raspberry Pi Compute Modules (RPi CMs) & Dev. Kit



Raspberry Pi Compute Module 3 + (CM3+) with 8GB eMMC

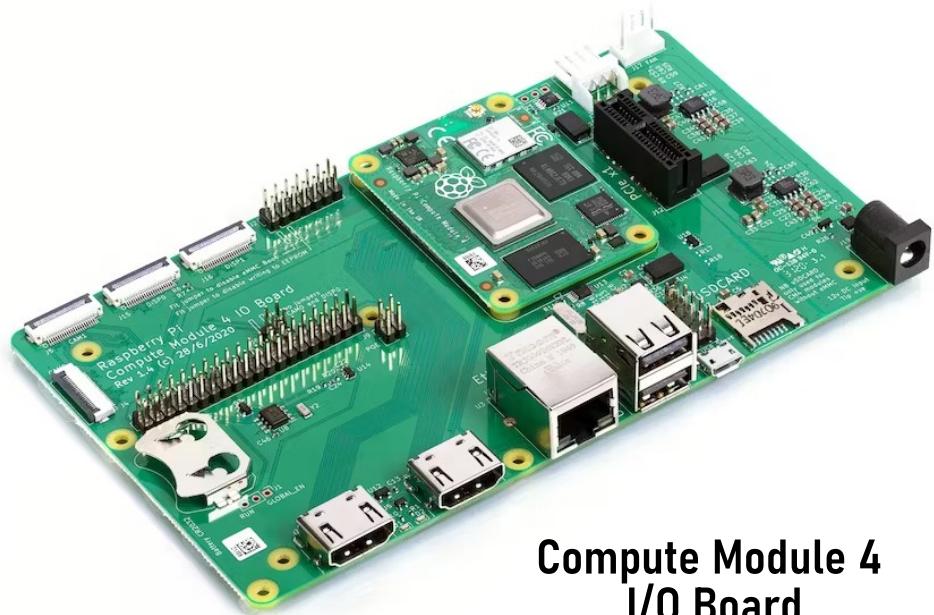
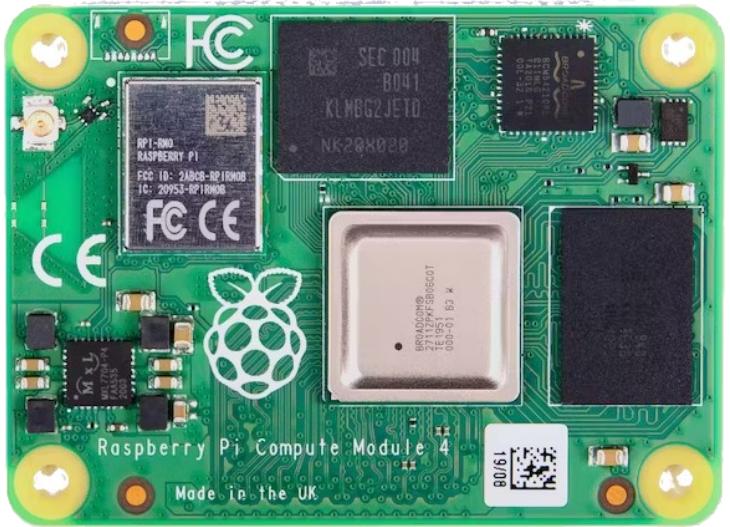
🔗 <https://www.raspberrypi.org/products/compute-module-3/>



Raspberry Pi Compute Module Development Kit for CM3+, CM3+/Lite, CM3, CM3 Lite, and CM1

🔗 <https://www.raspberrypi.com/products/compute-module-development-kit-2/>

# Raspberry Pi Compute Modules 4



Compute Module 4  
I/O Board

## RPi CMs (pin-compatible SODIMM modules)

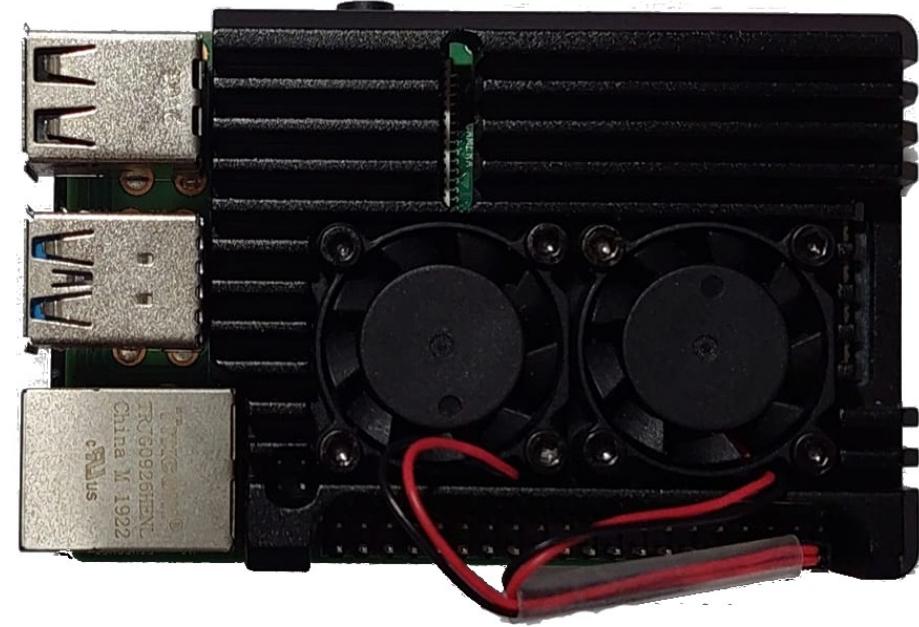
- 2014: [CM1](#) [BCM2835, 700MHz, 512MB RAM, 4GB eMMC Flash storage]
- 2017: [CM3](#) [BCM2837, 1.2GHz, 1GB RAM, 4GB eMMC] and [CM3L](#) [no eMMC]
- 2019: [CM3+](#) [BCM2837B0, 1.2GHz, 1GB RAM, 8GB/16GB/32GB eMMC] and [CM3+L](#) [no eMMC]
- 2020: [CM4](#) [BCM2711, 1.5GHz, 1GB/2GB/4GB/8GB LPDDR4, 8GB/16GB/32GB eMMC]

# Raspberry Pi 4 Model B

RPi 4 Board with a Heatsink



RPi 4 Metal Case + 5V DC Fan





# Raspberry Pi 5



Raspberry Pi 5 Computer

- 8GB RAM: THB3,325.00
- 4GB RAM: THB2,495.00

Source: <https://th.cytron.io/c-raspberry-pi>



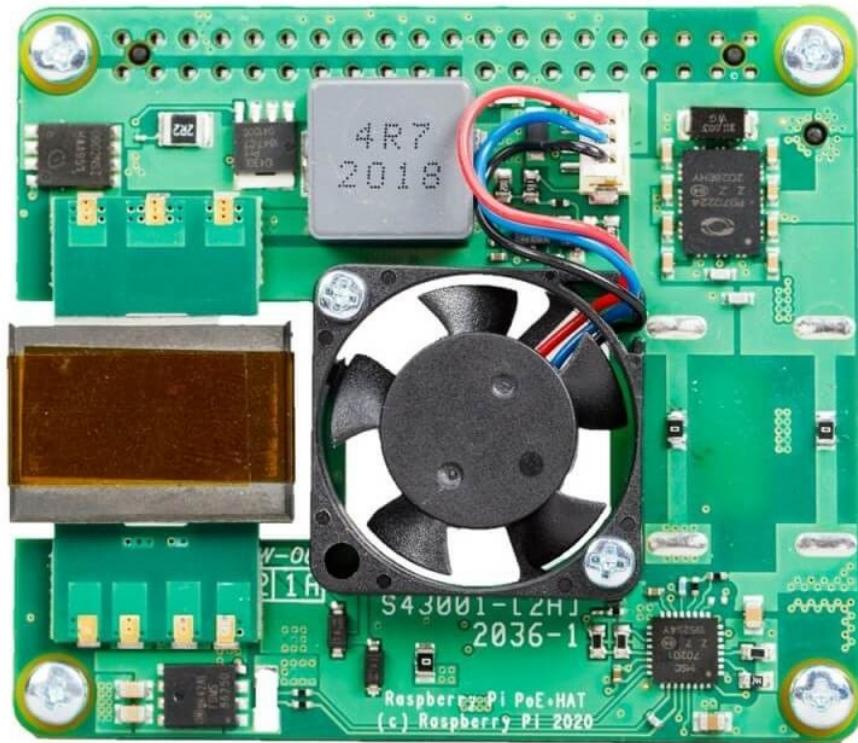
Active Cooler for RPi5  
THB200.00



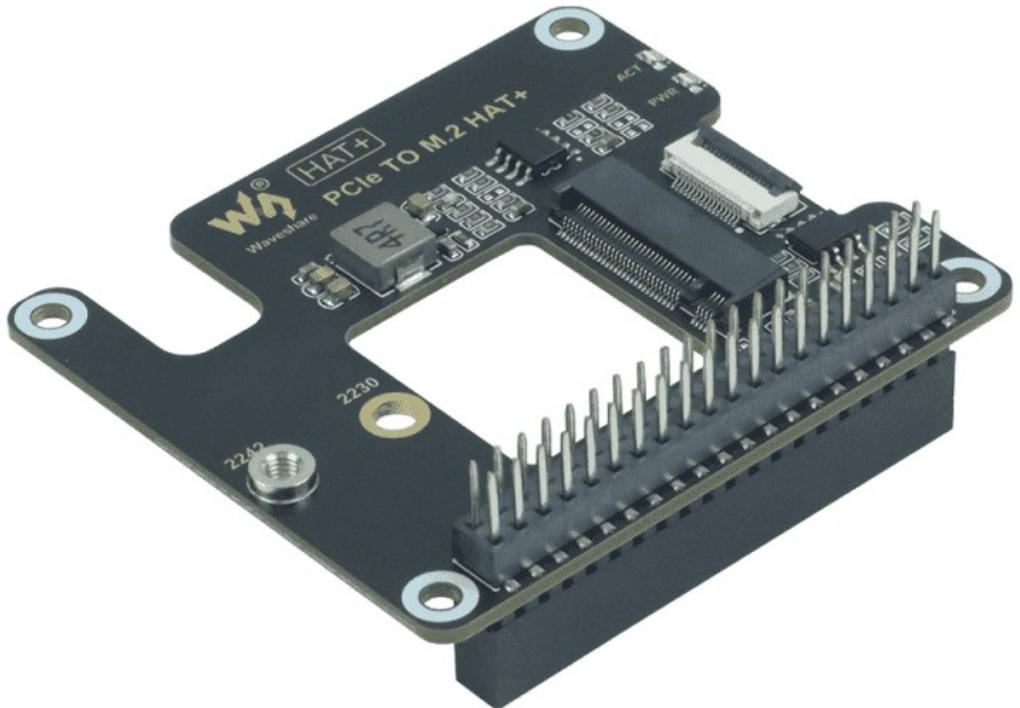
Black Active Cooler for RPi5  
THB230.00



Raspberry Pi USB-C PD 27W PSU  
THB500.00



5V 5A Power over Ethernet Plus (PoE+)  
THB1,100.00



PCIe M.2 M-Key HAT+ for RPi 5  
THB 380.00



PCIe Hat for RPi 5  
with MakerDisk NVMe SSD

# Raspberry Pi System Setup

- Raspberry Pi 3 or 4 Model B Board
- MicroSD Card (at least 8GB, Class 10)
  - MicroSD Card Reader / USB Adapter (for installing the OS image)
- 5V Power Supply Adapter
  - MicroUSB Connector for RPi 3
  - USB Type-C Connector for RPi 4
- Ethernet Cable / Network Switch / WiFi-Internet Router
- Desktop Mode: USB HID (keyboard, mouse), HDMI LCD Monitor

# 5Vdc Power Supply for Raspberry Pi SBCs



MicroUSB Connector  
(for RPi 3)

Power Supply 5V / 3A  
(AC-to-DC Adapter) for RPi 4



USB Type-C Connector  
(for RPi 4)

Power Supply 5V / 3A  
Type-C Adapter with  
ON/OFF Switch for RPi 4



EU plug

# Raspberry Pi Accessories

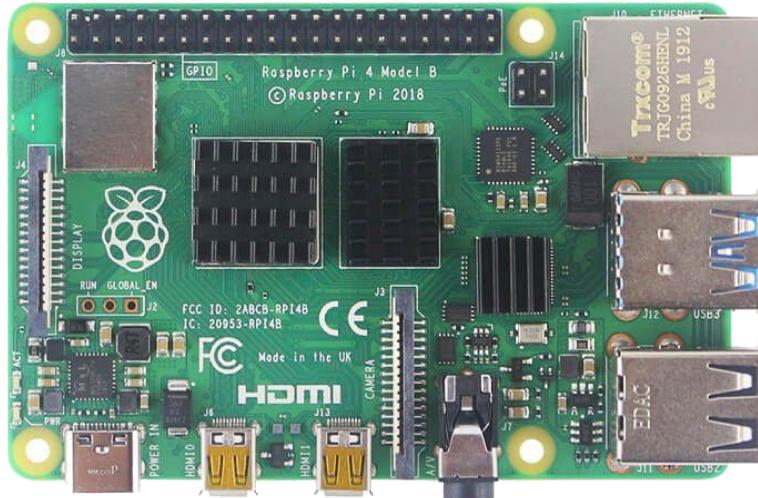


Raspberry Pi Official  
Micro-HDMI to HDMI-A Cable

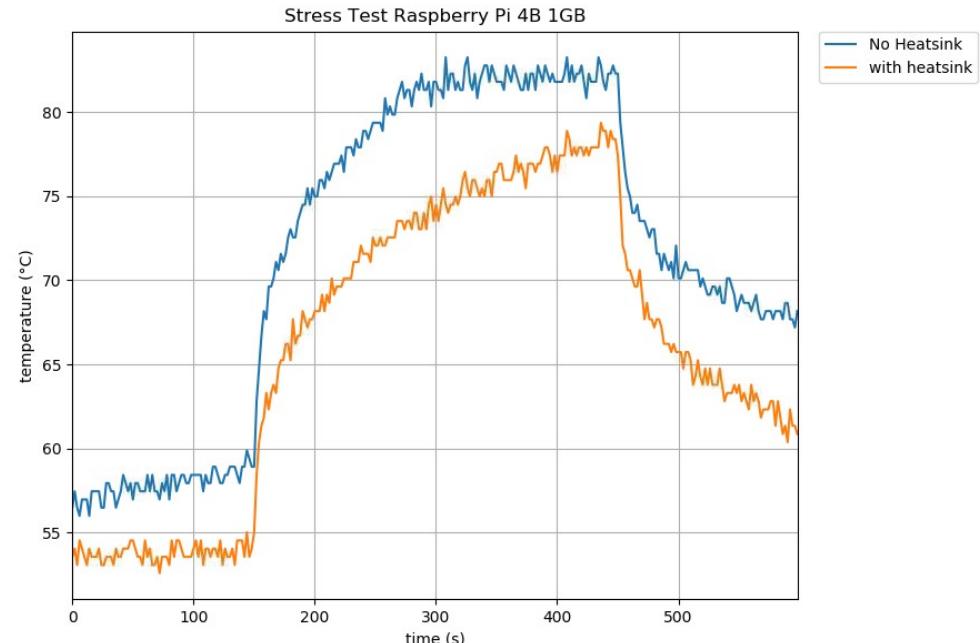


HDMI Video Capture USB Adapters

# Raspberry Pi Accessories: Cooling



Aluminum  
heatsink

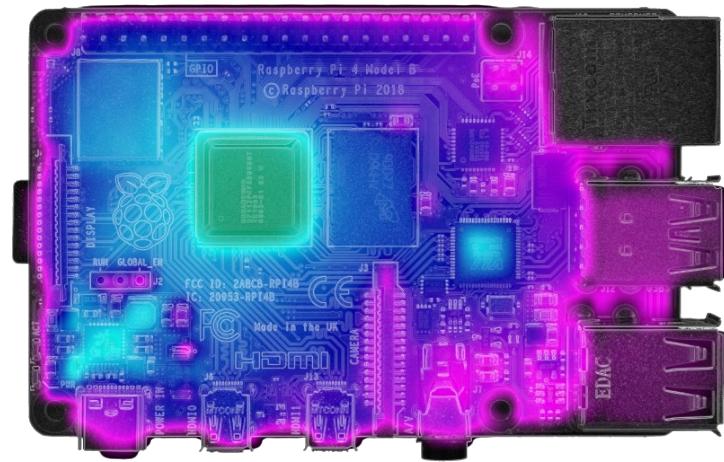


<https://th.cytron.io/p-raspberry-pi-4-heatsink-set-3pcs-black>

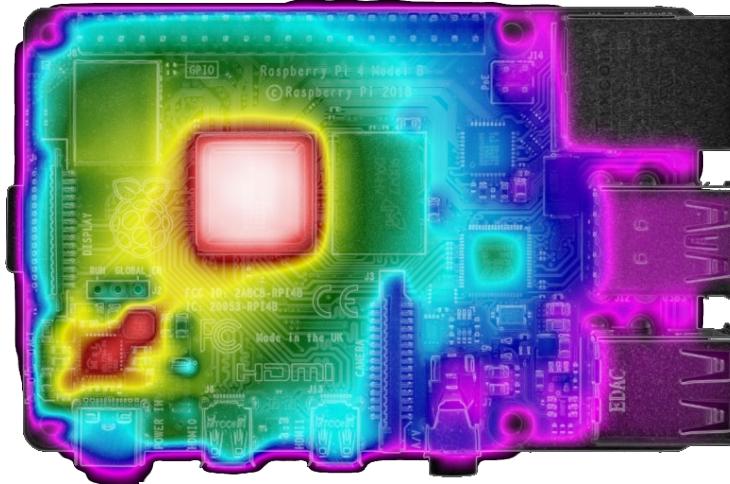
3V-5V 0.2A Cooling Fan  
(DC Brushless Motor)

# Raspberry Pi Thermal Testing

75 °C

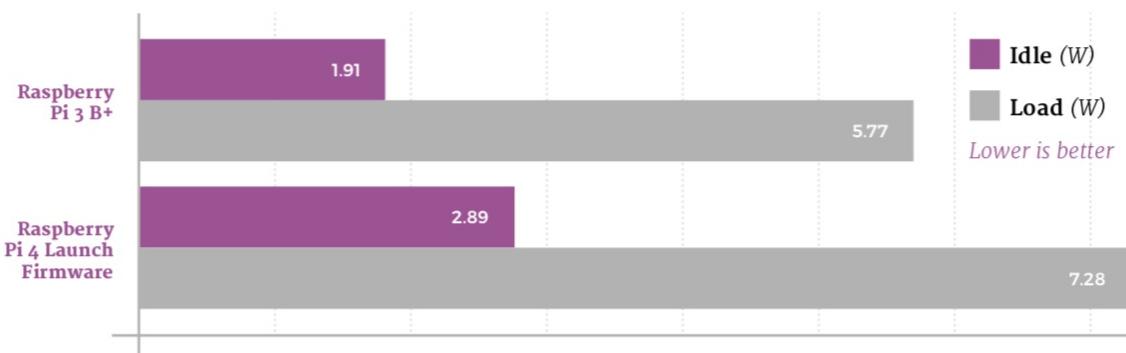


Thermal imaging: RPi 4 (Idle Load)



Thermal imaging: RPi 4 (Stress-Test Load)

35 °C



Source: <https://www.raspberrypi.com/news/thermal-testing-raspberry-pi-4/>

# RPi for Industrial Applications



**Brainboxes BB-400  
NeuronEdge Controller**



**Techbase's ModBerry M500**

# RPi for Industrial Applications



Kunbus RevolutionPi RevPi Connect



RevolutionPi RevPi DIO

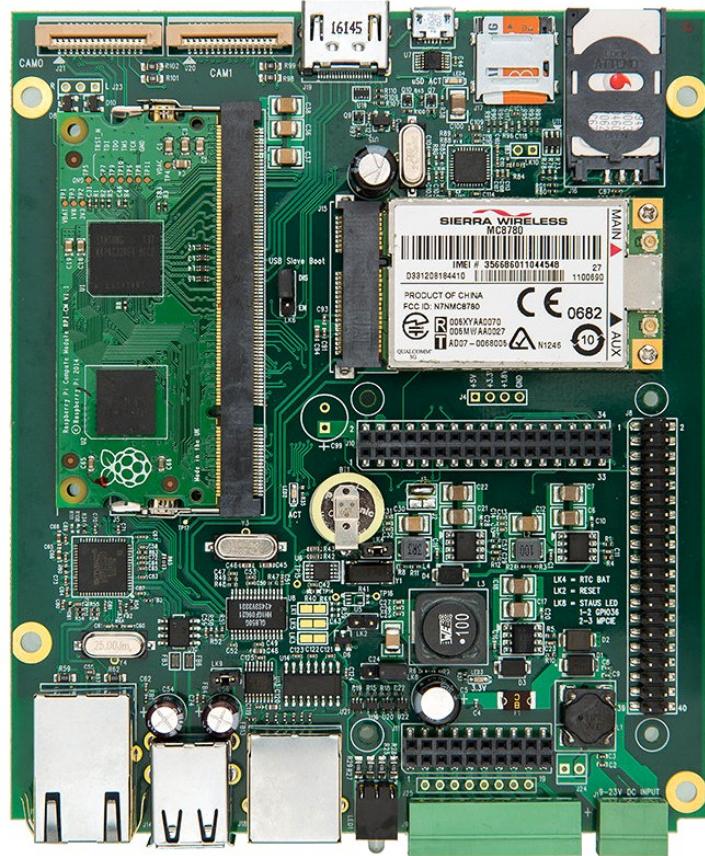


Unipi Neuron S103 and M103

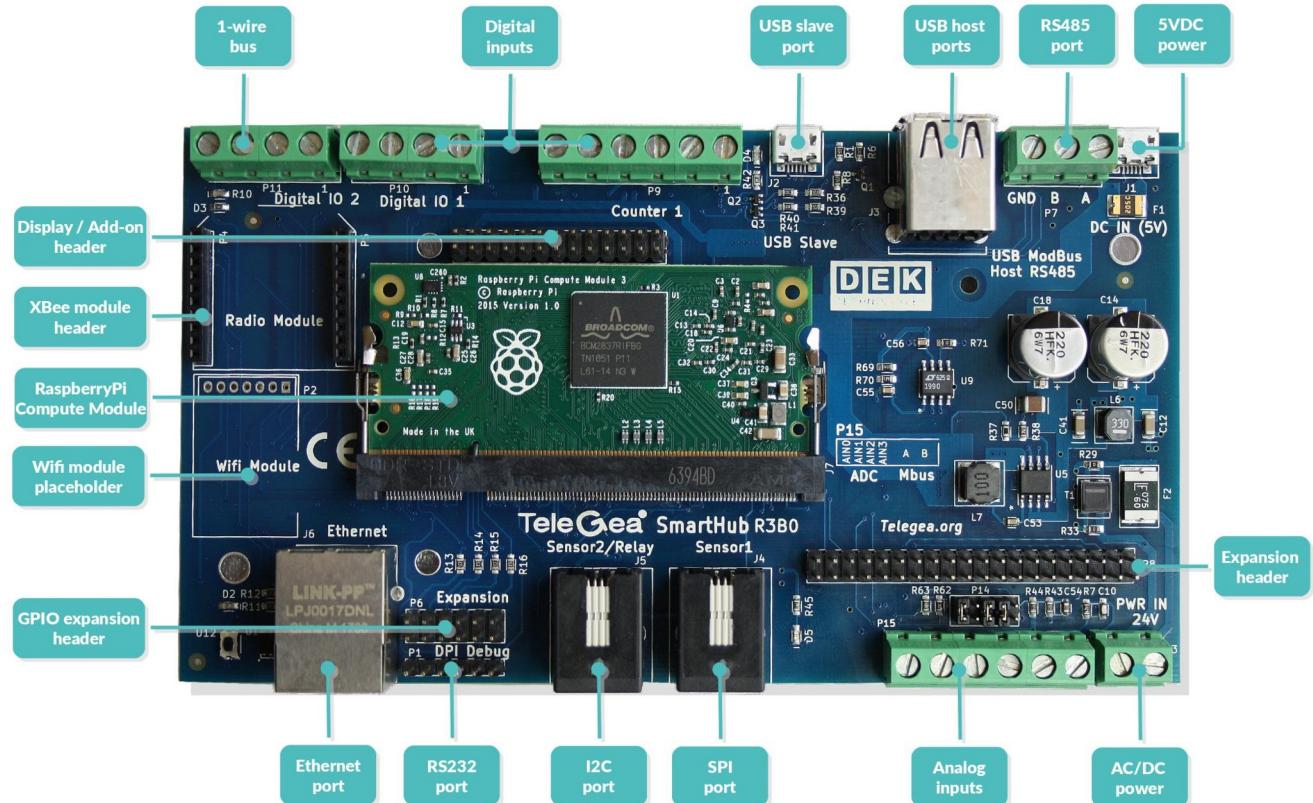
# RPi for Industrial Applications



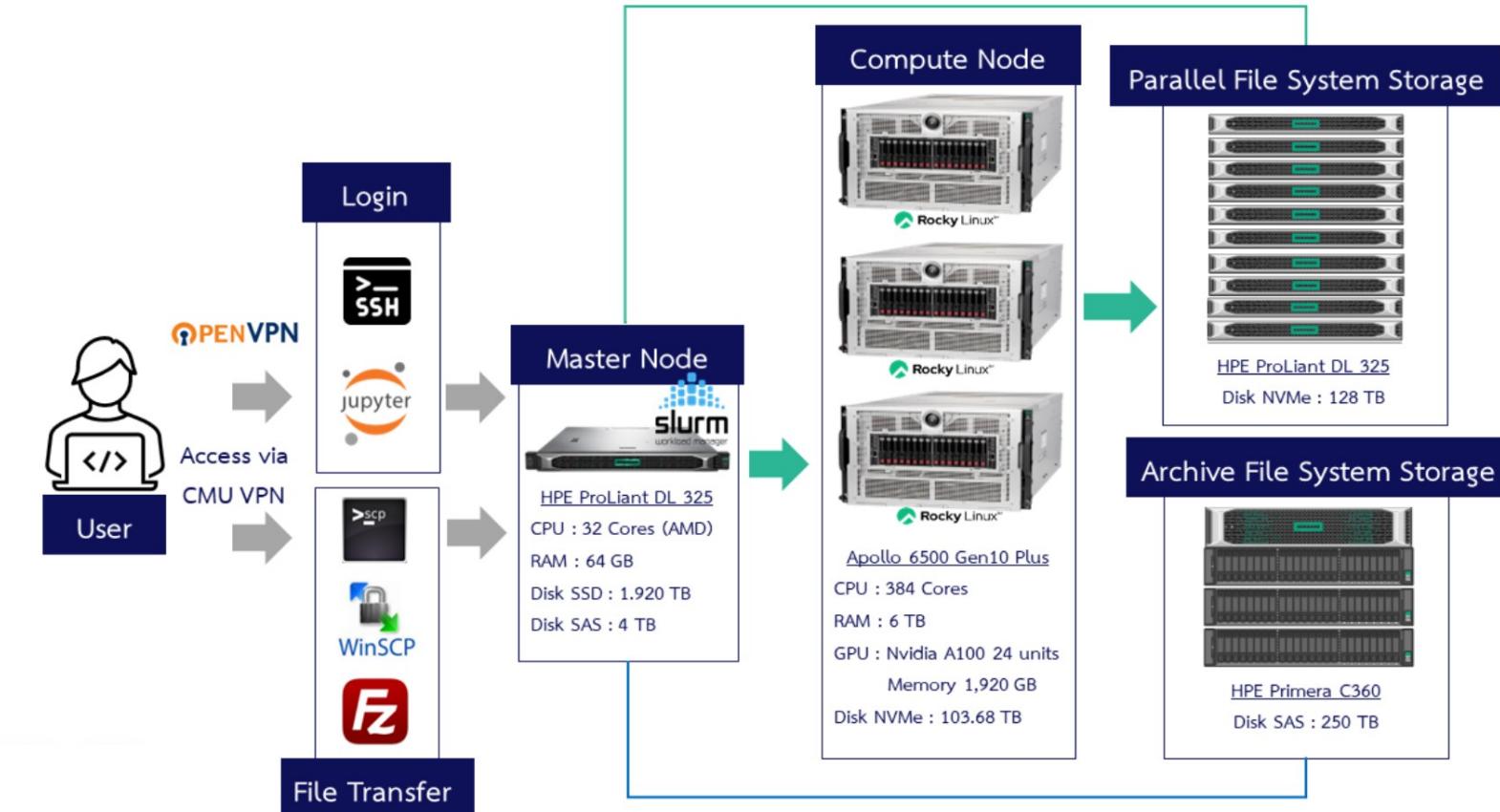
EmbeddedPi - MyPi Industrial IoT  
Edge Gateway



# RPi for Industrial Applications



Telegea Smart Hub: an IoT gateway based on Raspberry Pi CM3



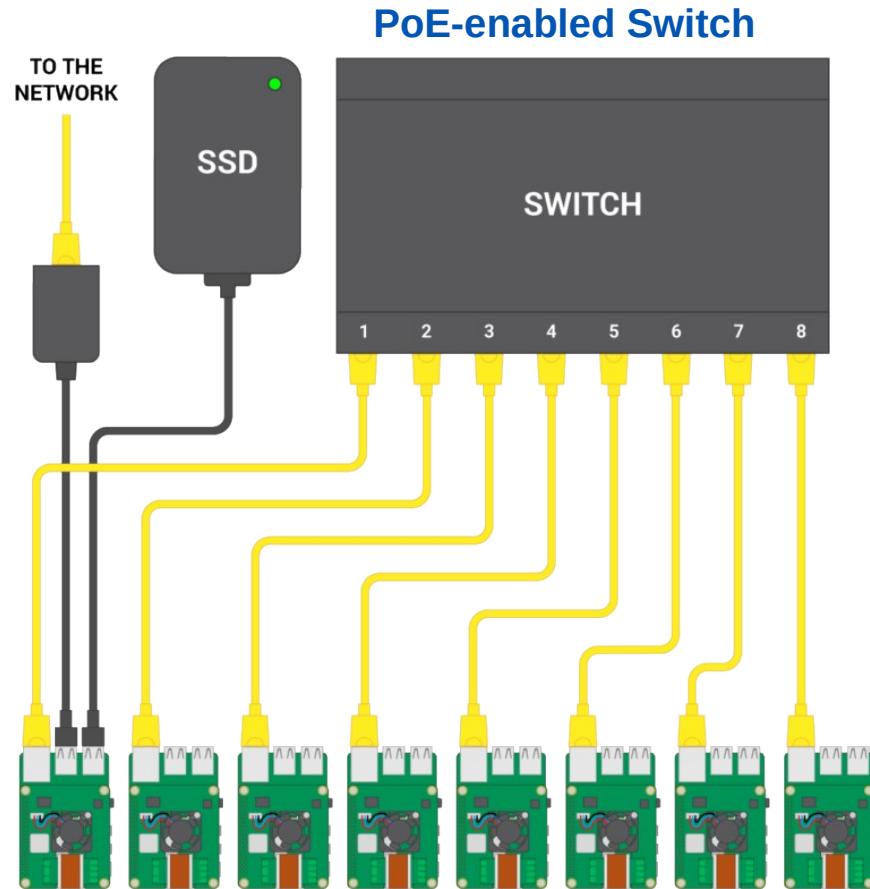
## High-End Computer Cluster for High-Performance Computing

# How to build a Raspberry Pi cluster

## Shopping list

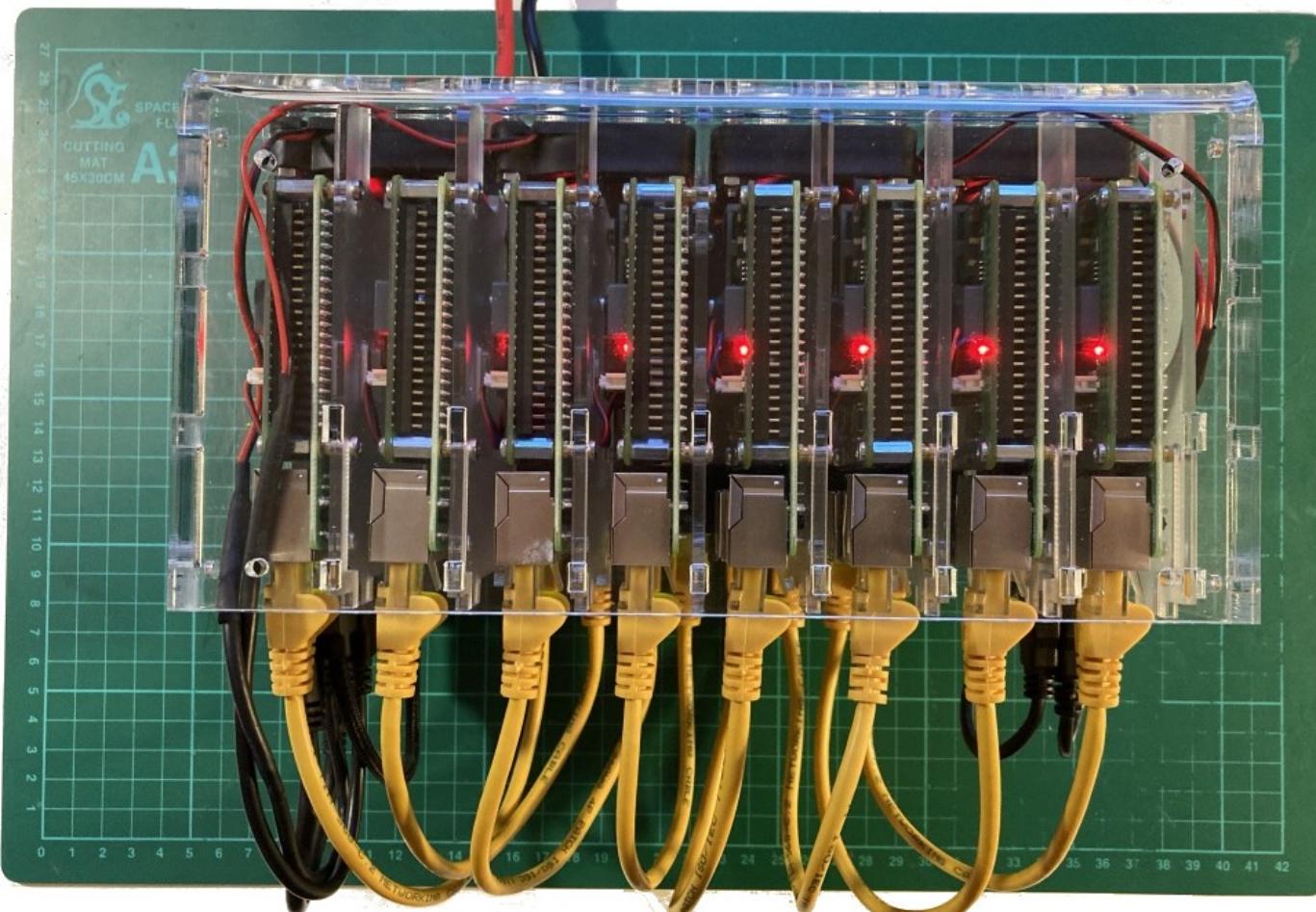
- 8 x Raspberry Pi 4
- 8 x Raspberry Pi PoE+ HAT
- 8-port Gigabit PoE-enabled switch
- USB 3 to Gigabit Ethernet adaptor
- USB 3 to SATA adaptor
- SSD SATA drive
- 8 x Ethernet cables
- 16 GB SD card
- Cluster case

- The Head node has a **USB 3.0 Ethernet dongle** and an **external SSD** mounted via a **USB3-to-SATA** connector.
- The Head node will boot from an **SD card** as normal, the other nodes (the “Compute” nodes) will be configured to **network boot**.
- All eight of Raspberry Pi boards will have a **Raspberry Pi PoE+ HAT** attached.



Source: <https://www.raspberrypi.com/tutorials/cluster-raspberry-pi-tutorial/>

# How to build a Raspberry Pi cluster



Source: <https://www.raspberrypi.com/tutorials/cluster-raspberry-pi-tutorial/>

# RPi Software Support

- Linux OS (Debian-based): Raspberry Pi OS
  - 32-bit vs. 64-bit versions
  - Desktop (GUI mode) vs. Server (Headless mode)
    - Ubuntu Desktop to Server for Raspberry Pi
    - Armbian for RPi 4
- Android OS
- Windows 10 IoT Core

<https://www.raspberrypi.com/software/operating-systems/>  
<https://ubuntu.com/download/raspberry-pi>  
<https://www.armbian.com/rpi4b/>

# Raspberry Pi OS Images: 32-bit

Compatible with:

All Raspberry Pi models

## Raspberry Pi OS with desktop

Release date: May 3rd 2023

System: 32-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 872MB

## Raspberry Pi OS Lite

Release date: May 3rd 2023

System: 32-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 364MB

## Raspberry Pi OS with desktop and recommended software

Release date: May 3rd 2023

System: 32-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 2,701MB

# Raspberry Pi OS Images: 64-bit

## Raspberry Pi OS (64-bit)

Compatible with:

[3B](#) [3B+](#) [3A+](#) [4](#) [400](#)  
[CM3](#) [CM3+](#) [CM4](#)  
[Zero 2 W](#)

### Raspberry Pi OS with desktop

Release date: May 3rd 2023

System: 64-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 818MB

### Raspberry Pi OS Lite

Release date: May 3rd 2023

System: 64-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 308MB

# OS Installation Steps

- Download and install **Raspberry Pi Imager**.
  - Alternative tool for MicroSD flashing: **Balena Etcher**
- Download an OS image (**64-bit**).
  - **RPi 3 or RPi 4**: Raspberry Pi OS
  - **RPi 4**: Ubuntu Desktop or Server 22.04 LTS
  - **RPi 5**: Ubuntu Desktop or Server 24.04 LTS
- Use Raspberry Pi Imager to write an OS image to an microSD card (8GB or more) or USB-to-SSD storage.

<https://ubuntu.com/tutorials/how-to-install-ubuntu-on-your-raspberry-pi>

<https://ubuntu.com/tutorials/how-to-install-ubuntu-desktop-on-raspberry-pi-4>

Operating system images – Raspberry Pi

raspberrypi.com/software/operating-systems/

## Raspberry Pi OS (64-bit)

Compatible with:

3B 3B+ 3A+ 4  
400 CM3 CM3+  
CM4 Zero 2 W

### Raspberry Pi OS with desktop

Release date: February 21st 2023  
System: 64-bit  
Kernel version: 5.15  
Debian version: 11 (bullseye)  
Size: 816MB  
[Show SHA256 file integrity hash](#)  
[Release notes](#)

[Download](#)  
[Download torrent](#)  
[Archive](#)

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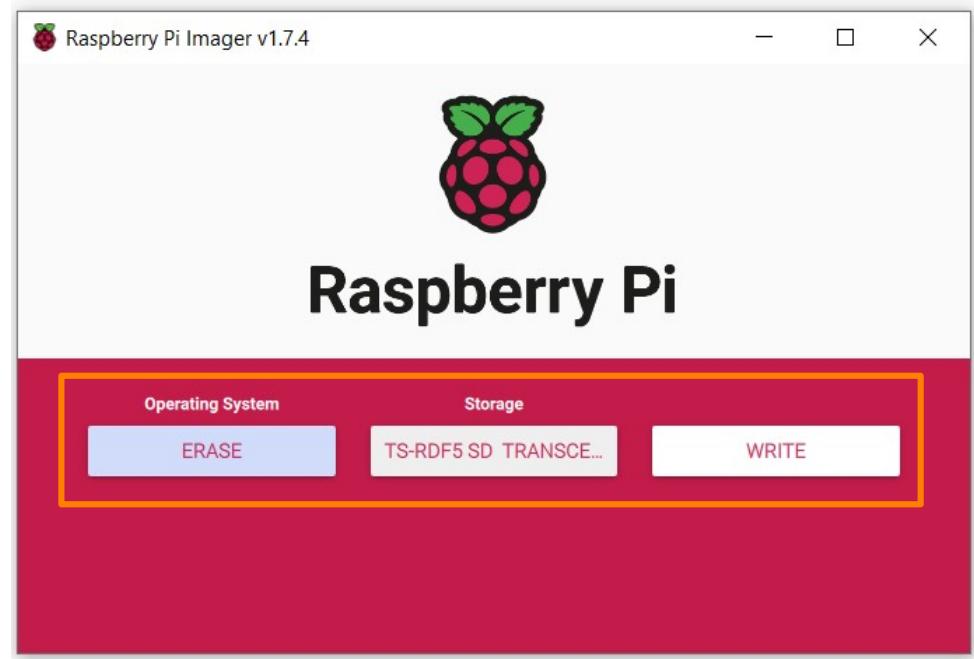
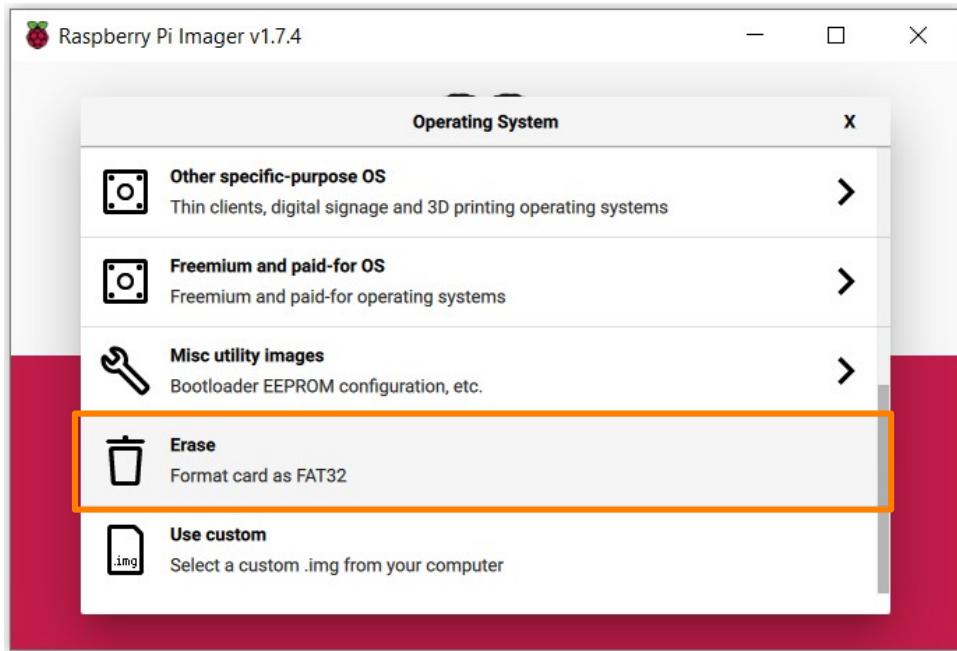
### Raspberry Pi OS Lite

Release date: February 21st 2023  
System: 64-bit  
Kernel version: 5.15  
Debian version: 11 (bullseye)  
Size: 307MB  
[Show SHA256 file integrity hash](#)  
[Release notes](#)

[Download](#)  
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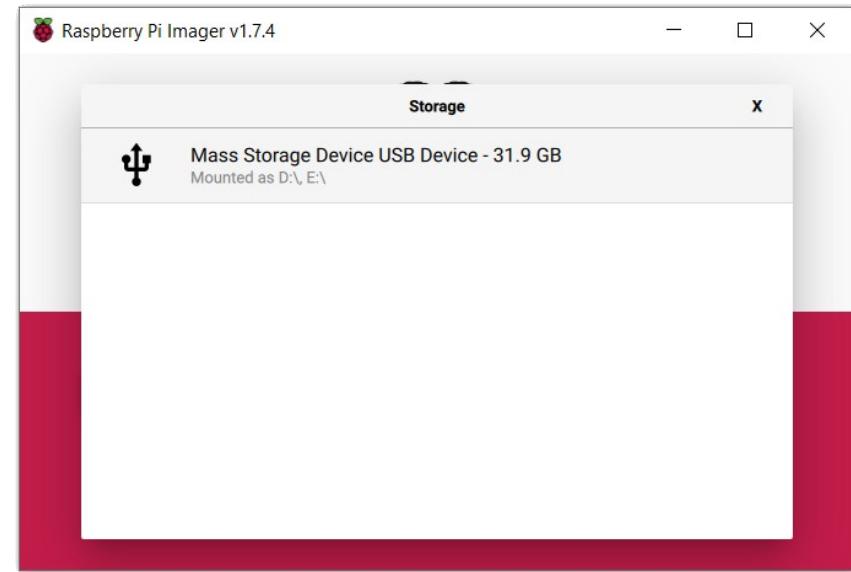
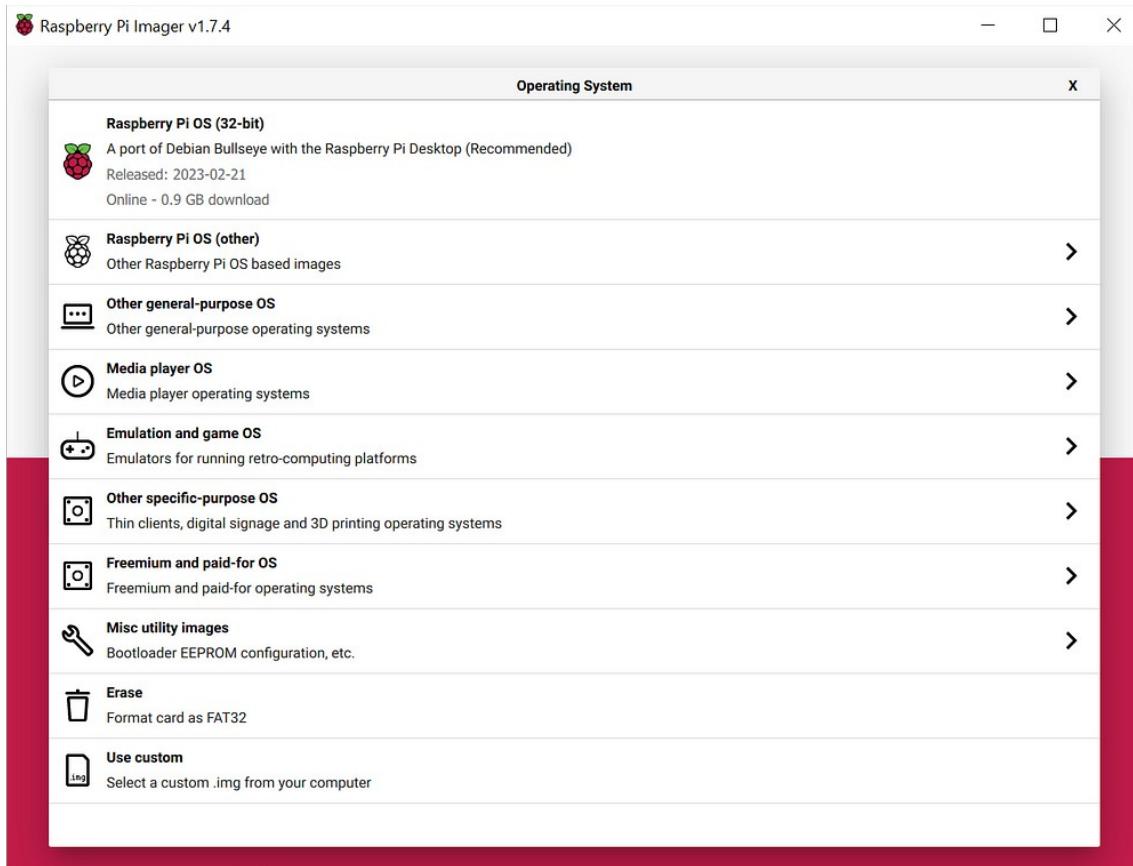
<https://www.raspberrypi.com/software/operating-systems/>

# Raspberry Pi OS Installation

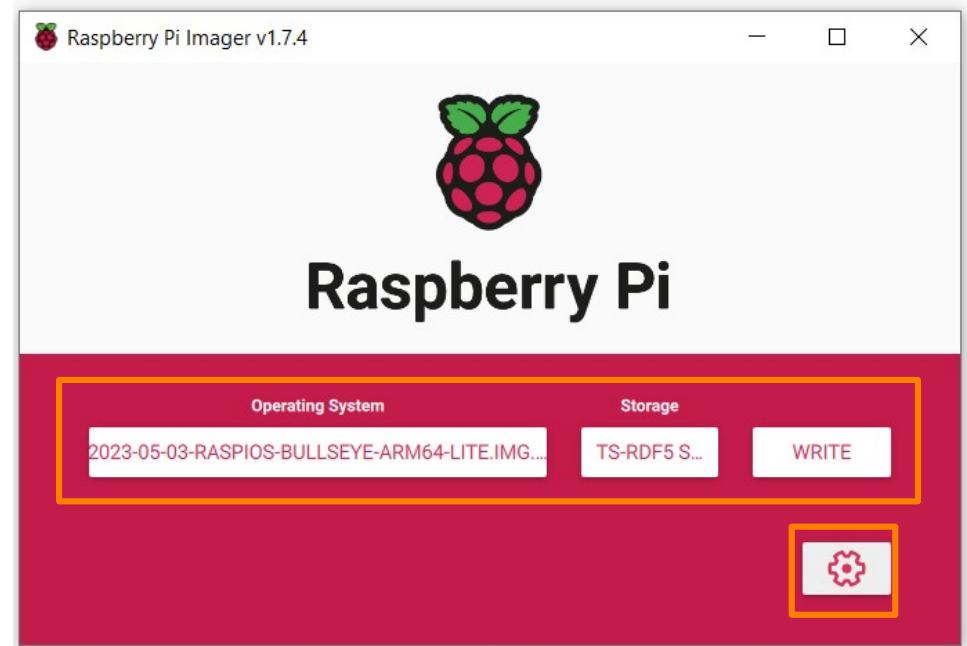
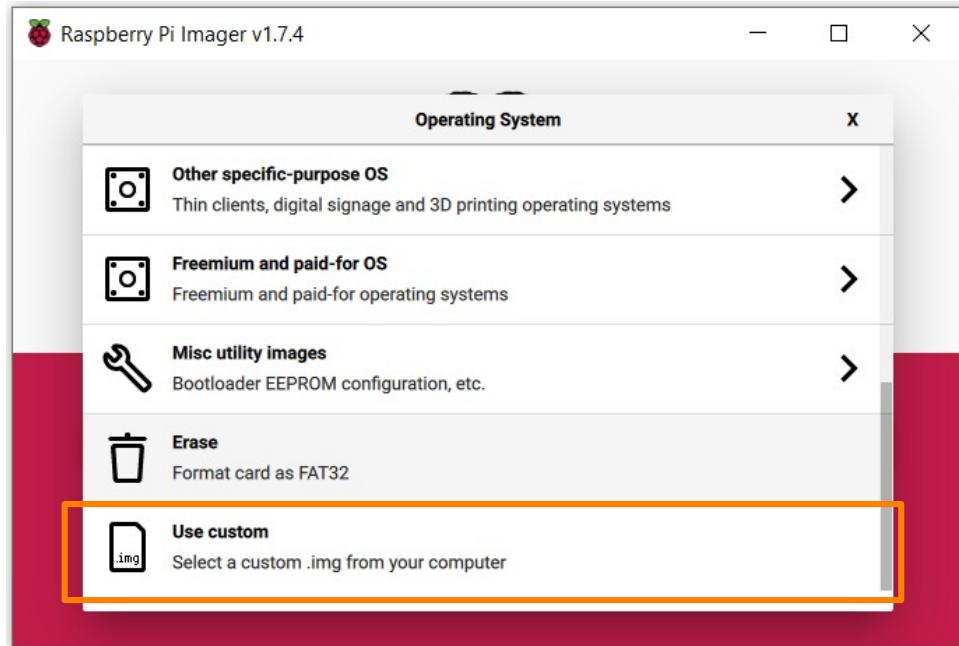


- Insert the microSD into the user's computer.
- Start Raspberry Pi Imager.
- Select “Erase” to format the microSD card.
- Select the microSD storage.
- Press “WRITE” to format the microSD card.

# Raspberry Pi OS Installation



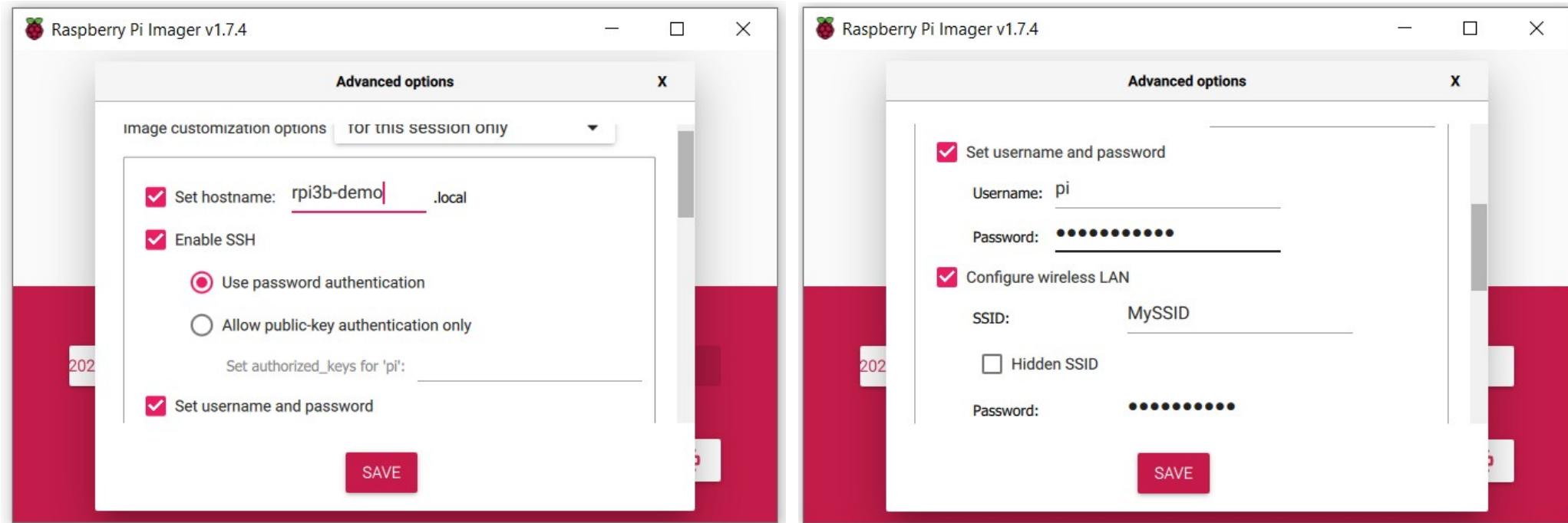
# Raspberry Pi OS Installation



- Select “Use custom” for an OS.
- Select the downloaded image file (.img.xz).

- Select the target microSD storage drive.
- Configure the OS Installation Settings.
- Press “WRITE” to flash the image to the microSD card.

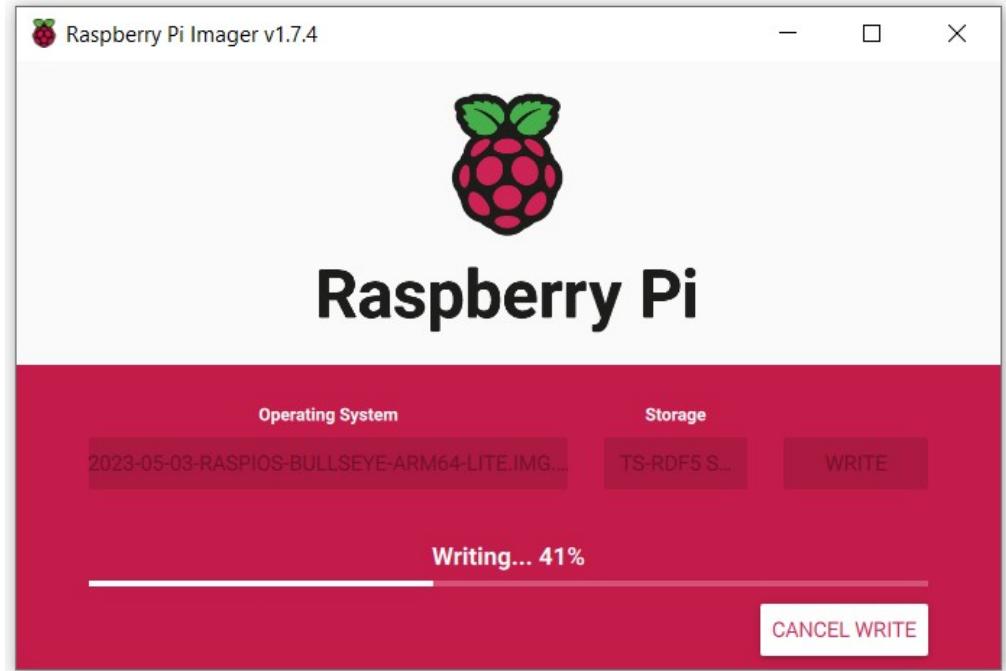
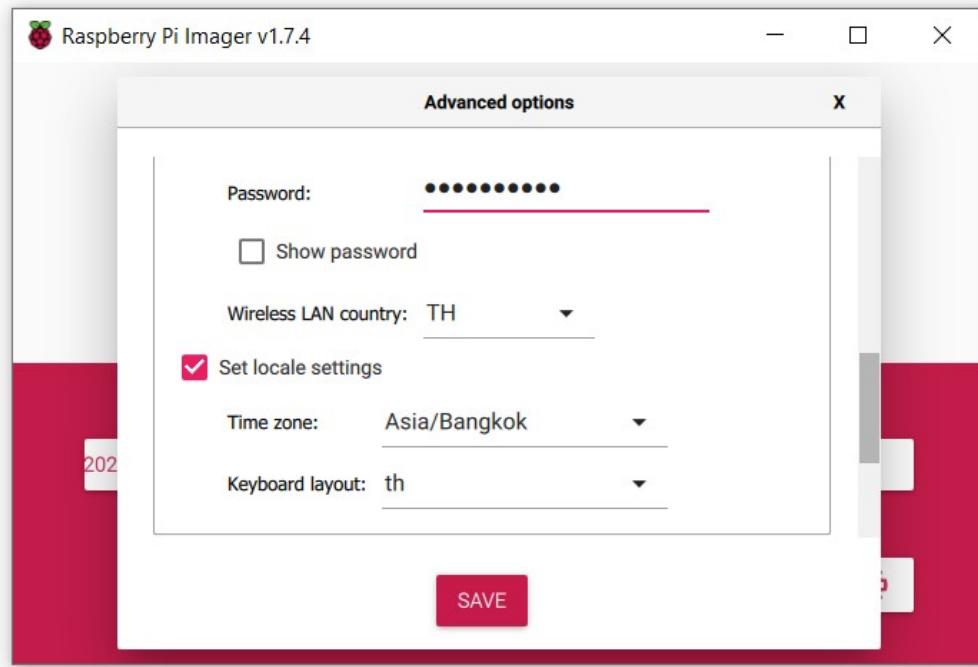
# Raspberry Pi OS Installation



- Set the host name for the RPi.
- Enable the SSH service for remote access.

- Set the default username and password for login.
- Set WiFi SSID and password (optional).

# Raspberry Pi OS Installation



- Set locale settings (Asia/BKK) and Thai keyboard.
- Press the “WRITE” button to start the flashing process.

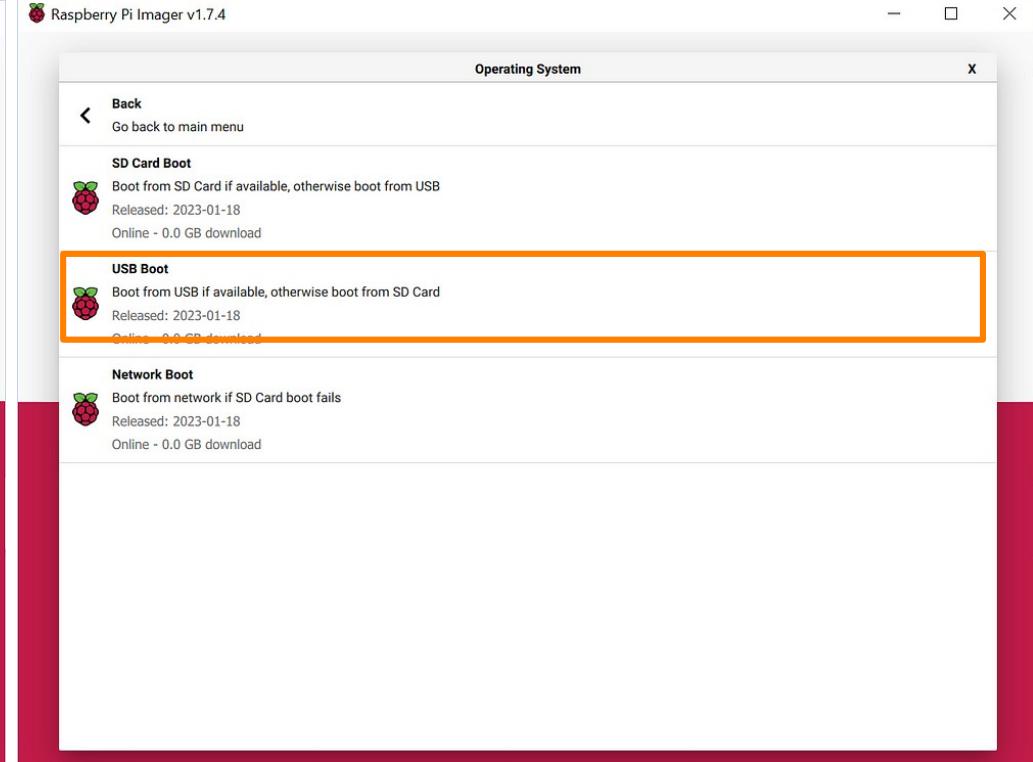
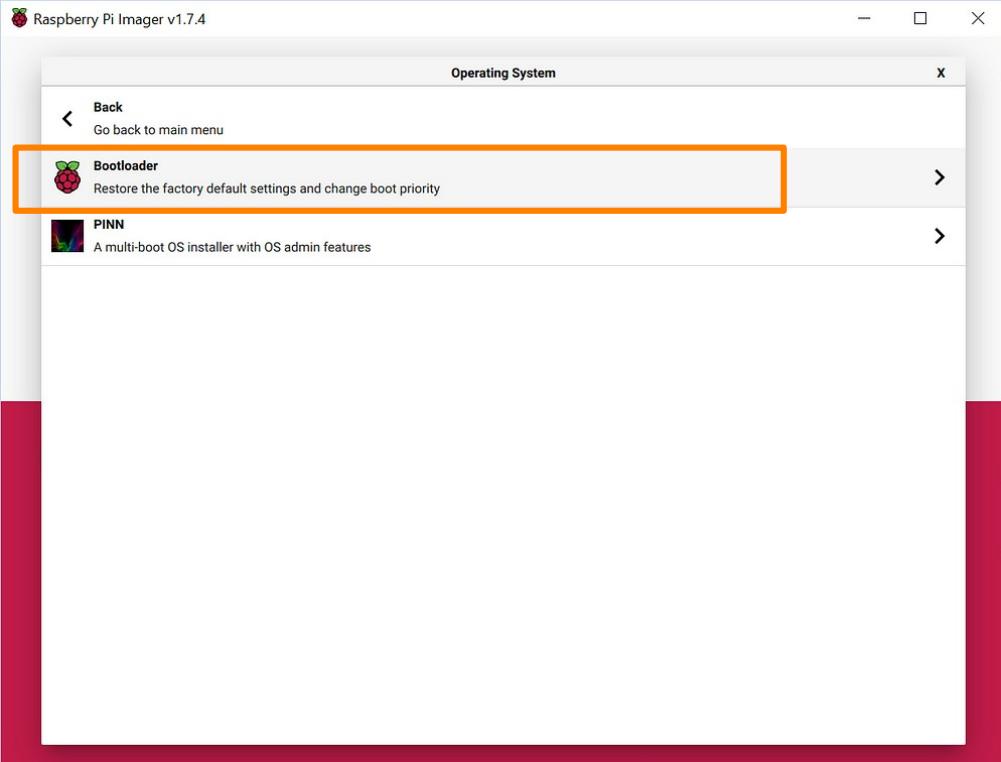
# Write the bootloader with USB boot option to a microSD.

The screenshot shows the 'Operating System' section of the Raspberry Pi Imager software. It lists various operating systems with their descriptions and download sizes. A red box highlights the 'Misc utility images' option, which is described as 'Bootloader EEPROM configuration, etc.' Below this, other options like 'Erase' and 'Use custom' are visible. To the right, a yellow callout box contains two bullet points about installing Raspberry Pi OS on an SSD and configuring the bootloader for USB boot.

- It is possible to install the Raspberry Pi OS on an SSD (Solid State Drive) connected to a USB port on a RPi 4.
- In this case, a bootloader with USB boot option must be installed properly.

Misc Utility images > Bootloader > Change Boot Priority / Boot from USB

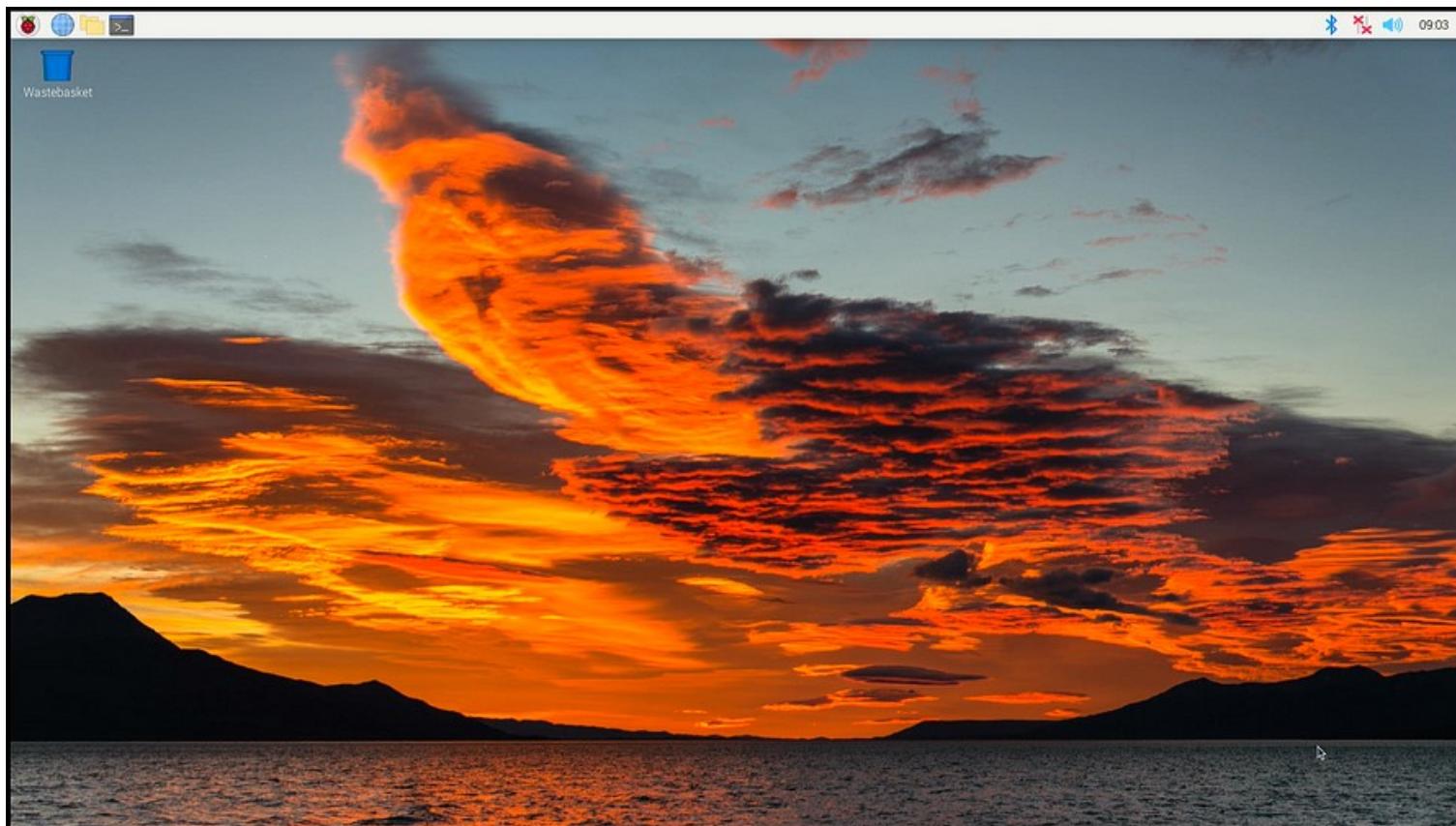
# Write the bootloader with USB boot option to a microSD.



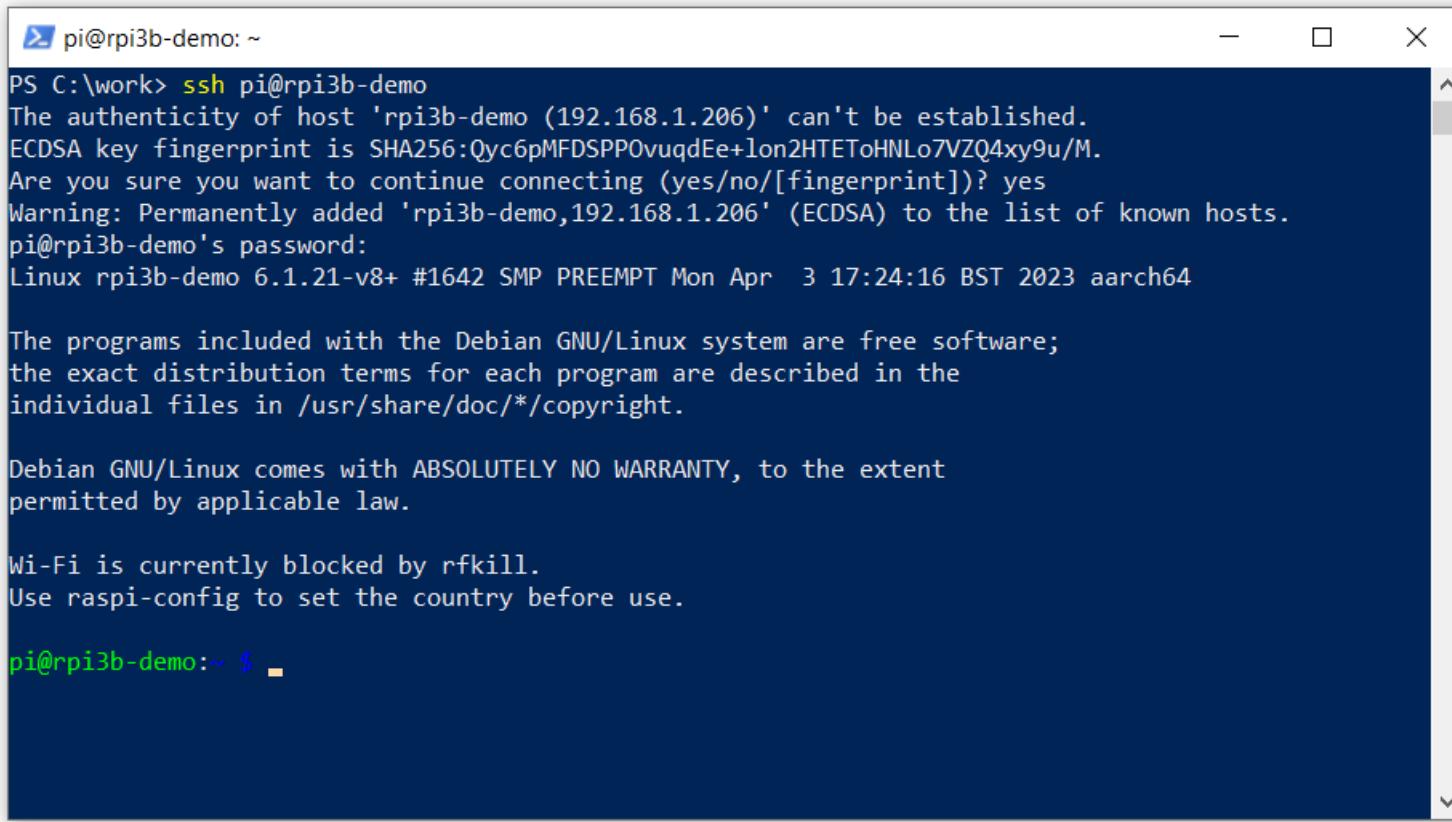
## Write Raspberry Pi OS image to SSD via USB-Adapter



# Raspberry Pi Desktop on Raspberry Pi 4 Model B (MicroSD Boot)

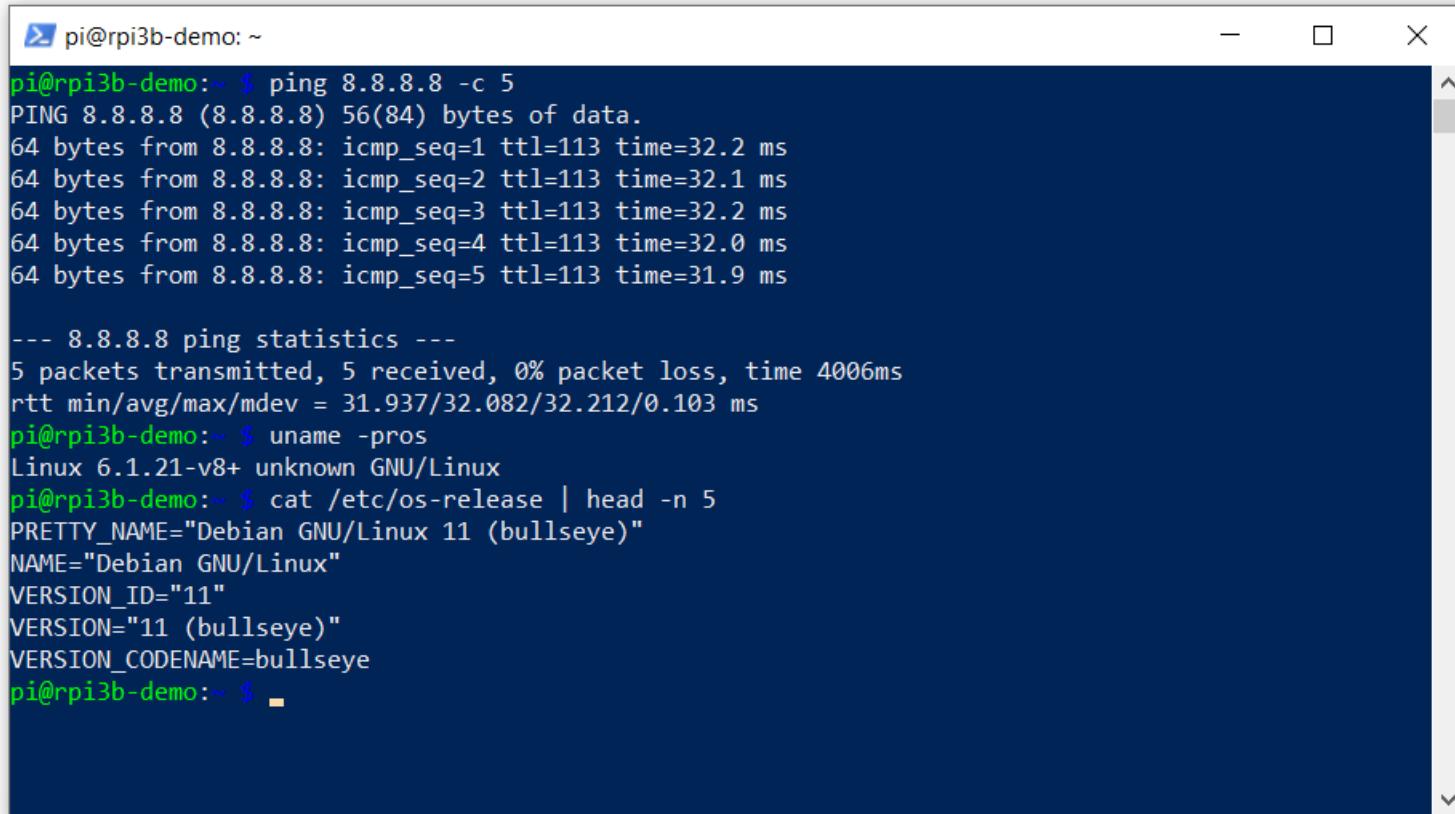


# SSH Access To RPi



The screenshot shows a terminal window titled "pi@rpi3b-demo: ~". The session starts with the command "PS C:\work> ssh pi@rpi3b-demo". The terminal displays a warning about host authenticity, asking if the user wants to continue connecting. The user responds with "yes". A warning message indicates that the host has been added to the list of known hosts. The user is then prompted for their password. The terminal then shows the system information: "Linux rpi3b-demo 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr 3 17:24:16 BST 2023 aarch64". Following this, standard Debian Linux copyright and warranty notices are displayed. At the bottom, a message about Wi-Fi being blocked by rfkill is shown, along with instructions to use raspi-config to set the country before use. The prompt "pi@rpi3b-demo:~ \$" is visible at the bottom of the terminal.

# SSH Access To RPi

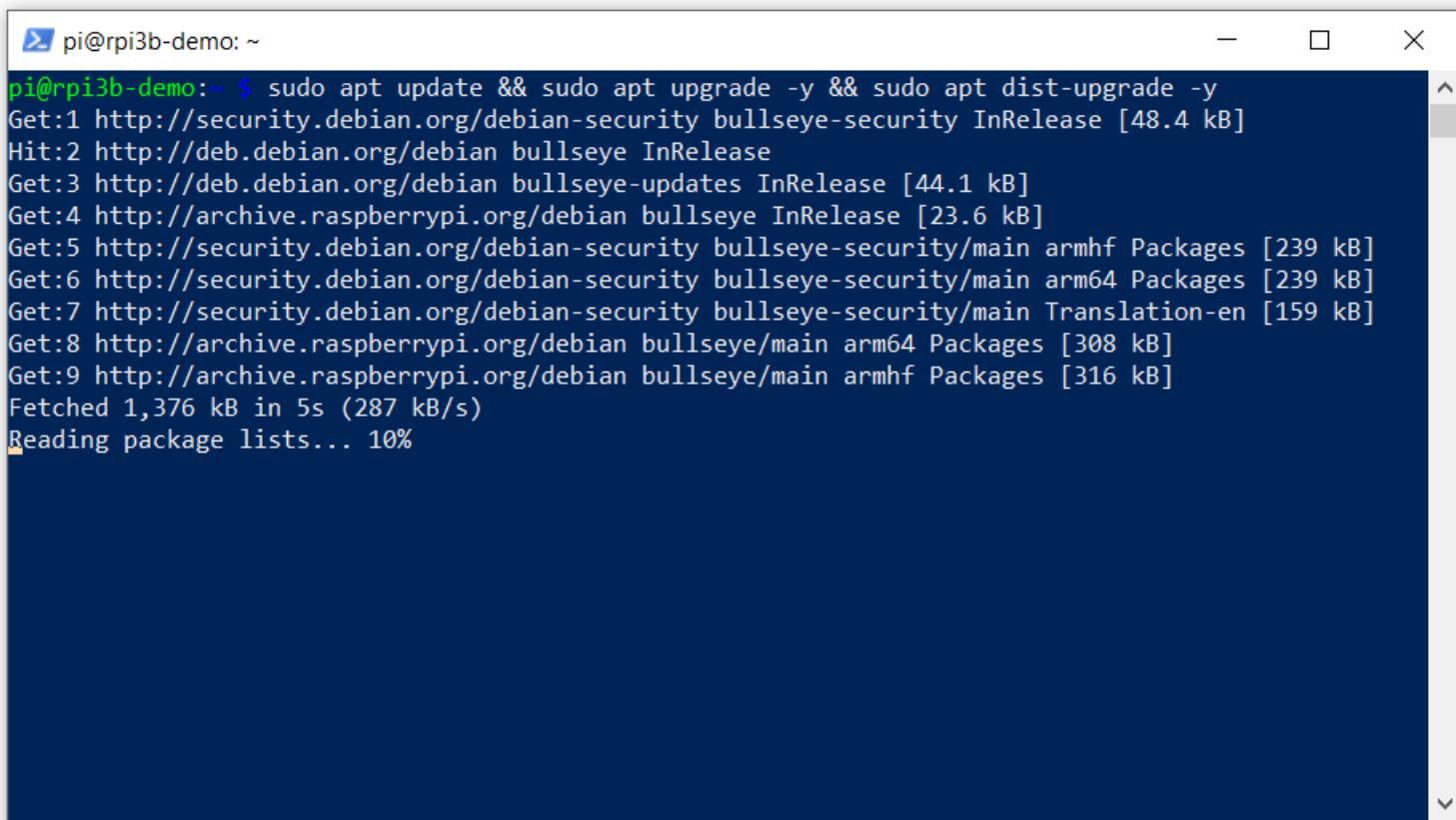


A screenshot of a terminal window titled "pi@rpi3b-demo: ~". The window contains the following command-line session:

```
pi@rpi3b-demo:~ $ ping 8.8.8.8 -c 5
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=32.2 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=32.1 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=113 time=32.2 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=113 time=32.0 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=113 time=31.9 ms

--- 8.8.8.8 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4006ms
rtt min/avg/max/mdev = 31.937/32.082/32.212/0.103 ms
pi@rpi3b-demo:~ $ uname -ros
Linux 6.1.21-v8+ unknown GNU/Linux
pi@rpi3b-demo:~ $ cat /etc/os-release | head -n 5
PRETTY_NAME="Debian GNU/Linux 11 (bullseye)"
NAME="Debian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
pi@rpi3b-demo:~ $
```

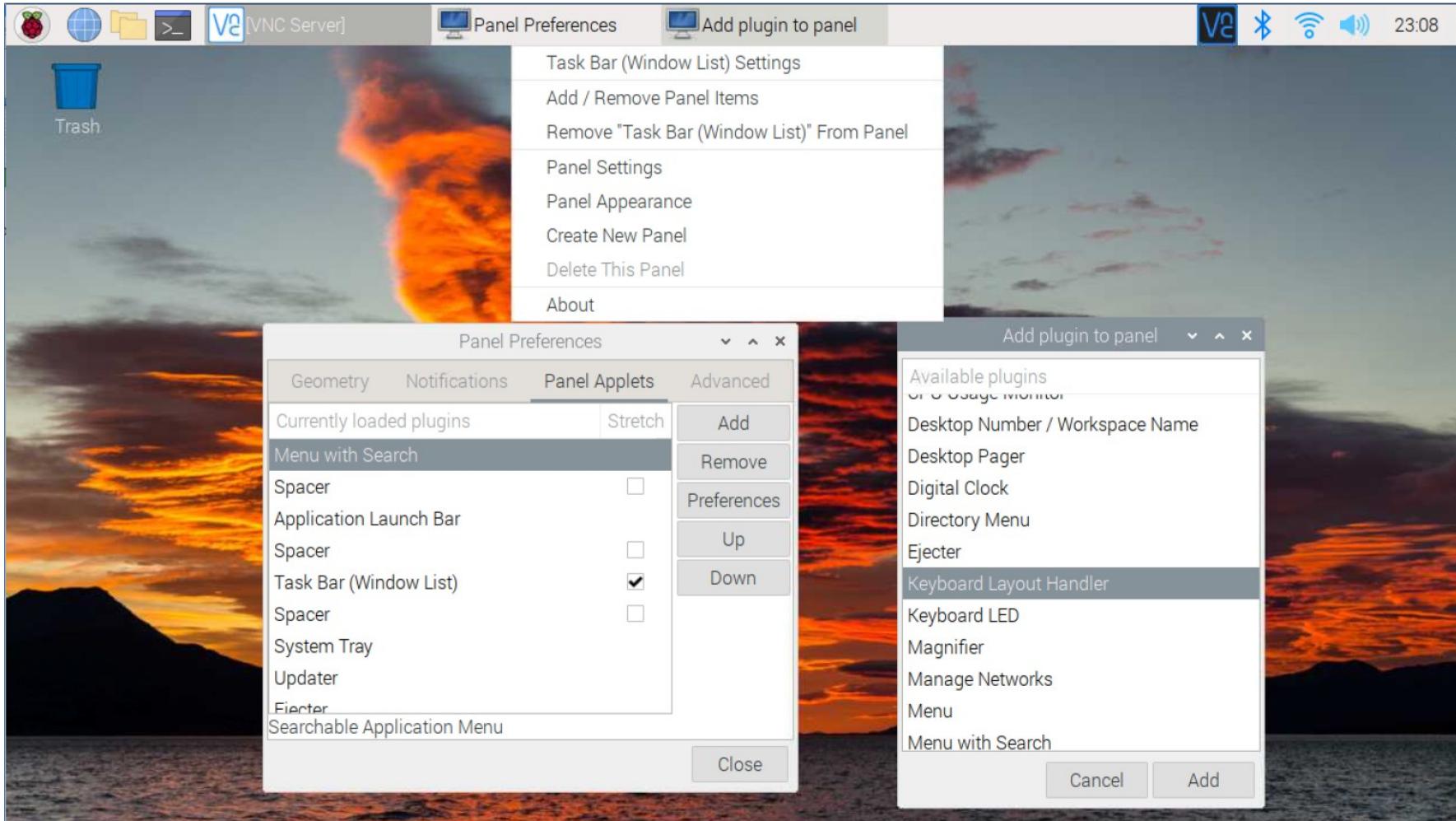
# Software Package Update



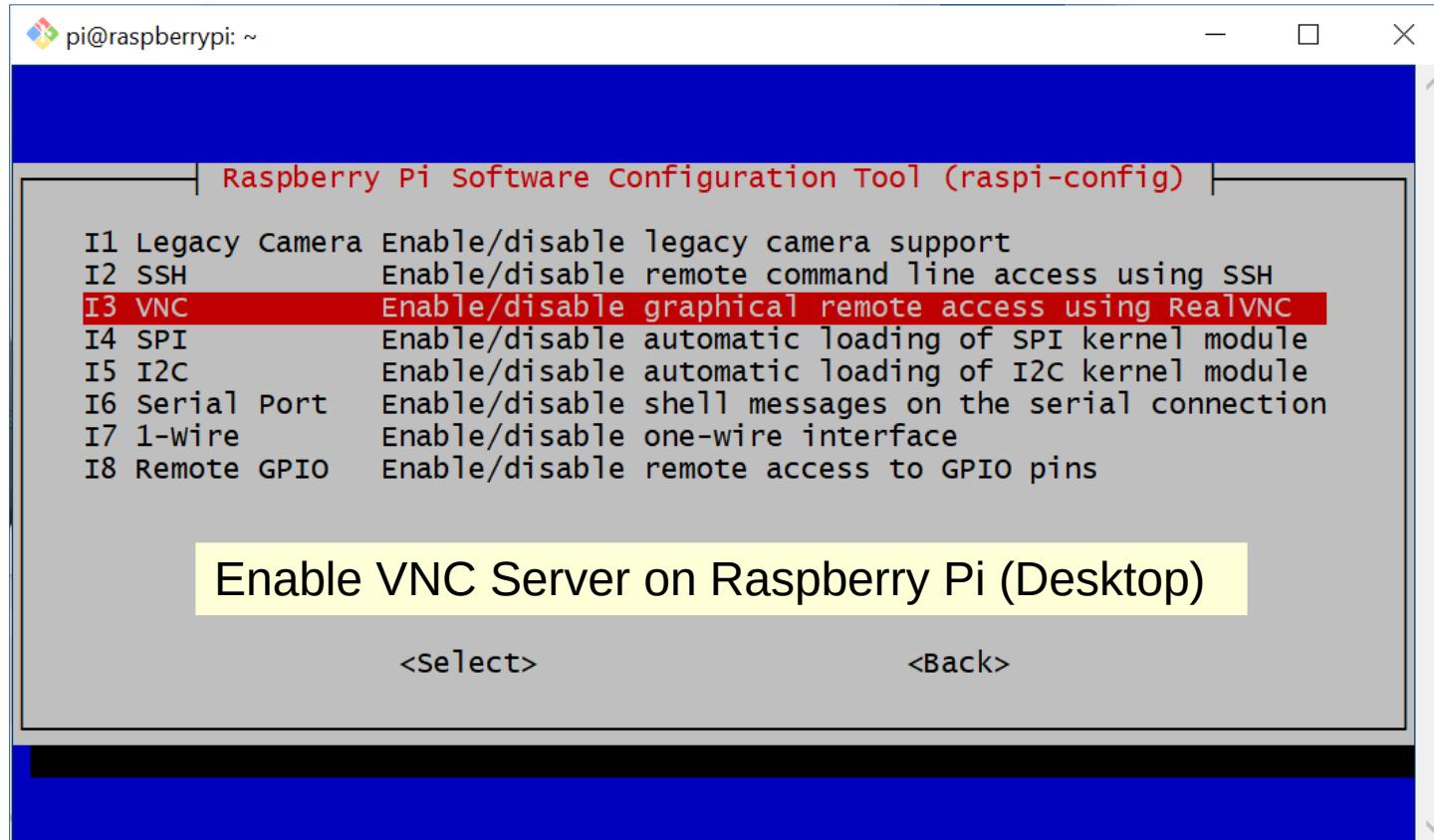
A screenshot of a terminal window titled "pi@rpi3b-demo: ~". The window contains the following text:

```
pi@rpi3b-demo:~ $ sudo apt update && sudo apt upgrade -y && sudo apt dist-upgrade -y
Get:1 http://security.debian.org/debian-security bullseye-security InRelease [48.4 kB]
Hit:2 http://deb.debian.org/debian bullseye InRelease
Get:3 http://deb.debian.org/debian bullseye-updates InRelease [44.1 kB]
Get:4 http://archive.raspberrypi.org/debian bullseye InRelease [23.6 kB]
Get:5 http://security.debian.org/debian-security/bullseye/main armhf Packages [239 kB]
Get:6 http://security.debian.org/debian-security/bullseye/main arm64 Packages [239 kB]
Get:7 http://security.debian.org/debian-security/bullseye/main Translation-en [159 kB]
Get:8 http://archive.raspberrypi.org/debian/bullseye/main arm64 Packages [308 kB]
Get:9 http://archive.raspberrypi.org/debian/bullseye/main armhf Packages [316 kB]
Fetched 1,376 kB in 5s (287 kB/s)
Reading package lists... 10%
```

# Add Keyboard Layout for TH / EN

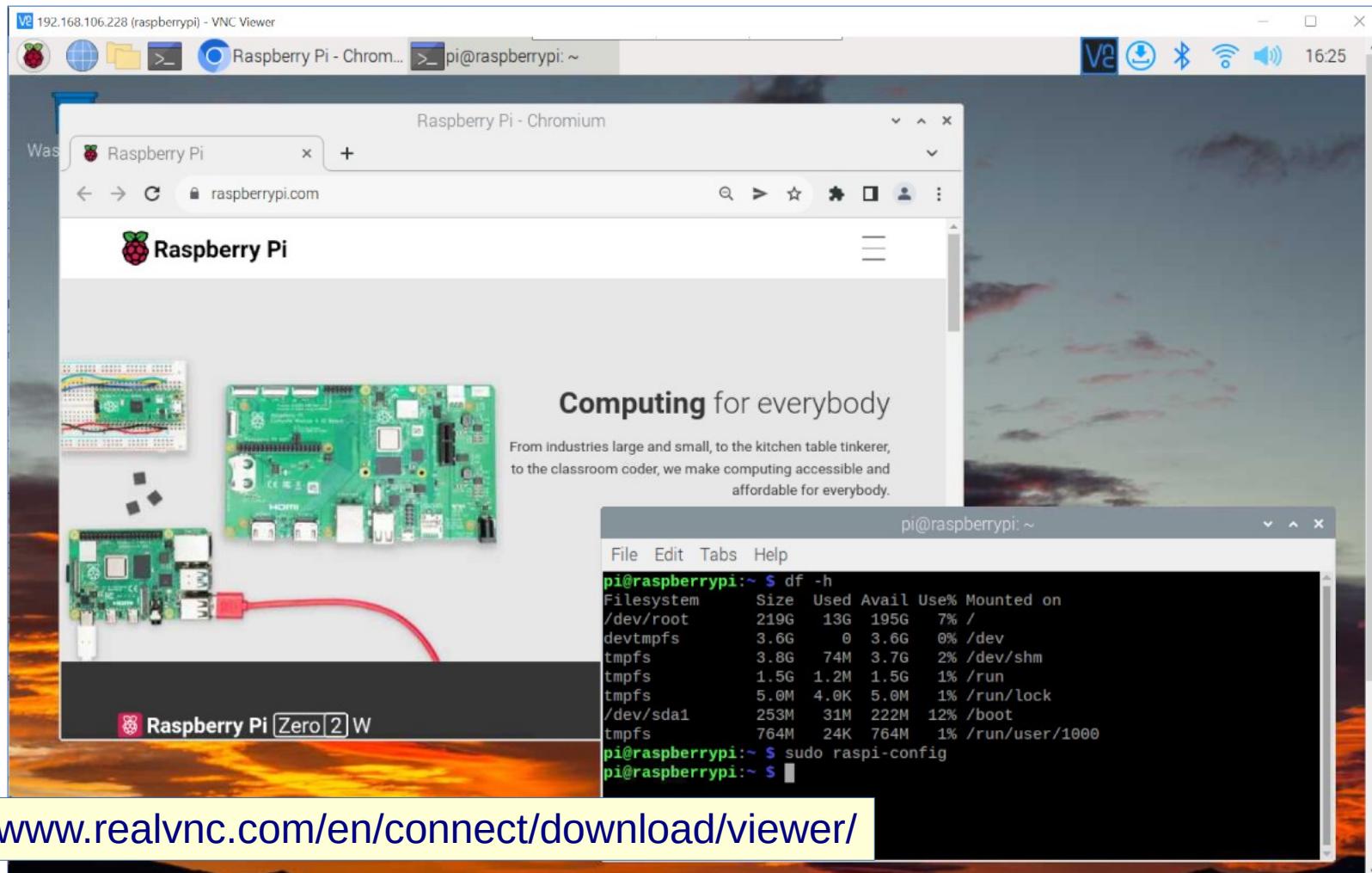


# Raspberry Pi Configuration Tool

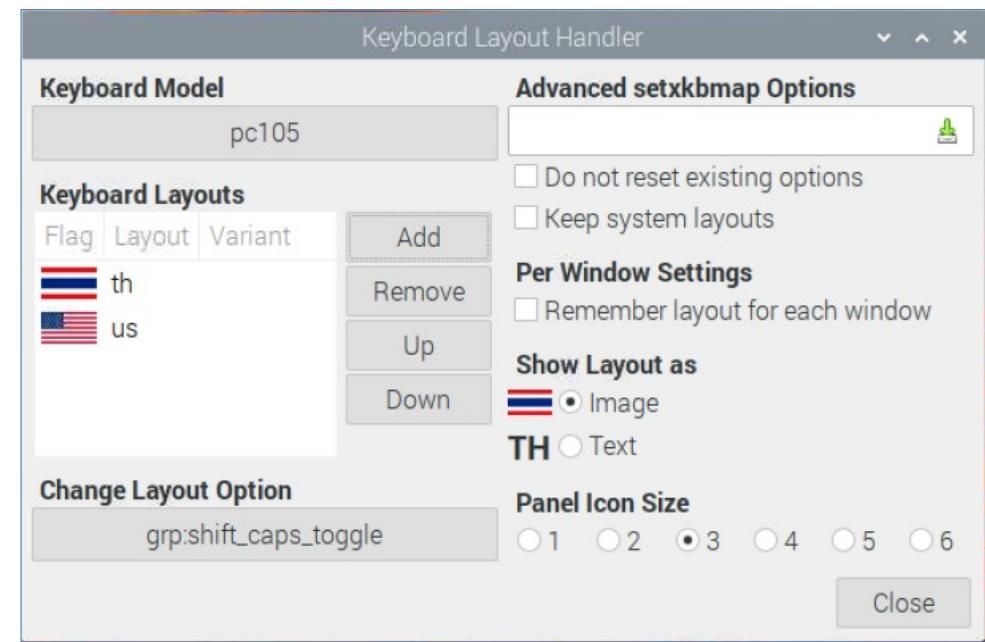
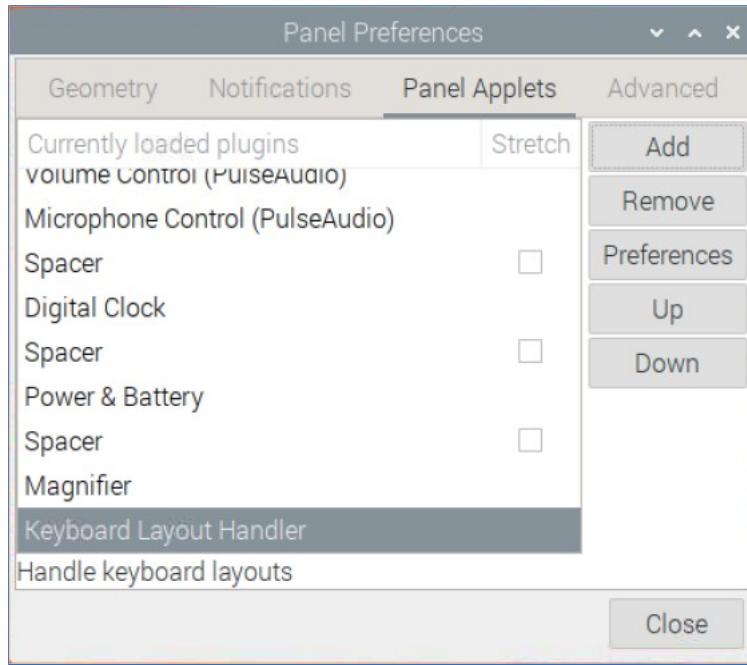


**raspi-config** is a configuration tool in Raspbian / Raspberry Pi OS, used to configure various settings on Raspberry Pi.

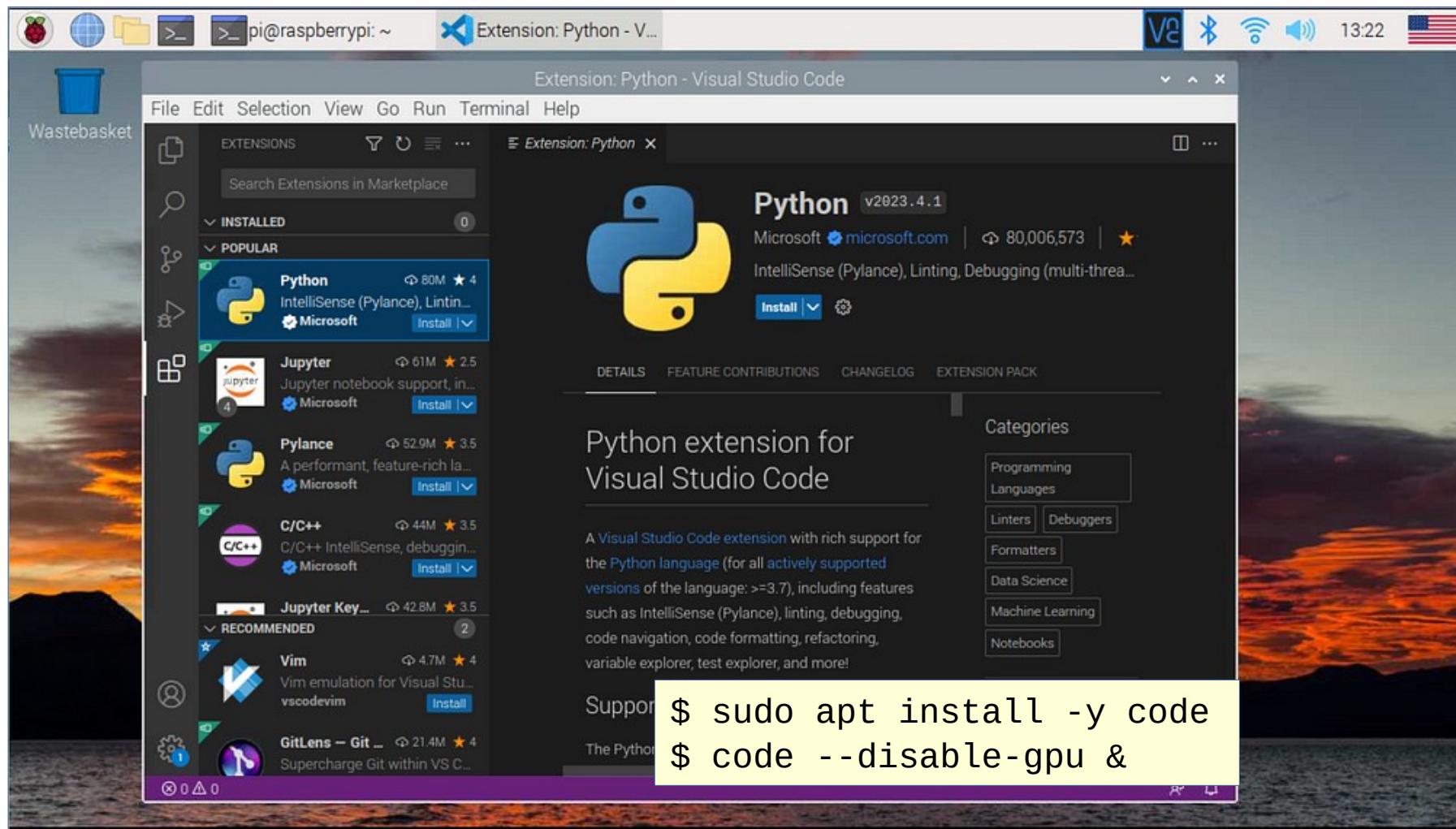
# Remote Desktop with RealView VNC Viewer (VNC Client) on Windows



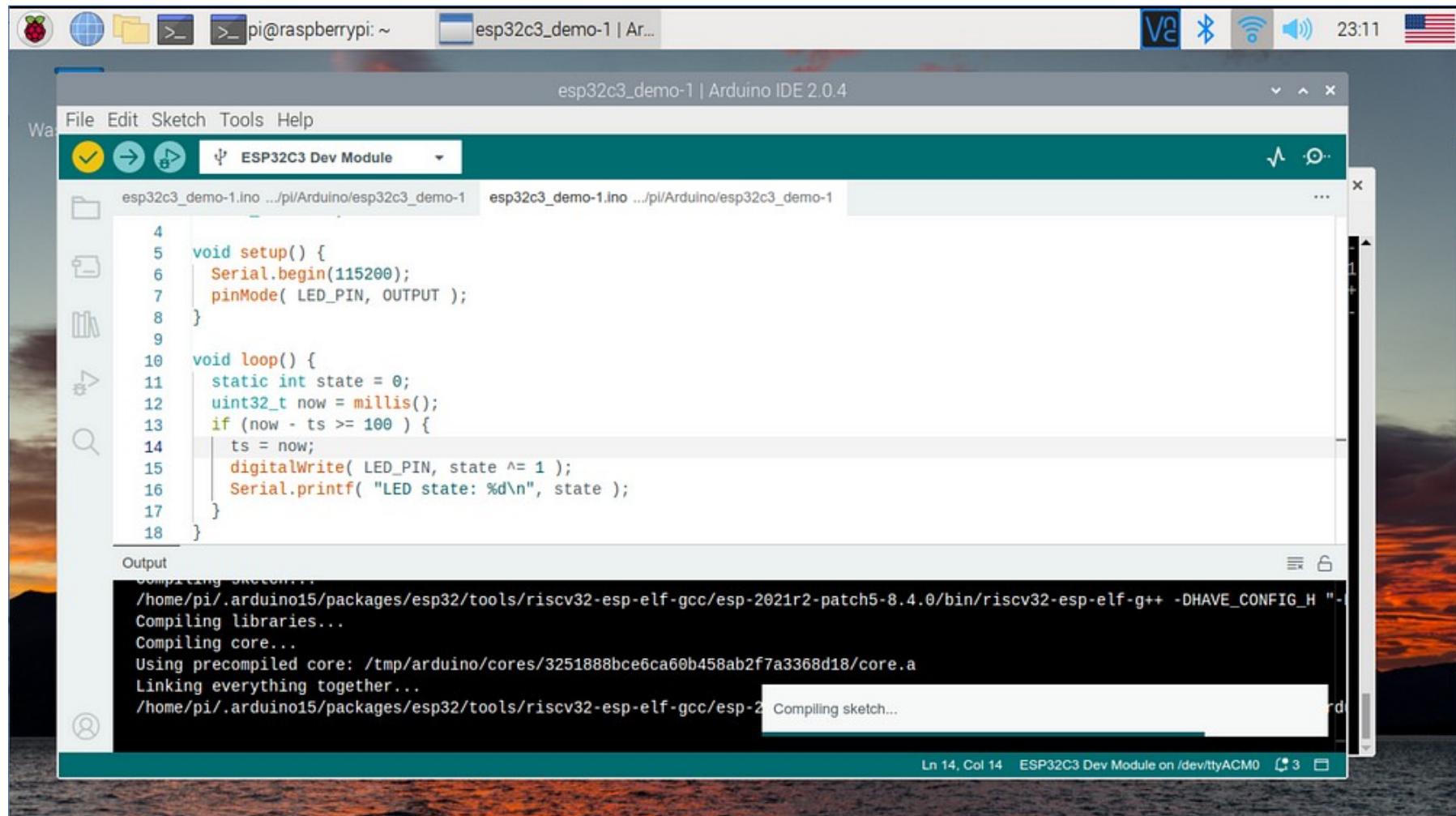
# Add Keyboard Layout for THAI / ENG



# Using VS Code IDE on Raspbian OS Desktop / RPi 4



# Using Arduino IDE on Raspbian OS Desktop / RPi 4



# Arduino IDE Installation

```
# see: https://github.com/koendv/arduino-ide-raspberrypi/releases/
$ wget https://github.com/koendv/arduino-ide-raspberrypi/releases/download/
2.0.4/Linux_arm64_zip.zip
$ sudo apt install zlib1g-dev fuse libfuse-dev
$ unzip Linux_arm64_zip.zip
$ unzip arduino-ide_2.0.4_Linux_arm64.zip
$ sudo mv arduino-ide_2.0.4_Linux_arm64 /opt/
$ sudo chown -R pi:pi /opt/arduino-ide_2.0.4_Linux_arm64
$ sudo ln -s /opt/arduino-ide_2.0.4_Linux_arm64/arduino-ide
/usr/local/bin/arduino-ide
$ arduino-ide --disable-gpu > /dev/null 2>&1 &
```

## Note:

- The latest version of the pre-built Arduino IDE for 64-bit RPi is v2.2.0  
(Last access: 2024-07-05).
- An AppImage file is also available for download.