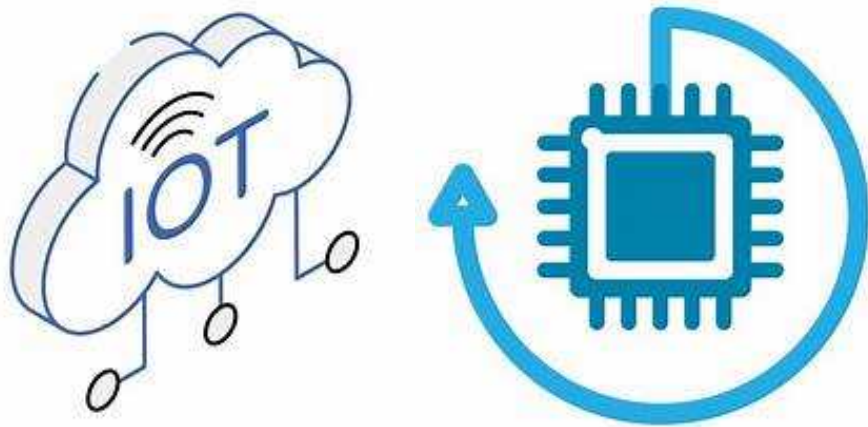


Internet of Things (IoT) Systems



Lecture 03

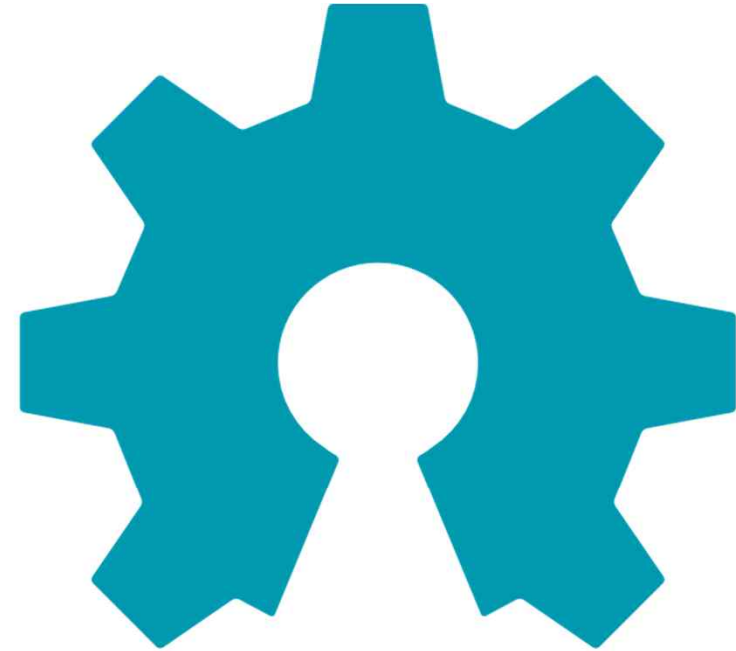
Raspberry Pi Configuration/Set-up

Ikram Syed, Ph.D.
Associate Professor
Department of Information and Communication Engineering
Hankuk University of Foreign Studies (HUFS)

Spring – 2025

Open-Source Hardware for IoT

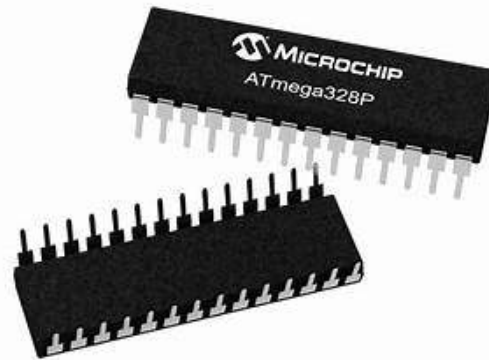
- Microcontrollers
- Arduino
- Raspberry Pi



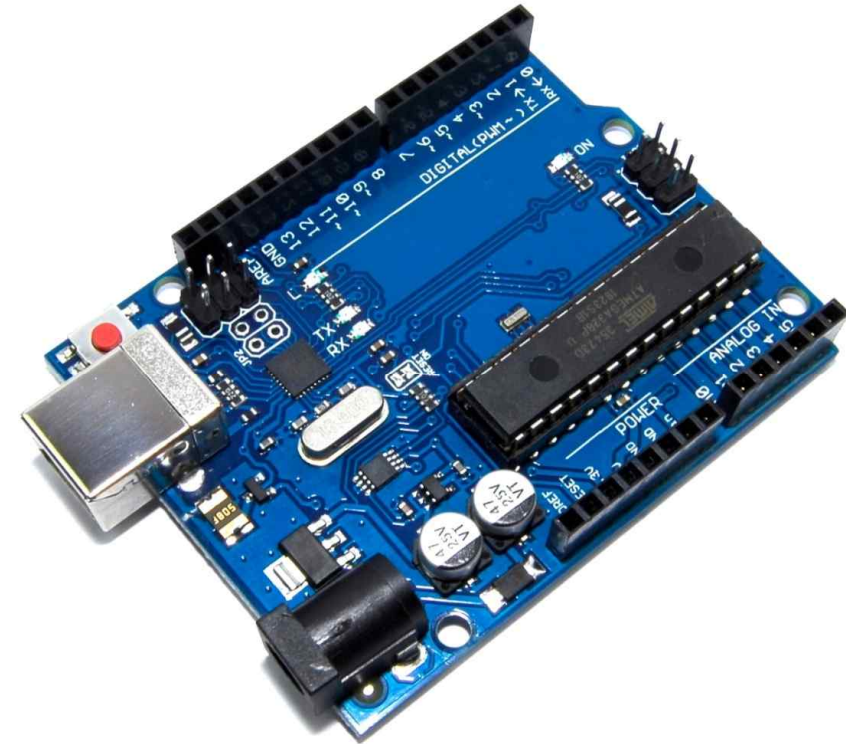
open source
hardware

Microcontroller

- **A microcontroller** is a compact integrated circuit designed to govern a specific operation in an embedded system.
- A typical microcontroller includes a **processor, memory and input/output (I/O) peripherals** on a single chip.
- Sometimes referred to as an **embedded controller** or **microcontroller unit (MCU)**.
- **Microcontrollers are found in:**
 - vehicles,
 - robots,
 - medical devices,
 - mobile radio transceivers,
 - vending machines
 - home appliances,
 - among other devices.



Microcontroller chip

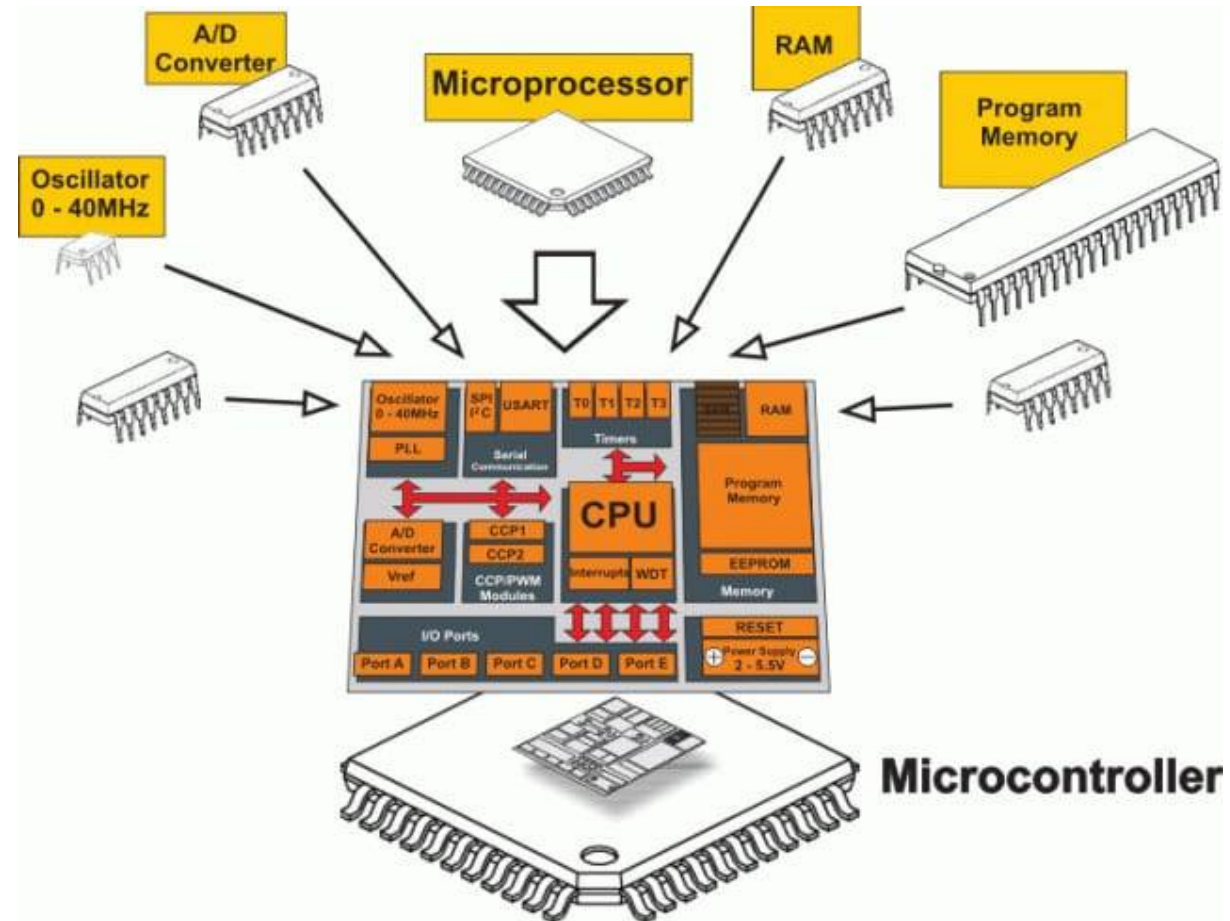


Microcontroller chip + board

Inside a Microcontroller: Essential Components

A microcontroller can be seen as a **small computer**, and this is because of the essential components inside of it;

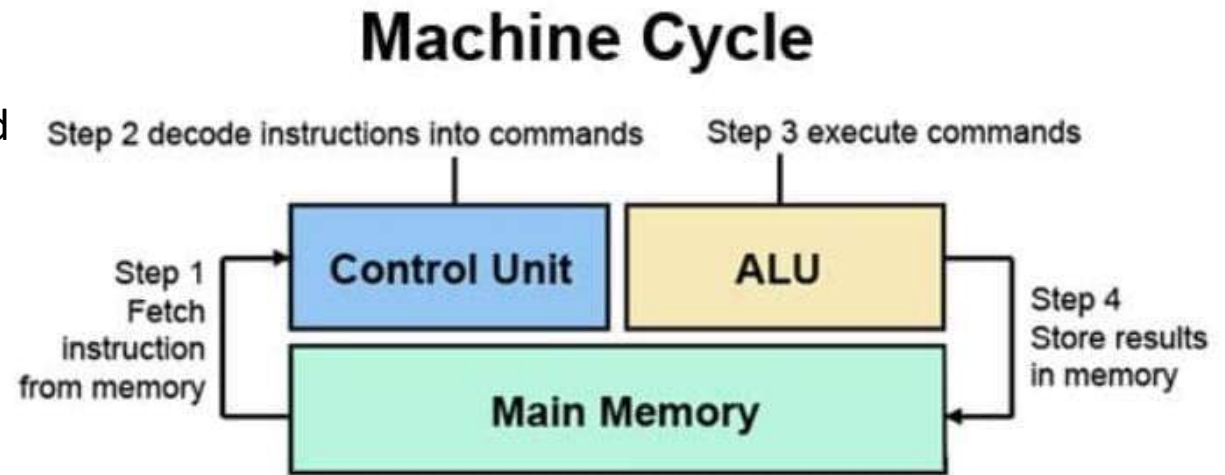
- Central Processing Unit (CPU),
- Random-Access Memory (RAM),
- Flash Memory,
- Serial Bus Interface,
- Input/Output Ports (I/O Ports),
- Electrical Erasable Programmable Read-Only Memory (EEPROM).



Inside a Microcontroller: Essential Components

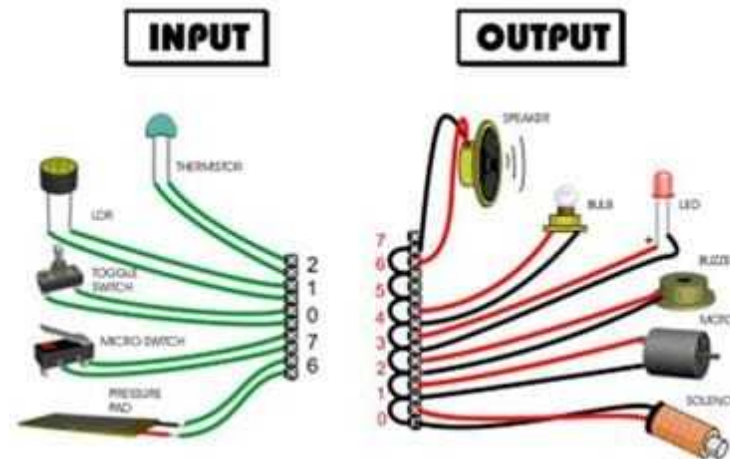
Design of Microcontroller CPU

- Processing all the data input it receives and executes the required instructions.
- ALU performs arithmetic and logical operations,
- Control Unit (CU), which handles all of the processor's instruction executions.



Microcontroller I/O Ports

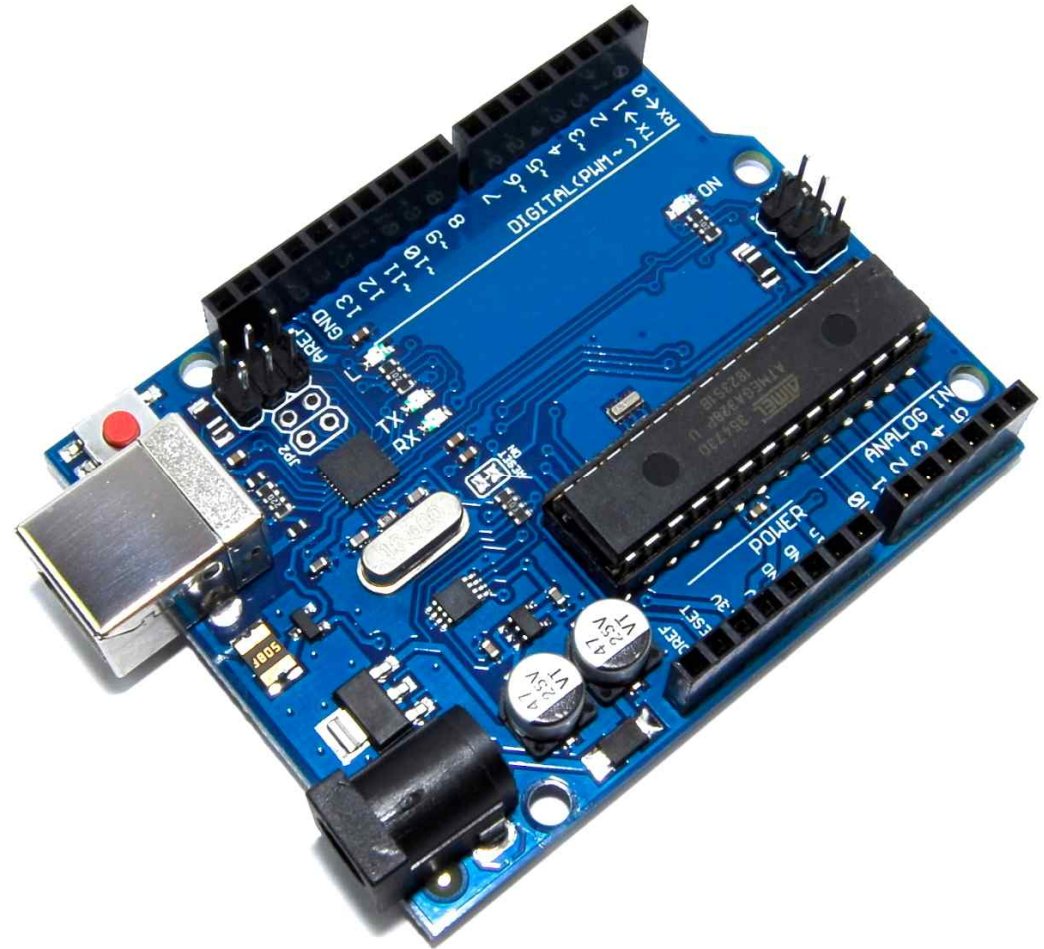
- I/O ports are what the microcontroller uses to connect to real-world applications.
- Inputs such as temperature sensing, motion sensing, push buttons,.....
- Output ports such as LED lights, LCD, running a motor, speaker,



Types of the Microcontroller

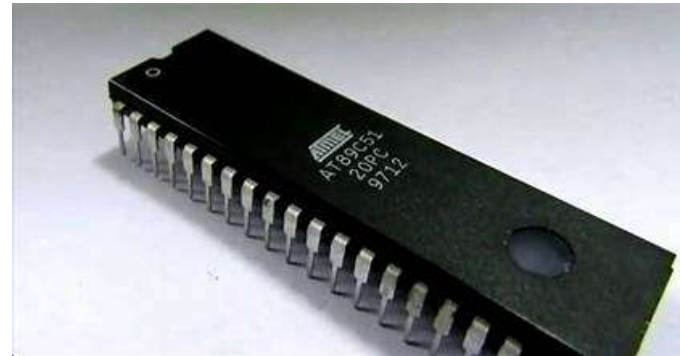
(XCK/T0) PB0	1	40	PA0 (ADC0)
(T1) PB1	2	39	PA1 (ADC1)
(INT2/AIN0) PB2	3	38	PA2 (ADC2)
(OC0/AIN1) PB3	4	37	PA3 (ADC3)
(SS) PB4	5	36	PA4 (ADC4)
(MOSI) PB5	6	35	PA5 (ADC5)
(MISO) PB6	7	34	PA6 (ADC6)
(SCK) PB7	8	33	PA7 (ADC7)
RESET	9	32	AREF
VCC	10	31	GND
GND	11	30	AVCC
XTAL2	12	29	PC7 (TOSC2)
XTAL1	13	28	PC6 (TOSC1)
(RXD) PD0	14	27	PC5 (TDI)
(TXD) PD1	15	26	PC4 (TDO)
(INT0) PD2	16	25	PC3 (TMS)
(INT1) PD3	17	24	PC2 (TCK)
(OC1B) PD4	18	23	PC1 (SDA)
(OC1A) PD5	19	22	PC0 (SCL)
(ICP1) PD6	20	21	PD7 (OC2)

ATmega32A microcontroller which is 8-bit and 40 pin AVR chip.



ATmega32A microcontroller Board.

Types of the Microcontroller (SW/HD)



Programming Languages

Assembly language

Very small Code size
Hard to write
Totally Control
Old language

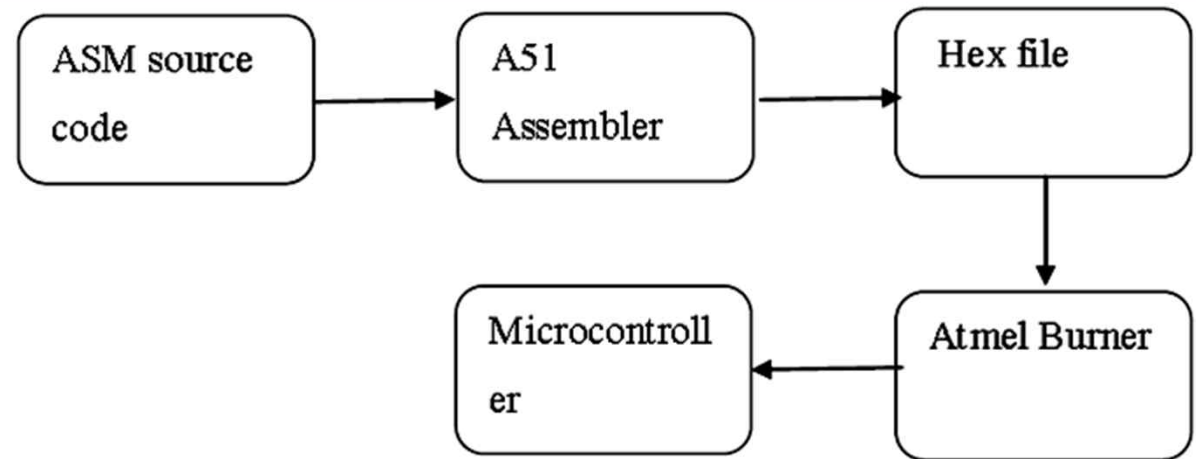
C language

Code size is larger
than Assembly
language .
Easy to write
Not perfect Control
New language

C++ language

Code size is larger
than C language .
Very Easy to write
Not perfect Control
Upgraded language

How to program Microcontroller?

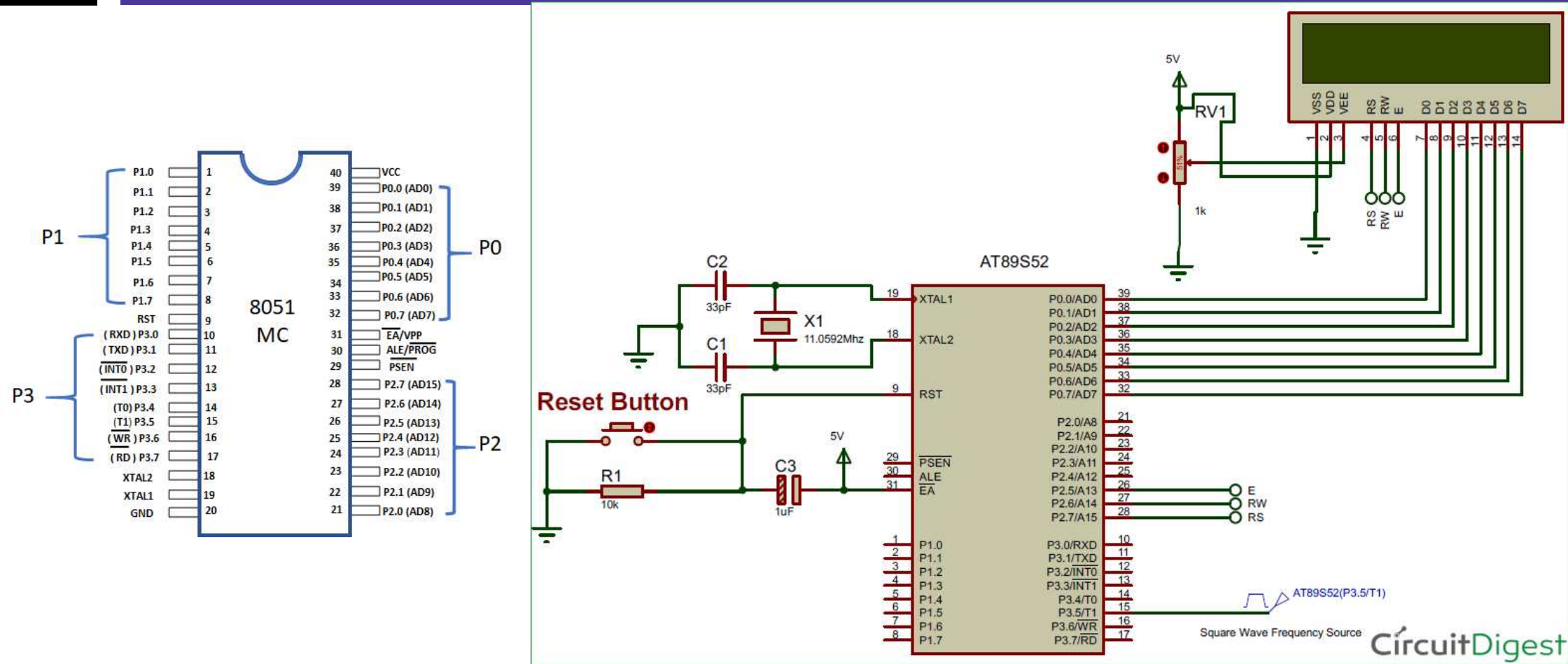


```
code.asm
1  org 00H
2
3  ;MAIN PROGRAM
4
5  toggle: MOV P1, #01H      ; move 00000001 to PORT1
6          CALL delay       ; execute delay
7          MOV A, P1        ; move PORT1 value to accumulator
8          CPL A            ; complement PORT1 value
9          MOV P1, A        ; move 11111110 to PORT1
10         CALL delay       ; execute delay
11
12         sjmp toggle
13
14
15  ;DELAY SUB-ROUTINE
16
17  delay:  MOV R5, #10      ; load register R5 with 10
18  third:  MOV R6, #200    ; load register R6 with 200
19  second: MOV R7, #200    ; load register R7 with 200
20
21         DJNZ R7, $        ; decrement R7 till it is zero
22         DJNZ R6, second   ; decrement R6 till it is zero
23         DJNZ R5, third    ; decrement R5 till it is zero
24
25         ret              ; go back to main program
26 END
27
```

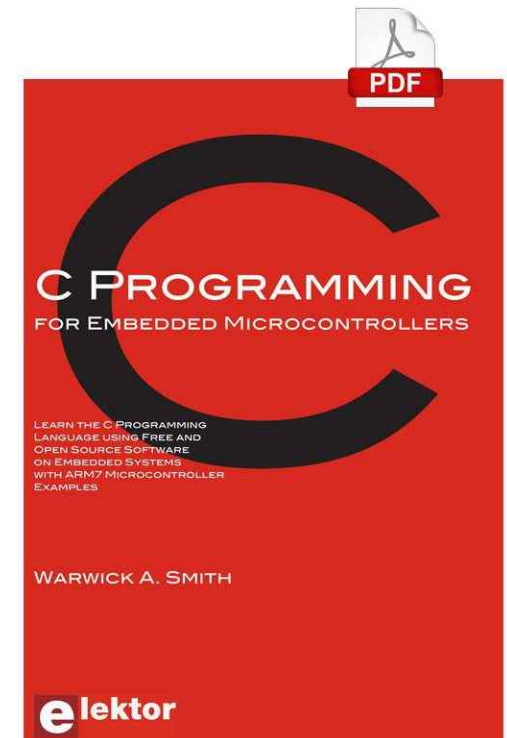
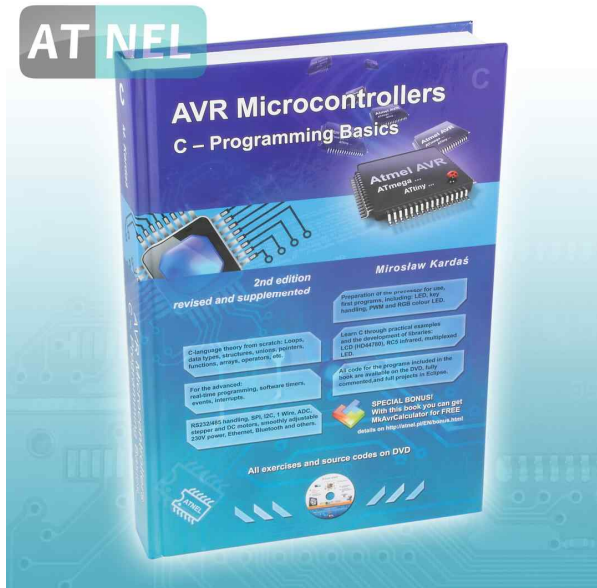
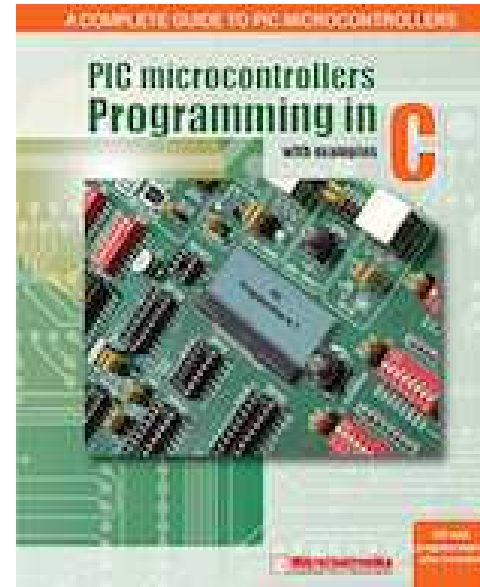
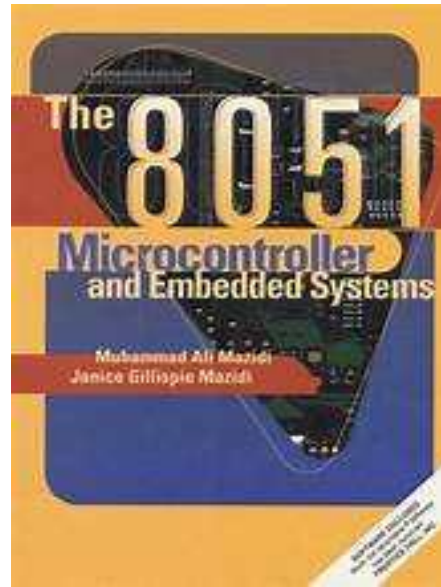
Assembly Programming code for 8051
Microcontroller



Simulation of the Microcontroller



References



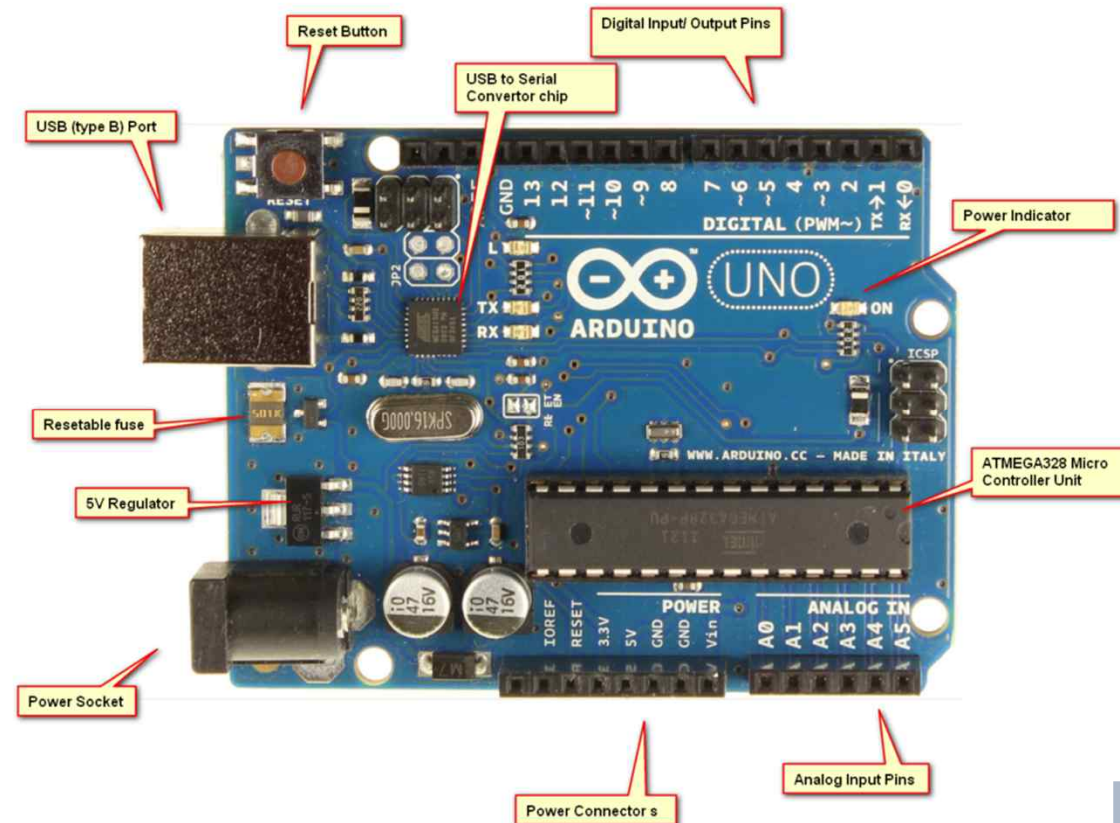


Arduino

Arduino



- Arduino is an **open-source electronics platform** based on easy-to-use hardware and software.
- Arduino boards are able to **read inputs** – light on a sensor, a finger on a button – and turn it into an **output** – activating a motor, turning on an LED, publishing something online.
- The Arduino **project started in 2005** in Italy to make a low-cost and simple solution for non-engineers to create digital projects.



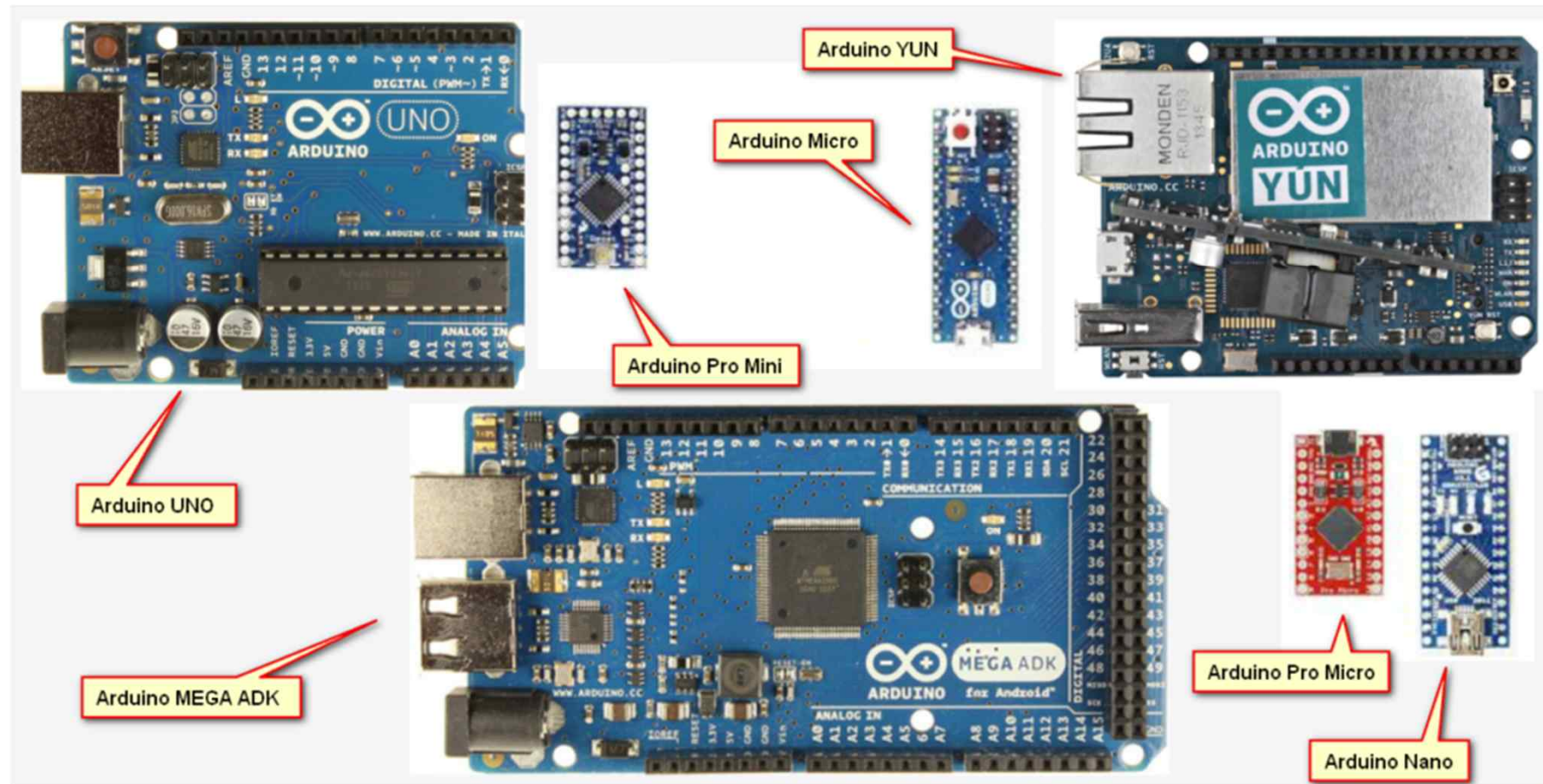
Arduino Hardware

The Arduino **UNO**, **MEGA** and **ZERO** are the best.

The Arduino UNO R3 is

- very easy to use,
- USB type-B port to connect with Computer
- Power socket
- fairly cheap.

It is compatible with most projects and code examples you will find on the internet.

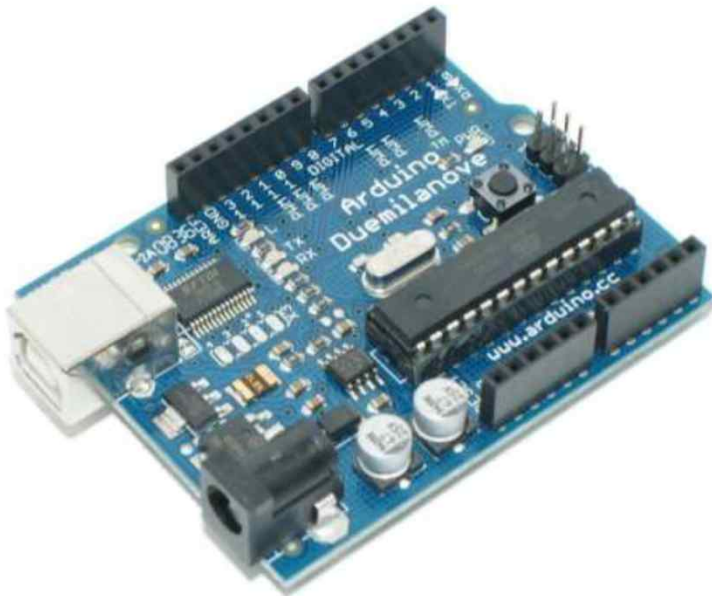


Arduino Hardware

- Small programmable device
- Easy connectable
- Is open source
- Has a simple to use software

- Small programmable device
- Easy connectable
- Is open source
- Has a simple to use software

Only around 4 simultaneous networking connections



Arduino Ethernet

Arduino IDE software

As of January 4, 2017, ARDUINO 1.8.0 is the latest version of Arduino IDE.



Arduino IDE 2.3.2

The new major release of the Arduino IDE is faster and even more powerful! In addition to a more modern editor and a more responsive interface it features autocompletion, code navigation, and even a live debugger.

For more details, please refer to the [Arduino IDE 2.0 documentation](#).

Nightly builds with the latest bugfixes are available through the section below.

SOURCE CODE

The Arduino IDE 2.0 is open source and its source code is hosted on [GitHub](#).

DOWNLOAD OPTIONS

Windows Win 10 and newer, 64 bits

Windows MSI installer

Windows ZIP file

Linux Appliance 64 bits (X86-64)

Linux ZIP file 64 bits (X86-64)

macOS Intel, 10.15: "Catalina" or newer, 64 bits

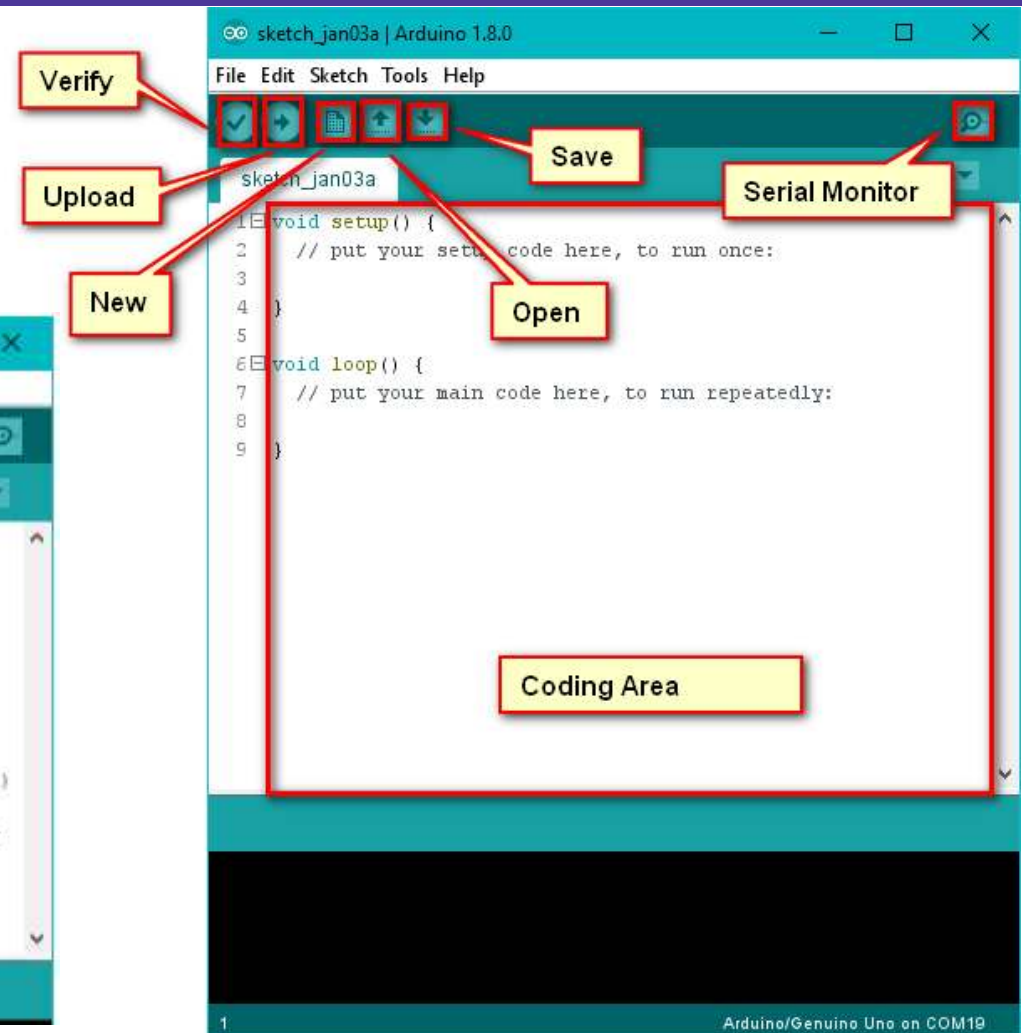
macOS Apple Silicon, 11: "Big Sur" or newer, 64 bits

[Release Notes](#)

<https://www.arduino.cc/en/software>

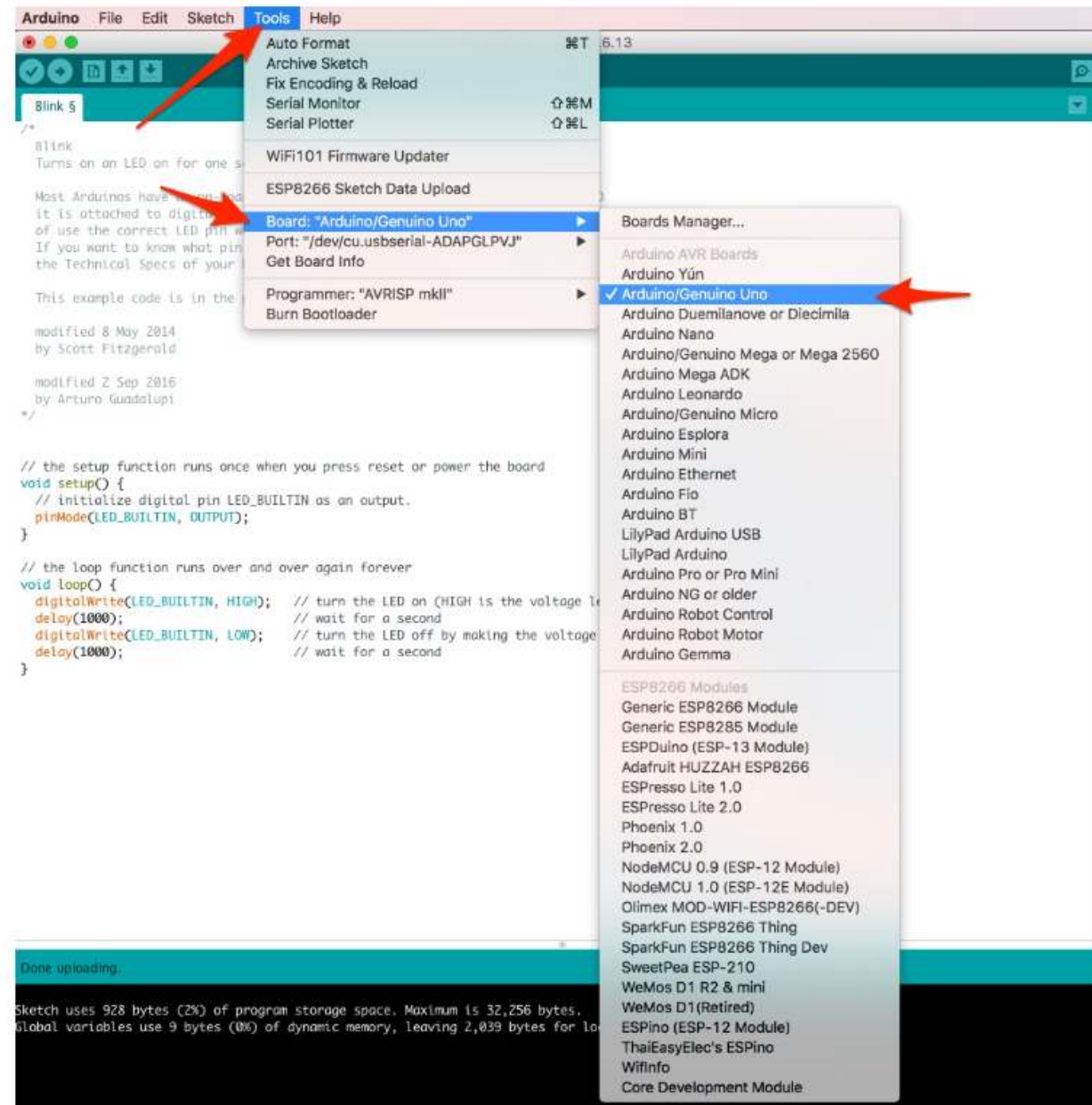
Arduino IDE software

- After downloading and installing the software, you can open and run the IDE.
- You will see the following window on your computer.



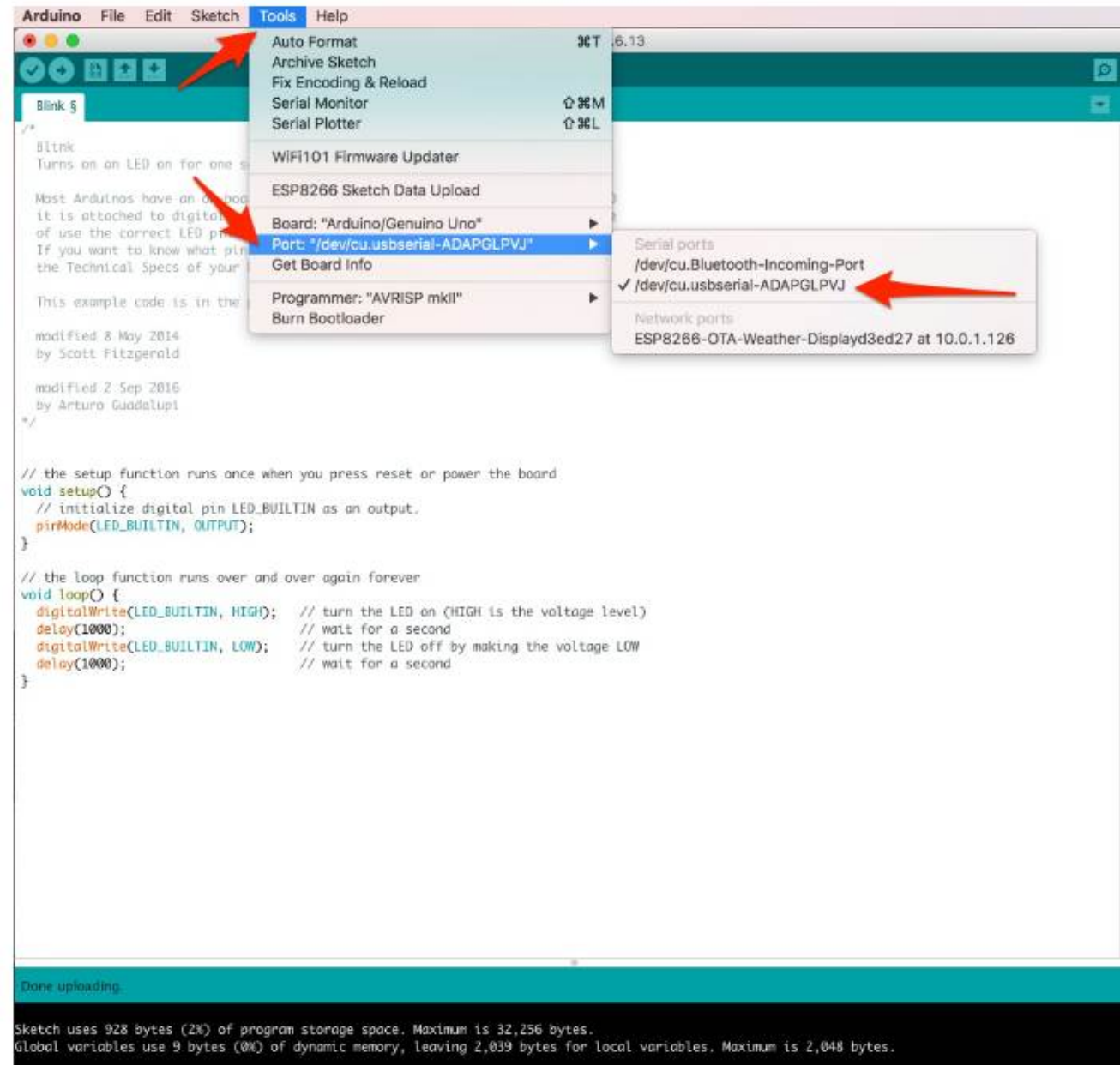
Arduino IDE software

- Before we can upload the program, **we need to get our Arduino board and Port configured** in the IDE.
- First, Select **Tools -> Board** and click on the **Arduino/Genuino Uno**



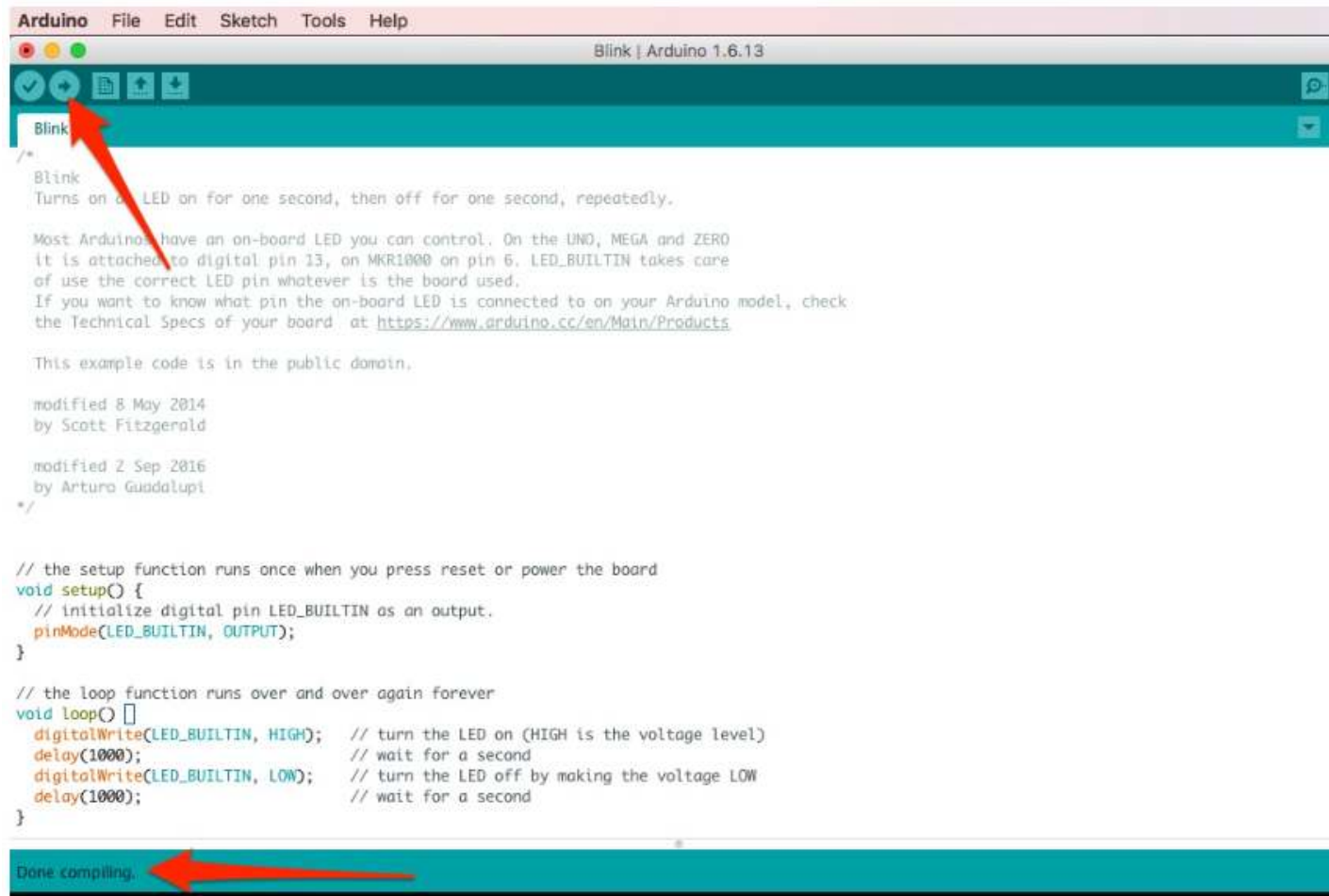
Arduino IDE software

Next, select the proper USB Port which will usually contain the words “usbserial” depending on your Operating System.



Arduino IDE software

Now you are ready to hit the upload button! This is commonly referred to as “Uploading the Sketch”





Raspberry Pi

Raspberry Pi

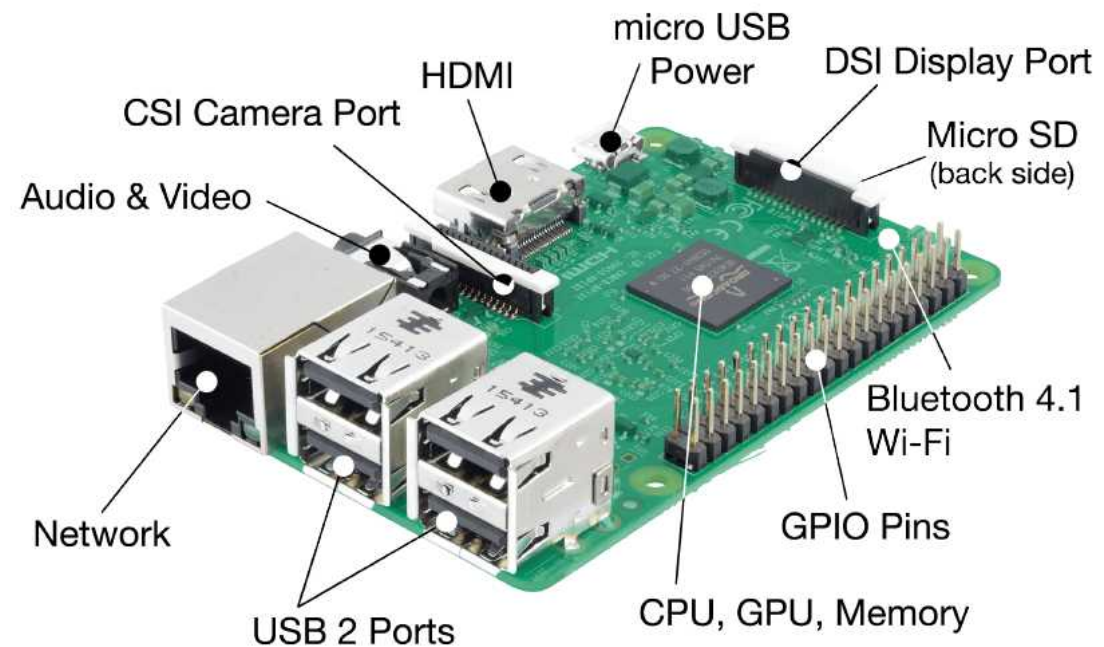
- Raspberry Pi boards are **most people use** in order to build Internet of Things projects.
- They are widely used especially due to:
 - Small price,
 - High resistance to current spikes and short-circuits.

Mini Computer

Runs Linux

More software-oriented programming

Full Networking System



Raspberry Pi 3 Model B Board

Models of Raspberry Pi

Raspberry Pi 5
Raspberry Pi 4 (all models)
Raspberry Pi 3 (all models)
Raspberry Pi 2 (all models)
Raspberry Pi 1 Model B+
Raspberry Pi 1 Model A+
Raspberry Pi Zero (all models)

Raspberry Pi 4 Model B



Raspberry Pi 3 Model A+



Raspberry Pi 3 Model B+



Raspberry Pi 3 Model B



Raspberry Pi 2 Model B



Raspberry Pi 1 Model B+



Raspberry Pi 1 Model A+



Raspberry Pi Zero

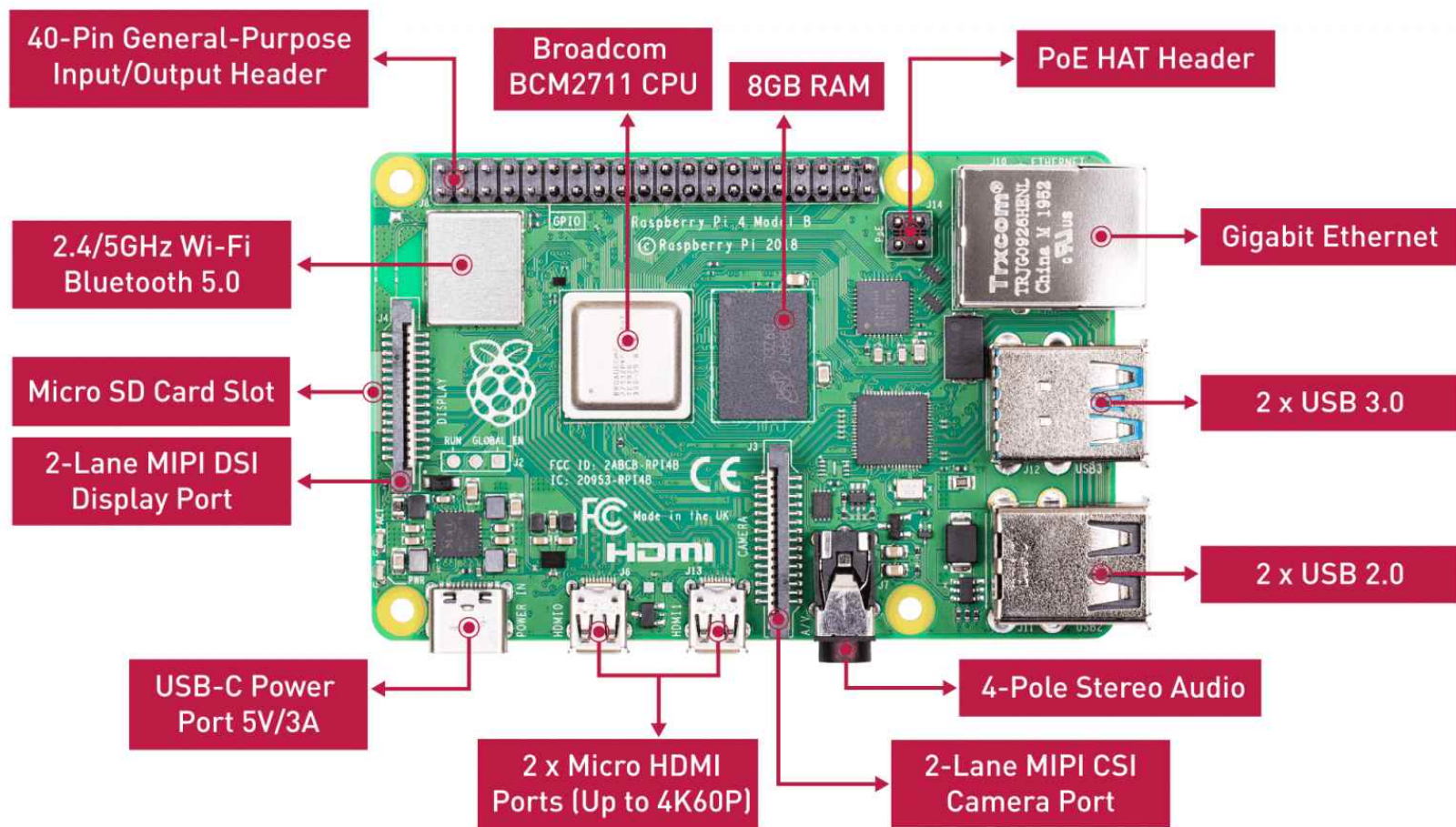


Raspberry Pi Zero W



Raspberry Pi 4 Model B

On May 28th, 2020, Raspberry Pi Foundation released their brand-new Raspberry Pi 4 8G



Raspberry Pi 4 Model B

Specification

- **Processor:** Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- **Memory:** 8GB
- **Connectivity:**
 - 2.4 GHz and 5.0 GHz IEEE 802.11b/g/n/ac wireless
 - LAN, Bluetooth 5.0, BLE
 - Gigabit Ethernet
 - 2 × USB 3.0 ports
 - 2 × USB 2.0 ports
- **GPIO:** Standard 40-pin GPIO header
- **Video & Sound:**
 - 2 × micro HDMI ports (up to 4Kp60 supported)
 - 2-lane MIPI DSI display port
 - 2-lane MIPI CSI camera port
 - 4-pole stereo audio and composite video port

Raspberry Pi 4 Model B


- **Multimedia:**
 - H.265 (4Kp60 decode)
 - H.264 (1080p60 decode, 1080p30 encode)
 - OpenGL ES, 3.0 graphics
- **SD card support:** Micro SD card slot for loading operating system and data storage
- **Input power:**
 - 5VDC via USB-C connector (minimum 3A)
 - 5VDC via GPIO header (minimum 3A)
 - Power over Ethernet (PoE)—enabled (requires separate PoE HAT)
- **Environment:** Operating temperature 0–50°C
- **Compliance:** For a full list of local and regional product approvals, please visit

Price of Raspberry Pi 4 Model B



\$75 **GET IT NOW**

New Raspberry Pi 4 Model B with
≡ 8GB RAM ≡



Sponsored ⓘ

GeeekPi

Raspberry Pi 4 8GB Starter Kit - 128GB Edition, Raspberry Pi 4 Case with PWM Fan, Raspberry Pi 18W 5V 3.6A Power Supply with ON/Off Switch, HDMI Cables for Rasperr...

★★★★★ 306

200+ bought in past month

\$149⁹⁹

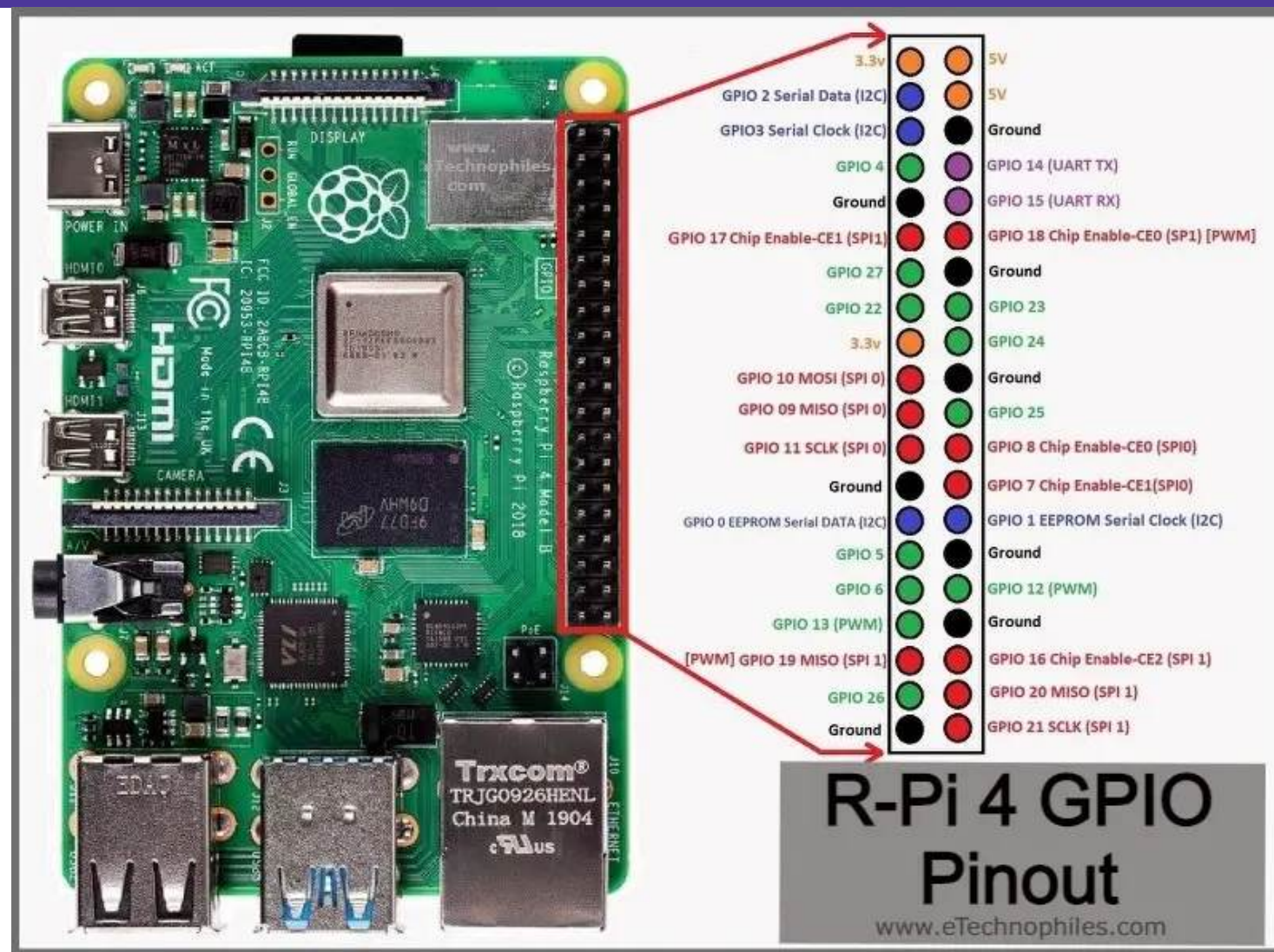
Save 5% with coupon

Delivery **Fri, Mar 22**

Ships to Republic of Korea

Pins layout Raspberry Pi 4 Model B

- two 5V pins;
- two 3.3V pins;
- 8 ground pins;
- 26 data pins;
- 1 PWM pin.



Get started with Raspberry Pi



To get started with your Raspberry Pi as an interactive computer, you'll need the following:

- Power supply
- Boot media (e.g. a microSD card with ample storage and speed)
- Display
- Cable to connect your Raspberry Pi to your display
- Keyboard
- Mouse

Get started with Raspberry Pi

Power supply



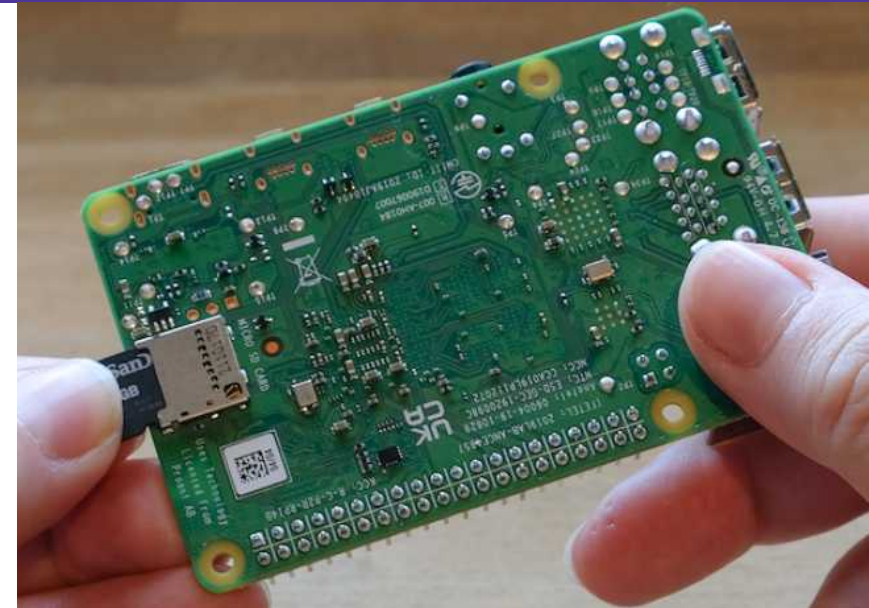
Model	Recommended power supply (voltage/current)	Raspberry Pi power supply
Raspberry Pi 5	5V/5A, 5V/3A limits peripherals to 600mA	27W USB-C power supply
Raspberry Pi 4 Model B	5V/3A	15W USB-C power supply
Raspberry Pi 3 (all models)	5V/2.5A	12.5W Micro USB power supply
Raspberry Pi 2 (all models)	5V/2.5A	12.5W Micro USB power supply
Raspberry Pi 1 (all models)	5V/2.5A	12.5W Micro USB power supply
Raspberry Pi Zero (all models)	5V/2.5A	12.5W Micro USB power supply

Get started with Raspberry Pi

Boot Media (Micro SD cards)

Recommended SD cards

- SD card with **at least 32GB** of storage for **Raspberry Pi OS installations**.
- You can use any SD card with a capacity of **less than 2TB**.
- Capacities above **2TB are currently not supported**.
- The following devices will only boot from a boot partition of **256GB or less**:
 - Raspberry Pi Zero
 - Raspberry Pi 1
 - early Raspberry Pi 2 models with the BCM2836 SoC



Get started with Raspberry Pi

Keyboard

You can use any of the USB ports on your Raspberry Pi to connect a wired keyboard or USB Bluetooth receiver.



Get started with Raspberry Pi

Mouse

You can use any of the USB ports on your Raspberry Pi to connect a **wired mouse** or **USB Bluetooth receiver**.



Get started with Raspberry Pi

Display

If your Raspberry Pi has more than one HDMI port, plug your primary monitor into the port marked **HDMI 0**.



Model	Display outputs
Raspberry Pi 5	2× micro HDMI
Raspberry Pi 4 (all models)	2× micro HDMI, audio and composite out via 3.5mm TRRS jack
Raspberry Pi 3 (all models)	HDMI, audio and composite out via 3.5mm TRRS jack
Raspberry Pi 2 (all models)	HDMI, audio and composite out via 3.5mm TRRS jack
Raspberry Pi 1 Model B+	HDMI, audio and composite out via 3.5mm TRRS jack
Raspberry Pi 1 Model A+	HDMI, RCA connector
Raspberry Pi Zero (all models)	mini HDMI

Get started with Raspberry Pi



Audio

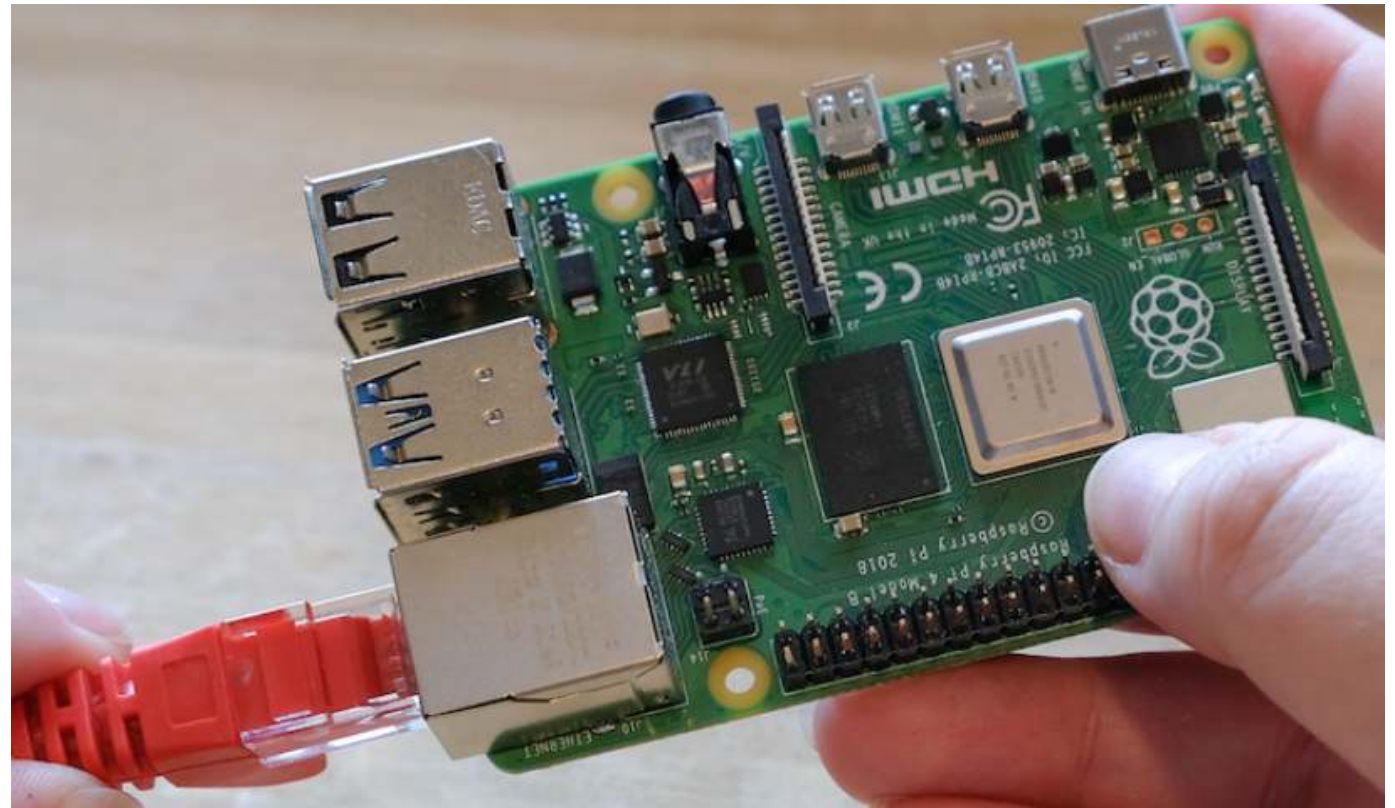
- All Raspberry Pi models with HDMI, micro HDMI, or mini HDMI support audio output over HDMI.
- All Raspberry Pi models support audio over USB.
- All Raspberry Pi models equipped with Bluetooth support Bluetooth audio.

Get started with Raspberry Pi

Networking

The following Raspberry Pi models come with **WiFi and Bluetooth** connectivity:

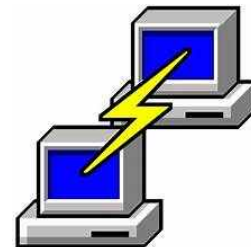
- Raspberry Pi 5
- Raspberry Pi 4
- Raspberry Pi 3B+
- Raspberry Pi 3
- Raspberry Pi Zero W
- Raspberry Pi Zero 2 W



The "Model B" suffix indicates variants with an Ethernet port; "Model A" indicates no Ethernet port.

Install an operating system (Method 1)

- To use your Raspberry Pi, you'll need an operating system on any SD card inserted in the SD card slot.
- You'll need:
 - A computer to flash the OS image into a boot device.
 - A SD card reader device.

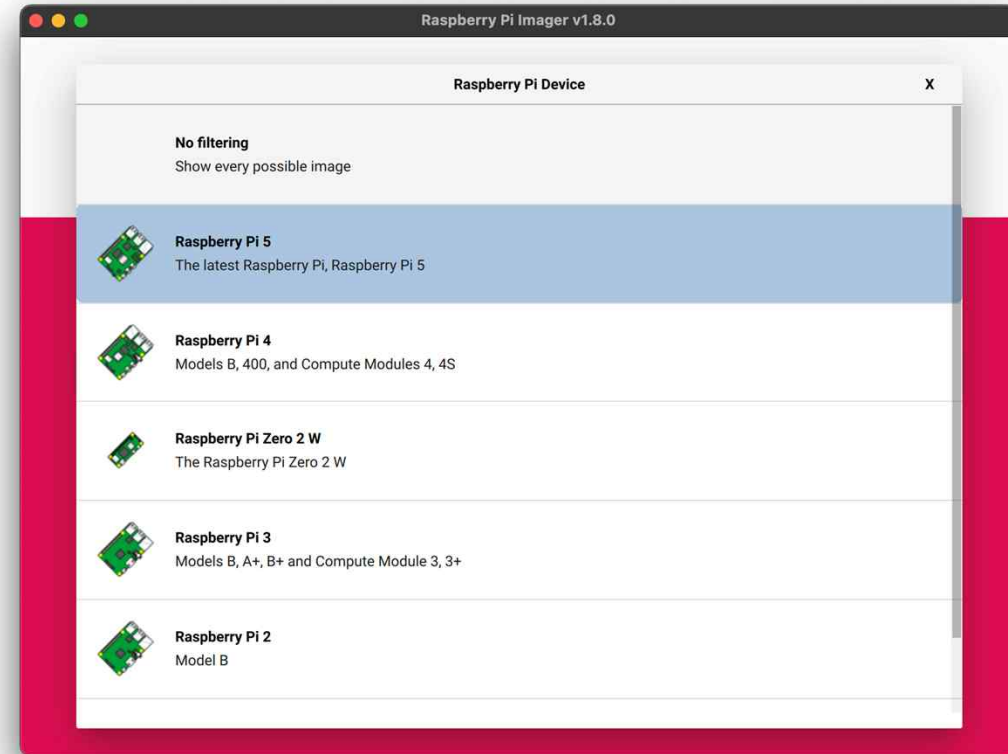
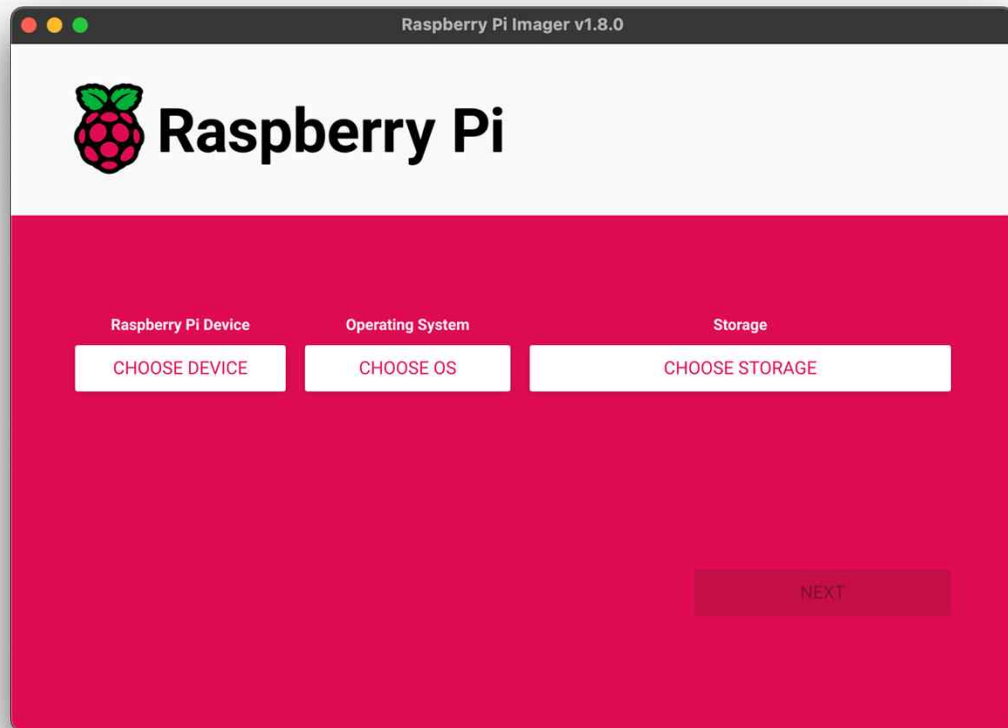


[Raspberry Pi Imager](#)

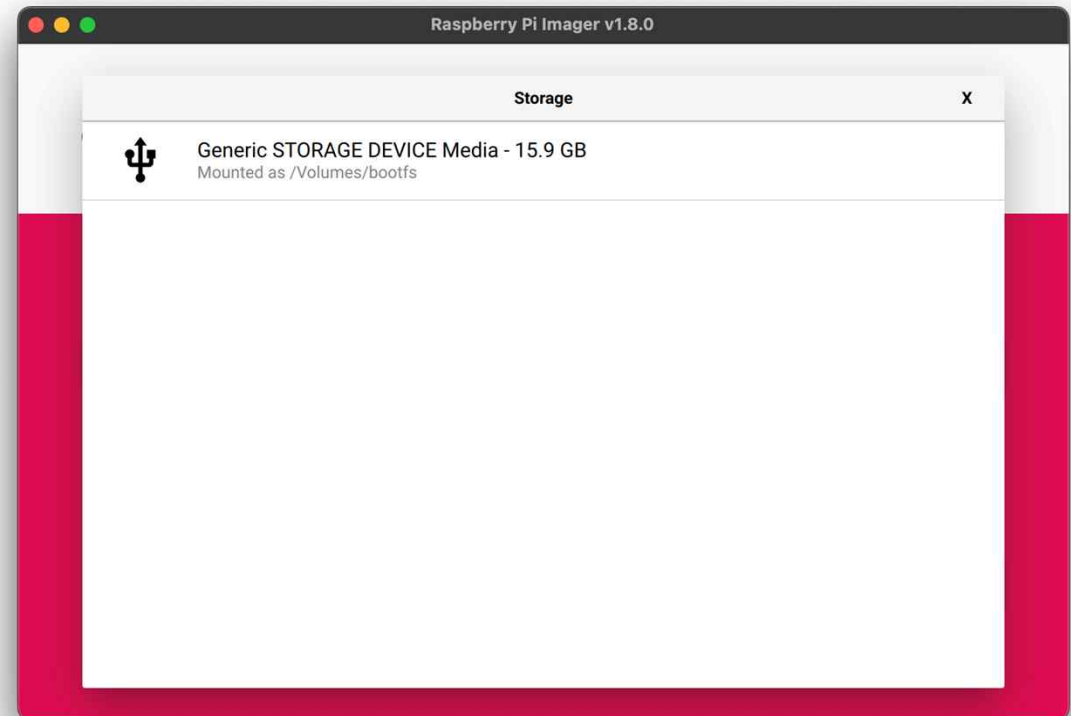
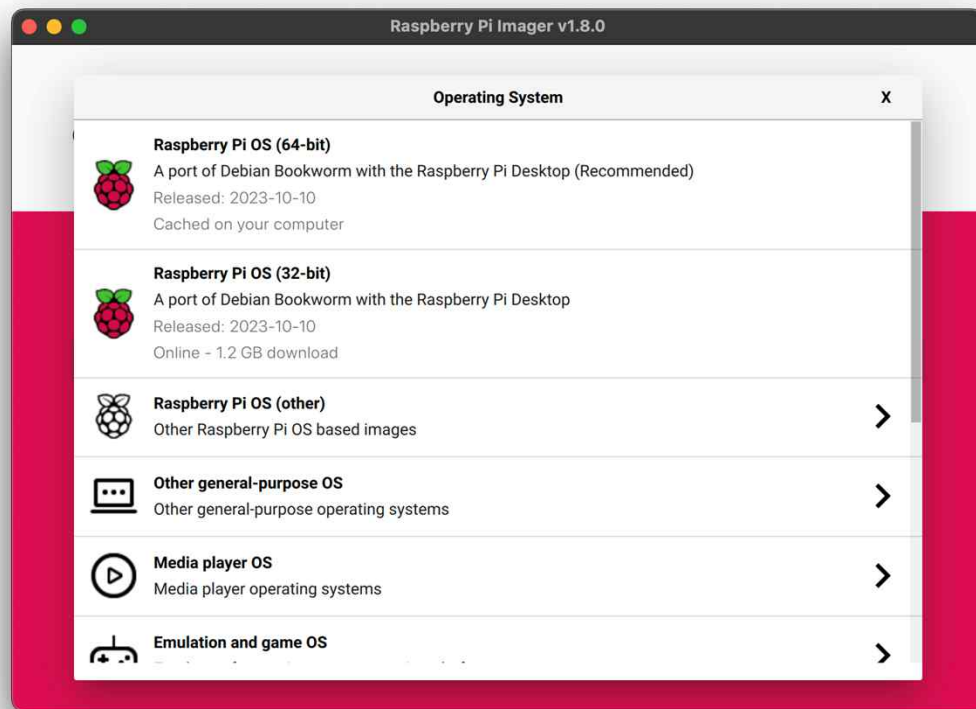
[RealVNC® Viewer](#)

[putty-ssh](#)

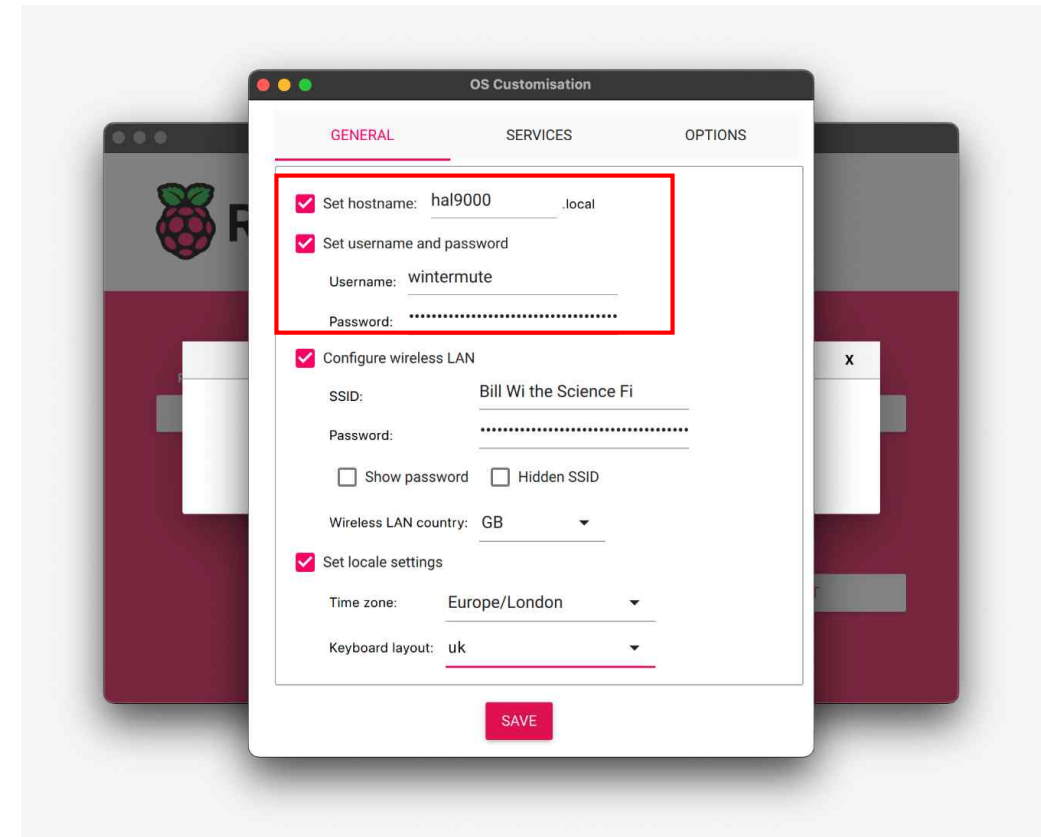
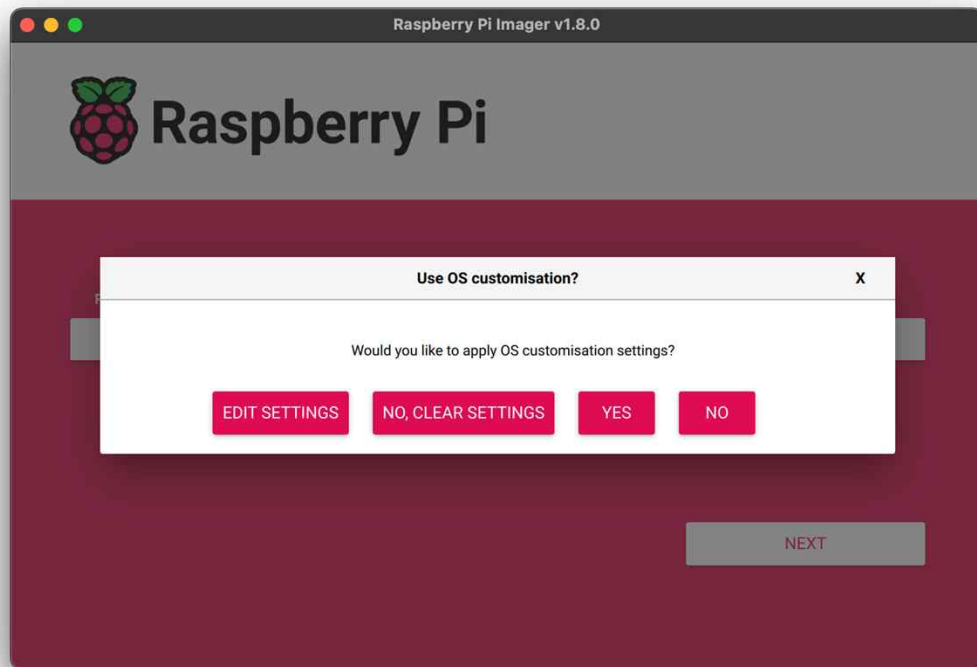
Install an operating system (Method 1)



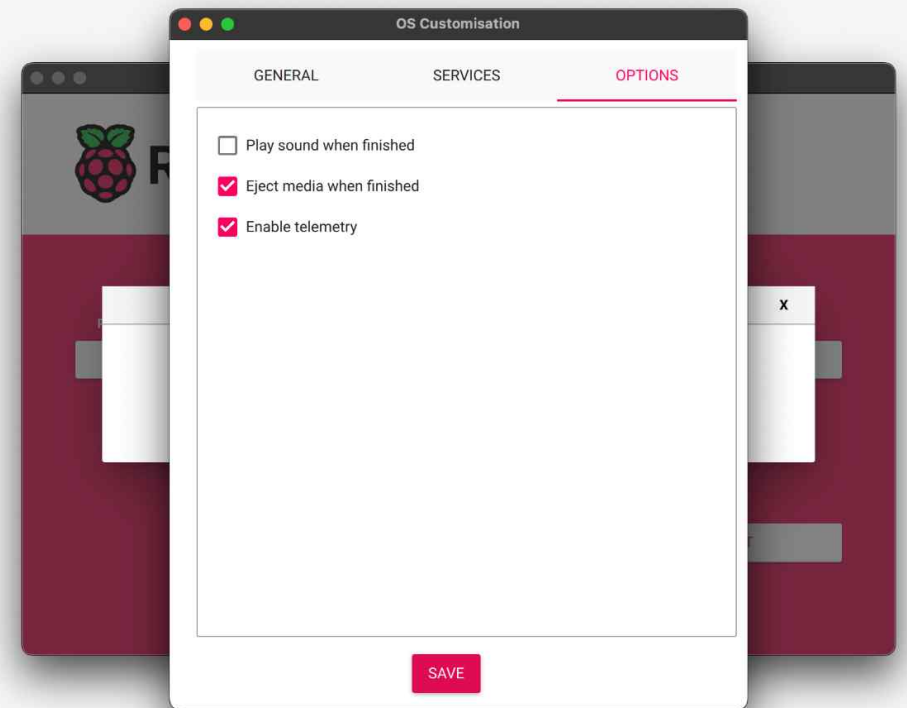
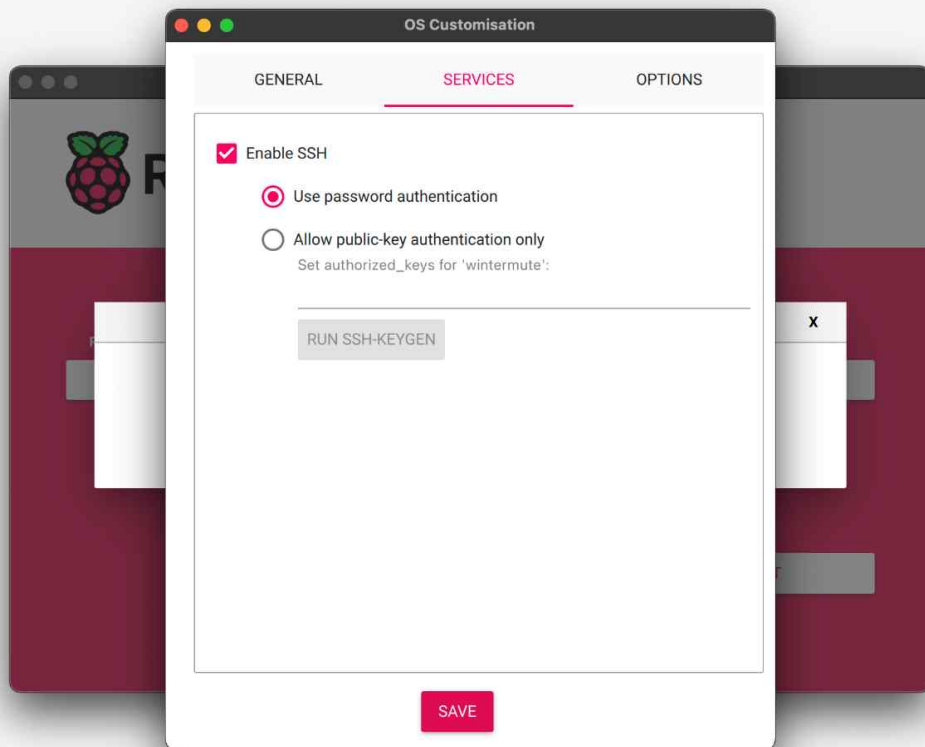
Install an operating system (Method 1)



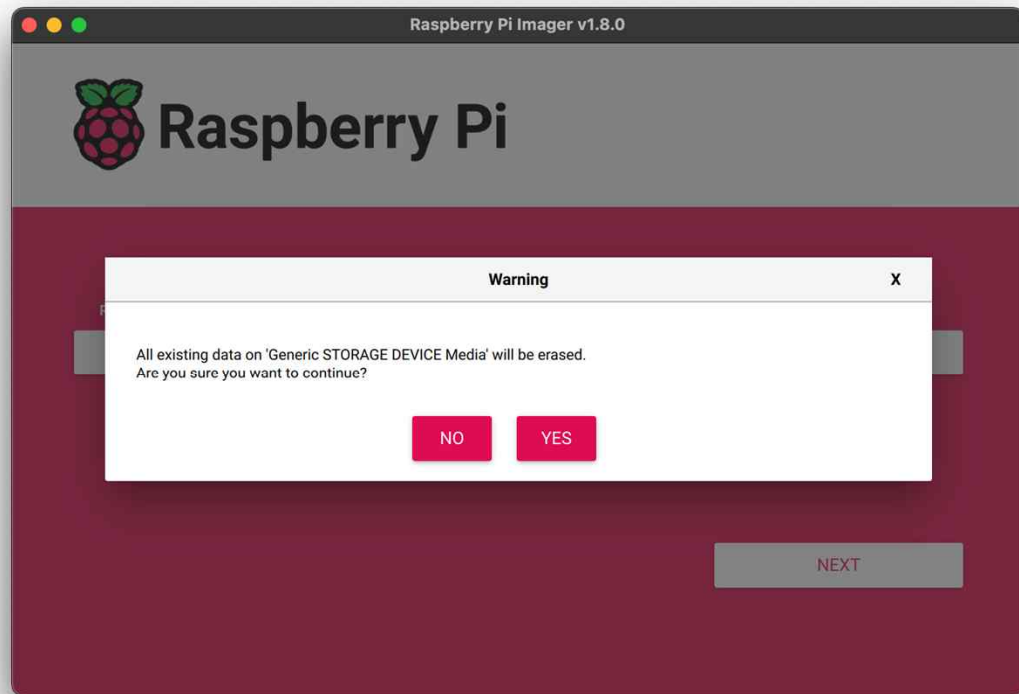
Install an operating system (Method 1)



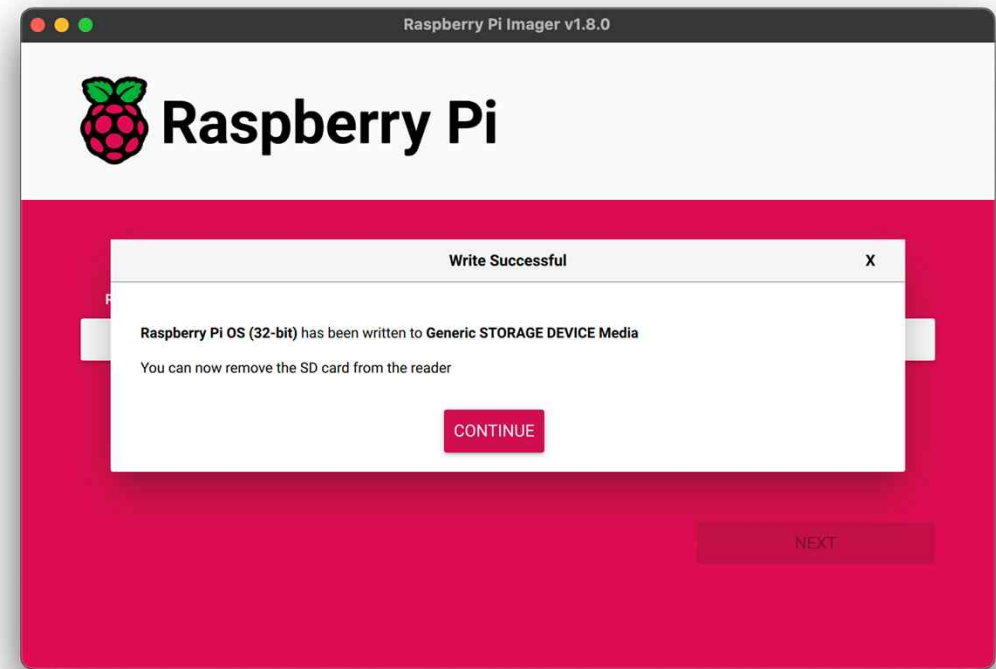
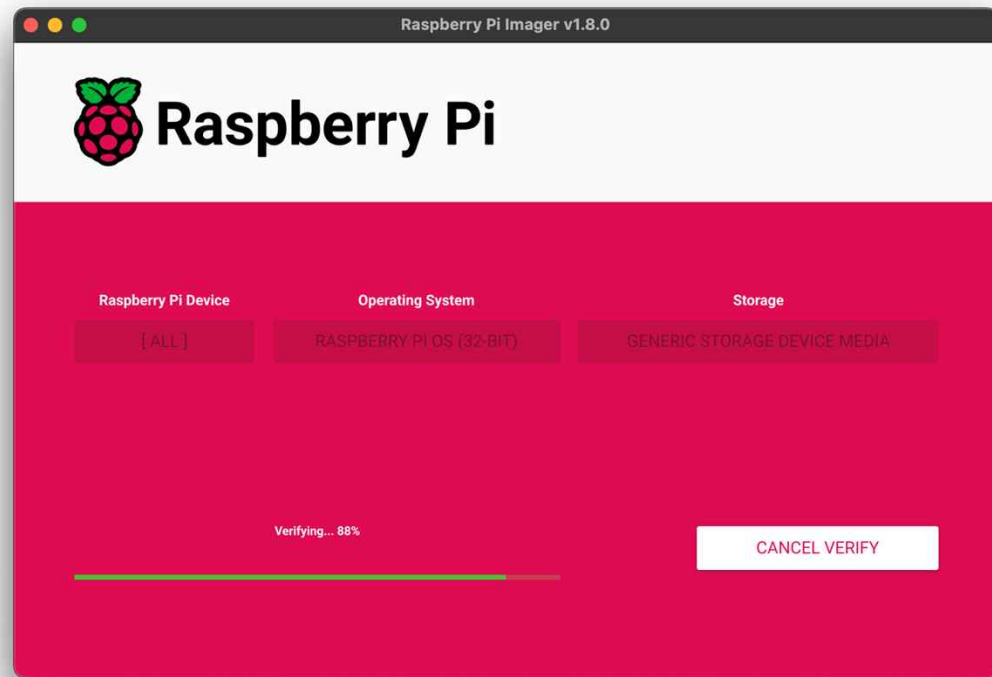
Install an operating system (Method 1)



Install an operating system (Method 1)

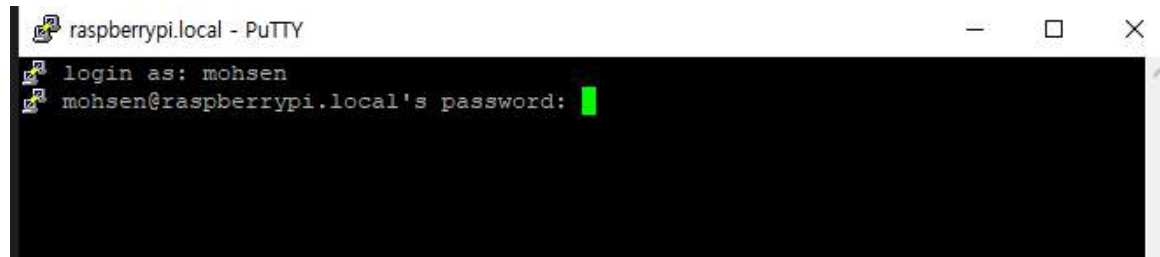


Install an operating system (Method 1)

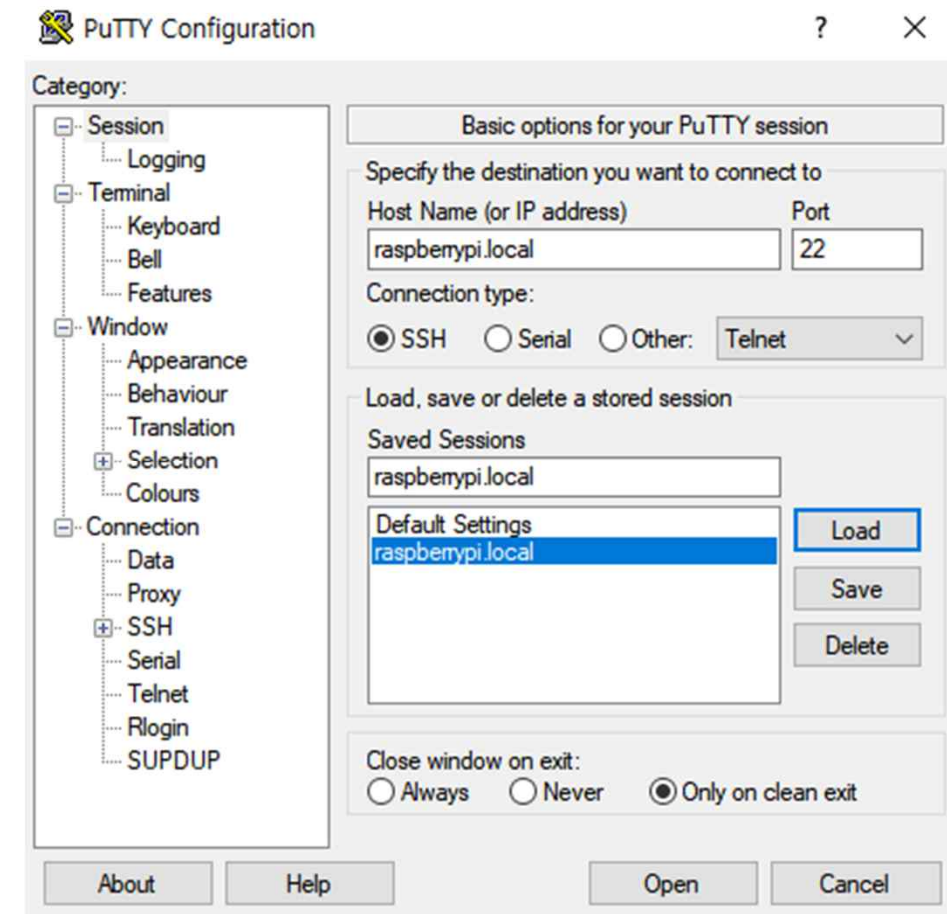


Install an operating system (Method 1)

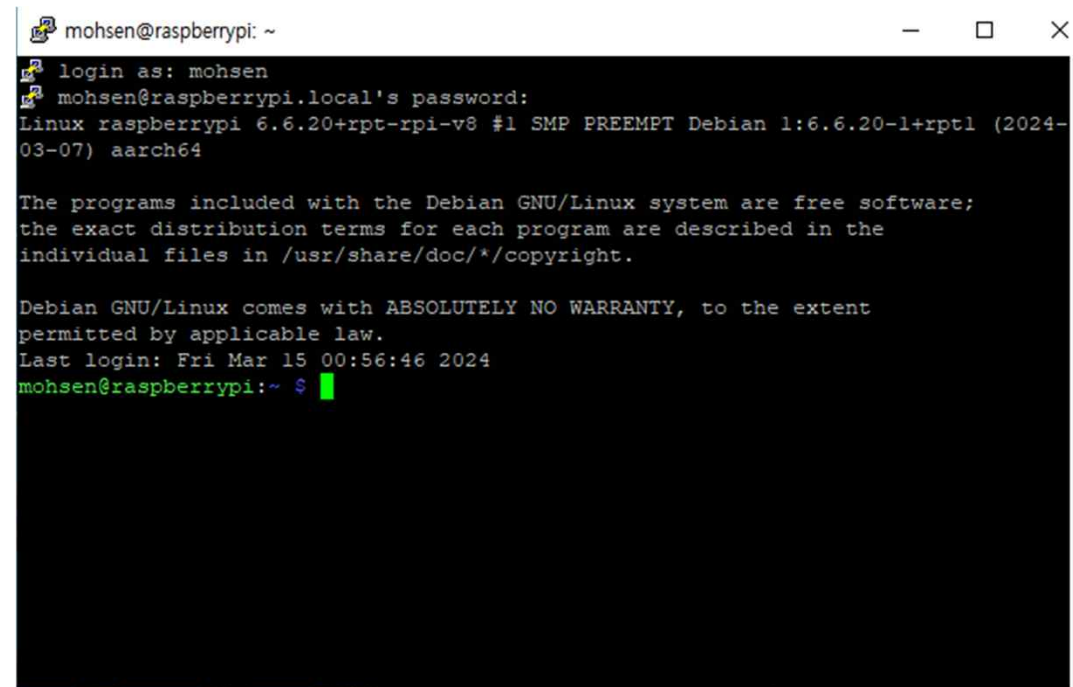
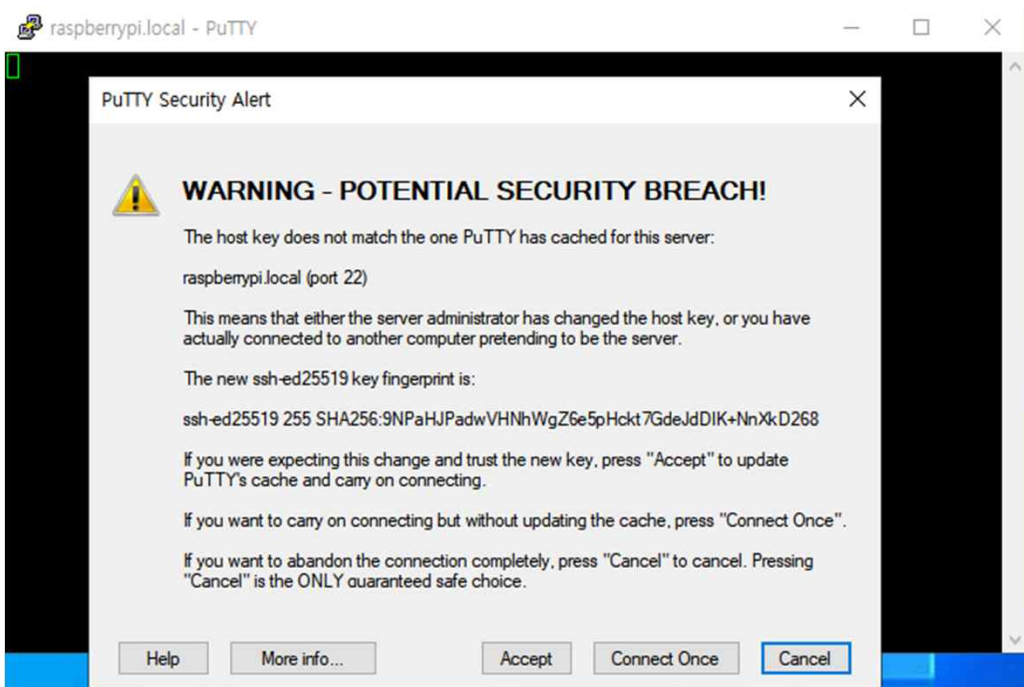
- 1- Install **RealVNC** Viewer
 - 2- Install **Putty** software
 - 3- Connect the Ethernet Cable from Raspberry Pi to the computer.
 - 4- Connect to Raspberry Pi using Putty SSH.
- You will need:
- >> Host name
 - >> ID, and password



```
raspberrypi.local - PuTTY
login as: mohsen
mohsen@raspberrypi.local's password: █
```



Install an operating system (Method 1)



Install an operating system (Method 1)

For first time:

Setting up the **VNC server** configurations on your computer

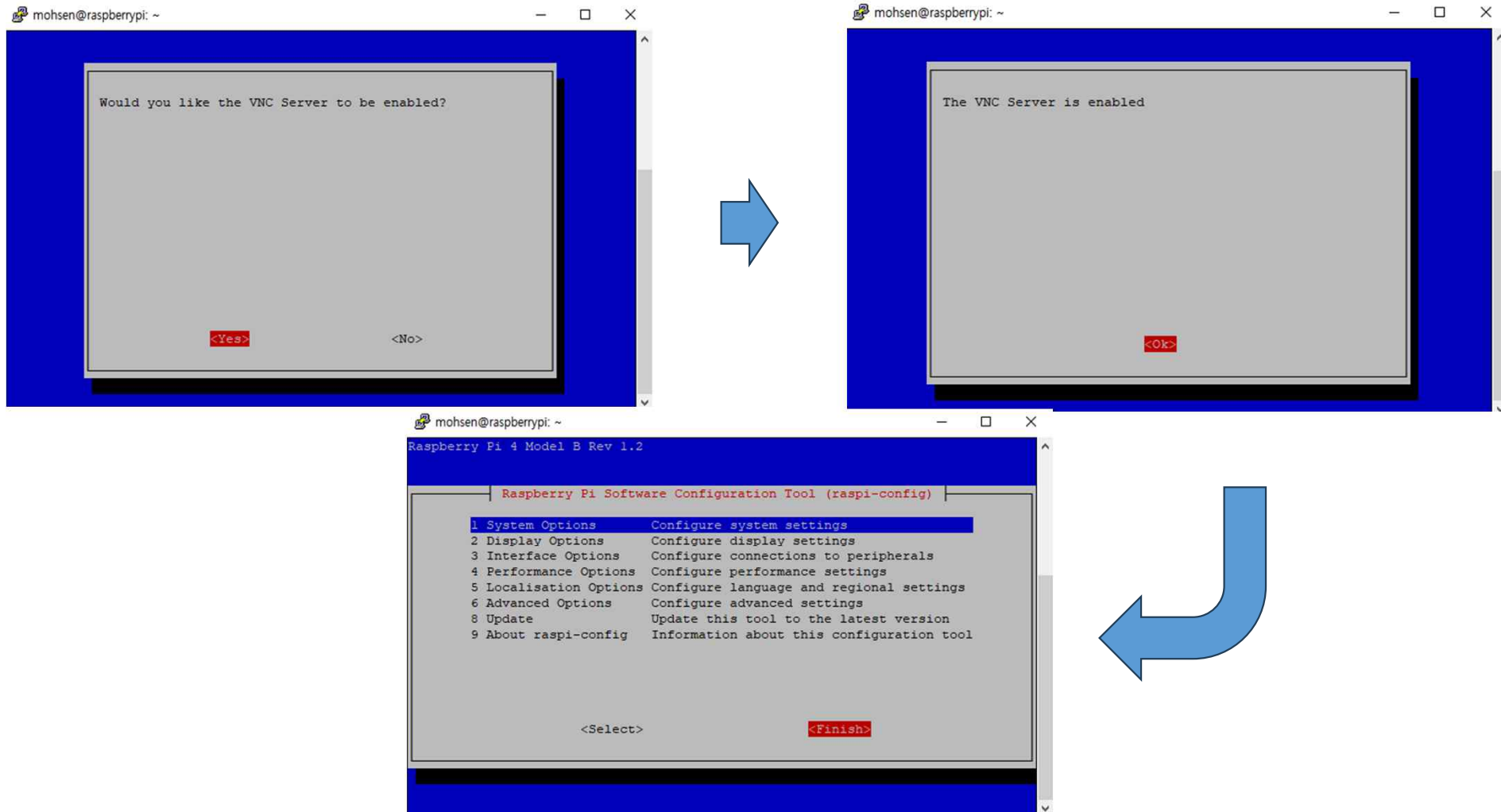
- in putty raspberry pi account: >> “**sudo raspi-config**”

```
mohsen@raspberrypi: ~  
Raspberry Pi 4 Model B Rev 1.2  
Raspberry Pi Software Configuration Tool (raspi-config)  
1 System Options      Configure system settings  
2 Display Options     Configure display settings  
3 Interface Options   Configure connections to peripherals  
4 Performance Options Configure performance settings  
5 Localisation Options Configure language and regional settings  
6 Advanced Options    Configure advanced settings  
8 Update              Update this tool to the latest version  
9 About raspi-config  Information about this configuration tool  
  
<Select>              <Finish>
```



```
mohsen@raspberrypi: ~  
Raspberry Pi Software Configuration Tool (raspi-config)  
I1 SSH      Enable/disable remote command line access using SSH  
I2 VNC      Enable/disable graphical remote desktop access  
I3 SPI      Enable/disable automatic loading of SPI kernel module  
I4 I2C      Enable/disable automatic loading of I2C kernel module  
I5 Serial Port Enable/disable shell messages on the serial connection  
I6 1-Wire   Enable/disable one-wire interface  
I7 Remote GPIO Enable/disable remote access to GPIO pins  
  
<Select>              <Back>
```

Install an operating system (Method 1)



Install an operating system (Method 1)

```
mohsen@raspberrypi: ~  
RX packets 318 bytes 30930 (30.2 KiB)  
RX errors 0 dropped 0 overruns 0 frame 0  
TX packets 150 bytes 24823 (24.2 KiB)  
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536  
inet 127.0.0.1 netmask 255.0.0.0  
inet6 ::1 prefixlen 128 scopeid 0x10<host>  
loop txqueuelen 1000 (Local Loopback)  
RX packets 100 bytes 8786 (8.5 KiB)  
RX errors 0 dropped 0 overruns 0 frame 0  
TX packets 100 bytes 8786 (8.5 KiB)  
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
inet 192.168.1.31 netmask 255.255.255.0 broadcast 192.168.1.255  
inet6 fe80::c1b6:3044:b46a:c9e prefixlen 64 scopeid 0x20<link>  
ether dc:a6:32:9d:fd:b4 txqueuelen 1000 (Ethernet)  
RX packets 442 bytes 43452 (42.4 KiB)  
RX errors 0 dropped 0 overruns 0 frame 0  
TX packets 222 bytes 54409 (53.1 KiB)  
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
mohsen@raspberrypi:~$
```

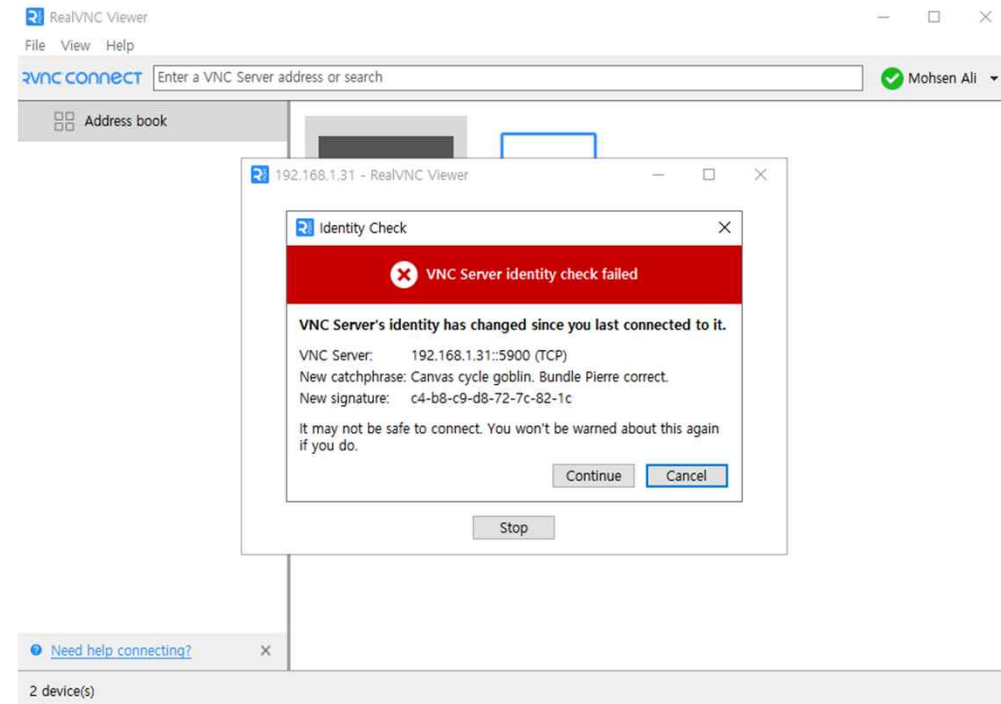
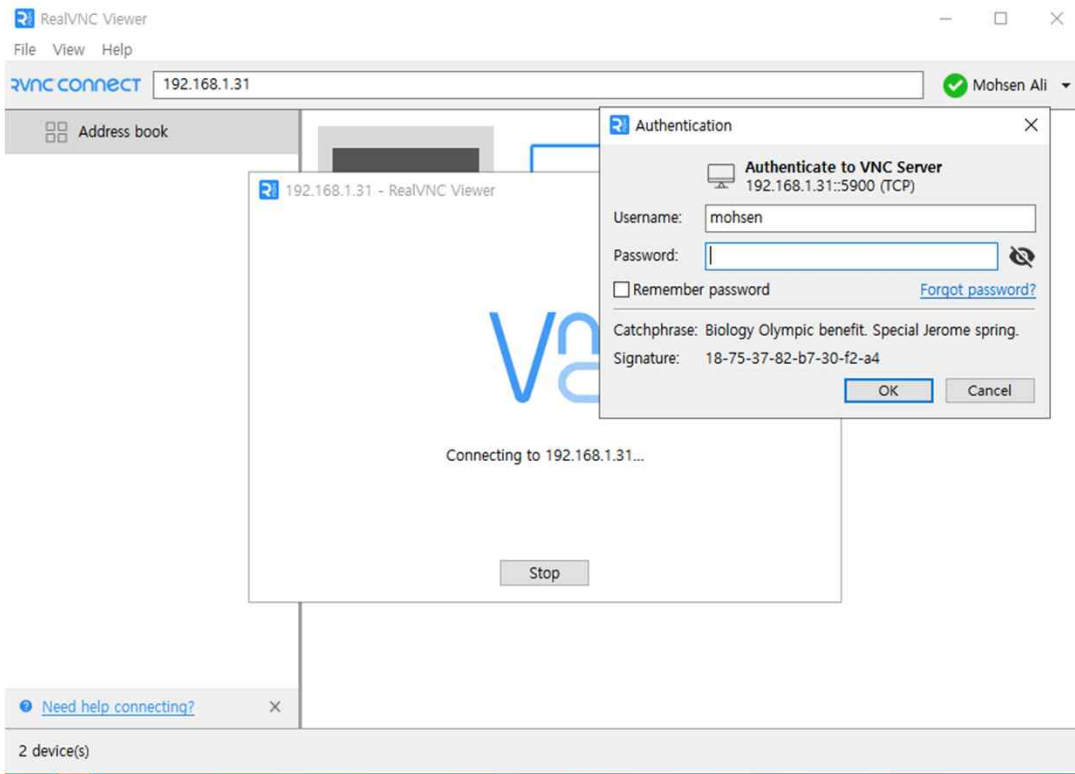
ifconfig



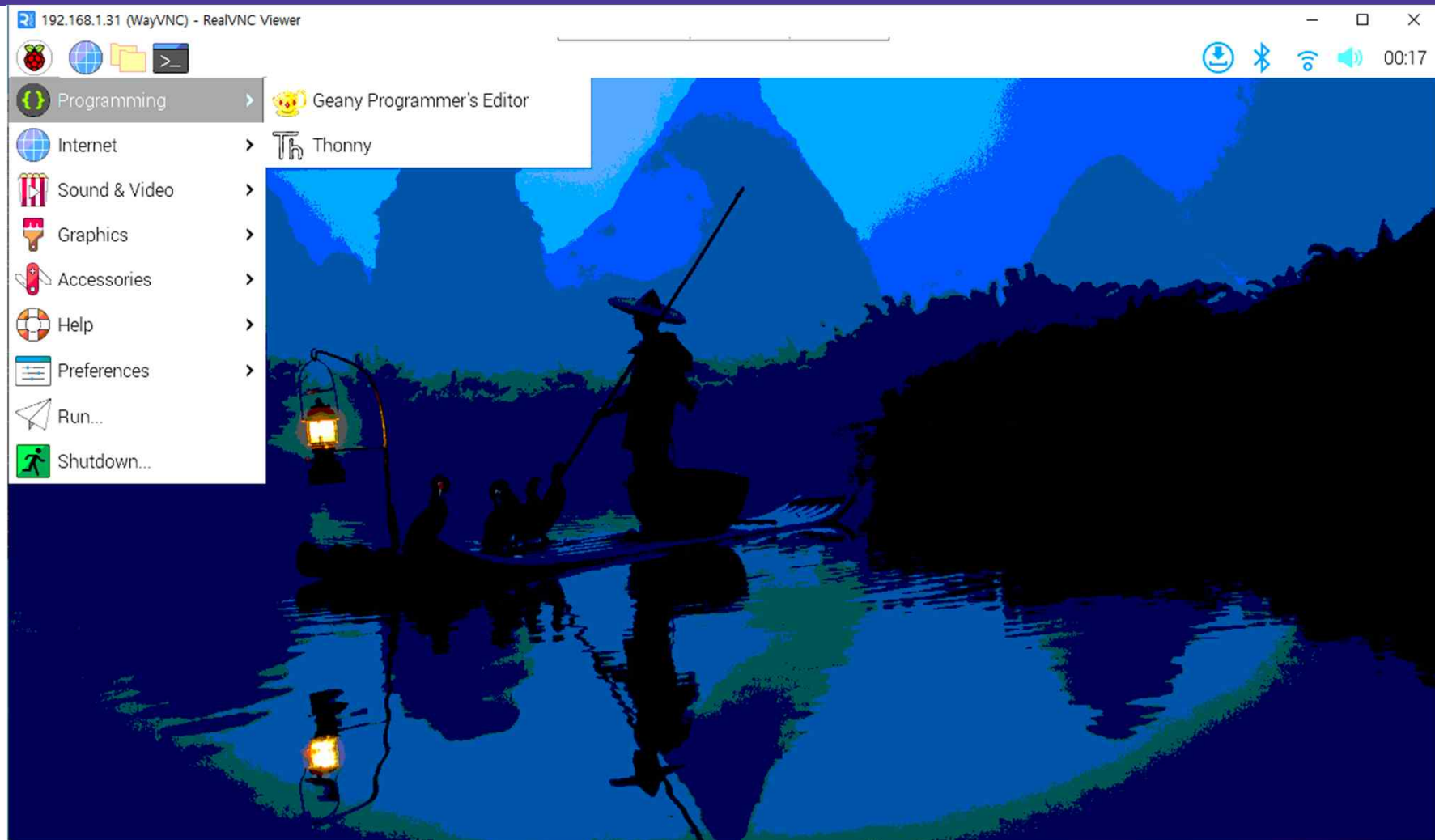
```
mohsen@raspberrypi: ~  
Copyright (C) RealVNC Ltd.  
RealVNC and VNC are trademarks of RealVNC Ltd and are protected by trademark  
registrations and/or pending trademark applications in the European Union,  
United States of America and other jurisdictions.  
Protected by UK patent 2481870; US patent 8760366; EU patent 2652951.  
See https://www.realvnc.com for information on VNC.  
For third party acknowledgements see:  
https://www.realvnc.com/docs/7/foss.html  
OS: Debian GNU/Linux 12, Linux 6.6.20+rpt, aarch64  
  
On some distributions (in particular Red Hat), you may get a better experience  
by running vncserver-virtual in conjunction with the system Xorg server, rather  
than the old version built-in to Xvnc. More desktop environments and  
applications will likely be compatible. For more information on this alternative  
implementation, please see: https://www.realvnc.com/doclink/kb-546  
  
Running applications in /etc/vnc/xstartup  
  
VNC Server catchphrase: "Annual Gregory Madrid. Miranda planet polo."  
signature: 62-ab-29-42-07-7f-3e-5c  
  
Log file is /home/mohsen/.vnc/raspberrypi:1.log  
New desktop is raspberrypi:1 (192.168.1.31:1)  
mohsen@raspberrypi:~$
```

vncserver-virtual

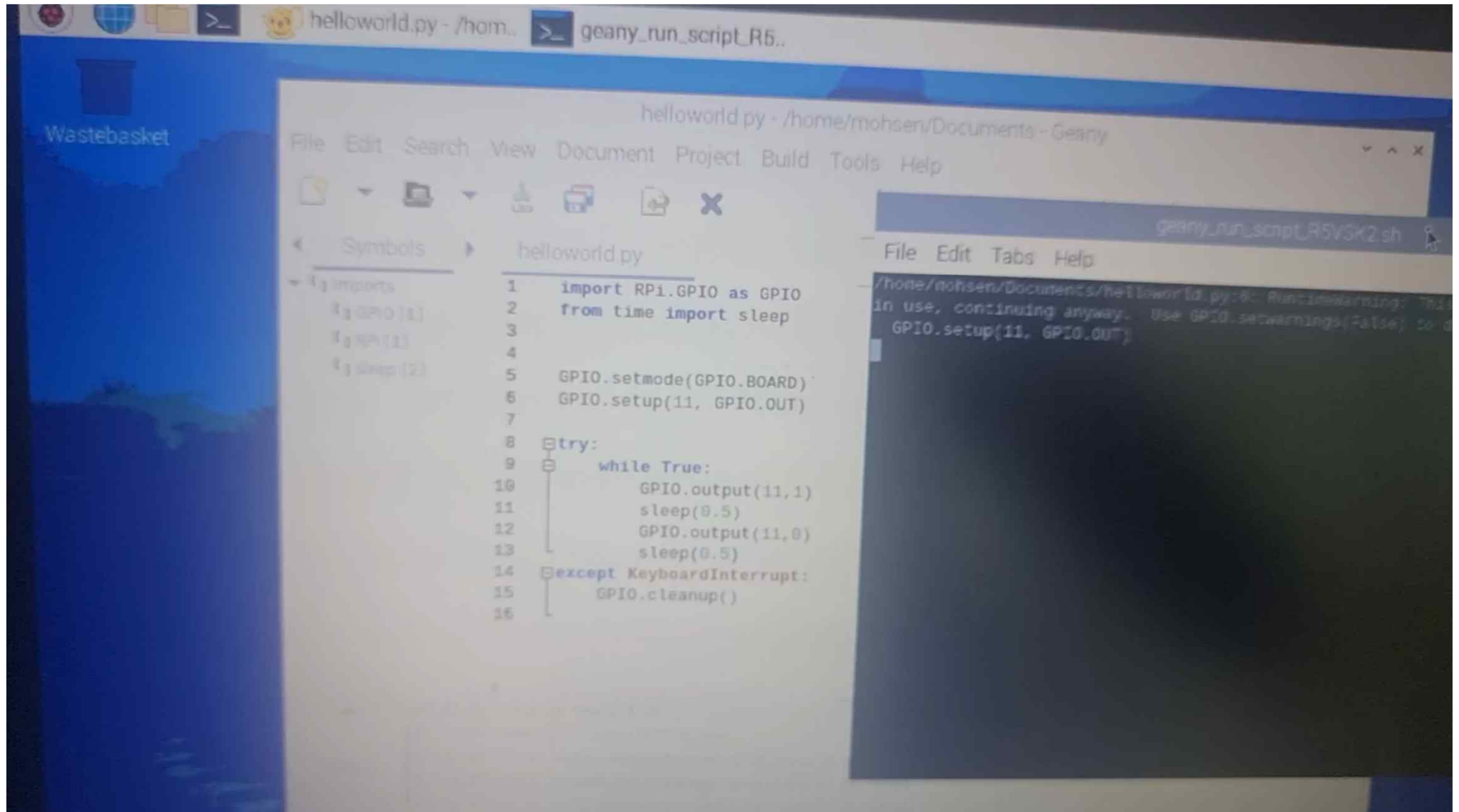
Install an operating system (Method 1)



Install an operating system (Method 1)



Led Blinking Experiment (Demo)



Install an operating system (Method 2)

1. Go to [Wylodrin Studio](#) Website
2. Download Wylodrin for Windows
3. From [here](#), download the pre-configured image Raspberry Pi.
4. Download [Etcher](#) to flash the Raspberry Pi OS.



Install an operating system (Method 2)

1. From [here](#), download the pre-configured image Raspberry Pi.

Download the pre-configured image

The easiest way to set up a Raspberry Pi board so that it becomes available for Wylidrin STUDIO is to download an image that is already configured.

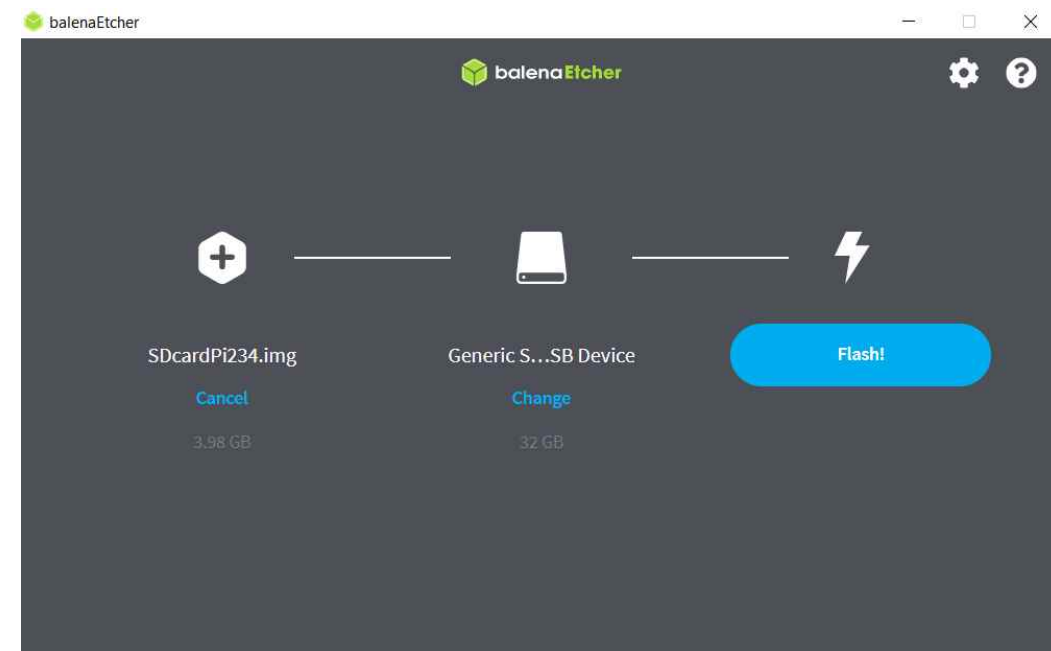
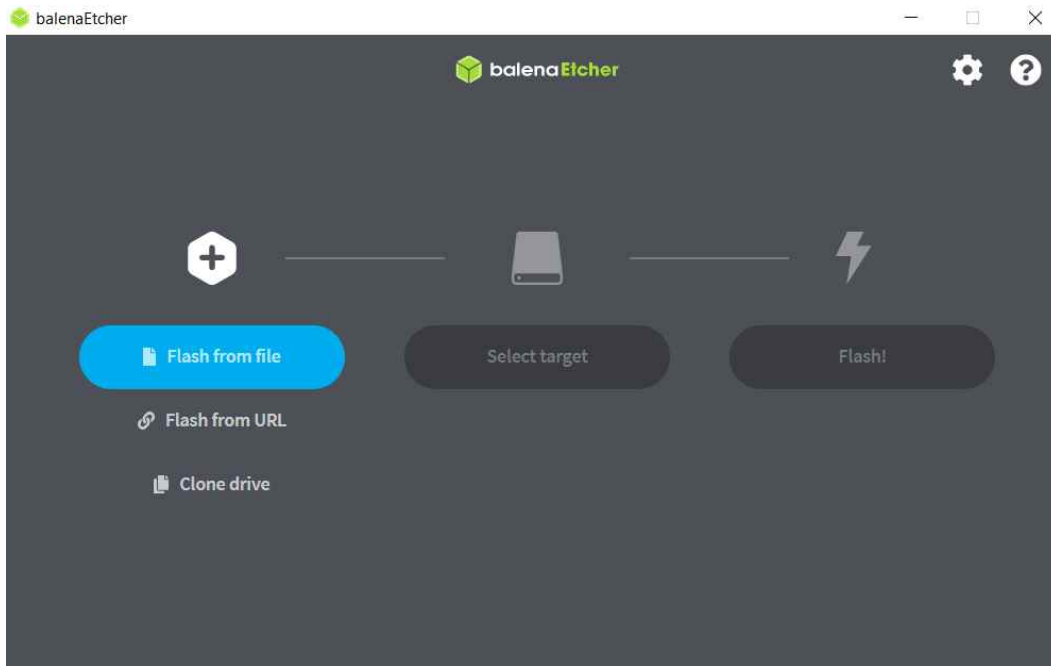
Download the image for [Raspberry Pi Zero](#) and [Raspberry Pi 1](#).

Download the image for [Raspberry Pi 2](#), [Raspberry Pi 3](#) and [Raspberry Pi 4](#).

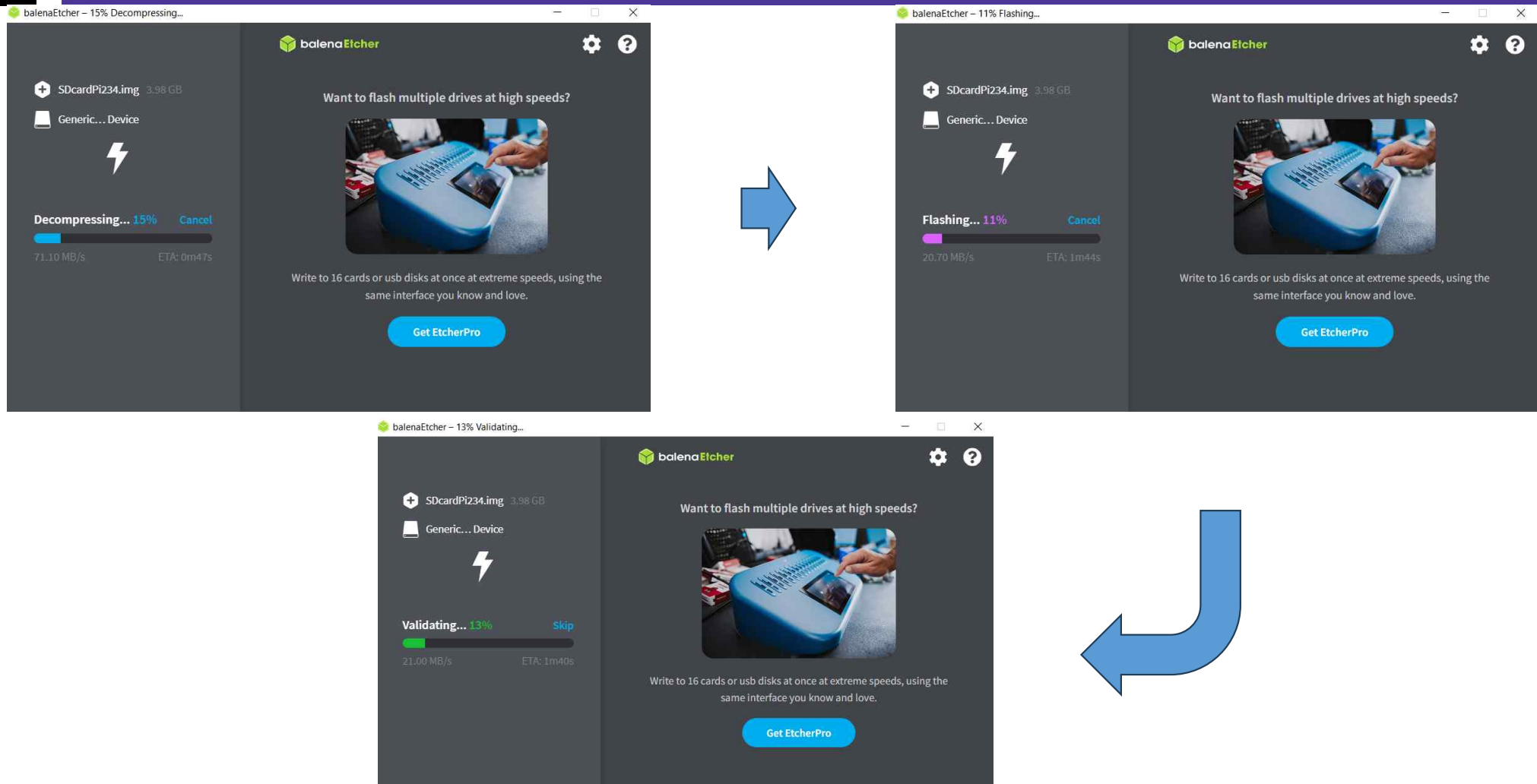
Once the image downloaded and unzipped, the only thing that you have to do is to [flash](#) it. After that, you can simply insert the SD card into the Raspberry Pi and your board should be visible within Wylidrin STUDIO.

Install an operating system (Method 2)

2. Download [Etcher](#) and start flash the Raspberry Pi OS to the SD card .

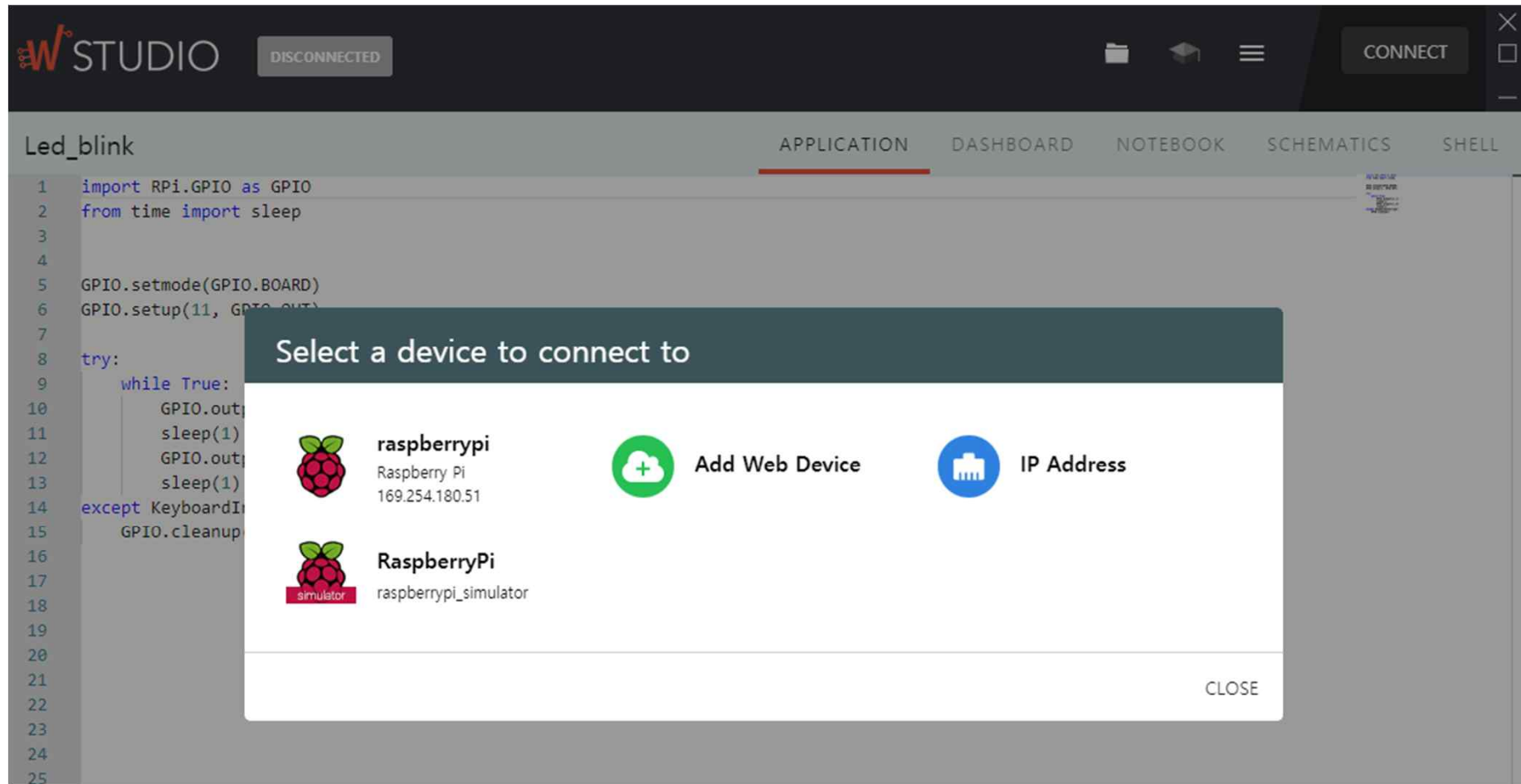


Install an operating system (Method 2)



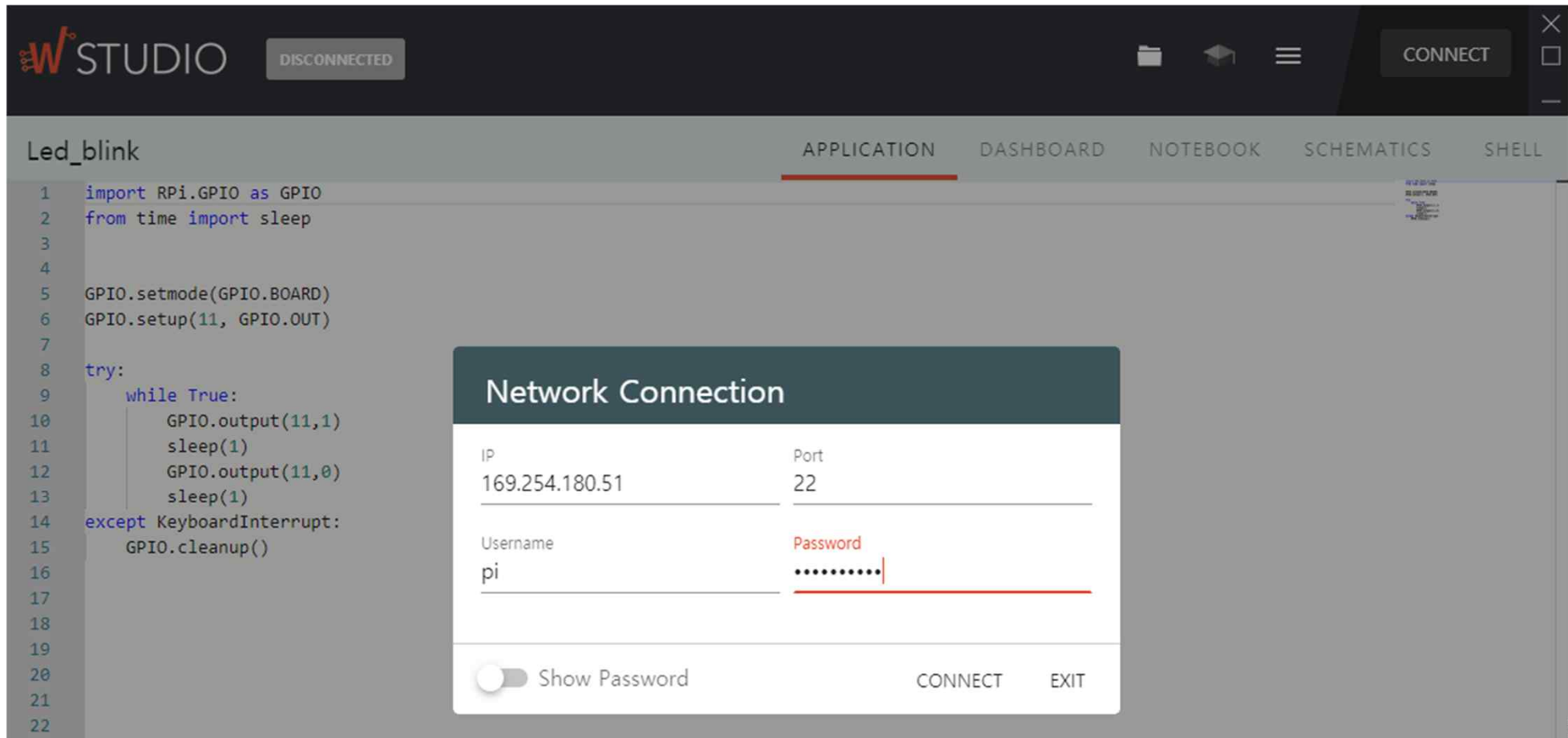
Install an operating system (Method 2)

3- Connect the Raspberry Pi to the computer using **Ethernet cable**. Select “Connect” in Wylidrin.



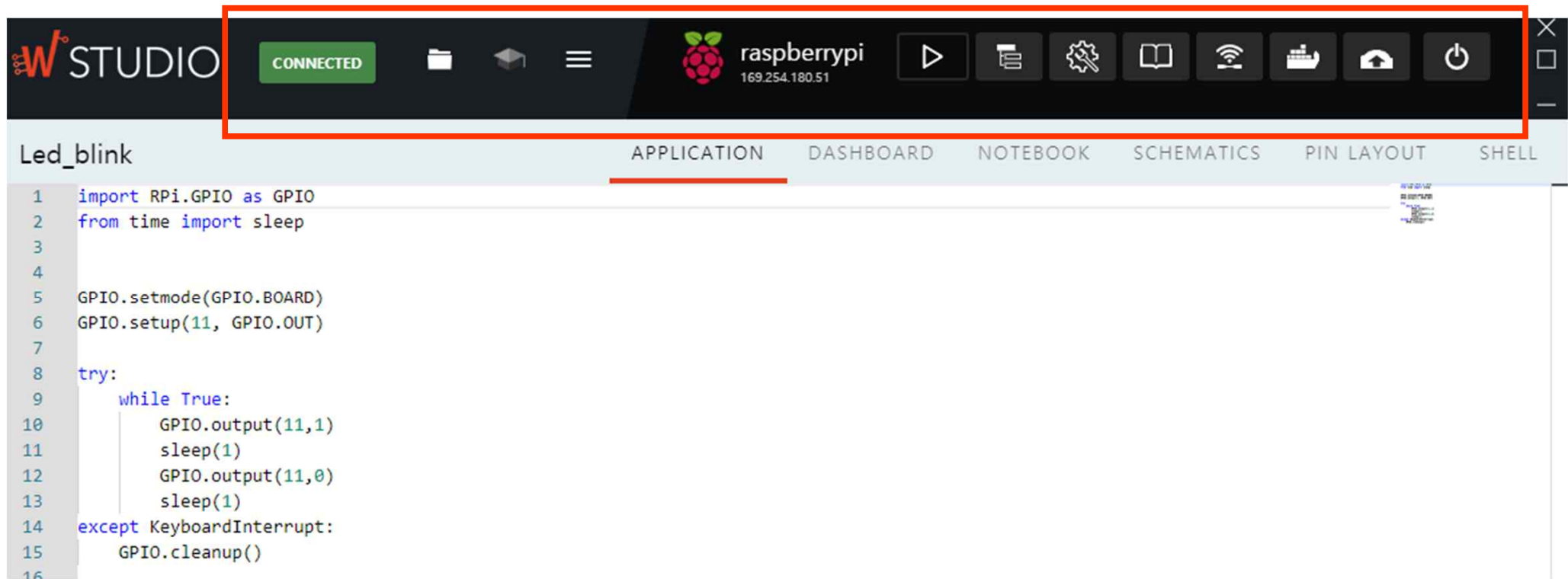
Install an operating system (Method 2)

Enter your credentials: ID: pi, Password: raspberry



Install an operating system (Method 2)

Finally, **CONNECTED!**





Any Questions!