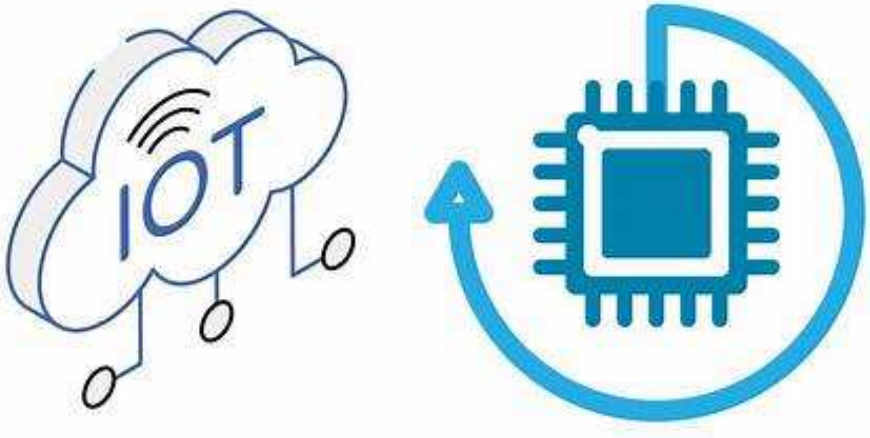
한국외국어대학교
HANKUK UNIVERSITY OF FOREIGN STUDIES

Internet of Things (IoT) Systems



Lecture 03

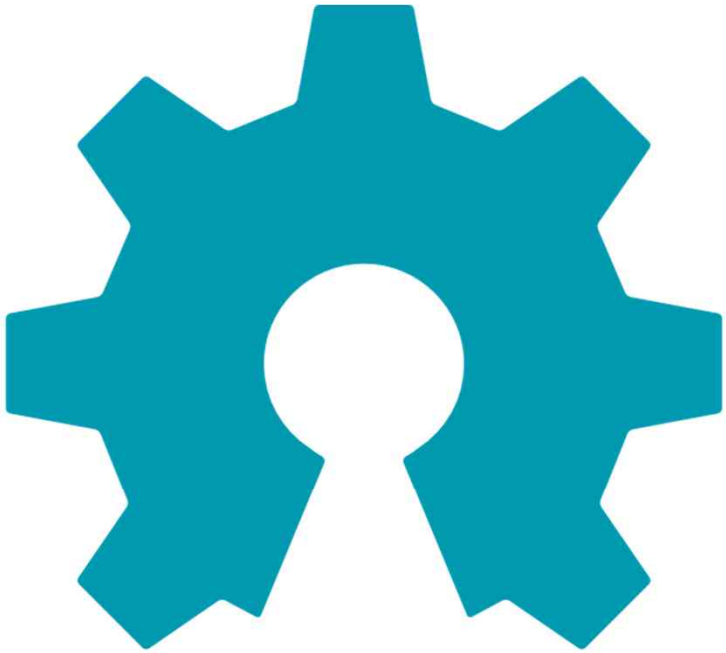
Raspberry Pi Configuration/Set-up

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

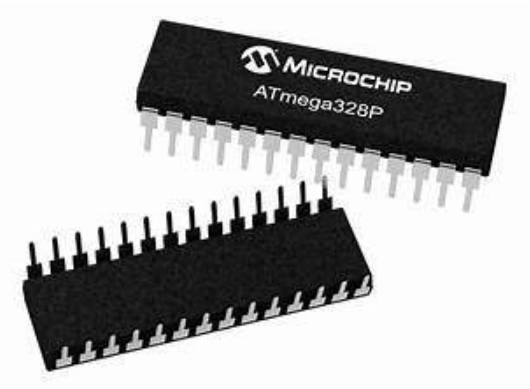
- Microcontrollers
- Arduino
- Raspberry Pi



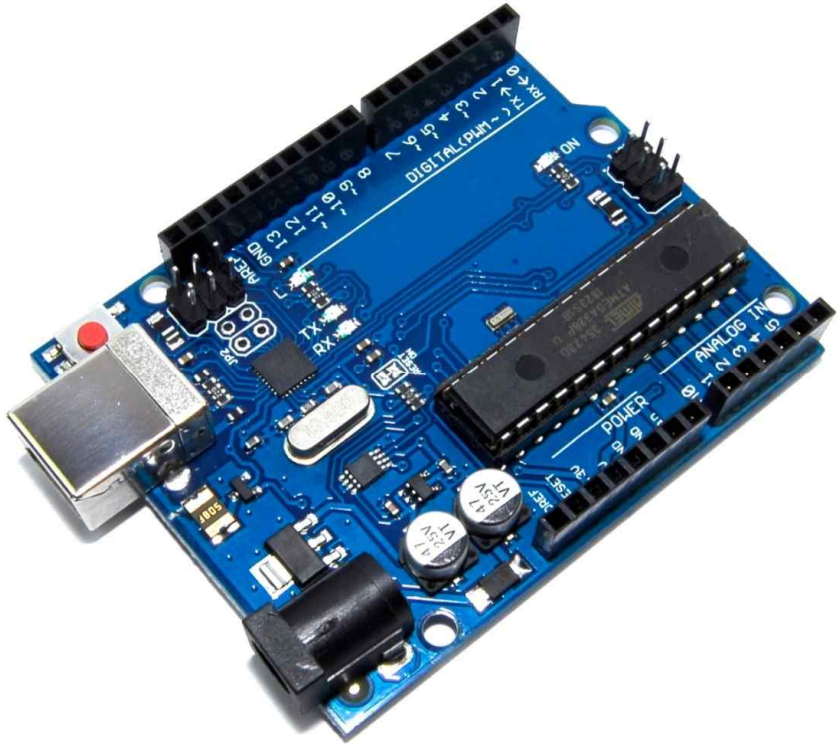
open source hardware

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



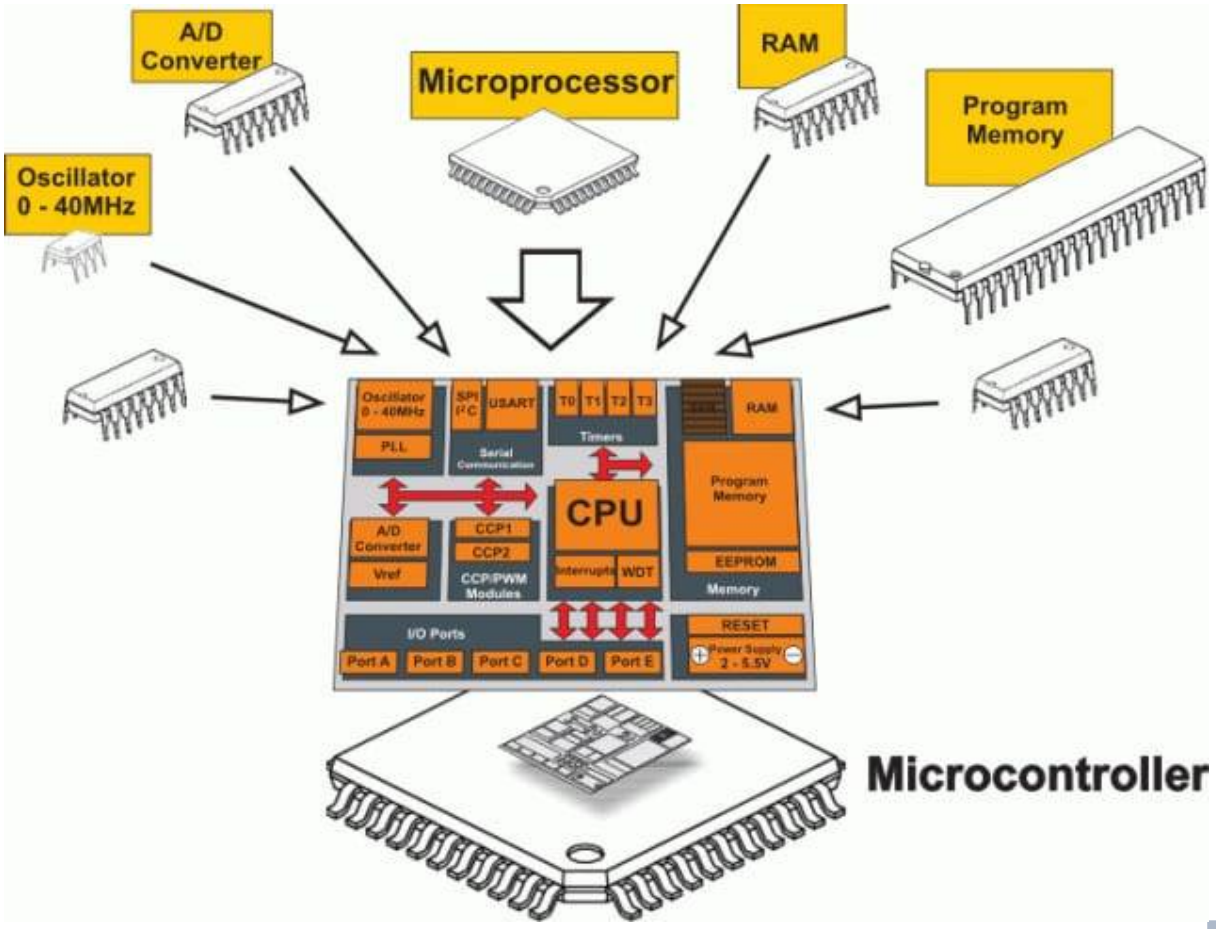
Microcontroller chip + board

https://www.techtarget.com/iotagenda/definition/microcontroller

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).

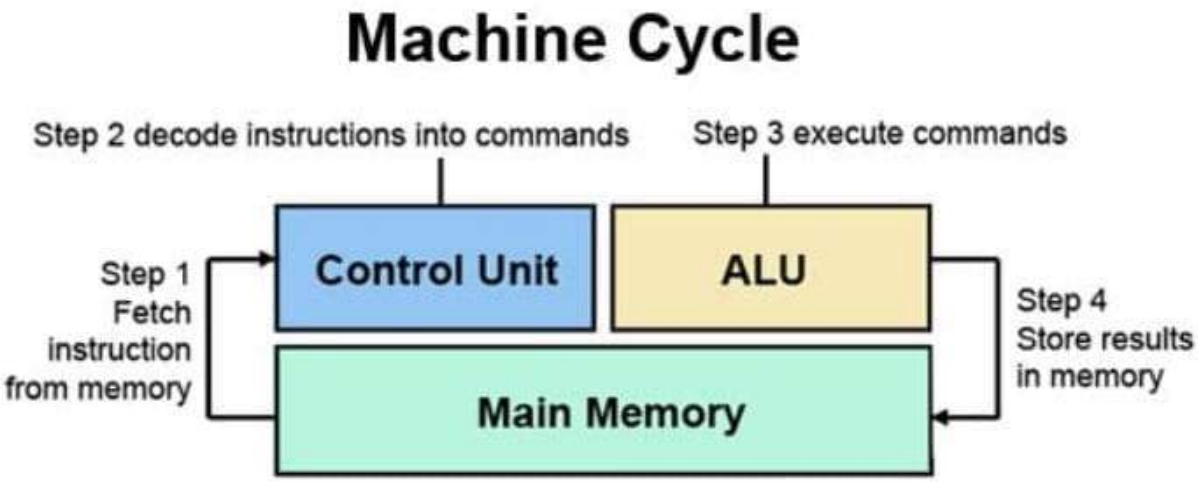


https://www.arrow.com/en/research-and-events/articles/engineering-basics-what-is-a-microcontroller

Inside a Microcontroller: Essential Components

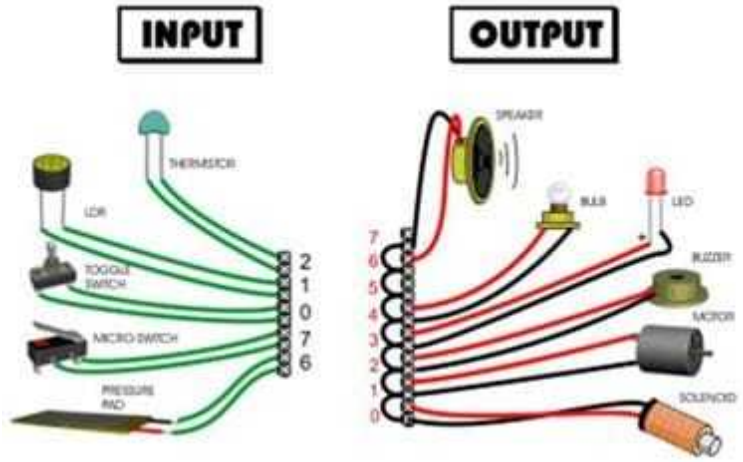
Design of Microcontroller CPU

- 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.

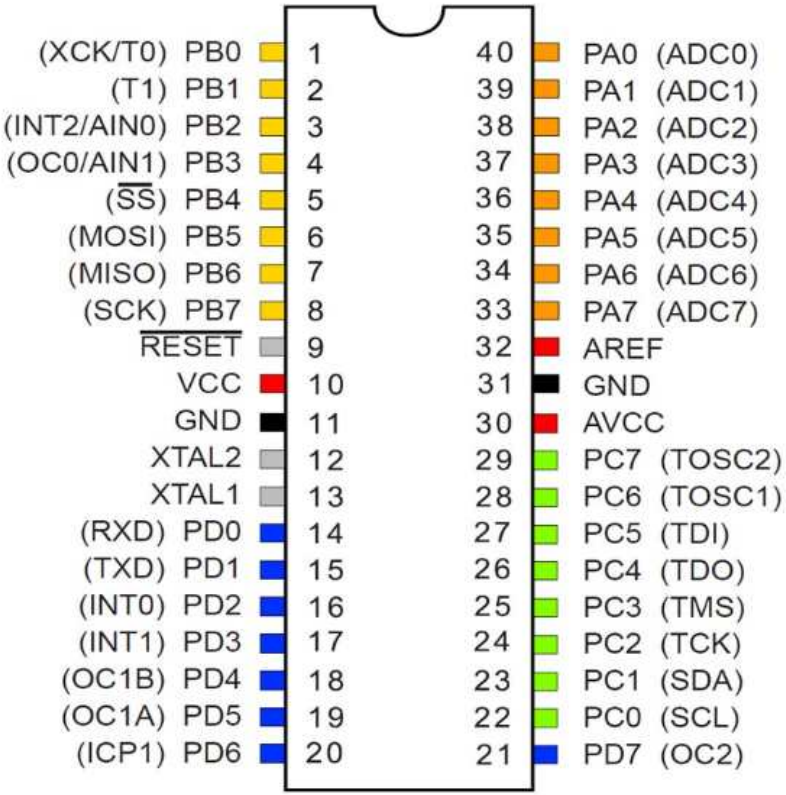


Microcontroller I/O Ports

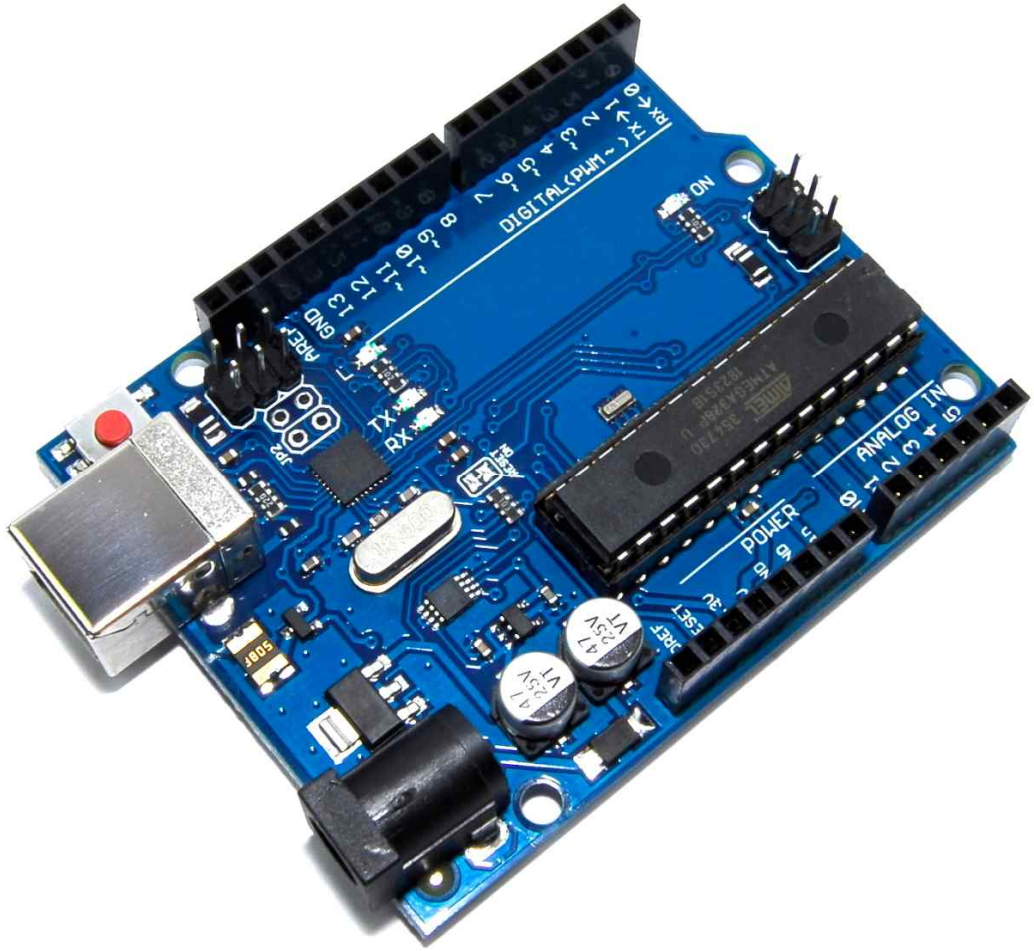
- I/O ports are what the microcontroller uses to connect to real-world applications.
- Inputs such as temperature sensing, motion sensing, push buttons,……
- Output ports such as LED lights, LCD, running a motor, speaker, …..



Types of the Microcontroller

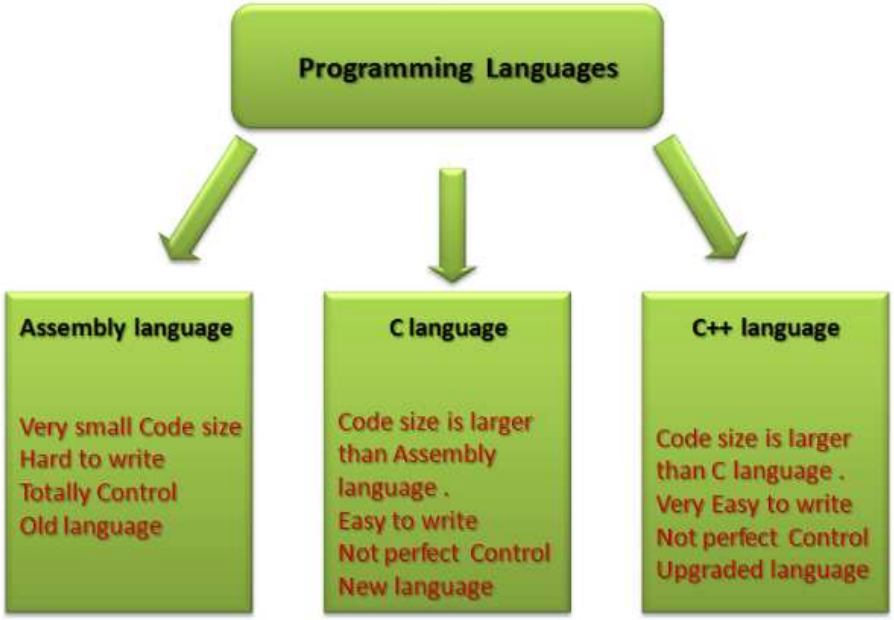


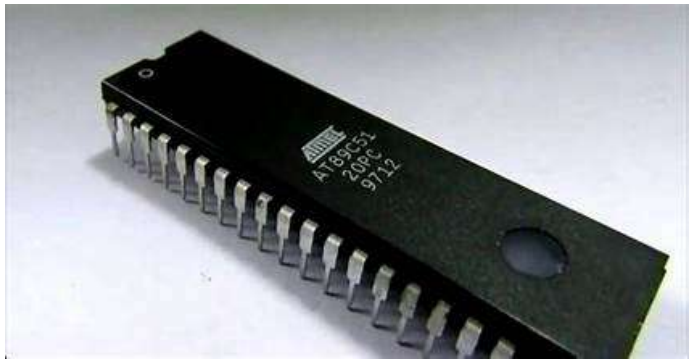
ATmega32A microcontroller which is 8-bit and 40 pin AVR chip.



ATmega32A microcontroller Board.

Types of the Microcontroller (SW/HD)



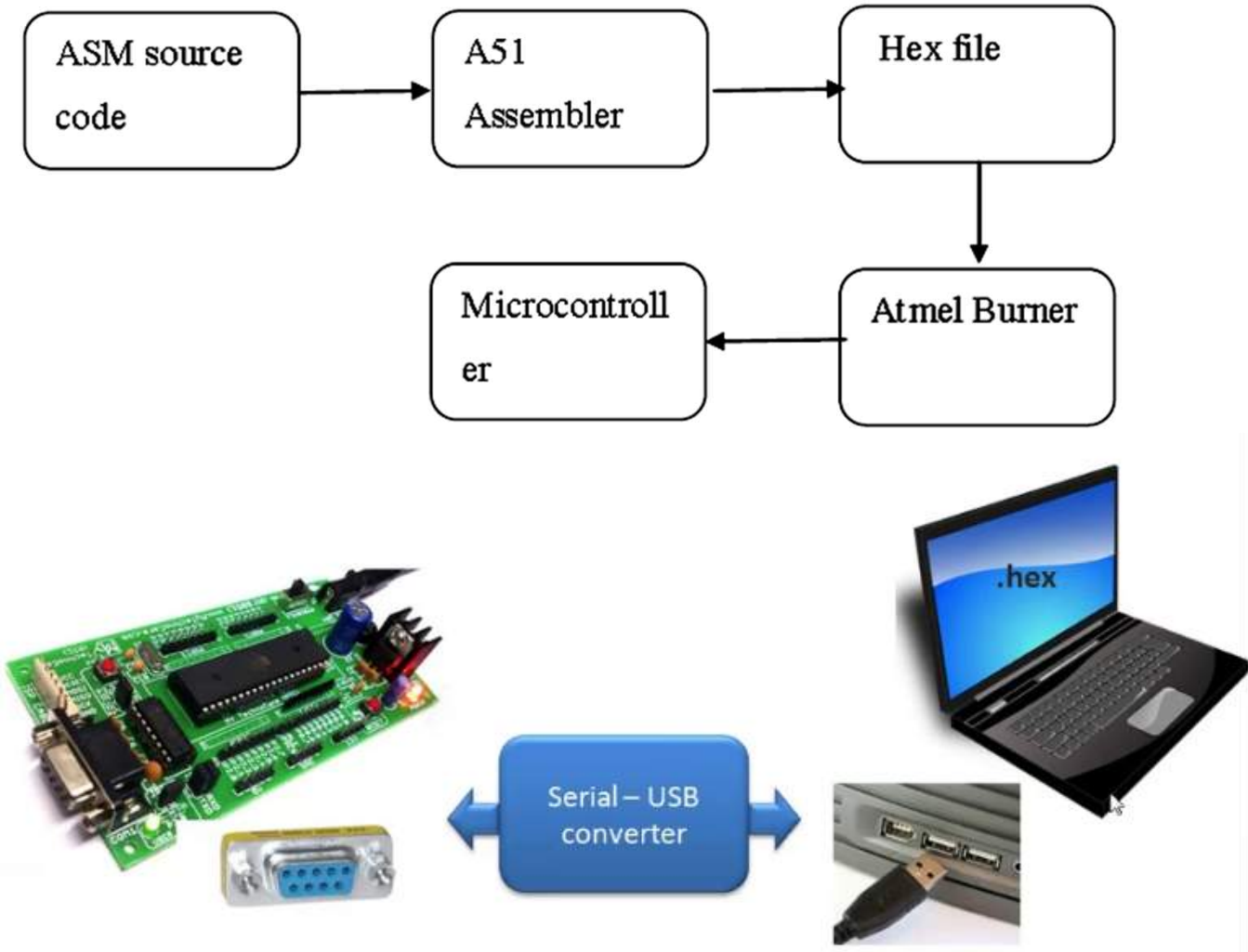


How to program Microcontroller?

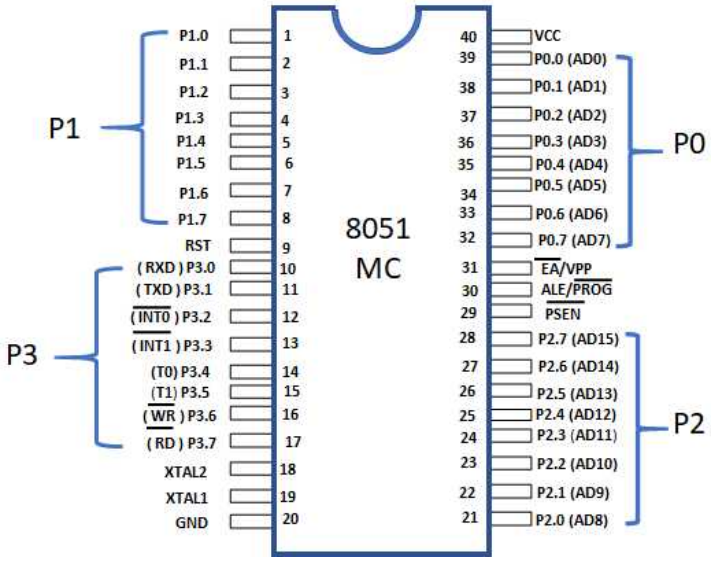
code.asm

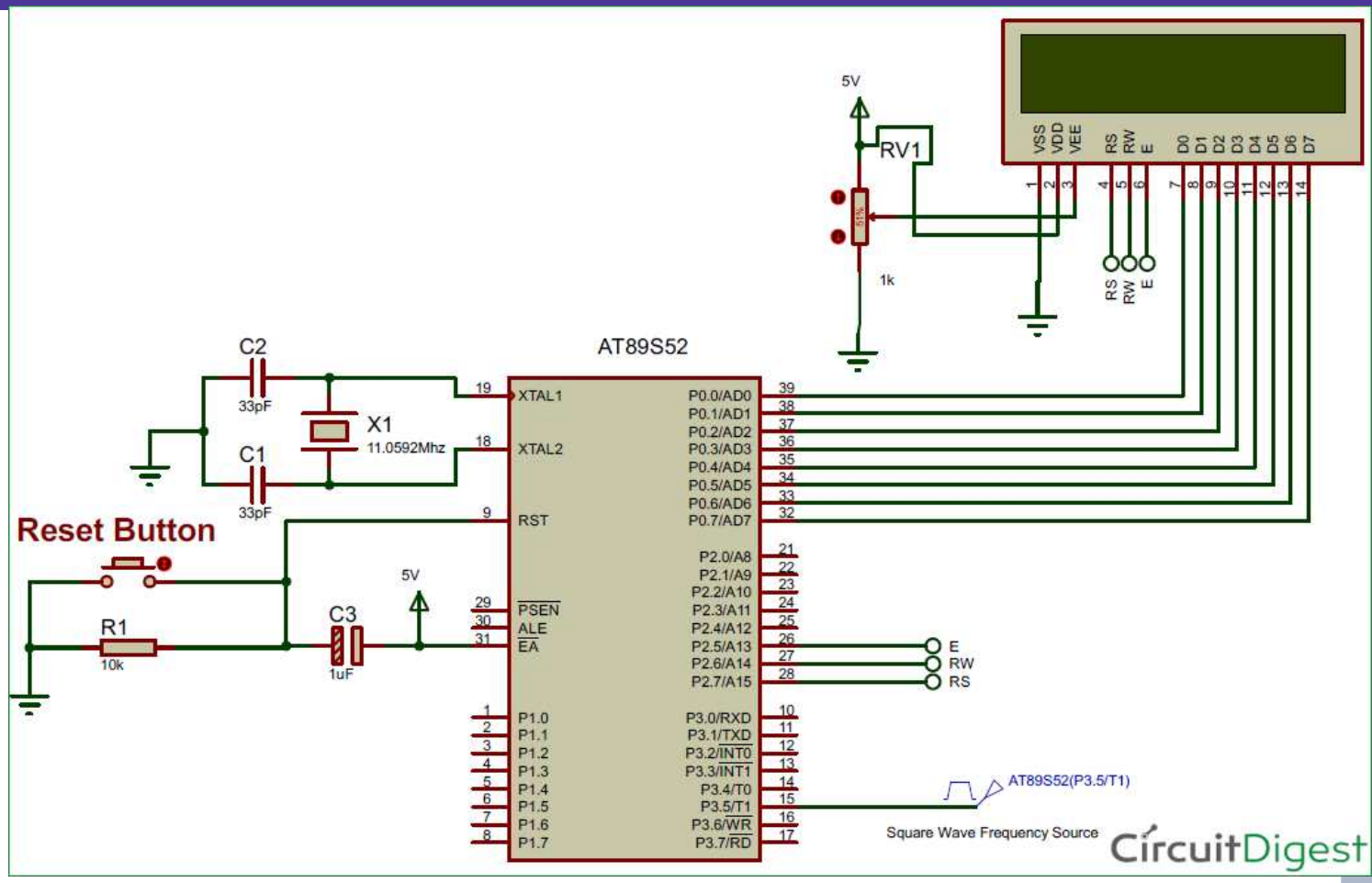
```
1  org 00H
2
3  ;MAIN PROGRAM
4
5  toggle:  MOV P1, #01H      ; move 00000001 to PORT1
6           CALL delay        ; execute dalay
7           MOV A, P1         ; move PORT1 value to accumulator
8           CPL A             ; complement PORT1 value
9           MOV P1, A         ; move 11111110 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

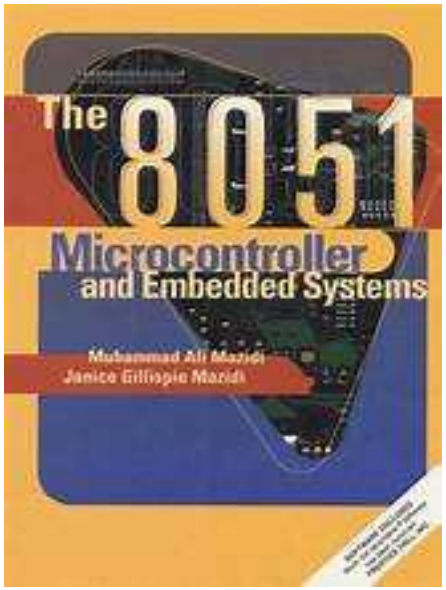


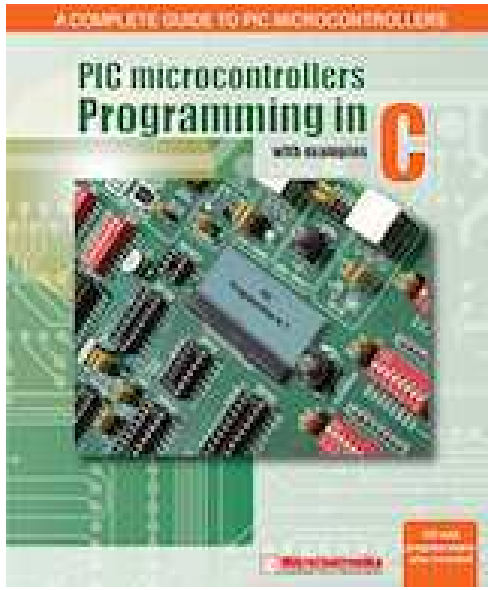
Simulation of the Microcontroller

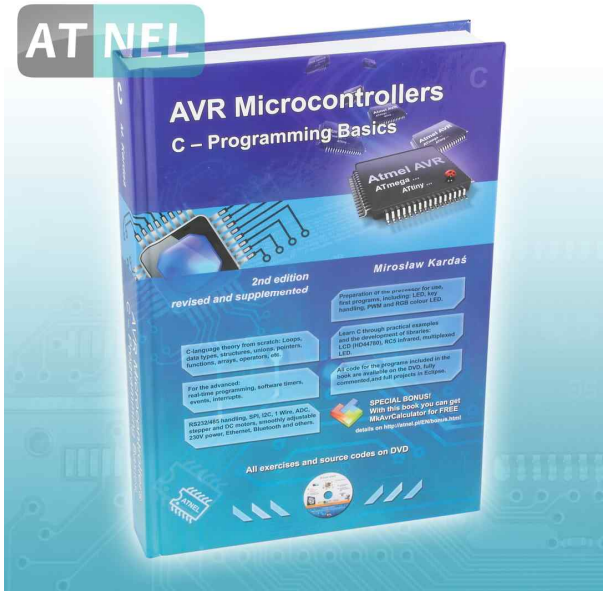


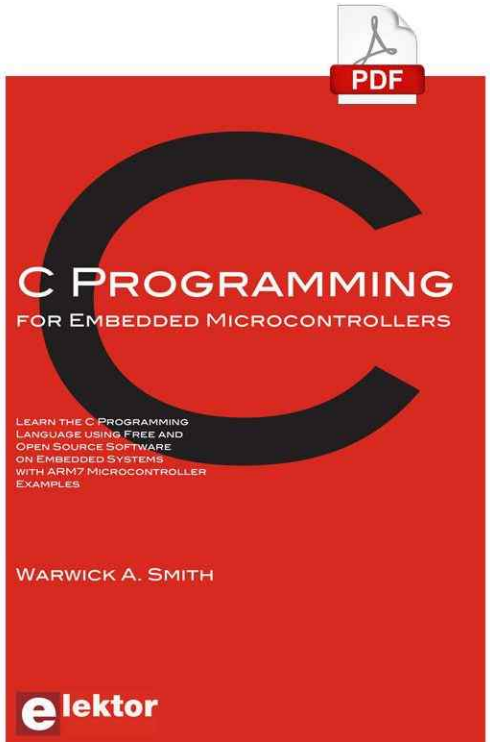


References


The 8051
Microcontroller
and Embedded Systems
Muhammad Ali Mazidi
Janice Gillispie Mazidi


A COMPLETE GUIDE TO PIC MICROCONTROLLERS
PIC microcontrollers
Programming in C


ATMEL
AVR Microcontrollers
C – Programming Basics
Atmel AVR
ATmega ...
ATtiny ...
2nd edition
revised and supplemented
Mirosław Kardaś
SPECIAL BONUS!
With this book you can get
MiAVRCalculator for FREE
All exercises and source codes on DVD


PDF
C PROGRAMMING
FOR EMBEDDED MICROCONTROLLERS
LEARN THE C PROGRAMMING
LANGUAGE USING FREE AND
OPEN SOURCE SOFTWARE
ON EMBEDDED SYSTEMS
WITH ARM7 MICROCONTROLLER
EXAMPLES
WARWICK A. SMITH
elektor

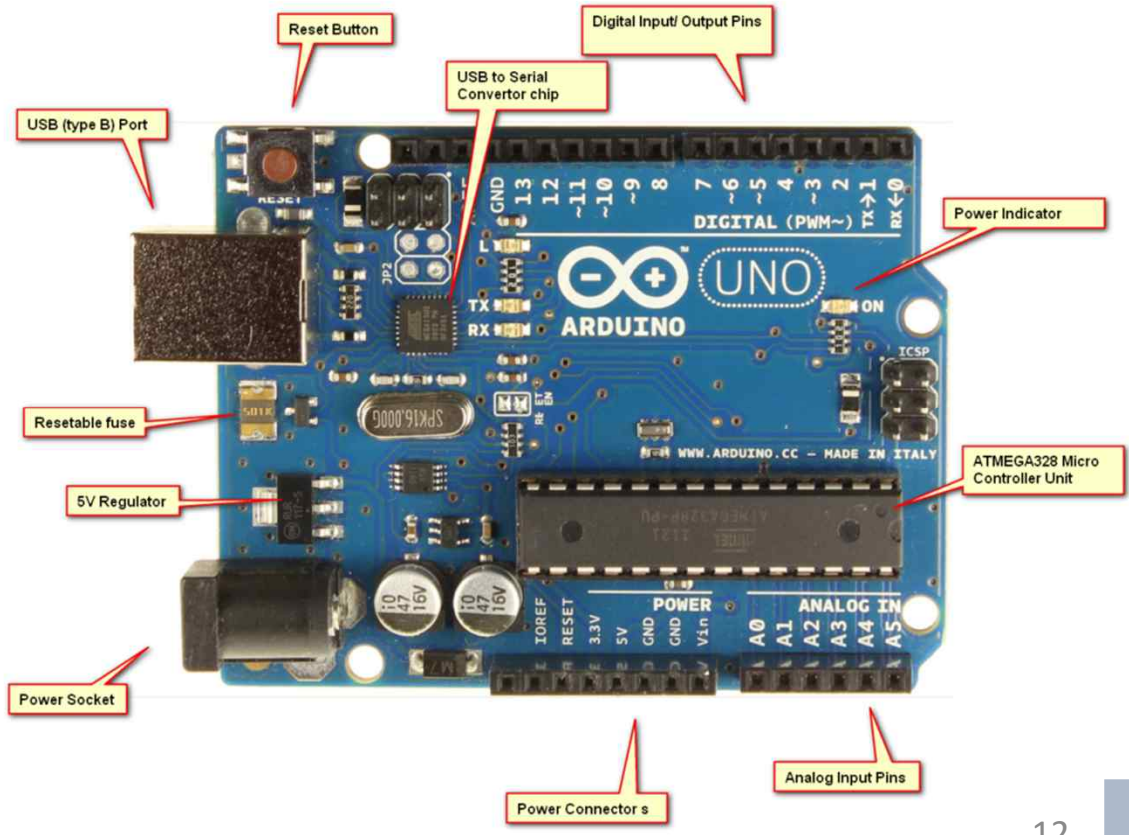
Arduino

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.



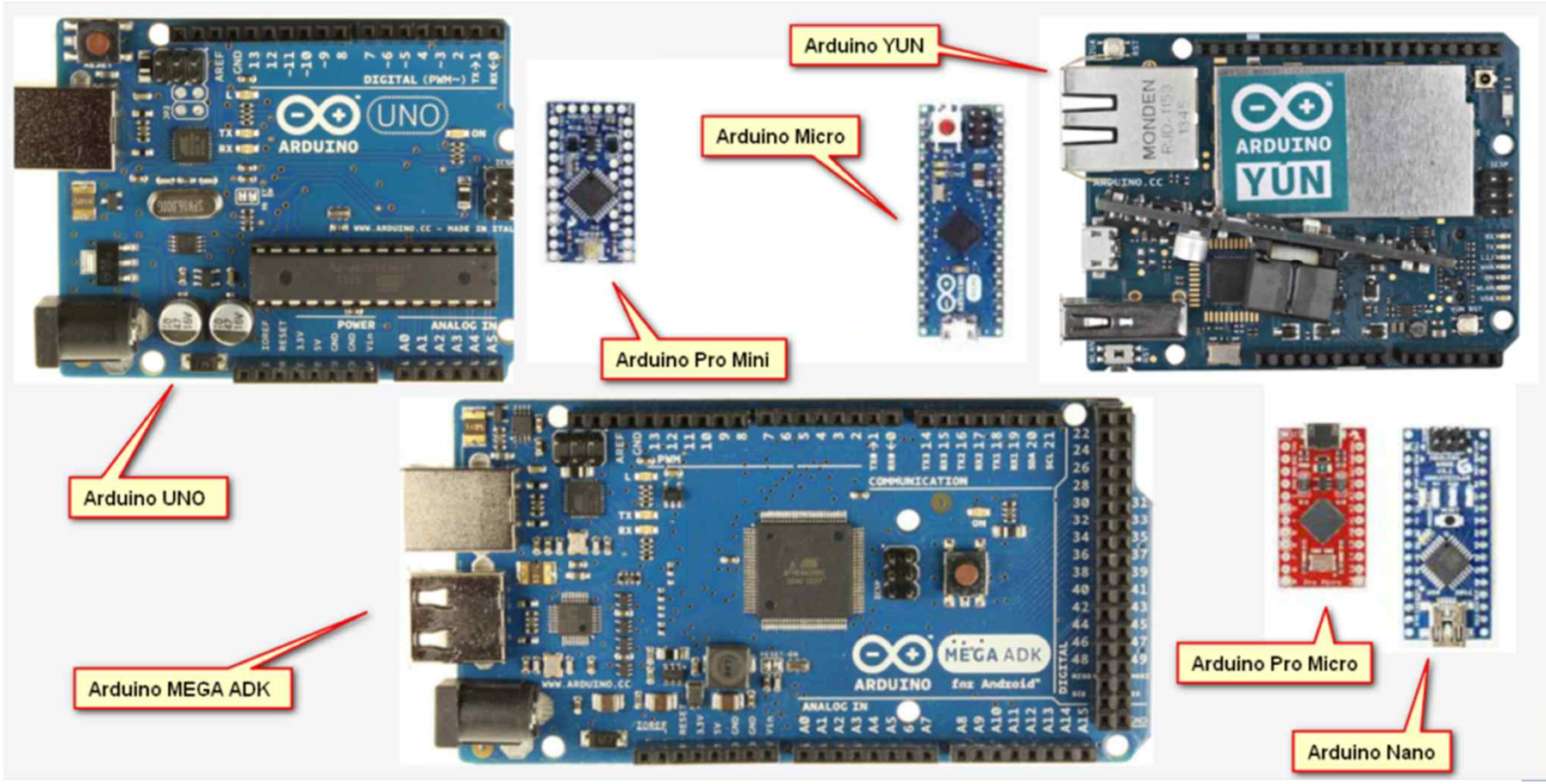
Arduino Hardware

The Arduino UNO, MEGA and ZERO are the best.

The Arduino UNO R3 is

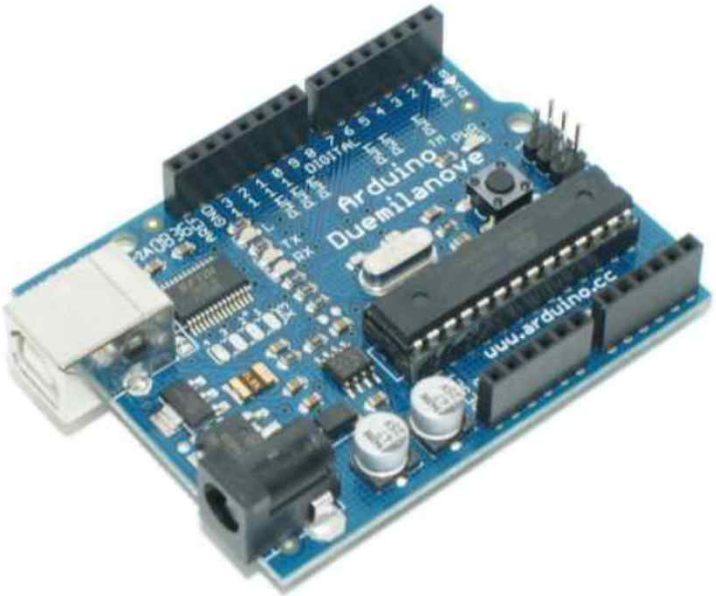
- very easy to use,
- USB type-B port to connect with Computer
- Power socket
- fairly cheap.

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

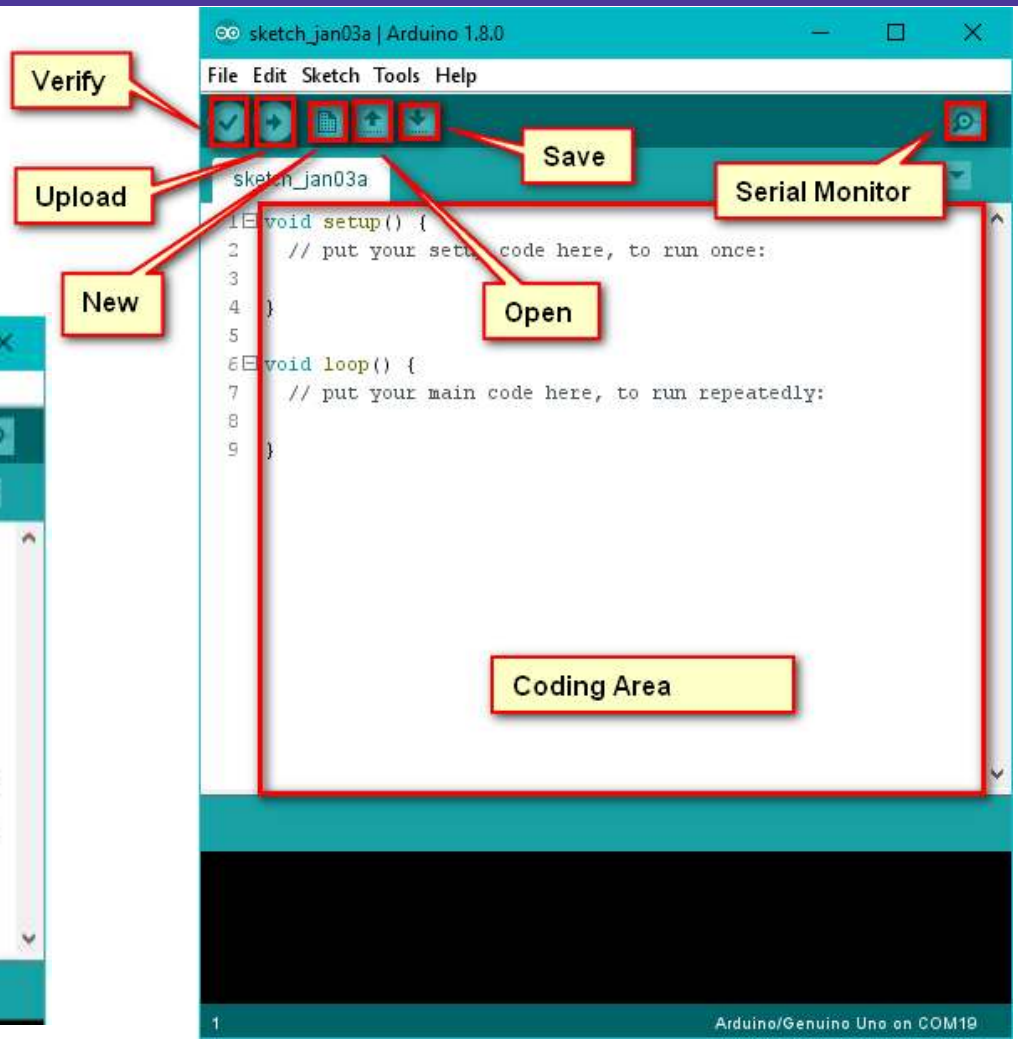
Arduino IDE software

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

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

Arduino IDE software

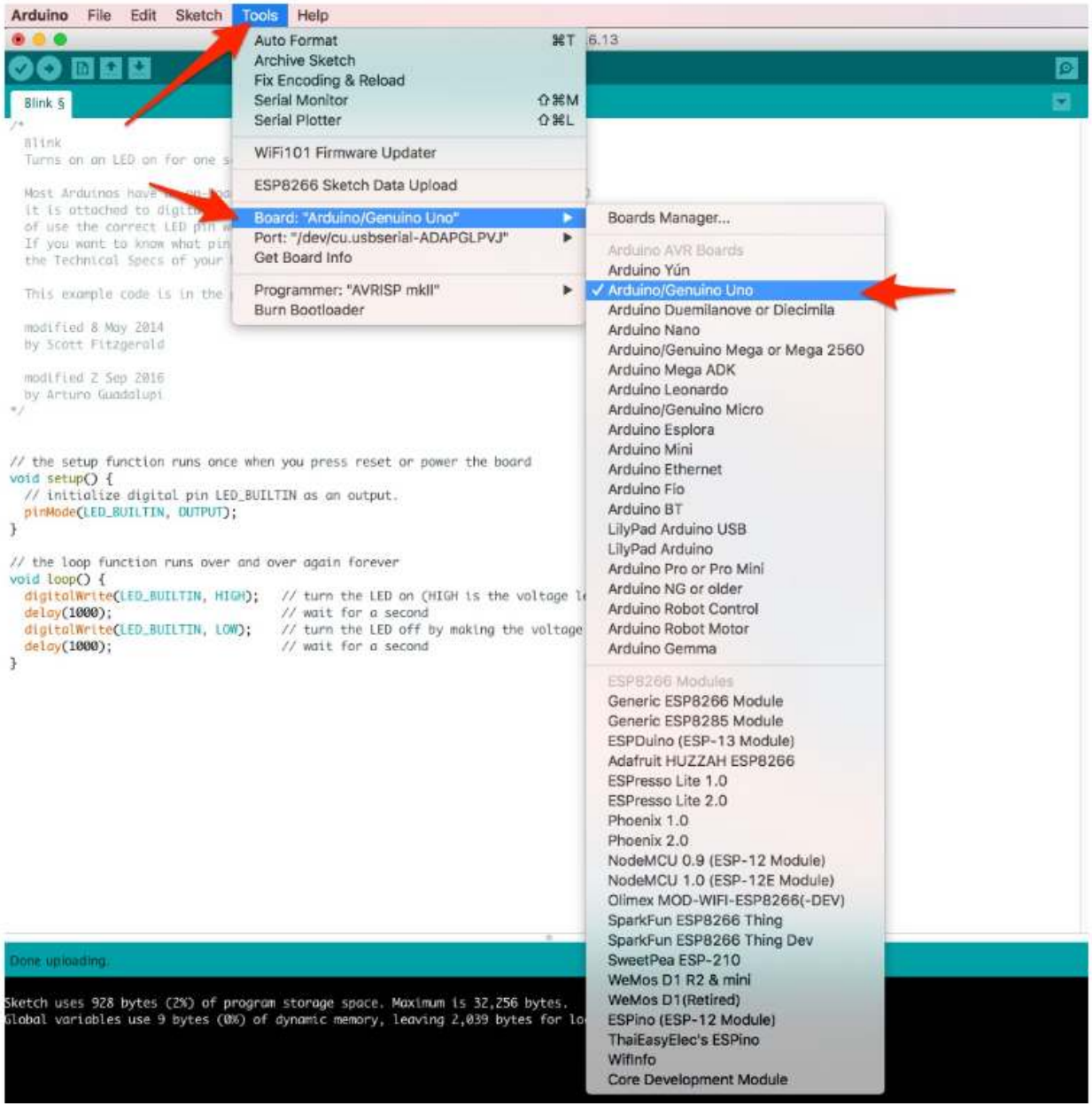
- After downloading and installing the software, you can open and run the IDE.
- You will see the following window on your computer.



Arduino IDE software

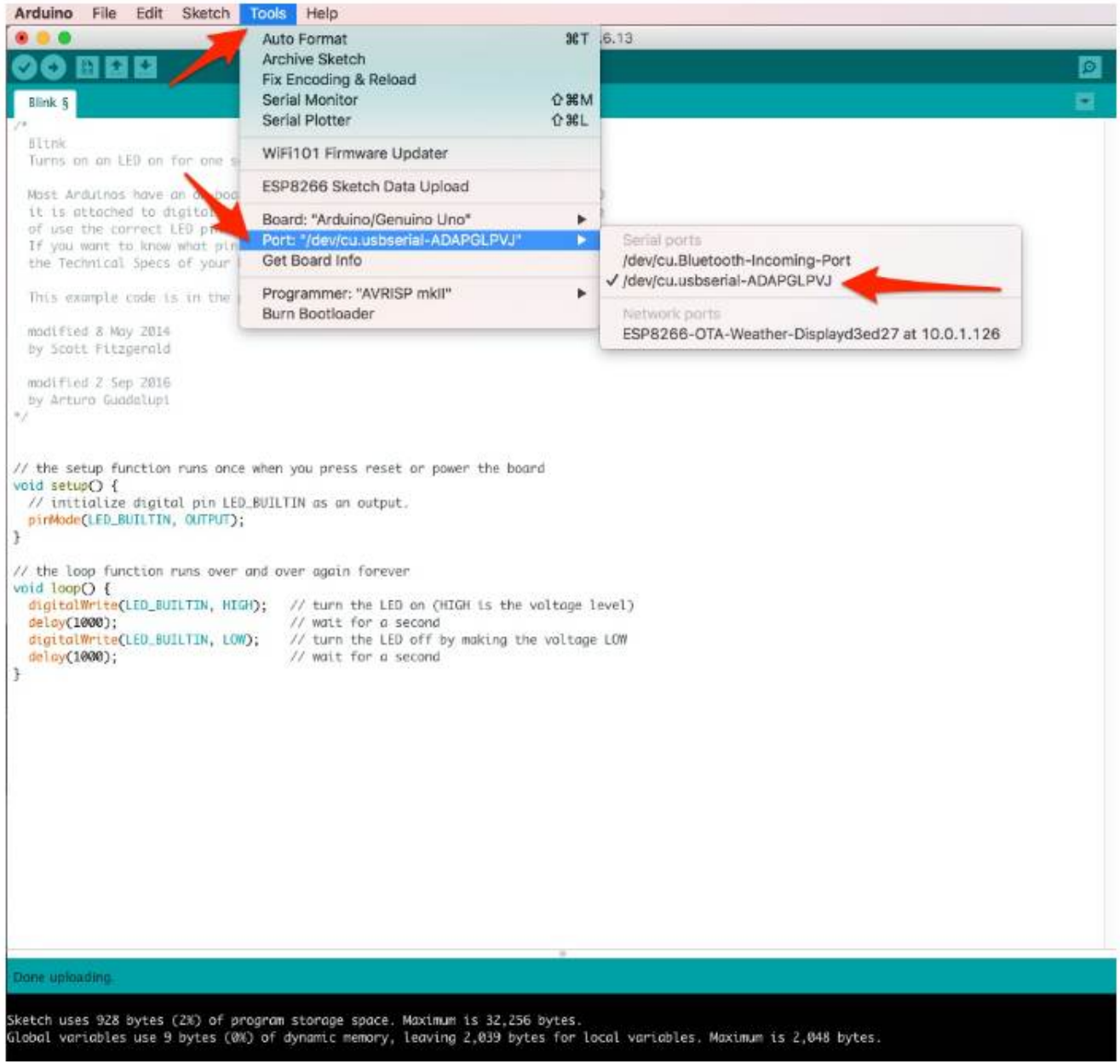
- Before we can upload the program, we need to get our Arduino board and Port configured in the IDE.

- First, Select **Tools** -> **Board** and click on the **Arduino/Genuino Uno**



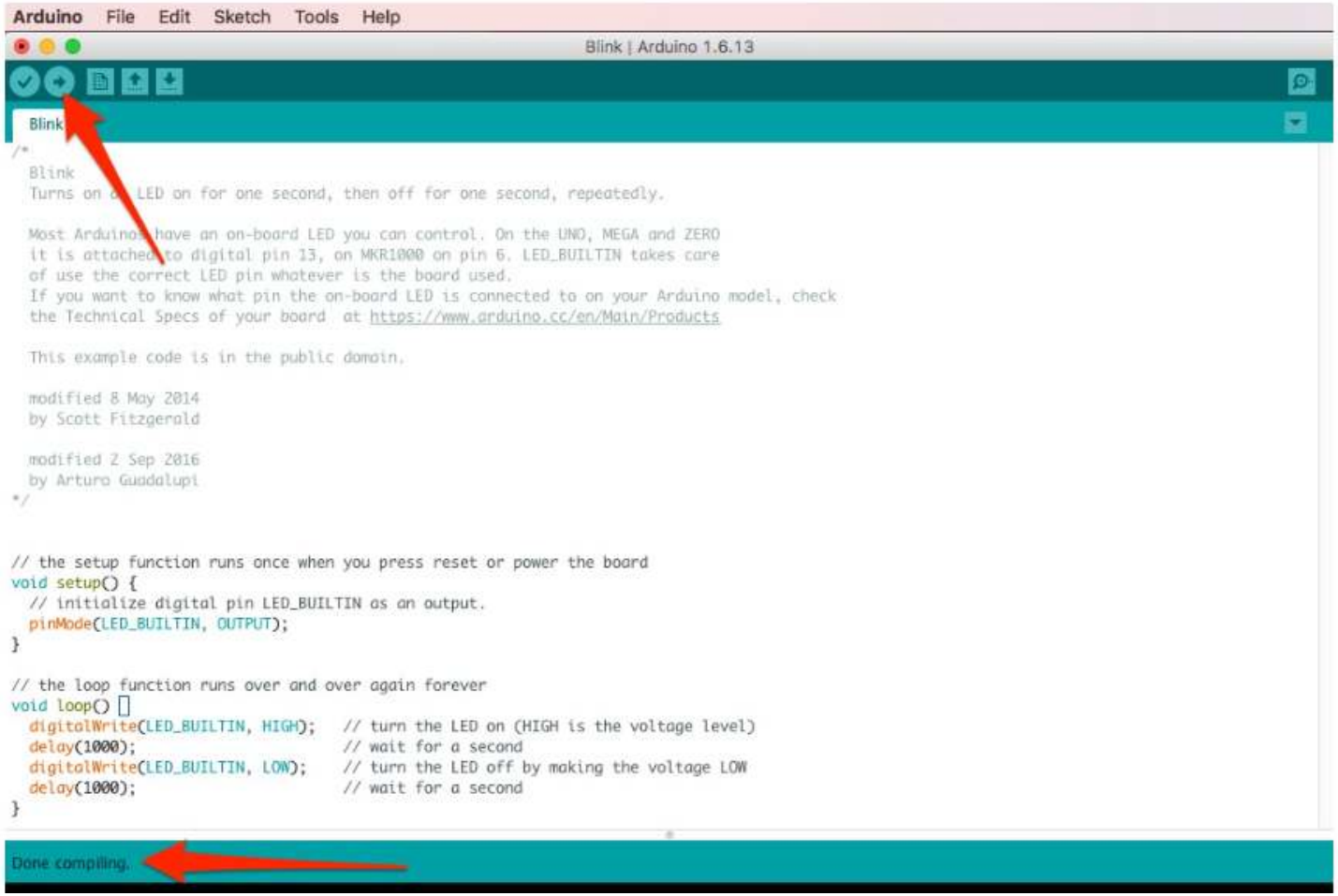
Arduino IDE software

Next, select the proper USB Port which will usual 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”



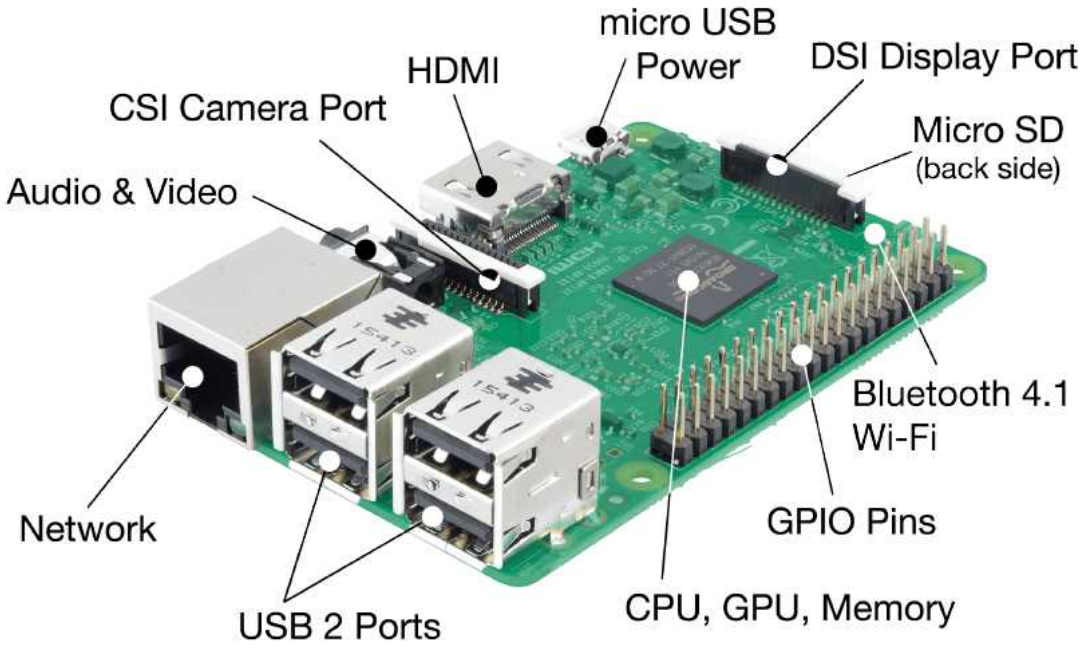
Raspberry Pi

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



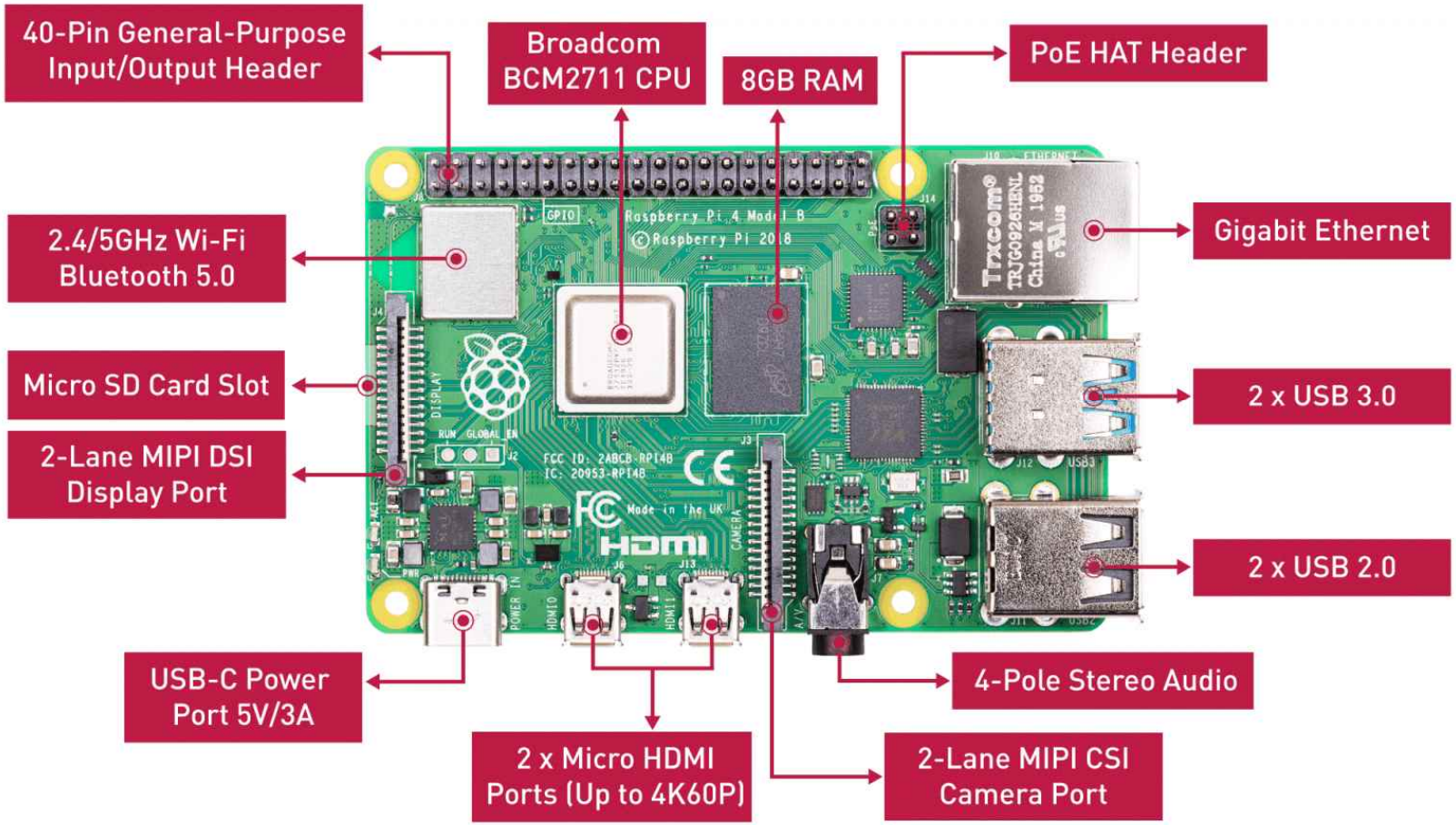
Raspberry Pi 3 Model B Board

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

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:
  - 5V DC via USB-C connector (minimum 3A)
  - 5V DC 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

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 Raspberr...

4.5 out of 5 stars ▾ 306

200+ bought in past month

$149.99

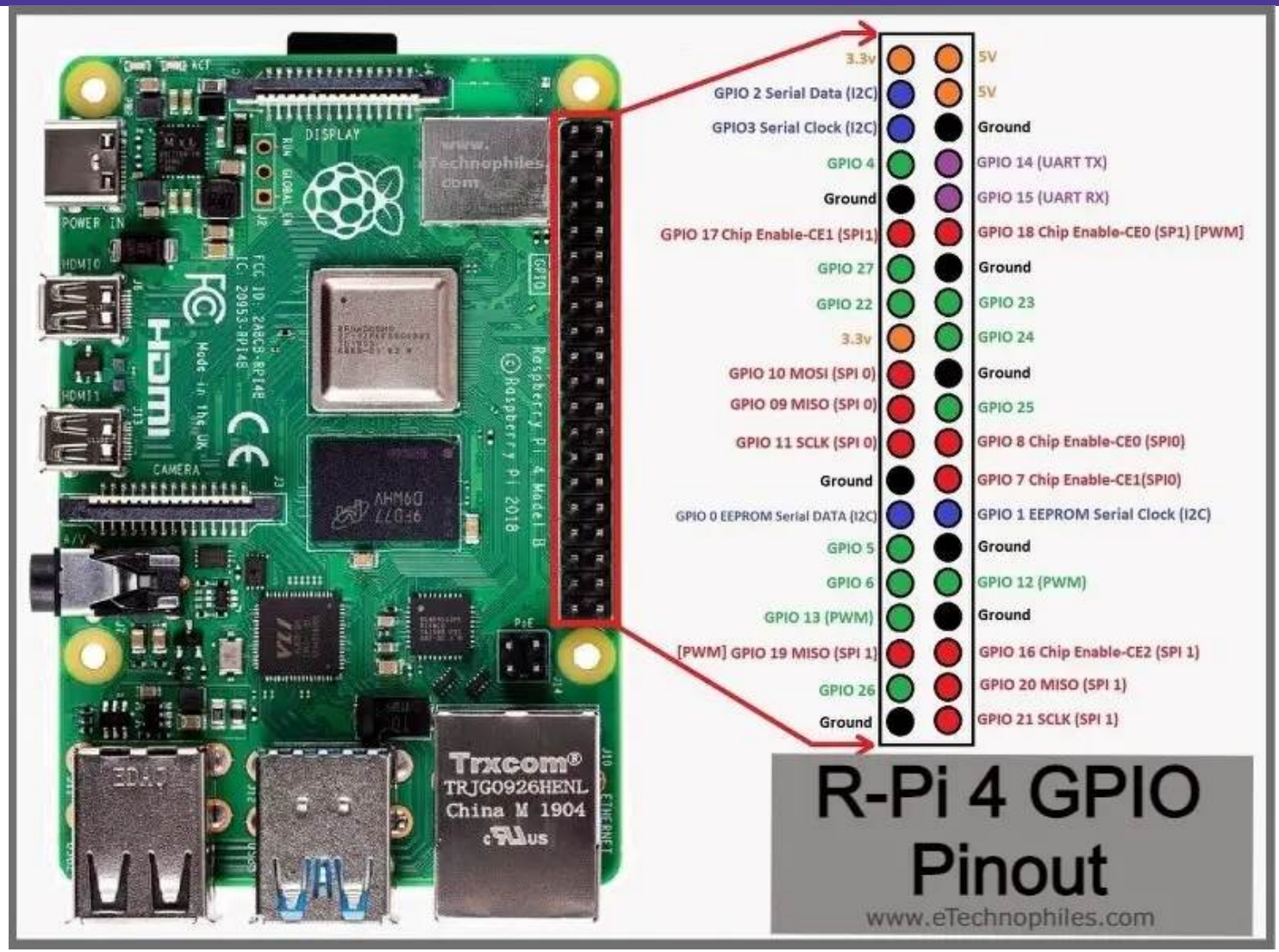
Save 5% with coupon

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.



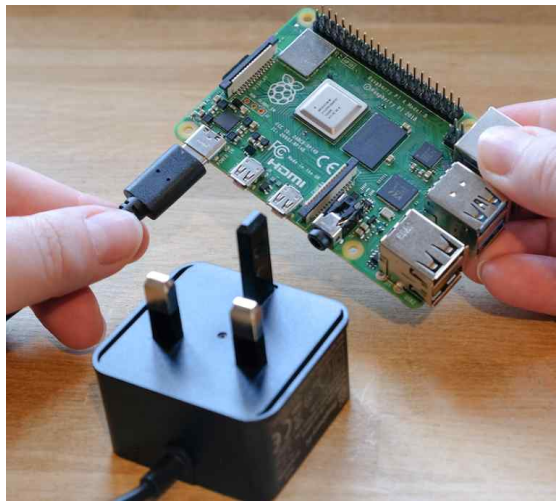
Get started with Raspberry Pi

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

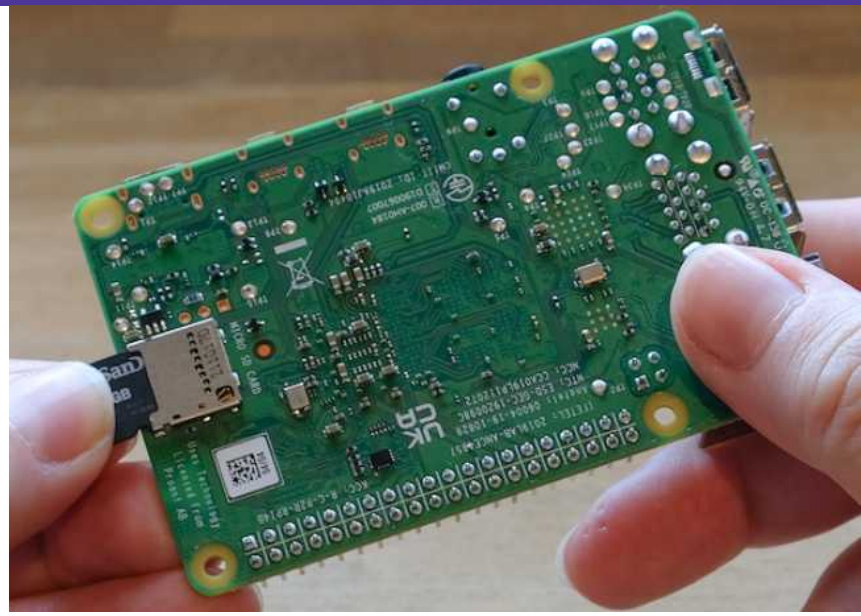
Power supply



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)



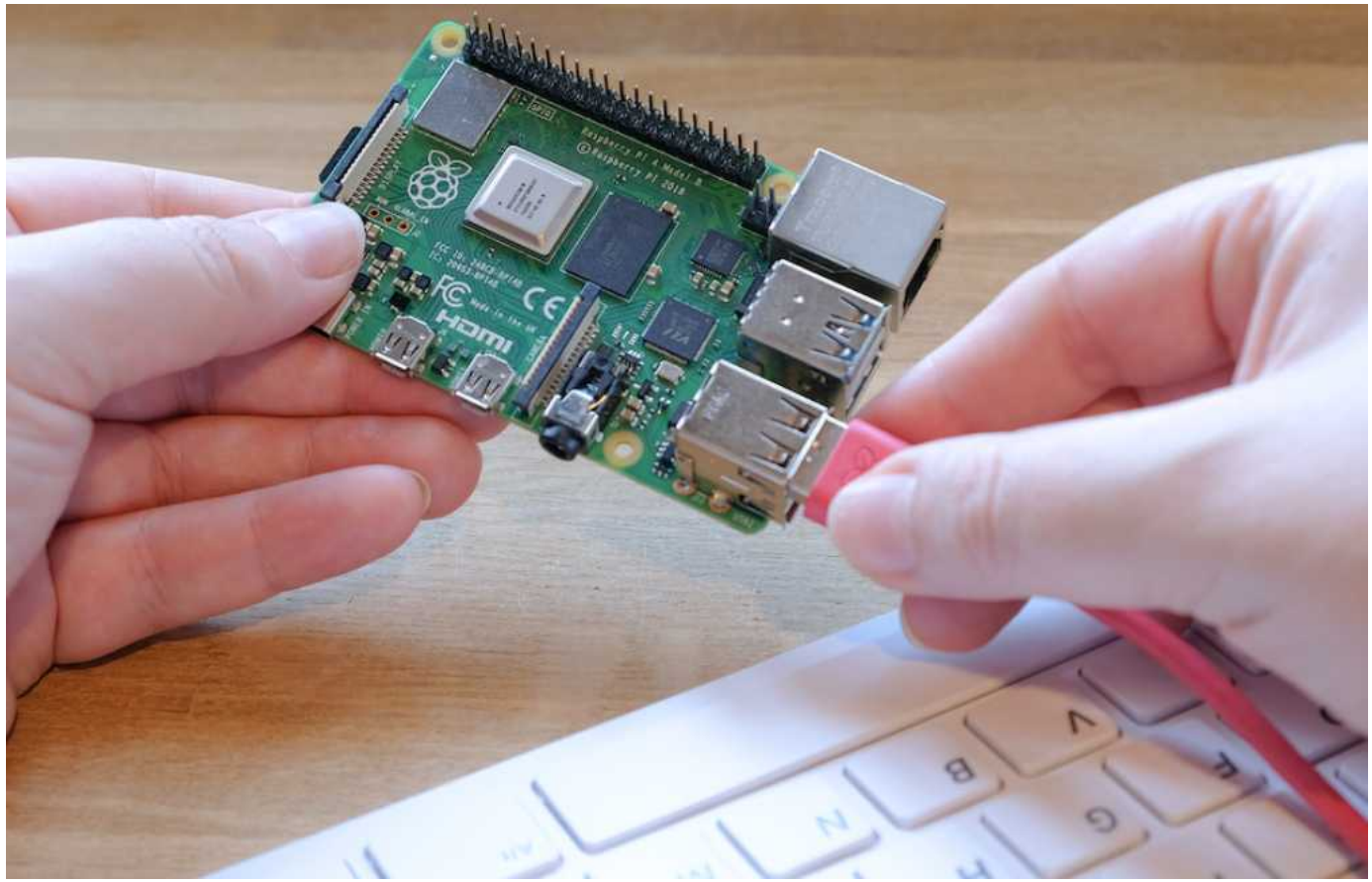
Recommended SD cards

- 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

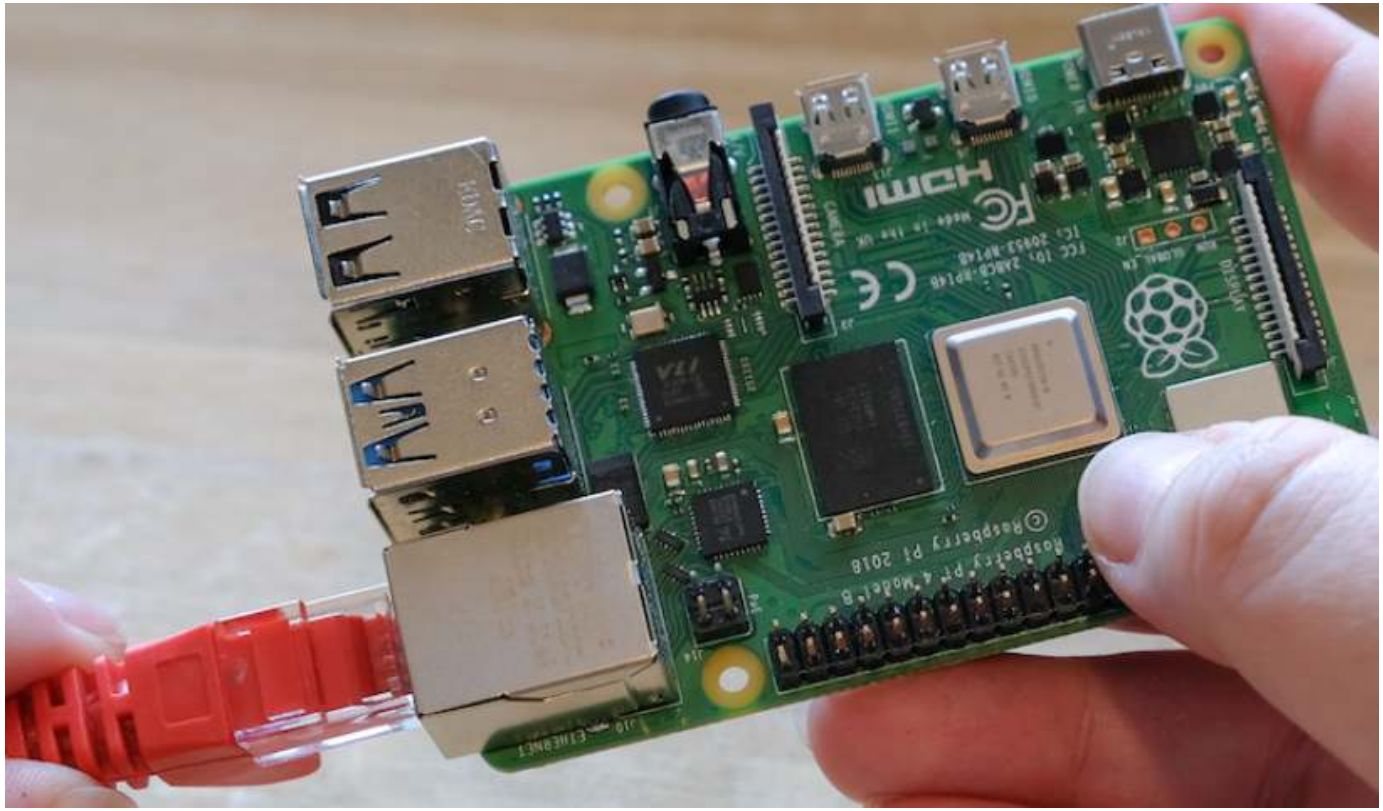
- All Raspberry Pi models with HDMI, micro HDMI, or mini HDMI support audio output over HDMI.
- All Raspberry Pi models support audio over USB.
- All Raspberry Pi models equipped with Bluetooth support Bluetooth audio.

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.

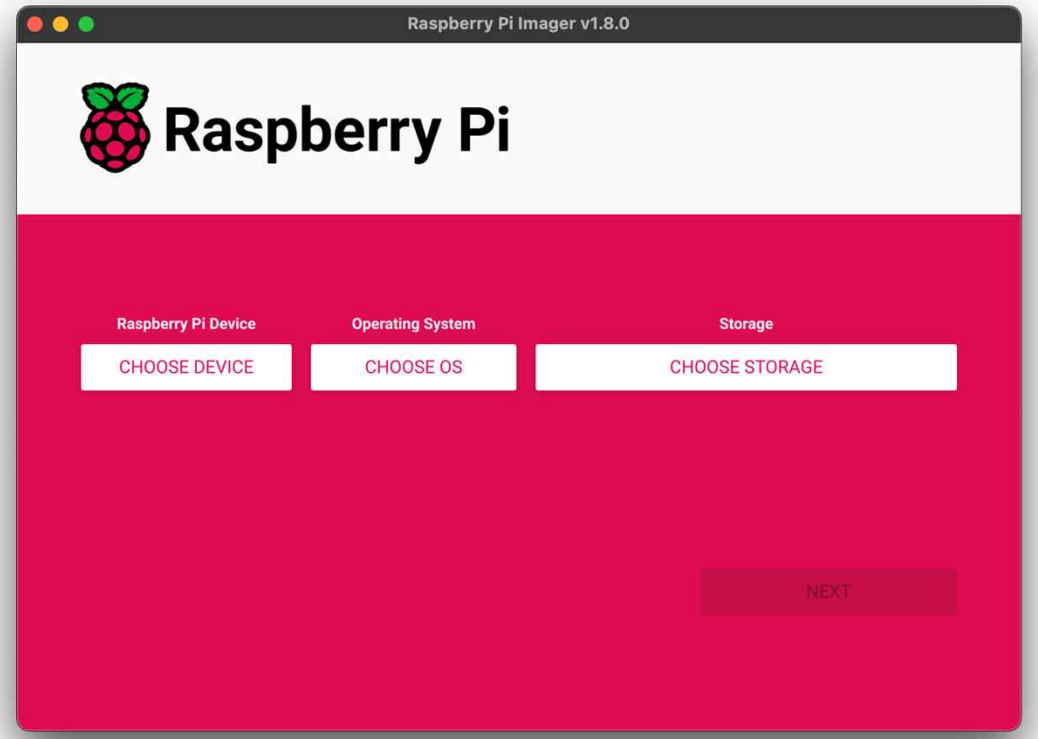
Raspberry Pi

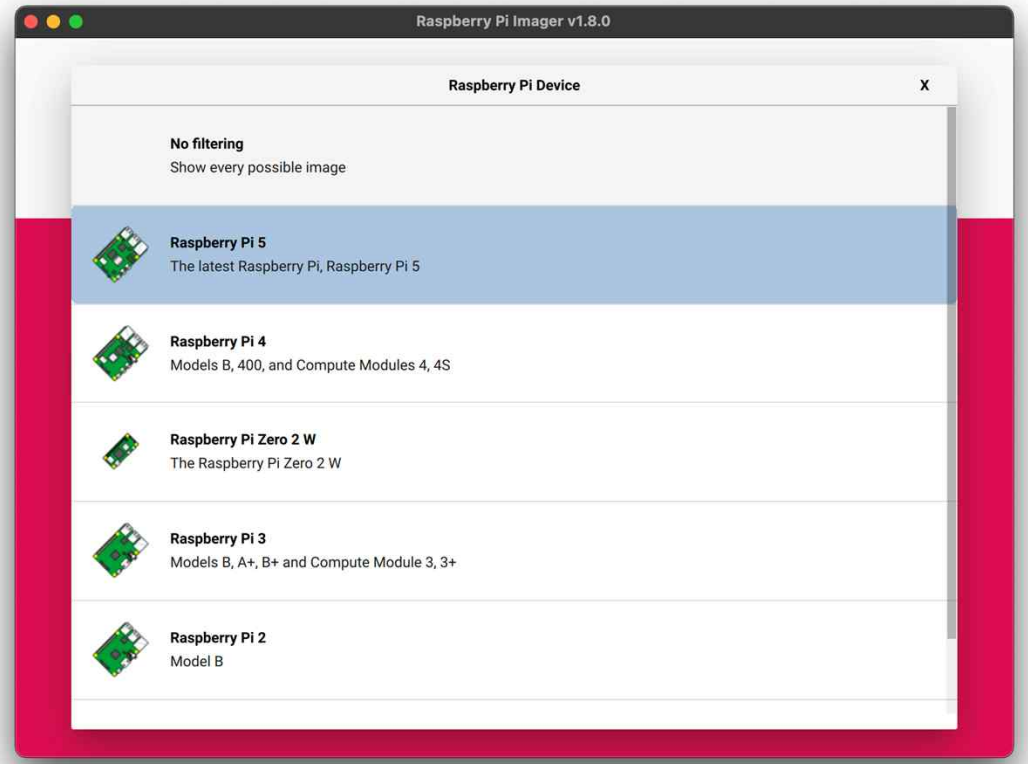
[Raspberry Pi Imager]

RealVNC® Viewer

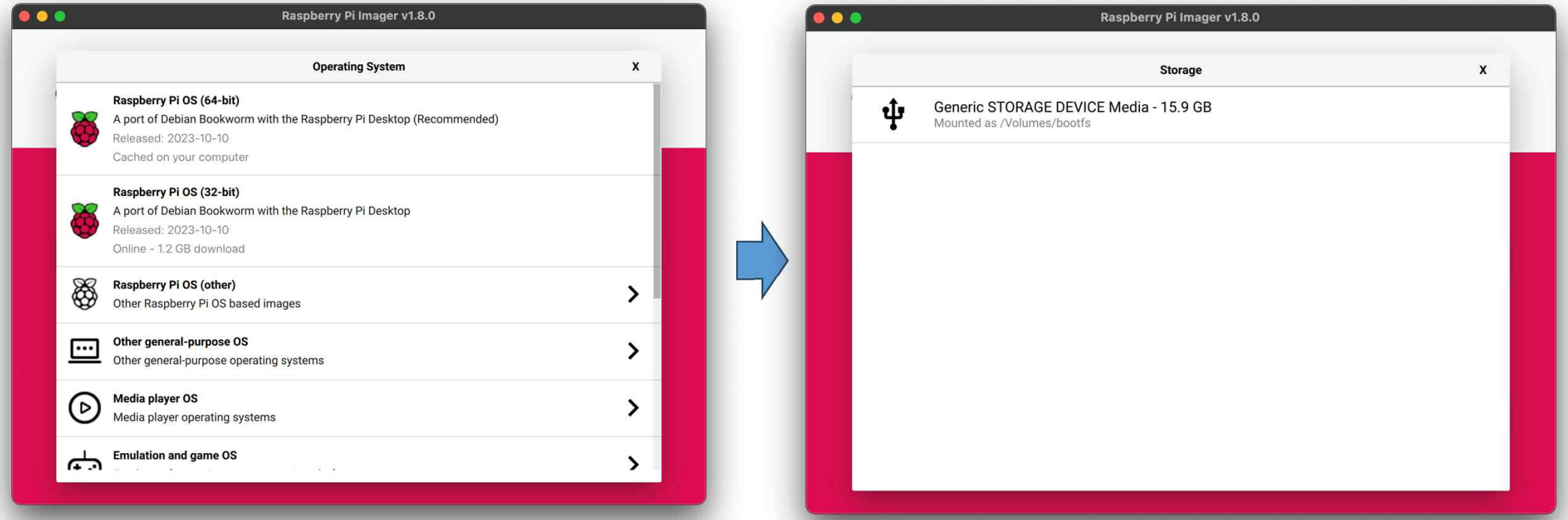
putty-ssh

Install an operating system (Method 1)

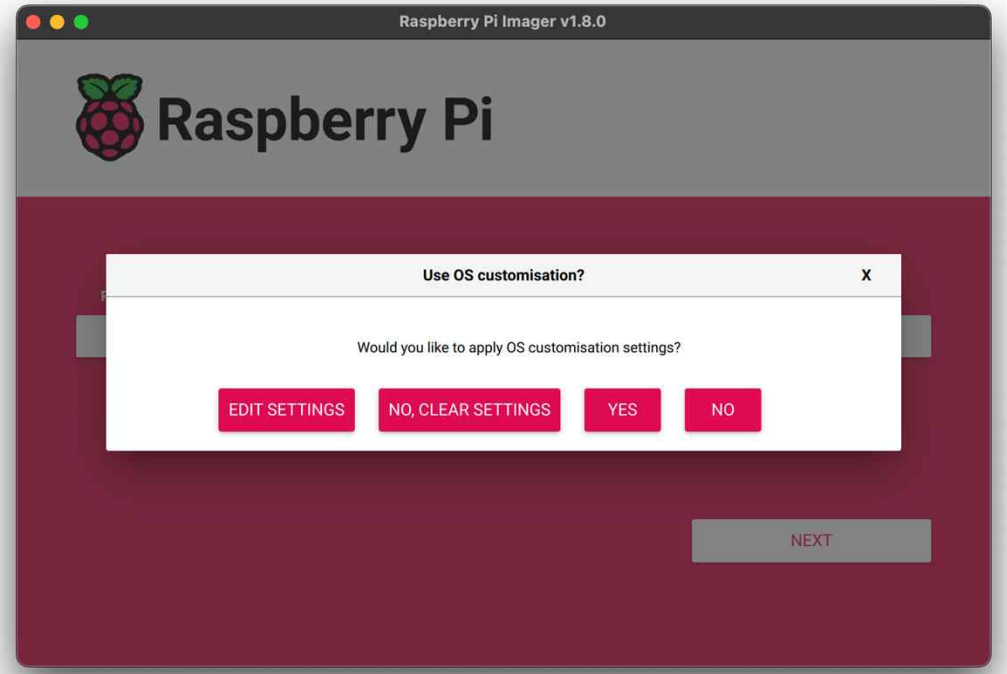


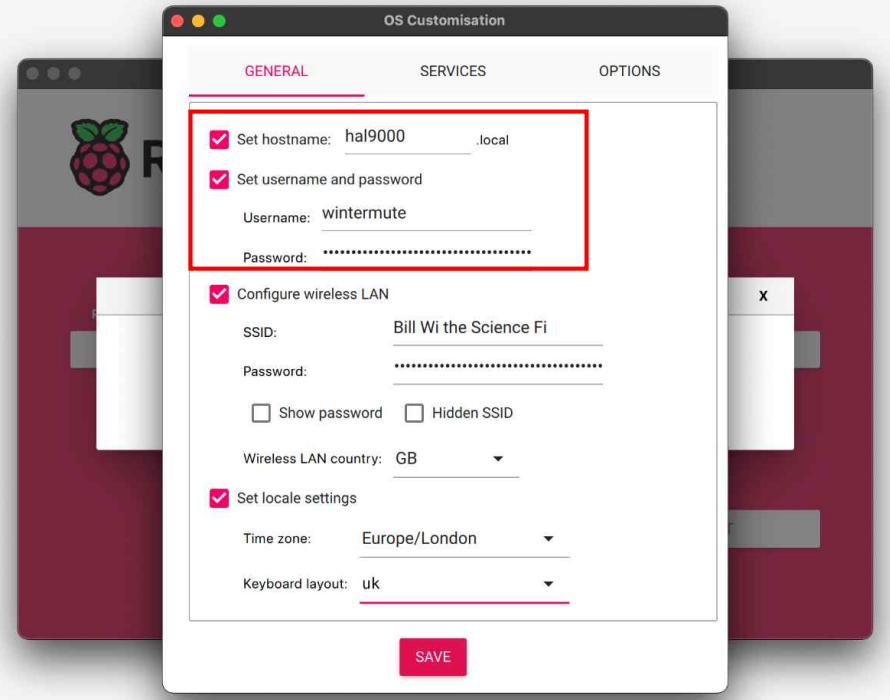


Install an operating system (Method 1)

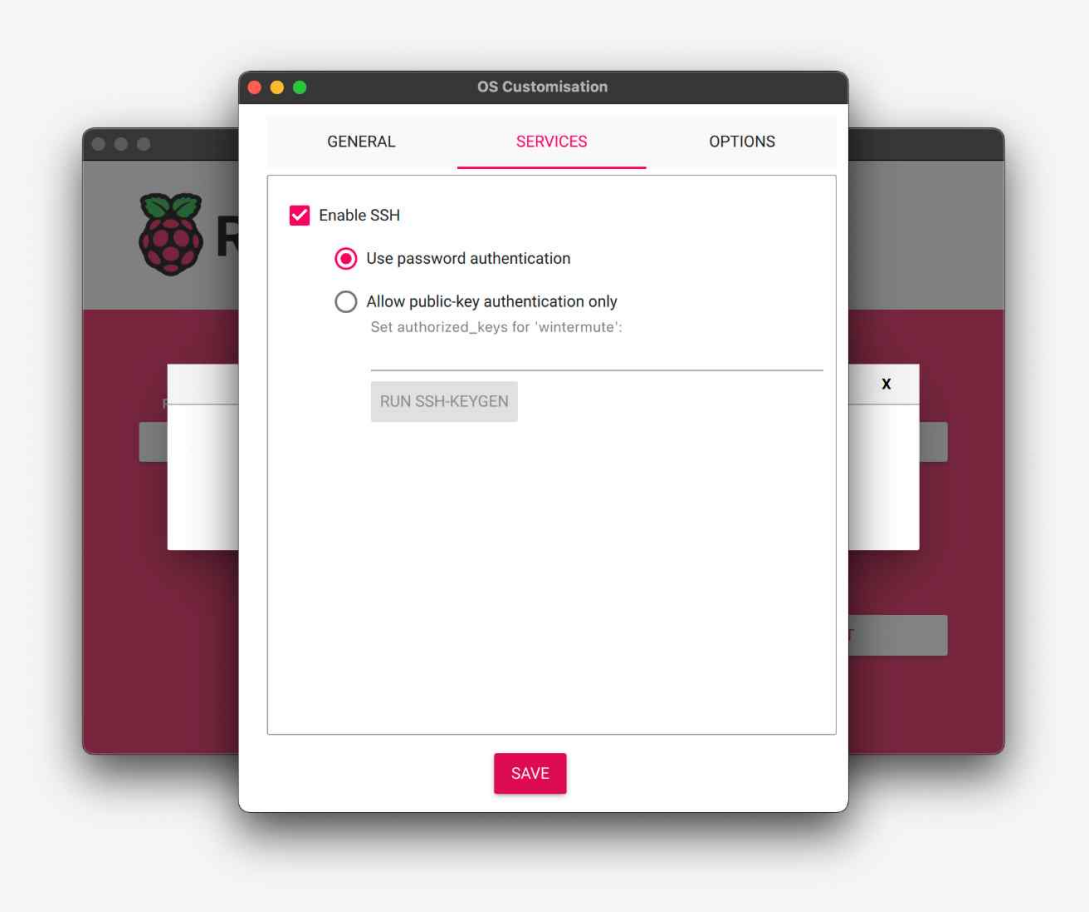


Install an operating system (Method 1)

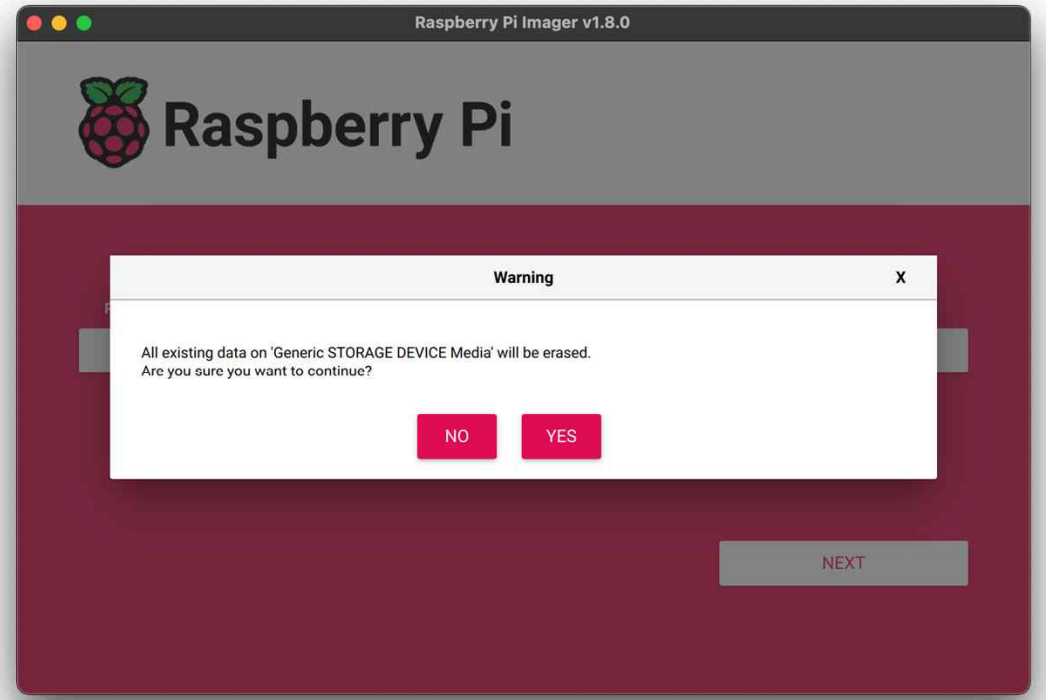




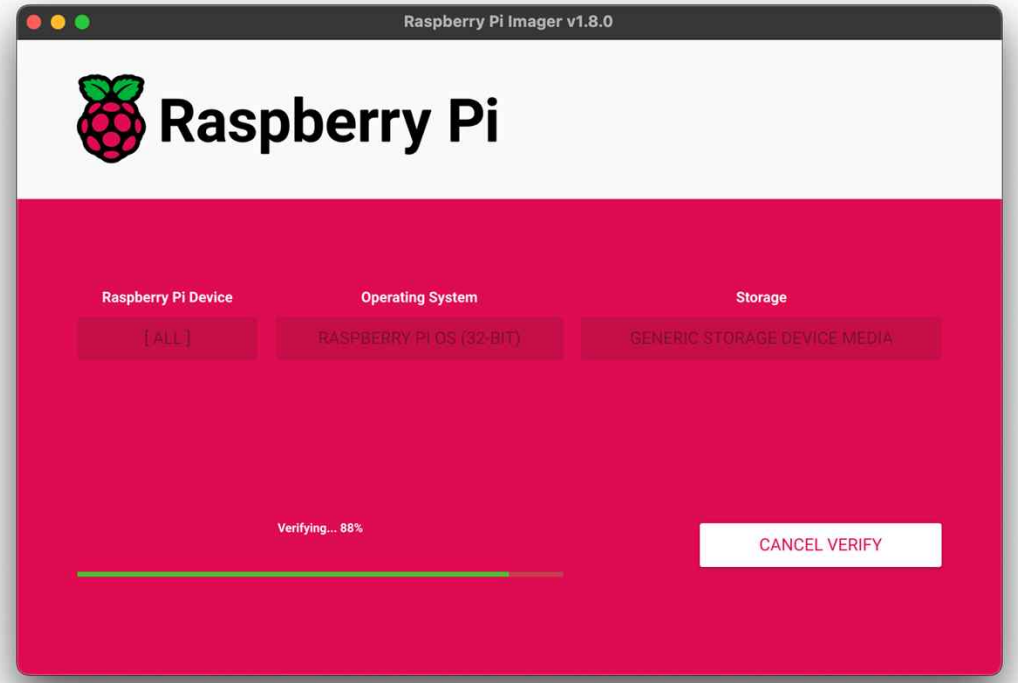
Install an operating system (Method 1)

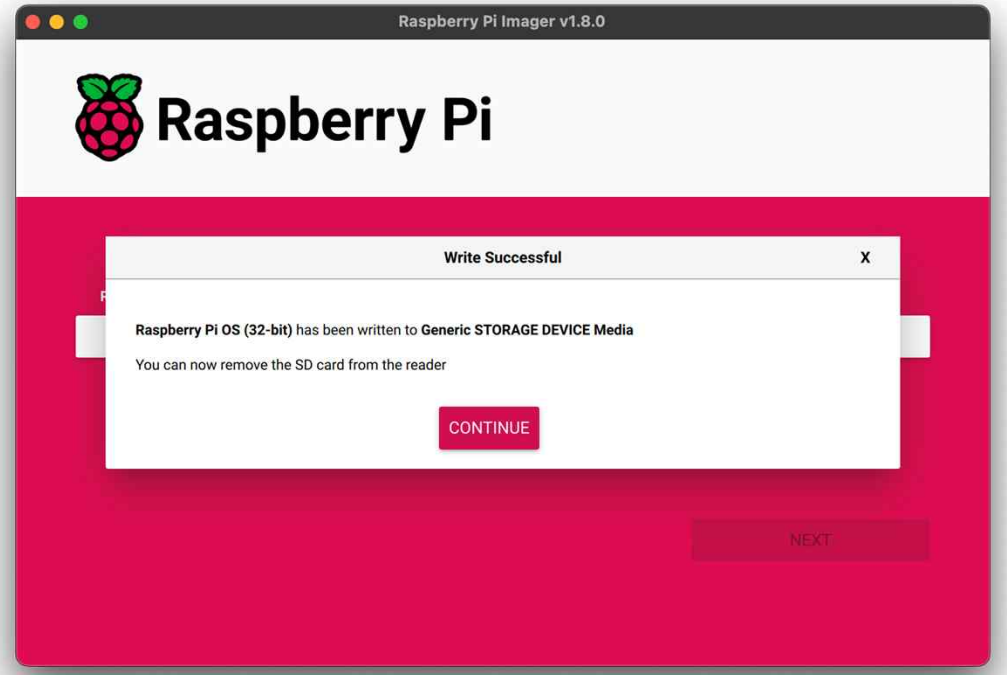


Install an operating system (Method 1)



Install an operating system (Method 1)

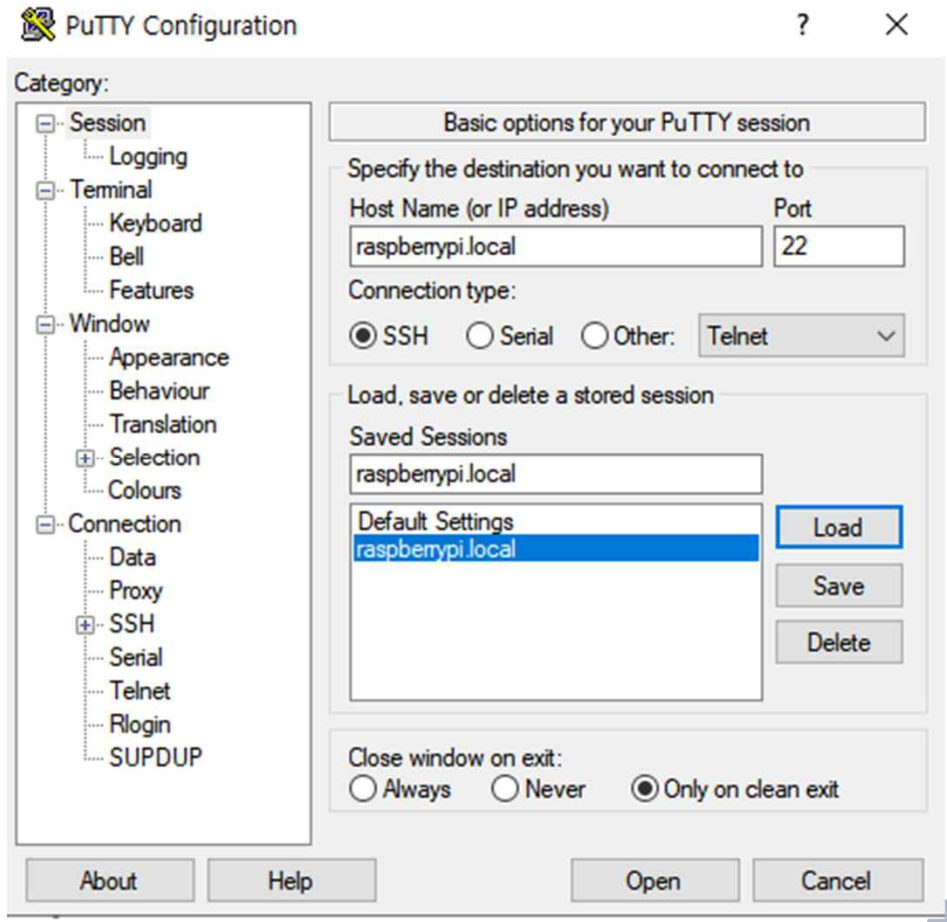




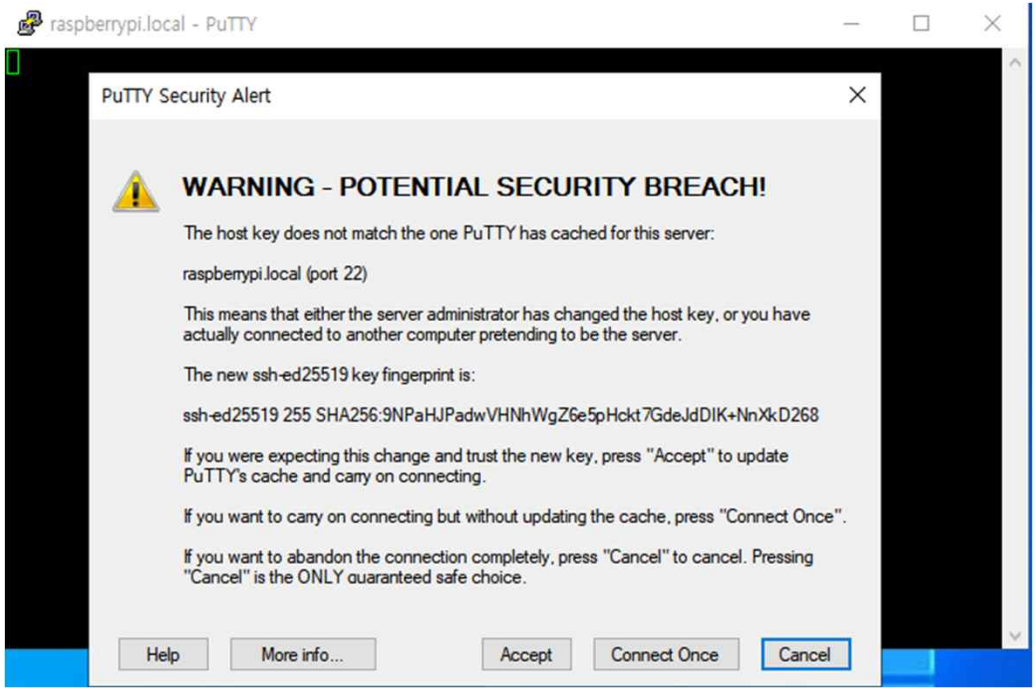
Install an operating system (Method 1)

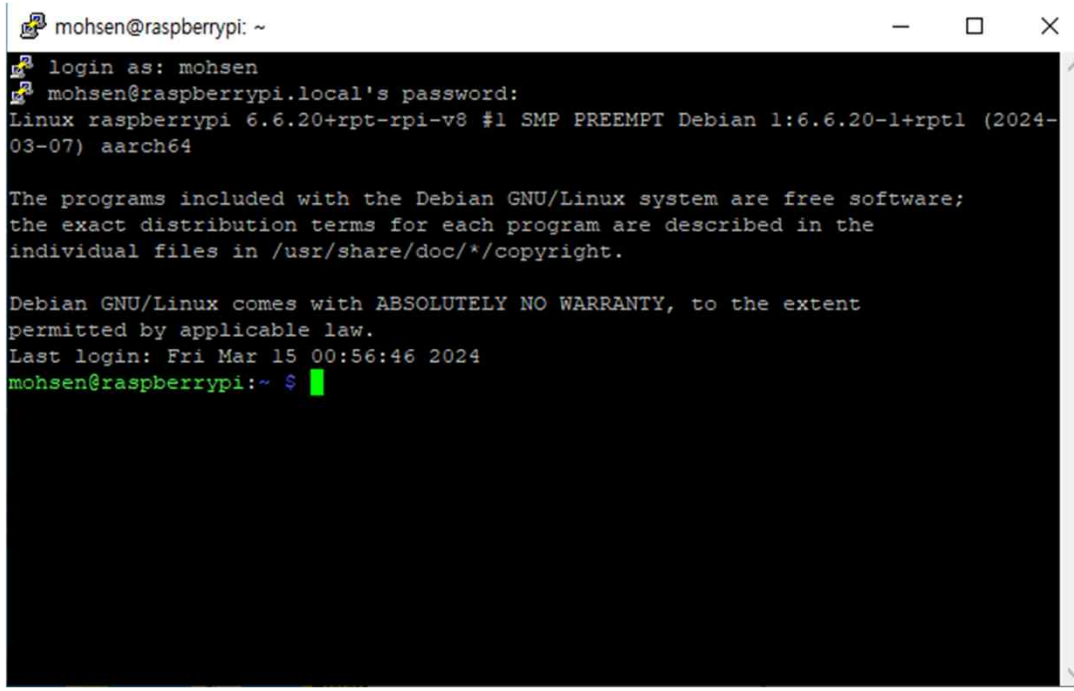
1- Install **RealVNC** Viewer
2- Install **Putty** software
3- Connect the Ethernet Cable from Raspberry Pi to the computer.

4- Connect to Raspberry Pi using Putty SSH.
You will need:
>> Host name
>> ID, and password



Install an operating system (Method 1)



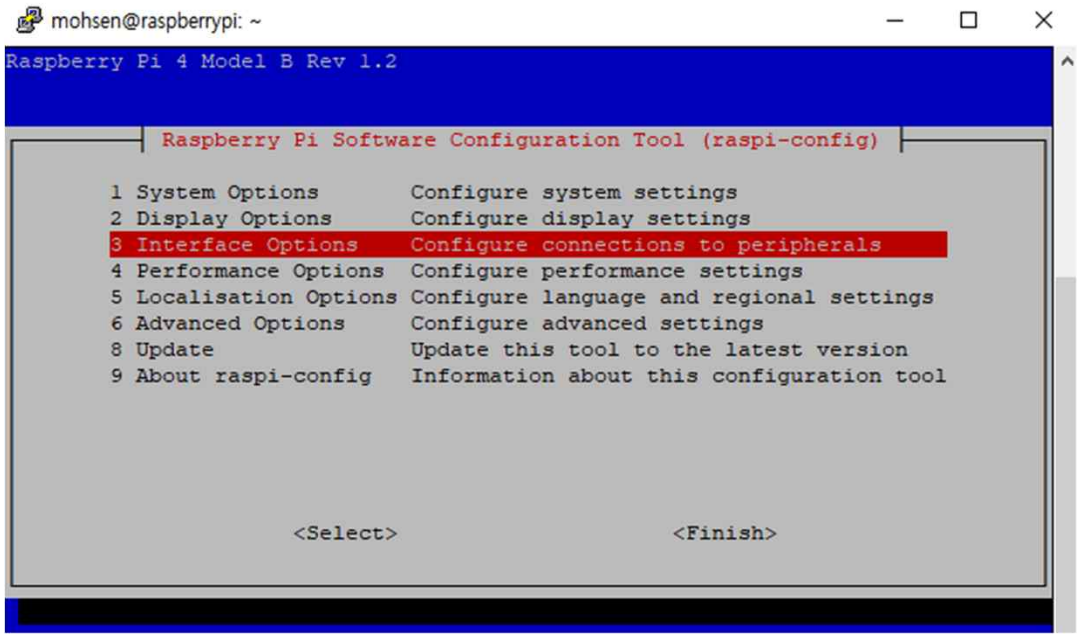


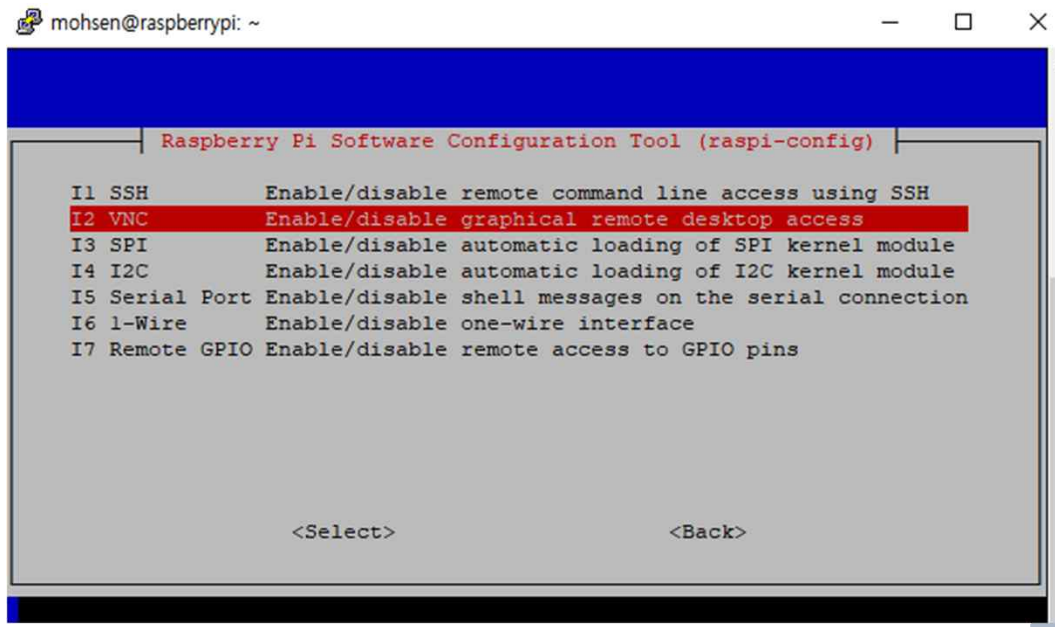
Install an operating system (Method 1)

For first time:

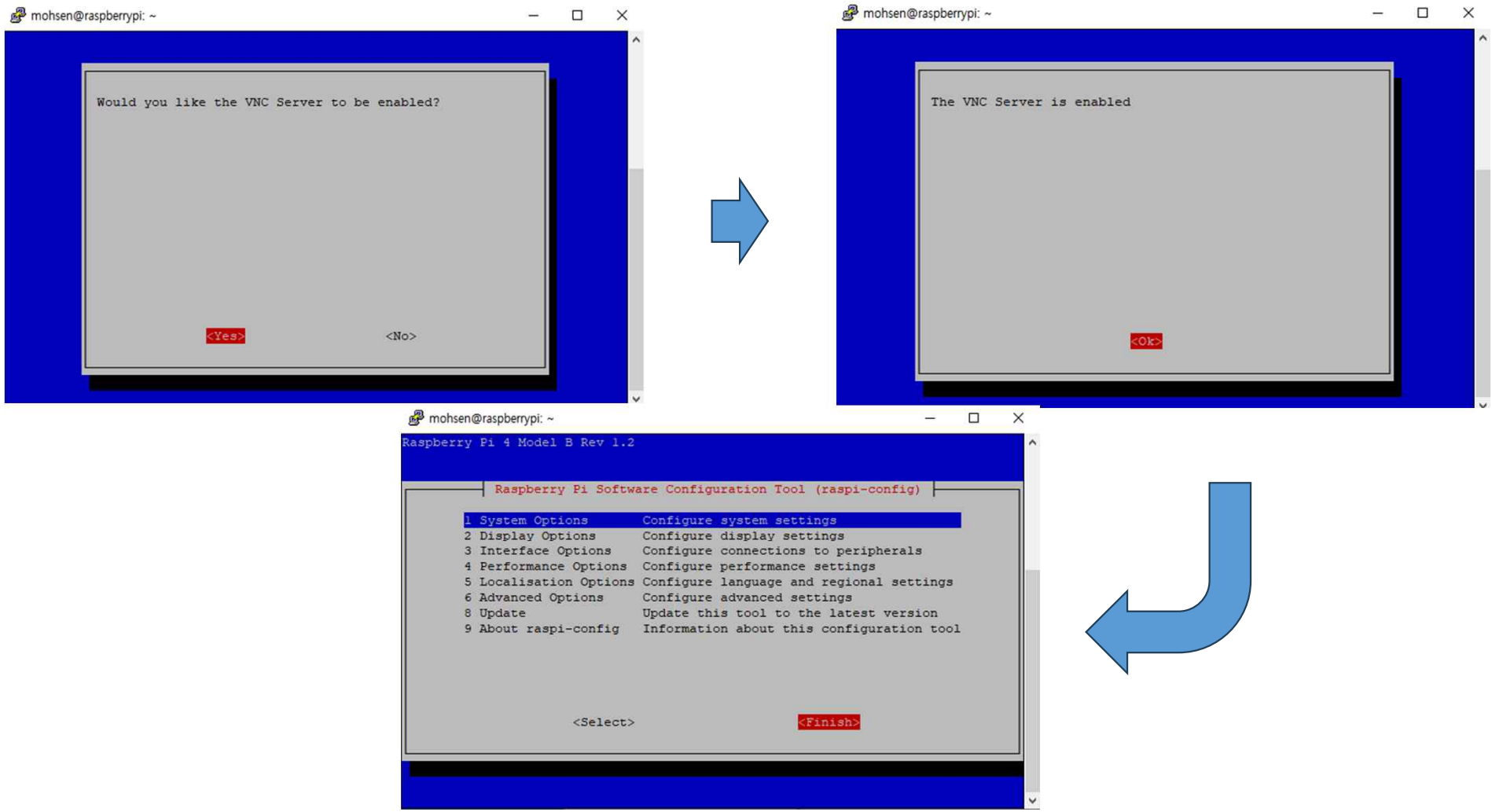
Setting up the VNC server configurations on your computer

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

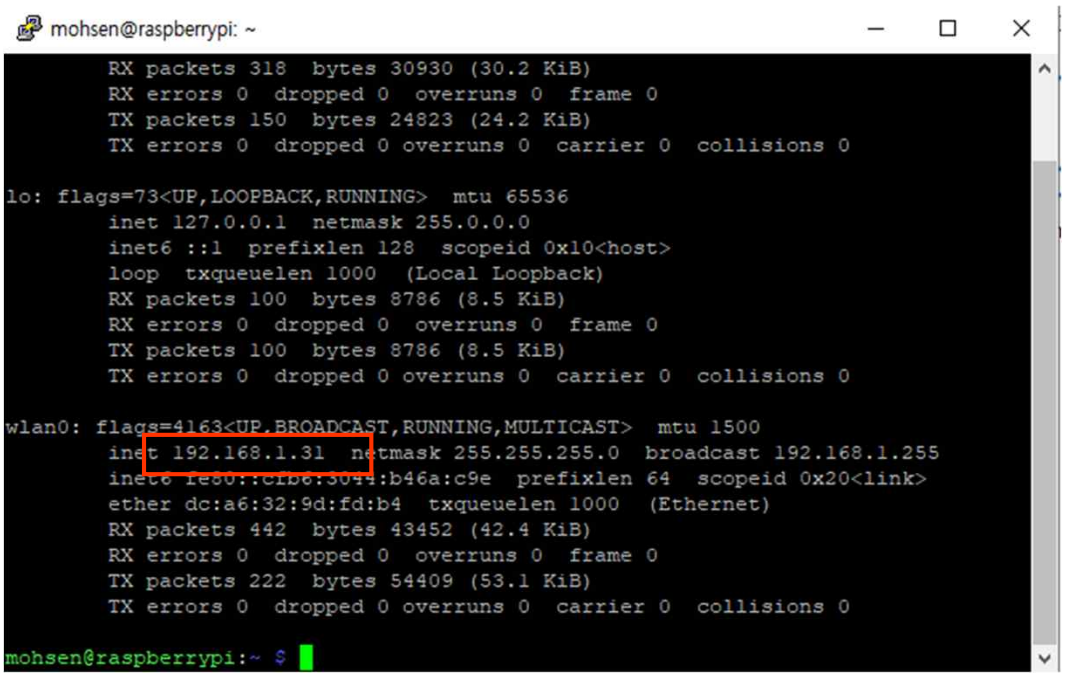




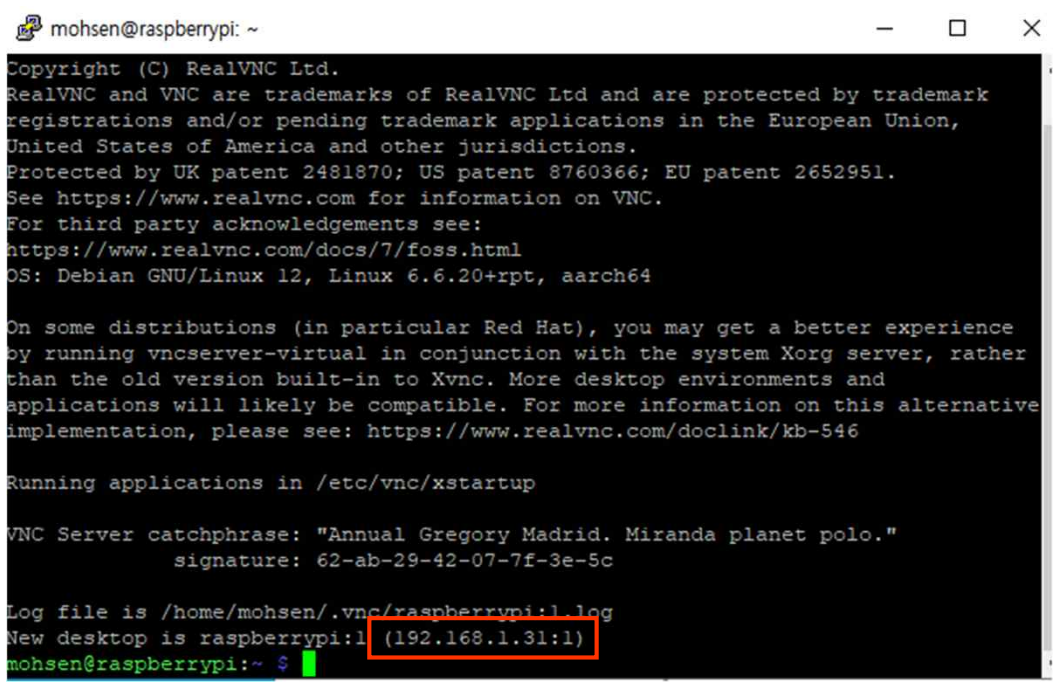
Install an operating system (Method 1)



Install an operating system (Method 1)

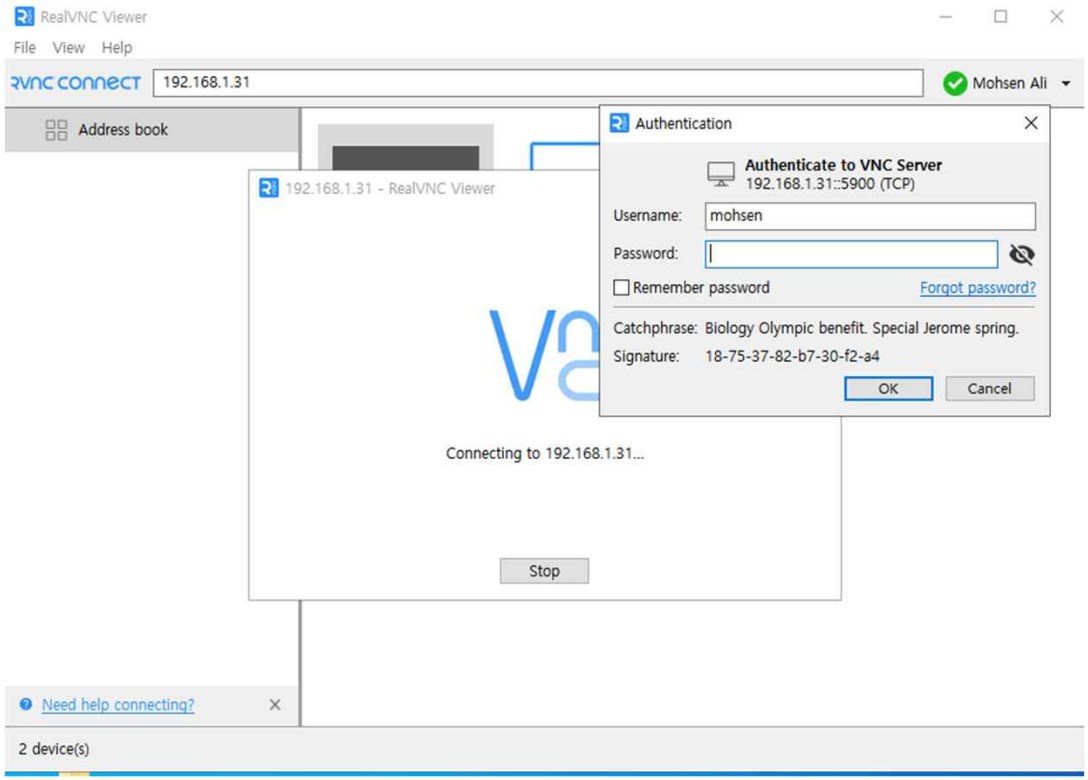


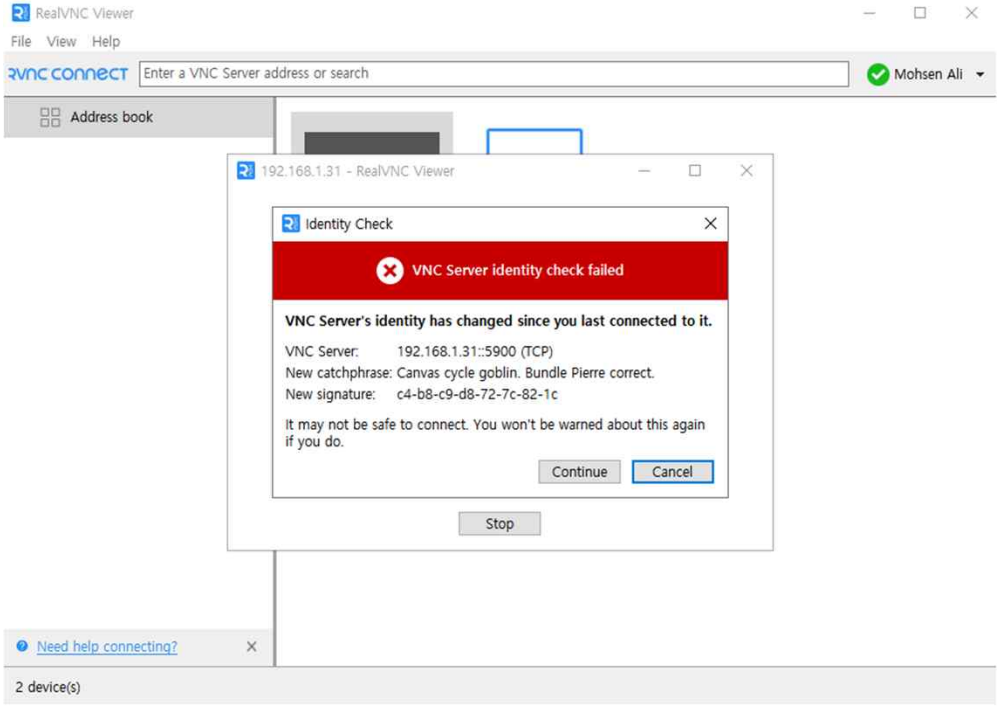
ifconfig



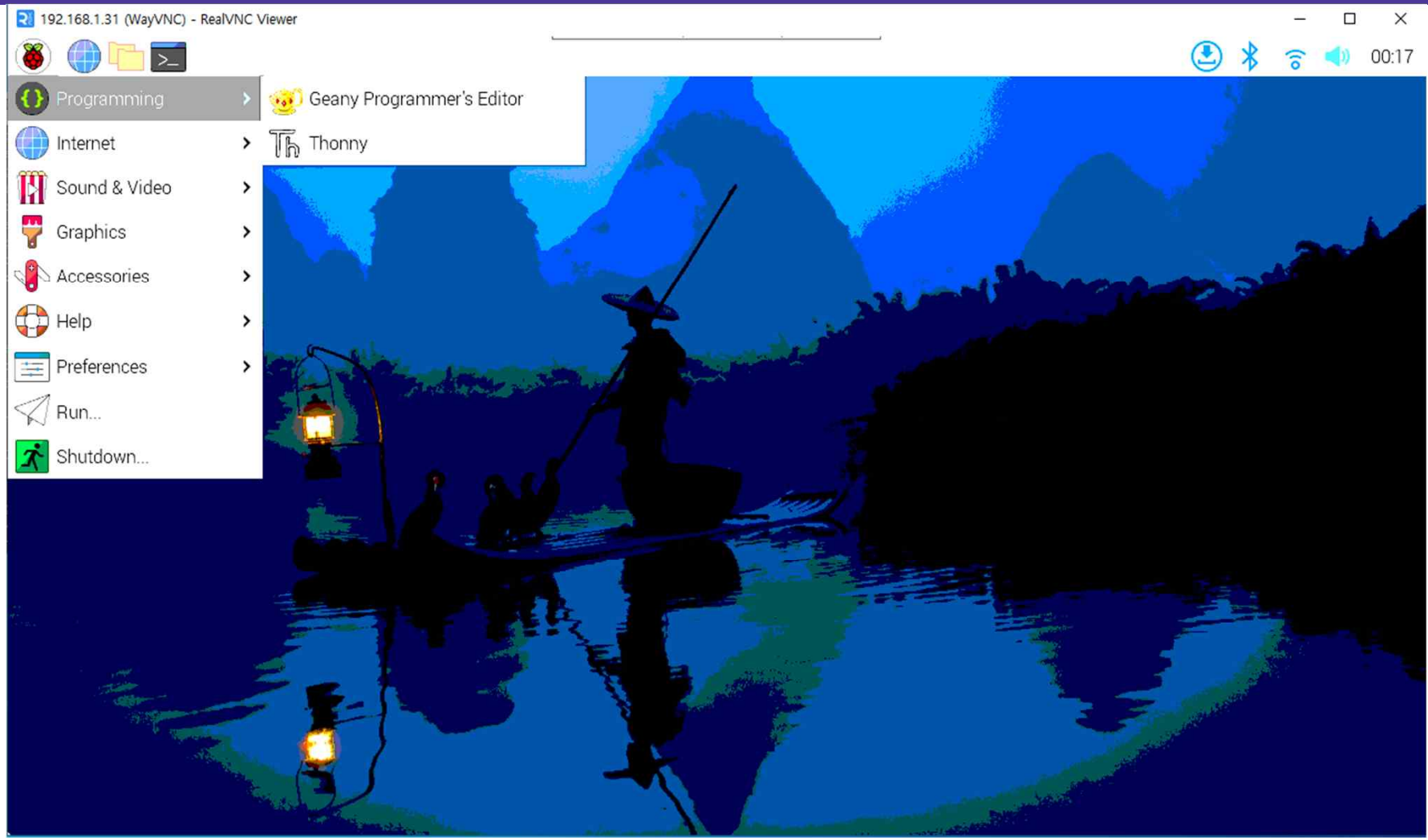
vncserver-virtual

Install an operating system (Method 1)

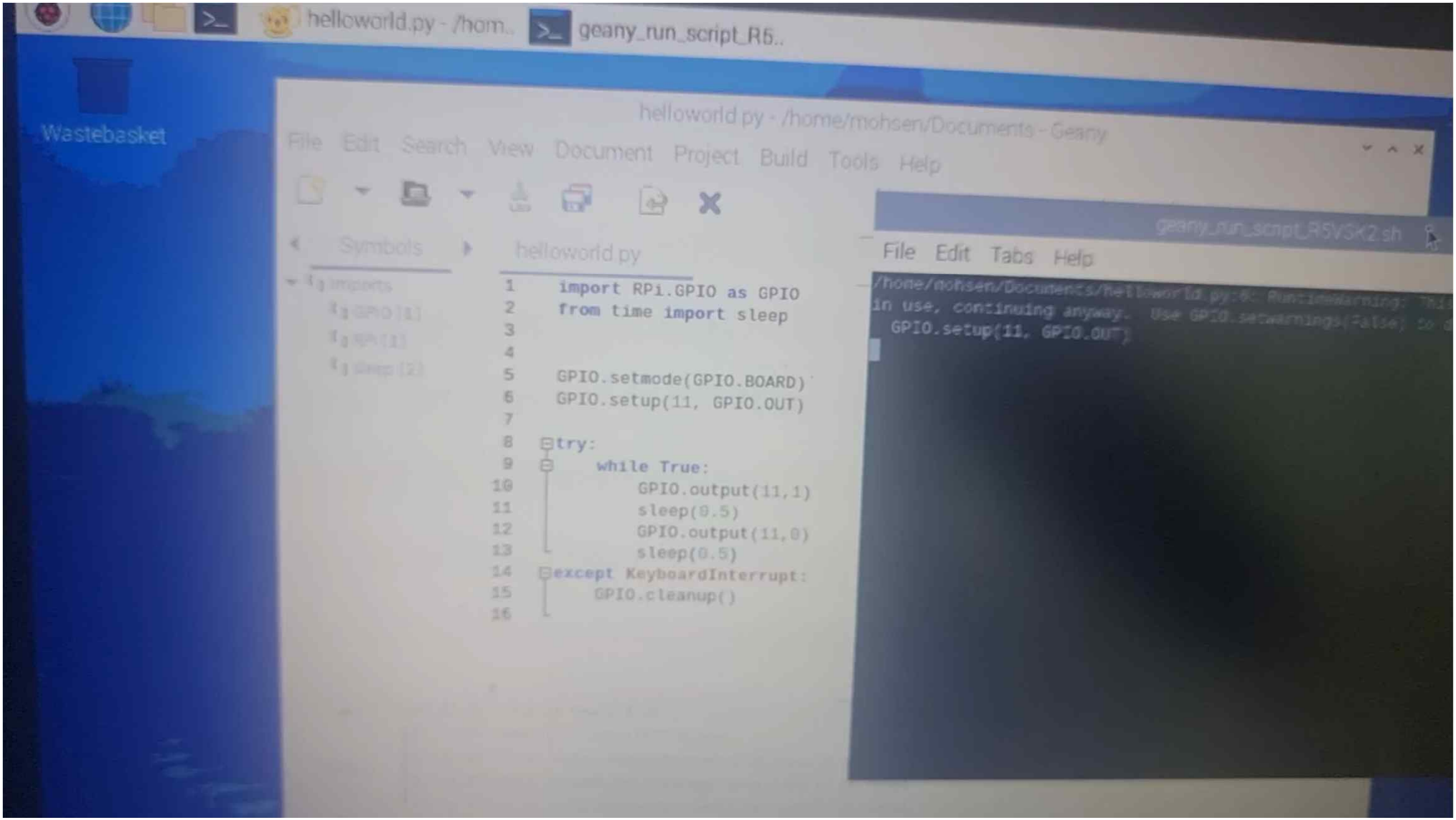




Install an operating system (Method 1)



Led Blinking Experiment (Demo)



Install an operating system (Method 2)

1. Go to Wyliodrin Studio Website
2. Download Wyliodrin 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 Wyliodrin STUDIO is to download an image that is already configured.

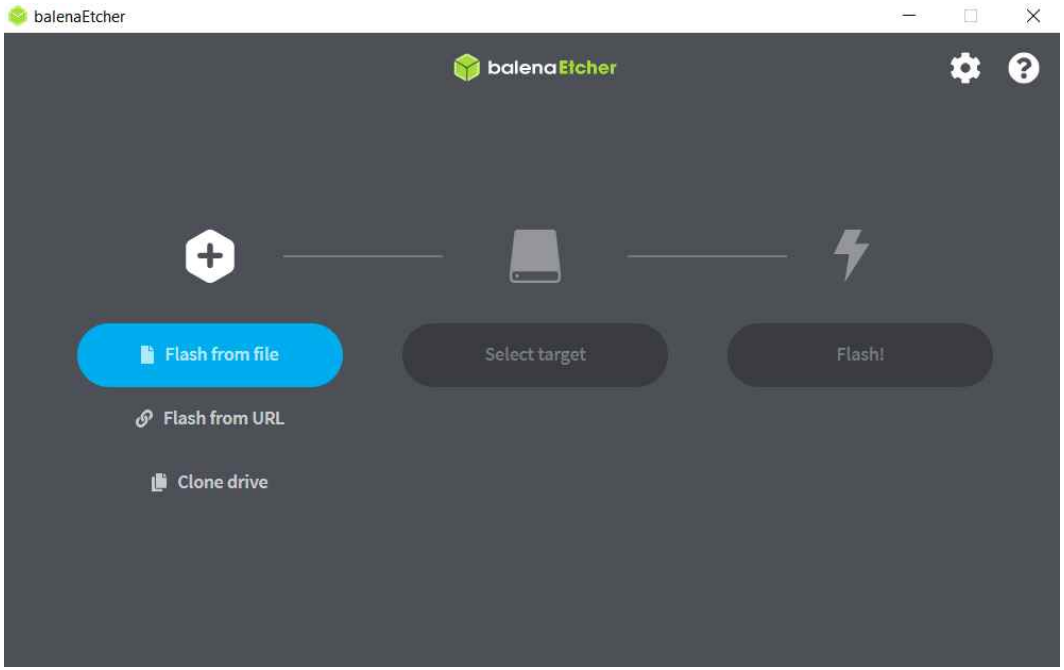
Download the image for Raspberry Pi Zero and Raspberry Pi 1.

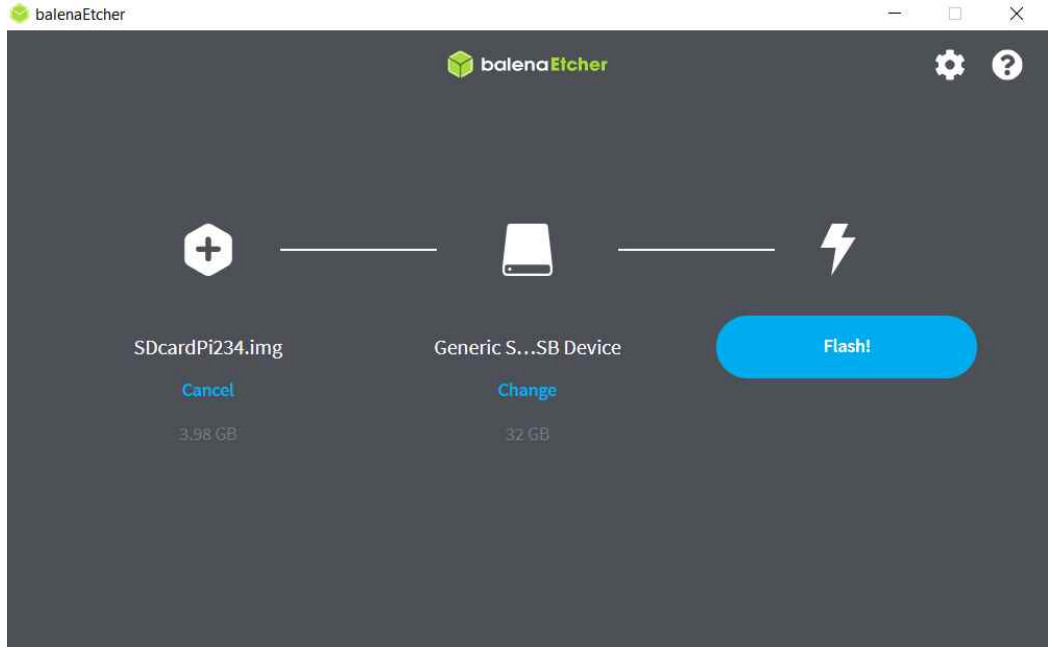
Download the image for Raspberry Pi 2, Raspberry Pi 3 and Raspberry Pi 4.

Once the image downloaded and unziped, 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 Wyliodrin STUDIO.

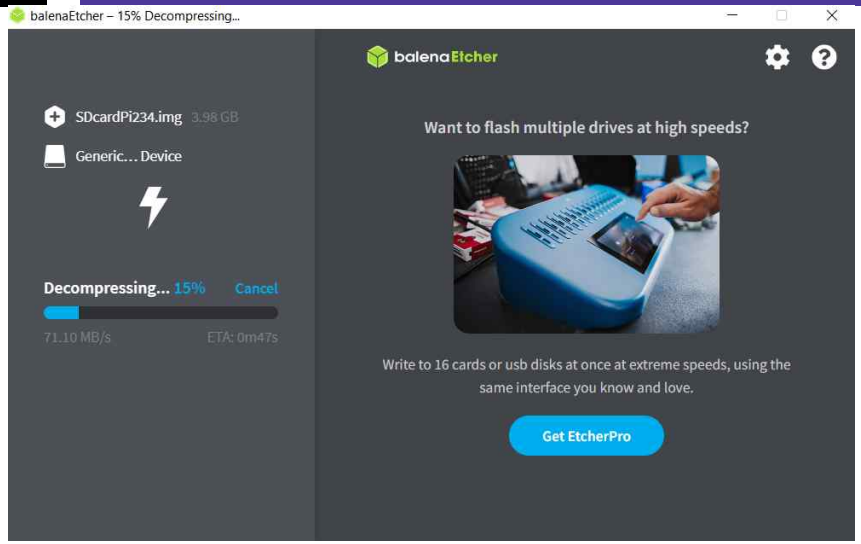
Install an operating system (Method 2)

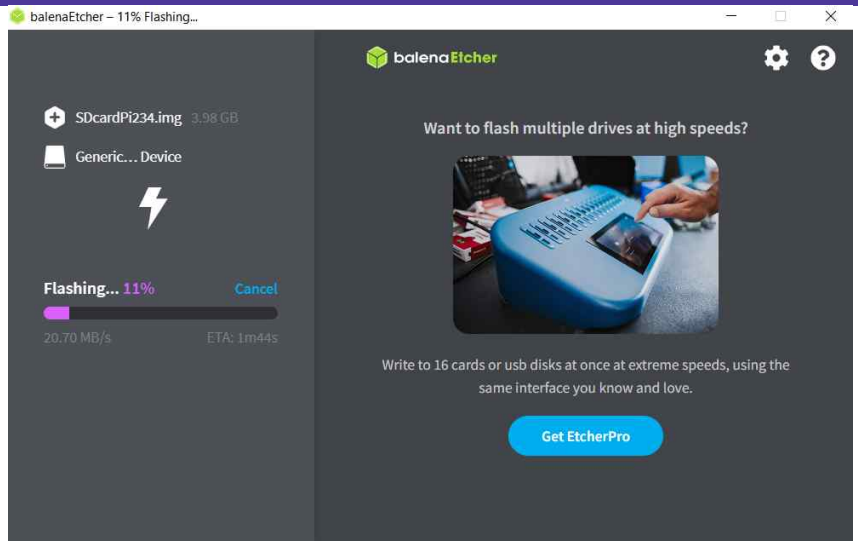
2. Download Etcher and start flash the Raspberry Pi OS to the SD card .

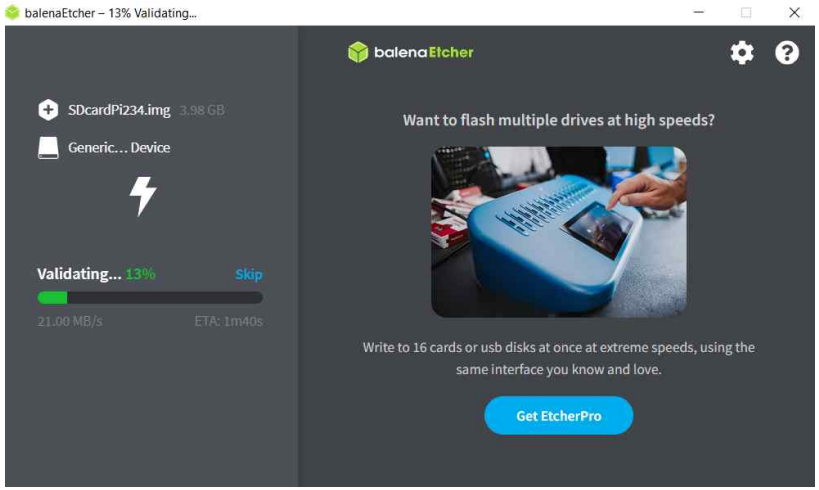




Install an operating system (Method 2)

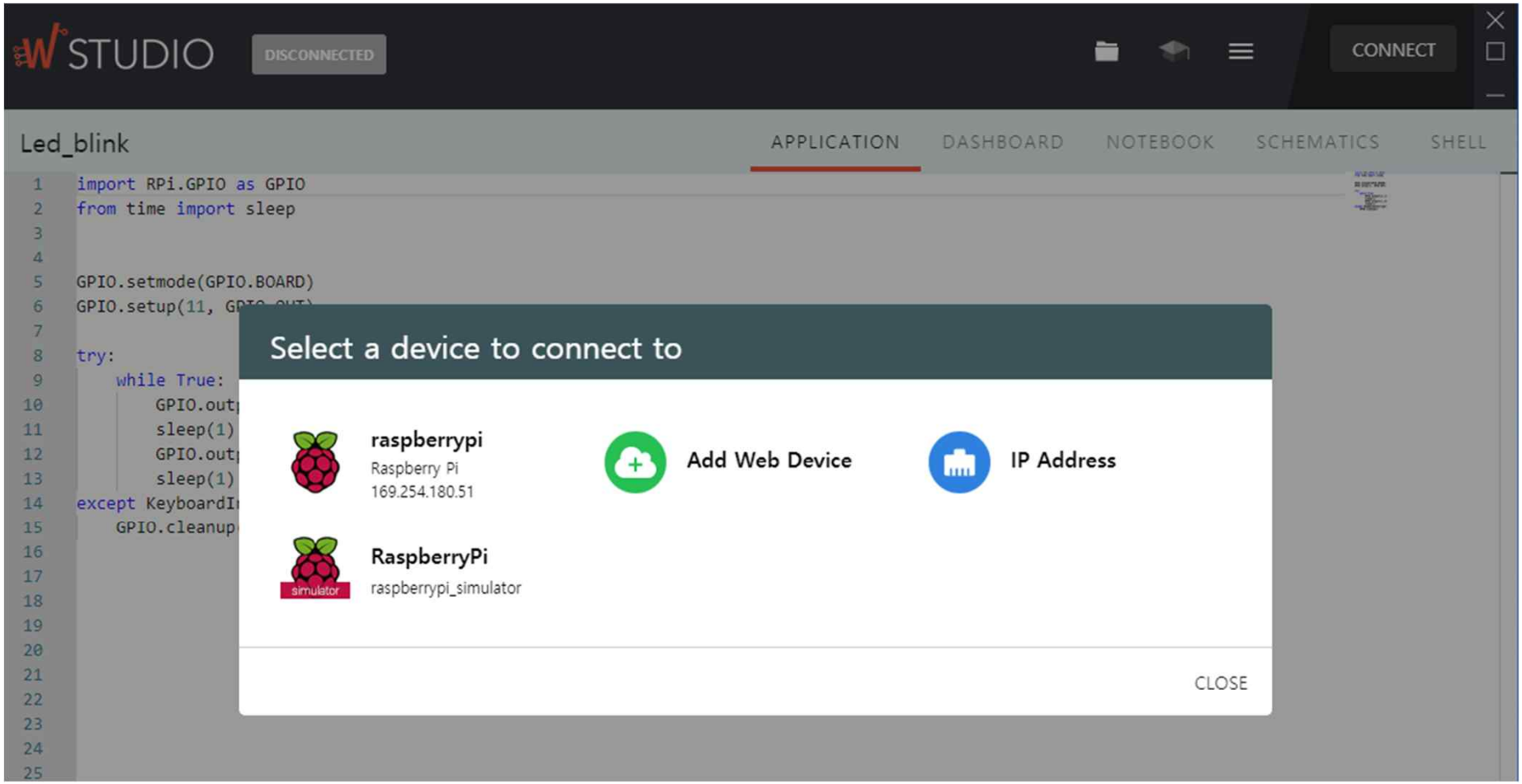






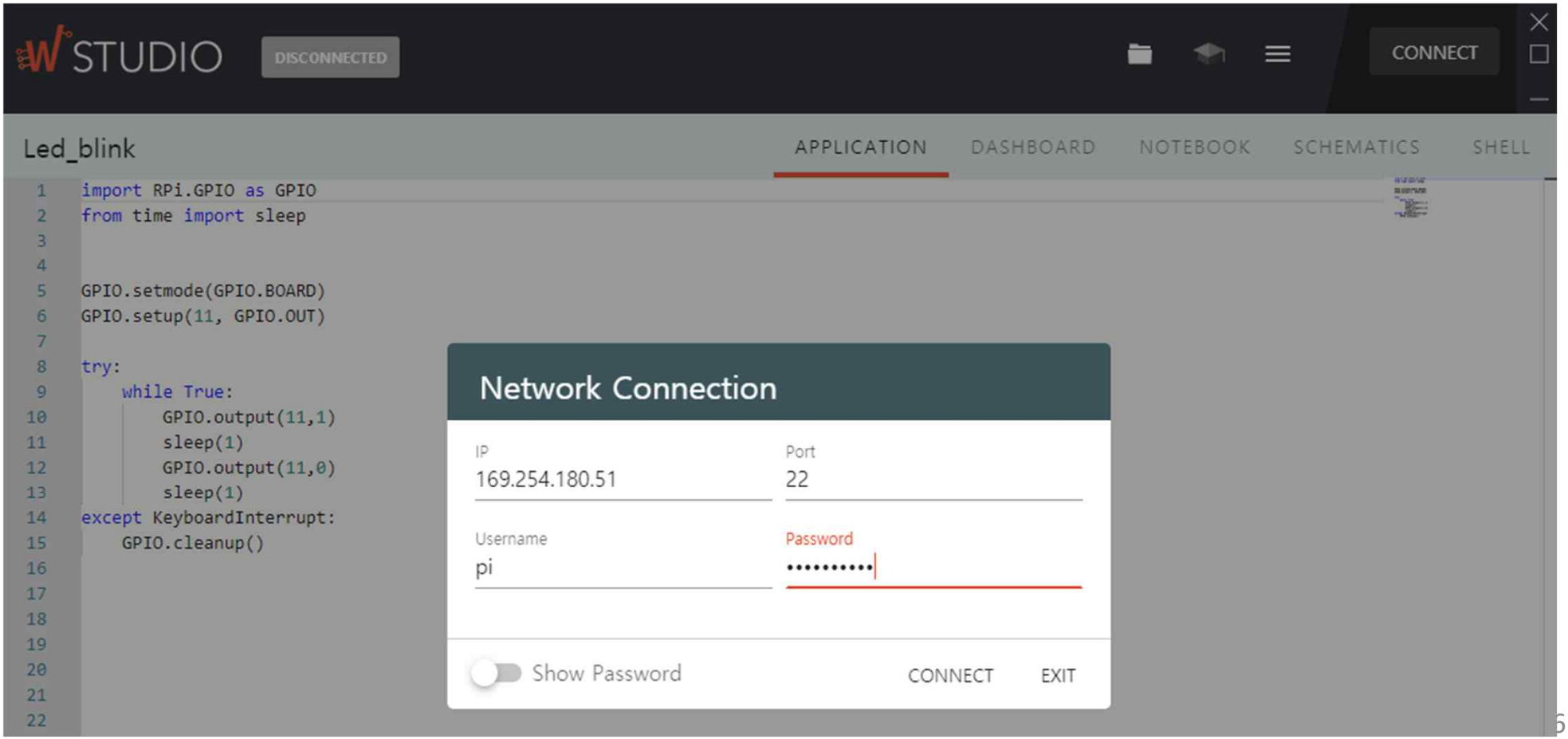
Install an operating system (Method 2)

3- Connect the Raspberry Pi to the computer using Ethernet cable. Select "Connect" in Wyliodrin.



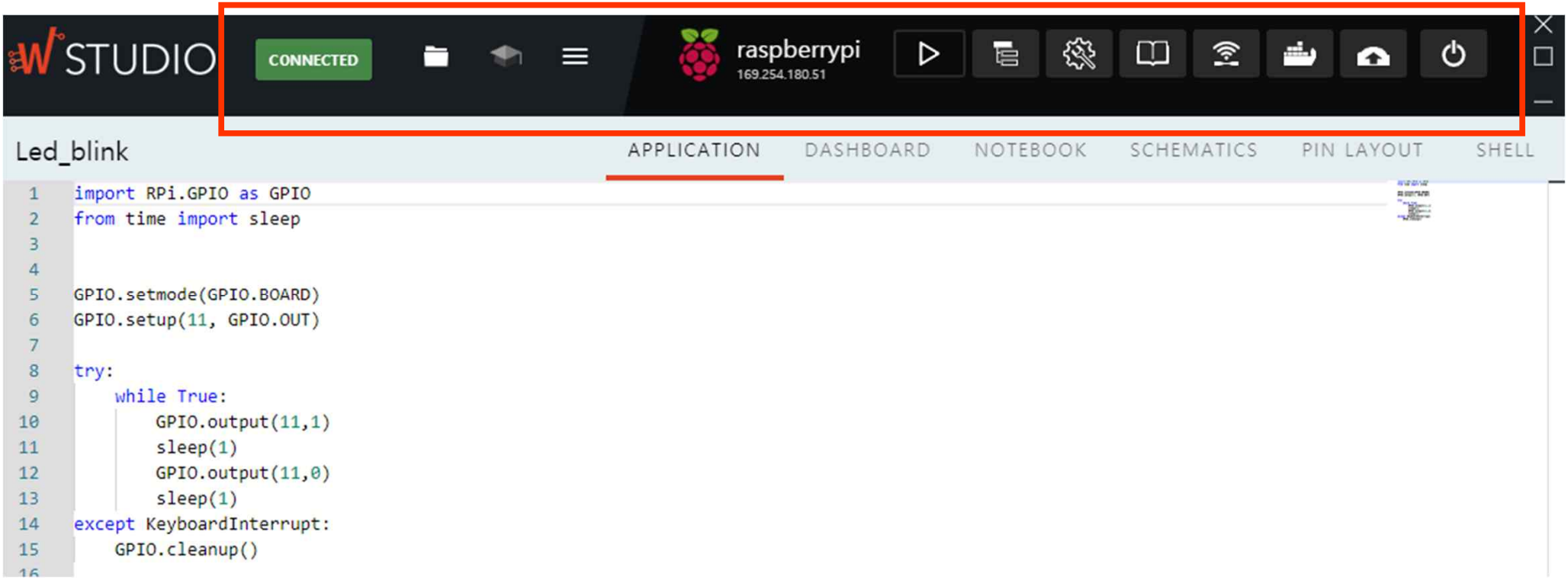
Install an operating system (Method 2)

Enter your credentials: ID: pi, Password: raspberry



Install an operating system (Method 2)

Finally, CONNECTED!



Any Questions!