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IOT DEVICE CONFIGURATION AND MANAGEMENT

Agenda

Microcontrollers and Microprocessors

IoT Device Configuration with RPi or Microprocessor

Programming in RPi IDE and Arduino IDE

Practical Exercise on IoT Device Configuration with RPi or Microprocessor

Homework Assignment

For support, contact: 8174861281, email: mpfittiitd@gmail.com

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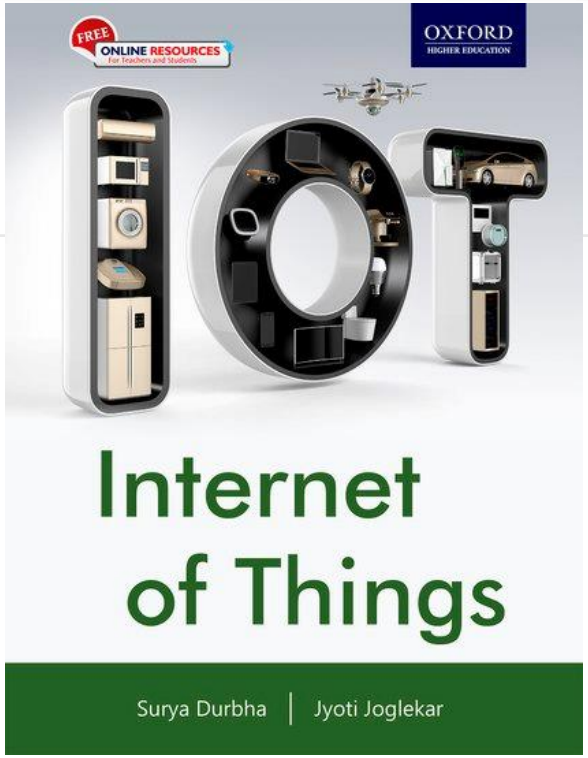

Recommended Book

https://www.amazon.in/Internet-Things-Surya-Durbha/dp/0190121092/ref=cm_cr_arp_d_bdcrb_top?ie=UTF8

Components

Category	Name	Link	Price	Optional
Microcontroller Microprocessor	Arduino Uno	https://robu.in/product/arduino-uno-r3/	583	
	Raspberry Pi	https://robu.in/product/raspberry-pi-desktop-kit/	5000	Optional
	ESP 32	https://www.electronicscomp.com/esp32-development-board-with-wifi-bluetooth-india?gad_source=1&gclid=CjwKCAiAkp6tBhB5EiwANTCx1Izl7nA92kGcQ9uYs9iVWVQ1HECWt3quTOa6jJnKmp_Xp6FlzeKccBoCnTYQAvD_BwE	345	
	Bharat pi	https://bharatpi.net/shop/	800-3000	Optional
Sensor	Sensors for Arduino	https://www.electronicscomp.com/37-in-1-sensor-module-kit-for-arduino?gad_source=1&gclid=Cj0KCQiAnfmsBhDfARIsAM7MKi2HKnCEAM8UyrOfLHAa50G1DGiYyMMORHKKipI5z2I1-7IfeyOcwtYaAkyUEALw_wcB	899	

Components

Category	Name	Link	Price	Optional
Camera	Raspberry pi camera	https://robu.in/product/raspberry-pi-camera-v2/?gad_source=1&gclid=Cj0KCQiAnfmsBhDfARIsAM7MKi2pPGRhotm26IT58y7jZxJOf9TWiMQ1HdXW3q9tlSos3RSMcrTo-jUaAvlzEALw_wcB	1999	Optional
Electronic kit	Basic electronic kit	https://www.sunrobotics.in/shop/2047-electronic-component-kit-v3-0-1562?srsltid=AfmBOoovIw4fcDmlU6eWVVmu3355__I7q8Uh8d5tyHHDdNECBARoirYq4rY#attr= (Module consists of breadboard, jumper wires, thermistor, potentiometer, resistor, capacitor, LED, sensor, etc.)	454	
Power	Power supply	https://robu.in/product/orange-5v-1a-power-supply-with-5-5mm-dc-plug-adapter/?gad_source=1&gclid=CjwKCAiAkp6tBhB5EiwANTCx1HrdRksm8imURA1OrlHHG-d3_vXm7TEo5jFkJJOOOlxn1h6-lpUzEBoCOioQAvD_BwE	169	

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Microcontrollers and Microprocessors

Microcontroller

- A microcontroller is a compact integrated circuit combining essential components for processing and controlling electronic systems.
- It acts as the brain, memory storage, and interface hub, making it a fundamental component in numerous applications.
- Microcontroller is a central unit for embedded system
- Arduino is one type of microcontroller which we will study.

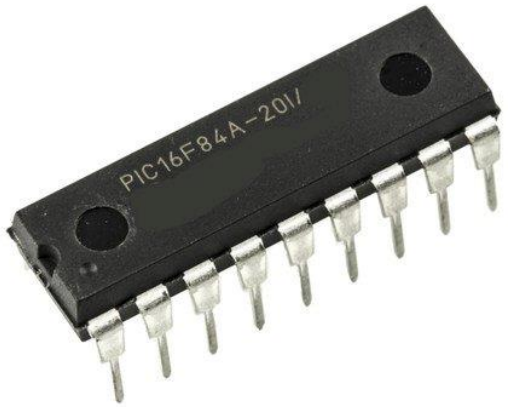

Fig. 1: Microcontroller
Source: PCBTok

Components of Microcontroller

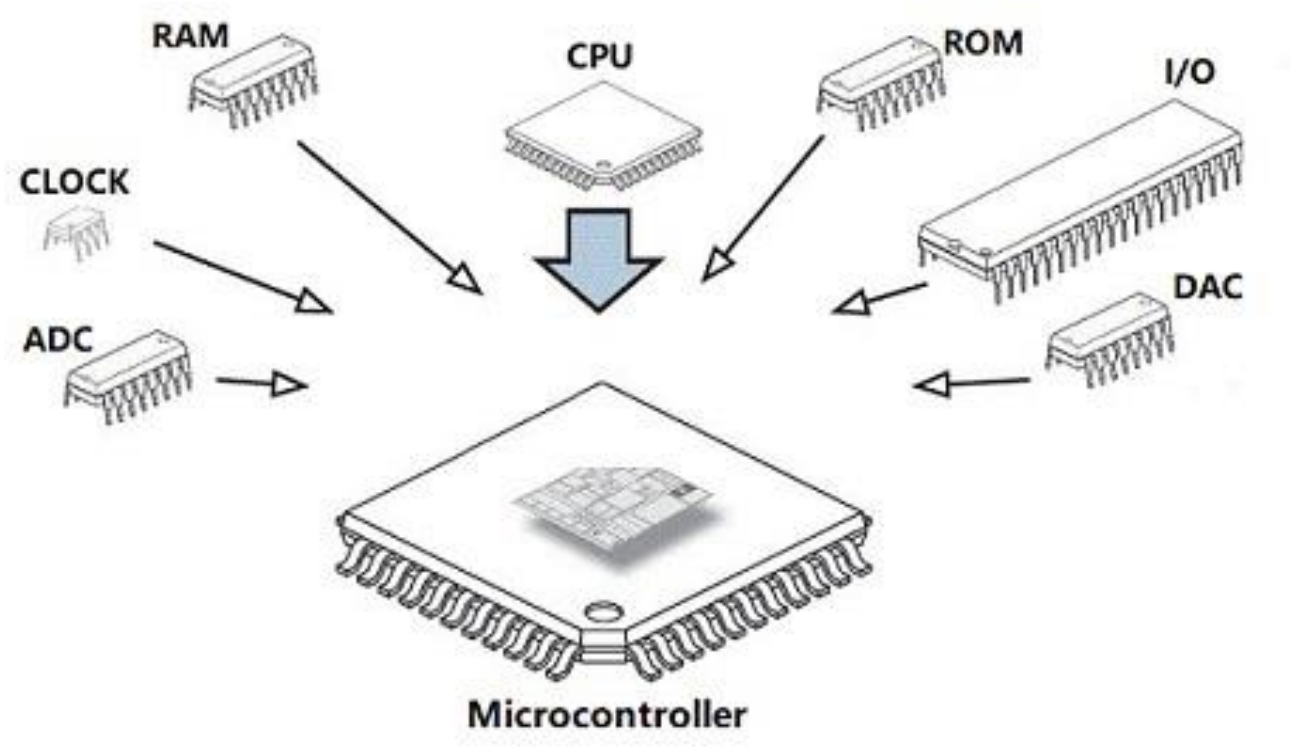

Fig. 2: Components of Microcontroller
Source: https://www.apogeeweb.net/article/58.html

CPU

- It is the part of the board that processes and executes instructions.
- CPU performs task with the registers and memory.
- The CPU has an instruction register that holds the instructions to be executed.
- It has one or few data registers where data can be loaded or stored during execution
- It has a stack register too

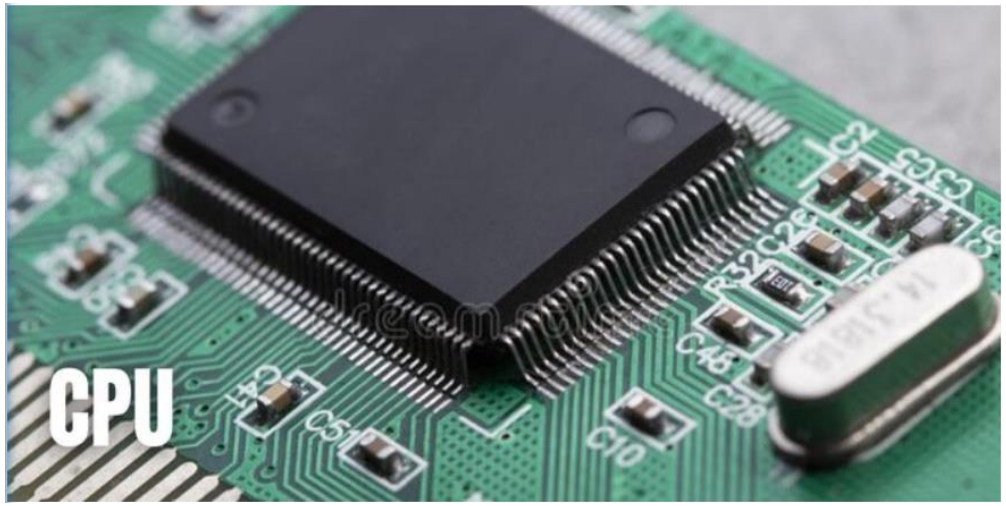

Fig. 3: CPU
Source: PCBTok

Memory

- Microcontroller uses memory to store instructions and data
- The amount of memory a microcontroller has is based on how much information it can hold at a time
- Memory is divided into:
  - Program memory
  - Data memory

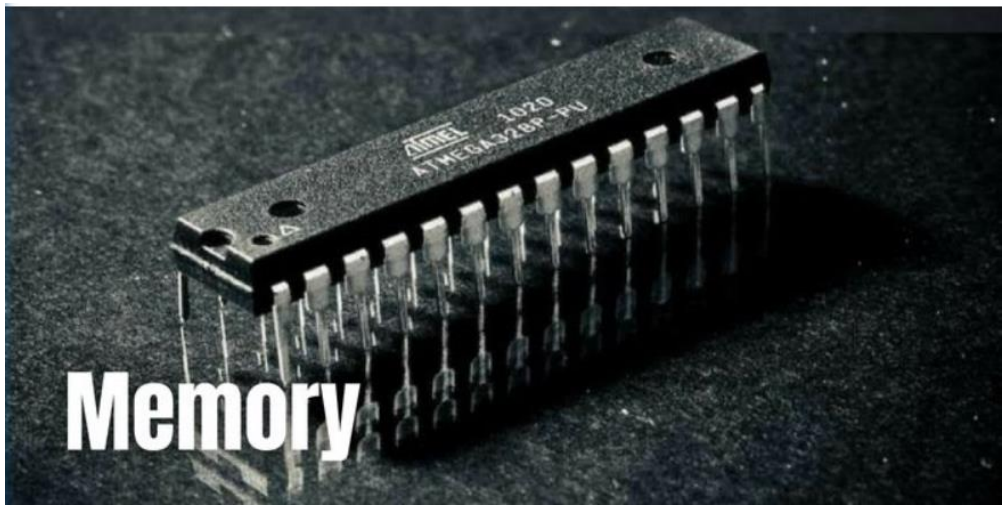

Fig. 4: Memory
Source: PCBTok

I/O Peripheral

- These are the devices that connect to your computer and lets you interact with those devices
- If we want mouse or keyboard, it connects through I/O peripherals

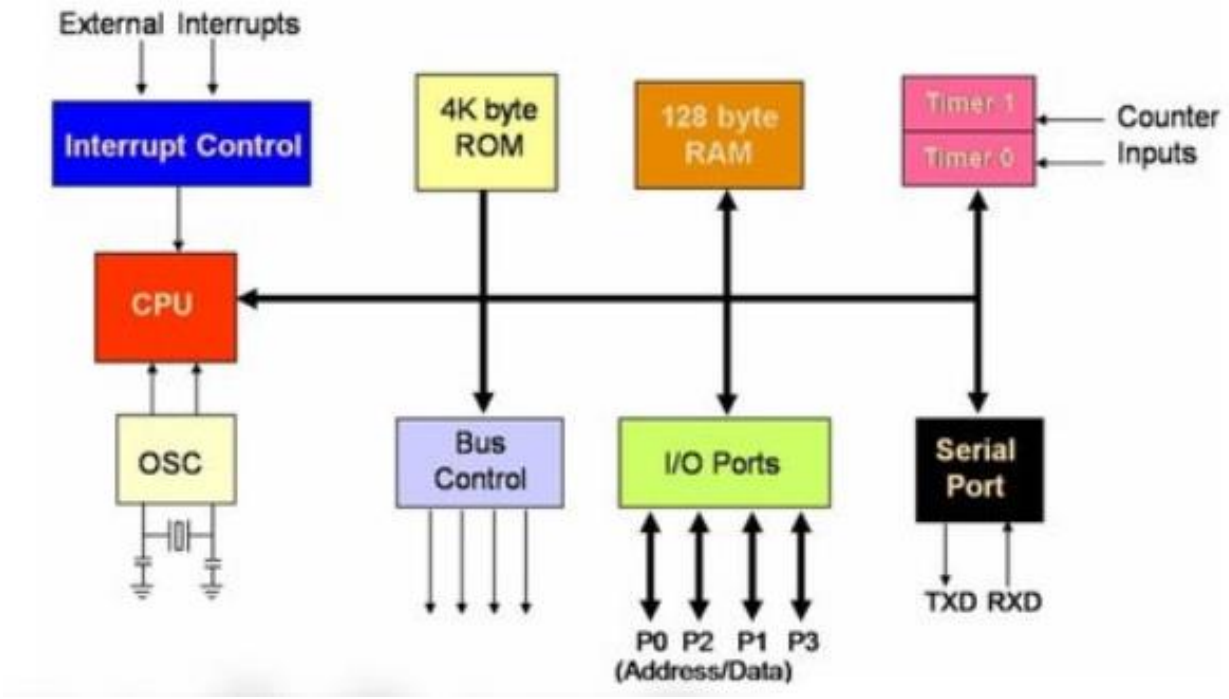

Fig. 5: I/O Peripheral
Source: PCBTok

Analog to Digital Converter (ADC)

- Analog to Digital Converter (ADC) is the key component of microcontroller.
- It takes the analog signals from the sensors like temperature, pressure, humidity, etc. and converts them into digital numbers

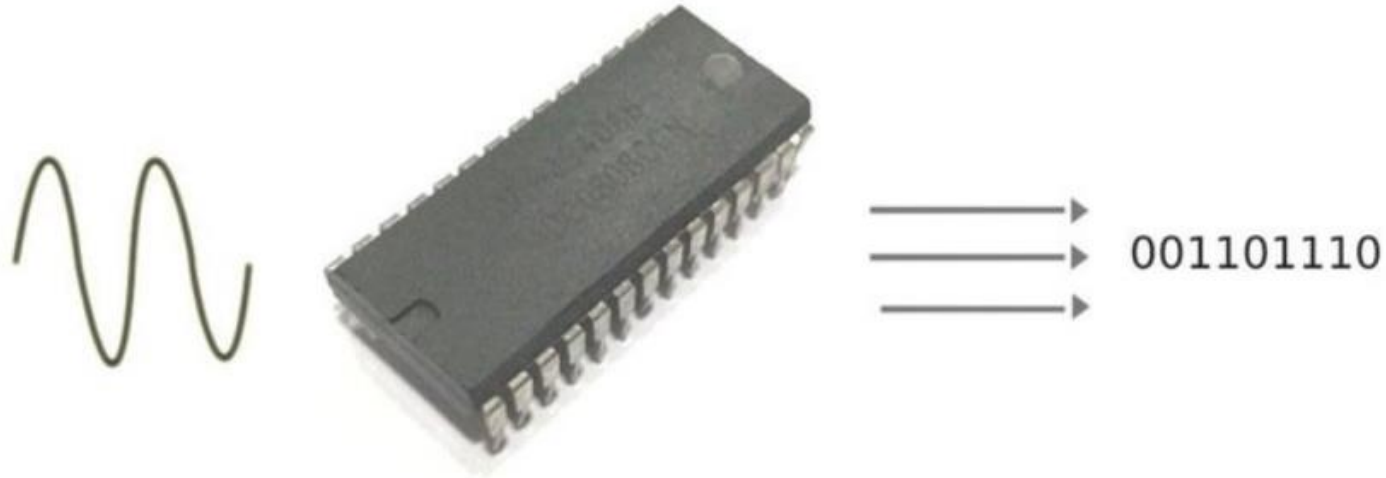

Fig. 6: ADC
Source: PCBTok

Temperature sensor - ADC

- A temperature sensor, such as a thermocouple, thermistor, or integrated temperature sensor, produces an analog signal in response to changes in temperature.
- The analog signal from the temperature sensor is sampled by the ADC at regular intervals. Each sample represents the sensor's output at a specific moment in time.
- The sampled analog signal is then quantized. This involves mapping the continuous range of analog values to digital values.
- The quantized digital values are converted into a binary format suitable for processing in digital systems.

Digital to Analog Converter (DAC)

- A digital to analog converter (DAC) is a component which converts digital bits to analog voltage levels
- A digital to analog converter in microcontroller is used to convert the integer values from user's keyboard into real continuous values that can control other component

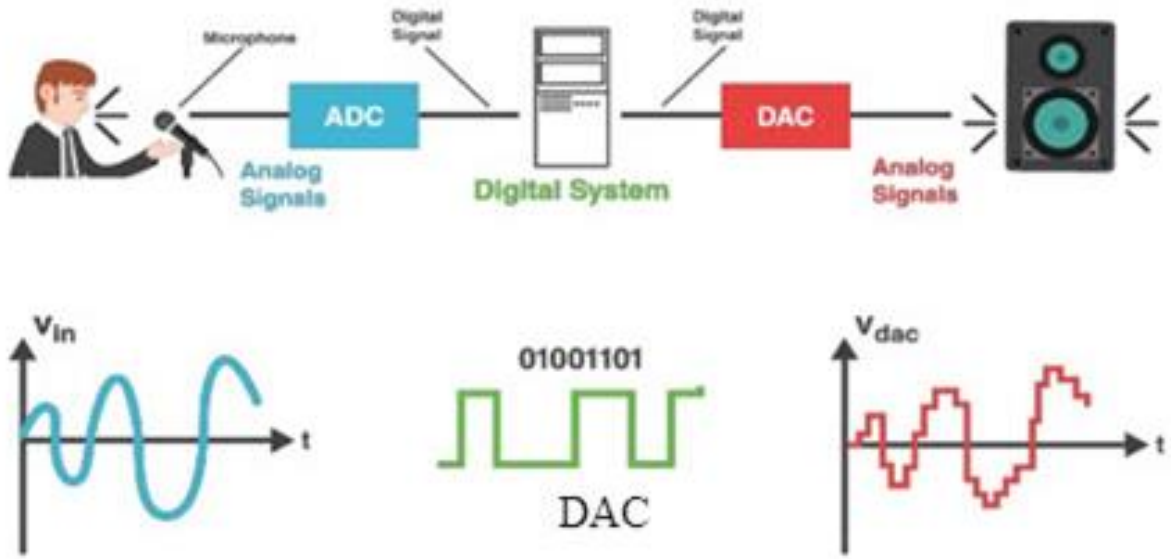

Fig. 7: DAC
Source: PCBTok

Camera sensor - DAC

- In a digital camera, the image sensor captures light and converts it into digital data.
- When you want to view or print the captured image, the digital image data needs to be converted into an analog signal. This is where a DAC comes into play.
- The output of the DAC results in an analog signal that represents the color and intensity of each pixel in the captured image.
- The analog signal from the DAC is used to control the brightness and color of each pixel on the display.

Microprocessor

- Microprocessors primarily consist of a CPU and memory, requiring external components for I/O and peripheral functions.
- Designed for general computing tasks, microprocessors power personal computers, servers, and other computing devices.
- Microprocessor is a central unit for personal computer
- Intel i7 is a type of microprocessor

Fig. 8: Microprocessor
Source: https://electrosome.com/microprocessor/

Components of Microprocessor

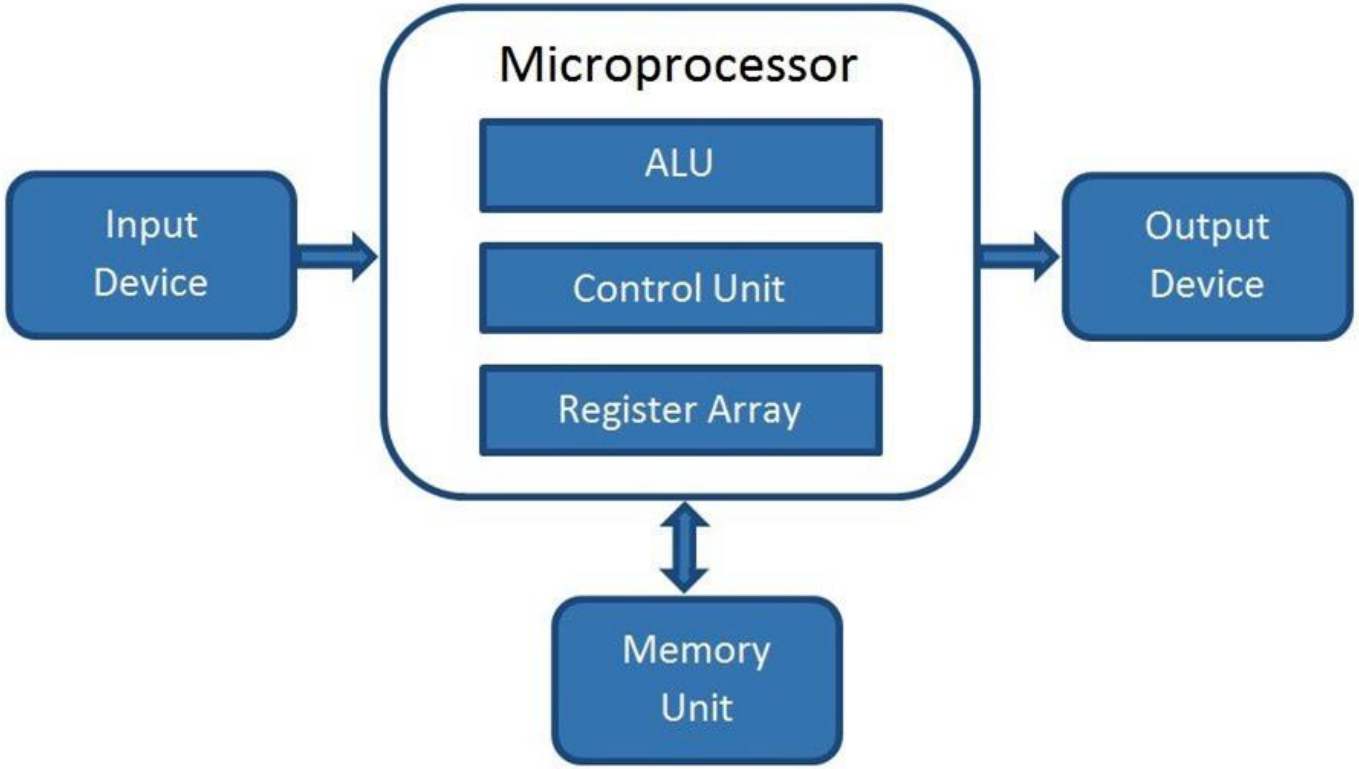

Fig. 9: Components of Microprocessor
Source: https://electrosome.com/microprocessor/

Components of Microprocessor

- ALU (arithmetic logic unit) performs both arithmetic and logical operations. Arithmetic operations such as addition, subtraction, multiplications, divisions, and logical operations such as NOR, AND, NAND, OR, XOR, NOT, XNOR, etc.
- The control unit is used to control the instructions and it generates the signals to operate the other components.
- Registers that are used by the programmer to store arbitrary data are known as general-purpose registers and the registers which are not used by a programmer to store the data are known as the reserved registers. The length of the register is known as the word length of the computer.

Working of Microprocessor

- To get the output, the first microprocessor fetches the instructions from the computer memory and then decodes it and executes those instructions as a result in a binary form. The power of the given microprocessor is measured in terms of bits.

Fig. 10: Working of Microprocessor
Source: https://www.elprocus.com/microprocessor-generations-and-its-types/

Arduino

- Arduino is a popular open-source electronics platform with hardware and software.
- Arduino boards support functionalities such as reading input from sensors, or an electronic message, turning such inputs into outputs by processing and publishing locally or online.
- To perform a specific task, the Arduino programming language and Arduino software (IDE) are used to write instructions to the microcontroller on the board.

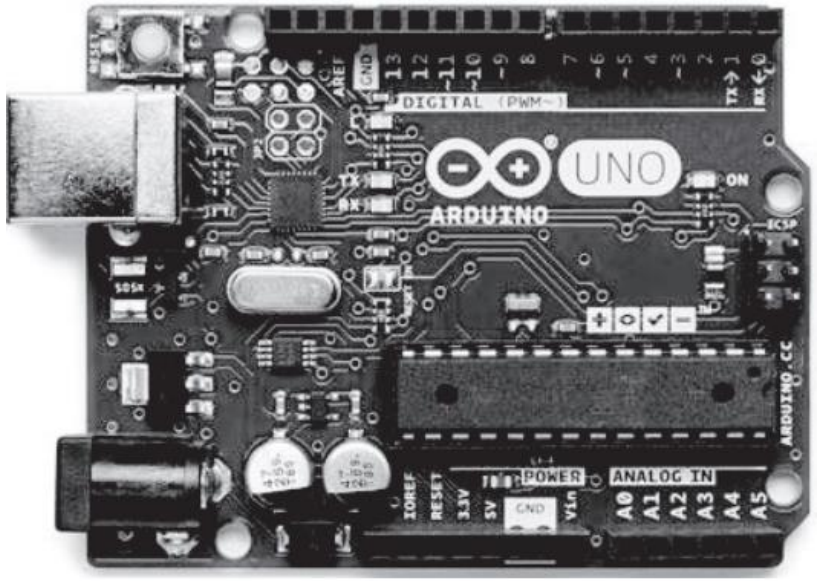

Fig. 11: Arduino Uno
Source: Internet of Things

Arduino

- Advantages of Arduino platform:
  - Low cost
  - Open-source as well as extensible software and hardware
  - Simple and easy-to-use programming environment
  - Compatibility with many OS

Arduino

Vin: This is the input voltage pin of the Arduino board used to provide input supply from an external power source.

5V: This pin of the Arduino board is used as a regulated power supply voltage and it is used to give supply to the board as well as onboard components.

3.3V: This pin of the board is used to provide a supply of 3.3V which is generated from a voltage regulator on the board

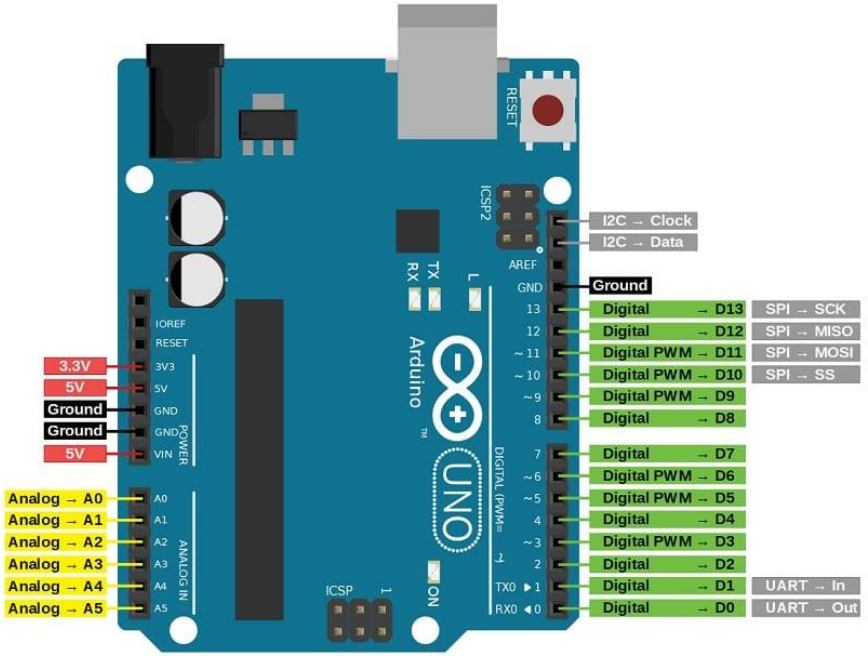

Fig. 12: Arduino pin-out diagram
Source: https://robu.in/arduino-pin-configuration/

Arduino

GND: This pin of the board is used to ground the Arduino board.

Reset: This pin of the board is used to reset the microcontroller. It is used to Resets the microcontroller.

Analog Pins: The pins A0 to A5 are used as an analog input and it is in the range of 0-5V.

Digital Pins: The pins 0 to 13 are used as a digital input or output for the Arduino board.

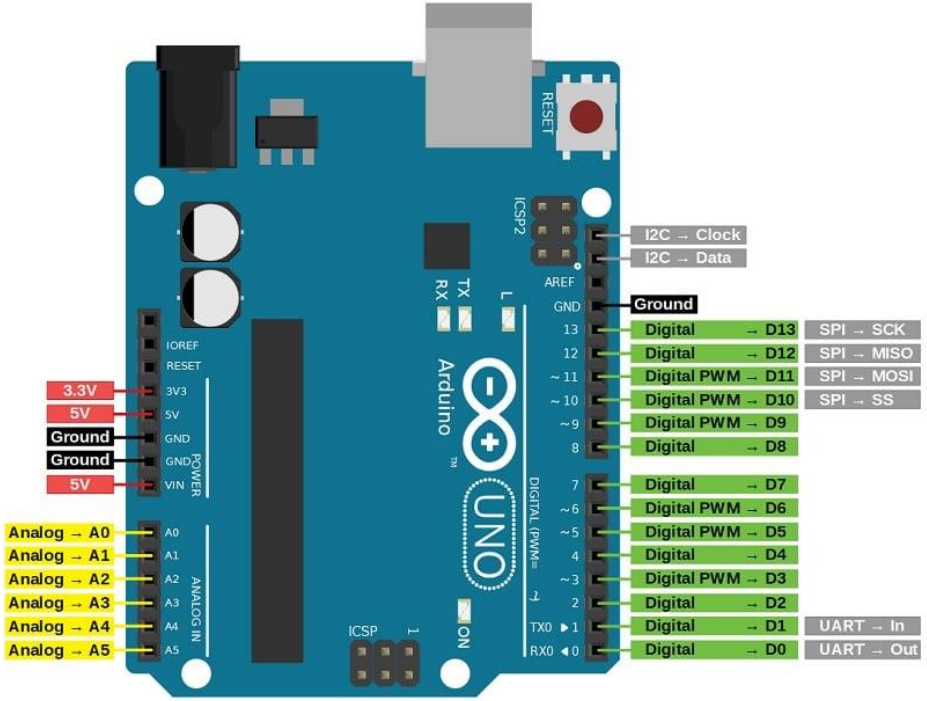

Fig. 12: Arduino pin-out diagram
Source: https://robu.in/arduino-pin-configuration/

Arduino

Serial Pins: These pins are also known as a UART pin.

External Interrupt Pins: This pin of the Arduino board is used to produce the External interrupt and it is done by pin # 2 and 3.

PWM Pins: This pins of the board is used to convert the digital signal into an analog by varying the width of the Pulse.

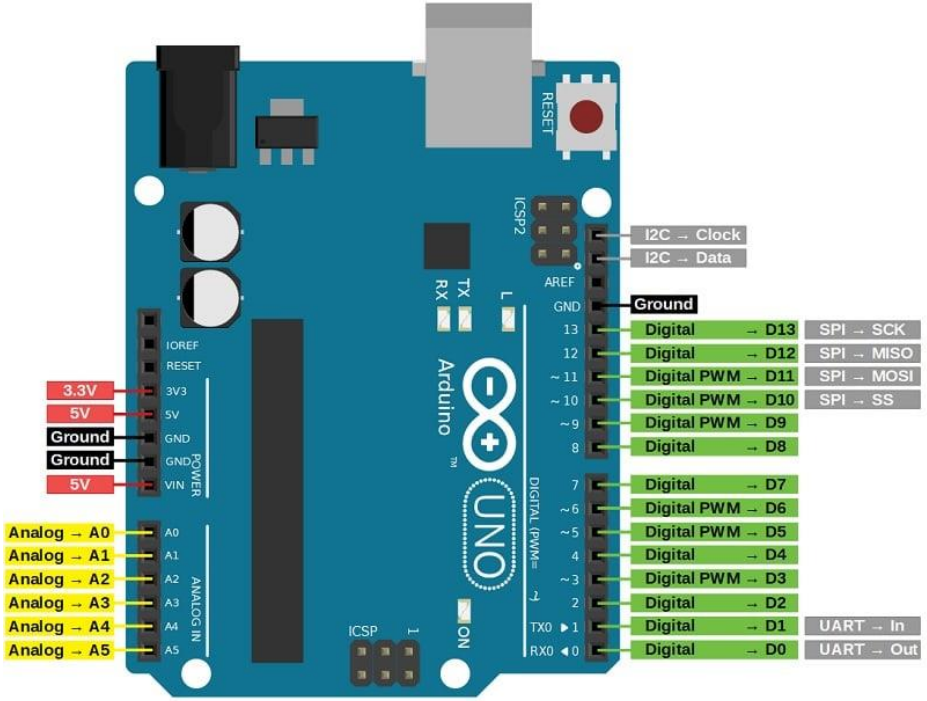

Fig. 12: Arduino pin-out diagram
Source: https://robu.in/arduino-pin-configuration/

Arduino

SPI Pins: This is the Serial Peripheral Interface pin, it is used to maintain SPI communication with the help of the SPI library.

LED Pin: The board has an inbuilt LED using digital pin-13. The LED glows only when the digital pin becomes high.

AREF Pin: This is an analog reference pin of the Arduino board.

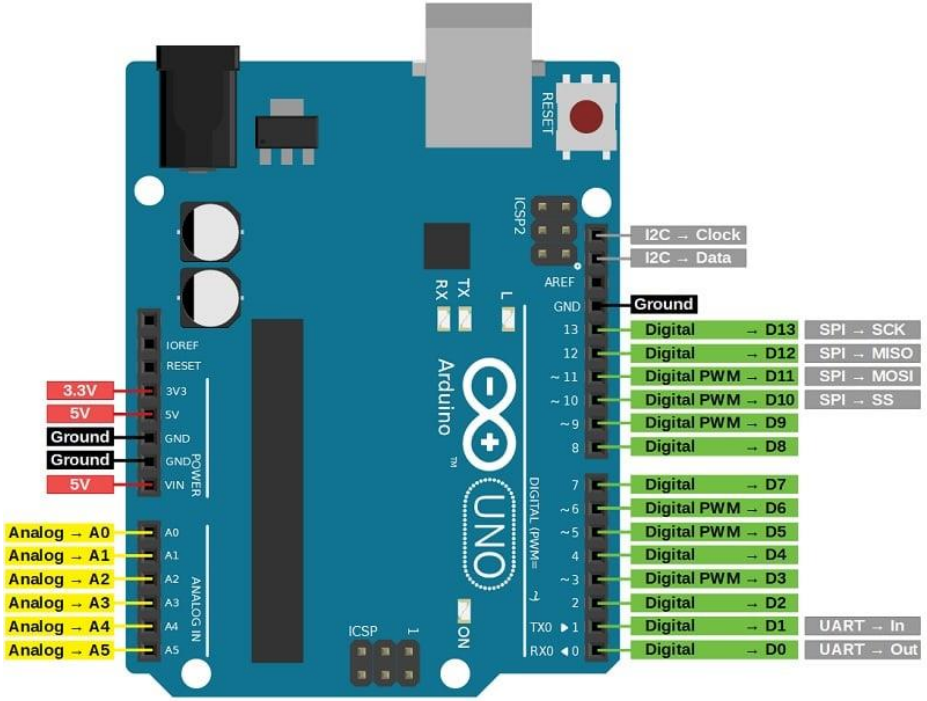

Fig. 12: Arduino pin-out diagram
Source: https://robu.in/arduino-pin-configuration/

Raspberry Pi

- Raspberry Pi Foundation developed the first two models of Raspberry Pi. After the first two models of Pi, model B and subsequently several models such as B+, Zero, etc. released
- Raspbian is the official OS of the foundation. The OS can be installed with NOOBS (New Out Of Box software for easy OS installation manager for Raspberry Pi) or by downloading the image Raspbian

Raspberry Pi board

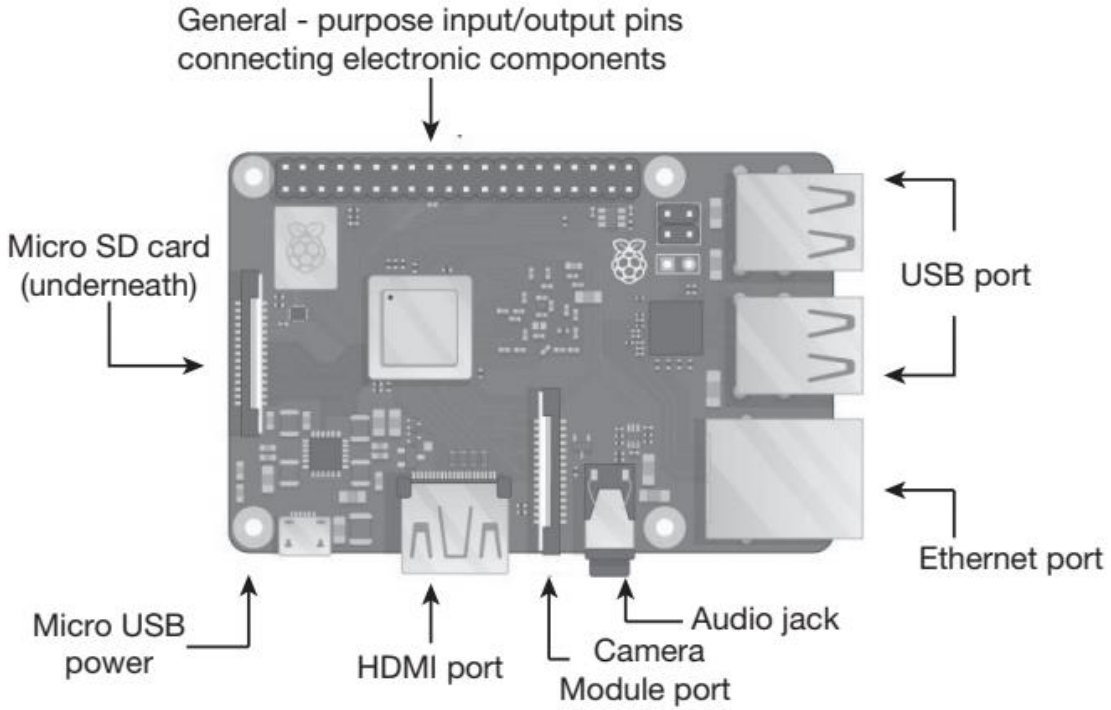

Fig. 13: Raspberry Pi board
Source: Internet of Things

Raspberry Pi pin

- Ground pins
- Power pins
- Reserved pins
- GPIO pins

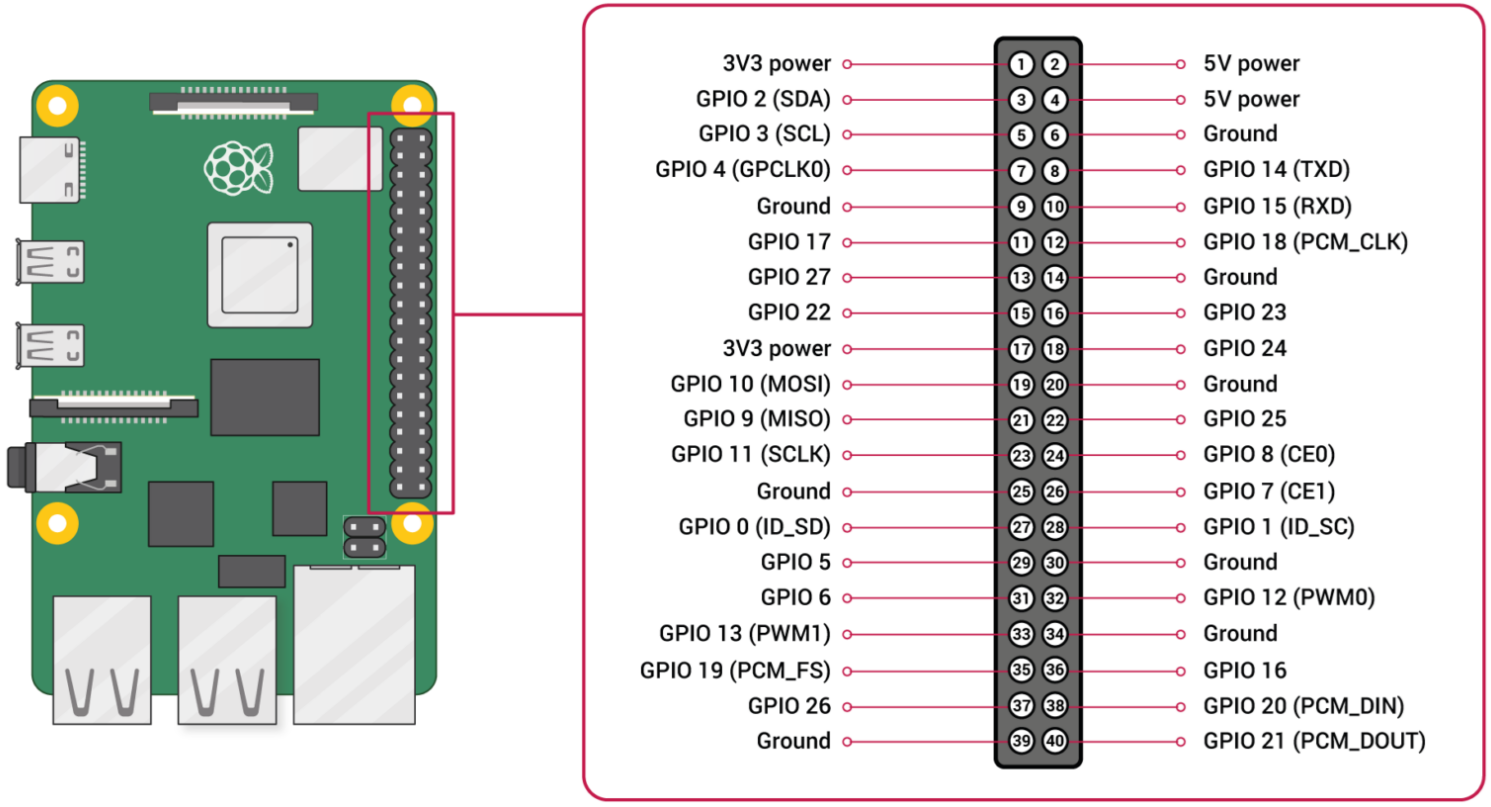

Fig. 14: Raspberry pi pin-out diagram
Source: https://www.raspberrypi.org/

ESP 32

- The ESP32 is a versatile microcontroller developed by Espressif Systems. It is part of the ESP (Espressif Systems Platform) family and has gained widespread popularity, particularly in the Internet of Things (IoT) community due to its powerful features and connectivity options.
- One of the key strengths of the ESP32 is its built-in connectivity options. It supports Wi-Fi for wireless networking and Bluetooth, making it suitable for a wide range of IoT applications.

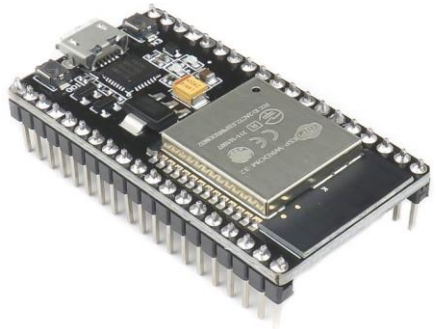

Fig. 15: ESP 32
Source: ElectronicsComp

Differences - Arduino, RPI, ESP32

Feature	Arduino Uno	Raspberry Pi 4	ESP32
Type	Microcontroller	Single-board Computer	Microcontroller
Architecture	AVR (ATmega328P), ARM (varies)	ARM Cortex-A72	Xtensa LX6
Clock Speed	Up to 20 MHz	1.5 GHz	Up to 240 MHz
Memory	Flash (32 KB), SRAM (2 KB)	Varies (e.g., 2 GB RAM)	Flash (varies), SRAM (varies)

Differences - Arduino, RPI, ESP32

Feature	Arduino Uno	Raspberry Pi 4	ESP32
Connectivity	Limited (depends on model)	Ethernet, Wi-Fi, Bluetooth	Wi-Fi, Bluetooth
GPIO Pins	Limited	Many	Many
Peripherals	Basic (e.g., UART, SPI, I2C)	Extensive (e.g., HDMI, USB)	Extensive (e.g., SPI, I2C, UART)
Operating System	No OS	Raspbian OS (Linux-based)	No OS (bare metal or RTOS)

Differences - Arduino, RPI, ESP32

Feature	Arduino Uno	Raspberry Pi 4	ESP32
Programming	Arduino IDE (C/C++), Others	Various (Python, C/C++, etc.)	Arduino IDE (C/C++), Others
Power Consumption	Low	Moderate	Low to Moderate
Applications	Embedded Systems, IoT	Desktop Computing, IoT	IoT, Embedded Systems

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IoT Device Configuration with Rpi and Arduino

IoT device configuration

- IoT device configuration is the process of setting up and customizing IoT devices to enable communication, data exchange, and functionality within a network
- Proper configuration ensures seamless integration into the IoT system

Key configuration parameters

- Device Identification: Unique identifiers, such as MAC addresses or device IDs, to distinguish devices on the network
- Network Settings: Configuration of Wi-Fi, Ethernet, or other connectivity options
- Security Credentials: Setting up encryption, authentication, and access control measures

Set up for Raspberry Pi

- SD card
  - 8 GB Class 4 SD card (ideally with Raspberry Pi imager preinstalled)
- Connectivity cables and display
  - Any DDMI or DVI monitor and any TV can be used as a display device for Raspberry Pi.
  - HDMI input will give best result but even other connections are available for compatibility with the older versions.

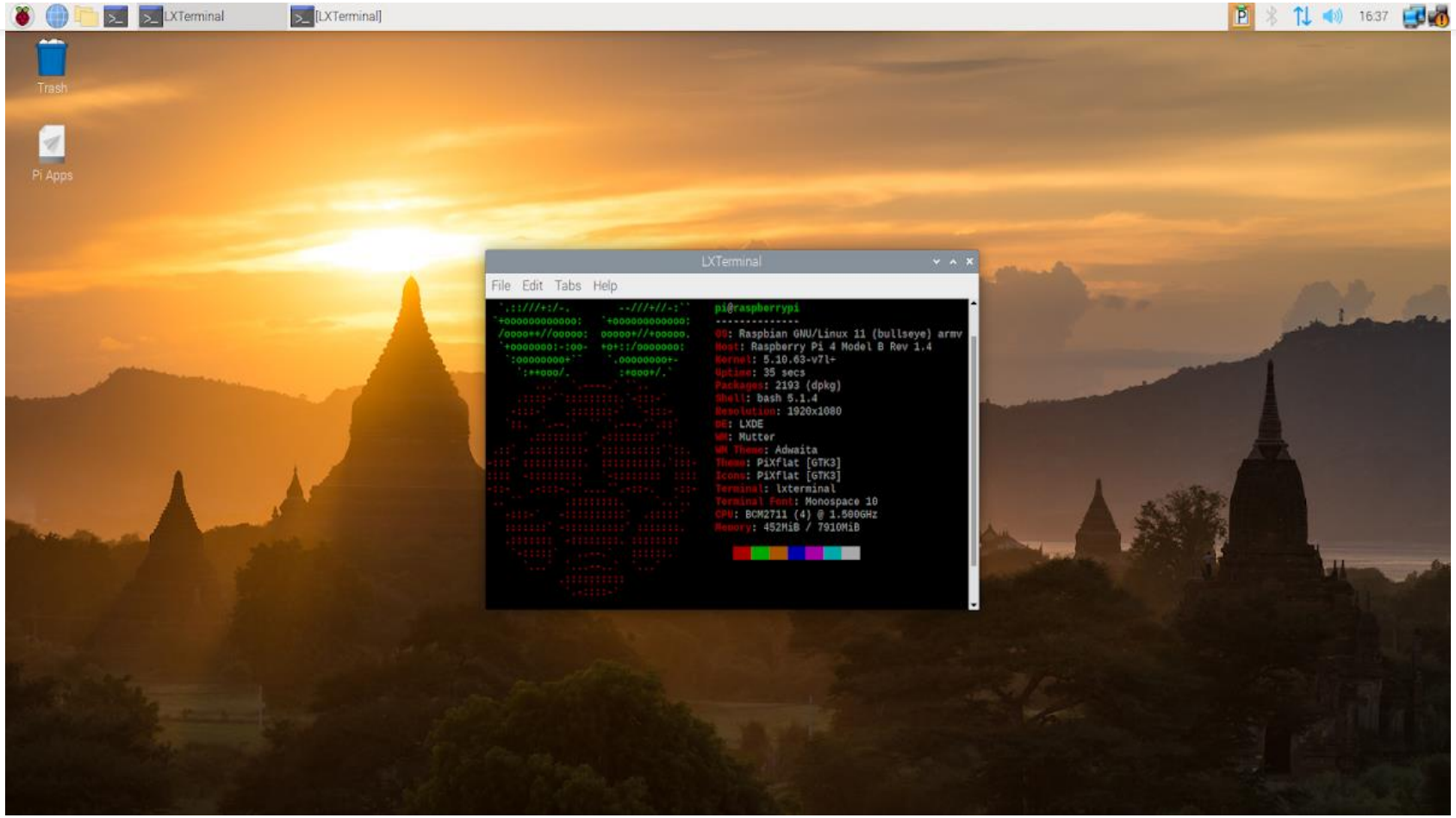
Set up for Raspberry Pi

- Keyboard and mouse
  - Any standard USB keyboard and mouse
  - With wireless pairing, wireless mouse and keyboard can be used
- Power supply
  - USB micro power supply (used for most standard mobile phone chargers)
  - A good-quality power supply with current specification at least 2A at 5V for 3B model or 700mA at 5V for earlier models (Low current power supply works for basic usage but are likely to cause Pi to reboot if too much power is drawn)

Set up for Raspberry Pi

- Optional (network) cable (model B, B+, 2, 3 only)
  - Local network can be connected to Raspberry Pi using Ethernet cable.
  - USB wireless dongle can be used to connect Pi to wireless network, which needs configuration.

Raspbian OS


LXTerminal
[LXTerminal]
16:37
Trash
Pi Apps
LXTerminal
File Edit Tabs Help
pi@raspberrypi
OS: Raspbian GNU/Linux 11 (bullseye) armv
Host: Raspberry Pi 4 Model B Rev 1.4
Kernel: 5.10.63-v7l+
Uptime: 35 secs
Packages: 2193 (dpkg)
Shell: bash 5.1.4
Resolution: 1920x1080
DE: LXDE
WM: Mutter
WM Theme: Adwaita
Theme: PiXflat [GTK3]
Icons: PiXflat [GTK3]
Terminal: lxterminal
Terminal Font: Monospace 10
CPU: BCM2711 (4) @ 1.500GHz
Memory: 452MiB / 7910MiB

Raspbian OS

Feature	Description
Target Platform	Raspberry Pi (ARM-based single-board computers)
User Interface	Lightweight desktop environment (LXDE/LXQt)
Package Management	Uses APT (Advanced Package Tool) for software installation
Optimization	Optimized for the ARM architecture and Raspberry Pi hardware
Educational Tools	Includes educational software and tools for learning programming and electronics
GPIO Support	Built-in support for General Purpose Input/Output pins
Python Pre-installed	Comes with Python pre-installed, suitable for Raspberry Pi development

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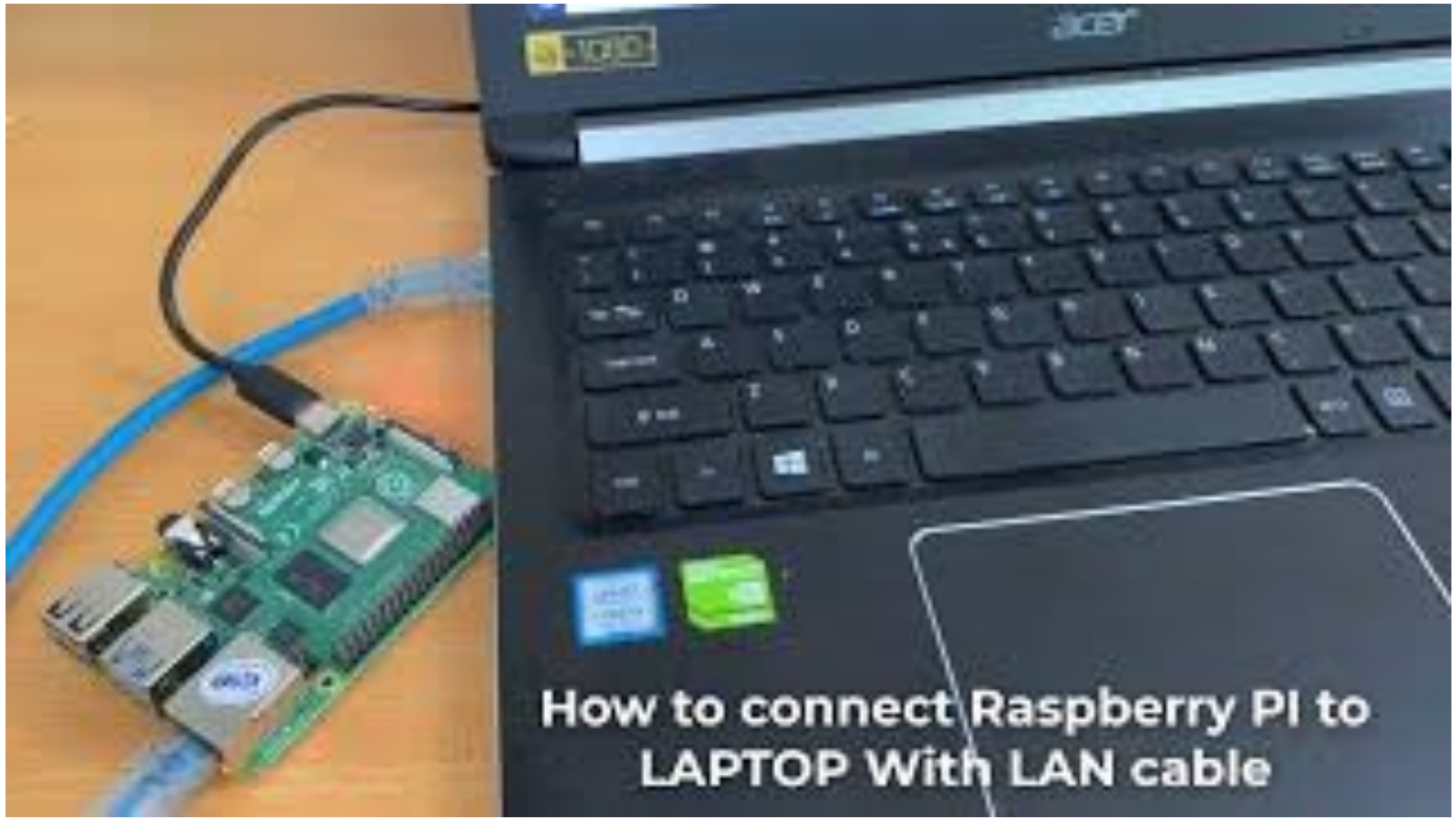
Practical

Arduino device configuration

Raspberry Pi device configuration



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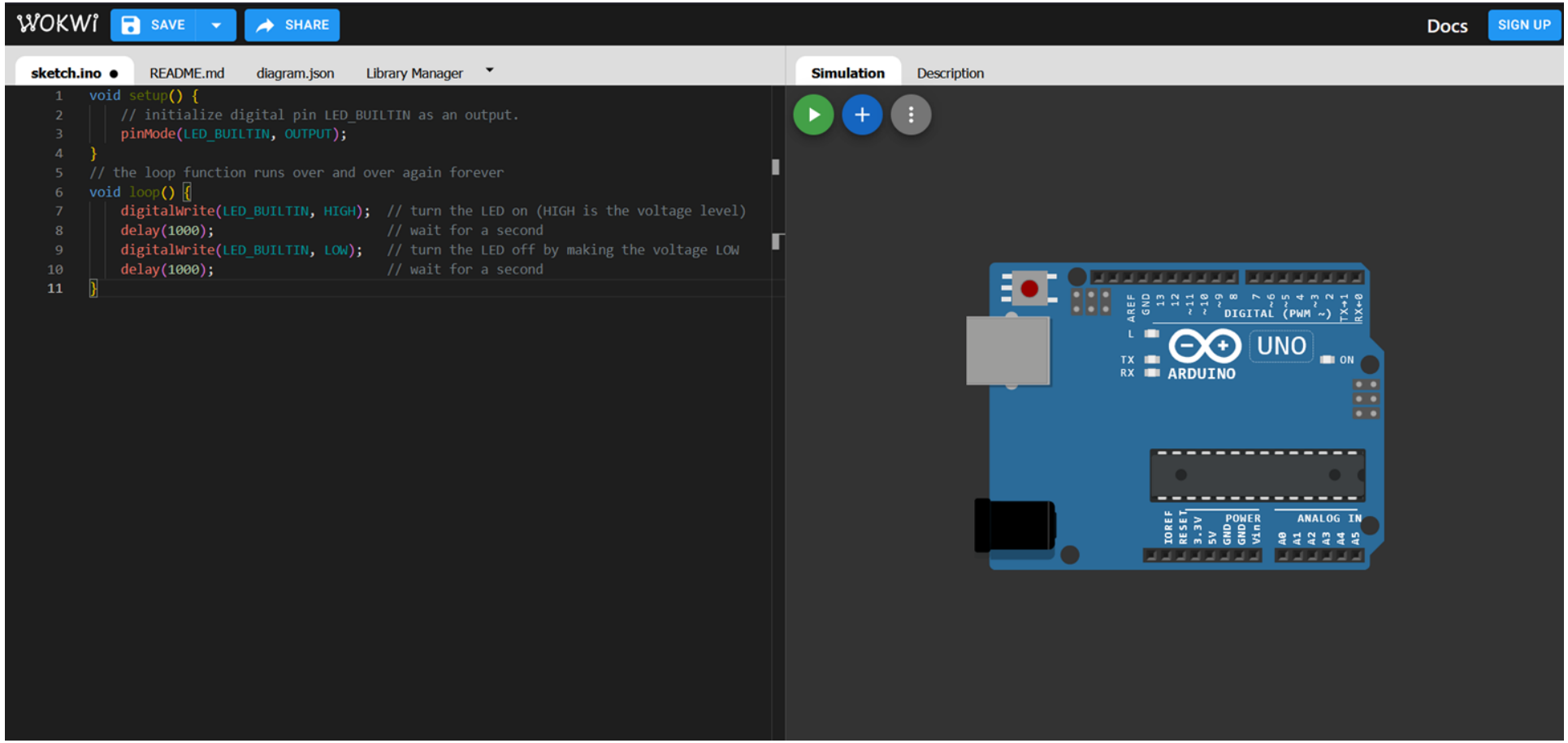
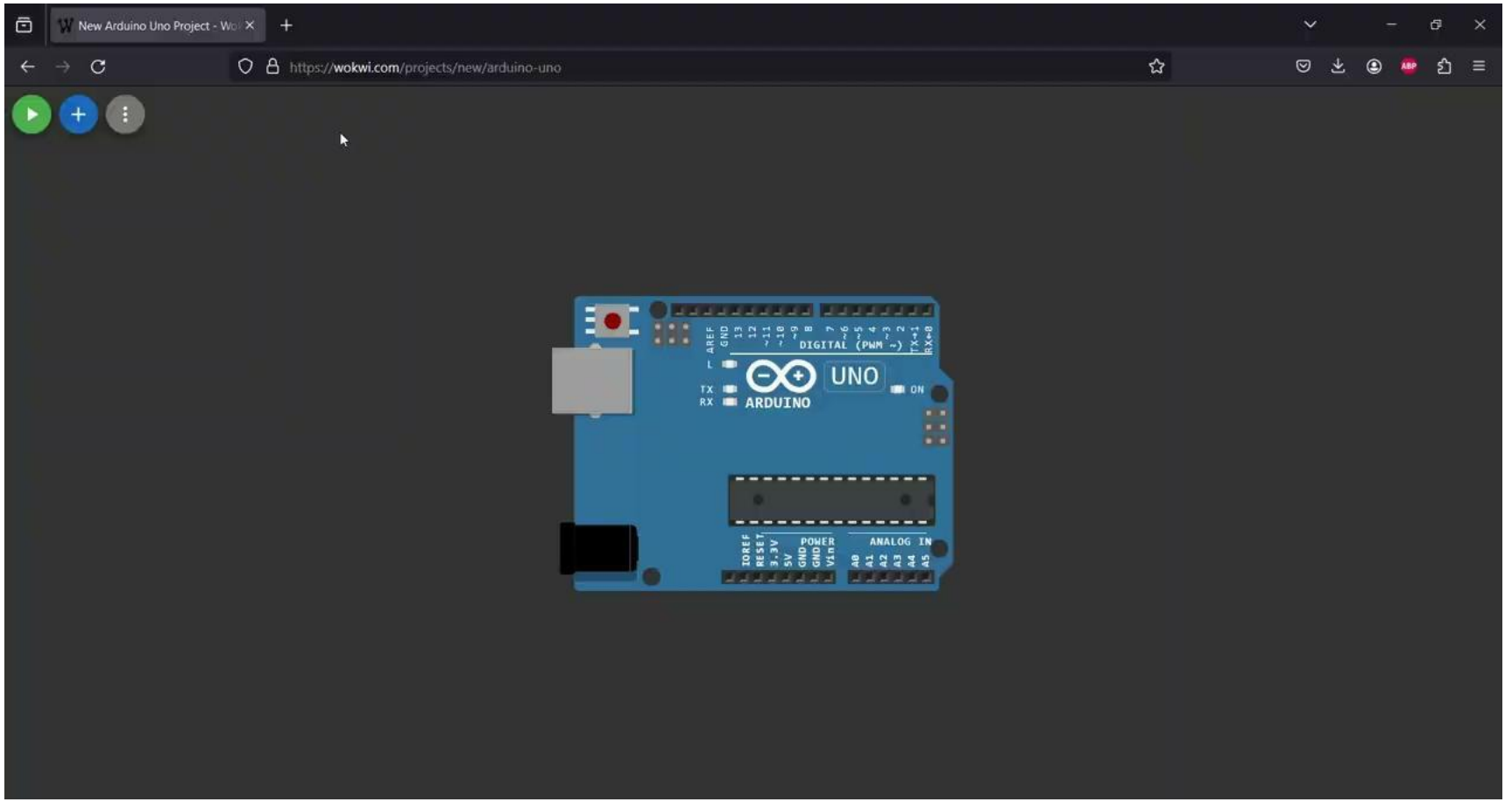
Programming

Arduino blink LED program



Output


New Arduino Uno Project - Wo
https://wokwi.com/projects/new/arduino-uno
UNO
ARDUINO
DIGITAL (PWM ~)
POWER
ANALOG IN

Arduino fading LED program

```
int led = 9;           // the PWM pin the LED is attached to
int brightness = 0;    // how bright the LED is
int fadeAmount = 5;    // how many points to fade the LED by

// the setup routine runs once when you press reset:
void setup() {
  // declare pin 9 to be an output:
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  // set the brightness of pin 9:
  analogWrite(led, brightness);

  // change the brightness for next time through the loop:
  brightness = brightness + fadeAmount;

  // reverse the direction of the fading at the ends of the fade:
  if (brightness <= 0 || brightness >= 255) {
    fadeAmount = -fadeAmount;
  }
  // wait for 30 milliseconds to see the dimming effect
  delay(30);
}
```

Python program 1 (Google Colab)

- **Write a Python Program to Convert Celsius To Fahrenheit**

```
celsius = 47

# calculate fahrenheit

fahrenheit = (celsius * 1.8) + 32

print('%0.1f degree Celsius is equal to %0.1f degree Fahrenheit' %(celsius,fahrenheit))
```

Python program 2 (Google Colab)

- **Write a Reverse a Number using a while loop**

```
num = 1234
reversed_num = 0
while num != 0:
        digit = num % 10
        reversed_num = reversed_num * 10 + digit
        num //= 10
print("Reversed Number: " + str(reversed_num))
```

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Homework Assignment

Homework

- What are the differences between Microcontroller and Microprocessor?
- Explain with a diagram the analog and digital pins of Arduino Uno board useful for interfacing input and output.
- Describe the steps to write Raspbian OS on the Raspberry pi board using Raspberry Pi Imager

Thank you