Experiment 1

Aim: Familiarization with Arduino/Raspberry Pi hardware and perform necessary software installation.

Objectives:

1. To study hardware and software related to IoT

2. To understand the function of Node MCU, Arduino Uno and Raspberry Pi.

Arduino Board:

An Arduino is actually a micro controller based kit. It is basically used in communications and in controlling or operating many devices. Arduino UNO board is the most popular board in the Arduino board family.

In addition, it is the best board to get started with electronics and coding. Some boards look a bit different from the one given below, but most Arduino's have majority of these components in common.

It consists of two memories- Program memory and the data memory.

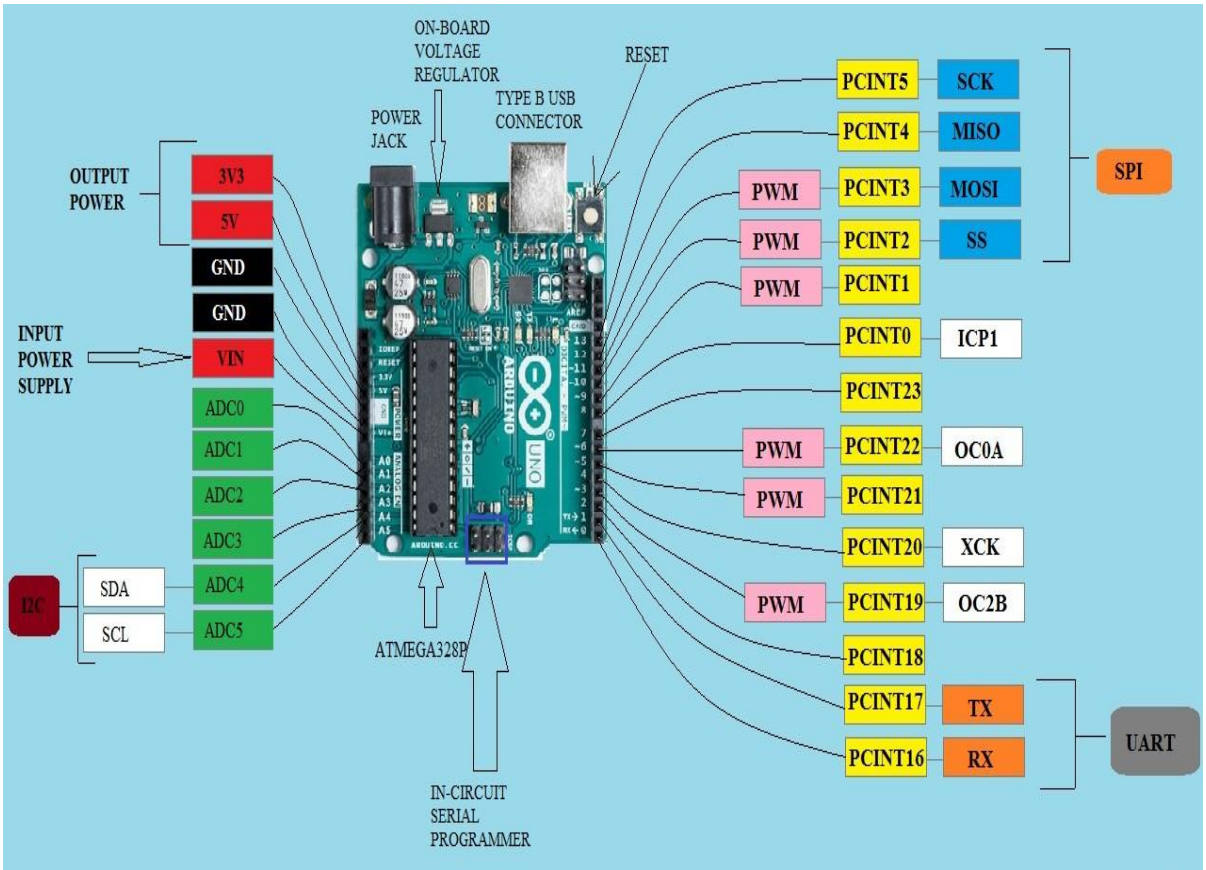


Figure: Diagram of Arduino Board

The code is stored in the flash program memory, whereas the data is stored in the data memory.

Arduino Uno consists of 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button

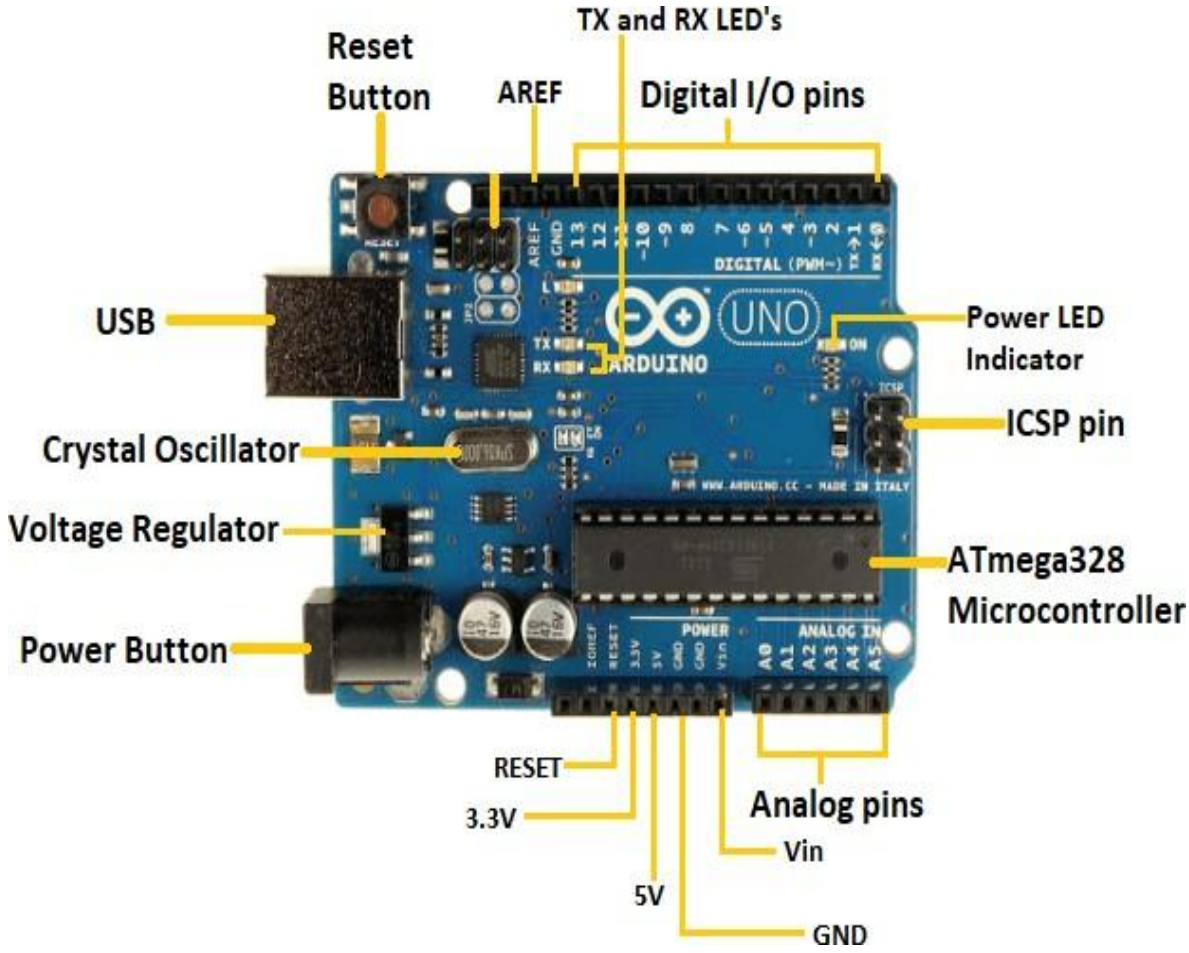


Figure: Arduino Uno

1. Power USB Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection (1).

2. Power (Barrel Jack) Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack (2).

3. Voltage Regulator The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

4. Crystal Oscillator The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

5,17.Arduino Reset You can reset your Arduino board, i.e., start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET (5).

6,7,8,9.Pins (3.3, 5, GND, Vin)

• 3.3V (6) − Supply 3.3 output volt

• 5V (7) − Supply 5 output volt

• Most of the components used with Arduino board works fine with 3.3 volt and 5 volt.

• GND (8)(Ground) − There are several GND pins on the Arduino, any of which can be used to ground your circuit.

• Vin (9) − This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

10. Analog pins The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

11. Main micro controller Each Arduino board has its own micro controller (11). You can assume it as the brain of your board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The micro controllers are usually of the ATMEL Company. You must know what IC your board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. For more details about the IC construction and functions, you can refer to the data sheet.

12. ICSP pin Mostly, ICSP (12) is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.

13. Power LED indicator This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.

14. TX and RX LEDs On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led (13). The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

15. Digital I/O

• The Arduino UNO board has 14 digital I/O pins (15) (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled “~” can be used to generate PWM.

16.AREF

AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins

Program an Arduino:

The most important advantage with Arduino is the programs can be directly loaded to the device without requiring any hardware programmer to burn the program.

This is done because of the presence of the 0.5KB of Boot-loader, which allows the program to be burned into the circuit.

All we have to do is to download the Arduino software and writing the code.

The Arduino tool window consists of the toolbar with the buttons like verify, upload, new, open, save, serial monitor.

It also consists of a text editor to write the code, a message area which displays the feedback like showing the errors, the text console which displays the output and a series of menus like the File, Edit, Tools menu.

Steps to program an Arduino

1. Programs written in Arduino are known as sketches. A basic sketch consists of 3 parts

a. Declaration of Variables

b. Initialisation: It is written in the setup () function.

c. Control code: It is written in the loop () function.

2. The sketch is saved with .ino extension. Any operations like verifying, opening a sketch, saving a sketch can be done using the buttons on the toolbar or using the tool menu.

3. The sketch should be stored in the sketchbook directory.

4. Chose the proper board from the tools menu and the serial port numbers.

5. Click on the upload button or chose upload from the tools menu. Thus the code is uploaded by the boot loader onto the micro controller.

Basic Adruino functions are:

1. digitalRead(pin): Reads the digital value at the given pin.

2. digitalWrite(pin, value): Writes the digital value to the given pin.

3. pinMode(pin, mode): Sets the pin to input or output mode.

4. analogRead(pin): Reads and returns the value.

5. analogWrite(pin, value): Writes the value to that pin.

6. serial.begin(baud rate): Sets the beginning of serial communication by setting the bit rate.

Advantages of Arduino Board

1. It is inexpensive

2. It comes with an open source hardware feature which enables users to develop their own kit using already available one as a reference source.

3. The Arduino software is compatible with all types of operating systems like Windows, Linux, and Macintosh etc.

4. It also comes with open source software feature which enables experienced software developers to use the Arduino code to merge with the existing programming language libraries and can be extended and modified.

5. It is easy to use for beginners.

6. We can develop an Arduino based project which can be completely stand alone or projects which involve direct communication with the software loaded in the computer.

7. It comes with an easy provision of connecting with the CPU of the computer using serial communication over USB as it contains built in power and reset circuitry.

Interfaces:

UART Peripheral:

1. A UART (Universal Asynchronous Receiver/Transmitter) is a serial interface.

2. It has only one UART module.

3. The pins (RX, TX) of the UART are connected to a USB-to-UART converter circuit and also connected to pin0 and pin1 in the digital header.

SPI Peripheral:

1. The SPI (Serial Peripheral Interface) is another serial interface. It has only one SPImodule.

TWI:

1. The I2C or Two Wire Interface is an interface consisting of only two wires, serial data, and a serial clock: SDA, SCL.

2. You can reach these pins from the last two pins in the digital header or pin4 and pin5 in the analog header.

RASPERRY PI

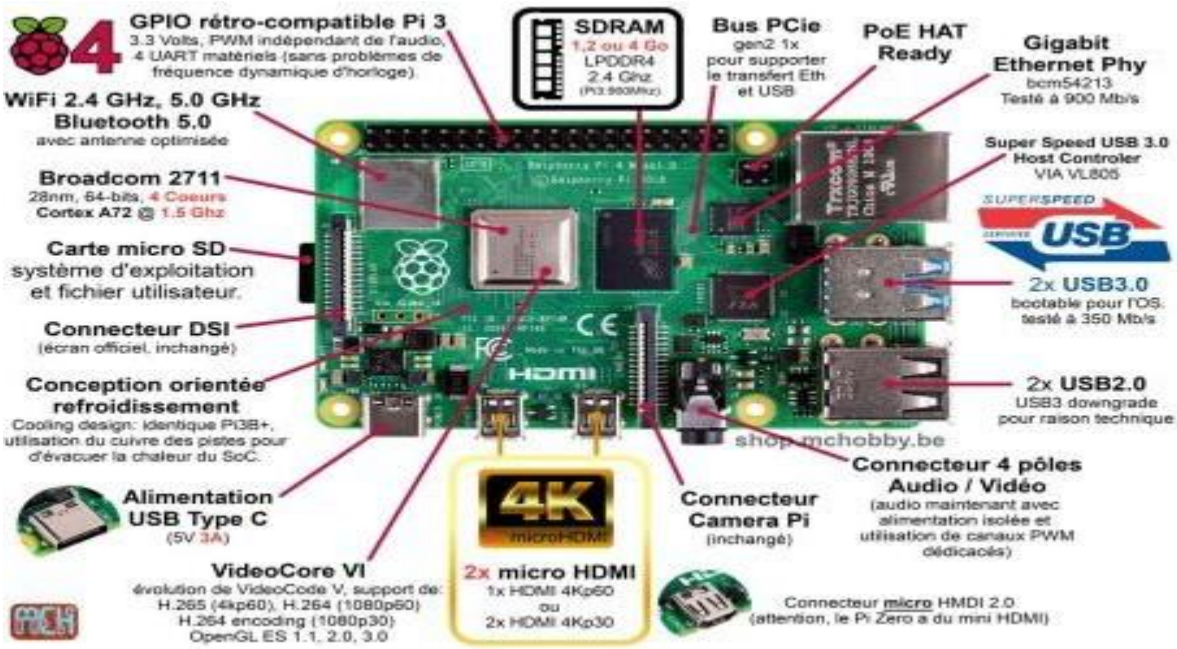


Figure: Raspberry Pi

1. The Raspberry Pi is a very cheap computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins that allow you to control electronic components for physical computing and explore the Internet of Things (IoT).

2. Raspberry Pi was basically introduced in 2006.

3. It is particularly designed for educational use and intended for Python.

4. A Raspberry Pi is of small size i.e., of a credit card sized single board computer, which is developed in the United Kingdom (U.K) by a foundation called Raspberry Pi.

5. There have been three generations of Raspberry Pis: Pi 1, Pi 2, and Pi 3

6. The first generation of Raspberry (Pi 1) was released in the year 2012, which has two types of models namely model A and model B.

7. Raspberry Pi can be plugged into a TV, computer monitor, and it uses a standard keyboard and mouse.

8. It is user friendly as can be handled by all the age groups.

9. It does everything you would expect a desktop computer to do like word-processing, browsing the internet spreadsheets, playing games to playing high definition videos.

10. All models feature on a broadcom system on a chip (SOC), which includes chip graphics processing unit GPU (a Video Core IV), an ARM compatible and CPU.

11. The CPU speed ranges from 700 MHz to 1.2 GHz for the Pi 3 and on board memory range from 256 MB to 1 GB RAM.

12. An operating system is stored in the secured digital SD cards and program memory in either the MicroSDHC or SDHC sizes.

13. Most boards have one to four USB slots, composite video output, HDMI and a 3.5 mm phone jack for audio. Some models have WiFi and Bluetooth.

14. Several generations of Raspberry Pis have been released.

15. All models feature a Broadcom system on a chip (SoC) with an integrated ARM compatible central processing unit (CPU) and on-chip graphics-processing unit (GPU).

16. Processor speed ranges from 700 MHz to 1.4 GHz for the Pi 3 Model B+ or 1.5 GHz for the Pi 4; on-board memory ranges from 256 MB to 1 GB with up to 4 GB available on the Pi 4 random-access memory (RAM).

17. Secure Digital (SD) cards in MicroSDHC form factor (SDHC on early models) are used to store the operating system and program memory.

18. The boards have one to five USB ports. For video output, HDMI and composite video are supported, with a standard 3.5 mm tip-ring-sleeve jack for audio output.

19. Lower-level output is provided by a number of GPIO pins, which support common protocols like I^2C. The B-models have an 8P8C Ethernet port and the Pi 3 and Pi Zero W have on-board Wi-Fi and Bluetooth.

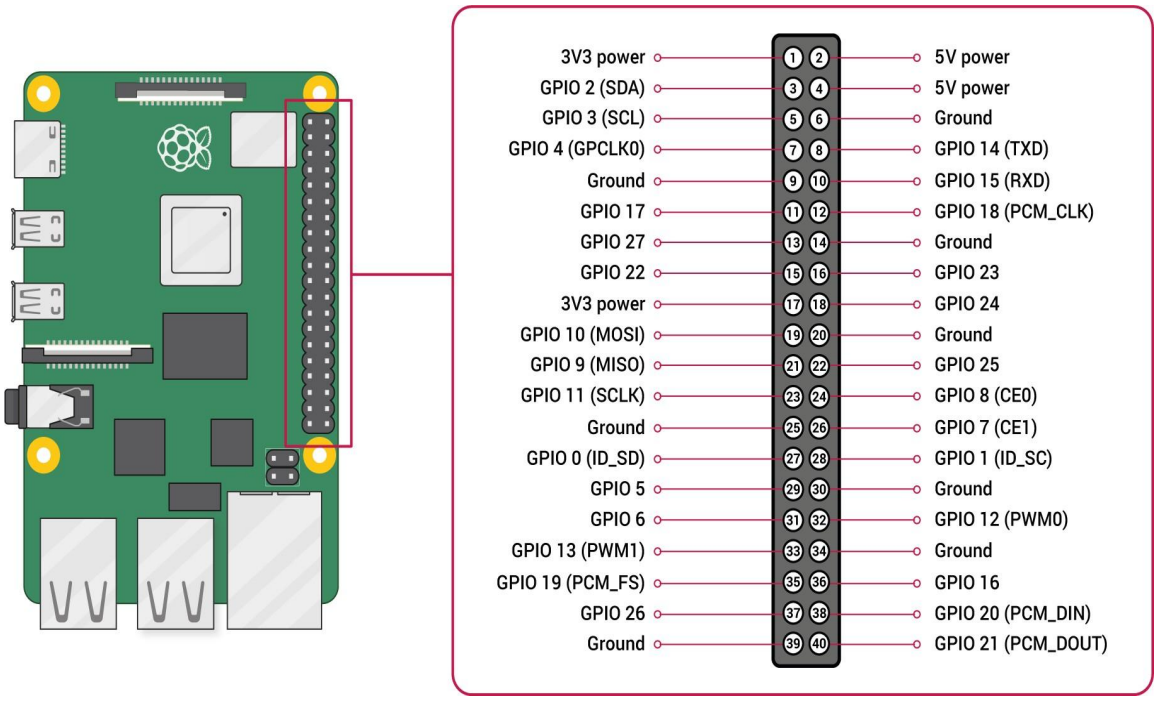


Figure: Raspberry Pi Pin Description

Components and Peripherals:

Voltages: Two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V). The remaining pins are all general purpose 3V3 pins

A GPIO pin designated as an output pin can be set to high (3V3) or low (0V). A GPIO pin designated as an input pin can be read as high (3V3) or low (0V).

Processor & RAM: Raspberry based on ARM11 processor. Latest version supports 700MHz processor and 512MB SDRAM. The Central processing unit is the brain of the raspberry pi board and that is responsible for carrying out the instructions of the computer through logical and mathematical operations.

Ethernet: The Ethernet port of the raspberry pi is the main gateway for communicating with additional devices. The raspberry pi Ethernet port is used to plug your home router to access the Internet.

USB Ports: It has 2 USB ports. USB port provides current upto 100mA. For connecting devices that draw current more than 100mA, an external USB powered hub is required.

Ethernet Port: It has standard RJ45 Ethernet port. Connect Ethernet cable or USB wifi adapter to provide internet connectivity.

HDMI Output: It supports both audio and video output. Connect raspberry Pi to monitor using HDMI cable.

Composite video Output: Raspberry comes with a composite video output with an RCA jack that supports both PAL and NTSC video output.

Audio Output: It has 3.5mm audio output jack. This audio jack is used for providing audio output to old television along with RCA jack for video.

GPIO Pins: It has a number of general-purpose input/output pins. These pins are used to connect other electronic components. For example, you can connect it to the temperature sensor to transmit digital data.

Display Serial Interface (DSI): DSI interface are used to connect an LCD panel to Raspberry PI.

Cameral Serial Interface (CSI): CSI interface are used to connect a camera module to Raspberry PI.

SD Card slot: Raspberry does not have built in OS and storage. Plug in an SD card loaded with Linux to SD card slot.

Power Input: Raspberry has a micro USP connector for power input.

Memory: The raspberry pi model A board is designed with 256MB of SDRAM and model B is designed with 51MB.Raspberry pi is a small size PC compare with other PCs. The normal PCs RAM memory is available in gigabytes. But in raspberry pi board, the RAM memory is available more than 256MB or 512MB

Status LEDs: Raspberry has 5 status LEDs.

1. ACT SD card Access

2. PWR 3.3V power is present

3. FDX Full duplex LAN Connected

4. LNK Link/Network Activity

5. 100 100 Mbit LAN connected

Raspberry PI Interfaces:
It supports SPI, serial and I2C interfaces for data transfer.

Serial : Serial Interface on Raspberry has receive(Rx) and Transmit(Tx) pins for communication with serial peripherals.

SPI: Serial Peripheral Interface (SPI) is a synchronous serial data protocol used for communicating with one or more peripheral devices. In an SPI connection, there is one master device and one or more peripheral devices.

There are 5 pins Raspberry for SPI interface.

- MISO(Master In Slave Out): Master line for sending data to the peripherals.
- MOSI(Master Out Slave In): Slave Line for sending data to the master.
- SCK(Serial Clock): Clock generated by master to synchronize data transmission.
- CE0(Chip Enable 0): To enable or disable devices.
- CE1(Chip Enable 1): To enable or disable devices.

I2C: I2C Interface pins are used to connect hardware modules. I2C interface allows synchronous data transfer with two pins: SDA(data line) and SCL (Clock Line)

Features of Raspberry PPI

1. Where the system processing is huge. They can process high end programs for applications like Weather Station, Cloud server, gaming console etc. With 1.2GHz clock speed and 1 GB RAM RASPBERRY PI can perform all those advanced functions.

2. RASPBERRY PI 3 has wireless LAN and Bluetooth facility by which you can setup WIFI HOTSPOT for internet connectivity.

3. RASPBERRY PI had dedicated port for connecting touch LCD display which is a feature that completely omits the need of monitor.

4. RASPBERRY PI also has dedicated camera port so one can connect camera without any hassle to the PI board.

5. RASPBERRY PI also has PWM outputs for application use.

6. It supports HD steaming

Applications

1. Hobby projects.

2. Low cost PC/tablet/laptop

3. IoT applications

4. Media center

5. Robotics/Industrial/Home automation

6. Server/cloud server

7. Print server

8. Security monitoring

9. Web camera

10. Gaming

11. Wireless access point

INSTALLING THE ARDUINO IDE

1. Visit http://www.arduino.cc/en/main/software to download the latest Arduino IDE version for your computer's operating system. There are versions for Windows, Mac, and Linux systems. At the download page, click on the "Windows Installer" option for the easiest installation.

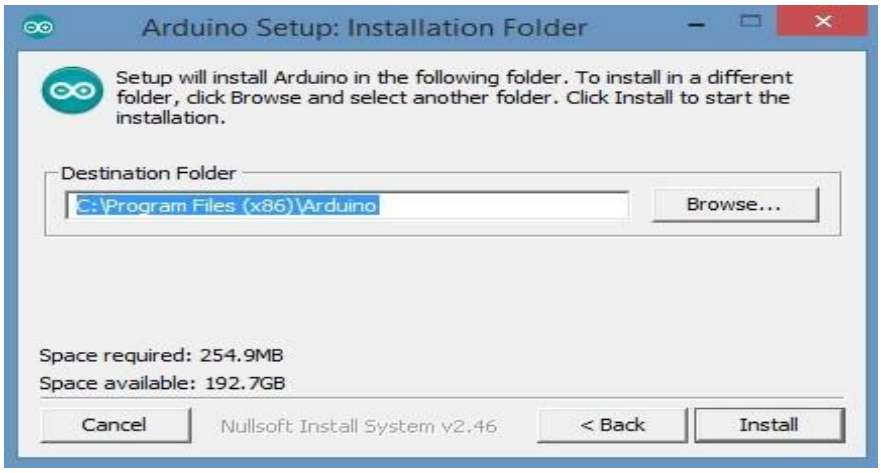
2. Save the .exe file to your hard drive.

3. Open the .exe file.

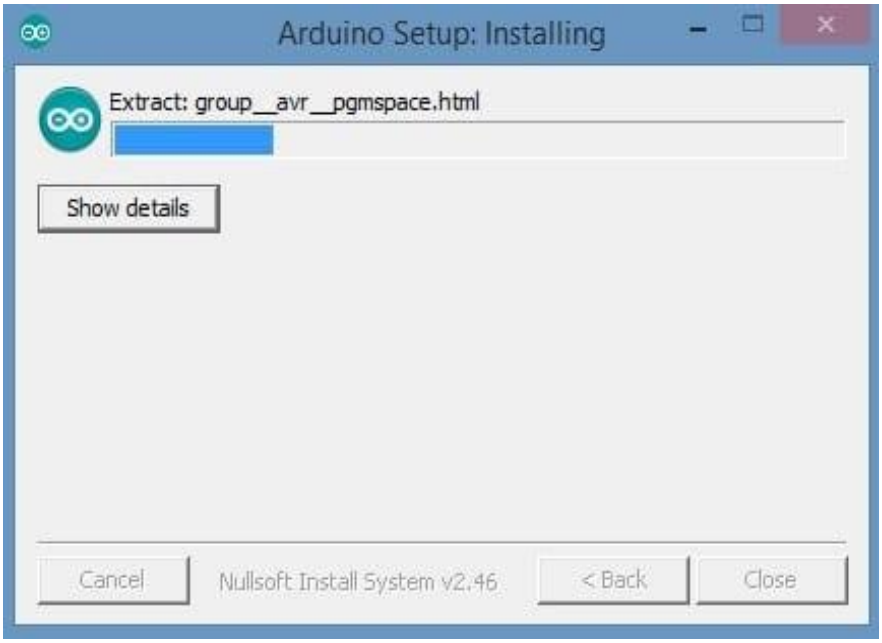
4. Click the button to agree to the licensing agreement:

5. Decide which components to install, then click "Next":

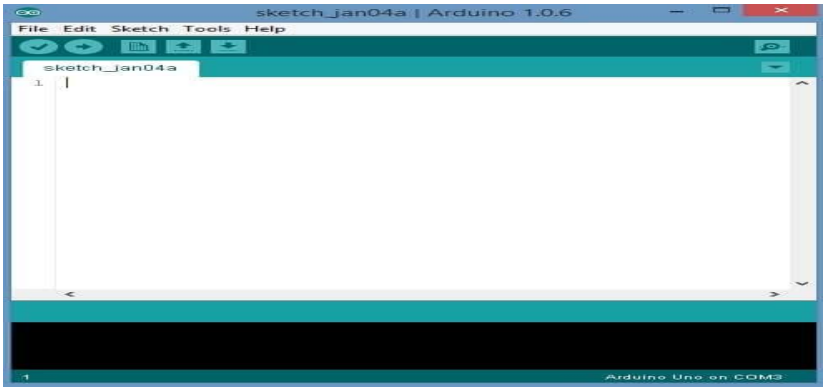
6. Select which folder to install the program to, then click "Install":



7. Wait for the program to finish installing, and then click “Close”:

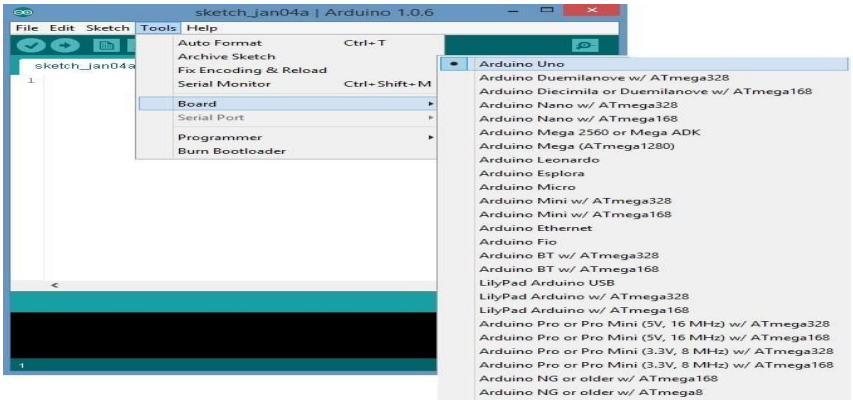


8. Now find the Arduino shortcut on your Desktop and click on it. The IDE will open up and you’ll see the code editor:



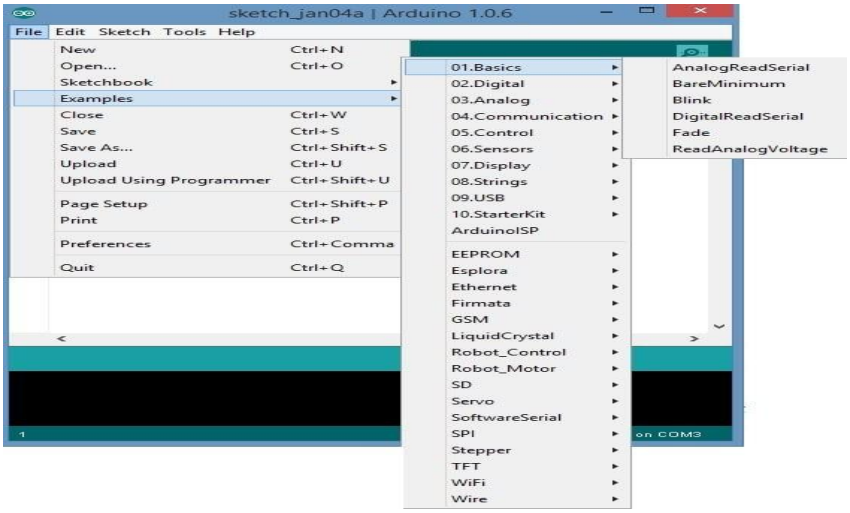
CONFIGURING THE ARDUINO IDE

The next thing to do is to make sure the software is set up for your particular Arduino board. Go to the “Tools” drop-down menu, and find “Board”. Another menu will appear, where you can select from a list of Arduino models. I have the Arduino Uno R3, so I chose “Arduino Uno”.



EXPLORING THE ARDUINO IDE

If you want, take a minute to browse through the different menus in the IDE. There is a good variety of example programs that come with the IDE in the “Examples” menu. These will help you get started with your Arduino right away without having to do lots of research:



EXPERIMENTING WITH THE ARDUINO

Play around with the example programs and try changing parts of the code to see what happens. But if you want to learn programming as a skill, it’s best not to rely too much on these examples in your projects. You’ll learn much more by experimenting and writing your own code from scratch.

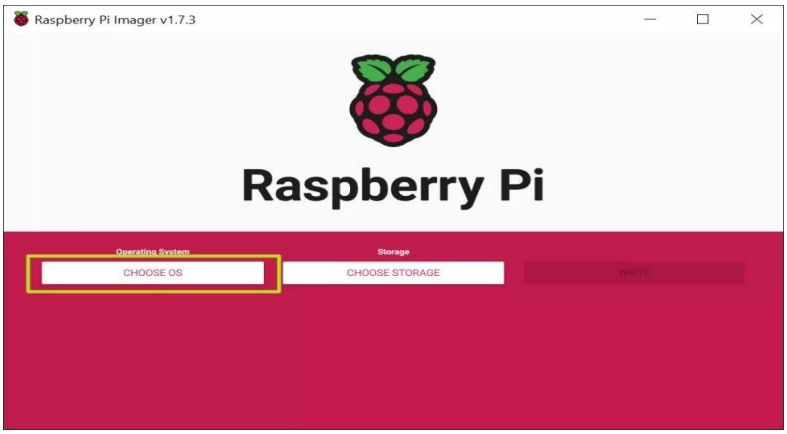
Downloading and Installing Raspberry Pi OS

Once you have all the components you need, use the following steps to create the boot disk you will need to set up your Raspberry Pi. These steps should work on a using a Windows, Mac or Linux-based PC (we tried this on Windows, but it should be the same on all three).

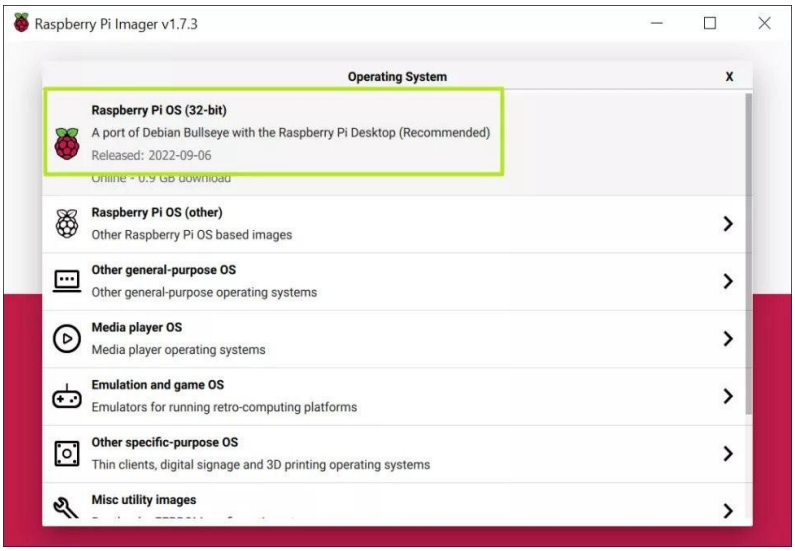
1. **Insert a microSD card/reader** into your computer.

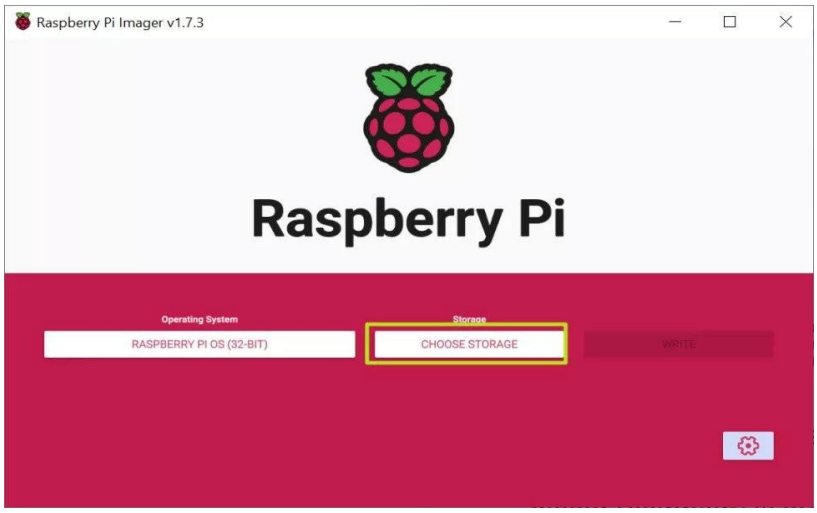
2. **Download and install the official Raspberry Pi Imager.** Available for Windows, macOS or Linux, this app will both download and install the latest Raspberry Pi OS. There are other ways to do this, namely by downloading a Raspberry Pi OS image file and then using a third-party app to "burn it," but the Imager makes it easier.

3. Click Choose OS.



4. **Select Raspberry Pi OS (32-bit)** from the OS menu (there are other choices, but for most uses, 32-bit is the best) and **Click Choose storage** and **pick the SD card** you're using.

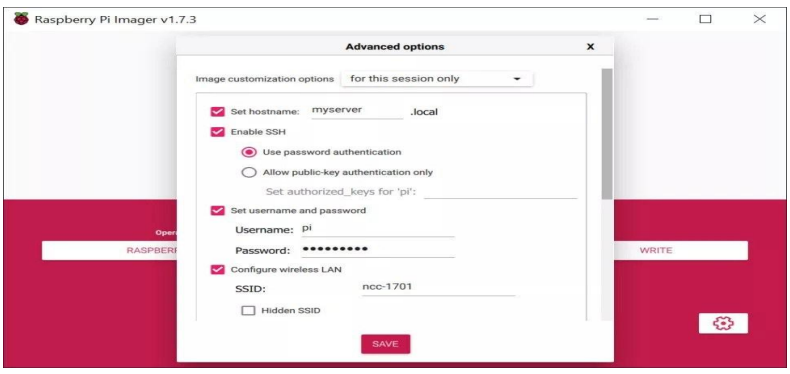




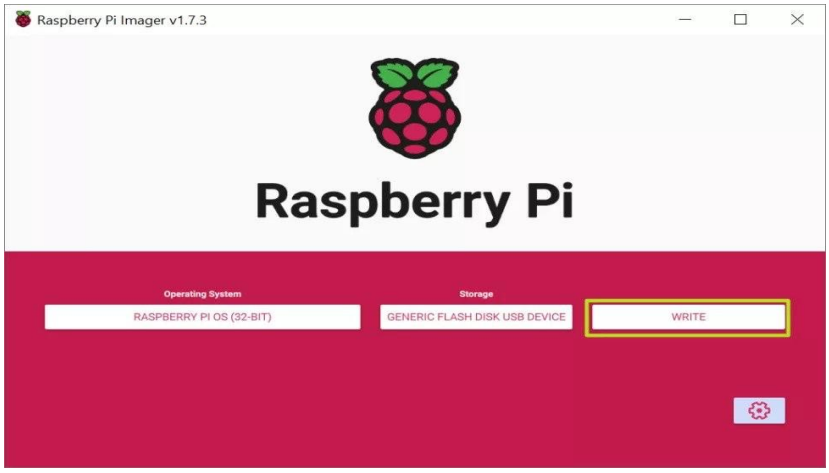
5. **Click the settings button** or hit CTRL + SHIFT + X to enter settings.

6. **Fill in settings fields** as follows and then **hit Save**. All of these fields are technically optional, but highly recommended so that can get your Raspberry Pi set up and online as soon as you boot it. If you don't set a username and password here, you'll have to go through a setup wizard that asks you to create them on first boot.

- **Set hostname**: the name of your Pi. It could be "raspberrypi" or anything you like.
- **Enable SSH**: Allow SSH connections to the Pi. Recommended.
- **Use password authentication / public key:** method of logging in via SSH
- **Set username and password:** Pick the username and password you'll use for the Pi
- **Configure wireless LAN: s**et the SSID and password of Wi-FI network
- **Wireless LAN country:** If you're setting up Wi-Fi, you must choose this.
- **Set locale settings:** Configure keyboard layout and time zone (probably chosen correctly by fault)



7. **Click Write.** The app will now take a few minutes to download the OS and write to your card.



Viva Voce:

1) Explain Raspberry Pi.

2) Explain the working of Raspberry Pi.

3) List some interesting projects can be made with Raspberry Pi.

4) Point down the uses of Raspberry Pi in IoT.

5) Define different components of a Raspberry Pi Board.

6) Discuss about NOOBS Software.

7) Deliberate the use of GPIO Pin in Raspberry Pi Boards.

8) Can Raspberry Pi be used as a server.

9) Discuss the language used by Raspberry Pi.

10) Difference between Raspberry Pi and Arduino.

11) With an example discuss the best-fit use of Raspberry Pi.

12) Deliberate on confront of overheating problem in Raspberry Pi.

13) Explain how can you measure power consumption used by Raspberry Pi.

14) List THE generations of Raspberry Pi available.

15) Difference between Raspberry pi version 3 and 4.

16) Define Arduino.

17) Discuss the stable version of Arduino Software.

18) Name the developer of Arduino.

19) With proper application discuss the use of Arduino.

20) Deliberate about IDE toolbar of Arduino.

21) Discuss the use of operator in Arduino.

22) Define the role of Sketch in Arduino.

23) Explain software structure functions.

24) Name the function used to find the length of a string.

25) List some advantages of Arduino.

26) Explain three important parts of Arduino.

27) Define the role of libraries in Arduino.

28) In which language Arduino software was written.

29) Explain the function of time in Arduino.

30) Explain the process of converting a string to upper case.