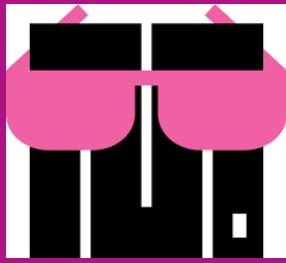
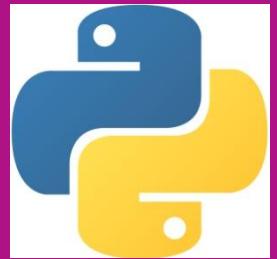
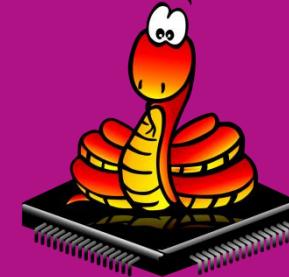


# INTERNET OF THINGS (IOT) PROJECTS USING PYTHON

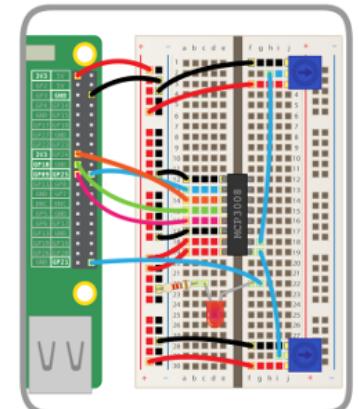
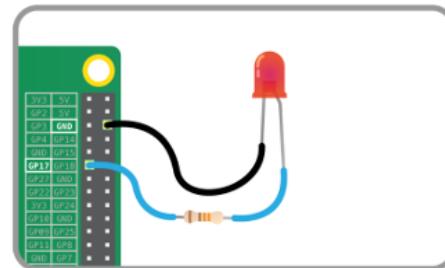
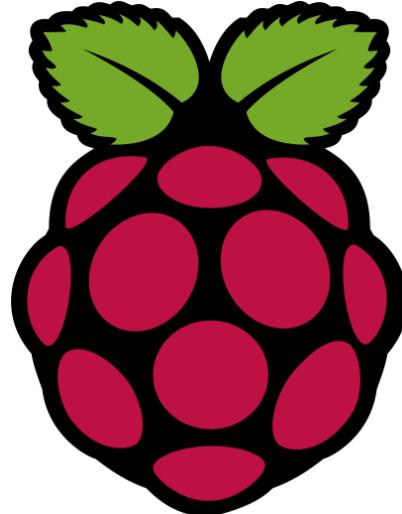


(CSE 4110)

(LECTURE – 1)



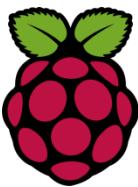
Th



Pin	Name	Function
1	GP2	
2	GP3	
3	GP4	
4	GP5	
5	GP6	
6	GP7	
7	GP8	
8	GP9	
9	GP10	
10	GP11	
11	GP12	
12	GP13	
13	GP14	
14	GP15	
15	GP16	
16	GP17	
17	GP18	
18	GP19	
19	GP20	
20	GP21	
21	GP22	
22	GP23	
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25	GP26	
26	GP27	
27	GP28	
28	GP29	
29	GP30	
30	GP31	



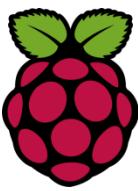
# What Is Outcome-Based Education? OBE Vs Traditional Education System



- Outcome-based education is a system where all the parts and aspects of education are focused on the outcomes of the course. The students take up courses with a certain goal of developing skills or gaining knowledge and they have to complete the goal by end of the course.
  
- There is no specific style or time limit of learning. The student can learn as per their choice. The faculty members, moderators, and instructors guide the students based on the target outcomes.



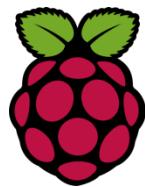
# Benefits Of Outcome-Based Education (OBE) For Students



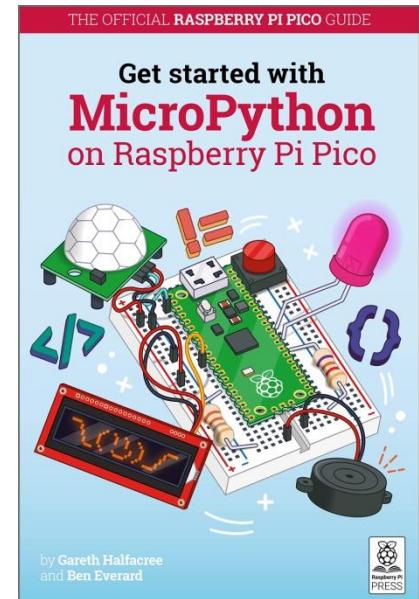
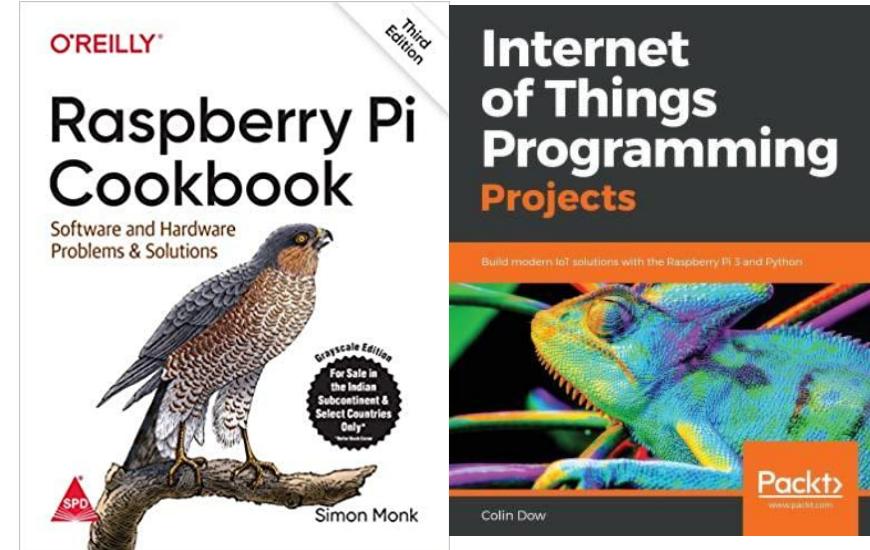
- Brings clarity among the teachers and students
- Every student has the flexibility and freedom of learning in their ways.
- There is more than one method of learning
- Reduces comparison among the students as everyone has a different target
- Completely involves students taking responsibility for their goals



# About your subject

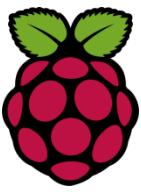


- Grading Pattern : 3
- Credit : 4
- TextBook:
  - 1) Raspberry Pi Cookbook by by Simon Monk, shroff/O'Reilly
  - 2) Internet of Things Programming Projects by By Colin Dow, Packt,
- Reference : 3) Get started with Micro-Python

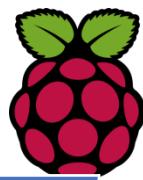




# Evaluation Scheme



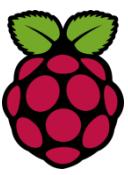
- ATTENDANCE : 5
- WEEKLY ASSIGNMENTS / QUIZZES : 20 MID-TERM
- MID TERM : 15
- TOTAL INTERNAL : 40
  
- FINAL ASSIGNMENT : 40
- ASSIGNMENT PRESENTATION : 20 END-TERM
- TOTAL EXTERNAL : 60



# Course Outcomes

## Course Outcomes

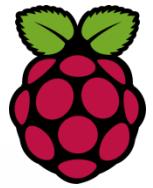
<b>CO1</b>	Understand general concepts of Internet of Things (IoT), the working of Raspberry Pi and its features.
<b>CO2</b>	Recognize various components, sensors, actuators, devices and their applications.
<b>CO3</b>	Analyze various python programs to interface with sensors, actuators, LED's, cloud and camera using Raspberry pi.
<b>CO4</b>	Measure physical parameters using sensors.
<b>CO5</b>	Demonstrate the ability to transmit data wirelessly between different devices to build simple IoT systems using Raspberry Pi.
<b>CO6</b>	Create IoT devices and systems through a variety of interfaces, including web apps and mobile apps.



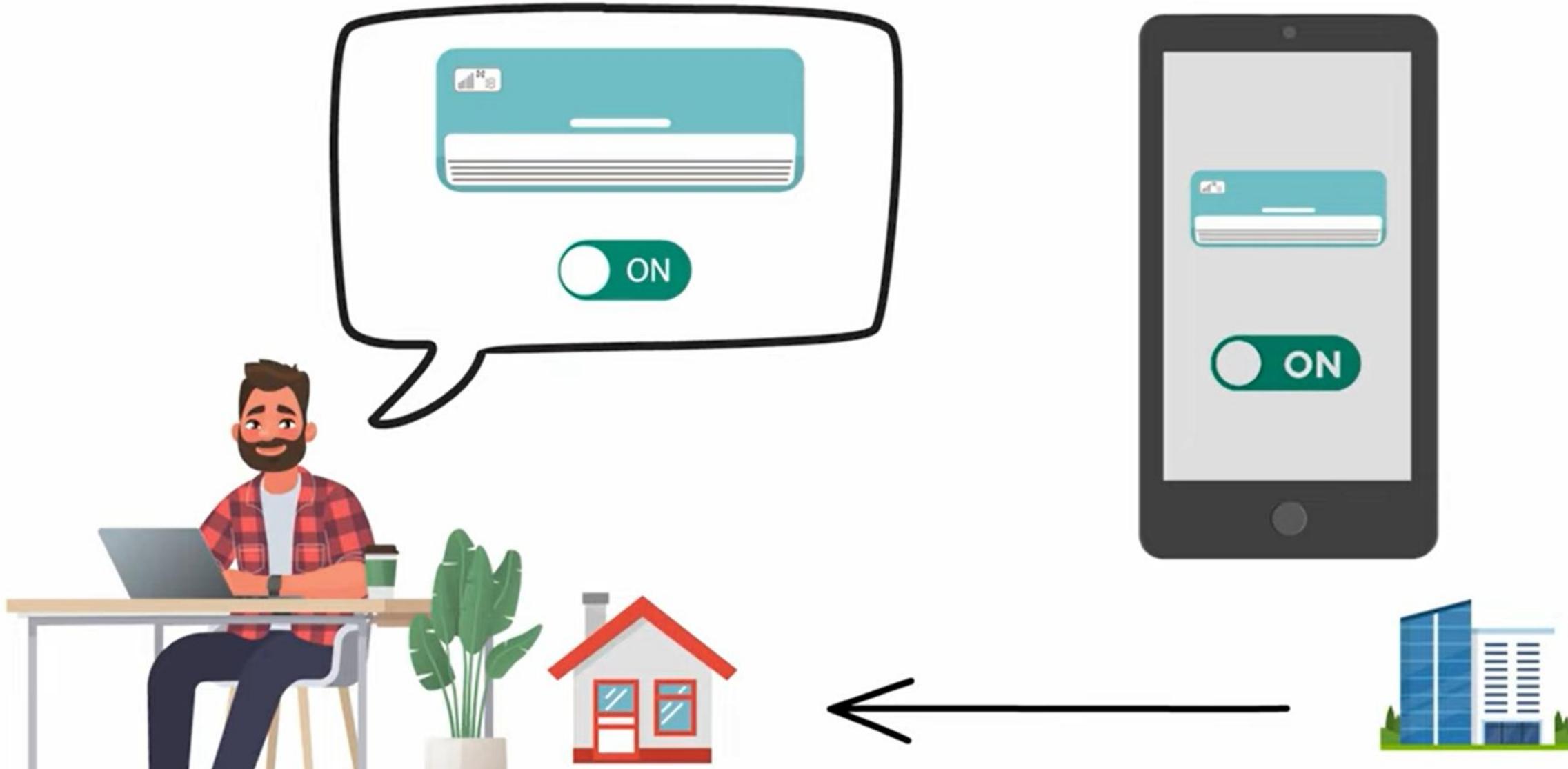
# What Students will learn?

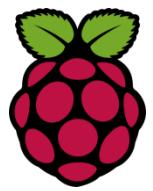
Students will get a glimpse into the ever-growing field of IoT, a technology that allows the intelligent exchange of data among a network of internet-connected objects. Also students will experience about “RP2040” chip which provides ample power for embedded as well as IOT projects and enables users of any age or ability to learn coding and electronics.

- ✓ Familiarization with IoT concepts, their origin, impact, methodologies and tools, and how IoT is integrated into different applications to improve technical as well as business results.
- ✓ Set up your Raspberry Pi Pico and start using it
- ✓ Prepare Raspberry Pi Pico with header for breadboard implementation.
- ✓ Introduction to the ONLINE SIMULATOR “WOKWI”

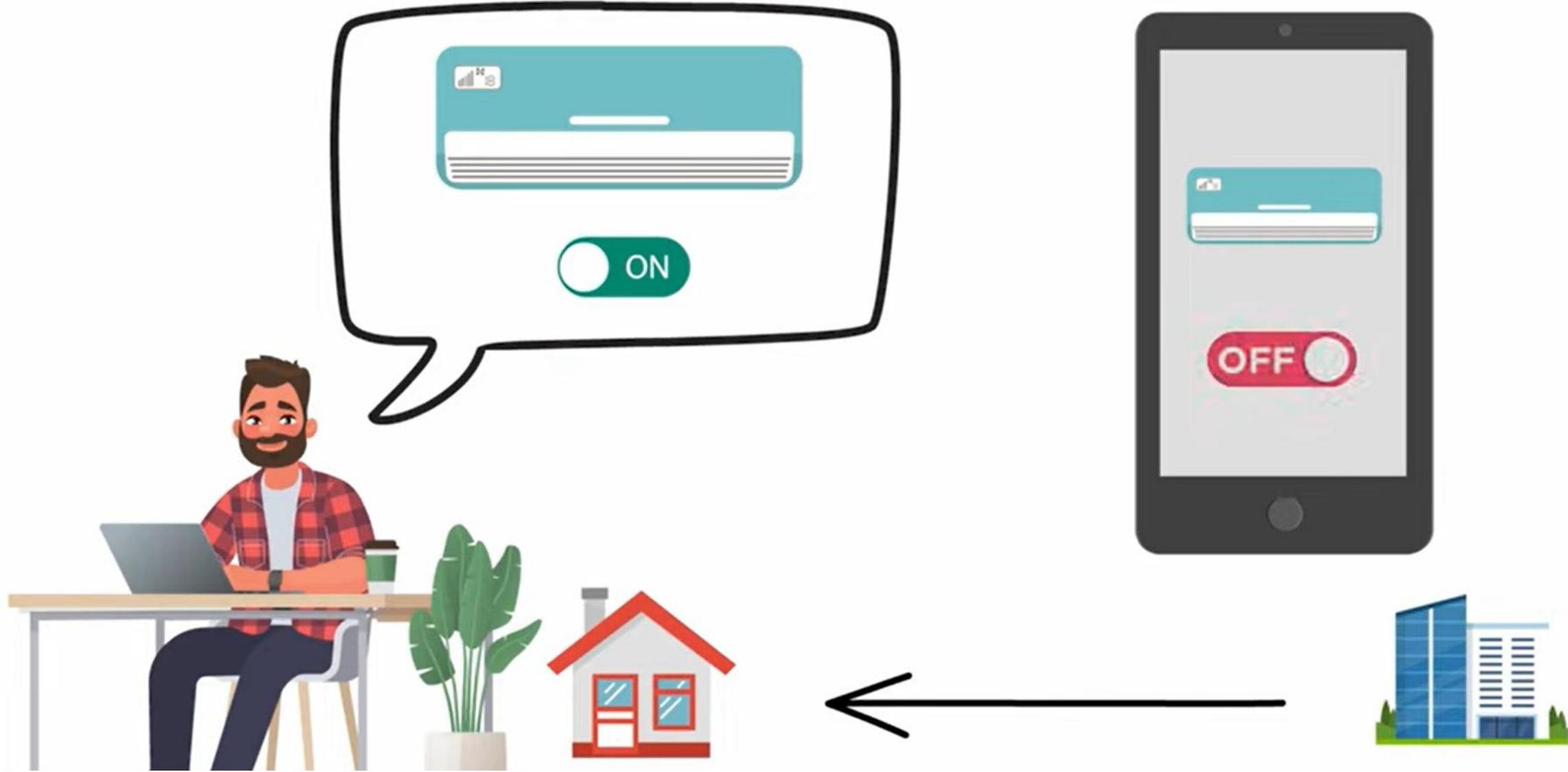


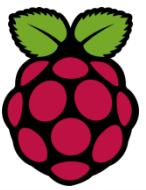
# Want to know status of my AC?



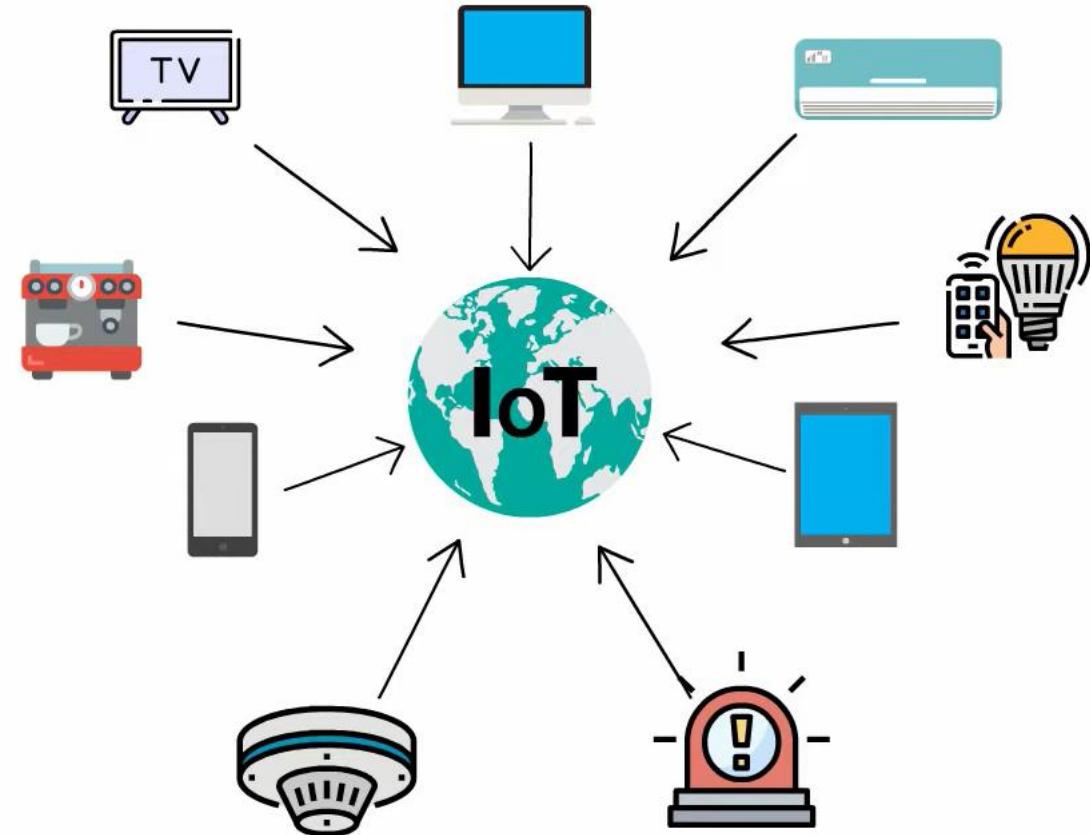


# Can I turn it off?

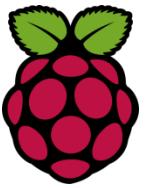




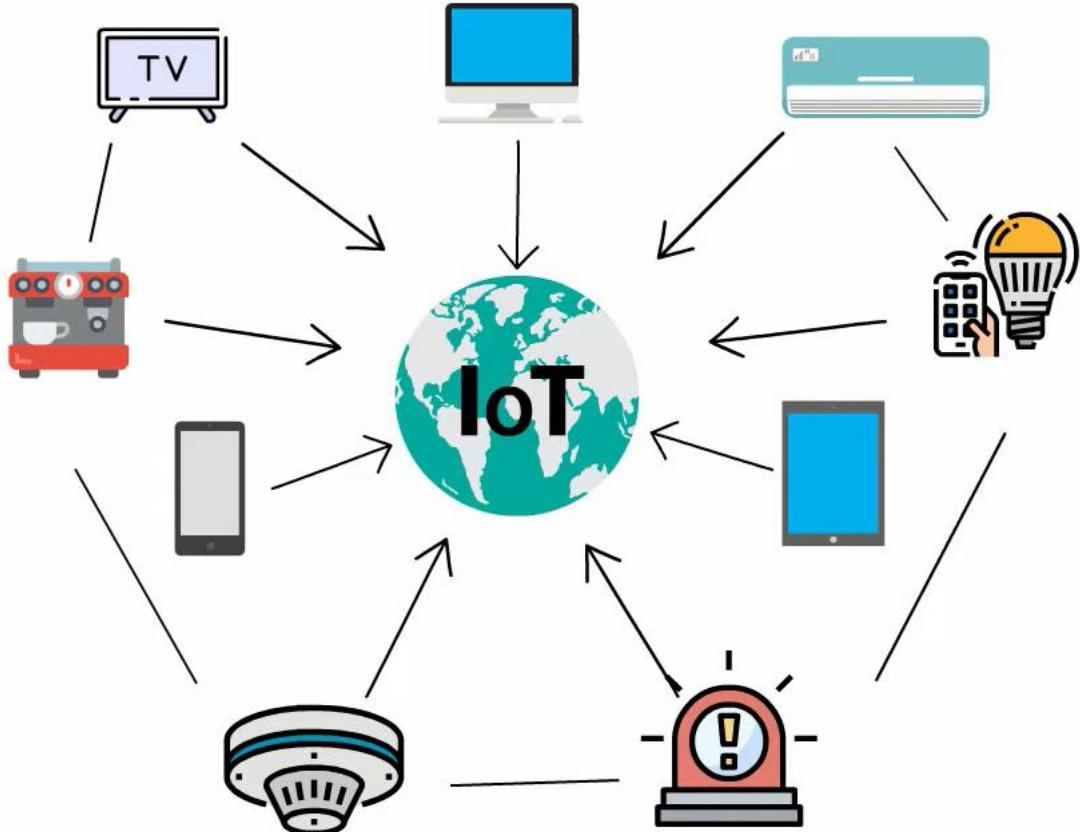
# What IoT can do?



IoT is shaping the way we live our lives



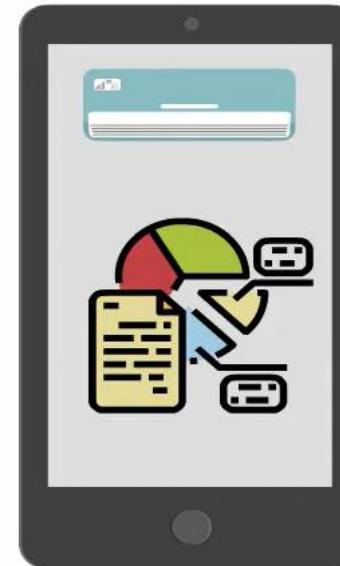
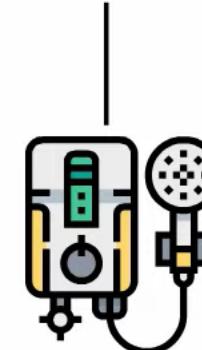
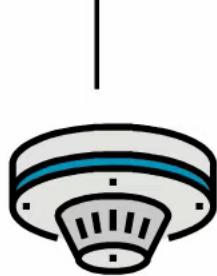
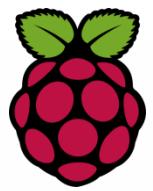
# What is IOT?

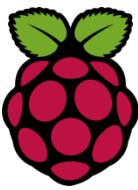


**Internet of Things (IOT) is a system of inter related devices connect to the internet to transfer and receive data from one to the other.**



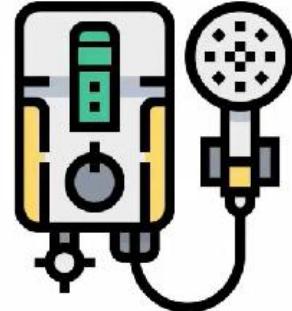
# A smart home is the best example of IoT



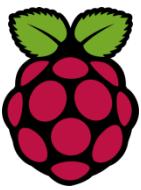


# Internet of Things

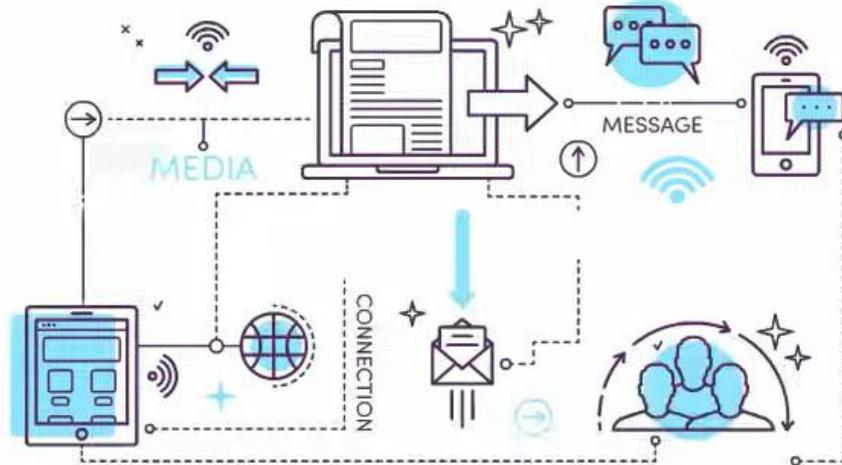
For example:



Although all of this is fascinating, there's a lot that goes on in the background to ensure seamless functioning



# Internet of Things

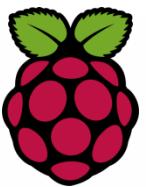


Communication  
between Devices

## Components

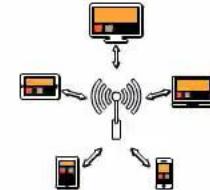


Accurate processing of  
received data

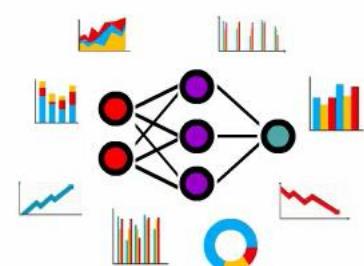
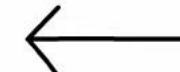
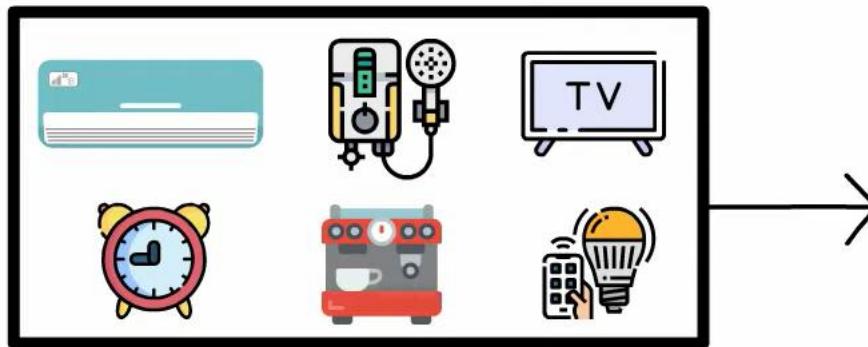
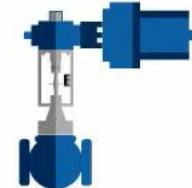


# IoT devices

General devices

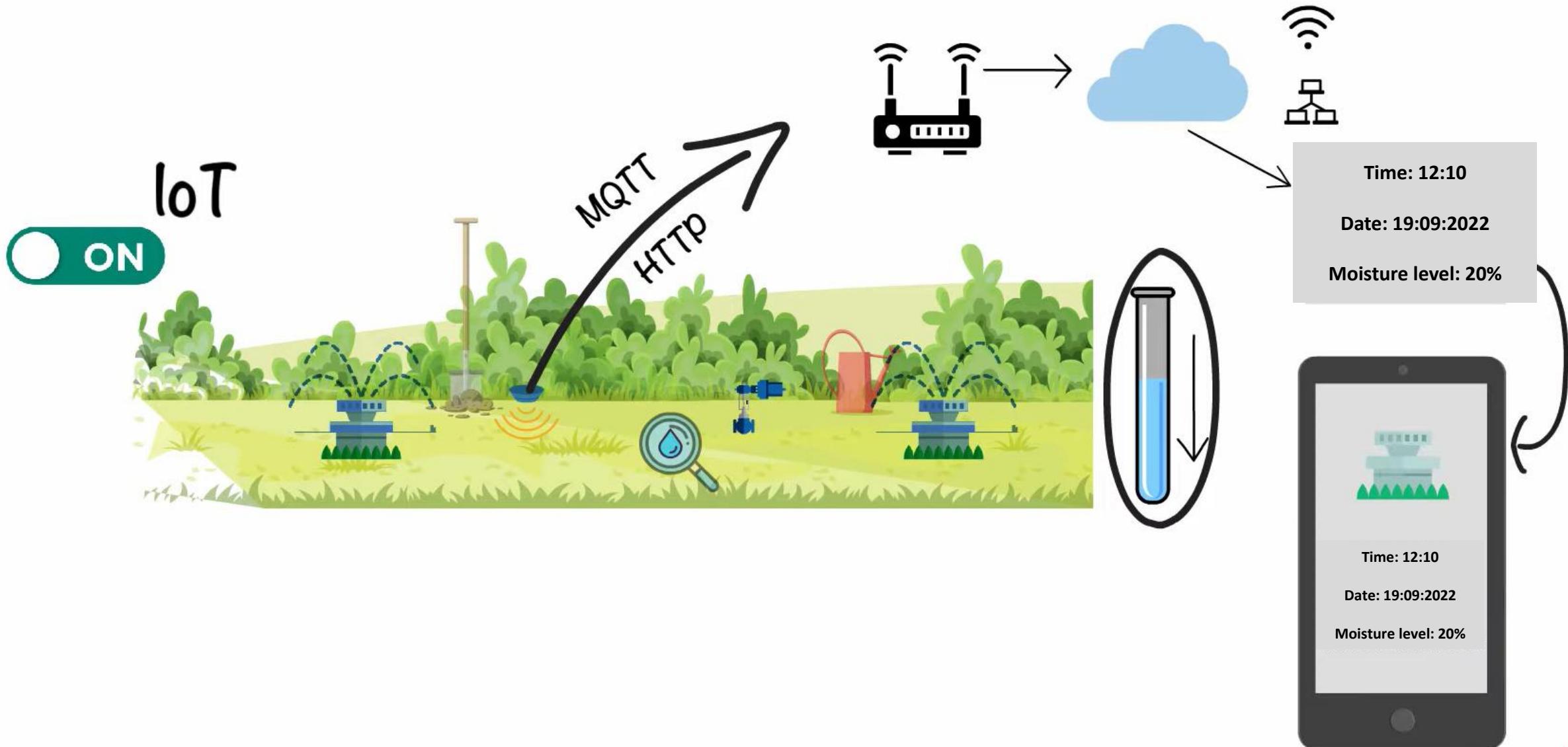
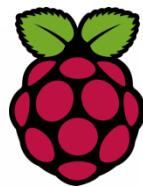


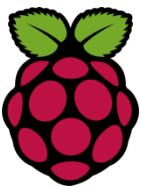
Sensing devices



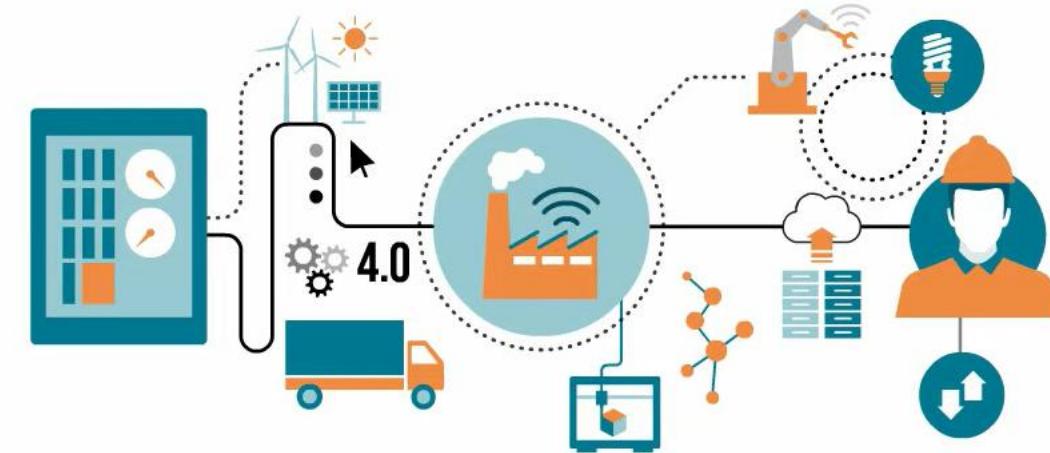
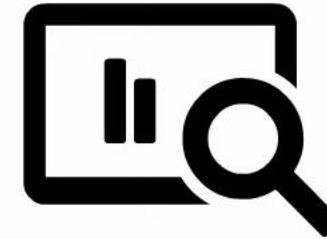


# To help you understand its working, let's take a simple scenario

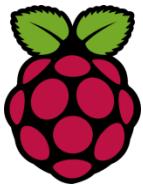




# Internet of Things



Today, IoT is being used extensively to lessen the burden on humans



# Internet of Things

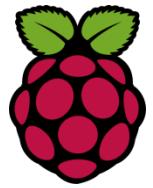
Today, IoT is being used extensively to lessen the burden on humans



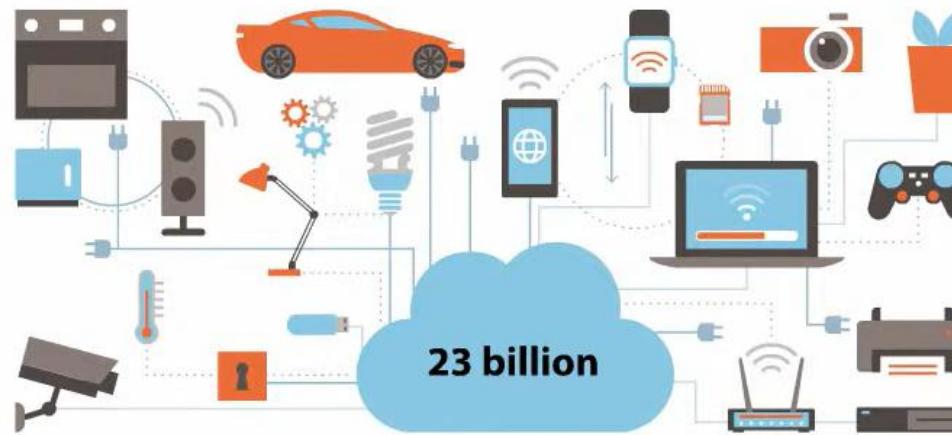
Promising than ever before



# Internet of Things



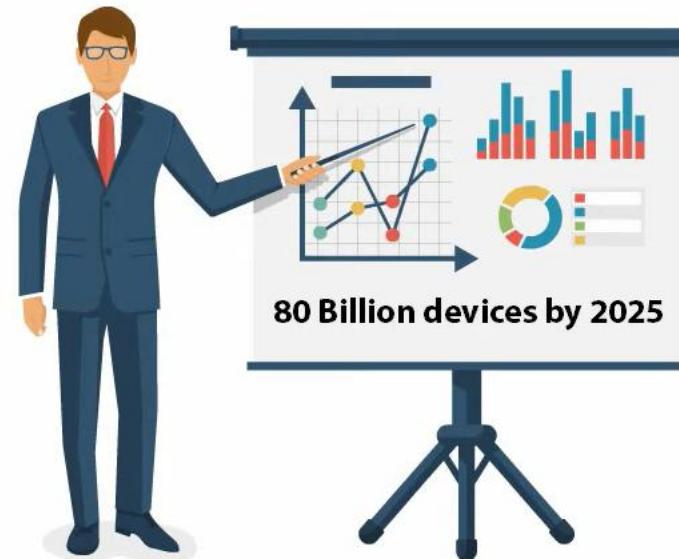
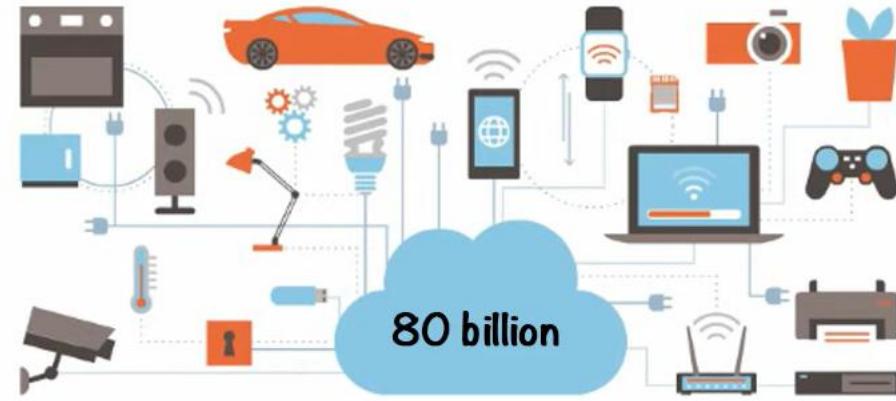
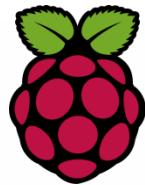
In 2018:



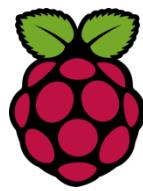


In 2025:

# Internet of Things



IoT is a vision to connect all devices with the power of the internet,  
always learning and always growing

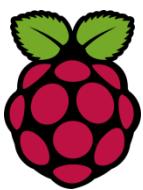


# QUIZ TIME???????

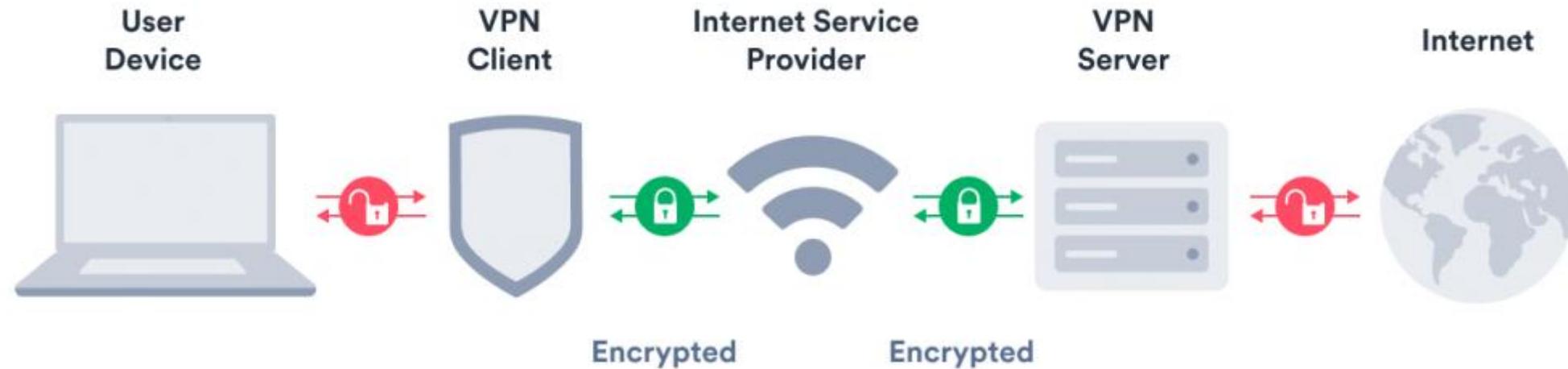


Which of the following technologies is not used as an interface for a network?

1. WiFi
2. Ethernet
3. ZigBee
4. VPN



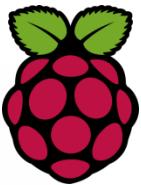
# Answer – D: VPN



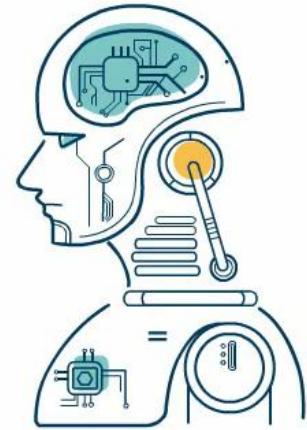
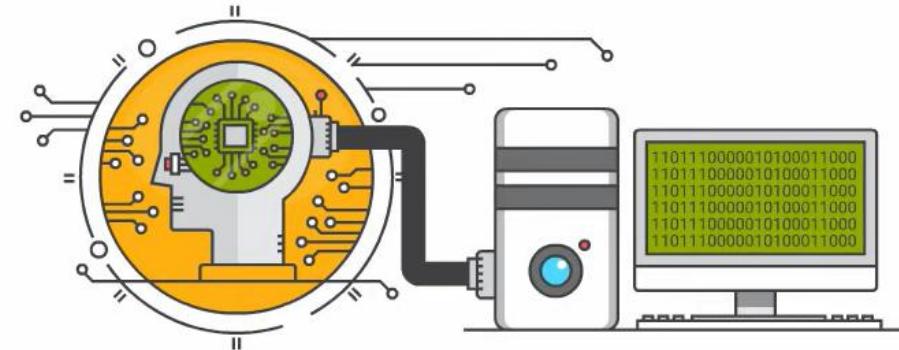
## VPN

A VPN (Virtual Private Network) **protects your connection while you're using the internet**. It makes your browsing private, hides your IP (Internet Protocol) address and ensures your internet service provider (ISP) doesn't track you.

**VPN is used to extend a private network over a public. The other options are used to provide a medium for data transfer.**



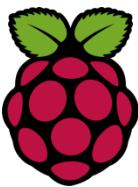
# The integration of IoT with other technologies like



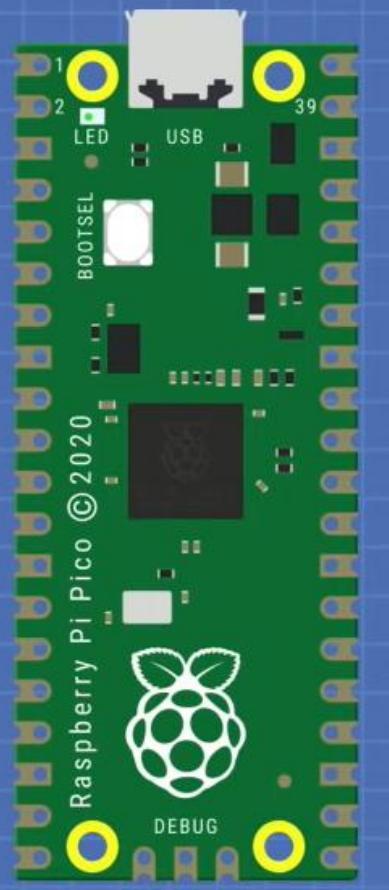
That is the  
Internet of Things  
for you in short

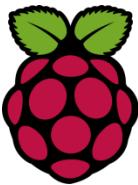


# Raspberry Pi Pico

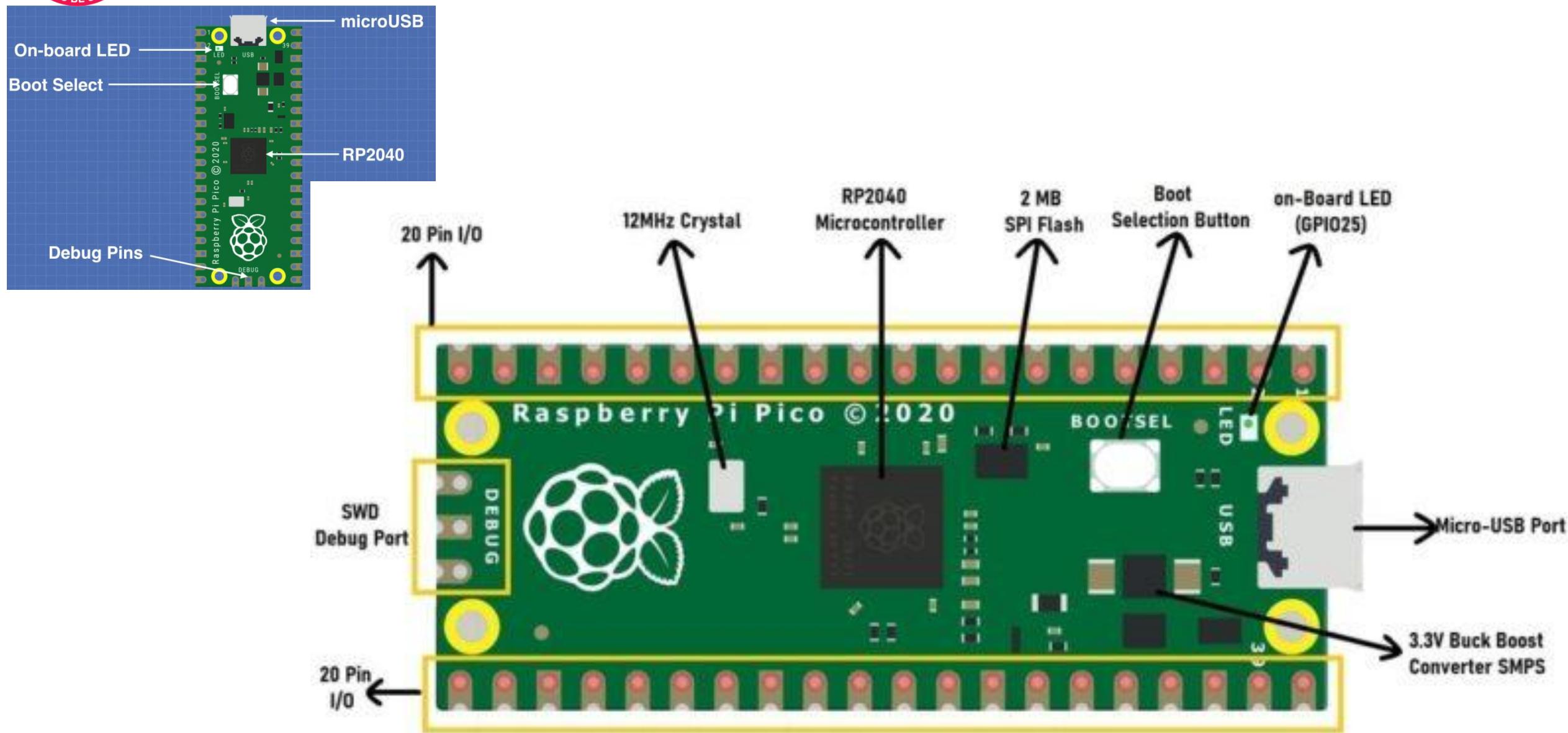


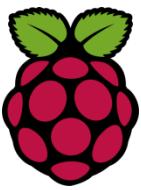
- Introduced by Raspberry Pi in January 2021
- First Microcontroller in Raspberry Pi Family
- Powered by RP2040 MCU
- Multiple PWM-capable I/O ports, I2C, SPI, ADC
- Retails for \$4.00 USD
- Other manufacturers also building with RP2040





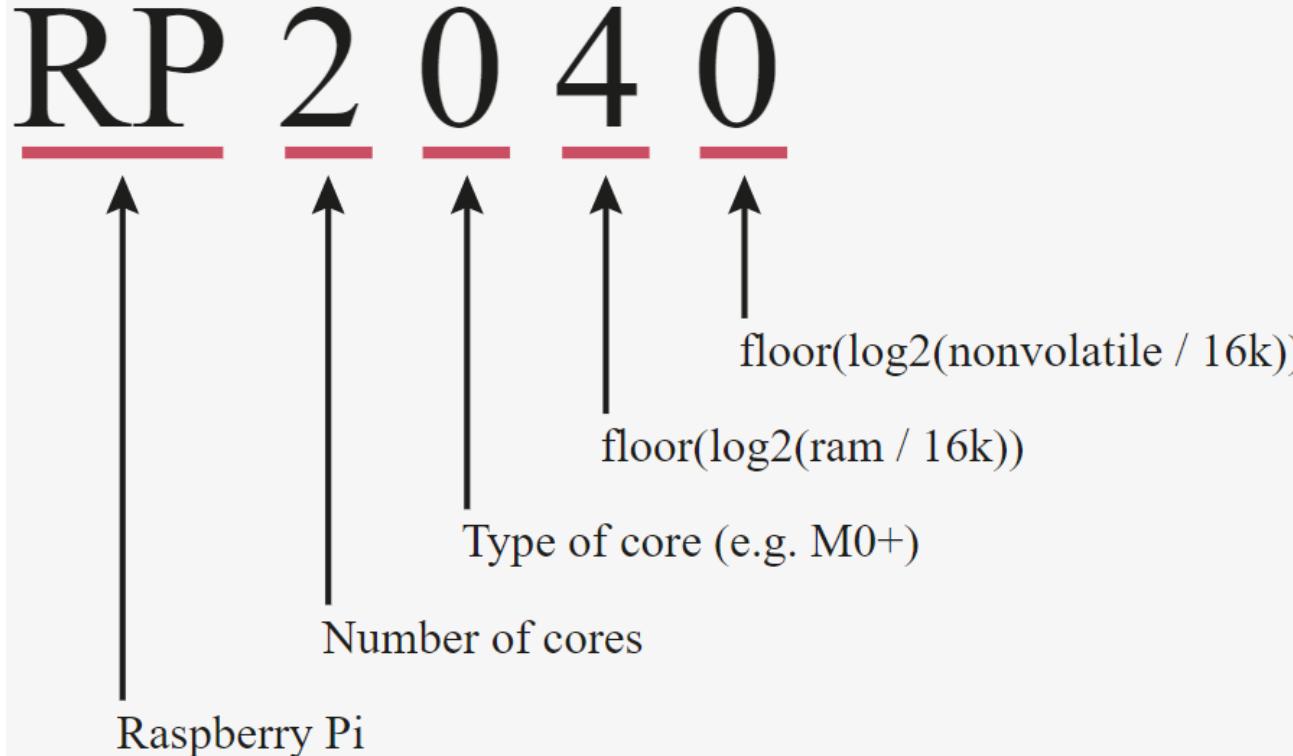
# Raspberry Pi Pico – Simple Pinout





# Why is the chip called RP2040?

The post-fix numeral on RP2040 comes from the following,



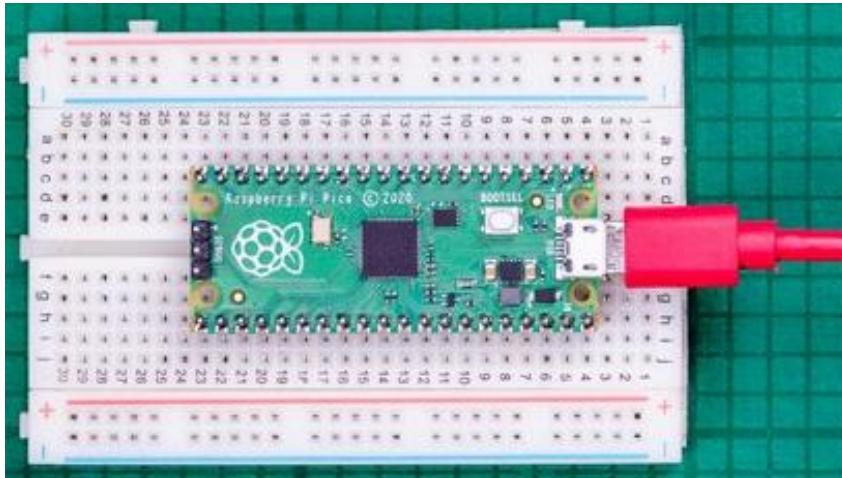
**1. Number of processor cores (2)**

**2. Loosely which type of processor (M0+)**

**3. floor(log2(ram / 16k))**

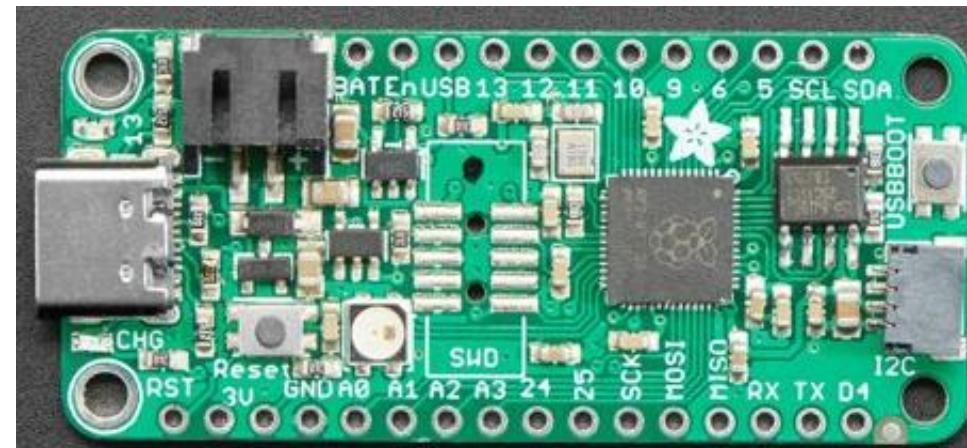
**4. floor(log2(nonvolatile / 16k)) or 0 if no onboard nonvolatile storage**

# RP2040-based Boards



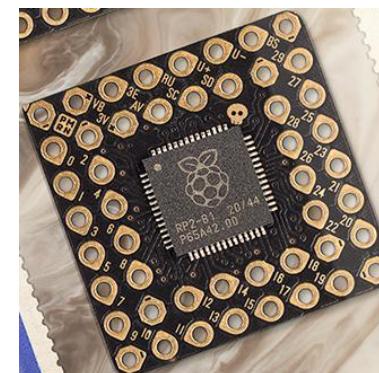
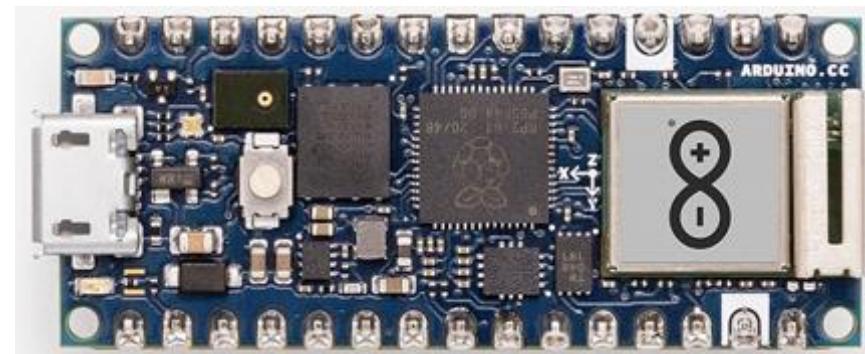
## Boards from Raspberry Pi

Raspberry Pi Pico, and Raspberry Pi Pico W



## Boards from Adafruit

Feather 2040 and ItsyBitsy 2040



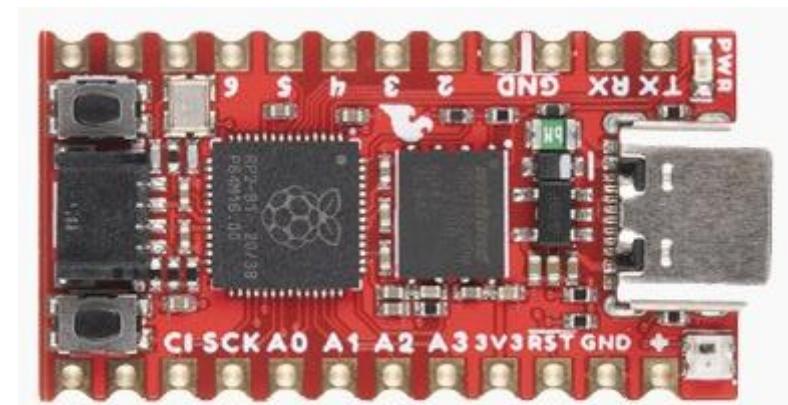
## Boards from

Arduino

Nano RP2040 Connect

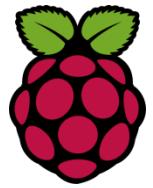
## Boards from Pimoroni

PGA2040, Pico LiPo, Tiny 2040,  
Keybow 2040, PicoSystem, Plasma 2040



## Boards from SparkFun

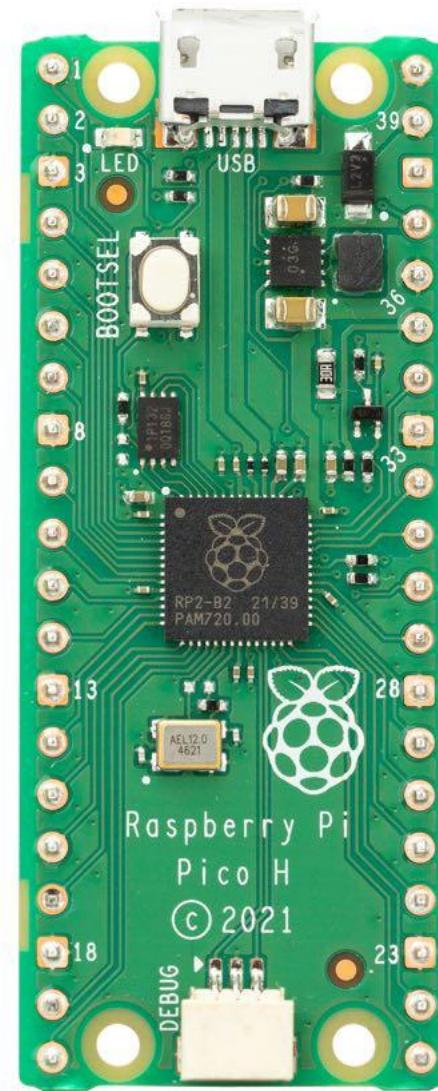
Pro Micro - RP2040, Thing Plus - RP2040, MicroMod RP2040 Processor



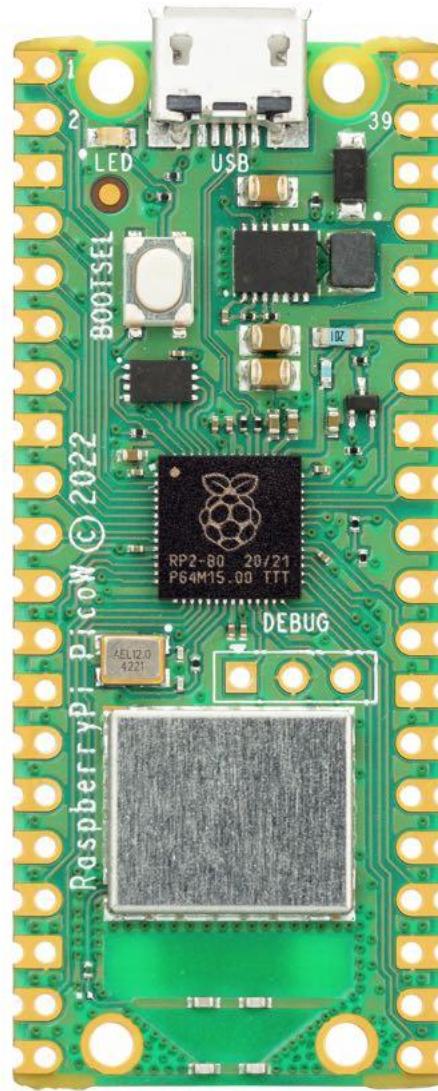
# Raspberry Pi Pico Family



Raspberry Pi  
Pico



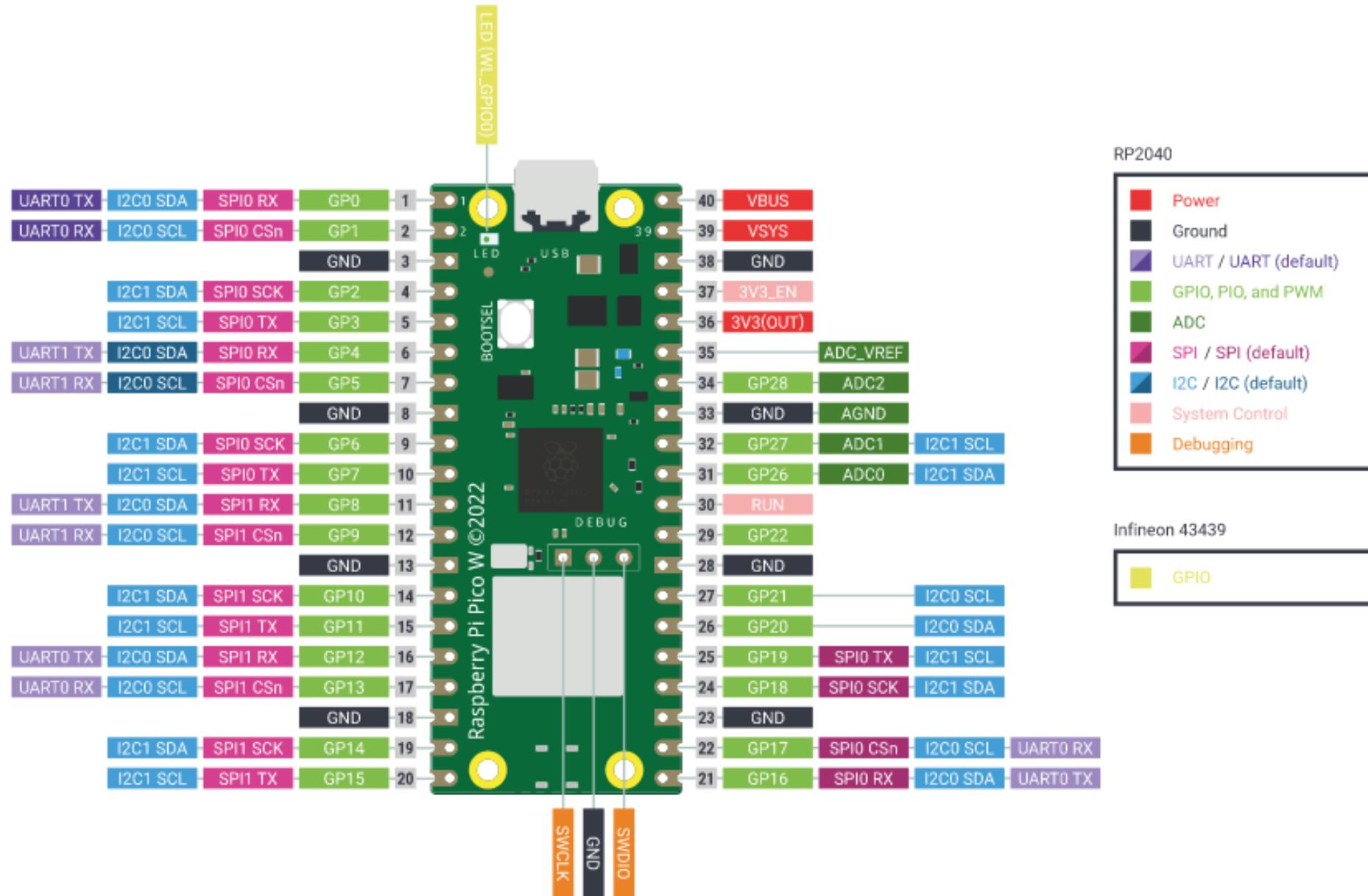
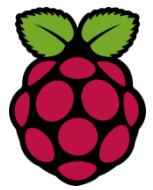
Raspberry Pi Pico H

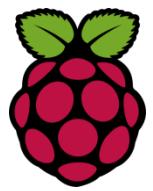


Raspberry Pi Pico W

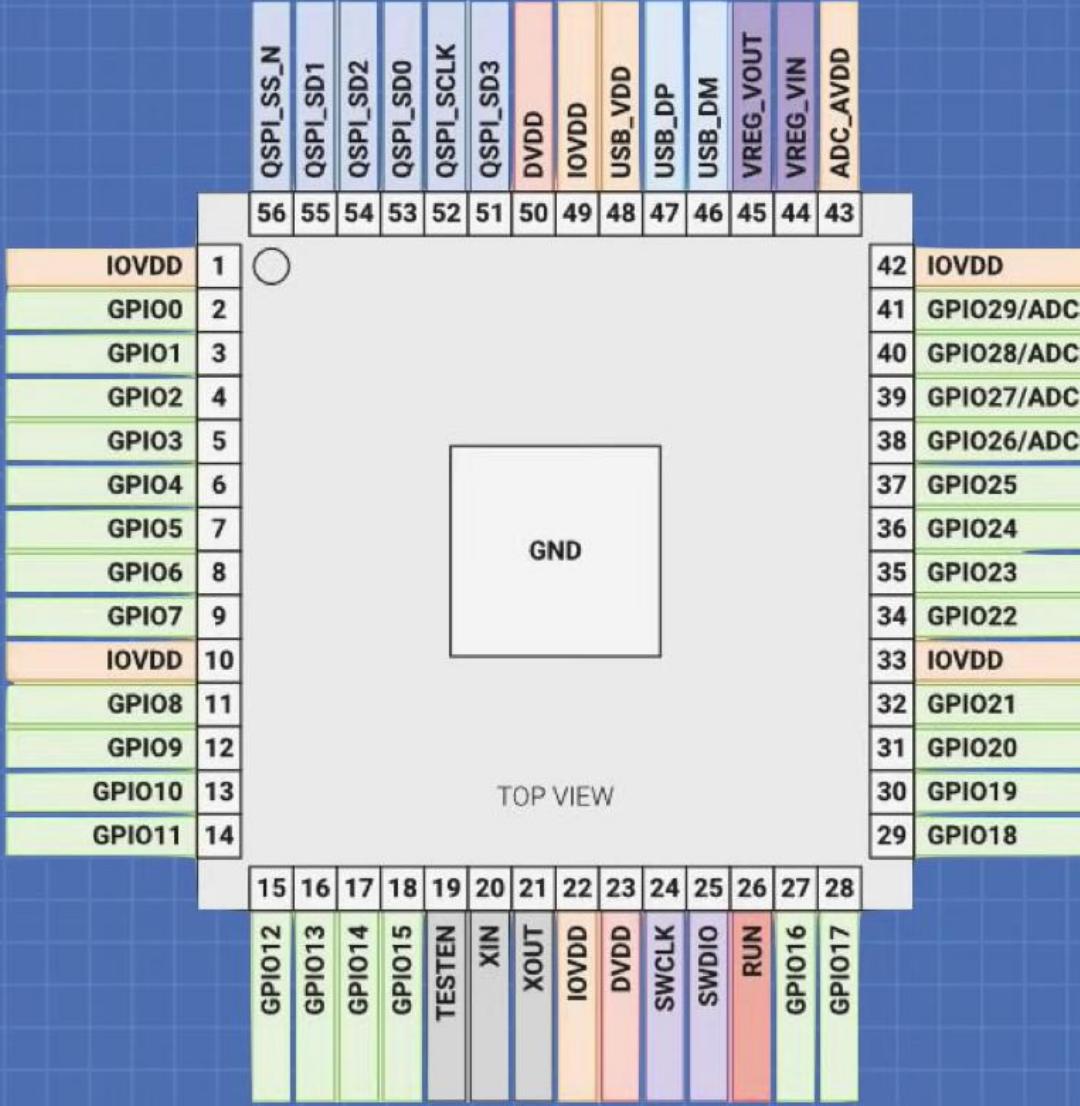


# Raspberry Pi Pico W Pinout



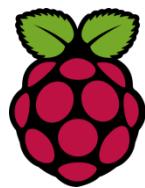


# Raspberry Pi Pico



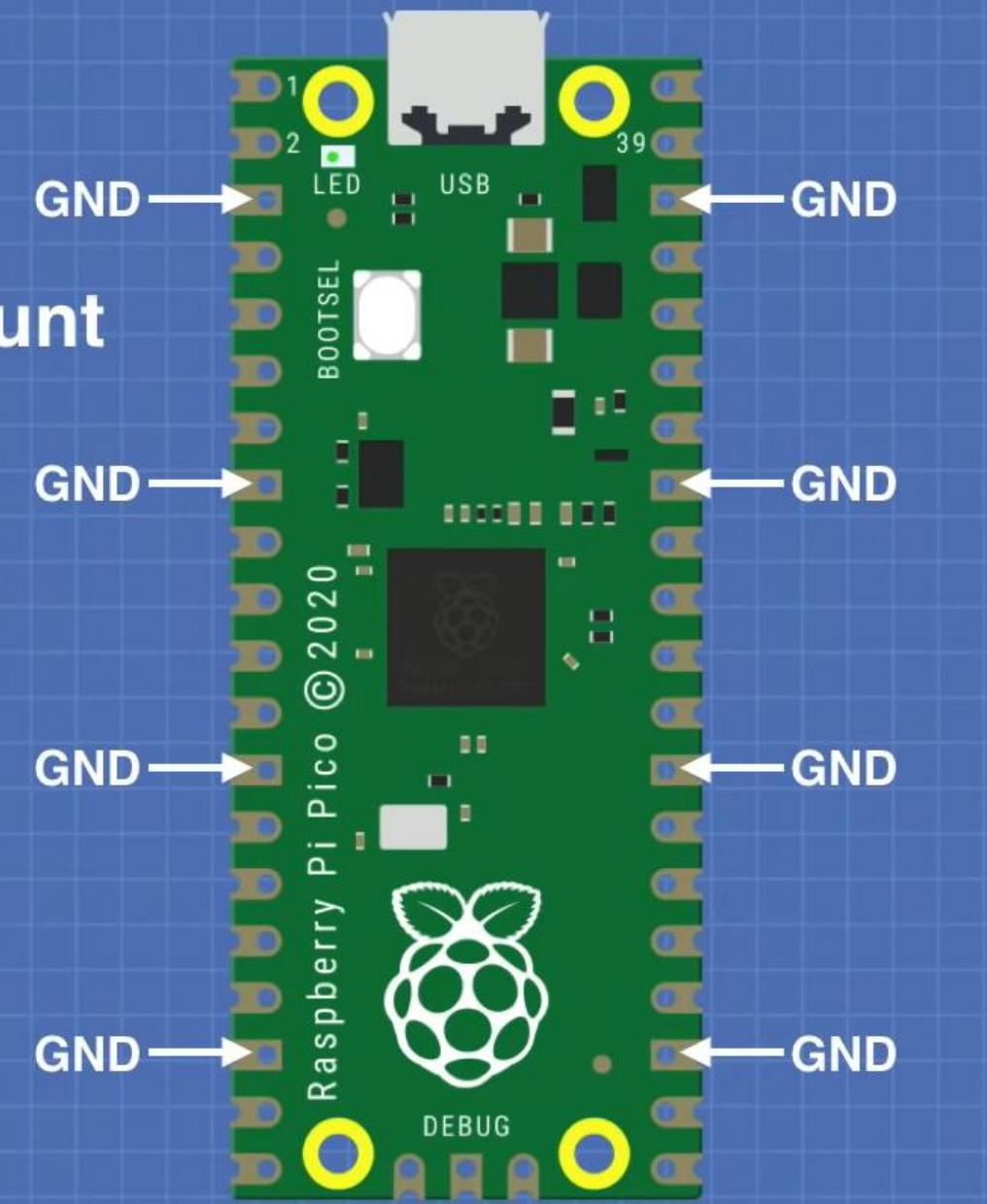
## RP2040

- 32-Bit Dual-Core ARM Cortex-M0+
- Clock speed 48MHz, boost to 133MHz
- 2MB onboard External Flash
- Onboard RTC
- Onboard Temperature Sensor



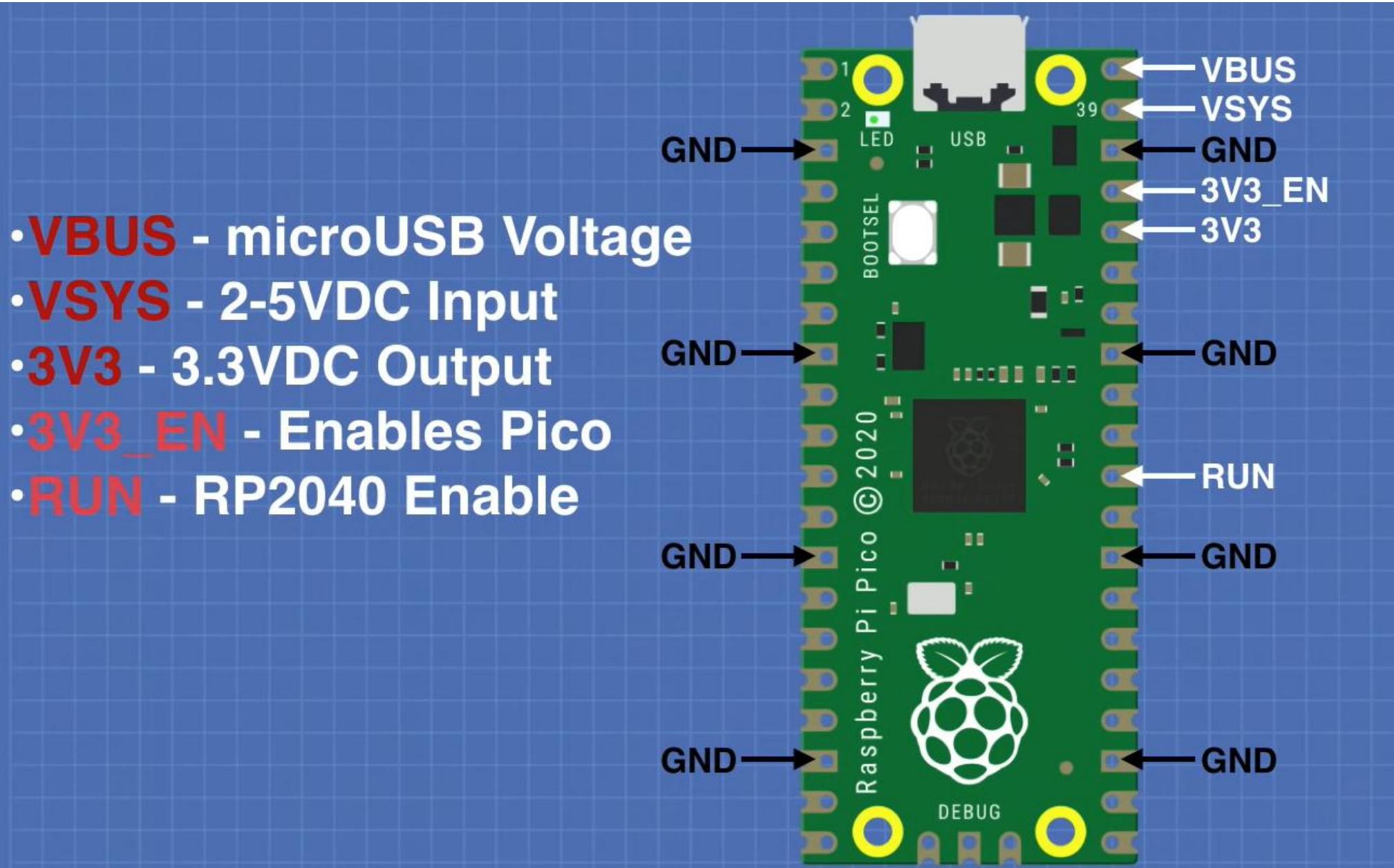
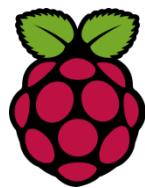
# Raspberry Pi Pico

- Use pins or surface-mount
- 8 Ground Points
- Evenly Spaced
- Square Pads

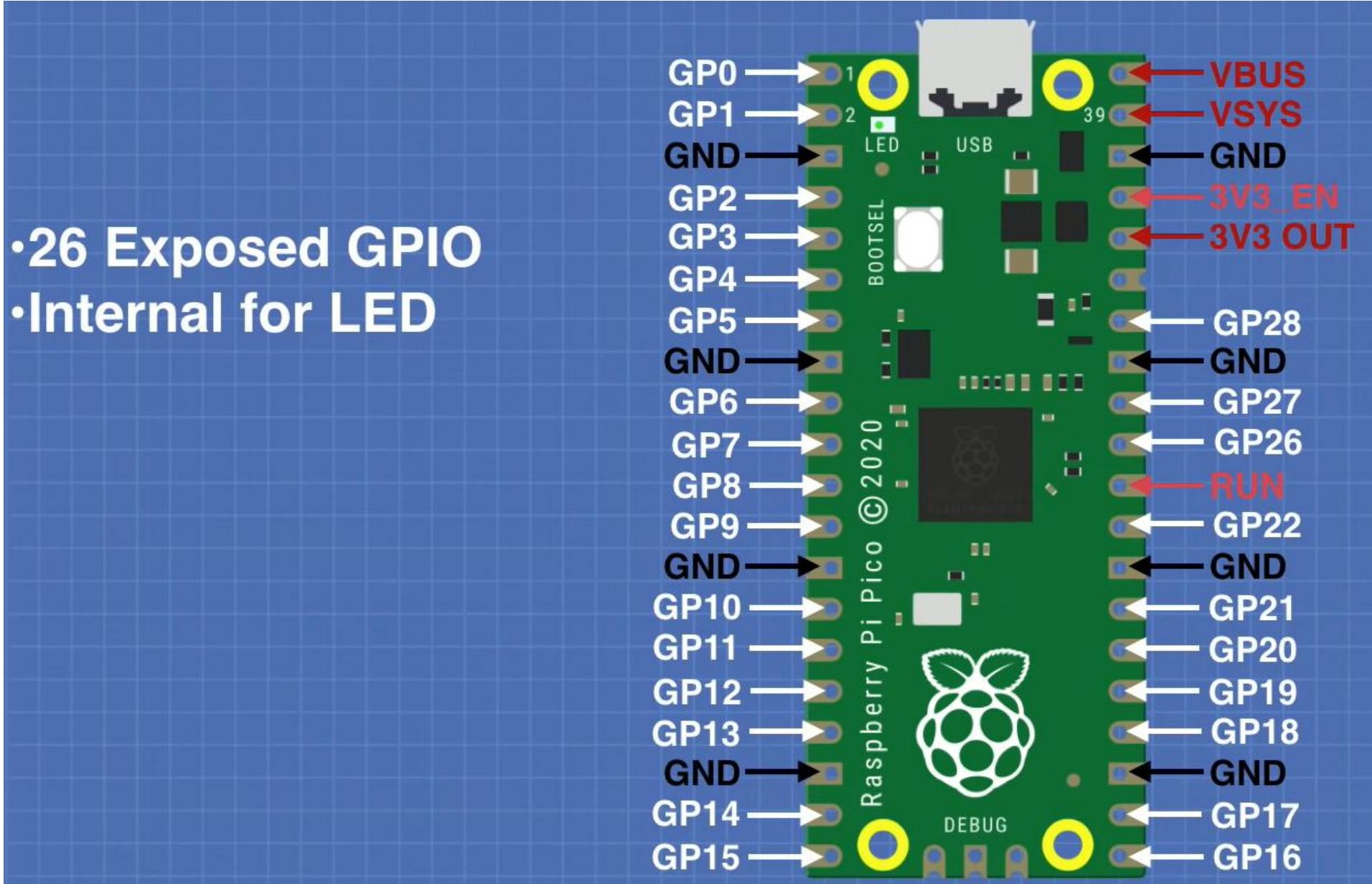
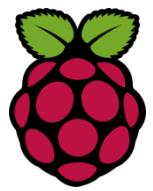




# Raspberry Pi Pico

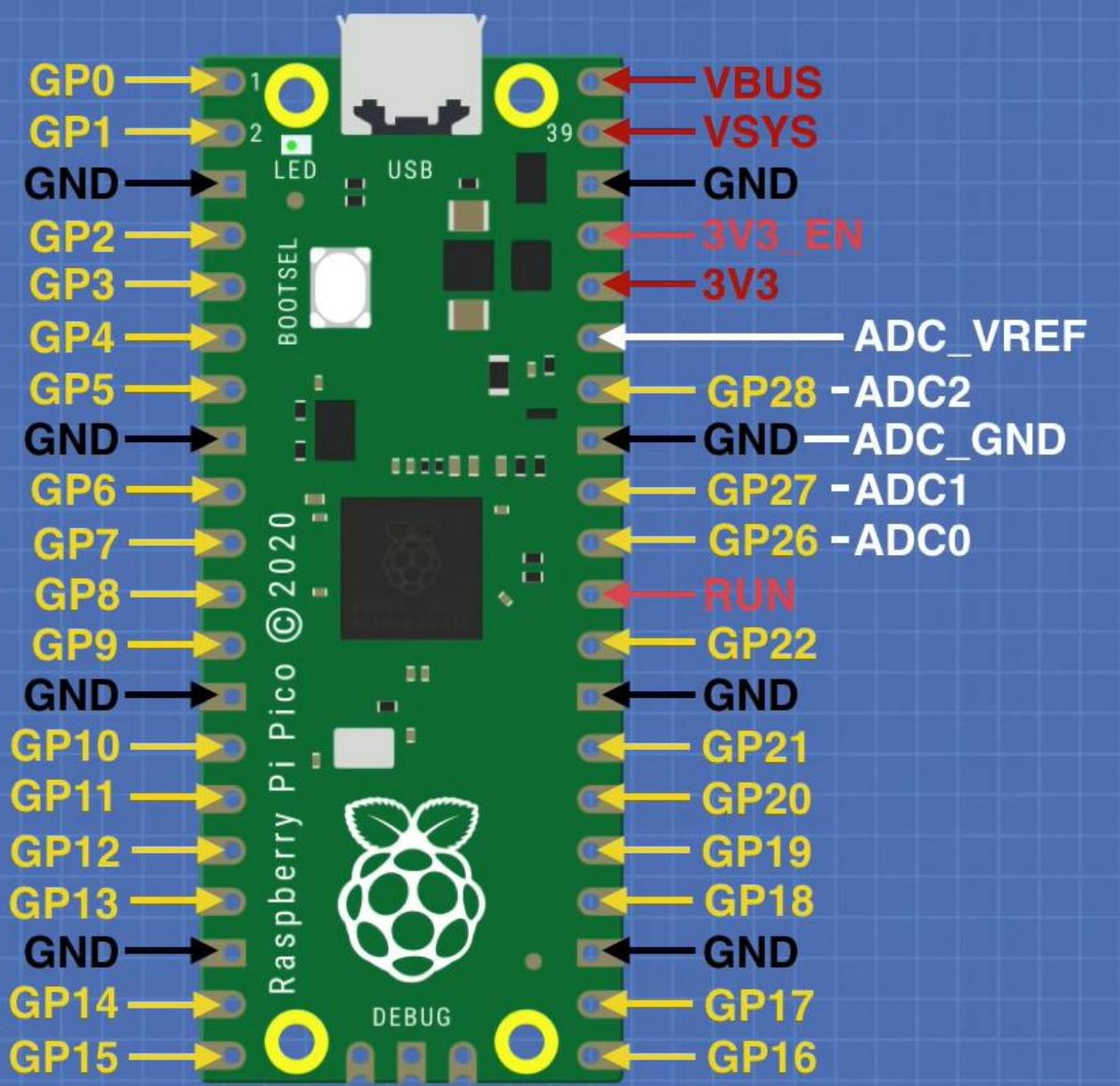


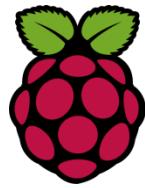
# Raspberry Pi Pico



# Raspberry Pi Pico

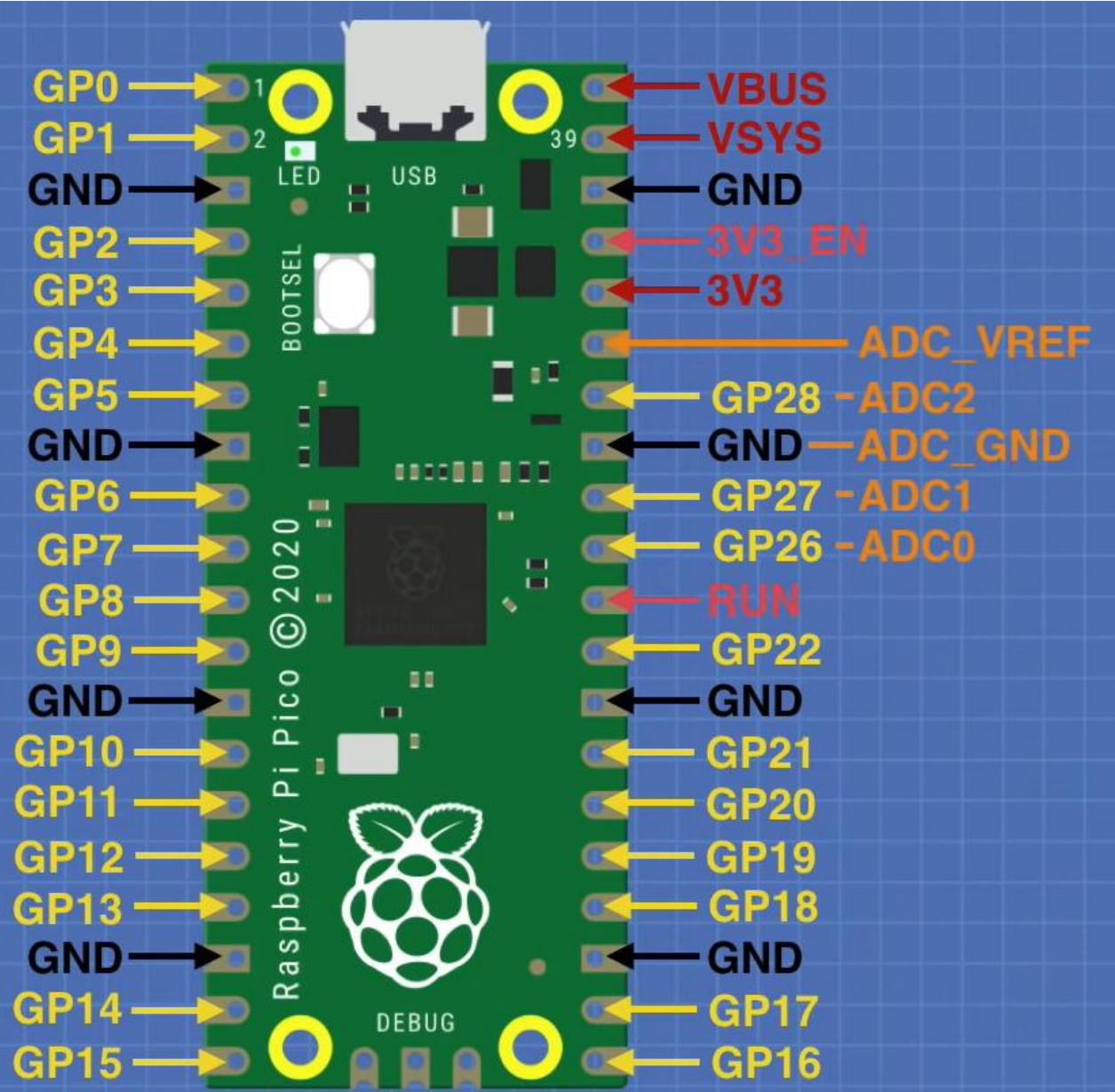
- 12-Bit ADC
- 3 plus Internal ADC
- Internal ADC for Temp
- **ADC\_VREF** for external
- **ADC\_GND** for external

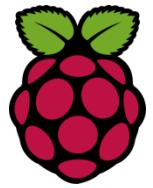




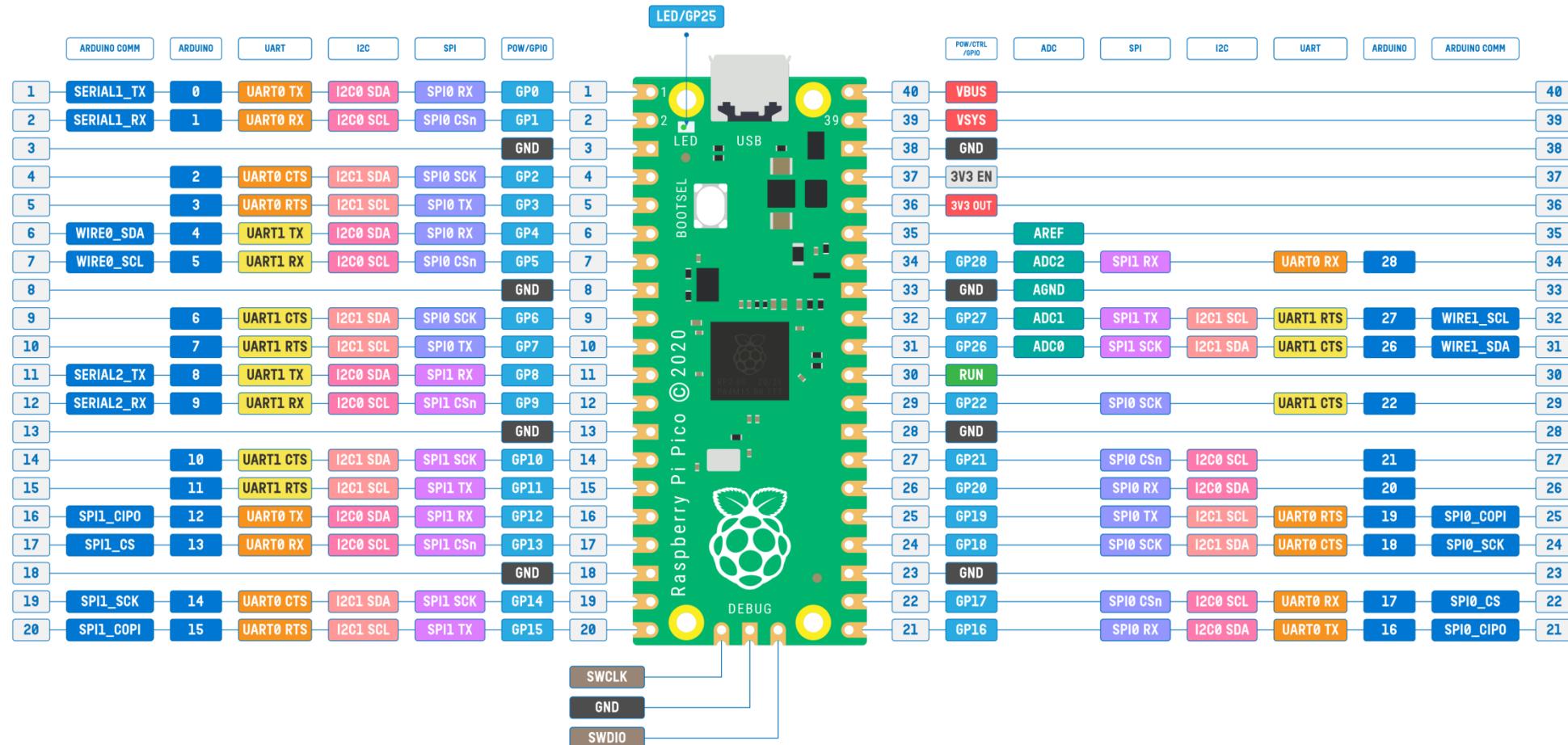
# Raspberry Pi Pico

- 2 x I2C Bus
- 2 x SPI Bus
- 2 x UART
- 16 x PWM Channels





# Raspberry Pi Pico – Full Pinout



\*Raspberry Pi and the Raspberry Pi logo are trademarks of Raspberry Pi Ltd.

Raspberry Pi Pico vector image is originally designed by Raspberry Pi. Please visit [raspberrypi.com](https://www.raspberrypi.com) for more info.

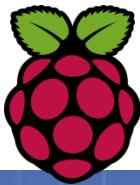
- GP29/ADC3 is used to measure VSYS.
- GP25 is used by debug LED.
- GP24 is used for VBUS sense.
- GP23 is connected to SMPS Power Save pin.
- All GPIO pins support PWM. There are total 16 PWM channels.
- All GPIO pins support level and edge interrupts.
- Arduino pins are as per [Arduino-Pico core](#) by [@earlephilhower](mailto:Earle F. Philhower, III)
- Arduino's default Serial is the USB-CDC of Pico.



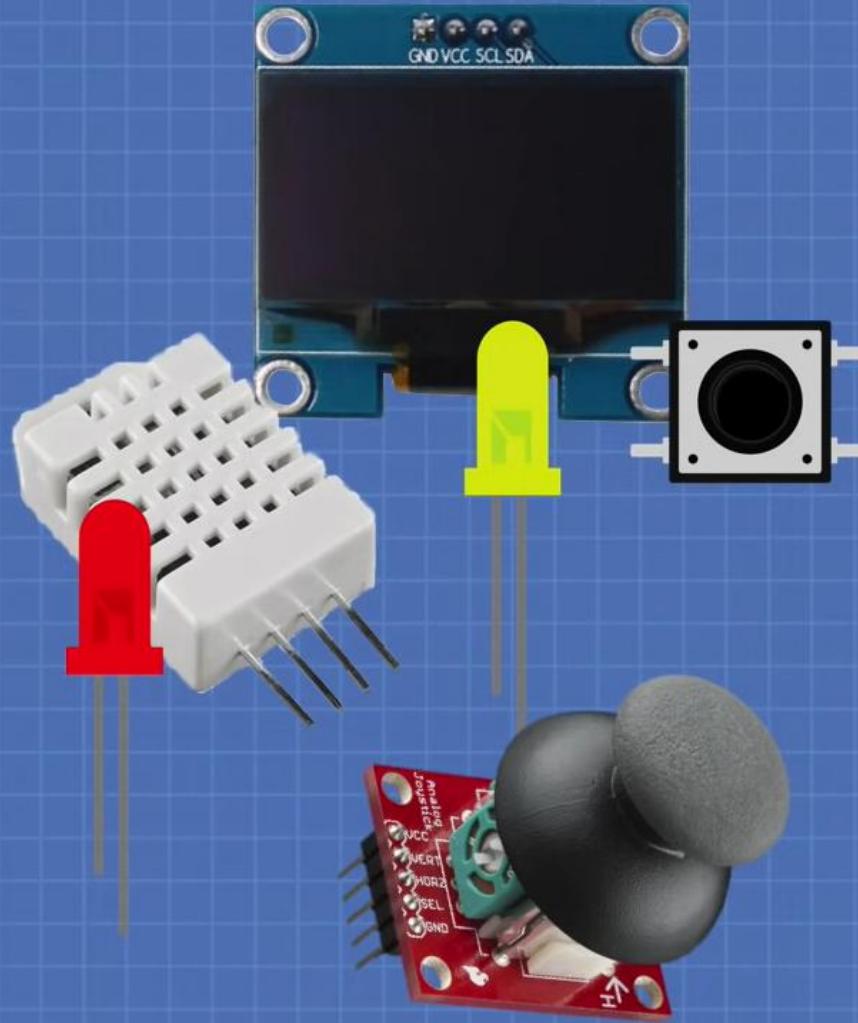
Rev. 0.2, 15-07-2022

Design: Vishnu Mohanan

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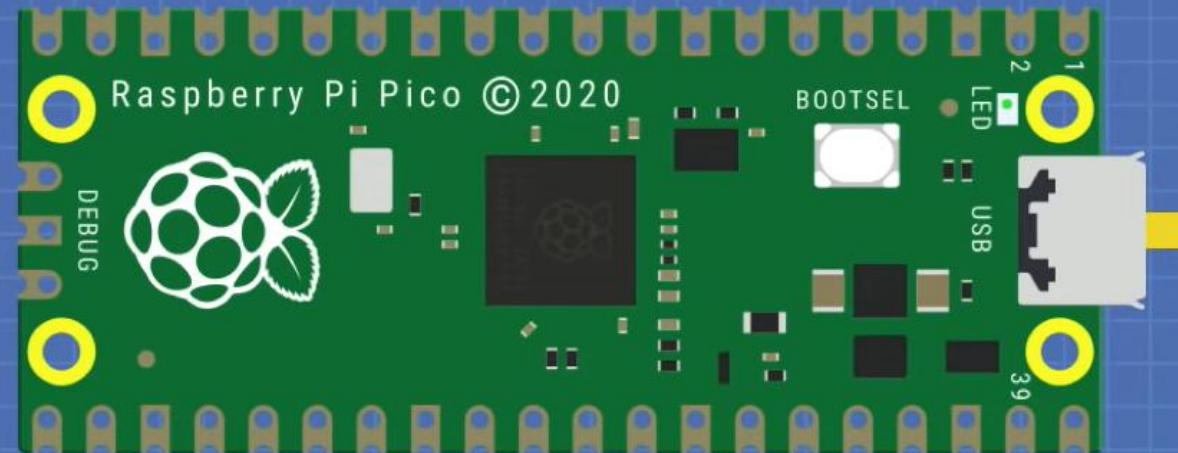
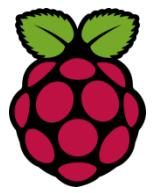
# Raspberry Pi Pico



- Can operate as normal MCU
- Power using microUSB
- Battery-powered, stand-alone
- Also operates as USB Device



# Raspberry Pi Pico

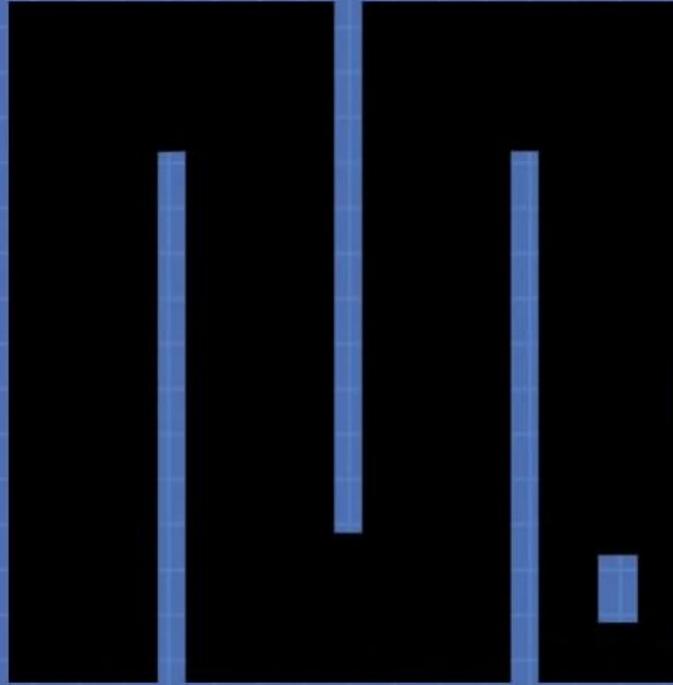
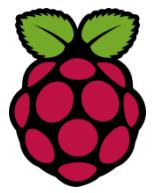


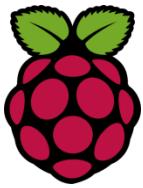
Can operate as a **USB device**



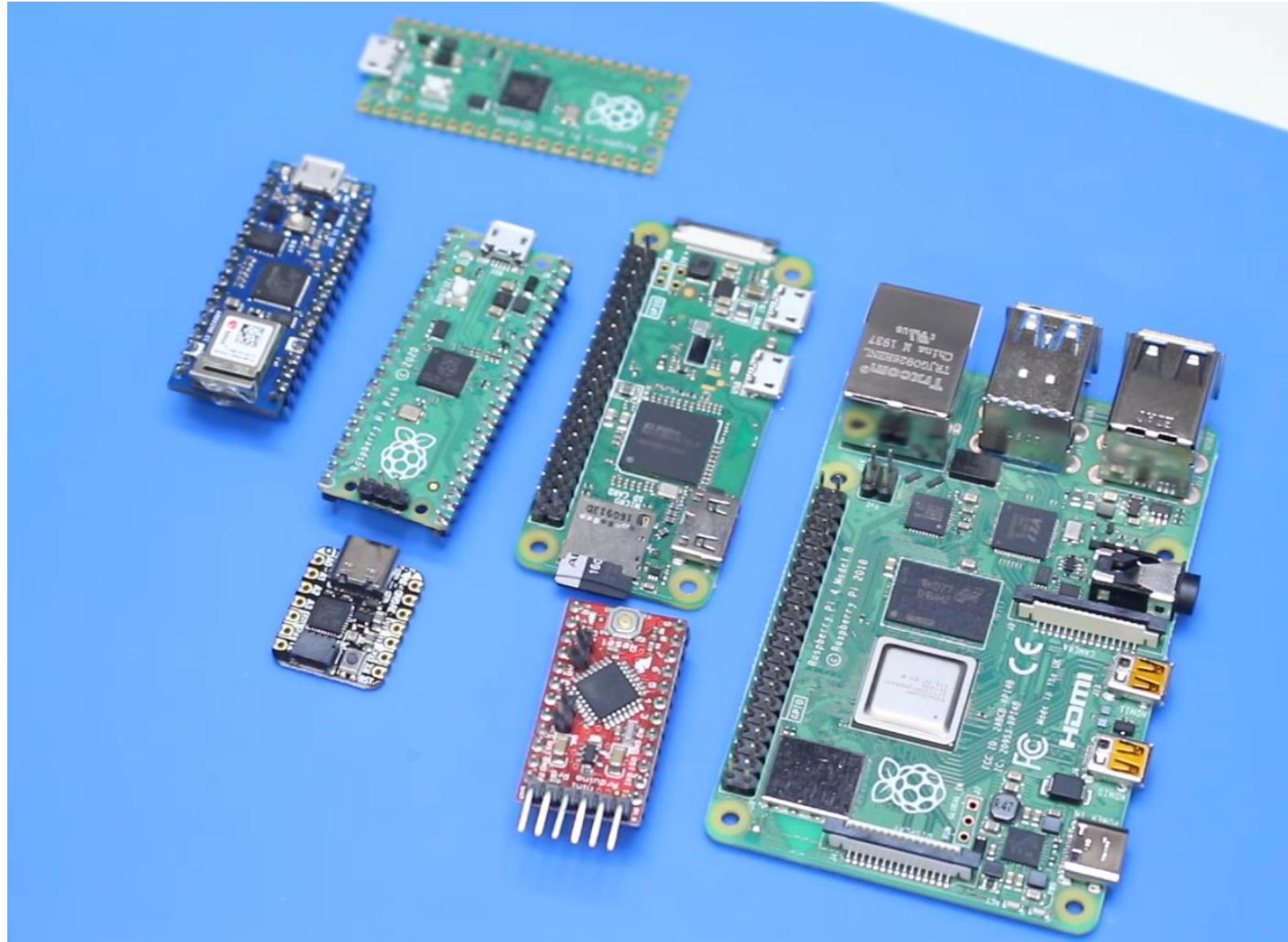


# languages used



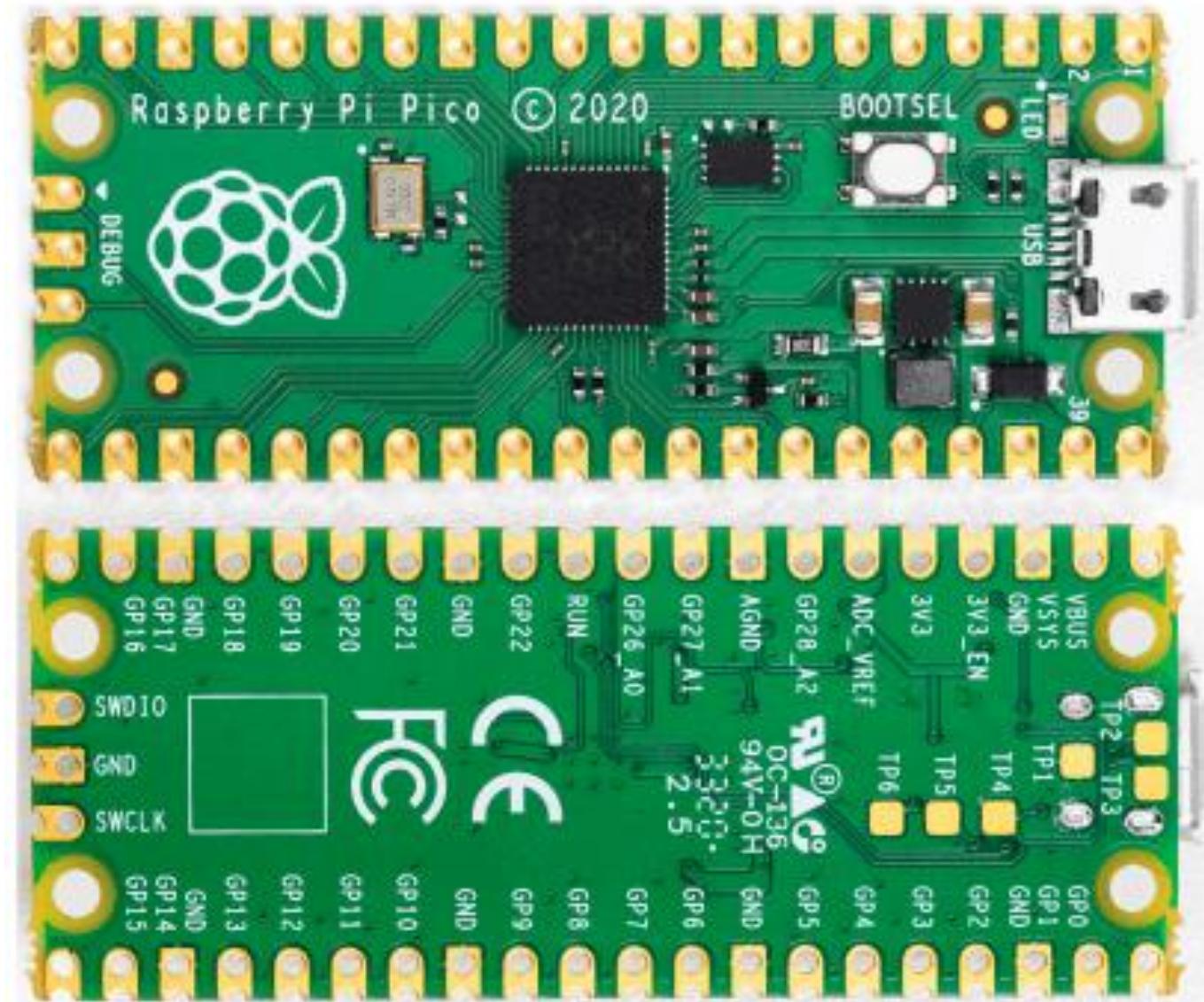


# Popular Raspberry Pi Family





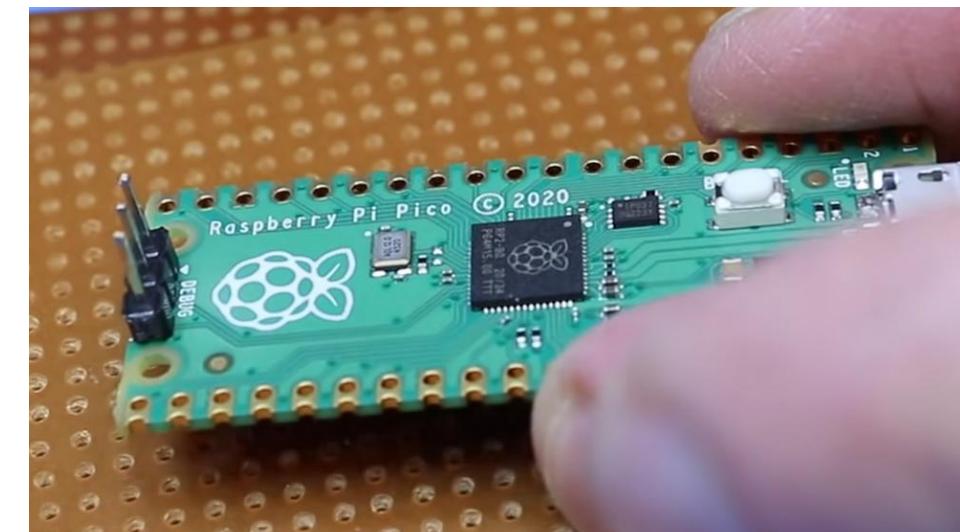
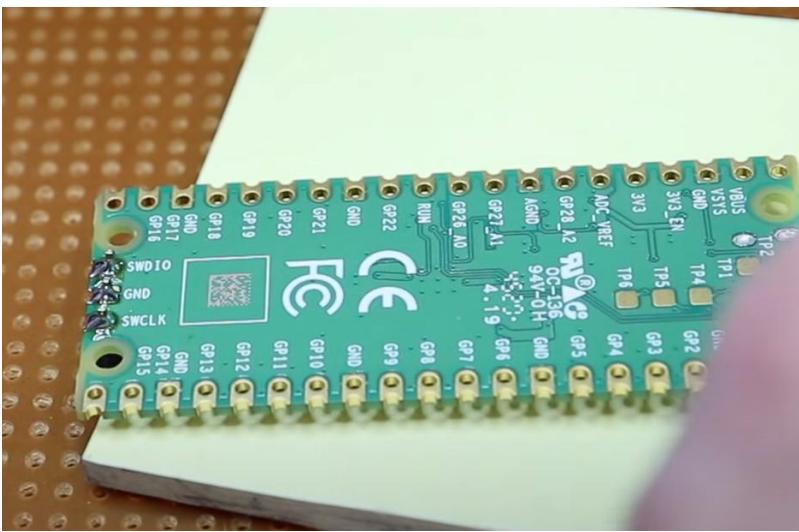
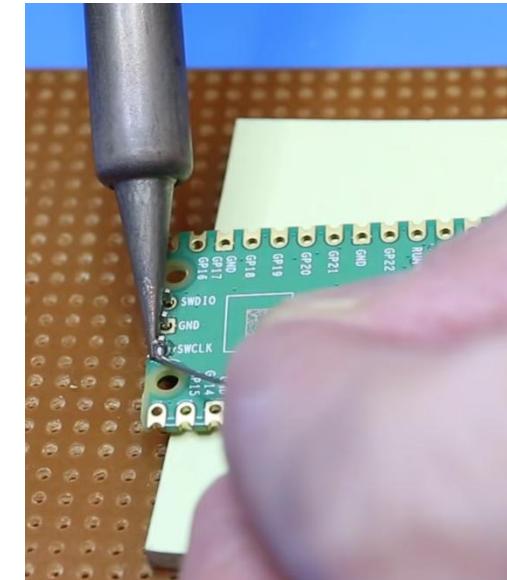
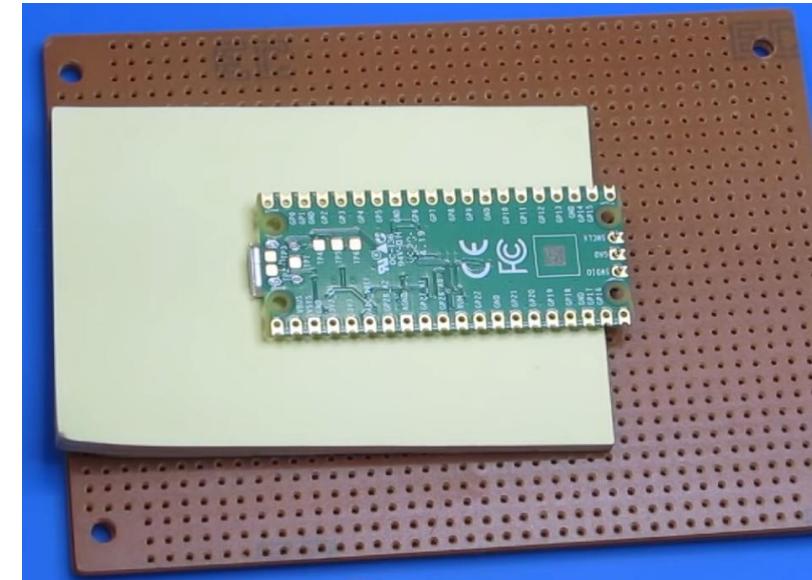
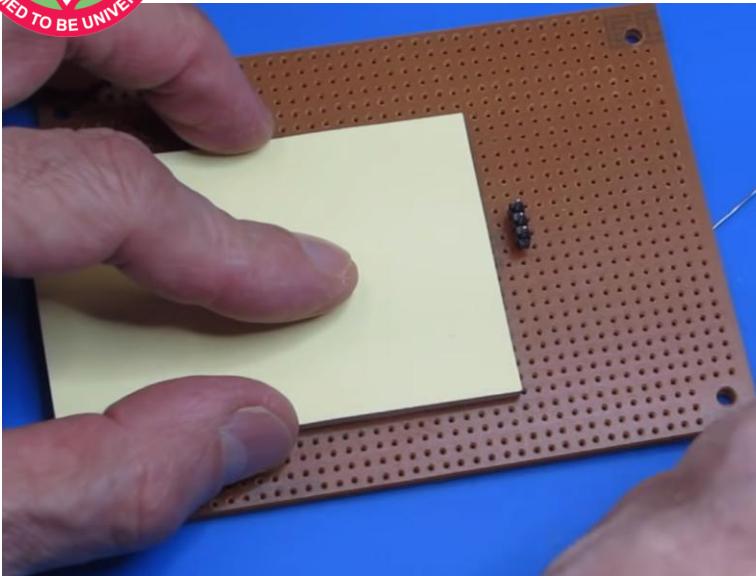
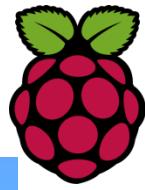
# Front and Back view



## Front and Back view of the Raspberry Pi Pico

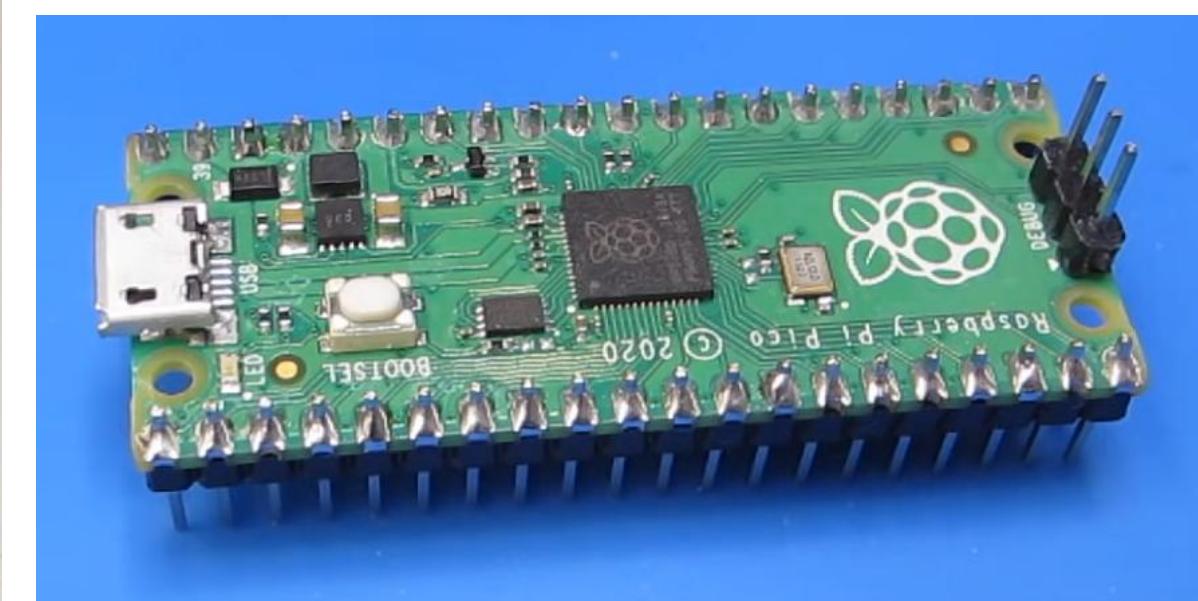
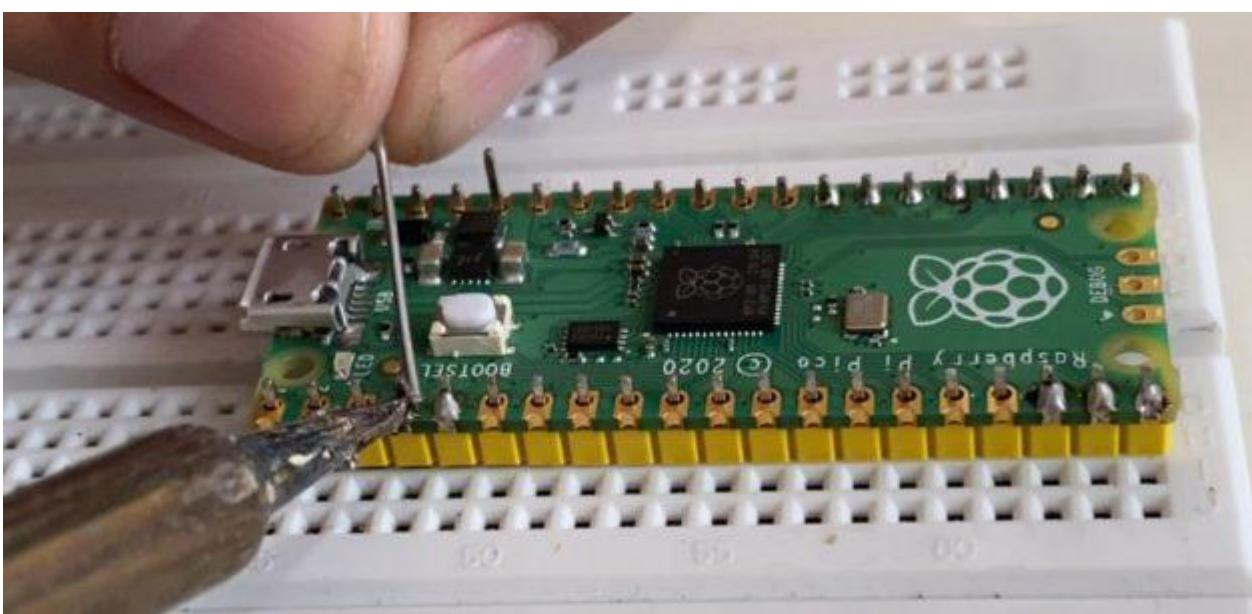
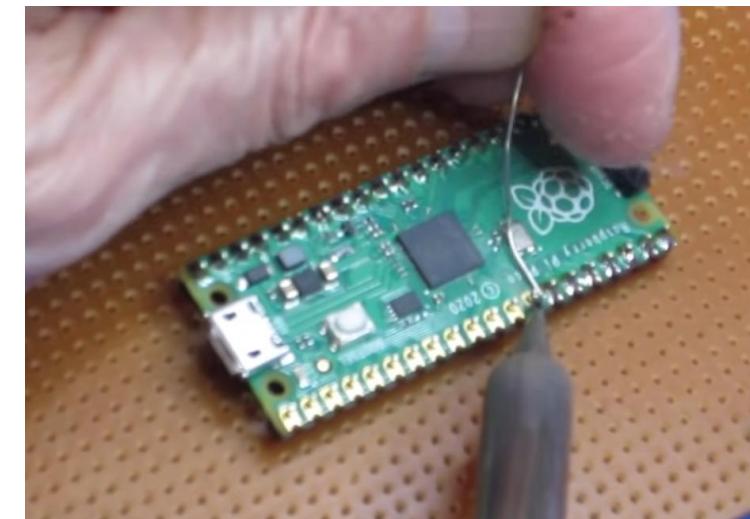
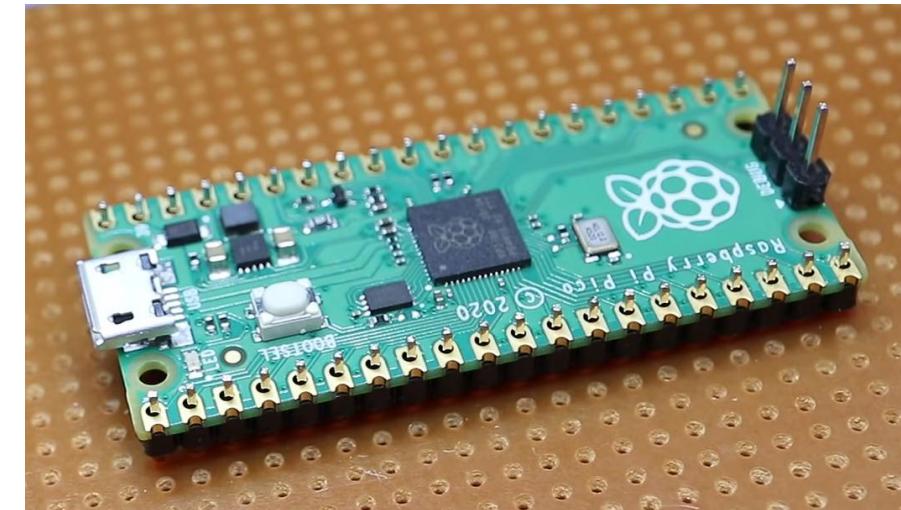
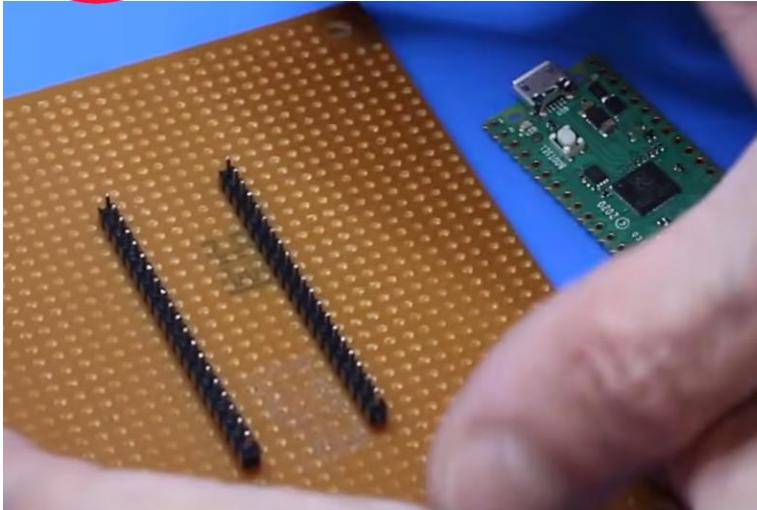
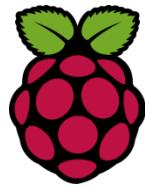


# Raspberry Pi Pico – H Preparation

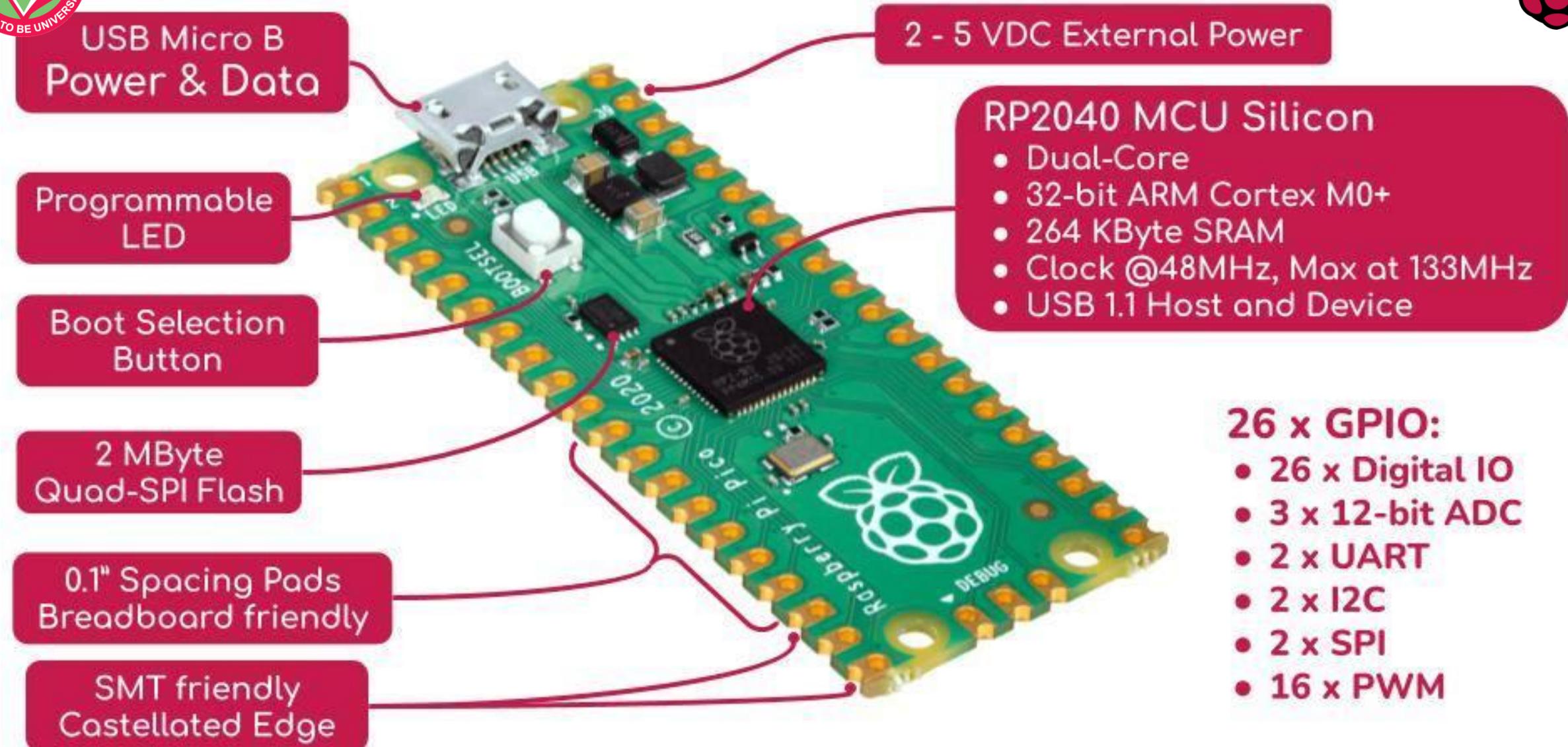
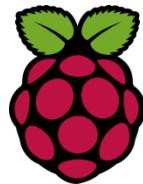




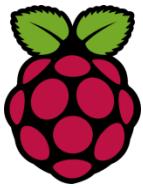
# Raspberry Pi Pico



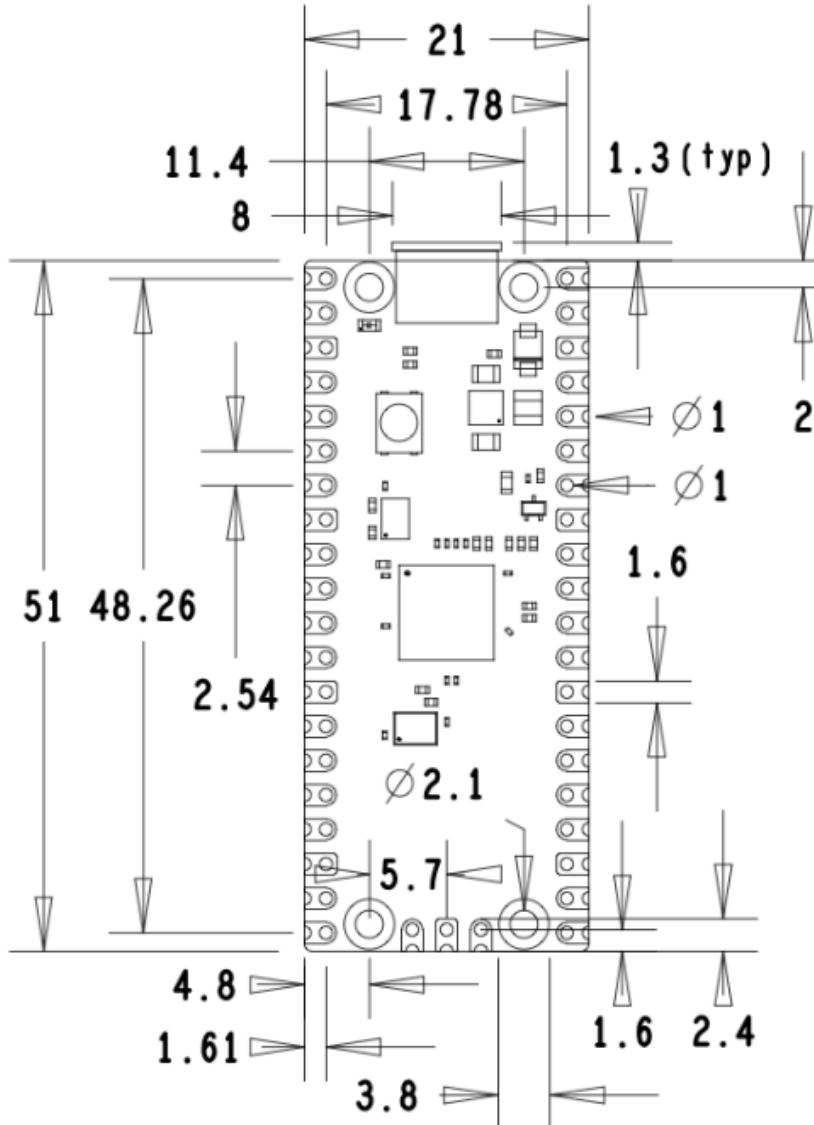
# Raspberry Pi Pico – In Short



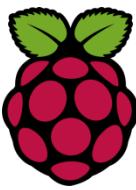
Pi Foundation has released an RP2040 Microprocessor based development board, in the same form factor as an Arduino Nano.



# Mechanical Specifications



- ✓ Single sided 51x21mm 1mm thick PCB
- ✓ Usable as a surface mount module as well as being in Dual Inline Package (DIP) type format
- ✓ 40 main user pins on a 2.54mm (0.1") pitch grid with 1mm holes and hence compatible with veroboard and breadboard.
- ✓ 4 x 2.1mm (+/- 0.05mm) drilled mounting holes to provide for mechanical fixing.



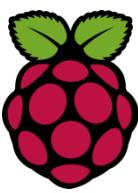
# QUIZ TIME???????

**1) How much memory does raspberry pi Pico have?**

- a) 12 MB
- b) 512 MB
- c) 1 MB
- d) 2 MB

**2) The clock speed of raspberry pi Pico is around**

- 
- a) 125 MHz
  - b) 512 MHz
  - c) 256 KHz
  - d) 1 GHz



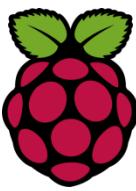
## QUIZ TIME

3) The input voltage for raspberry pi Pico is around

- 
- a) 5 V
  - b) 12 V
  - c) 1 V
  - d) 3.3 V

4) How many pins does raspberry pi Pico H contain?

- a) 32
- b) 40
- c) 20
- d) 57



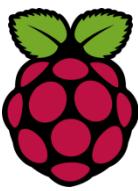
## QUIZ TIME

**5) In which year the raspberry pi Pico is launched?**

- a) January 2021
- b) February 2020
- c) January 2018
- d) January 2020

**6) The I2C pin on the raspberry pi board has \_\_\_\_\_ connections**

- a) one
- b) two
- c) three
- d) four



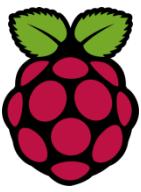
## QUIZ TIME

**7) How much RAM does raspberry pi Pico have?**

- a) 512 KB
- b) 128 KB
- c) 1 MB
- d) 256 KB

**8) Which SOC is used in raspberry pi Pico?**

- a) silicon RP2040
- b) Broadcom BCM2711
- c) Broadcom BCM2835
- d) silicon RP2004



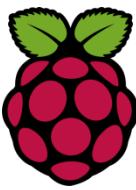
## QUIZ TIME

### 9) What are the advantages of Raspberry Pi Pico?

- a) Consumes less Power
- b) low cost
- c) Both a and b
- d) None of these

### 10) How many exposed GPIO pins does Raspberry Pi Pico?

- a) 25
- b) 26
- c) 27
- d) 29



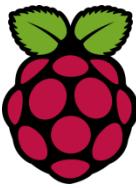
## QUIZ TIME

**11) Which cable is used to connect the PC to the Raspberry Pi Pico?**

- a) USB type A to A
- b) USB type A to B
- c) USB type A to Micro B
- d) USB type A to C

**12) What are the capabilities of raspberry pi?**

- a) Browsing the internet
- b) Making Spreadsheets
- c) Word Pressing
- d) All of the above



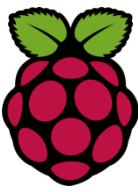
## QUIZ TIME

**13) The software pulse width modulation in raspberry pi pico is available on \_\_\_\_\_ pins**

- a) GPIO12
- b) GPIO18
- c) GPIO19
- d) All GPIO pins

**14) What is the form factor of Raspberry Pi Pico?**

- a) 51 x 21 mm
- b) 61 x 31 mm
- c) 61 x 21 mm
- d) 51 x 31 mm



## QUIZ TIME

**15) What is the standard form of SPI pin?**

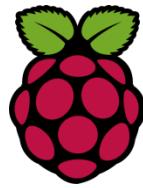
- a) Serial Parallel Input
- b) Serial Peripheral Interface
- c) Serial Parallel Interface
- d) None of the above

**16) How many PWM pins does Raspberry Pi Pico have?**

- a) 16
- b) 17
- c) 25
- d) 26



# Requirements



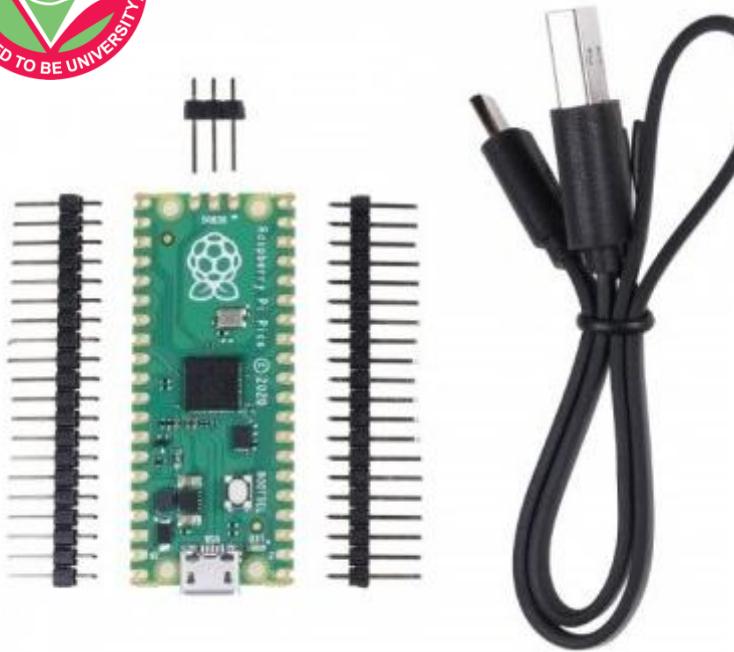
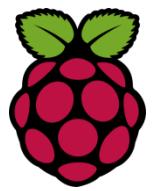
## Hardware

- A Raspberry Pi Pico with soldered headers
- A computer that can run the Thonny IDE and program a Raspberry Pi Pico
- A micro USB cable
- A selection of electronics components, such as a button, an LED with appropriate resistor, and a potentiometer (optional)
- A breadboard and M-M jumper leads for connecting additional components (optional)
- An external 5V micro USB power source (optional)

## ➤ Software

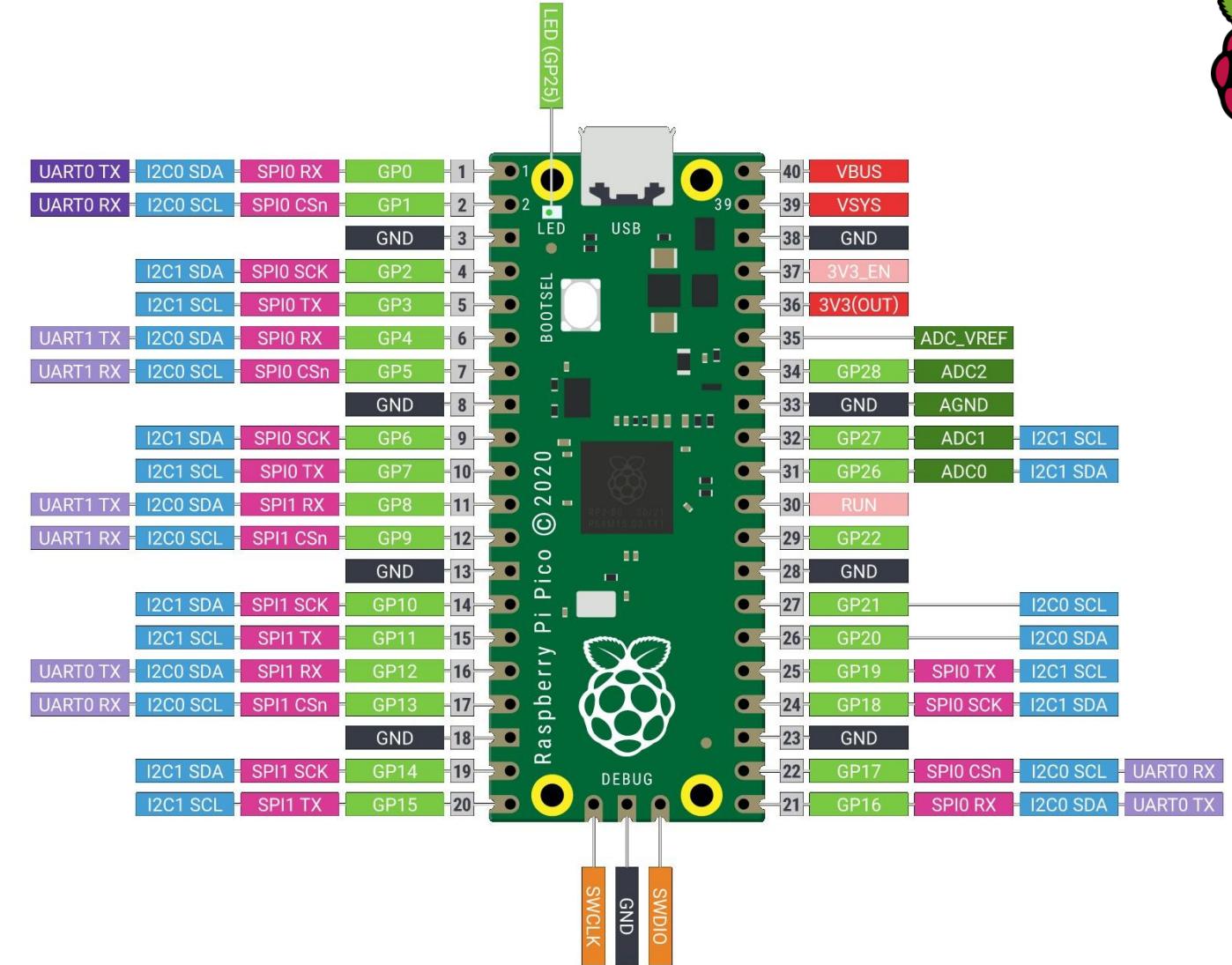
The next class will guide you through the installation of:

- MicroPython firmware for Raspberry Pi Pico
- The Thonny Python IDE

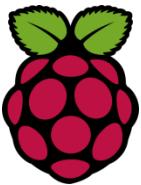


## Package Includes:

- 1 x Raspberry Pi Pico
- 1 x Micro-USB cable
- 2 x 20 Pin Header
- 1 x 3 Pin Header



■ Power ■ Ground ■ UART / UART (default) ■ GPIO, PIO, and PWM ■ ADC ■ SPI ■ I2C ■ System Control ■ Debugging



# Introduction to Online Simulator, WOKWI

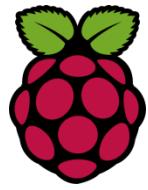
**Step 1:** Open <https://wokwi.com/>

**Step 2:** scroll down to Raspberry pi pico

The screenshot shows a web browser window with the title "Wokwi - Online Arduino and ESP". The address bar contains "wokwi.com". Below the address bar is a toolbar with various icons. The main content area is titled "Start from Scratch" and features six project cards arranged in two rows of three. Each card shows a circuit board image with a large white plus sign in the center. The projects are: Arduino Uno, Arduino Mega, ESP32 (top row); and Arduino Nano, Raspberry Pi Pico, MicroPython on ESP32 (bottom row). At the bottom of the screen, there is a purple navigation bar with the text "Franzininho Project | MicroPython on Pi Pico | + MORE OPTIONS". The bottom of the image shows the Windows taskbar with the Start button, a search bar, and several pinned application icons. The system tray shows the date and time as "12-09-2022 21:22" and includes icons for battery, signal, and network.



# WOKWI's First Look



## Step3: Click on Raspberry pi pico

New Raspberry Pi Pico Project - wokwi.com/projects/new/pi-pico

Bookmarks (81) Facebook Inbox (584) - swain.... UPSC NDA & NA (II...) RRB Senior Section... opsc Forums / Projects /... Electricity Generation... ScholarOne Manus...

WOKWI SAVE SHARE Docs SIGN IN

sketch.ino diagram.json Library Manager

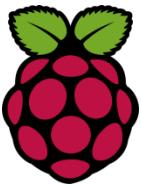
```
1 void setup() {
2     // put your setup code here, to run once:
3     Serial1.begin(115200);
4     Serial1.println("Hello, Raspberry Pi Pico!");
5 }
6
7 void loop() {
8     // put your main code here, to run repeatedly:
9     delay(1); // this speeds up the simulation
10}
11
```

Simulation

Raspberry Pi Pico

Type here to search

21:24 12-09-2022 4



# WOKWI's Setting

**Step4:** Sign in using your Gmail account

**Step5:** Delete sketch.ino window

The screenshot shows the WOKWI web-based development environment. In the center, there is a code editor window titled "sketch.ino" containing the following Arduino-style code:

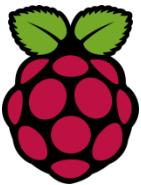
```
1 void setup() {
2     // put your setup code here, to run
3     // once the sketch starts
4     Serial1.begin(115200);
5     Serial1.println("Hello, Raspberry
6 
7 void loop() {
8     // put your main code here, to run
9     delay(1); // this speeds up the si
10 }
11 }
```

A context menu is open over the code, displaying the following options:

- Format code
- Rename
- Delete
- New file...
- Upload file(s)...

To the right of the code editor, there is a "Simulation" panel featuring a digital model of a Raspberry Pi Pico board. The board is green with a white central chip and two yellow circular pads labeled "LED" and "GND". Below the board, the text "Raspberry Pi Pico © 2020" is visible.

The browser's taskbar at the top shows several open tabs, including WhatsApp, The Electronics, and a "New Raspberry Pi Pico Project" tab. The bottom of the screen displays the Windows taskbar with various pinned icons and the system tray showing the date and time as 13-09-2022 at 22:44.



# WOKWI's new file creation

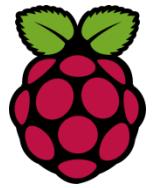
**Step6:** Create a new file with name “main.py”

The screenshot shows a browser window with four tabs: WhatsApp, The Electronics, New Raspberry Pi Pico Project - V, and another unnamed tab. The address bar shows wokwi.com/projects/new/pi-pico. The main content area is titled "diagram.json" and displays a JSON configuration for a Raspberry Pi Pico project. A context menu is open over the JSON code, with options: Rename, Delete, New file..., and Upload file(s)... The "New file..." option is highlighted. To the right of the JSON editor is a "Simulation" panel with three buttons: play, add, and more. Below the simulation is a 3D model of a Raspberry Pi Pico board. At the bottom of the screen is a Windows taskbar with various icons and a search bar.

```
1  {
2    "version": 1,
3    "author": "Biswaranjan",
4    "editor": "wokwi",
5    "parts": [ { "type": "pico", "top": 0, "left": 0 },
6    "connections": [ [ "pico:GND", "pico:GND" ], [ "pico:TX", "pico:RX", "", [ ] ], [ "pico:VDD", "pico:VDD" ] ] ]
7 }
```



# WOKWI's Toggling inbuilt LED



## Step-7: Toggling inbuilt LED

4 WhatsApp    x | The Electronics    x | W New Raspberry Pi Pico Project - v x

← → ⌛ ⌂ 🔒 wokwi.com/projects/new/pi-pico

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WOKWI SAVE SHARE Docs B

diagram.json • main.py • Library Manager PIO

```
1 from machine import Pin
2 import utime
3
4 ledPin = Pin(25,Pin.OUT)
5
6 while True:
7     ledPin.value(1)
8     print("LED ON")
9     utime.sleep(1)
10    ledPin.value(0)
11    print("LED OFF")
12    utime.sleep(1)
13
```

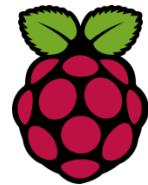
Simulation 00:08.331 100%

Type here to search

22:54 13-09-2022 ENG



# WOKWI's Toggling External LED



## Step-8: Toggling External LED

4 WhatsApp    x | The Electronics    x | W New Raspberry Pi Pico Project - v    +

← → ⌛ ⌂ wokwi.com/projects/new/pi-pico

Bookmarks Facebook Inbox (584) - swain.... UPSC NDA & NA (II...) RRB Senior Section... opsc Forums / Projects / ... Electricity Generatin... ScholarOne Manus...

WOKWI SAVE SHARE Docs B

diagram.json • main.py • Library Manager PIO

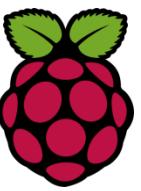
```
1 from machine import Pin
2 import utime
3
4 ledPin = Pin(15,Pin.OUT)
5
6 while True:
7     ledPin.value(1)
8     print("LED ON")
9     utime.sleep(1)
10    ledPin.value(0)
11    print("LED OFF")
12    utime.sleep(1)
13
```

Simulation 00:16.362 102%

The screenshot shows the Wokwi web-based development environment. On the left, there's a code editor with Python code for a Raspberry Pi Pico project. The code initializes pin 15 as an output and enters a loop where it alternates the LED state between high and low every second. On the right, a simulation window displays a breadboard circuit. A red LED is connected in series with a 220 ohm resistor, both of which are connected to a digital output pin on the Raspberry Pi Pico board. The simulation shows the LED toggling between being lit and off.

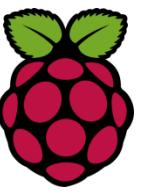
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# How Students will submit the Physical Prototype?

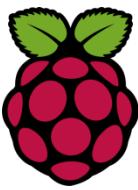
**COST of the Project???**



# How Students will submit the Physical Prototype?

**Mid-Sem : Mini Project (without IOT)**

**End-Sem: Major Project (With IOT)**



## What we need to do for NEXT class

- How to load the MicroPython firmware onto a Raspberry Pi Pico?
- How to program a Raspberry Pi Pico using MicroPython?
- How to connect additional components to a Raspberry Pi Pico and write MicroPython programs to interact with them?