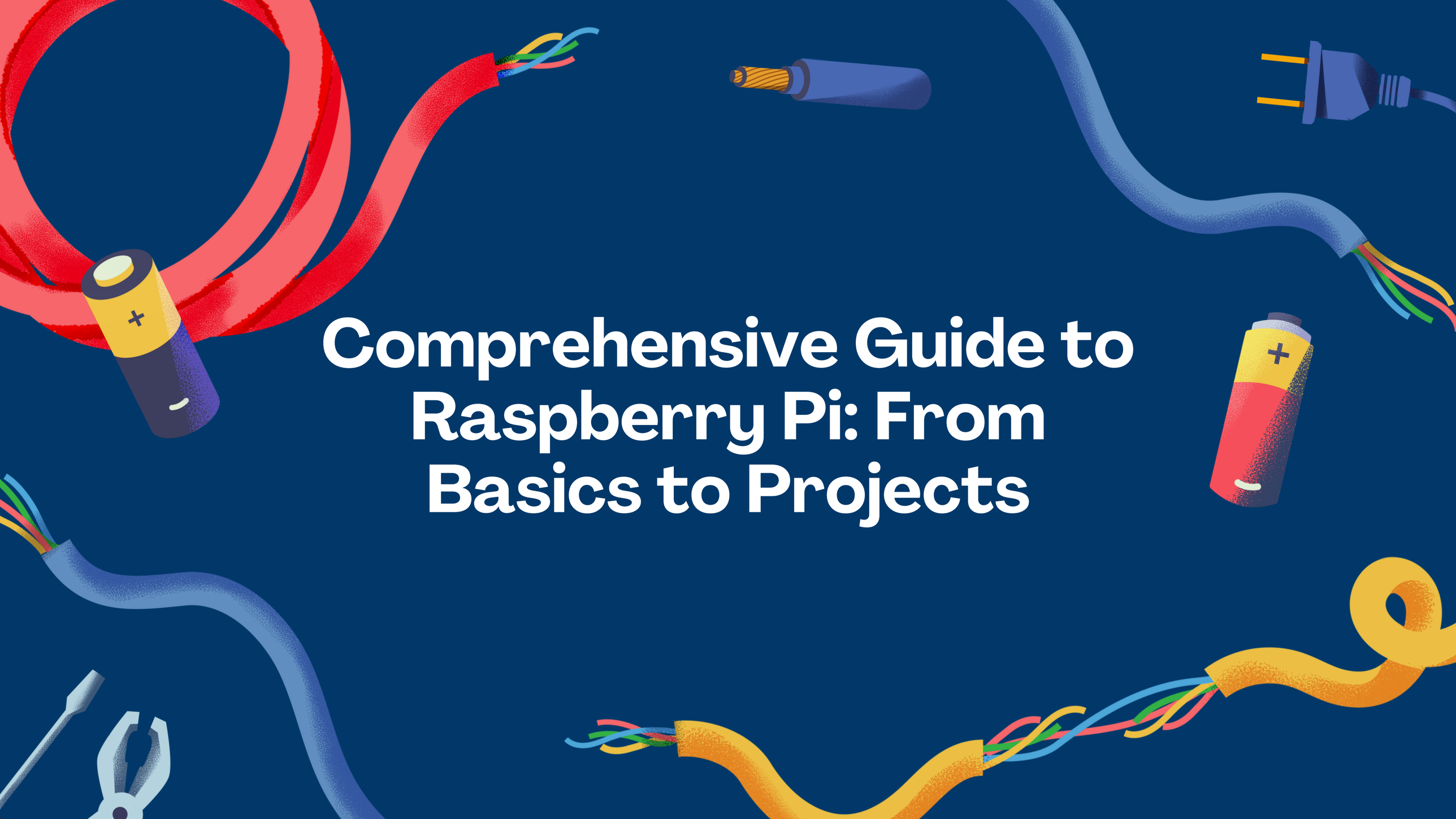


Comprehensive Guide to Raspberry Pi: From Basics to Projects

Introduction to Raspberry Pi

What is Raspberry Pi?

Small, affordable single-board computers developed by the Raspberry Pi Foundation. It is designed to promote computer science education and empower hobbyists, makers, and professionals worldwide with accessible computing power.

Key Features

- Compact size
- low cost
- various models to suit different needs, support for a broad operating system range including Linux-based OSes,
- a GPIO (General Purpose Input Output) interface for hardware interaction
- broad community support.

Why Learn Raspberry Pi?

Versatile Learning Platform

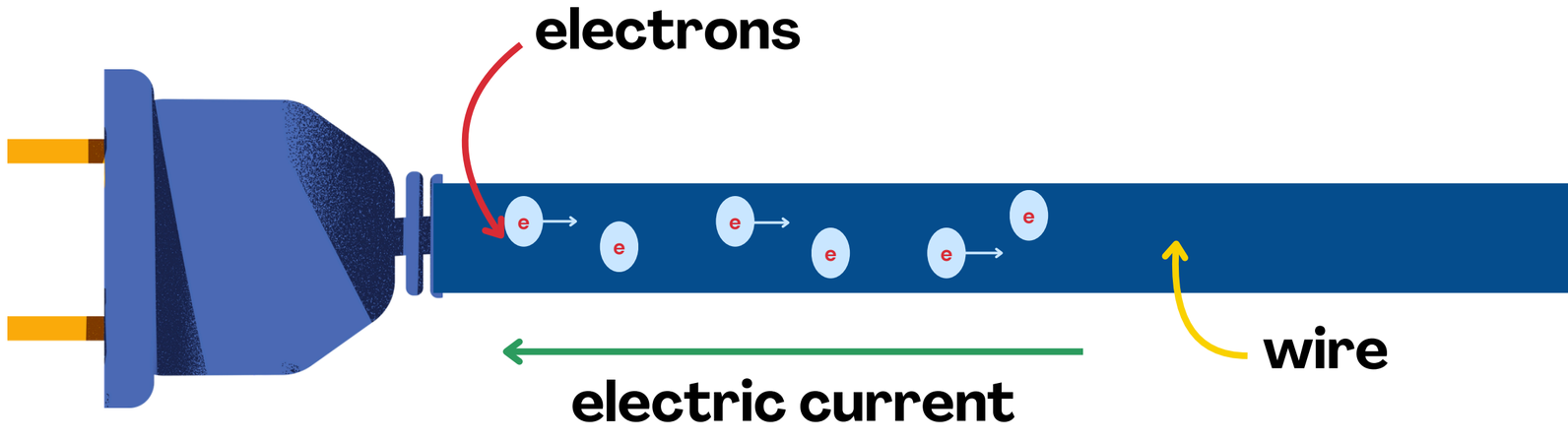
hands-on experience for learning programming, electronics, and hardware interfacing, making it ideal for both beginners and advanced users.

Empowers Creativity and Innovation

It enables building diverse projects from robotics, IoT devices, media centers, to home automation systems, encouraging creativity and problem-solving skills.

Affordability and Accessibility

With its low cost and wide availability, Raspberry Pi democratizes technology education across different demographics globally.

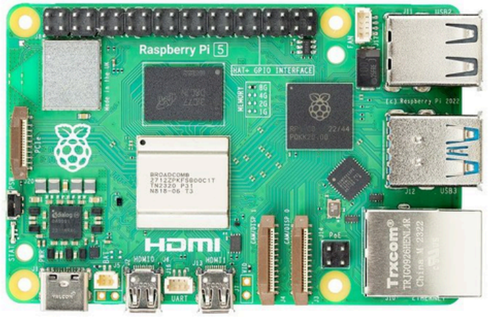


Arduino vs Raspberry Pi

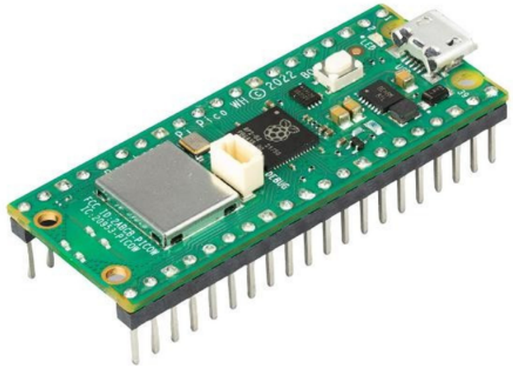
Feature	**Arduino**	**Raspberry Pi**
Type	Microcontroller	Mini computer (single-board computer)
Use Case	Controls **simple hardware tasks** like turning on LEDs, reading sensors	Can **run full programs**, host websites, run Linux, do AI, etc.
Operating System	No OS – runs a single program at a time	Runs a full OS (e.g., Raspberry Pi OS/Linux)
Programming Language	C/C++ (Arduino IDE)	Python, C++, JavaScript, etc.
Multitasking	❌ No – one task at a time	✅ Yes – can run multiple apps at once
Internet Connectivity	Needs external modules (like WiFi shield)	Built-in Ethernet, WiFi, Bluetooth (on Pi 3/4)
Boot Time	Instant	Takes time to boot OS (~20 sec)
Power Consumption	Very low	Higher than Arduino
Cost	Cheaper (₹300–₹800 for Uno/Nano)	More expensive (₹3000+ for Pi 4)
Real-time Control	✅ Great for real-time sensor/actuator control	❌ Not designed for real-time use
GPIO Pins	Digital/analog pins for sensors & motors	GPIO pins, but accessed through OS
Best For	Basic electronics, robotics, sensor interfacing	Projects needing a display, camera, internet, AI, etc.

Models of raspberry pi

- Raspberry pi

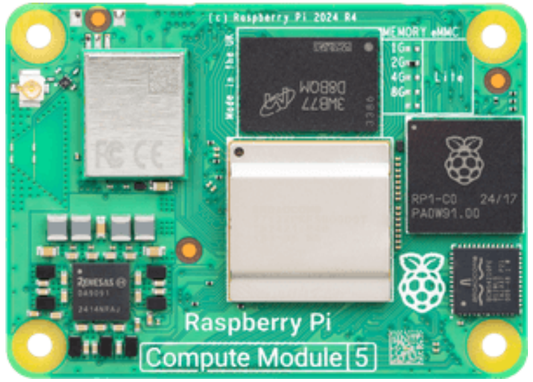


- Raspberry pi pico



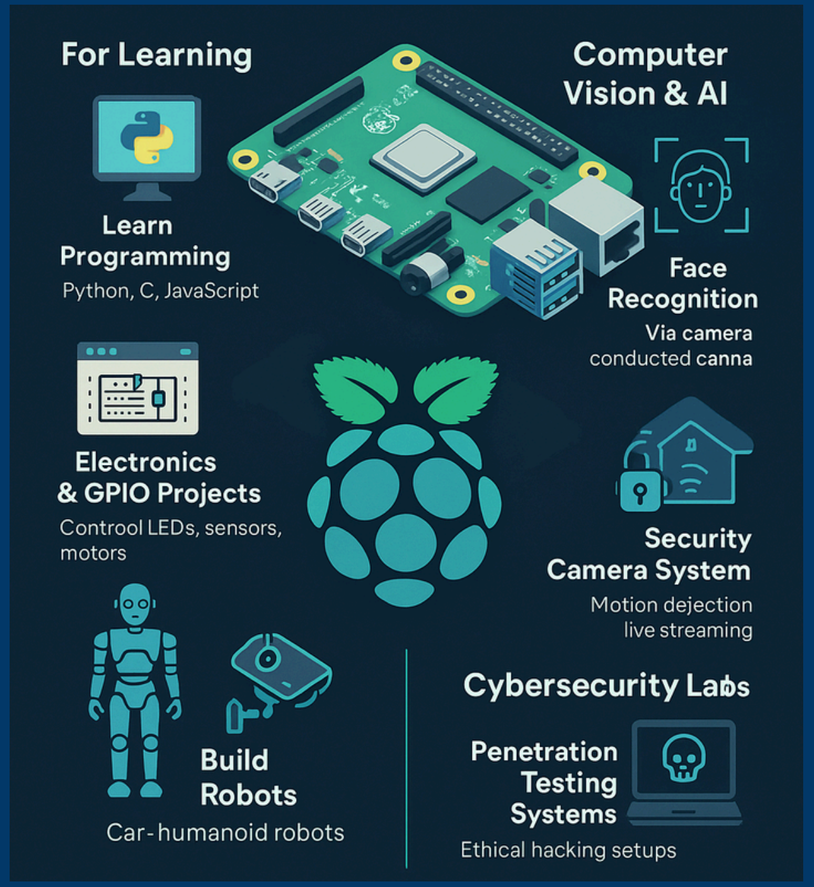
- Raspberry Pi Zero series

- Raspberry pi Compute module



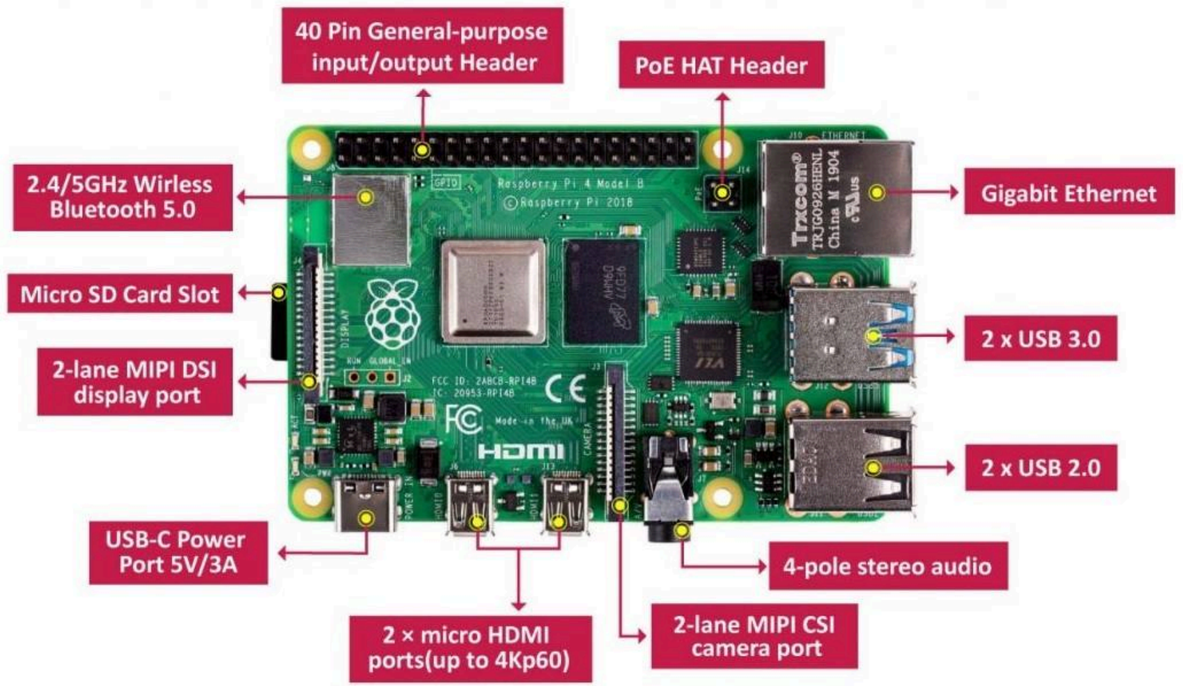
Uses of Raspberry Pi

- Learn programming (Python, C, JavaScript, etc.)
- Control electronics (LEDs, sensors, motors) via GPIO
- Practice Linux and command-line skills
- Use as a basic desktop computer
- Set up a media center (Kodi, Plex)
- Create face recognition or object detection systems
- Build a security camera system
- Host a website (Flask, Django, Apache)
- Create IoT and home automation projects
- Set up a VPN server or network tools
- Build a retro gaming console (RetroPie)
- Make a smart mirror (display time, weather, news)
- Run a Minecraft server or play Pi edition
- Build robots (line followers, car bots, etc.)

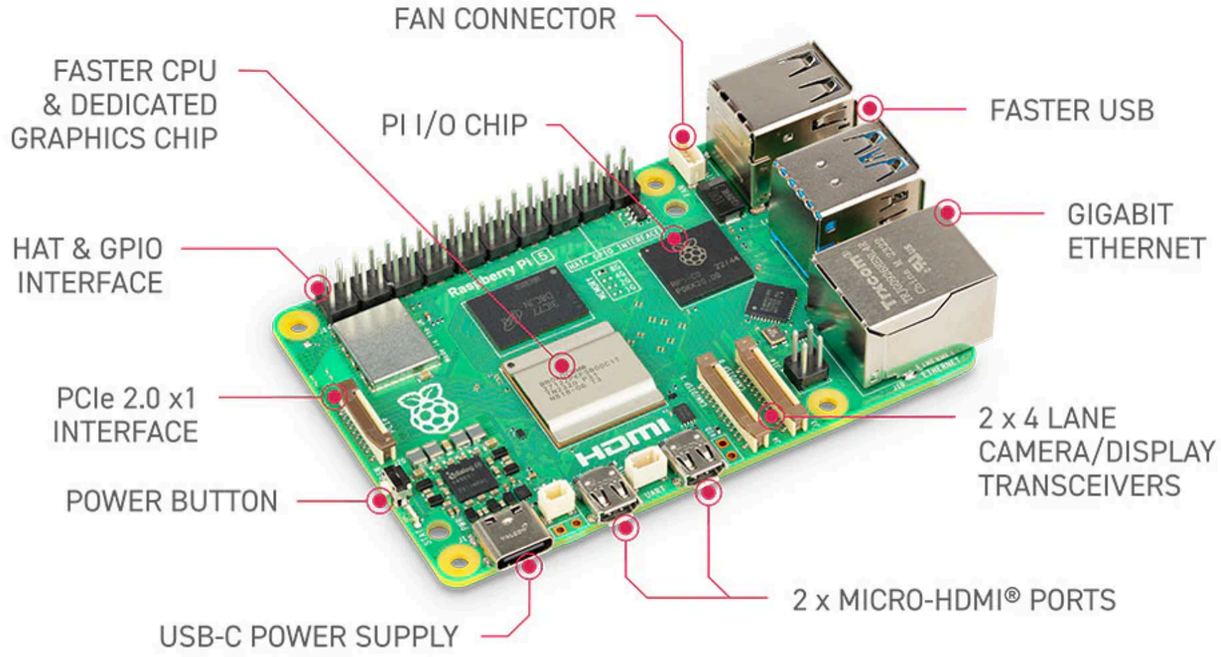


BULB

Raspberry Pi Hardware Overview



PI 4

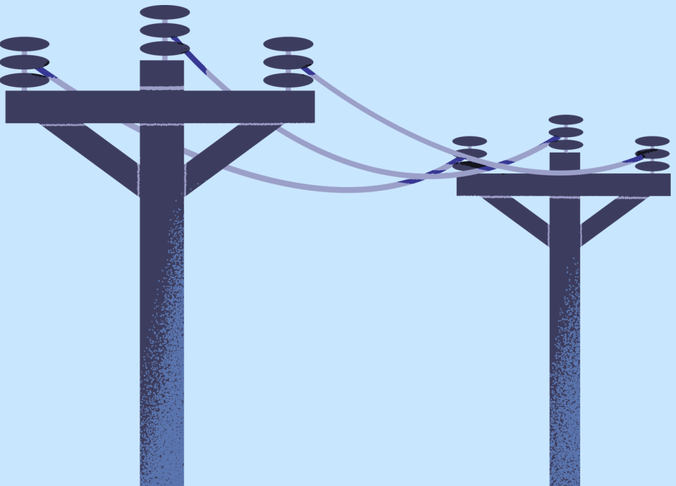


PI 5

Installing the Raspberry Pi Operating System

WHAT YOU NEED:

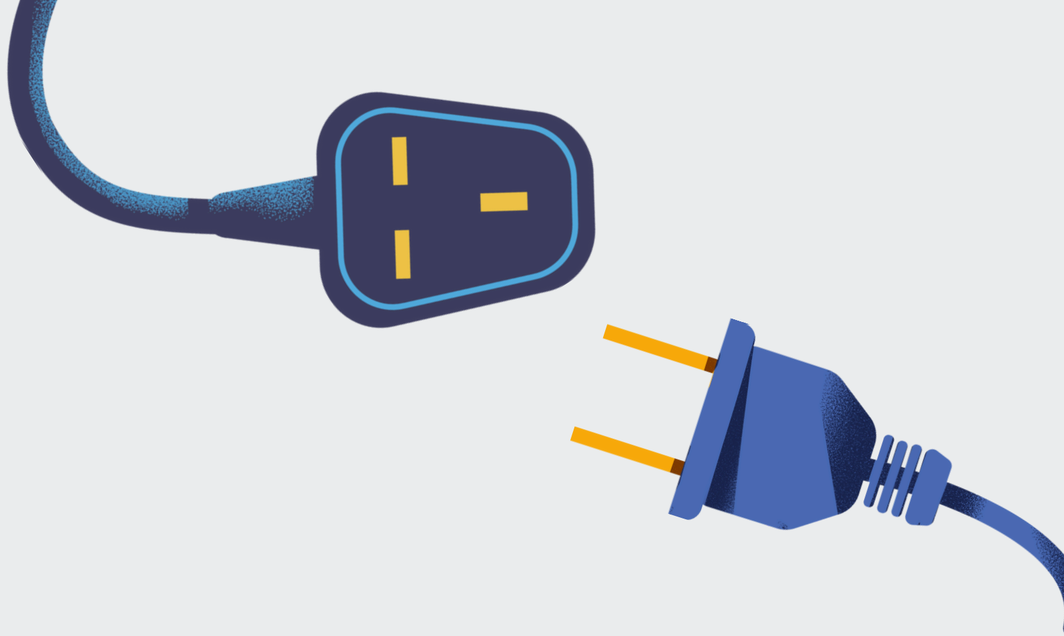
- **RASPBERRY PI BOARD (E.G., RASPBERRY PI 4)**
- **MICROSD CARD (16 GB OR MORE, CLASS 10 RECOMMENDED)**
- **SD CARD READER**
- **POWER SUPPLY**
- **MONITOR, KEYBOARD, MOUSE**
- **INTERNET CONNECTION (OPTIONAL, BUT USEFUL)**



Installation Steps:

1. **Download Raspberry Pi Imager**
2. **Insert microSD Card into your PC**
3. **Open Raspberry Pi Imager**
   - **Click "Choose OS" → Select “Raspberry Pi OS (64-bit)”**
   - **Click "Choose Storage" → Select your SD card**
4. **Click “Write”**
   - **Wait for the OS to install (takes ~5–10 minutes)**
5. **Insert microSD into Raspberry Pi**
6. **Power On the Raspberry Pi**
   - **It will boot into the Raspberry Pi OS setup screen**

Introduction to Linux



WHAT IS LINUX?

LINUX IS AN OPEN-SOURCE, UNIX-LIKE OPERATING SYSTEM WIDELY USED IN SERVERS, DESKTOPS, AND EMBEDDED SYSTEMS, INCLUDING RASPBERRY PI.

ADVANTAGES

STABILITY, SECURITY, CUSTOMIZATION CAPABILITIES, AND LARGE DEVELOPER COMMUNITY SUPPORT ARE KEY BENEFITS.

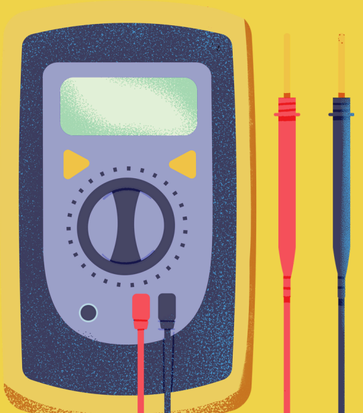
CORE COMPONENTS

- LINUX KERNEL
- SYSTEM LIBRARIES
- COMMAND-LINE TOOLS
- GRAPHICAL USER INTERFACES

Basic Linux commands

FILE & DIRECTORY COMMANDS

LS – LIST FILES AND DIRECTORIES
CD – CHANGE DIRECTORY
PWD – SHOW CURRENT DIRECTORY
MKDIR – MAKE A NEW DIRECTORY
RMDIR – REMOVE AN EMPTY DIRECTORY
RM – REMOVE FILES OR DIRECTORIES
CP – COPY FILES OR DIRECTORIES
MV – MOVE OR RENAME FILES
TOUCH – CREATE AN EMPTY FILE
CAT – DISPLAY FILE CONTENTS
NANO / VIM – EDIT TEXT FILES



VIEWING & SEARCHING

- CLEAR – CLEAR THE TERMINAL SCREEN
- LS -L – LONG LISTING FORMAT
- LS -A – SHOW HIDDEN FILES
- FIND – SEARCH FILES BY NAME
- GREP – SEARCH TEXT IN FILES
- HEAD / TAIL – VIEW BEGINNING/END OF A FILE

SYSTEM INFO & MANAGEMENT

- UNAME -A – SYSTEM INFO
- DF -H – DISK SPACE USAGE
- TOP – REAL-TIME SYSTEM RESOURCE USAGE
- FREE -H – RAM USAGE
- WHOAMI – SHOW CURRENT USERNAME
- DATE – SHOW CURRENT DATE/TIME
- UPTIME – SYSTEM RUNNING TIME

PACKAGE MANAGEMENT (DEBIAN-BASED)

- SUDO APT UPDATE – UPDATE PACKAGE LIST
- SUDO APT UPGRADE – UPGRADE INSTALLED PACKAGES
- SUDO APT INSTALL <PACKAGE> – INSTALL SOFTWARE
- SUDO APT REMOVE <PACKAGE> – UNINSTALL SOFTWARE

NETWORKING

- PING <ADDRESS> – CHECK NETWORK CONNECTION
- IFCONFIG / IP A – VIEW IP ADDRESSES
- HOSTNAME -I – SHOW LOCAL IP ADDRESS
- WGET <URL> – DOWNLOAD FROM INTERNET
- SSH USER@IP – SSH INTO ANOTHER SYSTEM

Headless Operation of Raspberry Pi (SSH & VNC)

WHAT IS HEADLESS OPERATION?
USING A RASPBERRY PI WITHOUT CONNECTING A MONITOR, KEYBOARD, OR MOUSE CONTROL IT REMOTELY FROM ANOTHER COMPUTER OR LAPTOP VIA THE NETWORK.

ACCESS VIA SSH

- FIND PI'S IP ADDRESS (USE YOUR ROUTER OR A TOOL LIKE ADVANCED IP SCANNER)
- OPEN A TERMINAL (MAC/LINUX) OR PUTTY (WINDOWS)
- SSH USERNAME@<IP_ADDRESS>OR<HOSTNAME>

ENABLE VNC (GRAPHICAL REMOTE ACCESS)

- SSH INTO THE PI
- SUDO RASPI-CONFIG
- GO TO INTERFACE OPTIONS > VNC > ENABLE
- INSTALL VNC VIEWER ON YOUR COMPUTER:
- HTTPS://WWW.REALVNC.COM
- ENTER PI'S IP ADDRESS IN VNC VIEWER → LOGIN WITH PI CREDENTIALS

What are Sensors?

Sensors are input devices that detect and measure physical changes in the environment and convert them into electrical signals.

Examples of Sensors:

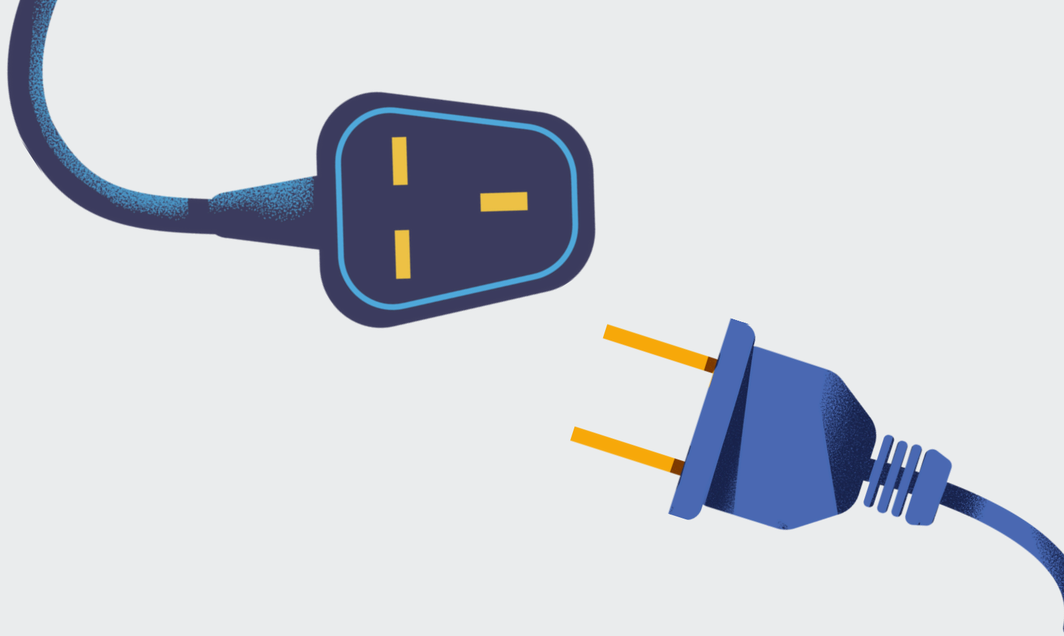
- Temperature Sensor (e.g., DHT22) – measures heat
- Motion Sensor (e.g., PIR) – detects movement
- Light Sensor (e.g., LDR) – senses brightness
- Gas Sensor (e.g., MQ2) – detects gas levels
- Ultrasonic Sensor – measures distance using sound

What are Actuators?

Actuators are output devices that perform an action based on the signal received — like moving, turning, or making sound.

Examples of Actuators:

- LED – lights up
- Buzzer – produces sound
- Motor – rotates or moves
- Servo Motor – precise rotation control
- Relay – switches high-power devices ON/OFF



Setting up python enviorment for sensor interfacing

CREATE A PROJECT FOLDER & VIRTUAL ENVIRONMENT

- mkdir gpio_project
- cd gpio_project
- python3 -m venv <name of venv>

ACTIVATE THE VIRTUAL ENVIRONMENT

- source <name of venv> /bin/activate

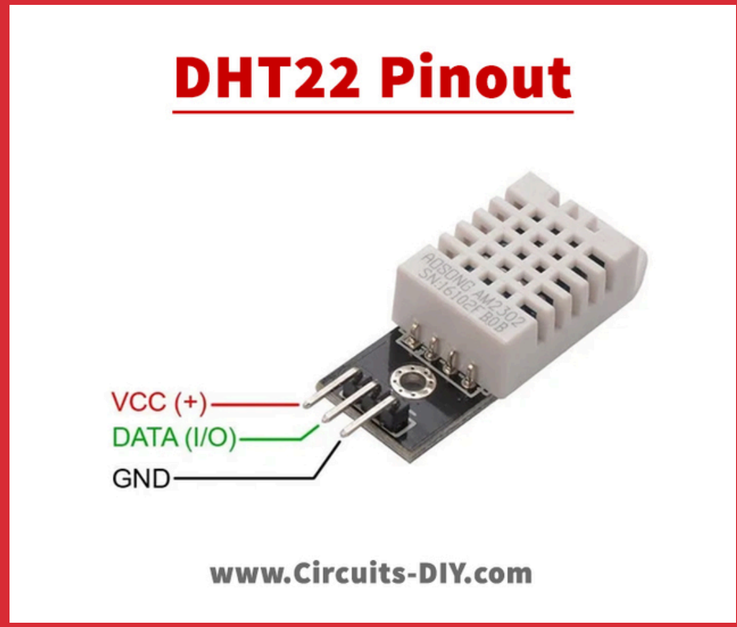
INSTALL REQUIRED LIBRARIES

- pip install <Libarary name>

Sensor interfacing (DHT22)

About DHT22 Sensor

- Measures temperature and humidity
- Digital output (uses a single data pin)
- More accurate and stable than DHT11



To run the program

- **Activate the venv**
- **run command “python dht.py”**

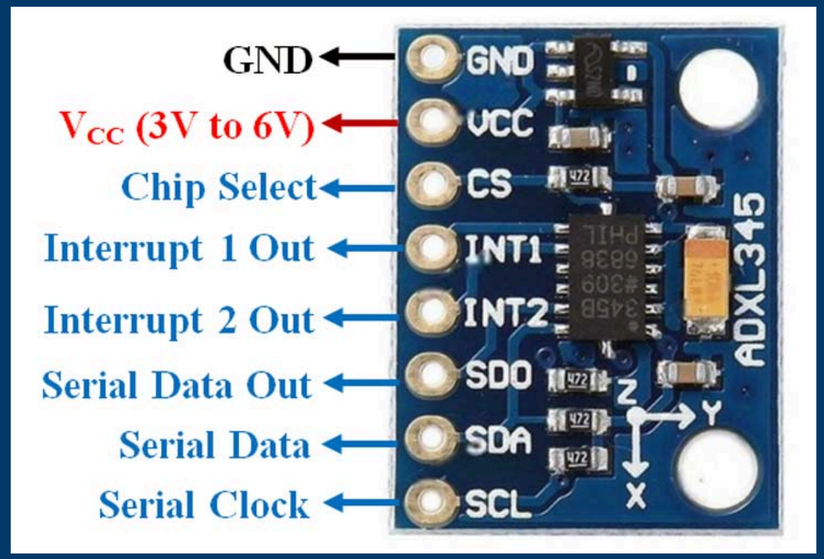
Sensor interfacing (ADXL345)

About ADXL345

- A 3-axis accelerometer (X, Y, Z)
- Measures acceleration, tilt, and vibration
- Communicates via I2C or SPI
- Used in smartphones, robotics, gaming, etc.

To run the program

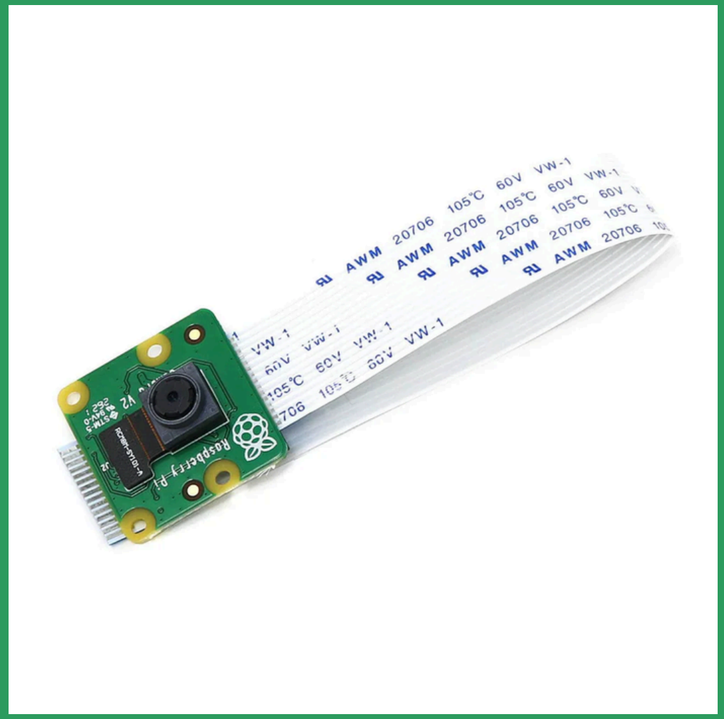
- Activate the venv
- run command “python acc.py”



Sensor interfacing (Camera Module 2)

About Camera Module 2

- 8 MP Sony IMX219 sensor
- Captures images and HD video (up to 1080p)
- Connects via CSI (Camera Serial Interface) port



Connecting the Camera Module

- Power off the Raspberry Pi
- Open the CSI port latch (next to HDMI port)
- Insert the ribbon cable (blue side facing HDMI port)
- Close the latch and power on the Pi

Test the Camera Module

- **run** “libcamera-hello” on terminal

Sensor interfacing (Camera Module 2)

To run the program

- Activate the venv
- run command “python cam.py”

There are several program in the given repo which include

- motion detection
- qr code scanner
- time- lapse photo capture
- face dectection

Setting up a Home Server

What is CasaOS?

CasaOS is an open-source, user-friendly home server OS that lets you easily run apps like a personal cloud, media center, download manager, and more – all from a simple web interface.

Installing CasaOS (on Raspberry Pi or Linux system)

- Flash Raspberry Pi OS
- Flash it using Raspberry Pi Imager
- Boot Pi, enable SSH and connect to Wi-Fi

Install CasaOS

- Run these commands on your Pi/PC:

```
curl -fsSL https://get.casaos.io | sudo bash
```

Uses of Home Server

Key Features of CasaOS

- 📦 App Store (Nextcloud, Jellyfin, Pi-hole, etc.)
- 📁 File Browser (like your own cloud)
- 🔁 Docker-based backend (lightweight and powerful)
- 📦 Easy storage management
- 🌍 Remote access option

Use Cases for Students & Makers

- Personal cloud (Nextcloud)
- Media streaming (Jellyfin, Plex)
- IoT dashboard
- Torrent box or download center
- Lightweight web hosting

Setting up a Local LLM

What is a Local LLM?

- A Local LLM is a chatbot or AI model like ChatGPT that runs entirely on your computer, without needing cloud access or internet.
- You can ask it questions, get summaries, write code, or chat — all offline!

Why Combine Local LLMs + IoT?

- 🛡️ Privacy – No cloud = no data leakage
- ⚡ Fast Decisions – No network latency
- 🌐 Offline Capability – Works without internet
- 🧠 Smarter Devices – Context-aware and interactive

Projects you can try

Smart Voice-Controlled Home Assistant (Offline)

🔧 **Components: Local LLM (e.g., LLaMA3 via Ollama), microphone, relays, smart plugs**

🧠 **LLM Task: Interpret voice commands like "Turn off bedroom lights" or "Is the fan on?"**

⚙️ **Actuator: Switch lights/fan using relays**

2. AI Fire & Gas Detection Alert System

🔧 **Sensors: Gas sensor (MQ2), temperature sensor (DHT22), flame sensor**

🧠 **LLM Task: Interpret sensor data and generate alerts in natural language**

"Warning! High gas concentration and rising heat detected."

⚙️ **Actuator: Activate buzzer or cooling fan**

3. AI-Powered Plant Care Assistant

🔧 **Sensors: Soil moisture, temperature, light sensor**

🧠 **LLM Task: Analyze data and provide suggestions**

"Soil is dry and temperature is high. Suggest watering the plant now."

⚙️ **Actuator: Auto-water pump activation**

4. AI Personal Health Station

🔧 **Sensors: Heart rate, body temperature, SpO2 (e.g., MAX30100)**

🧠 **LLM Task: Interpret readings, give advice**

"Heart rate is elevated after exercise. Take rest and hydrate."

⚙️ **Actuator: Show feedback via display or play voice output**

Projects you can try

5. Secure Smart Door with Face & Voice ID

🔧 Sensors: Camera module, mic, RFID

🧠 LLM Task: Understand “Who are you?” queries or detect visitor intent

“It’s the courier with your order. Should I unlock the door?”

⚙️ Actuator: Unlock door via servo or solenoid

6. AI-Based Weather Reporter

🔧 Sensors: DHT22 (temp/humidity), BMP180 (pressure), light sensor

🧠 LLM Task: Generate daily weather summary from live sensor values

“Today is warm and slightly humid. Good day to dry clothes outside.”

⚙️ Actuator: Display on screen / audio speaker output

7. Emotion-Aware Room Lighting

🔧 Input: Mic (voice tone), camera (facial expression)

🧠 LLM Task: Interpret emotions using cues and adjust mood lighting

“You sound tired. Switching to warm lights and playing soft music.”

⚙️ Actuator: LED strip, speaker

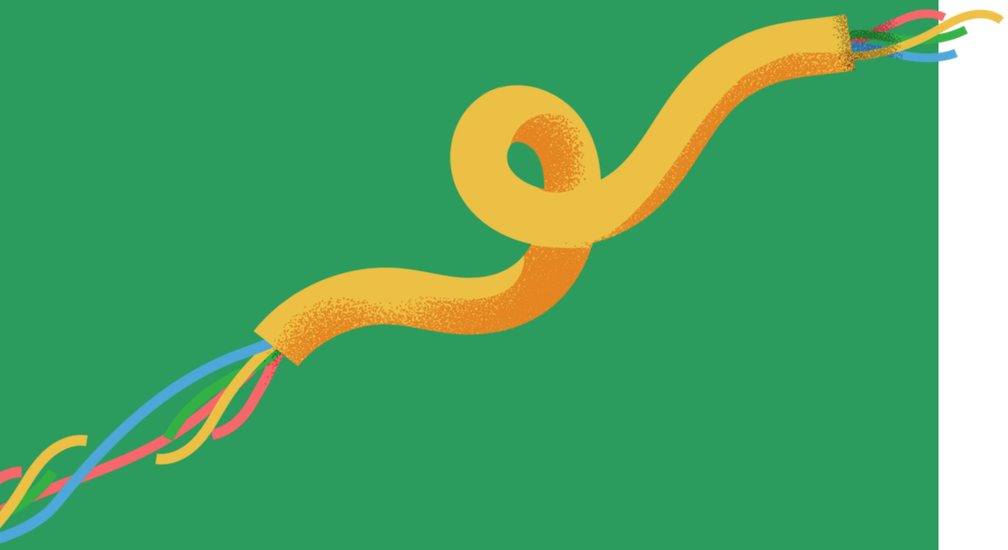
8. Smart Lab Assistant

🔧 Sensors: Any IoT sensors in a lab (gas, motion, etc.)

🧠 LLM Task: Answer context-aware queries

“Is the chemistry lab safe right now?”

⚙️ Actuator: Show alert, trigger alarms, or email notifications



Thank YOU