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IoT Basics

How everyday things learn to sense, think and talk

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Hello, inventor!

This little book shows you how everyday things, like lamps, plant pots and doorbells, can become smart. By the end, you will know how to build your own smart gadget.

You do not need to know anything about electronics yet. Each chapter is short, and every new word is explained.

HOW TO USE THIS BOOK

- Read one chapter a day. Each takes about 5 minutes.
- Try the **Do it yourself** ideas with someone experienced nearby.
- Look for **Safety** notes. They keep you and your parts safe.
- Finish with the quiz in the last chapter to test yourself.

WHAT YOU NEED TO START

An Arduino or ESP32 board, a USB cable, a breadboard, some jumper wires, a few LEDs and resistors, and a computer. That's it!

What is IoT?

IoT stands for **Internet of Things**. It means ordinary things that can sense the world, make a decision, do something, and share what happened over the internet.

A smart thing works a lot like your body:

YOUR BODY	A SMART DEVICE	EXAMPLE: SMART PLANT POT
Senses (eyes, skin, nose)	Sensors	Feels that the soil is dry
Brain	Microcontroller board	Decides "the plant needs water"
Hands and voice	Actuators	Turns on a tiny water pump
Talking to friends	Internet	Sends "I watered the plant!" to your phone

That's the whole idea: **sense, think, act, share**. Every IoT project in the world follows these four steps.

Every smart device repeats four steps: sense, think, act, share

1. **Sense** Sensor notices *soil is dry*
2. **Think** Brain decides *plant needs water*
3. **Act** Actuator works *pump turns on*
4. **Share** Internet tells *your phone*

↻ then it starts again, all day long

The smart plant pot goes around this loop every few minutes, all by itself.

SMART THINGS YOU MAY HAVE SEEN

- Street lights that switch on by themselves when it gets dark.
- Doors in malls that open when you walk up.
- Smart speakers that turn on lights when you ask.
- Fitness bands that count your steps.
- Water tanks that beep when they are full.

DO IT YOURSELF

Walk around your home and find three things that sense something by themselves. (Hint: a fridge light, a TV remote, a geyser.)

Electricity in five minutes

Electricity is the energy that powers every gadget. Think of it like water flowing through pipes.

WORD	WHAT IT MEANS	WATER PIPE IDEA
Voltage (volts, V)	How hard electricity is pushed	Water pressure
Current (amps, A)	How much electricity flows	How much water flows
Resistance (ohms, Ω)	How much something slows the flow	A narrow pipe

The circle rule

Electricity only flows in a complete loop, called a **circuit**. It leaves the battery's + side, goes through your LED, and comes back to the – side. If the loop is broken anywhere, nothing works. A switch simply opens or closes the loop.

Meet the basic parts

- **Battery or USB:** the power source.
- **Wire:** the road electricity travels on.
- **LED:** a tiny light. It has a long leg (+) and a short leg (–).
- **Resistor:** a small part with coloured stripes that protects the LED from too much current.
- **Breadboard:** a board full of holes that lets you connect parts without soldering.

DO IT YOURSELF

Connect two AA batteries (3 V), a 220 Ω resistor and an LED in a loop on a breadboard. Flip the LED around and see what happens. (It only lights one way!)

SAFETY

The small batteries and USB power in this book are safe. The electricity from wall sockets is **not**. Never touch or connect anything to a wall socket.

Meet the brains

Every smart device needs a brain. In IoT, the brain is a small board with a chip called a **microcontroller**. It runs one program, over and over, all day long.

BOARD	THINK OF IT AS	SUPERPOWER	BEST FOR
Arduino Uno / Nano	The friendly teacher	Easiest to learn; very hard to break	Your very first projects
ESP32	The talkative one	Built-in WiFi and Bluetooth	Projects that talk to your phone or the internet
Raspberry Pi	The mini computer	Runs a full computer system; handles cameras and AI	Big projects like face recognition
Raspberry Pi Pico	The small, smart helper	Cheap and easy with the Python language	Learning to code with Python

Parts of a board

- **Pins:** the little metal legs along the edges. You connect sensors and lights to them.
- **USB port:** connects to your computer to send it a program and give it power.
- **Reset button:** restarts the program from the beginning.
- **Built-in LED:** a tiny light you can blink with your first program.

Q WHICH ONE SHOULD YOU START WITH?

Start with an Arduino Uno to learn the basics. When you want your project to talk to a phone, move to an ESP32.

Sensors: the device's senses

A sensor notices something in the real world and turns it into an electrical signal the brain can read. Here is how sensors match your own senses.

YOUR SENSE	SENSOR	WHAT IT NOTICES	POPULAR PART
Seeing light	Light sensor (LDR)	Bright or dark	LDR
Seeing distance	Ultrasonic sensor	How far away something is, using sound echoes like a bat	HC-SR04
Noticing movement	Motion sensor (PIR)	A person or pet moving nearby	HC-SR501
Feeling hot or cold	Temperature sensor	How warm the air or water is	DHT11, DS18B20
Feeling wet or dry	Soil moisture sensor	Whether a plant needs water	Capacitive soil sensor
Smelling	Gas sensor	Smoke or cooking gas in the air	MQ-2
Hearing	Sound sensor	Claps and loud noises	KY-038
Touching	Touch sensor	A finger tap	TTP223
Knowing who you are	RFID reader	A special card or key tag	RC522
Knowing where you are	GPS module	Your location on Earth	NEO-6M
Feeling tilt and shakes	Motion sensor (IMU)	Tilting, falling, shaking	MPU6050

Two kinds of signals

- **Digital (yes or no):** "Is someone there?" The answer is either yes or no, like a light switch.
- **Analog (how much):** "How bright is it?" The answer is a number on a scale, like a volume knob.

FUN FACT

An ultrasonic sensor works exactly like a bat. It shouts a sound too high for you to hear, waits for the echo, and works out the distance from how long the echo took.

DO IT YOURSELF

Cover a light sensor with your hand and watch the numbers change on your computer screen.

Actuators: the device's hands and voice

An actuator is the part that **does** something after the brain decides. Sensors listen; actuators act.

ACTUATOR	WHAT IT DOES	EXAMPLE USE
LED	Gives light	Shows "ON" or warns of danger
RGB LED / LED strip	Glow in any colour	Mood lights, party lights
Buzzer	Beeps	Alarms and reminders
Small speaker + MP3 player	Plays sounds and voices	"Welcome home!" messages
Display screen (OLED, LCD)	Shows words and numbers	Temperature display
DC motor	Spins round and round	Wheels of a robot car, fans
Servo motor	Turns to an exact angle	Opening a dustbin lid or a gate
Water pump	Pushes water	Watering plants
Relay	A switch the brain can flip	Turning a lamp or fan on and off (only a qualified electrician does wall-socket wiring)

Why motors need helpers

The brain's pins are weak; they can light a small LED but cannot spin a motor. So motors use a helper board called a **motor driver**, and big things like lamps use a **relay**. Think of it like a manager (the brain) giving orders to a strong worker (the driver) who does the heavy lifting.

DO IT YOURSELF

Make a servo motor wave hello by moving it from 0° to 90° and back.

How things talk

Smart things need to send messages: to the brain, to each other and to your phone. Some use wires, and some talk through the air with invisible radio waves.

Talking through wires

Inside a project, sensors talk to the brain through wires. Some sensors need just one signal wire. Others share two wires called **I2C**, like several people taking turns on one phone line, each with their own name (an address).

Talking through the air

WAY TO TALK	HOW FAR	LIKE...	GOOD FOR
WiFi	Inside a house	Talking in a room	Sending data to the internet
Bluetooth	About 10 metres	Whispering to a friend	Controlling things from a nearby phone
Infrared (IR)	Across a room, in a straight line	Flashing a torch signal	TV-remote control
LoRa	Several kilometres	Shouting across a valley	Farms and villages without WiFi
Mobile network (4G / GSM)	Anywhere with phone signal	Making a phone call	Trackers and SMS alerts

Messages need a language

Devices agree on a language, called a **protocol**, so they understand each other. A popular IoT language is **MQTT**. It works like a school notice board: one device pins a message on a topic, such as "garden/soil", and every device that follows that topic reads it.

DO IT YOURSELF

Point a TV remote at your phone camera and press a button. You can see the invisible infrared light blinking!

Code: telling the brain what to do

A board does nothing until you give it a **program**: a list of instructions written in a coding language. You write it on a computer in the free **Arduino IDE** app, then send it to the board through the USB cable. This is called **uploading**.

Think in “if-then”

Most IoT programs are just smart if-then rules:

- **If** it is dark, **then** turn on the light.
- **If** the soil is dry, **then** start the pump.
- **If** someone moves, **then** sound the buzzer.

Every Arduino program has two parts

- `setup()` runs **once** when the board starts, like getting ready in the morning.
- `loop()` runs **again and again forever**, like checking your homework over and over.

Your first program: blink a light

```
<>Arduino C++

void setup() {
  pinMode(LED_BUILTIN, OUTPUT);    // get the light ready
}

void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // light ON
  delay(1000);                     // wait 1 second
  digitalWrite(LED_BUILTIN, LOW);  // light OFF
  delay(1000);                     // wait 1 second
}
```

Text after `//` is a **comment**: a note for humans that the board ignores.

A smart night lamp in a few lines

<>Arduino C++

```
void setup() {  
  pinMode(13, OUTPUT);           // the Lamp LED is on pin 13  
}  
  
void loop() {  
  int light = analogRead(A0);    // read the light sensor  
  if (light < 300) {             // if it is dark...  
    digitalWrite(13, HIGH);      // ...turn the Lamp on  
  } else {  
    digitalWrite(13, LOW);       // otherwise, turn it off  
  }  
}
```

TIP

No hardware yet? Try free simulators like **Wokwi** or **Tinkercad Circuits** to build and run circuits in your web browser.

DO IT YOURSELF

Change `delay(1000)` to `delay(200)` . What happens to the blinking?

The cloud and apps

The **cloud** is simply computers somewhere else on the internet that store your data and pass on messages. It lets you check on your gadget from anywhere in the world.

Here is what happens when your smart plant pot is connected:

1. The sensor checks the soil every few minutes.
2. The ESP32 sends the reading over WiFi to the cloud.
3. The cloud saves it, like writing in a diary.
4. Your phone app reads the diary and draws a graph.
5. You tap **Water now** in the app, and the message travels back to the pump.

Easy tools for beginners

TOOL	WHAT YOU CAN DO WITH IT
Blynk	Build a phone app by dragging buttons and gauges onto the screen
Arduino Cloud	Make a dashboard for your Arduino or ESP32 in your web browser
ThingSpeak	Draw graphs of your sensor data automatically
Telegram bot	Get chat messages like "Your plant is thirsty!"
ESP32 web page	Control your project from any phone on the same WiFi, with no app at all

DO IT YOURSELF

Make a free Blynk account, then add one button that turns an LED on and off from your phone.

Stay safe

Great inventors are safe inventors. Follow these rules every time you build.

Electricity and tools

- Only use batteries or USB power. **Never** touch, open or connect anything to a wall socket.
- Unplug the power before you change any wires.
- Check that + goes to + and – goes to – before connecting a battery.
- If something gets hot, smells like burning or makes smoke, unplug it at once and get help.
- Learn safe soldering from someone experienced before using a soldering iron. It is hot enough to burn skin instantly.
- Never use a swollen, damaged or leaking battery.
- Keep water and drinks away from your project table.

Internet safety

- Never share personal details, such as your home address or phone number, in a public project.
- Use a strong, unique password for every online account.
- Keep your WiFi password secret, even in code you share online.
- Do not point a camera project at people without their permission.

GOLDEN RULE

If you are not sure whether something is safe, stop and ask someone experienced first.

Your first five projects

Start with project 1 and work your way up. Each one follows the same pattern: **sense** → **think** → **act**, and the last one adds **share**.

#	PROJECT	LEVEL	SENSE	ACT
1	Automatic night lamp	Easy	Light sensor (LDR)	LED turns on
2	Intruder alarm	Easy	Motion sensor (PIR)	Buzzer and red LED
3	Thirsty-plant alarm	Medium	Soil moisture sensor	Buzzer beeps
4	Smart dustbin	Medium	Ultrasonic sensor	Servo opens the lid
5	Phone-controlled light	Hard	Your phone (app button)	LED turns on through WiFi

Project 1: Automatic night lamp

YOU NEED

Arduino Uno LDR 10 kΩ resistor LED 220 Ω resistor wires breadboard

1. Connect the LDR and 10 kΩ resistor in a line between 5V and GND; join their middle point to pin A0.
2. Connect the LED and 220 Ω resistor from pin 13 to GND.
3. Upload the night-lamp code from Chapter 7.
4. Cover the LDR with your hand. The LED should switch on!

Project 2: Intruder alarm

YOU NEED

Arduino Uno PIR sensor buzzer red LED 220 Ω resistor

1. PIR pins: VCC to 5V, GND to GND, OUT to pin 2.
2. Buzzer to pin 8, LED (with resistor) to pin 13.
3. Code idea: **if** pin 2 is HIGH, **then** turn on the buzzer and LED for 3 seconds.
4. Wait one minute after powering on; the PIR needs time to settle.

Project 3: Thirsty-plant alarm

YOU NEED

Arduino Uno capacitive soil moisture sensor buzzer

1. Sensor: VCC to 5V, GND to GND, AOUT to A0.

2. Read the number with the sensor in dry soil, then in wet soil.
3. Code idea: **if** the reading says "dry", **then** beep twice every minute.
4. Level up: later, add a relay and a small pump so the plant waters itself.

Project 4: Smart dustbin

YOU NEED

Arduino Uno

HC-SR04 ultrasonic sensor

SG90 servo

a small bin

1. Ultrasonic: VCC to 5V, GND to GND, TRIG to pin 9, ECHO to pin 10.
2. Servo: brown to GND, red to 5V, orange to pin 6.
3. Code idea: **if** a hand is closer than 20 cm, **then** turn the servo to 90° (lid open), wait 3 seconds, then back to 0°.
4. Tape the servo arm to the lid and the sensor to the front of the bin.

Project 5: Phone-controlled light

YOU NEED

ESP32 board

LED

220 Ω resistor

a phone with the Blynk app

home WiFi

1. Create a Blynk account and a new device template.
 2. Connect the LED and resistor from GPIO 2 to GND (many ESP32 boards also have a built-in LED on GPIO 2).
 3. Upload Blynk's example code with your WiFi name, password and Blynk details filled in.
 4. Add a button in the app linked to the LED. Tap it, and your light turns on through the internet!
- Congratulations: project 5 is a real IoT device. It senses your command, thinks, acts and shares over the internet.

Fun words, quiz and what's next

Fun words to know

WORD	SIMPLE MEANING
IoT	Things that sense, think, act and share over the internet
Sensor	A part that notices something, like light or heat
Actuator	A part that does something, like a motor or buzzer
Microcontroller	The tiny brain chip on a board
Circuit	A complete loop that electricity flows around
LED	A small light that glows when electricity flows the right way
Resistor	A part that slows electricity to protect other parts
Breadboard	A board with holes for building circuits without soldering
Program / code	Instructions that tell the brain what to do
Upload	Sending your program from the computer to the board
WiFi	Wireless internet in your home or school
Bluetooth	Short-distance wireless talk between devices
Cloud	Computers on the internet that store data
Relay	A switch the brain can flip to control bigger things
Servo	A motor that turns to an exact angle

Quick quiz

1. What are the four steps every smart device follows?
2. Which sensor works like a bat?
3. Why does an LED need a resistor?
4. Which board has built-in WiFi: Arduino Uno or ESP32?
5. Which part of an Arduino program runs again and again?
6. Which wireless way would you use on a big farm with no WiFi?
7. What should you do if your project smells like burning?

Answers

1. Sense, think, act, share.
2. The ultrasonic sensor.
3. To stop too much current from burning it out.
4. The ESP32.
5. `loop()` .
6. LoRa.
7. Unplug it at once and get help.

What to learn next

- Build all five projects from Chapter 10.
- Join a maker club, a robotics club or an online maker community.
- Try coding with MicroPython on a Raspberry Pi Pico.
- When you are ready for more, move up to the full **Engorio IoT Encyclopedia**, which goes from beginner all the way to advanced.

Keep asking "what if this thing could think?" That question is how every inventor starts.