Project 4

Home Automation

0885CH04

Home automation enables you to operate devices at home automatically with the help of technology. In this project, you will learn how to make electronic circuits and write simple programmes.

As a part of the project, you will be able to:

Figure 4.1: *Making things operate automatically using circuits and programmes*

Automation means using technology to control everyday devices automatically. Instead of switching things on and off by hand, automation uses sensors, controllers and simple computer programmes to run these tasks independently (Figure 4.1).

Imagine a classroom where all students and teachers leave immediately after the final bell. The lights and fans often remain on because no one remembers to switch them off. This wastes electricity and increases electricity bills.

Automation can help in such situations. If the classroom has an automated power system with a motion sensor, the lights will automatically turn off when no motion is detected. This simple change can save energy and reduce costs.

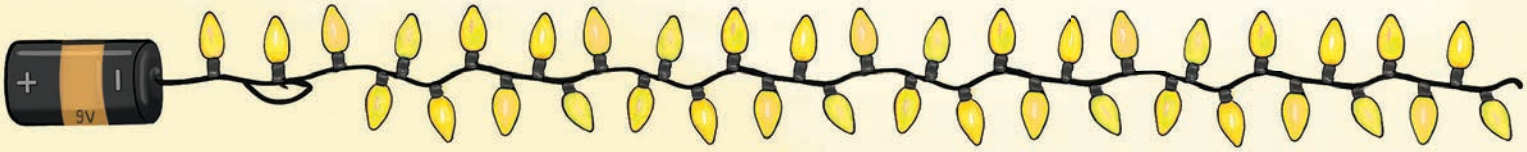
Another example of automation is an automatic garden irrigation system, where a moisture sensor is installed in the soil. When the soil becomes too dry, the sensor sends a signal to a water pump. The pump then automatically turns on and waters your plants. Once the soil has enough moisture, the system turns the pump off. This saves you from having to check the garden every day and helps conserve water by watering plants only when needed.

Automation is not a new idea — it has always been a part of our world. Nature had already perfected automation before humans started creating machines to automate tasks.

Look at the human body. Without thinking about it, your heart beats automatically to pump blood, your lungs breathe in oxygen and release carbon dioxide, and your stomach digests food after eating. All these functions happen without conscious effort, just like an automated machine. The body uses signals, such as nerve impulses and hormones, to decide when and how to act, just as an intelligent system uses sensors and controllers.

If we look around, nature itself is in automation mode. Like modern automation, nature follows systems that work independently, using signals and patterns.

- **Sunrise and Sunset:** The sun rises and sets daily without any action on our part.
- **Water Cycle:** Water evaporates from lakes and oceans, forms clouds, and falls back as rain, following a natural cycle.



- **Animal Instincts:** Birds migrate without Global Positioning System (GPS), generally used by humans. Flowers bloom at the right time, and bees build perfect honeycombs without being taught.

From our bodies to the natural world, automation has always existed. Humans have been inspired by automation in nature and made automated things to make life easier. For example,

- A thermostat is a device that automatically adjust the heating or cooling system, adjusts the temperature in a room, just like our body regulates heat by sweating when we are hot.
- A motion sensor turns on lights when someone enters in a room, just like the pupils of the eyes adjust to brightness automatically.

Humans have always been fascinated by making things that work automatically. Over the centuries, these have evolved from simple devices to complex machines. A journey of automation is shown in Figure 4.2.

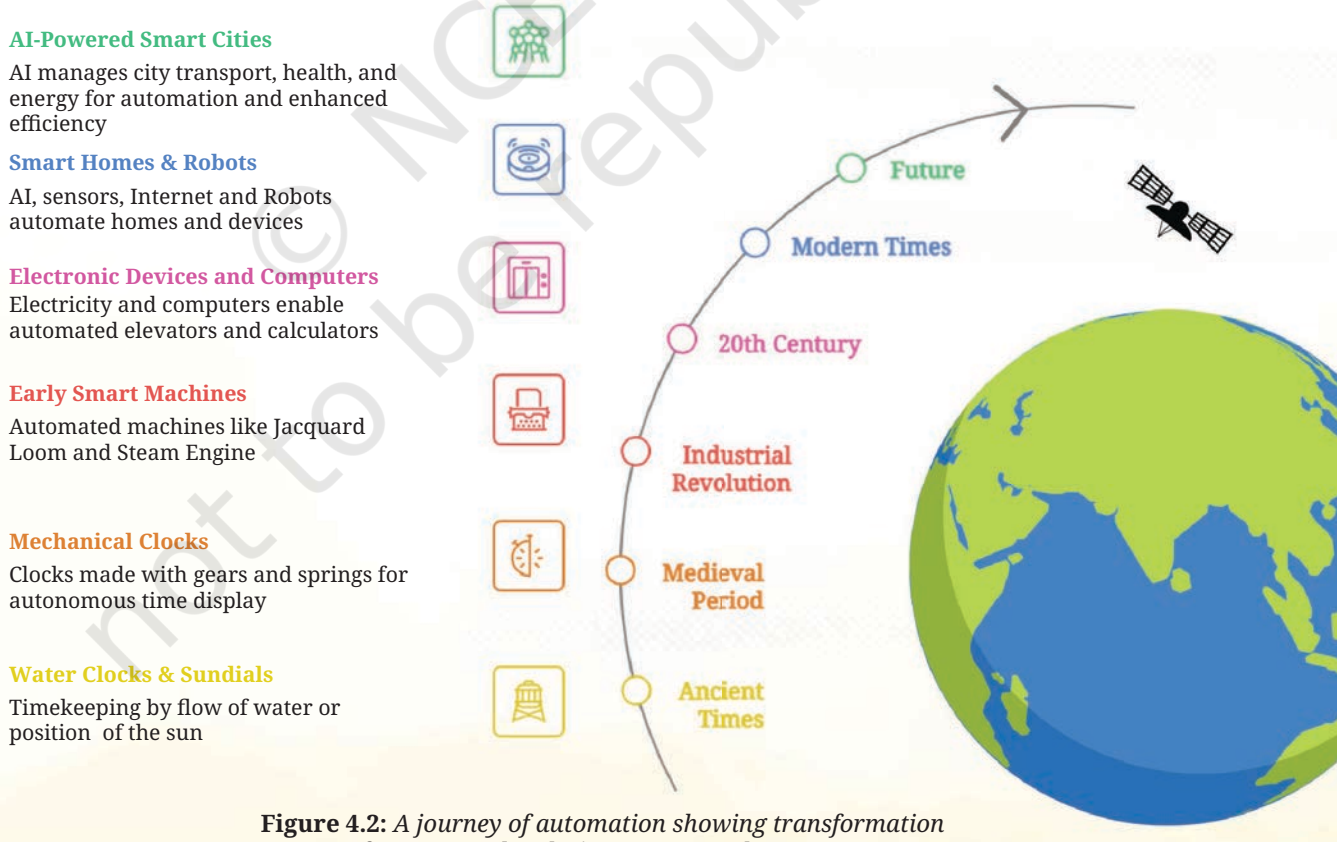
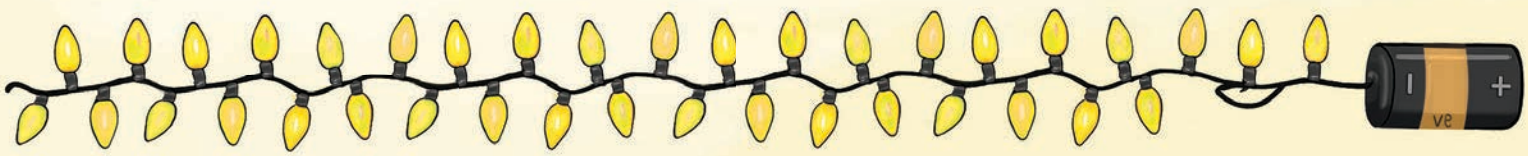


Figure 4.2: *A journey of automation showing transformation from manual tasks into automated systems*



In this project, you will learn how to build similar systems using simple electronics and a microcontroller. You will observe how a tiny sensor can detect movement, how a computer chip can think and send commands, and how a light or a fan acts on those commands.

By exploring automation, you will learn about electronics and programming, and how these ideas can be used in your homes and classrooms to save energy and improve comfort. Enjoy the journey into this exciting world of innovative technology!

What will I be able to do?

By the end of this project, you will be able to:

1. Identify electronic components used in automation systems.
2. Read and draw electronic circuits.
3. Design an automation system for a home or a school.
4. Select appropriate sensors and programme them.
5. Install automation systems and test them.

What will I need?

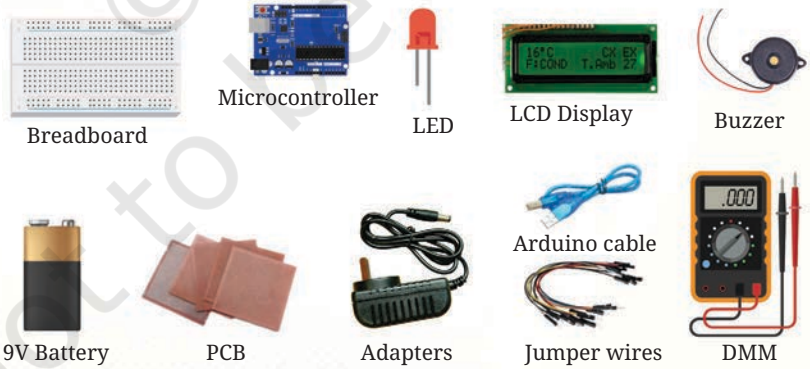
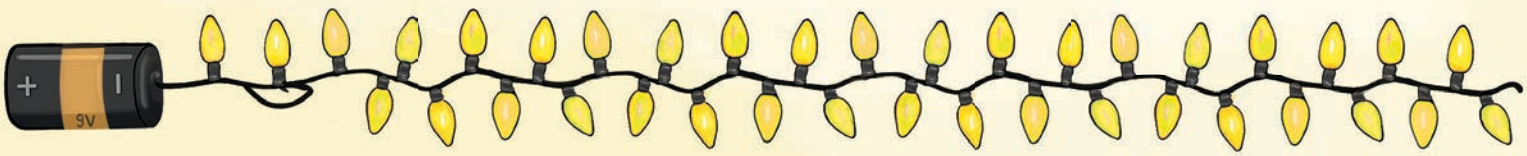


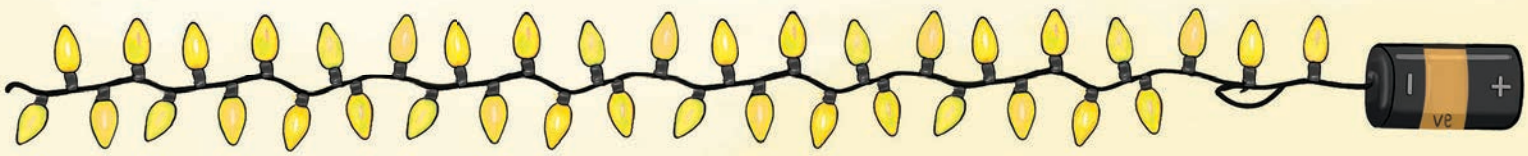
Figure 4.3: *Electrical and electronic components*

Electrical and Electronics Components

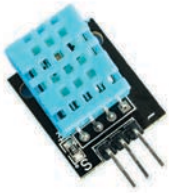
1. **Breadboard:** Metal strips inside the breadboard allow electronic components to be connected without soldering. This makes it possible to test circuits.



2. **Microcontroller:** A microcontroller like Arduino Uno or Raspberry Pi can be programmed using a computer to control various devices, like Light Emitting Diodes (LEDs), buzzers, motors, and sensors.
3. **Light Emitting Diode (LED):** A small electronic component that emits light when electricity passes through it. It has two legs—the longer one is positive (anode) and the shorter one is negative (cathode).
4. **Liquid Crystal Display (LCD) Display:** It is a small screen that can display 16 characters per row and has 2 rows, connected to Arduino with multiple wires. It is used to show messages, sensor readings, and data from an Arduino project. It requires a small potentiometer to adjust its brightness.
5. **Buzzer:** A tiny electronic component that produces a sound when electricity flows through it. They are commonly used in alarms, timers and notification systems.
6. **Battery:** A portable power source that stores electrical energy and provides Direct Current (DC) power to circuits.
7. **Printed Circuit Boards:** Hard boards made of insulating material with thin copper tracks. These tracks connect different electronic components, like resistors, LEDs and microcontrollers, making a permanent circuit.
8. **Adapters:** Device that converts high-voltage AC power (from a wall socket) into low-voltage DC power that electronic devices like Arduino can use. It ensures a steady power supply and prevents damage to sensitive components. A common adapter for Arduino provides 9V or 12V DC output.
9. **Arduino Cables:** They are used to connect an Arduino board to a PC.
10. **Jumper Wires:** Small insulated wire used to connect components on a breadboard or circuit without soldering. It helps transfer electricity from one point to another.
11. **Digital Multimeter (DMM):** An electronic measuring tool used to check voltage, current, and resistance in electrical circuits. It is commonly used by engineers, electricians, and hobbyists to test and troubleshoot circuits.




Motion Detection Sensor


Temperature sensor


Sound sensor

Figure 4.4: *Sensors used in automation*

Sensors

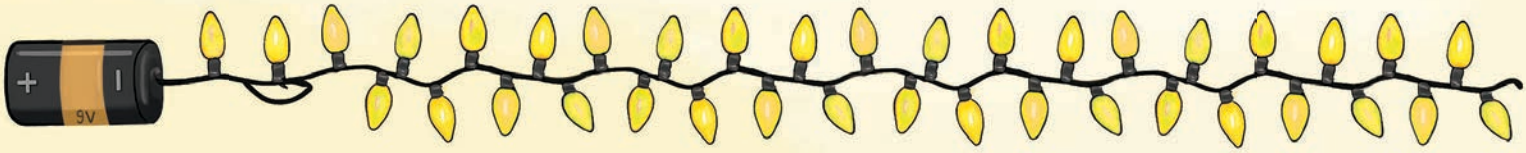
1. **Motion Detection Sensor:** It senses infrared radiation (heat) from objects like humans and animals. When someone moves in front of it, the sensor detects the heat change and sends a signal to trigger an action.
2. **Sound Sensor:** It detects sound levels in the surrounding environment. It converts sound vibrations into electrical signals, which can be used to control devices like LED lights or buzzers.
3. **Temperature Sensor:** It measures the temperature of air, water, or any surface. One popular type is the DHT11, which provides accurate temperature readings in degrees Celsius.

Other Material and Tools: Soldering iron, soldering metal and flux, multimeter, screwdriver, wire stripper, and laptop/computer.

How do I keep myself and others safe?

Some key precautions to be followed while working with electronics are as follows:

1. **Safety from electrical gadgets:** Avoid short circuits and check for loose connections.
2. **Soldering precautions:** Use safety goggles, avoid inhaling fumes and keep your hands away from the hot soldering iron.
3. **Handling tools:** Use wire cutters and strippers carefully to prevent injuries.
4. **Workplace safety:** Keep the workspace organised and free from unnecessary wires.



Internet Safety: Ask your teachers for help while using the Internet. Be careful not to upload or download anything, and do not share personal information anywhere online.

Important Note: Most of the home appliances use **'230 V, AC supply'.** Electronics circuits we include in our activities work on **'DC supply'**. It would be dangerous to connect electronic circuits directly to AC Mains. Only make circuits using DC batteries when you are a beginner.

Figure 4.5: *It is harmful to connect Electronic circuits directly to the AC Mains*

What do I need to know before I start?

Before beginning this project, it will help if you remember some ideas from Science:

- Basic understanding of simple circuits.
- Simple circuit diagrams–draw and read simple circuit diagrams and their components, as well as basic electronic components and their functions.
- Basic symbols used in electrical and electronic circuits are given below:

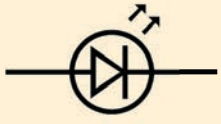
Battery
Provides electrical energy

Resistance
Limits current flow

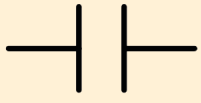
Earthing
Provides a safe path for excess current

Switch
Controls the circuit

Diode
Controls the circuit and direction of the current flow

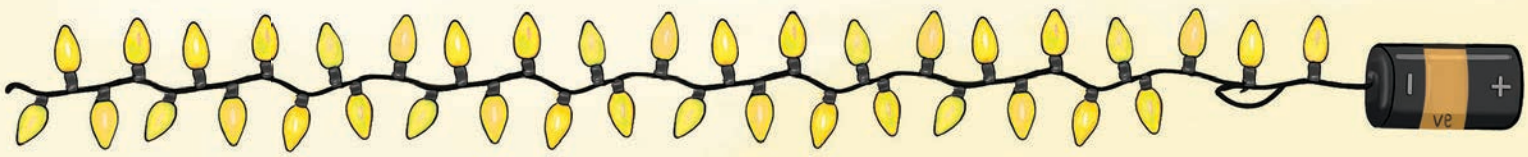


LED
Light Emitting Diode used in lighting



Capacitor
Stores electrical energy temporarily

Before you start working on automation systems, explore the automation systems around you.



Activity 1: Exploring Automation in Our Surroundings

Look around your classroom, home, car, train, nearby market place and community, or even in films and television. Look carefully for things that work automatically. Note your observations in Table 4.1.

Table 4.1: Record observations for the automated systems

Place/ Location	What is Automated?	What is Happening?	How Do You Think It Works?	Notes
Refrigerator	Cut-off in case of voltage surge	If there is a voltage surge, the refrigerator gets switched off	A sensor detects a change in voltage	Protects the refrigerator

Reflect on your learnings

1. Why do you think automation is required?

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2. What excites you the most about the automated systems you observed?

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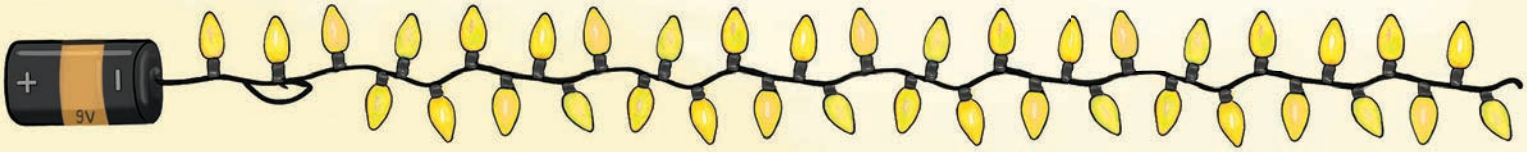

3. Brainstorm ideas you may have to make life easier and free of drudgery (for example, to help your parents or complete any laborious activities). Let your imagination run free.

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.....

What do I have to do?

Activity 2: Exploring circuits using a simulation platform

Have you ever played car racing games on a computer or mobile phone? If you have done that, then you were not driving a real car but a simulation.

Do you know how pilots learn to fly a plane? Besides learning about aeroplanes and their functioning and flying with an instructor, they also use 'simulators'. Simulators allow pilots to experience flying without actually being in a plane. Similarly, there are simulation platforms where you can try different electronic circuits without physically building them. You can draw circuits on a computer screen and test them to check if they work successfully.

Simulation platforms help you prepare for building physical systems. In such case, you will not be making mistakes when you make 'real-life' circuits.

In this activity, you will work on circuit simulation software to build and try out simple circuits.

Tinkercad is a simulation platform. You can explore other platforms using the following search words:

- Simulation for building circuits for beginners
- Platform for making circuits

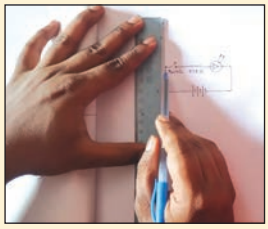
You can search for tutorials for simulations. For example, you can use the search keywords, 'Tutorial for making electronic circuit + Tinkercad'.

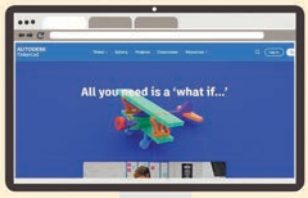
Now, make a simulated circuit using the following components:

- LED, 220 ohms resistor, DC battery 9V, switch
- Buzzer, 220 ohms resistor, DC battery 9V, switch

Follow the steps in Figure 4.6 to make and test circuits.

Step 1: Draw the circuit you want to test.





Step 2: Open Tinkercad or any other simulation platform.

Step 3: Open workplace and place the required components.

Step 4: Make connections and test the circuit.

Figure 4.6: *Using simulation to build and test circuits*

Now, design a few circuits on your own and try them out. Answer the following questions based on the circuits you designed on the simulation platform.

1. Which software did you use?

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2. Did your circuits work? Try different components, such as other batteries and resistance values. Write down your observations of changes as a result of these trials.

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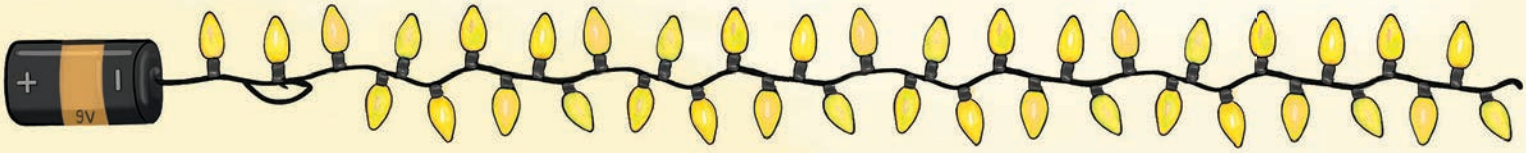
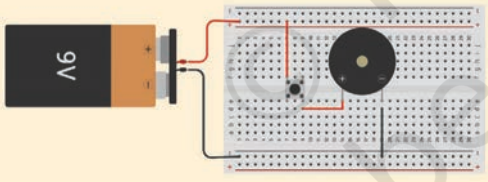


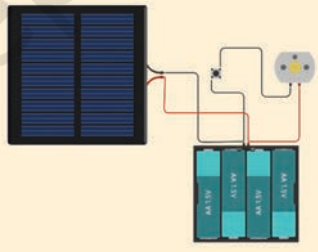
3. Draw the diagrams of the circuits you designed.

Activity 3: Building circuits using physical components

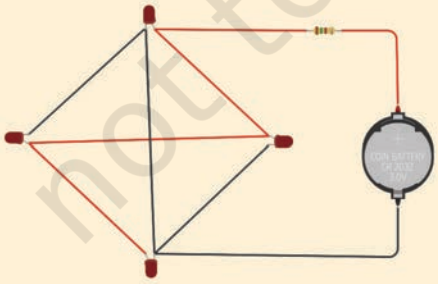
You have tried out different circuits on the simulation platform. Now, build a circuit using physical components. Figure 4.6 has some suggestions.



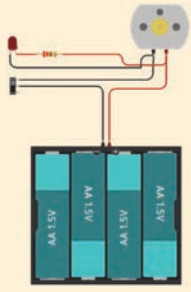
Buzzer with battery and switch



3-V DC motor with solar panel



Electronic *Rakhi*



Dancing doll using LED and DC motor

Figure 4.7: *Creating electronic items with physical components*

You can search for other circuits online using the following keywords:

- DIY circuits for beginners
- Electronic projects for beginners

Reflect on your learnings

On the basis of the activity, answer the following questions:

1. Which circuit did you make?

   .....
   .....
   .....

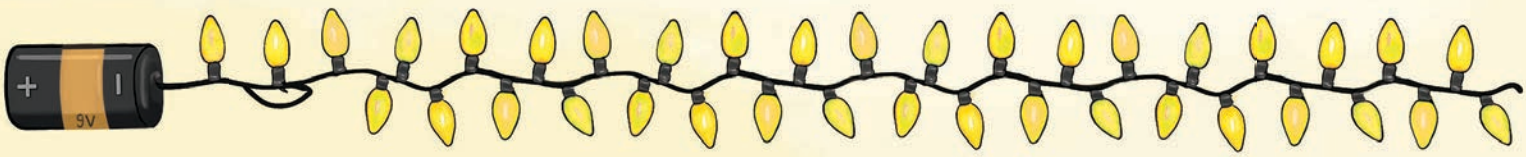
2. Which components did you use? Write their specifications.

   .....
   .....
   .....

3. Draw circuit diagrams of the circuits you designed.

Activity 4: Making the circuit smart

In the activities so far, circuits are controlled by a switch. You can turn a switch either ON or OFF. This allows you to control the flow of electricity to operate the circuit. But you need to manage the switch manually.



Now, what if you want to make the circuit smart? You want your circuit to switch the circuit 'ON' when it is dark or switch the electric pump 'OFF' when the tank is full.

When it becomes dark at night, our eyes sense the darkness, or when water starts overflowing from a tank, our ears hear that sound. Our sensing organs are the eyes, ears, tongue, nose, and skin. They inform our brains about things happening around us. Now, to inform an electronic circuit that it needs to become automatic, it needs to sense things. This is done by components called 'sensors'.

How automation works?

When we touch something hot, our skin senses the temperature (input). It sends a signal to our brain (process). Our brain signals our hand to move away from the hot object. A representation of how one brain senses an input and processes it into output in given in Figure 4.8.

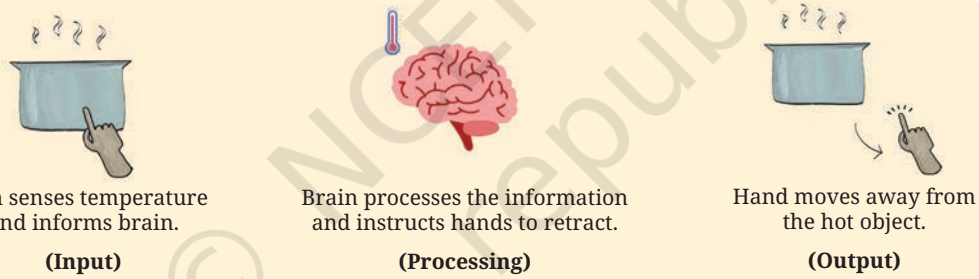


Figure 4.8: *Representation of how our brain senses an input and processes it into output*

Similarly, automation follows a simple cycle that allows machines or systems to perform tasks without constant human control. This cycle consists of three key steps:

1. **Input (Sensing)**
   - Sensors detect changes in the surrounding, such as motion, temperature or light.
     Example: A motion sensor detects movement in a room.
2. **Processing (Decision making)**
   - A microcontroller or processor analyses the input and decides what action to take.
     Example: If movement is detected, the processor turns the lights on.

3. **Output (Action/Execution)**
    - The system carries out the action based on the decision. *Example:* The lights turn on automatically whenever motion is detected.

This cycle continues as long as the system is active, making automation an efficient way to reduce manual work and improve efficiency in daily life.

The microcontroller is the brain of the circuit (Figure 4.8). It processes the sensor information and asks the output devices to act. You need to give instructions to get the desired response from the microcontrollers (Figure 4.9). This set of instructions given to the microcontroller is called a 'programme'.

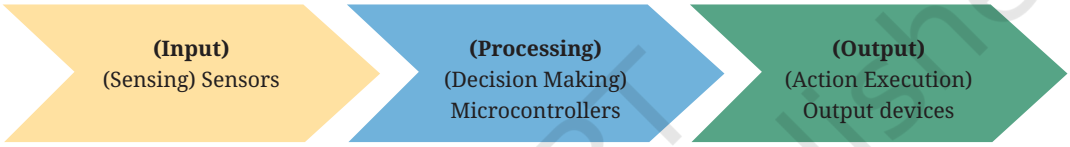


Figure 4.9: *Microcontroller handles both input and output to make decisions*

These microcontrollers are like small computers. Depending on their processing power and functions, different types of microcontrollers are available in the market. You need to choose the microcontroller depending on your application.

Figure 4.10 shows examples of microcontrollers that are commonly used by beginners—Arduino Uno and Raspberry Pi Pico (Figure 4.10).

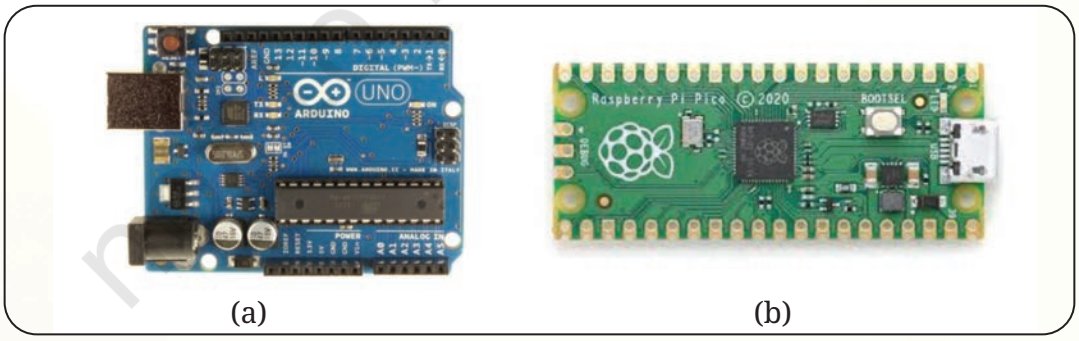


Figure 4.10: *Arduino Uno (a) and Raspberry Pi (b) microcontrollers*

Output Devices

An output device is any piece of hardware item that takes commands from a microcontroller to perform specific tasks. Typical examples of output devices are LEDs, buzzers, DC motors, servo motors, stepper motors, relays, LCD, and speakers. Output devices can exist with or without sensor-like input devices. A person can operate the output device through a sensor or from the signal received from a microcontroller.

Making simple circuits using microcontrollers

You learnt about input devices, microcontrollers and output devices. Now, let us connect them to make a smart circuit. You can use a breadboard to connect different components without soldering them. This will help you to test the circuit quickly. If something does not work, you can rearrange the parts. The breadboard is only for prototyping, a model used to test the circuit (Figure 4.11). Once your circuit is tested and working, you must solder the components and make the circuit permanent.

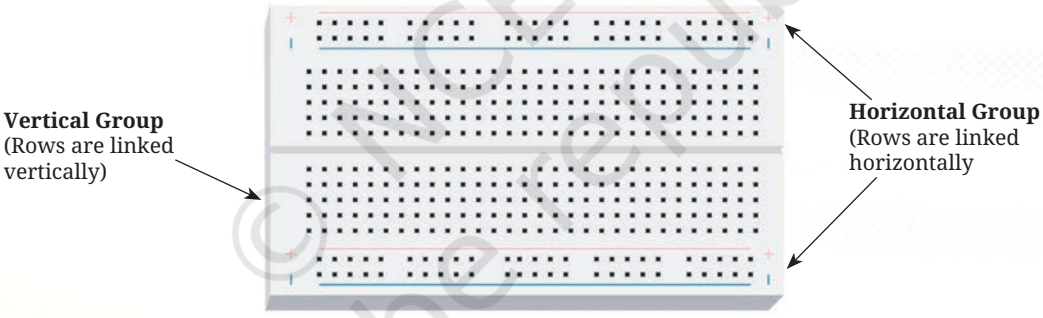


Figure 4.11: *A breadboard*

Microcontrollers: You can create an automation system using a microcontroller. Each microcontroller has a different number of pins. Each pin is for a specific purpose, such as connecting the power supply, ground, and input and output devices.

You can search online using keyword, 'Understanding Pin Configuration of – Name of the microcontroller'.

Arduino Uno is shown in Figure 4.12.

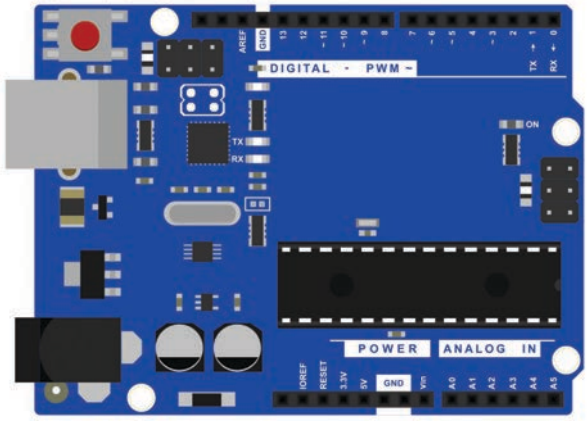


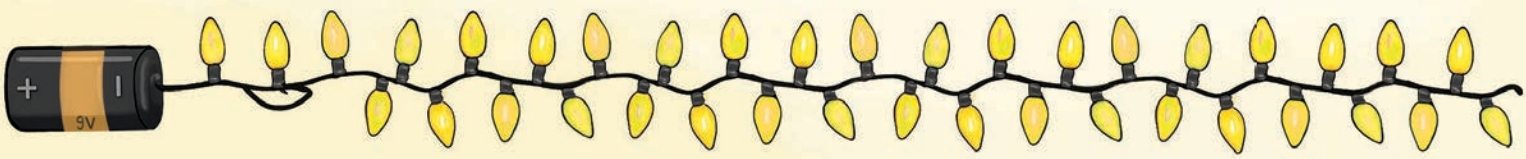
Figure 4.12: *Arduino Uno*

- **Analog pins (labelled A0 to A5):** Connect input or output devices, such as parts like LEDs, sensors, and motors.
- **Digital pins (labelled 0 to 13):** To give an 'On–Off' signal. They control LEDs, buzzers, motors (On/Off signals), etc.
- **Universal Serial Bus (USB) port:** Connects to a computer for programming.
- **Power supply:** A USB cable or a battery can power the microcontroller.
- **Reset button:** Restarts the programme running on the board.
- **GND:** GND stands for 'Ground'. It is a reference point of voltage in circuits and protects the circuit and the person working the circuit.

You can try the following activities using microcontrollers, breadboard(s) and sensors.

Glowing LED bulb using a microcontroller (for example, Arduino Uno)

1. Search for an online tutorial using the search keywords, 'Tutorial + beginner + microcontroller' (e.g., Arduino Uno).
2. Connect the LED, battery, and Arduino pins with the help of your teacher. Download the Arduino IDE programme from the official Arduino website.
3. Start the Arduino IDE programme on the computer; go to File ⇒ Examples ⇒ Basics ⇒ Blink. This will open a new window with the Blink programme.



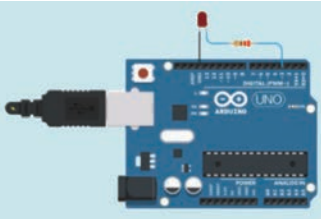


Figure 4.13: *LED off*

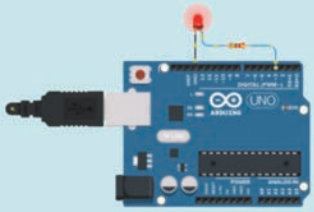


Figure 4.14: *LED on*

4. Now, connect the Arduino board to the computer using its cable. Then open the tools menu on the computer, go to the port and select Arduino Uno Com (com number will be selected automatically by computer).
5. When done, click on the arrow under the file menu. This will upload the programme to the Uno board. This should blink the Uno onboard LED every second.
6. Now, change the value in the delay command to set a different time for the on and off state of the LED and upload the programme again.

You can also try the following:

1. On/Off LED
2. Reduce or increase the blinking time of LED
3. Add multiple LEDs and blink them

Activity 5: Exploring automation cycle

Now, you know how to connect a microcontroller and programmes it using a computer; you also know how to give it power. Now, connect input and output devices to try the automation cycle.

All automation processes have an input, a process and an output (Figure 4.15).

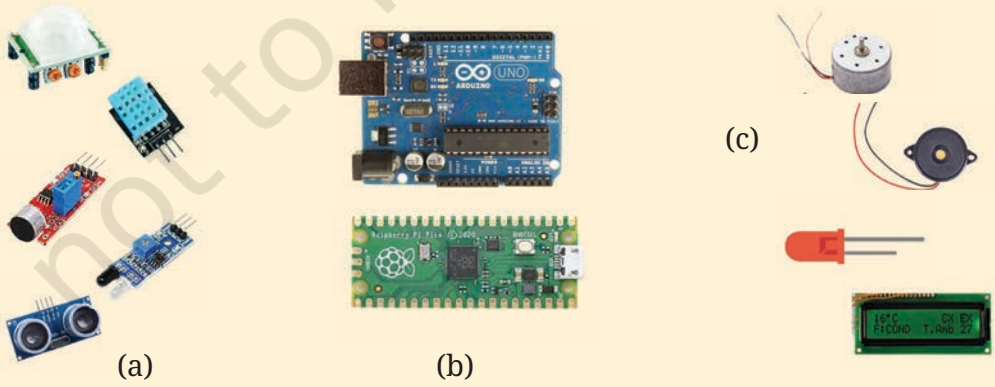


Figure 4.15: *Some sensor modules (a), microcontroller (b), and motor toy (c)*

What can be the input, process and output for each digital device? One example for automatic street light is given below. Complete the details for water sprinkler and any device of your choice.

Automatic Street Light

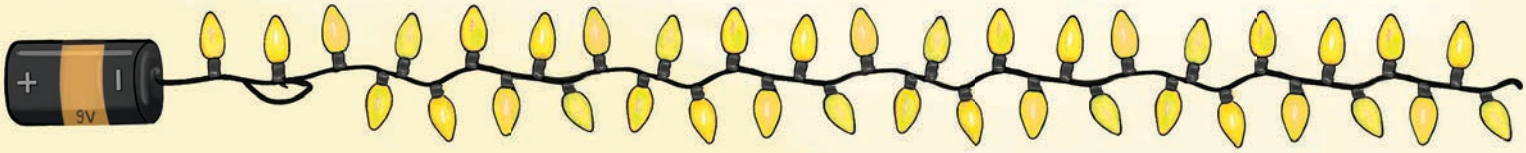
Input	Process	Output
LDR (light sensor) senses light. Its resistance changes. It informs the microcontroller when light intensity drops. →	Microcontroller get a signal from LDR. It decides if it is getting dark from value of the input received. It instructs put light 'ON'. →	Light switches 'ON' with the instructions received from the microcontroller.

Automatic Water Sprinkler System

Input	Process	Output

An Automation Device of Your Choice

Input	Process	Output



You can search online for tutorials or circuits. You can use search keywords, 'Tutorial + automated + streetlight (or your Mobile/ Laptop) + (Your microcontroller, for example – Arduino)'.

Now, make a small automation system using microcontrollers.

Automation System: Smart light system using a microcontroller.

Function: If some movement happens in the room, then the light will switch 'ON'.

Microcontroller: Arduino Uno

Materials: The microcontroller (Arduino Uno), PIR motion sensor, 5 mm LED, 220-ohm resistor, breadboard, jumper wires, USB cable, computer with Arduino IDE installed.

Circuit Diagram:

Process: Open the Arduino IDE and write/modify the code. Test the circuit.

Automation System: .....

Function: .....

.....

Microcontroller: .....

Circuit Diagram:

Process: .....

Did your circuit work the first time? If not, please write down what you need to fix.

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Activity 6: Make your own automation system using a microcontroller

You have learned about microcontrollers, their connections and how they are connected with sensors and output devices. Use this knowledge and skills to make an automation system of your own.

Following are examples of few automation systems. You can search for their tutorial online by putting them in the 'search words'.

- Instructions + automatic plant watering system + using Arduino (or any microcontroller)
- DIY + automatic obstacle detecting system + using Arduino (or any microcontroller)
- DIY + beginners + automatic fire alarm system + using Arduino (or any microcontroller)
- DIY + automatic + gate opening system
- DIY + automatic + theft detection alarm system
- Instruction + smart fan + (or any microcontroller)

If not exactly, then you can get programme or instructions close to your application. You can take it as a reference and build on it to make programme for your application.

Reflect on your learnings

1. What automation system do you want to make? What is the process?

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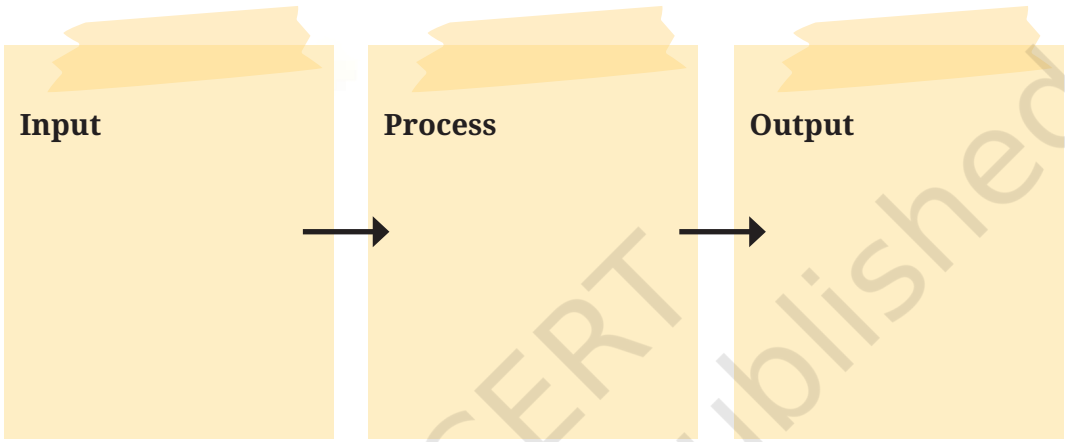
2. Write about the Input, Process and Output of your project.



3. What are the materials required by the automation system?

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4. Did you modify the code received from other sources? Mention the site, the information you got, and the modification you made.

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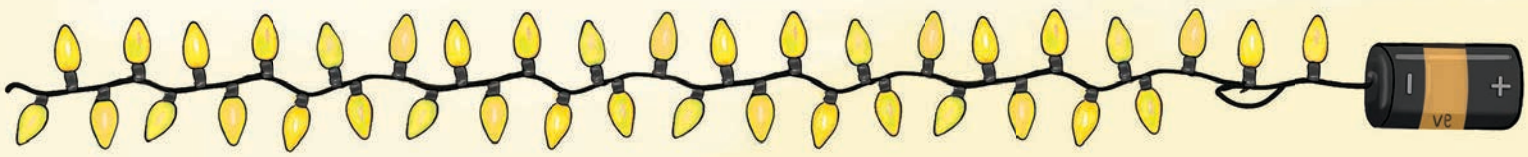

5. Draw the block diagram/sketch/circuit of your automation system.

6. Did your automation system work as per the plan? If not, what are the reasons? What will you change next time?

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What did I learn from others?

1. What are the precautions to be taken to protect the circuits from electricity fluctuations?

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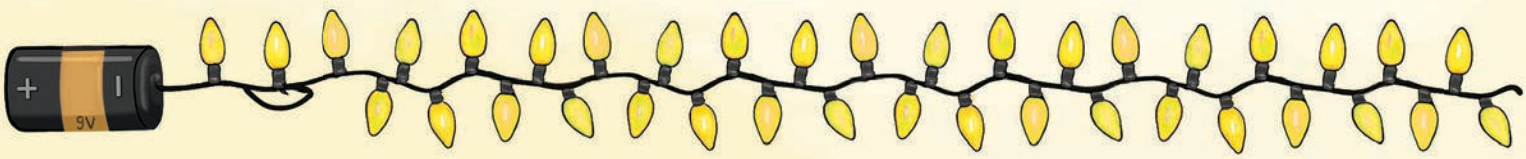

2. Did you take help from experts or peers? What are the three most important things you learned about home automation?

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What did I do and how long did it take?

It is important to understand how much time is required for an activity to be completed.

Calculate the approximate number of hours you spent on each activity. Mark them on the timeline below. If you did more than the activities suggested in the book, please add the number and time taken.

Activity	*1*	*2*	*3*	*4*	*5*	*6*
Time taken (Periods)	---	---	---	---	---	---

What else can I do?

So far, you have provided power supply through a computer USB port to the Arduino board. But to make circuits independent of the computer, you need to package them with batteries or power adapters. Arduino boards take power from the laptop/computer. To deploy your system in the field, you need to package it with batteries.

The Arduino board needs Lithium–Ion batteries. It also needs DC connector cables to connect the batteries to the Arduino board. You can make a casing using a 3D-printer or use any other available materials to make a suitable casing.

Think and Answer

1. Did you enjoy doing this project?
2. What did you like, and what would you do differently next time?
3. Compare sensors and human sense organs. What can humans do with their senses that sensors cannot? What capabilities do humans have that automated systems do not? For example, can systems be designed to respond to human emotions.
4. Examples of jobs related to the work you did are automation engineer, technical support specialist, programmer, etc. What other jobs are related to the project? Look around, speak to people, and write your answer.