Chapter 6
The World of Robots

What do you see in the picture? It's a robot cleaning the trash.

Have you seen robots ? In which fields are robots used?

- In factories
- In agricultural areas
- For entertainment
- .....
- .....

Today, robots are used in various fields such as agriculture, vehicle manufacturing, space missions, and many others. Their use increases the productivity and reduces the workload on humans. Let's explore the fascinating world of robotics.

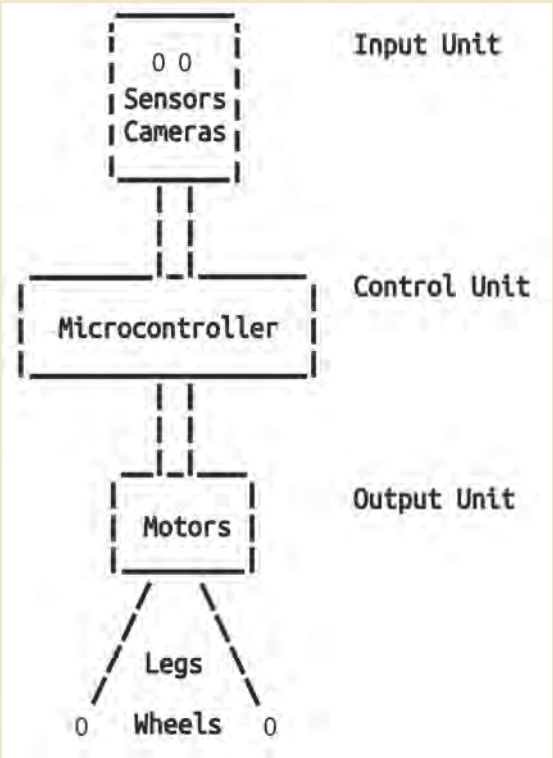
How Robots Work

Have you ever thought about what robots are capable of? Robots can perform complex tasks quickly

and accurately for extended periods without tiring. These machines come in different sizes and shapes, designed to suit specific tasks and environments. Robots can take forms such as small vehicles, birds, animals, human hands, and even full human-like figures.

Have you ever thought about how robots work? Robots recognize their surroundings and analyze the information they recognize. Based on the analyzed information and the instructions they receive, they make decisions and act independently.

Basic Components of a Robotic System



Robots use various types of sensors to perceive their surroundings. These sensors (input devices) gather information, which is then processed by microcontrollers or microprocessors. The choice of processor depends on the volume and complexity of the data to be processed. As the data requirements grow, the efficiency and number of processors are scaled accordingly. Based on the processed information, the robot's control unit manages the output devices.

Output devices in robots include LEDs, buzzers, display units, motors, and complex mechanical components, depending on the specific application. The components responsible for enabling automatic movement in robots are known as actuators. Examples of actuators include servo motors and stepper motors.

Have you understood the basic components required for the functioning of robots?

Now complete the table 6.1 on the components of robots and their uses. Some of the components mentioned in this are available in the **robotics kit** in your computer lab. Check them out to complete the list.

Category	Component	Use
Input Unit	Light Sensor	To detect the presence of light.
	IR Sensor	To detect the presence of objects with the help of infrared rays.
	Microphone	
	Camera	To collect information in the form of images.
Control Unit	Arduino	The information received through input devices is processed, decisions are made based on the given instructions and actions are carried out throught the output devices.
	Raspberry Pi	
	ESP32	
Output Unit	LED	To display the output in the form of light.
	Buzzer	
	Servo Motor	Used to perform automatic/mechanical movement.

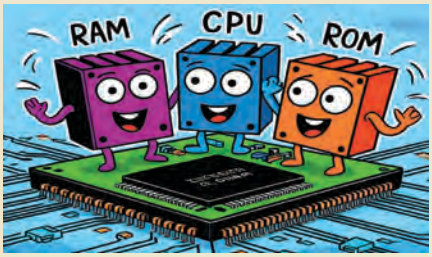
Table 6.1 Components of Robots and their Uses

Robotics

Robotics is the science that studies the design, construction, operation and control of robots using appropriate software. It combines electronics, mechanical engineering, and computer science. Knowledge in these diverse fields is essential for building robots. The rapid advancement of artificial intelligence technology is also driving significant progress in the field of robotics today.

Usually, programmable **microcontroller** chips act as the brains of robots. The Arduino UNO board in the robotics kit given to schools has a microcontroller

Microcontroller



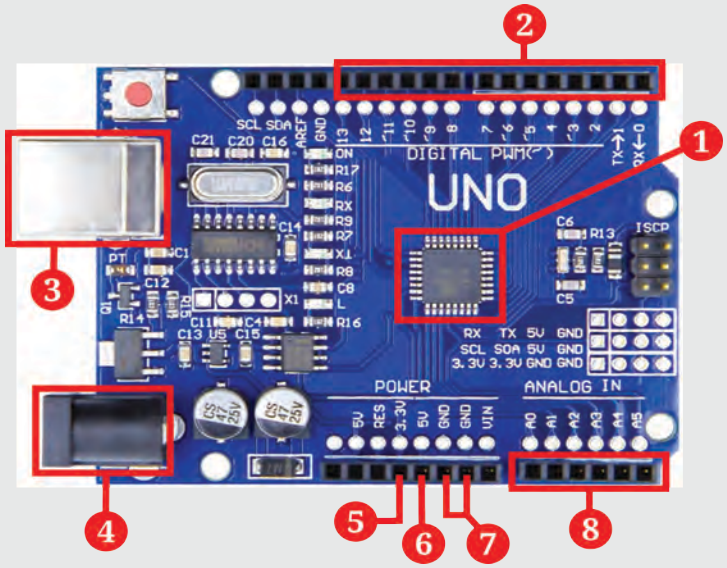
A microcontroller is a small computer integrated into a single chip. It contains the main components of a computer system, including the processor, RAM, ROM, and input/output interfaces, all within the microcontroller chip.

called ATmega328P embedded in it. Using Arduino and its related components, we can create prototypes or miniature versions of electronic devices commonly seen around us. Let's explore how to make such devices using the components in the robotics kit.

Let's Get to Know Arduino

Arduino is a world famous open-source hardware/ software platform. Arduino was created in 2005 by a research team at the Interaction Design Institute Ivrea in Italy, with the aim of making physical computing devices that connect sensors, actuators and other components easier, cheaper, and more popular to build.

Arduino models are available to suit different needs. The Arduino Uno R3 model is shown in Fig 6.1.



1. Microcontroller Chip (ATmega328P)
2. DIGITAL I/O PINs (0 to 13)
3. USB Port
4. External Power Supply
5. 3.3V DC PIN
6. 5V DC PIN
7. GND
8. Analog Input

Fig 6.1 Arduino Uno R3 - Major Components

Look at Table 6.2 and find the major components of Arduino and their uses.

Component	Use
Microcontroller Chip (ATnega328P)	This part is called the brain of Arduino. It collects information and controls the devices according to the instructions.
DIGITAL I/O PINs	Collects data from input devices. Controls output devices. The pins marked with tilde (~) symbol can also be used for Pulse Width Modulation (PWM).
USB Port	For connecting to computer to upload programs and transfer data.
External Power Supply	For supplying power to the board from the battery or other external source.
5V PIN	This provides a steady 5V.
3.3V PIN	This provides a steady 3.3V.
GND	This provides the ground potential (0V) of the Arduino.
Analog Input	For measuring analog voltage.

Table 6.2 Arduino Uno R3 - Major Components and their Uses

Breadboard

A breadboard is a device that allows you to build and reuse circuits by connecting electronic components to each other without soldering. The terminals of electronic components can be attached to the holes in the breadboard. These holes are internally connected to each other using conductive wires, as shown in the second picture.

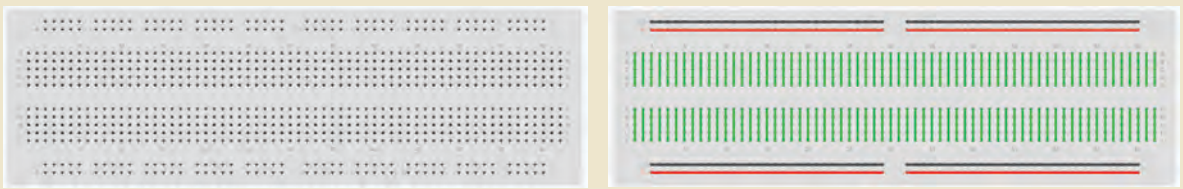


Fig 6.2 Breadboard

Let's Light LED Lamps

Haven't you prepared circuits for lighting a filament bulb used in a torch battery (Fig 6.3) in

Fig 6.3 Circuit of Filament Bulb

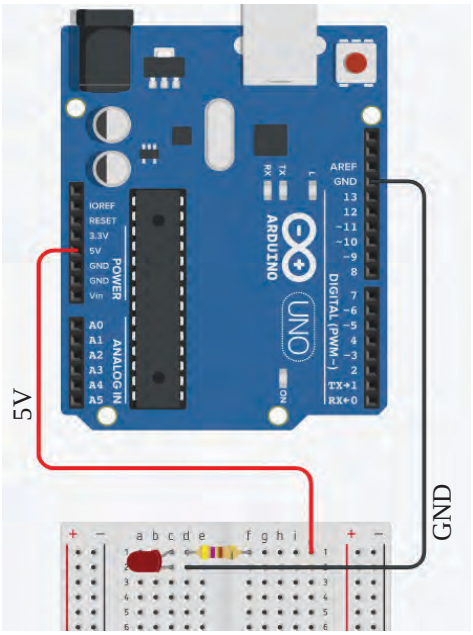


Fig 6.4 LED bulb Circuit Using Arduino

science classes? Now, what about preparing a circuit for lighting an LED?

See the circuit diagram given in Figure 6.4. Here, instead of a battery, Arduino is used to provide power.

Let's take a look at the things to note when designing a circuit like this.

- The positive terminal of the power supply should be connected to the anode of the LED and the negative terminal should be connected to the cathode of the LED.
- A suitable resistor should be connected in series in the circuit.

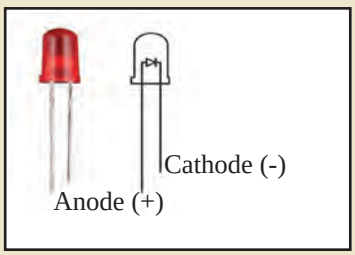
Open the robotic kit and make a circuit as shown in Fig 6.4 using the *Arduino, LED, resistor* and *jumper wires*. Then, connect the Arduino to the computer. The USB cable in the kit can be used for this.

Doesn't the LED light up? Repeat the experiment using LEDs of different colours.

Blinking LED

You now understand how to power an LED using an Arduino.

LED (Light Emitting Diode)



An LED is a two-terminal electronic device belonging to the diode category that conducts electricity in only one direction and emits energy in the form of light. Electricity will flow through the LED circuit only if its anode terminal is connected to the +ve of the battery and cathode to the -ve of the battery. Typically, the anode terminal of the LED is slightly longer than the cathode. To prevent excessive current flow and potential damage to the LED, a resistor must be connected in series with the LED circuit. The resistor's value depends on the maximum power the LED can handle and the voltage of the power source.

Now, let's learn how to make an LED blink using Arduino. What changes need to be made in the circuit for this?

We are using 5V power from the Arduino to operate the LED. But is it enough to simply connect the 5V pin to make the LED blink? No, the 5V pin provides a constant 5 volts, so it cannot be used to make the LED blink.

To create a blinking LED, we need to connect it to one of the **digital pins** (PIN 0 to 13), which can control the power (turning it ON/OFF). We then give the necessary instructions to the Arduino to control this power.

Observe the circuit diagram shown in Fig 6.5 and build the circuit based on this model.

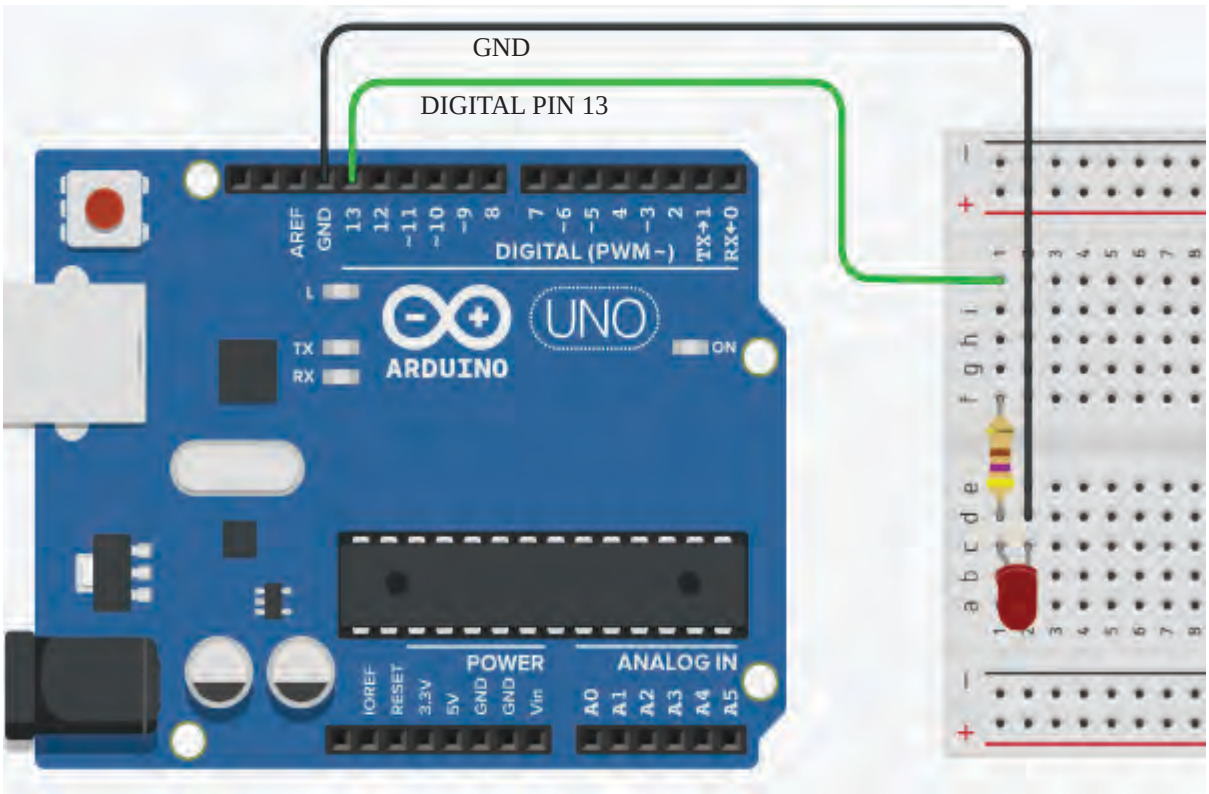


Fig 6.5 LED Circuit Connected in PIN 13 of Arduino

In the circuit, the anode of the LED is connected to DIGITAL PIN 13 through a resistor. When this pin is ON, the LED will light up, and when it is OFF, the LED will go out.

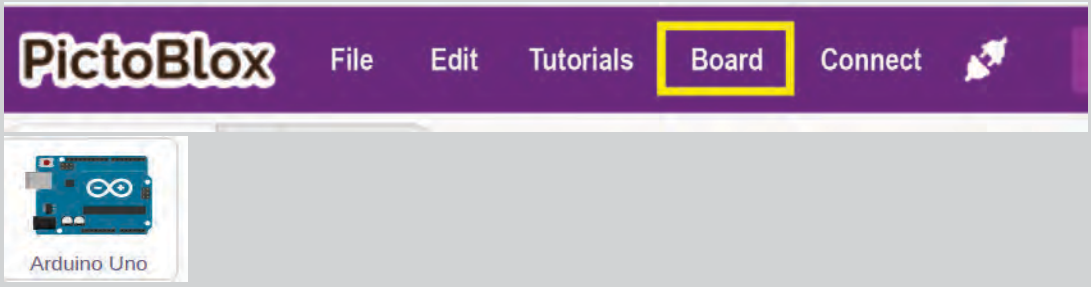
The Arduino circuit is now complete. Next, we need to give the Arduino a command to turn PIN 13 ON/OFF.

To do this, you need to write a program on the computer. This can be done using **PictoBlox**, which we learned in previous classes. Before writing the program, we need to set up the connection between the Arduino and the computer.

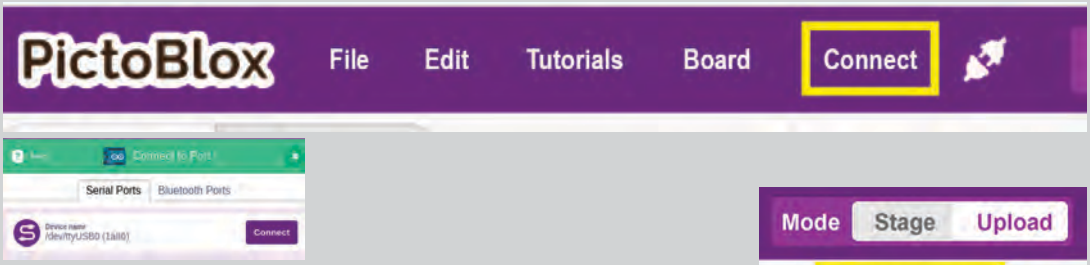
Connect the Arduino board to the computer as shown below.

To Connect Arduino to Computer

- Connect Arduino to computer using USB cable.
- Open **PictoBlox** on computer and select **Block Coding**.
- Then, select **Ardunio UNO** board from **Board** menu.



- Open the **Connect** menu and click the **Connect** button against the Arduino connected via USB to establish the connection.

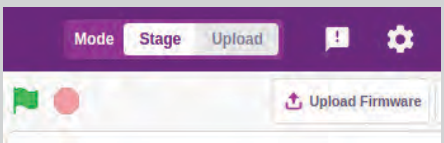


- After that, change the programming mode to **Upload Mode.**

Programming Modes in PictoBlox

There are two ways to program Arduino using PictoBlox.

1. Upload Mode:



In this mode, the program prepared on the computer is completely uploaded to the memory of the Arduino microcontroller. Later, it does not require a computer to **run** the program. The Arduino only needs to be powered on.

The given code block will only work in **upload mode**.

2. Stage Mode:

In this mode, the Arduino must first be configured using the **Upload Firmware** method to **run** the Arduino. Once the firmware is uploaded, the Arduino will operate according to the instructions received via the USB cable. In this mode the program can be **run** only when the Arduino is connected to the computer.

This code block will only work in **stage mode**.

Have you connected the Arduino board to the computer? Now, check the Blocks tab in pictoblox. Here you will see some new code blocks related to the Arduino Uno.

From this, you can find out which instruction should be used to turn *DIGITAL PIN 13* ON.

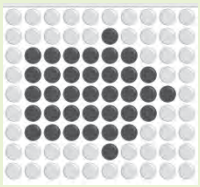
If so which instruction should be used to turn *DIGITAL PIN 13* OFF?

- Just make the output of *DIGITAL PIN 13* LOW.

Now prepare the program given in Figure 6.6 and upload the program to the Arduino using the 

button.

Language of Computers



In the previous chapter, we have learned about binary language, the only language that computers can understand. We have already discussed that instead of **0** and **1** in the binary number system, we use **LOW, HIGH, FALSE, TRUE, OFF, ON** respectively. These are called "bits". Each bit represents a switch, which can be on (1) or off (0). These bits are added together to represent all the information we use on computers every day, such as text, images, and videos.

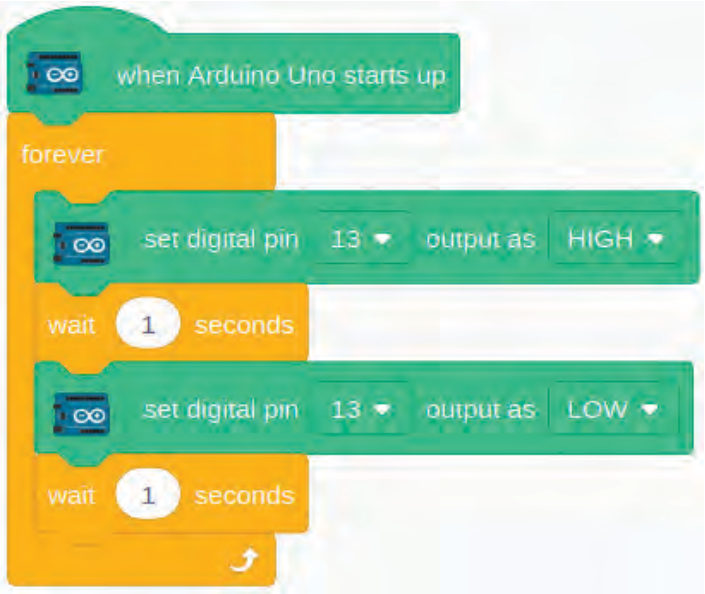


Fig 6.6 LED Blinking Program

Is the LED in the circuit blinking?

What changes should be made in the code to increase the speed of blinking of the LED? Try to do it.

Beep... Beep…

We made a system, blinking LED using a computer program. Is it possible to make a device that produces a beep sound at intervals in the same model?

Observe the circuit diagram in Fig 6.7. Here, a buzzer is connected in the circuit instead of an LED.

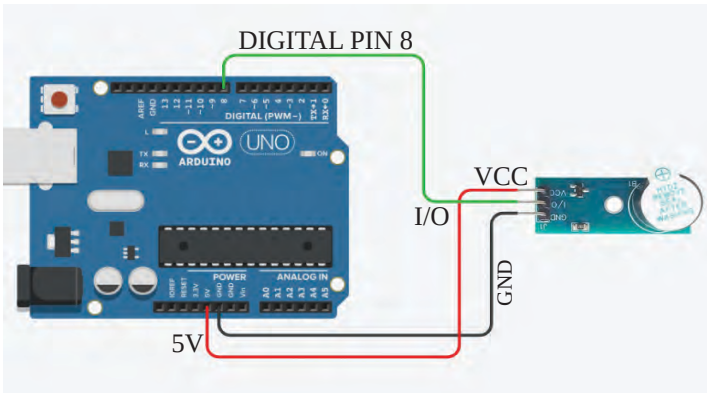


Fig 6.7 Circuit in which Buzzer is Connected

Buzzer Module

This is an electronic component used to produce a beep sound. It can be powered by connecting the VCC of the buzzer to the 5V of the Arduino and the GND of the buzzer to the GND of the Arduino. It produces sound when a LOW signal is given to the I/O PIN. The sound stops when a HIGH signal is received on the I/O PIN.

Observe the figure and identify the digital pin in Arduino board with which the middle pin of buzzer (I/O PIN) is connected.

If we want the buzzer to produce a 'beep' sound at regular intervals, what changes should we make in the program we prepared earlier? Try it.

Automatic Sanitizer Dispenser

We have discussed that robots collect information from their surroundings through various sensors and act accordingly. Let's try to build a sensor-based device.

Do you remember how we used sanitizer to clean our hands during the COVID-19 pandemic to prevent the spread of disease?

Imagine a sanitizer bottle that dispenses sanitizer as soon as our hand comes near it, without having to touch the bottle.

How do these devices detect the presence of our hand?

- IR sensors
- Ultrasonic sensors
- LiDAR (Light Detection and Ranging)

This can be achieved by using the above given sensors.

Mini pumps or electronic taps are commonly used to control the release of sanitizer. There should also be a controller chip to connect the sensor and the tap to each other.

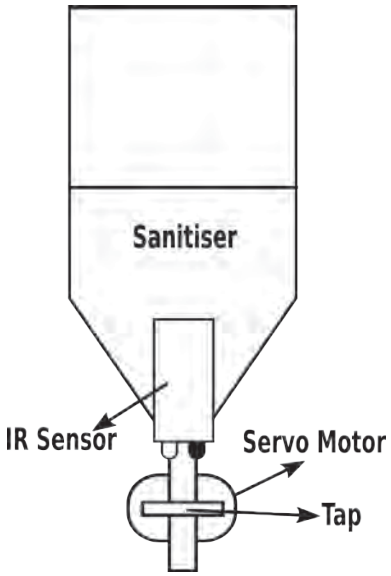


Fig 6.8
Automatic sanitizer dispenser Design

Let's make a device that detects the presence of hand and dispenses sanitizer. It should be made according to the model given in Fig 6.8.

What components are needed for this? Let's check the availability of these components in our robotic kit.

- *IR sensor module* to recognize the presence of hand.
- *Servo motor* to control the tap of the sanitizer bottle.
- *Arduino* to control these logically.

Observe the circuit in Fig 6.9. What settings are made in it?

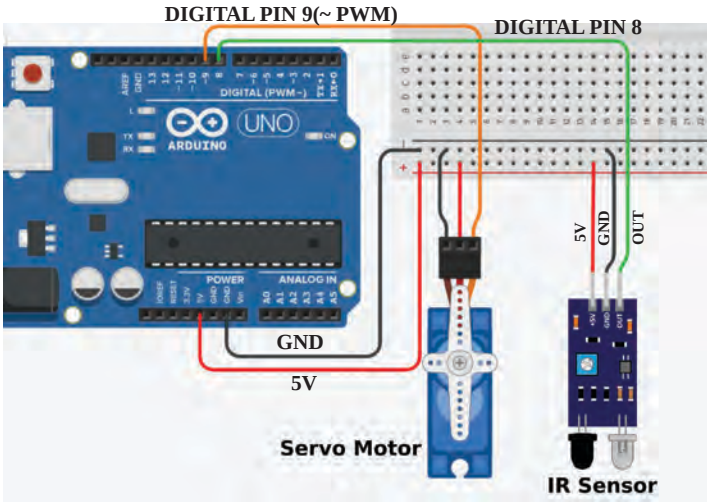
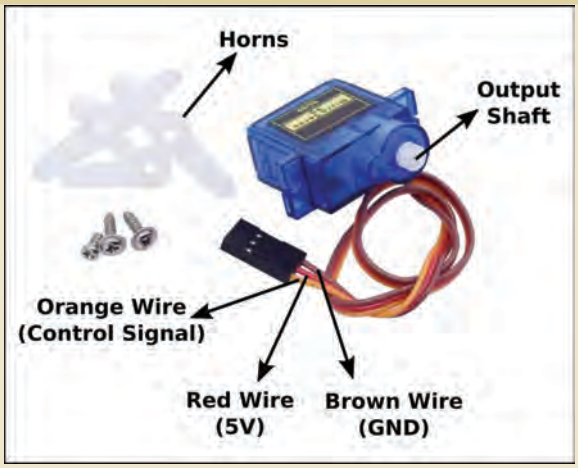


Fig 6.9 Automatic Sanitizer Dispenser Circuit

- Power is given to the servo motor and IR sensor from Arduino.
- The output pin of the IR sensor module is connected to DIGITAL PIN 8 of Arduino.
- The control pin of the servo motor is connected to DIGITAL PIN 9 of the Arduino. (DIGITAL PIN 9 is also a PWM pin. PWM pins are used to control the servo motor).

Set up this device as shown in the diagram in Fig 6.8 using Arduino, servo motor, IR sensor module and sanitizer bottle.

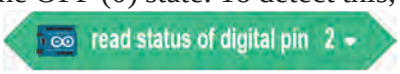
Servo Motor



Servo motors are not designed to rotate continuously like other motors. A servo motor with three connection wires has a control wire in addition to the power wires. The servo motor shaft rotates through angles from 0 to 180 in accordance with the signal voltage supplied to this control wire. Servo motors are usually controlled by Arduino using PWM (Pulse Width Modulation).

The red wire of the servo motor shown in the picture can be connected to the 5V of the Arduino and the brown wire to the GND of the Arduino to provide power. The signal received on the orange wire determines the angle to which the output shaft of the motor should rotate.

Now, let's prepare a program to make this system work.

- When an object comes in front of the IR sensor, the output pin will be in the OFF (0) state. To detect this, we can use the code 

in PictoBlox. In this state, the tap of the sanitizer bottle should be opened.
- The device should be set up in such a way that when the shaft of the servo motor reaches 90 degrees, the tap of the sanitizer bottle should be opened. Then, to open the tap, just give the code 

.
- After that, the device should also be adjusted in such a way that the tap closes when the servo motor shaft reaches 0 degrees. The device configured in this way opens the tap when the hand comes near and closes the tap when the hand is removed. The code prepared in PictoBlox for this is shown in Fig 6.10.

IR Sensor Module

This is an electronic component that is used to detect obstacles in front with the help of infrared waves. If an object comes in front of the IR sensor module, the OUT PIN will become LOW (OFF) and when the object moves, the OUT PIN will become HIGH (ON).

Fig 6.10 Automatic Sanitizer Dispenser - Program

Make necessary changes in this code as per the design you made for your Sanitizer Dispenser and upload it to the Arduino and run it.

The automatic sanitizer dispenser works by recognizing the presence of our hand.

Have you seen other devices that work by recognizing our presence in this way?

- Automatic tap
- Automatic door
- ……..……..

Discuss whether it is possible to prepare a model of these devices using the components in the robotic kit.

Artificial Intelligence and Robotics

We have learned in previous classes that artificial intelligence is a technology that enables machines to learn and solve problems by imitating human intelligence and thinking skills. Artificial intelligence and robotics can do many amazing things when they come together. Just imagine what they could be.

- Robots that perform surgeries in the healthcare sector.
- Robots that manufacture products in factories.
- Robots that engage in space travel.
- Robots that engage in agricultural work.
- Robots that prevent environmental pollution.
- ……..……...

In short, robots are growing to be able to perform tasks with precision and efficiency beyond human intelligence.

Aren't you interested in creating devices that work with artificial intelligence? How about we make one of them?

A Door that Opens by Recognizing Faces

We have discussed the functioning of a door that opens automatically by recognizing human presence. A passive infrared sensor (PIR sensor) is usually used in such a system. This sensor detects the infrared heat radiation emitted by the body of living beings. Therefore, the door will open even if animals come.

How can we make a door that opens only when there is a human presence? Why not use the computer vision technology that we learned in previous classes for this?

Shall we make a smart door system that opens only when a human face is seen in front of the camera?

Since Arduino does not have a camera, we can use our laptop's camera to prepare this system. Therefore, we need to prepare the program in **Stage Mod**e in Pictoblox.

Human faces can be detected using the extension named **Face Detection** in Pictoblox.

To Include Face Detection in Stage Mode

- In Stage Mode, connect the Arduino to the laptop and configure the Arduino using the **Upload Firmware** option.
- Then include the facility in the following way:,

 Add Extension →

 Face Detection

Set **Stage Mode** in Pictoblox as shown on the left and include the **Face Detection** extension.

Did you add the Face Detection extension to your system?

Now, let's prepare a miniature of the door that works by recognizing faces. Examine the diagram in Fig 6.11. Prepare the circuit and create a miniature of the smart door system.

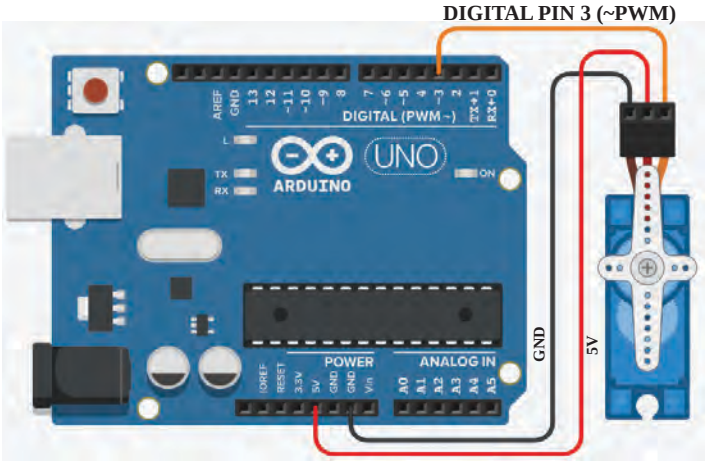


Fig 6.11 Smart Door System - Circuit

Now let's program it.

How can we detect if a human face is caught on camera?

- In Pictoblox, we can turn on the camera using the code 

.

- You can analyze the images captured by the camera using 

and find the number of faces identified using the 

code.

Examine the code given in Fig 6.12. The shaft of the servo motor is rotated to 90 degrees to open the door and to 0 degrees to close it.

Make necessary changes in this code according to the configuration of the servo motor attached to the smart door system you have prepared and try it out.

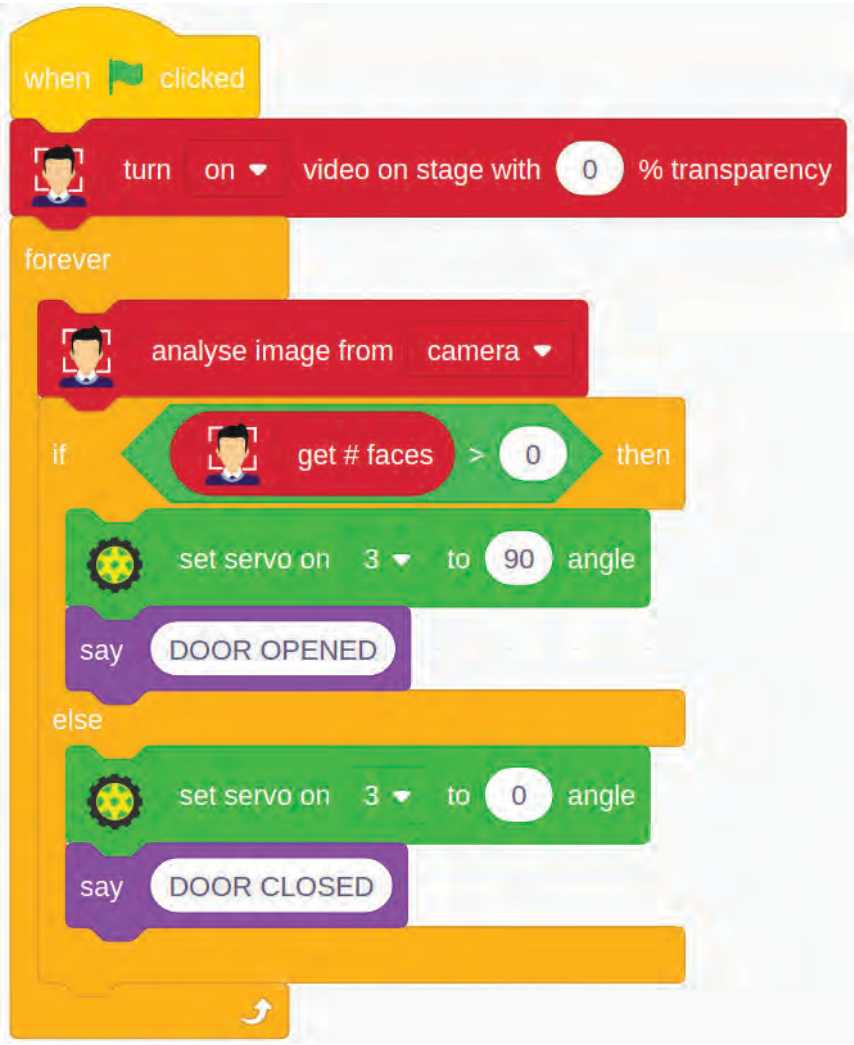


Fig 6.12 Smart Door System - Program

Let's Assess

- Which of the following can be used as an actuator in a robot?

a) IR sensor
b) Servo motor
c) LED
d) Arduino

- Analyze the code given in the figure and find the correct statements given below.

a) An output device is connected to Digital PIN 4.
b) An output device is connected to Digital PIN 10.
c) An input device is connected to Digital PIN 4.
d) An input device is connected to Digital PIN 10

Extended Activities

1. Did you use Arduino to light up an LED? Make a model of a traffic signal using green, red, and yellow LEDs.
2. Modify the smart door system you created so that it recognizes only you and functions accordingly.
3. Using the light sensor from the robotic kit, create a model of an LED light system that automatically turns on at night.