MECHATRONICS

राष्ट्रीय डिजाइन संस्थान
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What is mechatronics?

Mechatronics is the integration of mechanical engineering, electronics, and programming into a single system.
It focuses on creating smart machines that can sense, process information, and act automatically.
From robots to modern appliances, it powers devices that think and respond like never before.

How it would help Designers?

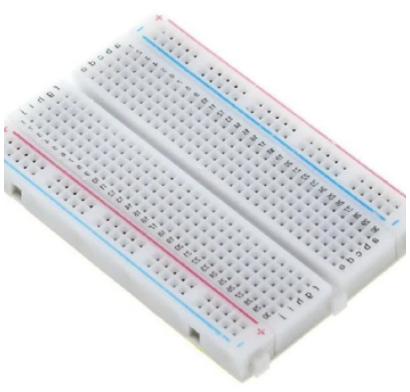
Helps designers by enabling the creation of smart, responsive, and automated products. It allows rapid prototyping using sensors, actuators, and microcontrollers, making it easier to test and refine ideas quickly. In manufacturing, mechatronics ensures faster, more precise, and consistent production processes. It supports user-centered design by collecting real-time interaction data to improve product performance and usability.

Basic understanding of mechatronics?

When starting out in mechatronics, it’s easiest to begin with small, hands-on projects—like making a light respond to a button press. These simple activities introduce the flow from sensing something, to processing the information, to producing an action. Working with beginner-friendly tools such as Arduino helps you discover how electronics and mechanics can work together to turn creative ideas into working prototypes.

A power supply provides the electrical energy needed for a circuit to work. It can be a battery, USB power, or a lab DC power source.

A resistor limits the amount of current flowing in a circuit.
ohm’s Law: V=I×R
V = Voltage,
I = Current,
R = Resistance.



A breadboard lets you build and test circuits without soldering.
Rows & Columns: Understand how rows are connected horizontally and power rails vertically.

An LED is a diode that emits light when current flows through it in the correct direction. LEDs have a positive anode and negative cathode).

A capacitor is like a small rechargeable battery that stores and releases electrical energy. It collects charge and then gives it back when needed.

A potentiometer is a type of variable resistor that lets you control the flow of electricity by turning a knob. It works like a volume dial

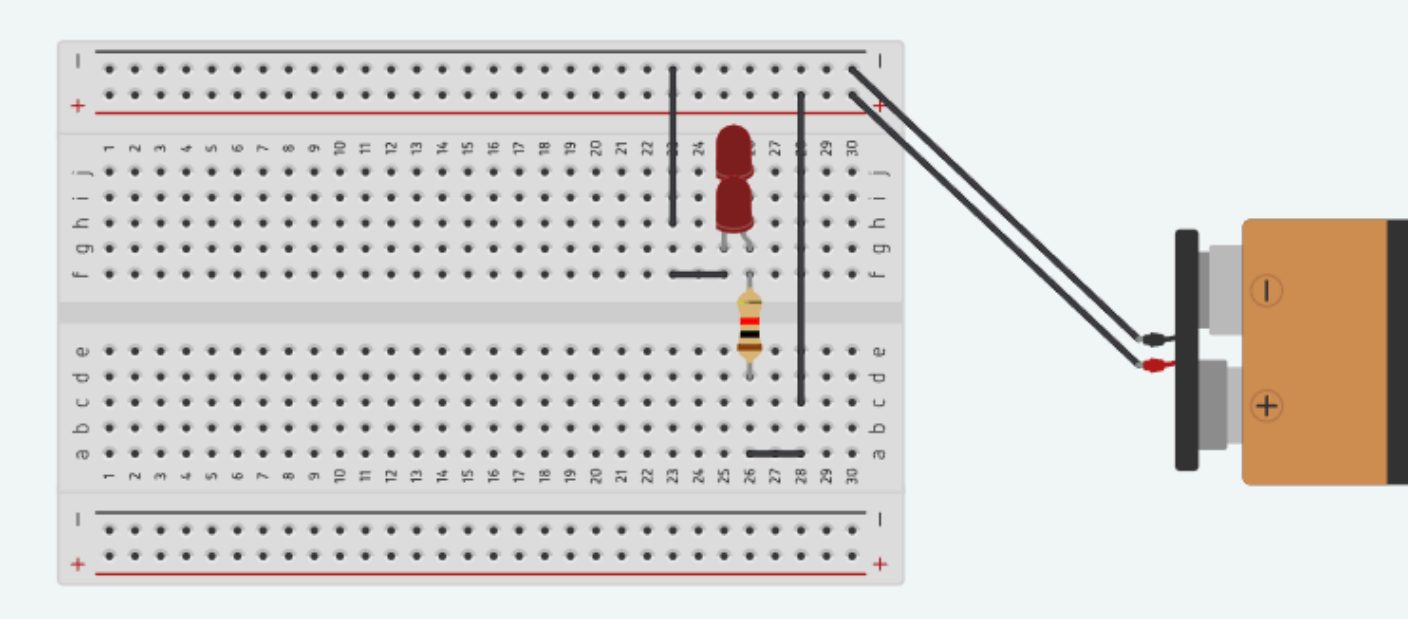
Introductory Electronic Experiments:

1. Parallel Connection:

An experiment to understand how enery flows in series and parallel connection

Parts Required:

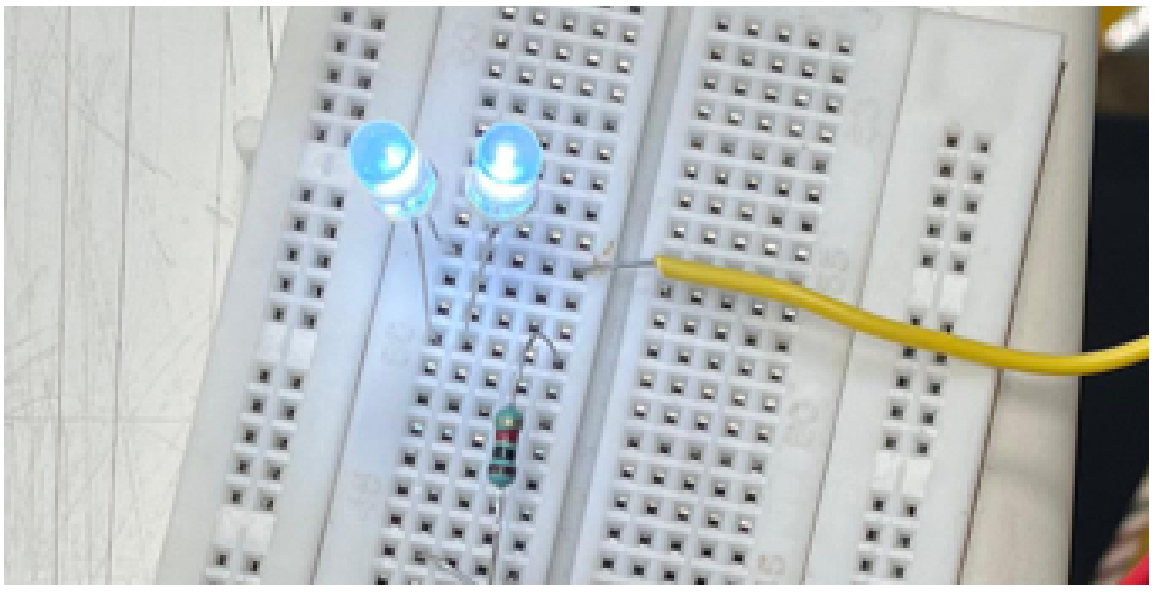
- 2 × LEDs
- 1 × Resistor (i.e. 1KΩ)
- Jumper wires
- Breadbox
- 9V Battery/Power supply



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

Component	Pin	Connected To
9 V Battery	+ (red wire)	Top red power rail
9 V Battery	– (black wire)	Bottom blue ground
LED 1	Anode (long leg)	Top red power rail
LED 1	Cathode (short leg)	One side of Resistor
Resistor	Other end	Bottom blue ground
LED 2	Anode (long leg)	Top red power rail
LED 2	Cathode (short leg)	Other side of Resistor
Jumper Wires	—	Used to connect
Breadboard	—	Holds and connects all

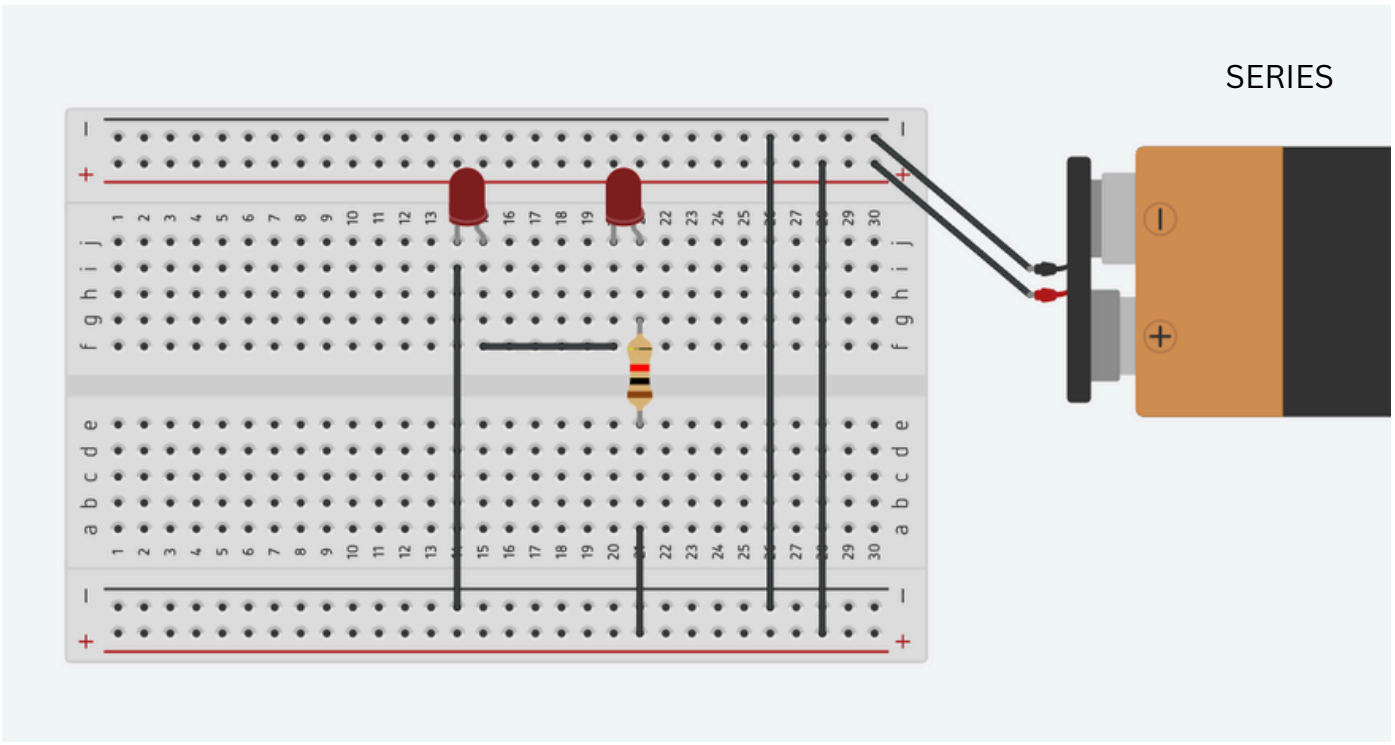


2. Series Connection:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 2 × LEDs
- 1 × Resistor (i.e. 1KΩ)
- Jumper wires
- Breadbox
- 9V Battery/Power supply



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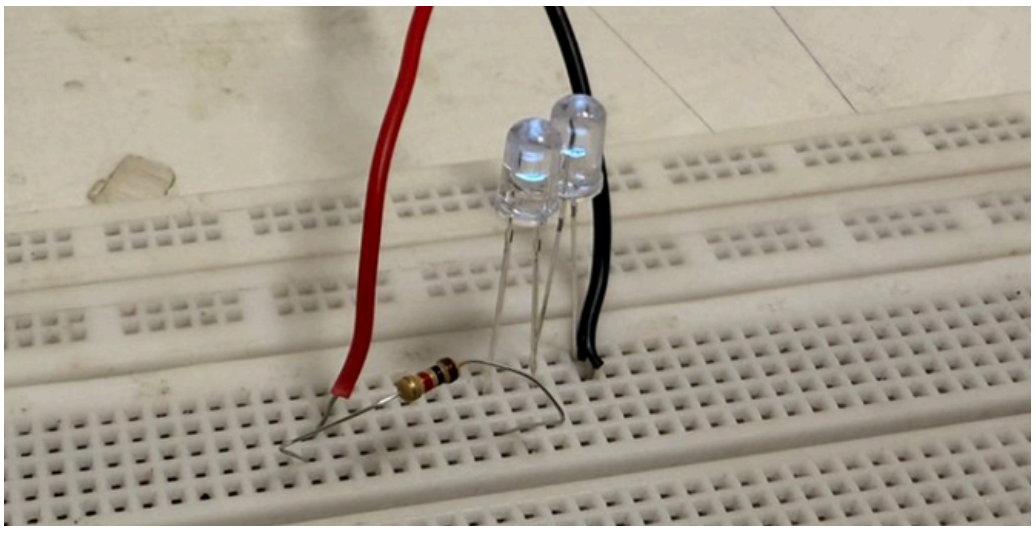
Connections:

Component	Pin	Connected To
9 V Battery	+ (red wire)	Top red power rail (Positive)
9 V Battery	– (black wire)	Bottom blue ground rail
LED 1	Anode (long leg)	Top red power rail (Positive)
LED 1	Cathode (short leg)	Ground rail (Negative)
Resistor	Other end	Bottom red power rail
LED 2	Anode (long leg)	One side of resistor
LED 2	Cathode (short leg)	Anode of Led 1
Jumper Wires	—	Used to connect power rails
Breadboard	—	Holds and connects all

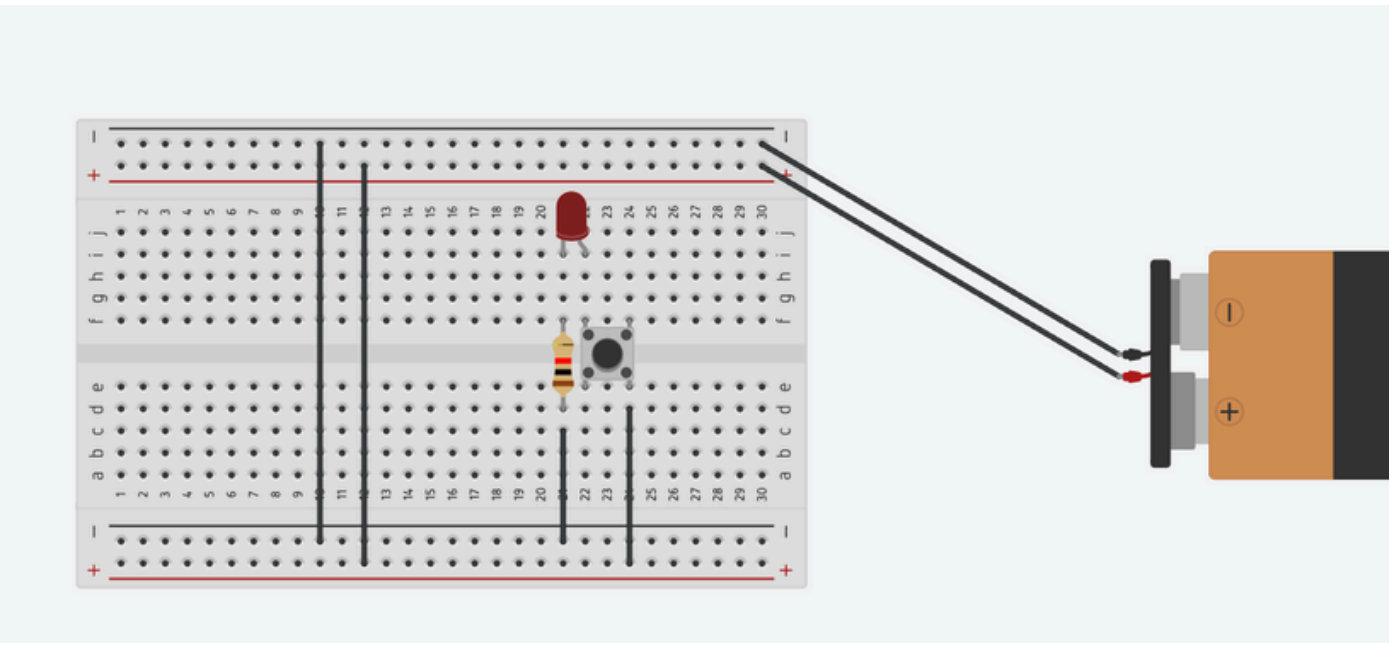


3. Controlling LED with Push Button:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

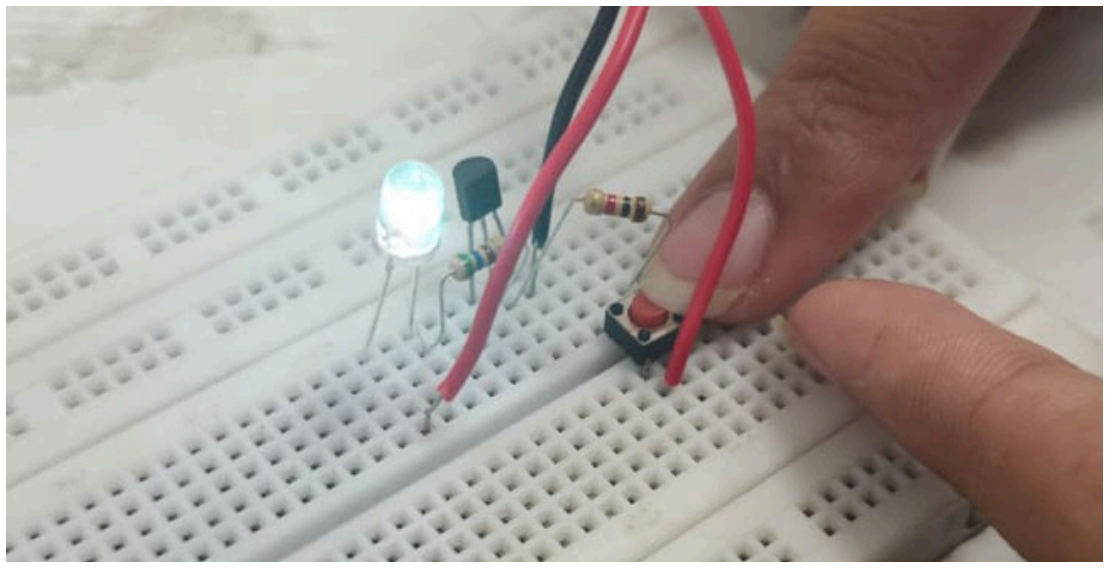
- 1 × LED (any color)
- 1 × Push Button
- 1 × Resistor (i.e. 1KΩ)
- Jumper wires
- Breadbox
- 9V Battery/Power supply



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

Component	Pin / Leg	Connected To
9 V Battery	+ (red wire)	Top red power rail (Positive)
9 V Battery	– (black wire)	Bottom blue ground rail
LED	Anode (long leg)	One side of resistor
LED	Cathode (short leg)	Bottom blue ground rail
Resistor	One end	LED anode
Resistor	Other end	Push button output leg
Push Button	Other leg	Resistor input (leading to LED
Jumper Wires	—	Used to connect battery clips
Breadboard	—	Holds and connects all

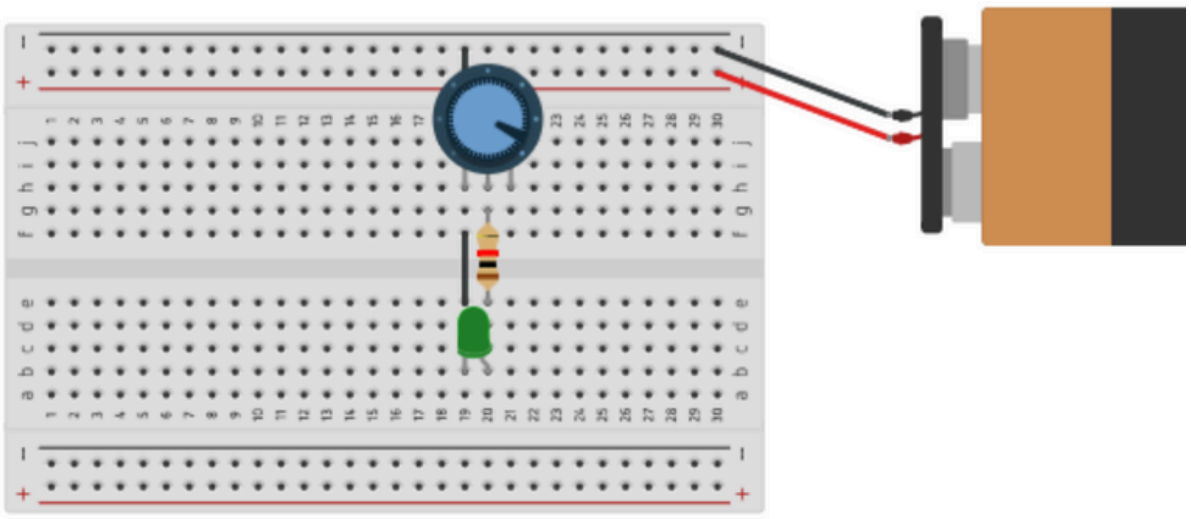


4. Controlling LED with Potentiometer:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

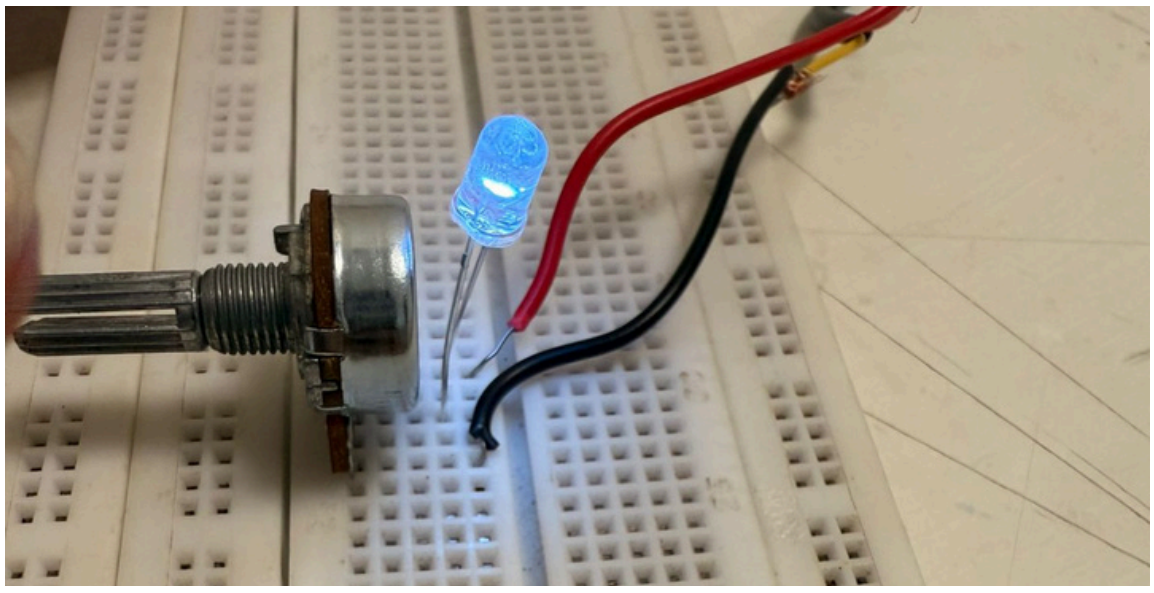
- 1 × LED (any color)
- 1 × Potentiometer
- 1 × Resistor (i.e. 1KΩ)
- Jumper wires
- Breadbox
- 9V Battery/Power supply



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

Component	Pin / Leg	Connected To
9 V Battery	+ (red wire)	Top red power rail (Positive)
9 V Battery	– (black wire)	Bottom blue ground rail
Potentiometer	One outer pin	Top red power rail (Positive)
Potentiometer	Other outer pin	Bottom blue ground rail
Potentiometer	Middle pin (wiper)	One end of resistor
Resistor	Other end	LED anode (long leg)
LED	Anode (long leg)	Resistor output
LED	Cathode (short leg)	Bottom blue ground rail
Jumper Wires	—	Used to connect power rails,
Breadboard	—	Holds and connects all

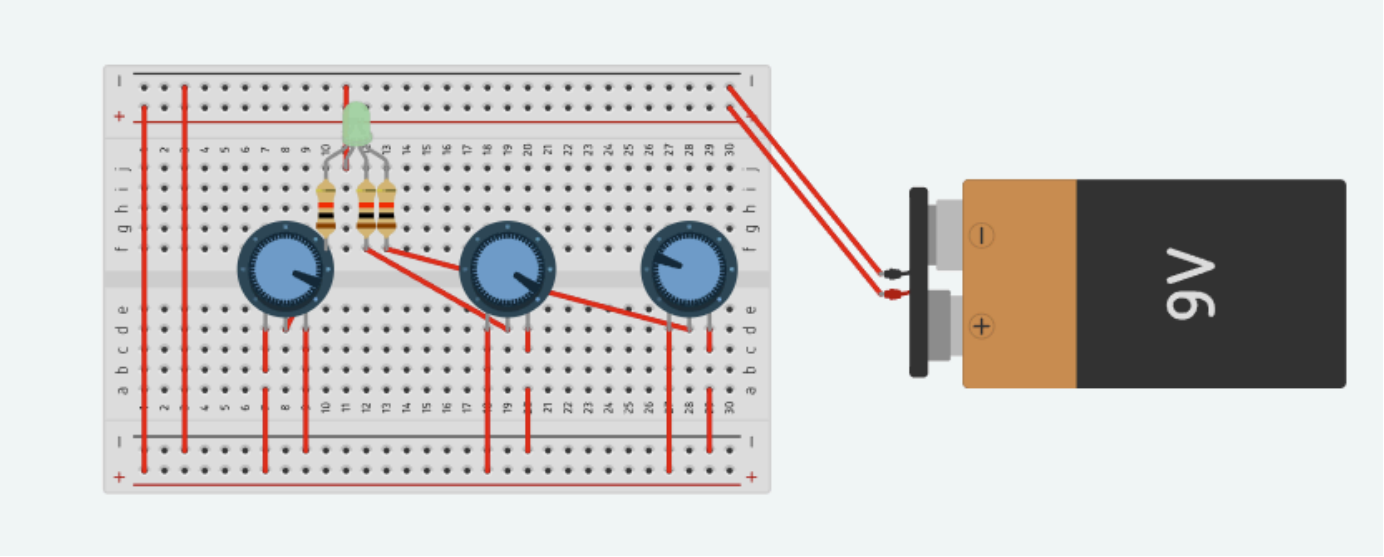


5. Controlling RGB LED with Potentiometer:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × RGB LED
- 3 × Potentiometer
- 3 × Resistor (i.e. 1KΩ)
- Jumper wires
- Breadbox
- 9V Battery/Power supply
-



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

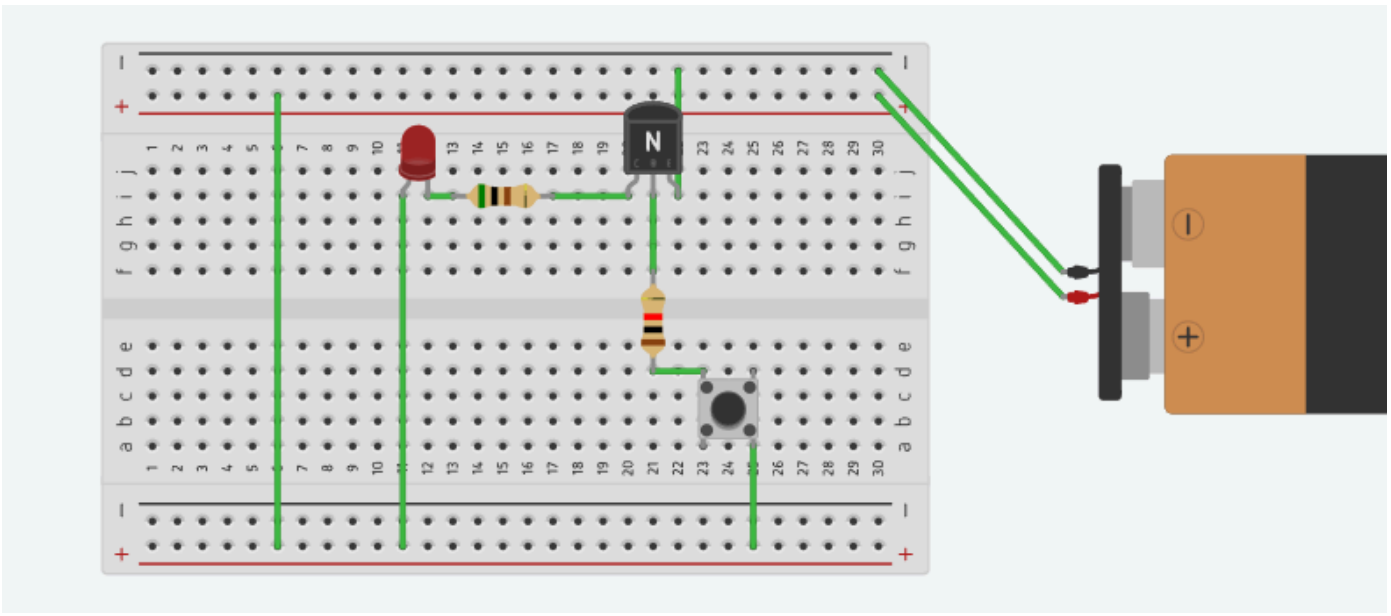
Component	Pin / Leg	Connected To
9 V Battery	+ (red wire)	Top red power rail (Positive)
9 V Battery	– (black wire)	Bottom blue ground rail
RGB LED	Common cathode pin	Bottom blue ground rail
RGB LED	Red anode pin	One end of Resistor 1
RGB LED	Green anode pin	One end of Resistor 2
RGB LED	Blue anode pin	One end of Resistor 3
Resistor 1	One end	Red LED pin (RGB LED)
Resistor 1	Other end	Middle pin (wiper) of
Resistor 2	One end	Green LED pin (RGB LED)
Resistor 2	Other end	Middle pin (wiper) of
Resistor 3	One end	Blue LED pin (RGB LED)
Resistor 3	Other end	Middle pin (wiper) of
Potentiometer 1	One outer pin	Top red power rail (Positive)
Potentiometer 1	Other outer pin	Bottom blue ground rail
Potentiometer 2	One outer pin	Top red power rail (Positive)
Potentiometer 2	Other outer pin	Bottom blue ground rail
Potentiometer 3	One outer pin	Top red power rail (Positive)
Potentiometer 3	Other outer pin	Bottom blue ground rail
Jumper Wires	—	Connect battery,
Breadboard	—	Holds and connects all

5. Using NPN Transistor as a Switch:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × LED (any color)
- 1 × PNP Transistor (i.e. BC547)
- 1 × Push Button
- 2 × Resistor (i.e. 1KΩ and 220ΩΩ)
- Jumper wires
- Breadbox
- 9V Battery/Power supply



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

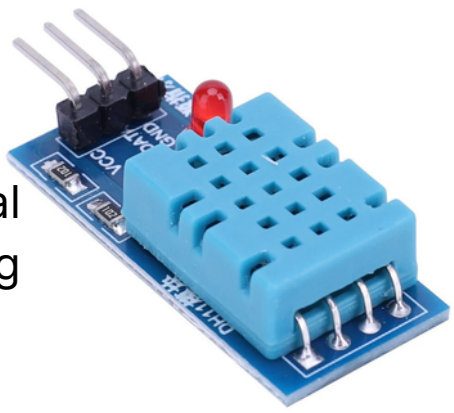
Connections:

Component	Pin / Leg	Connected To
9 V Battery	+ (red wire)	Top red power rail (Positive)
9 V Battery	– (black wire)	Bottom blue ground rail
LED	Anode (+, long leg)	Collector pin of PNP transistor
LED	Cathode (–, short leg)	One end of 220 Ω resistor
220 Ω Resistor	One end	LED cathode
220 Ω Resistor	Other end	Bottom blue ground rail
BC547 Transistor	Emitter pin	Top red power rail (Positive)
BC547 Transistor	Collector pin	LED anode
BC547 Transistor	Base pin	One end of 1 kΩ resistor
1 kΩ Resistor	One end	Base pin of BC547
1 kΩ Resistor	Other end	One leg of push button
Push Button	One leg	Other end of 1 kΩ resistor
Push Button	Other leg	Bottom blue ground rail
Jumper Wires	—	For connections between power
Breadboard	—	Holds and connects all

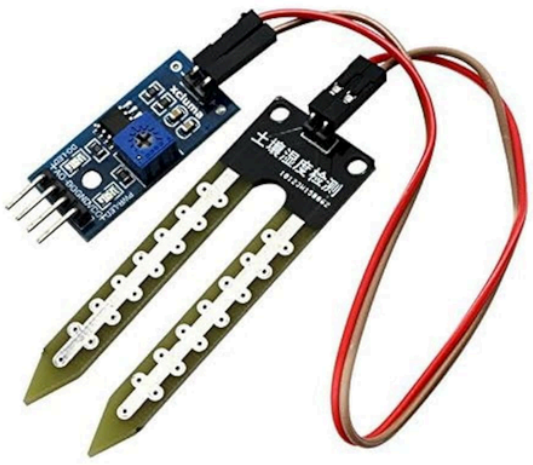
Arduino UNO – A microcontroller board used to control and connect all the sensors and components in your project. It acts as the “brain” of the system.

PIR Motion Sensor – Detects movement of people or animals by sensing changes in infrared heat. Often used in security and automatic lighting systems.

MQ Gas Sensor – Detects gases like smoke, LPG, methane, or carbon monoxide in the air.

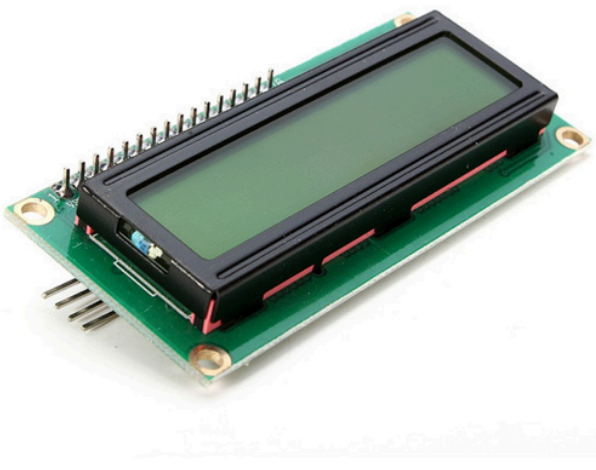


DHT11 Sensor – Measures temperature and humidity for environmental monitoring



Soil Moisture Sensor – Measures water content in soil. Used in gardening and agriculture automation**.**

Buzzer – Produces sound alerts or notifications in a project**.**



LCD Display (16x2) – Shows data such as sensor readings or messages from the Arduino.

Servo Motor (SG90) – A small motor that moves to a specific angle, used for precise positioning in robotics and mechanisms

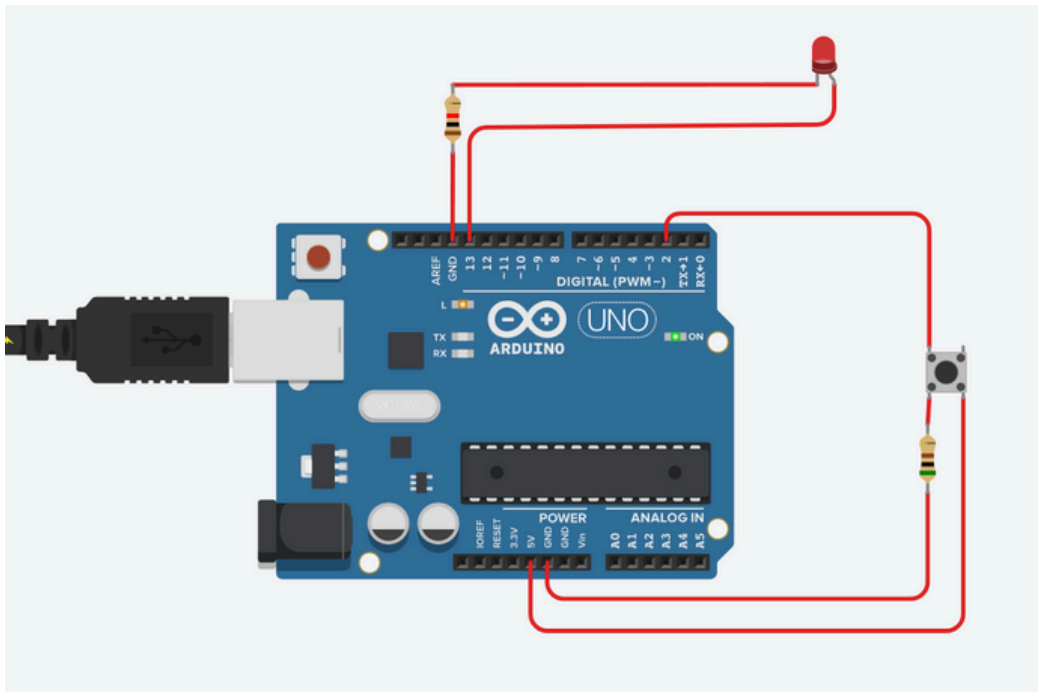
Ultrasonic Sensor (HC-SR04) – Measures distance by sending and receiving sound waves. Useful for obstacle detection and ranging**.**

6. Introduction To Arduino:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × LED
- 1 × Push Button
- 1 × Resistors (i.e. 1KΩ and 1MΩ)
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

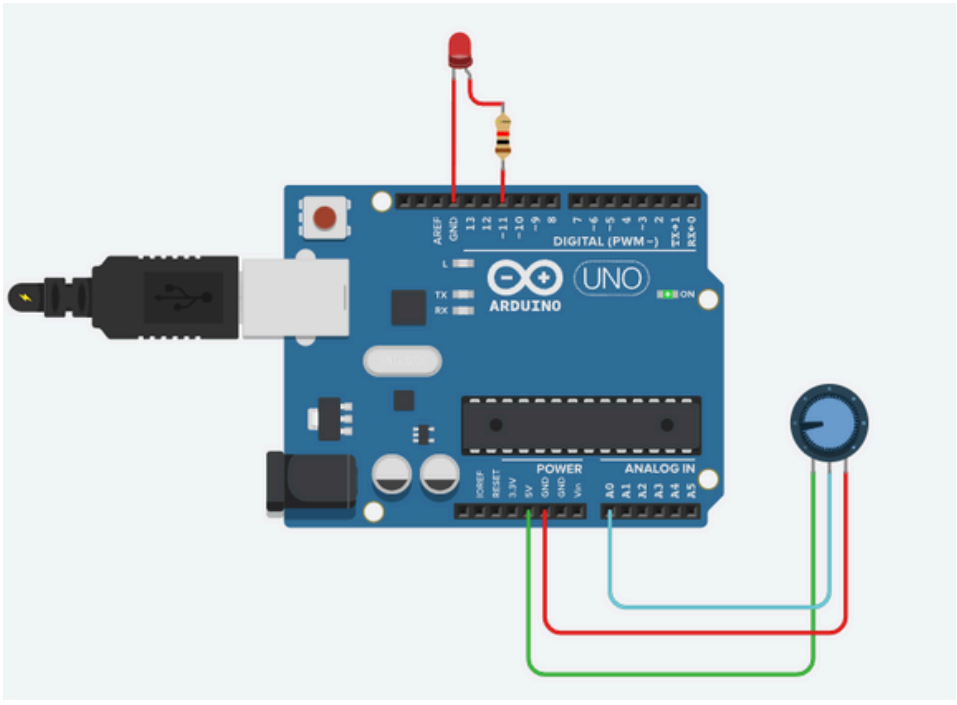
From	To	Description
Arduino Pin 13 (Digital)	LED Anode (+)	Digital output pin to control LED
LED Cathode (–)	1 kΩ Resistor	Current limiting resistor for LED
Resistor (other end)	Arduino GND	Completes LED circuit to ground
Arduino Pin 2 (Digital)	Push Button Leg 1	Input pin to read button state
Push Button Leg 2	1 MΩ Resistor	Pull-down resistor to ground
Push Button Leg 2	Arduino 5V	Provides high signal when

7. Controlling LED with Potentiometer :

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × LED
- 1 × Potentiometer
- 1 × Resistors (i.e. 1KΩ)
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

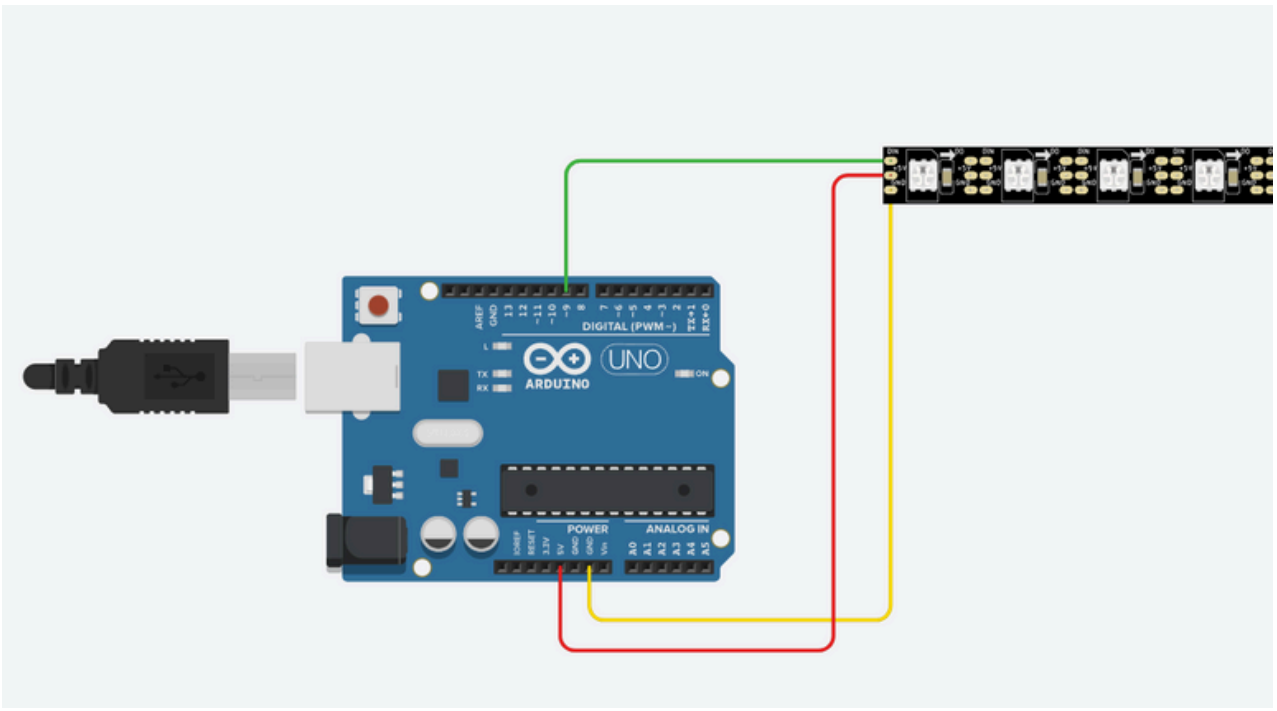
From	To	Description
Arduino Pin 9 (Digital PWM)	LED Anode (+)	Output pin to control LED
LED Cathode (–)	1 kΩ Resistor	Current limiting resistor for LED
Resistor (other end)	Arduino GND	Completes LED circuit to ground
Potentiometer VCC pin	Arduino 5V	Provides voltage reference to
Potentiometer GND pin	Arduino GND	Ground connection for
Potentiometer middle pin	Arduino A0 (Analog In)	Sends variable voltage signal to

8. Connecting Neopixel with Arduino :

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × Neopixel strips
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

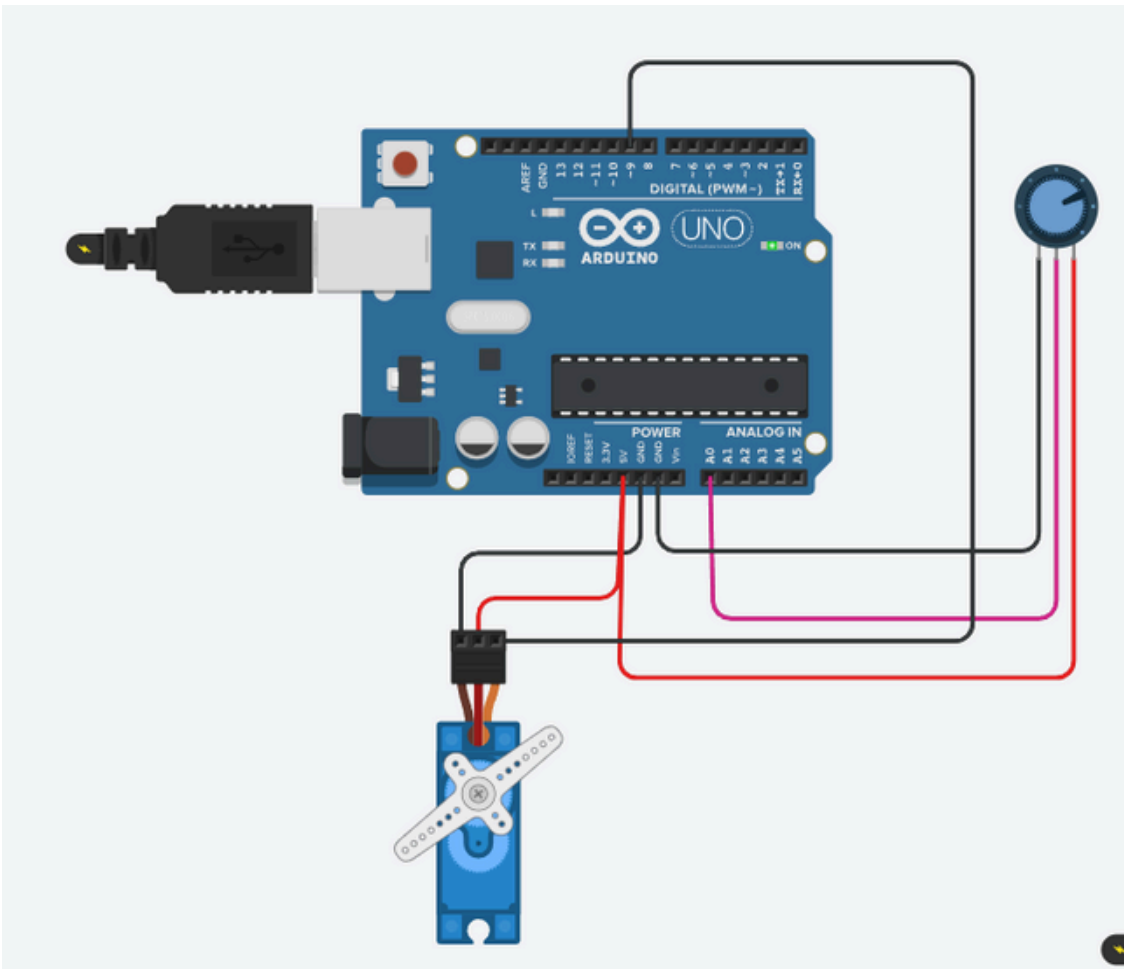
From	To	Description
Arduino Pin 6 (Digital I/O)	NeoPixel Data In (DI)	Sends control signals to the LED strip
Arduino 5V	NeoPixel +5V (VCC)	Powers the NeoPixel strip
Arduino GND	NeoPixel GND	Common ground between Arduino and NeoPixel strip

8. Controlling Microserver Motor with Potentiometer:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × Microserver Motor
- 1 × Potentiometer
- 1 × Resistors (i.e. 1KΩ)
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

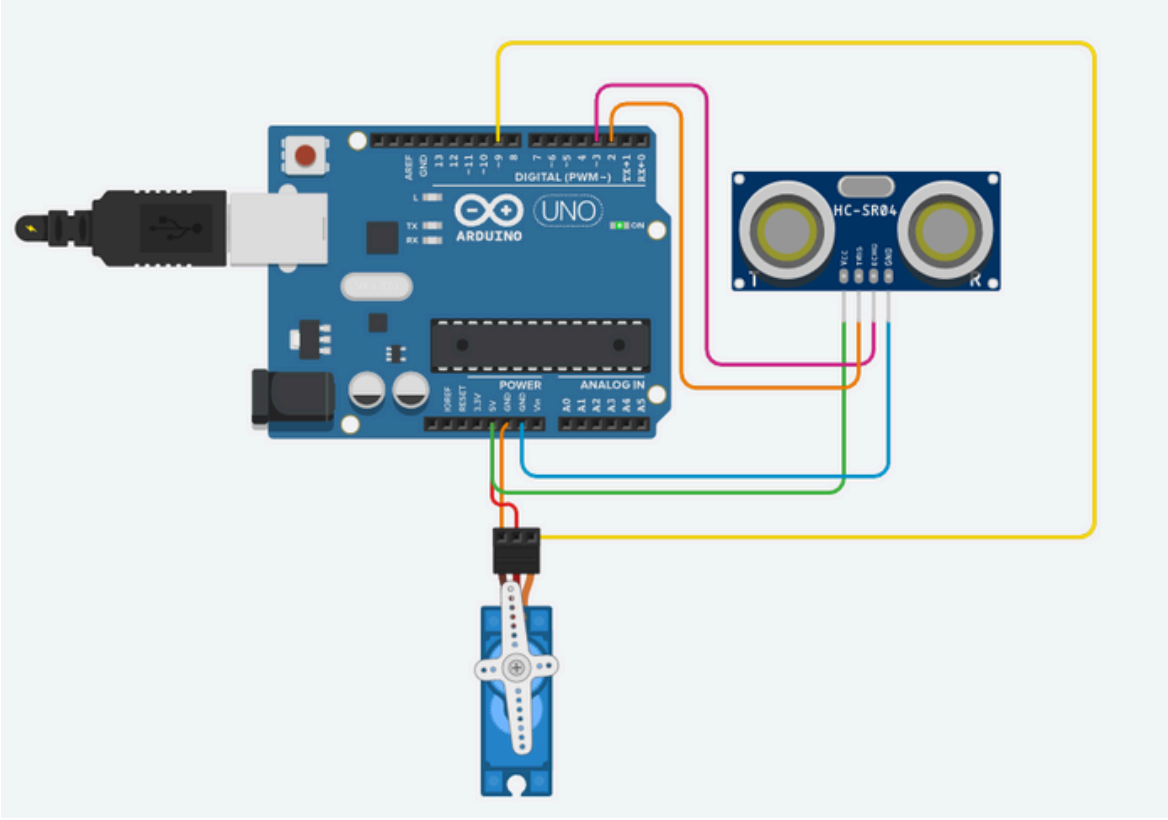
From	To	Description
Arduino 5V	Potentiometer VCC pin	Powers the potentiometer
Arduino GND	Potentiometer GND pin	Common ground
Arduino Analog Pin A0	Potentiometer middle pin	Reads the potentiometer’s
Arduino Pin 9 (PWM)	Servo motor signal pin	Sends control signals to the
Arduino 5V	Servo motor VCC pin (red)	Powers the servo motor
Arduino GND	Servo motor GND pin	Common ground for servo

9. Exploring Microserver Motor with Ultrasonic Sensor :

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × Microserver Motor
- 1 × Ultrasonic sensor
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

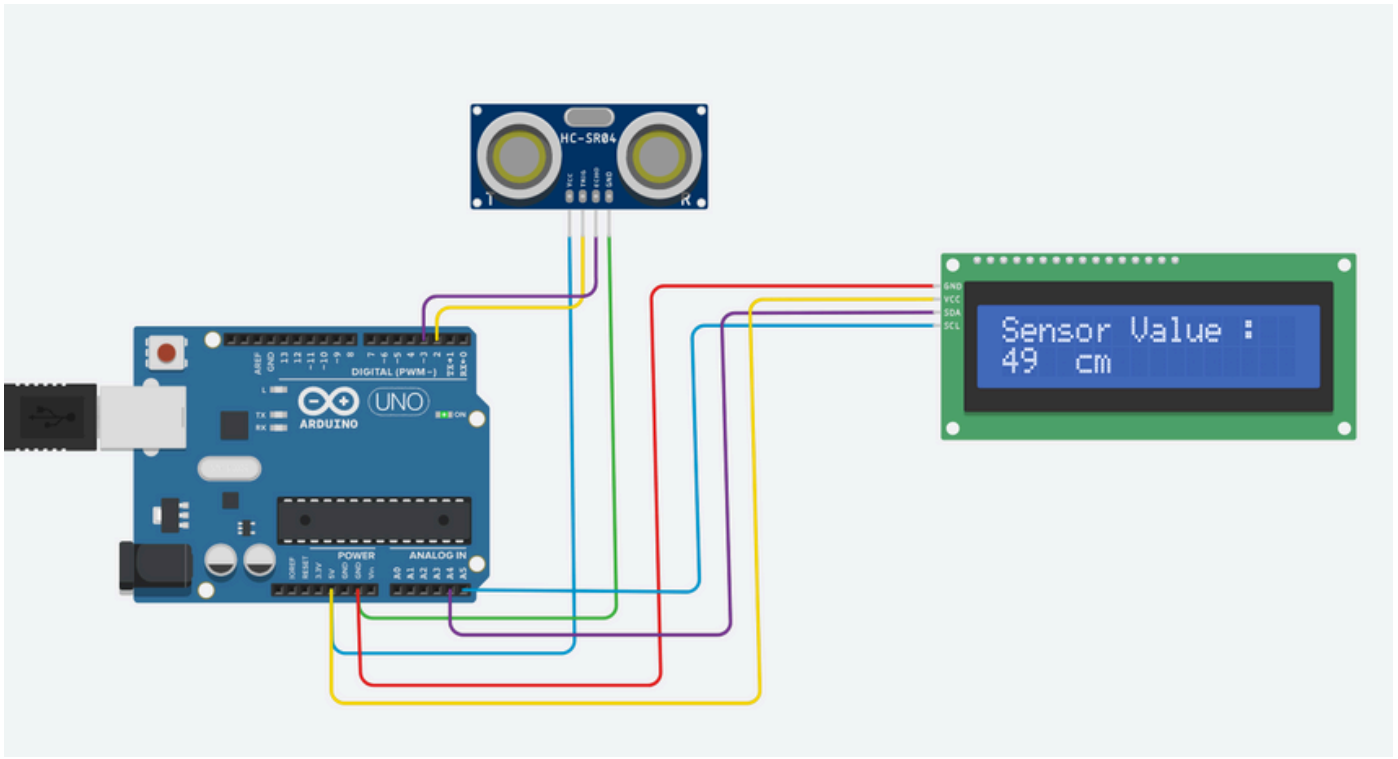
From	To	Description
Arduino 5V	Ultrasonic sensor VCC	Powers the ultrasonic sensor
Arduino GND	Ultrasonic sensor GND	Common ground
Arduino Pin 7 (Digital I/O)	Ultrasonic sensor Trig	Sends trigger signal for distance
Arduino Pin 6 (Digital I/O)	Ultrasonic sensor Echo	Receives the reflected signal
Arduino Pin 9 (PWM)	Servo motor signal pin	Sends control signals to the
Arduino 5V	Servo motor VCC pin (red)	Powers the servo motor
Arduino GND	Servo motor GND pin	Common ground for servo motor

10. Listing Ultrasonic Sensor Data Through LCD Display:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × Ultrasonic sensor
- 1 × LCD I2C Display
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

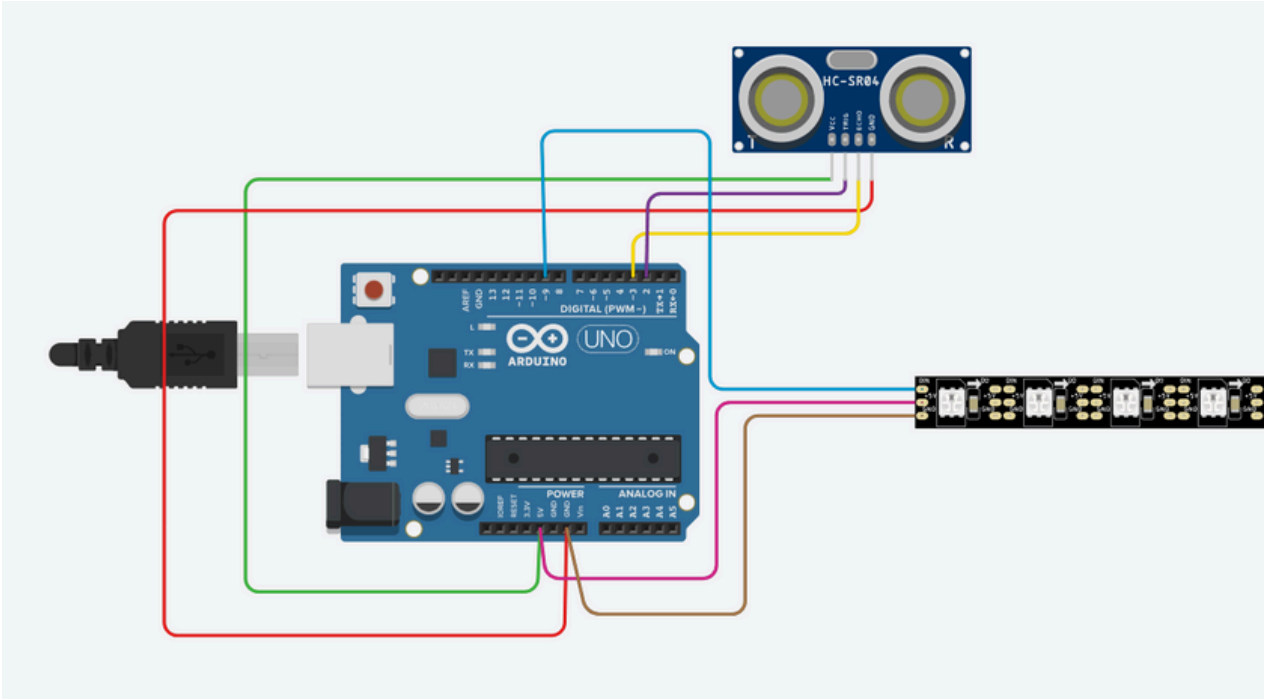
From	To	Description
Arduino 5V	Ultrasonic sensor VCC	Powers the ultrasonic sensor
Arduino GND	Ultrasonic sensor GND	Common ground
Arduino Pin 7 (Digital I/O)	Ultrasonic sensor Trig	Sends trigger signal for distance
Arduino Pin 6 (Digital I/O)	Ultrasonic sensor Echo	Receives the reflected signal
Arduino 5V	LCD I2C VCC	Powers the LCD display
Arduino GND	LCD I2C GND	Common ground for LCD and
Arduino A4 (SDA)	LCD I2C SDA	Data line for I2C communication
Arduino A5 (SCL)	LCD I2C SCL	Clock line for I2C

11. Experimenting with Neopixel light via Ultrasonic Sensor:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × Ultrasonic sensor
- 1 × Neopixel strip
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

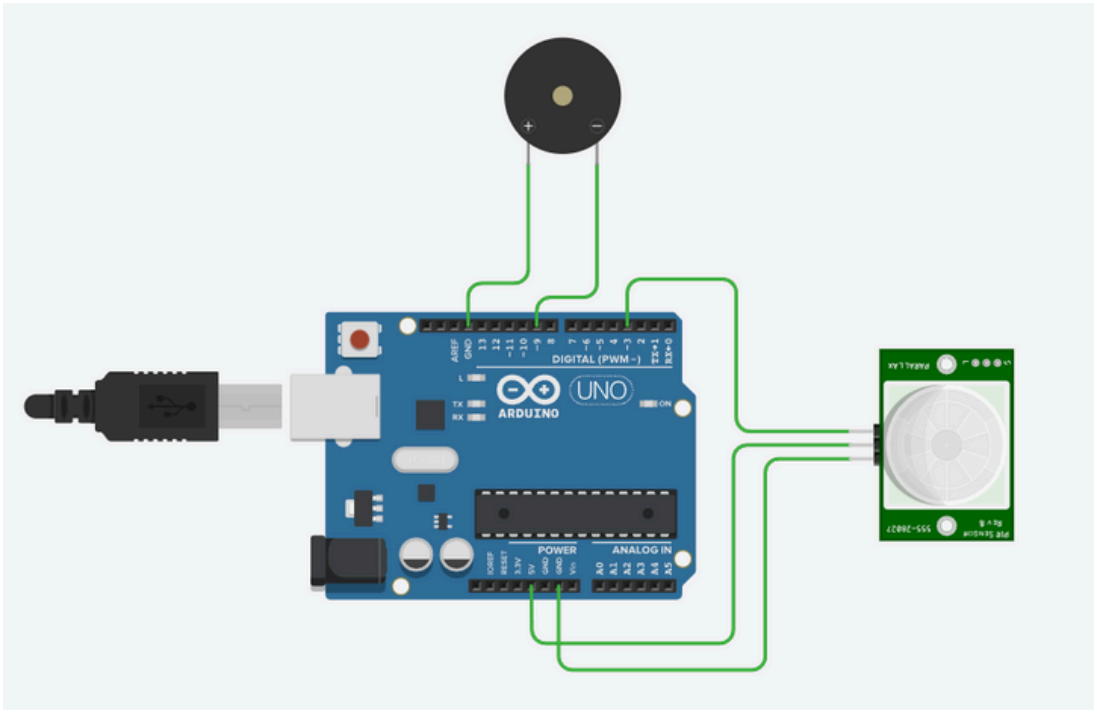
From	To	Description
Arduino 5V	Ultrasonic sensor VCC	Powers the ultrasonic sensor
Arduino GND	Ultrasonic sensor GND	Common ground
Arduino Pin 7 (Digital I/O)	Ultrasonic sensor Trig	Sends trigger signal for distance
Arduino Pin 6 (Digital I/O)	Ultrasonic sensor Echo	Receives the reflected signal
Arduino Pin 5 (Digital I/O)	NeoPixel Data In (DI)	Sends control signals to the
Arduino 5V	NeoPixel +5V (VCC)	Powers the NeoPixel strip
Arduino GND	NeoPixel GND	Common ground for NeoPixel

12. Connecting Buzzer with PIR Sensor:

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Type A USB cable
- 1 × Buzzer
- 1 × PIR Sensor
- Jumper wires



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

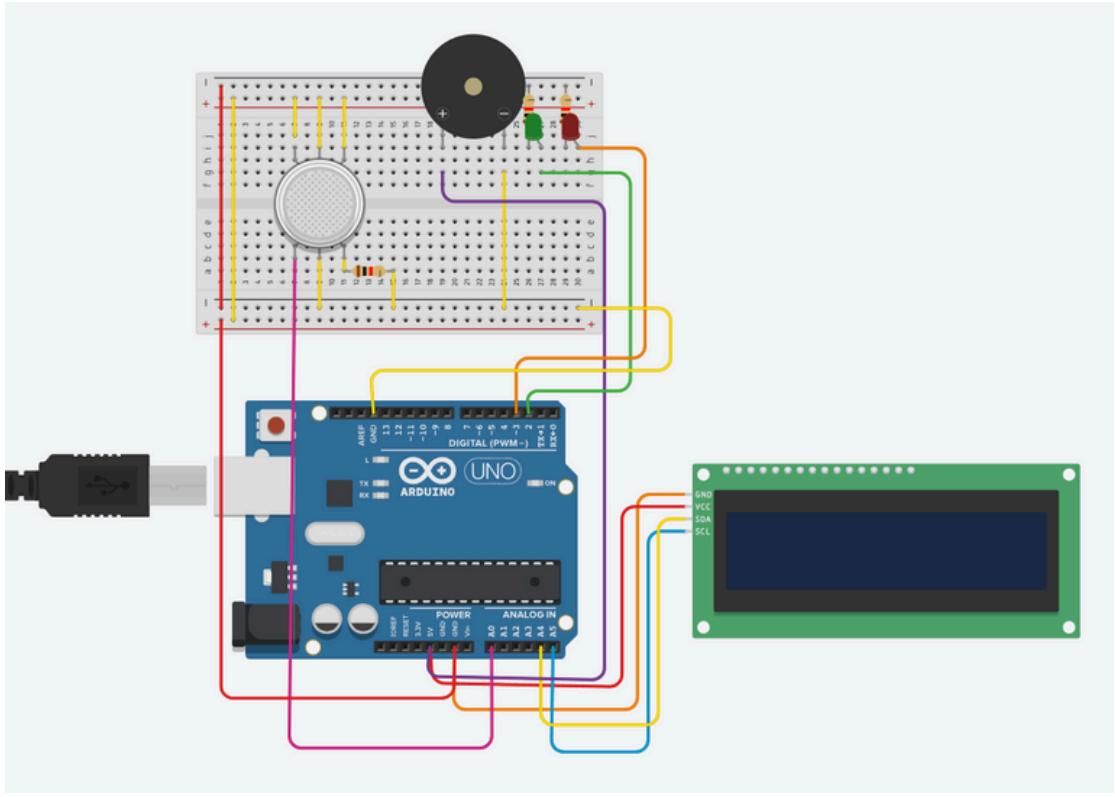
From	To	Description
Arduino 5V	PIR sensor VCC	Powers the PIR sensor
Arduino GND	PIR sensor GND	Common ground
Arduino Pin 2 (Digital I/O)	PIR sensor OUT	Receives motion detection
Arduino Pin 8 (Digital I/O)	Buzzer positive (+)	Sends control signal to buzzer
Arduino GND	Buzzer negative (–)	Common ground for buzzer and

13. Creating circuit of Gas sensor via LCD and Buzzer :

In a series connection, the same current flows through all components, but the voltage is divided among them.

Parts Required:

- 1 × Arduino UNO
- 1 × Gas Sensor
- 1 × Type A USB cable
- 1 × Buzzer
- 1 × LCD I2C Display
- 3 × Resistor (i.e. 1KΩ)
- 2 × LED (i.e. red and green)
- Jumper wires
- Breadbox



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

From	To	Description
Arduino 5V	Gas sensor VCC	Powers the gas sensor
Arduino GND	Gas sensor GND	Common ground
Arduino A0 (Analog In)	Gas sensor analog output (A0)	Reads gas level
Arduino Pin 8 (Digital I/O)	Buzzer positive (+)	Sends control signal to buzzer
Arduino GND	Buzzer negative (–)	Common ground for buzzer and
Arduino Pin 7 (Digital I/O)	Red LED anode (via resistor)	Turns on red LED
Arduino Pin 6 (Digital I/O)	Green LED anode (via resistor)	Turns on green LED
LED cathodes	Arduino GND	Common ground for LEDs
Arduino 5V	LCD I2C VCC	Powers the LCD display
Arduino GND	LCD I2C GND	Common ground for LCD and
Arduino A4 (SDA)	LCD I2C SDA	Data line for I2C communication
Arduino A5 (SCL)	LCD I2C SCL	Clock line for I2C communication

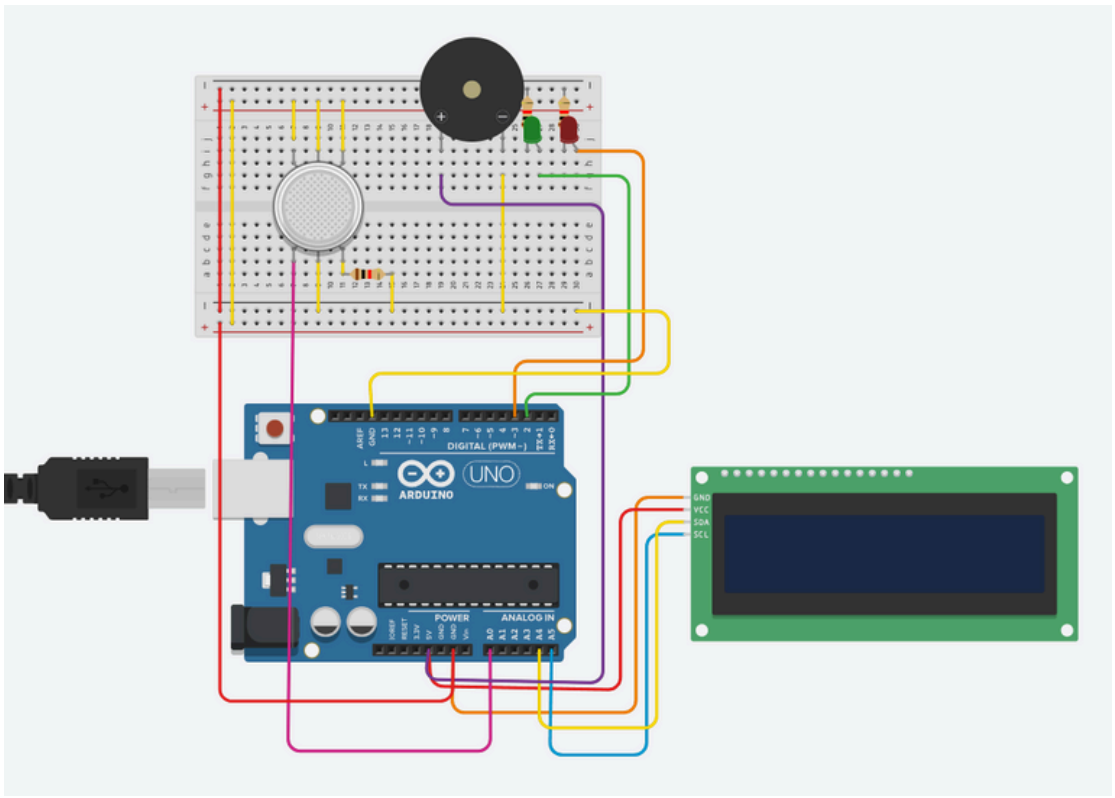
Understanding about ESP 32:

The ESP32 (38-pin) is a Wi-Fi and Bluetooth-enabled microcontroller used for IoT, automation, and sensor-based projects. Its extra pins allow more devices and sensors to be connected, making it ideal for complex, wireless applications.

ESP 32 to OLED display:

Parts Required

- 1 x ESP32 (38-pin) development board
- 1 x OLED display module (I^2C type, e.g., SSD1306)
- Breadboard
- Jumper wires
- USB cable for power and programming



Before **assembling** the circuit physically, we first prototyped it on **Tinkercad** to ideate, experiment, and document each step of the process.

Connections:

Component	Pin	Connected To
ESP32 to Temperature & Humidity Sensor	VCC	3.3 V
	GND	GND
	Data	GPIO 4
ESP32 to OLED Display	VCC	3.3 V
	GND	GND
	SDA	GPIO 21
	SCL	GPIO 22