The Electrostatic Force – Triboelectric Study

Part 1 – Building the Sensor Circuit

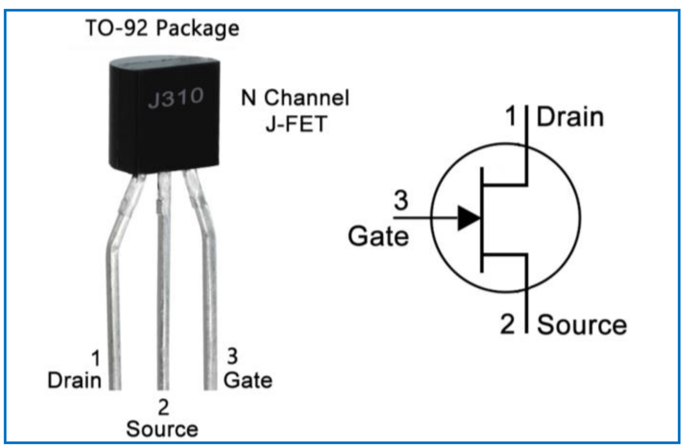
Our main goal is to develop a high-precision sensor capable of accurately measuring electrostatic force. We aim to analyze how different materials affect the creation of this force, to determine which one generates a larger or smaller electrostatic pulse. As a part of our research, we intend to carry out thorough experiments and conduct in-depth analyses of the outcomes to gain a better understanding of and optimize this process.

To conduct our experiment, we will require the following components:

- Arduino microcontroller
- Breadboard
- Connecting wires
- LED
- 200 Ohm resistor
- Piezo speaker
- J310 transistor
- Computer with Arduino IDE installed
- Several different materials from the triboelectric table

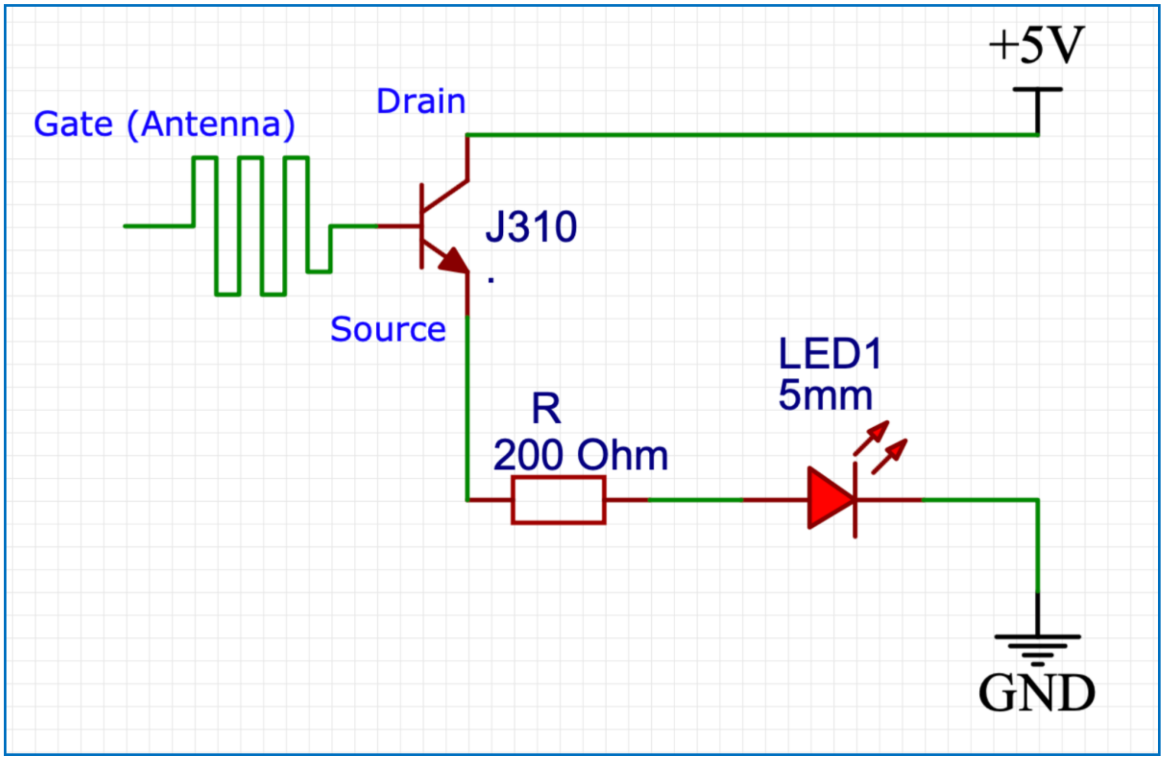
The J310 transistor plays a crucial role in determining the electrostatic force. It's essential to pay attention to the configuration of the transistor's pins, which are as follows:

Transistor Pinout

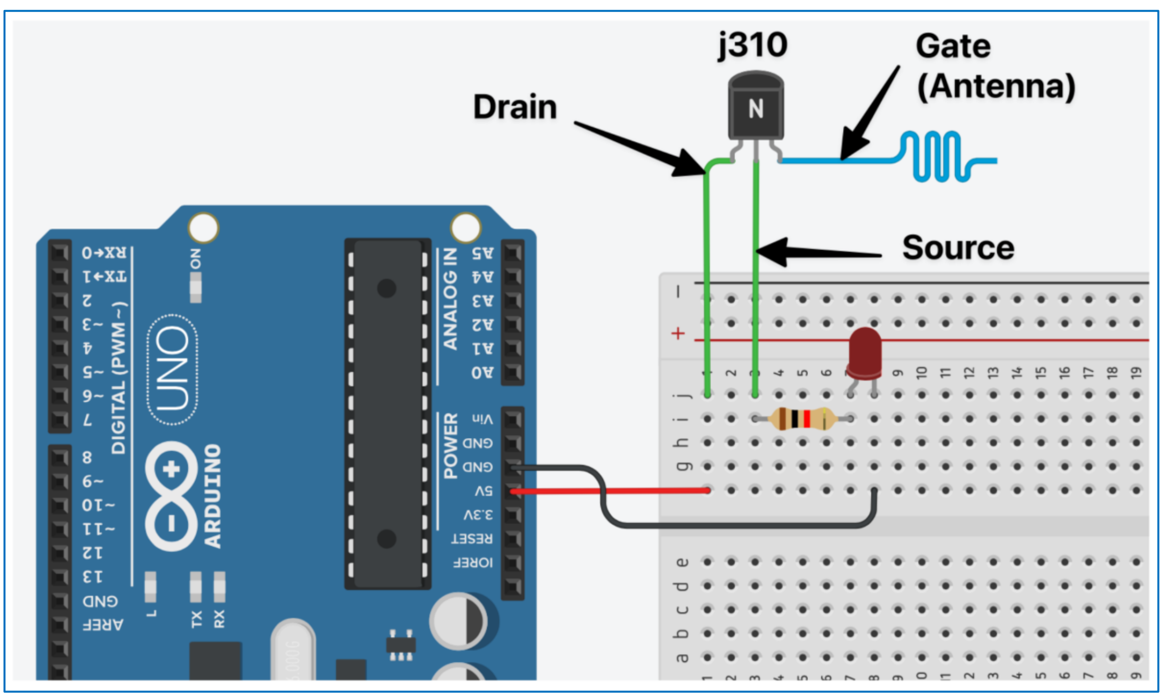


The Gate pin is responsible for sensing the state of the electrostatic force. It's important to be extra careful when connecting this pin to ensure accurate measurements.

Wiring Diagram



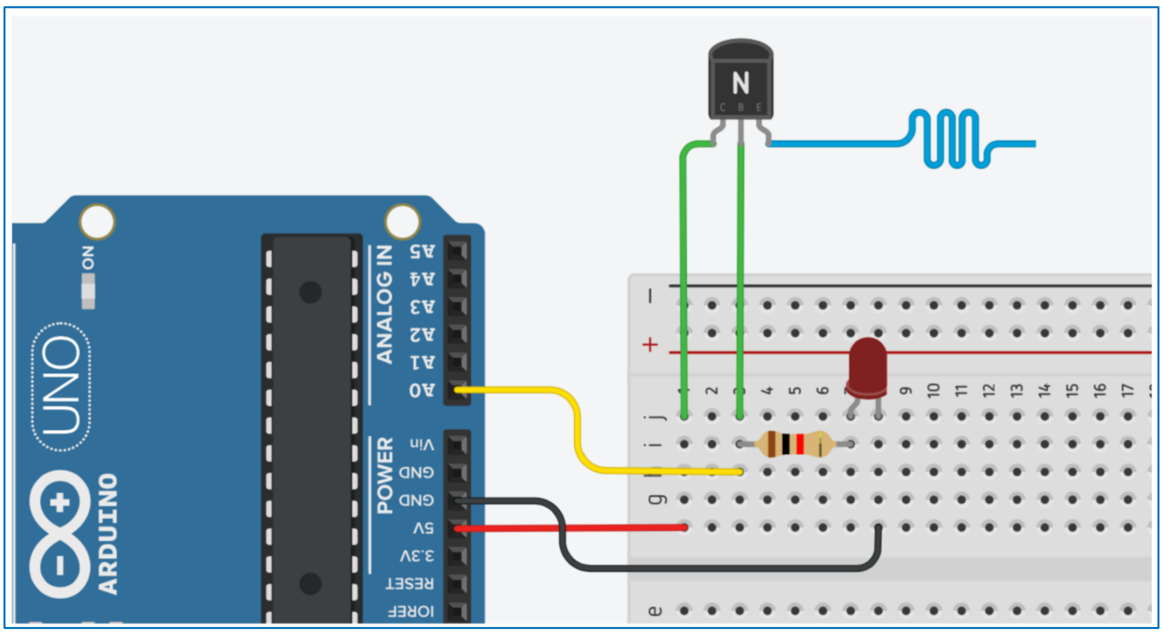
Arduino/Breadboard Diagram



When you connect this circuit, you'll notice that the LED is illuminated, which is normal. Now, hold a comb near the sensor. You'll observe that the LED continues to glow, and nothing changes. However, when you brush your hair with the comb and then bring the comb near the sensor again, the LED turns off. This happens because the transistor detects the presence of static electricity. If you remove the comb after the static charge dissipates, the LED will light up once more. You can repeat this experiment to further observe this effect.

We can utilize the Arduino to read data from our sensor. To accomplish this, we will establish a connection between the source pin and analog pin A0 using an extra connector.

Arduino/Breadboard Diagram



Let's start Arduino IDE and write a program to read the values from our sensor. There is a ready-made example that we will use for this. You can find it by going to File - Examples - Basics - AnalogReadSerial.

In the code, change the value of **delay(1);** to **delay(100);** to slow the rate at which the data displays. The code should look as shown.

Arduino Code

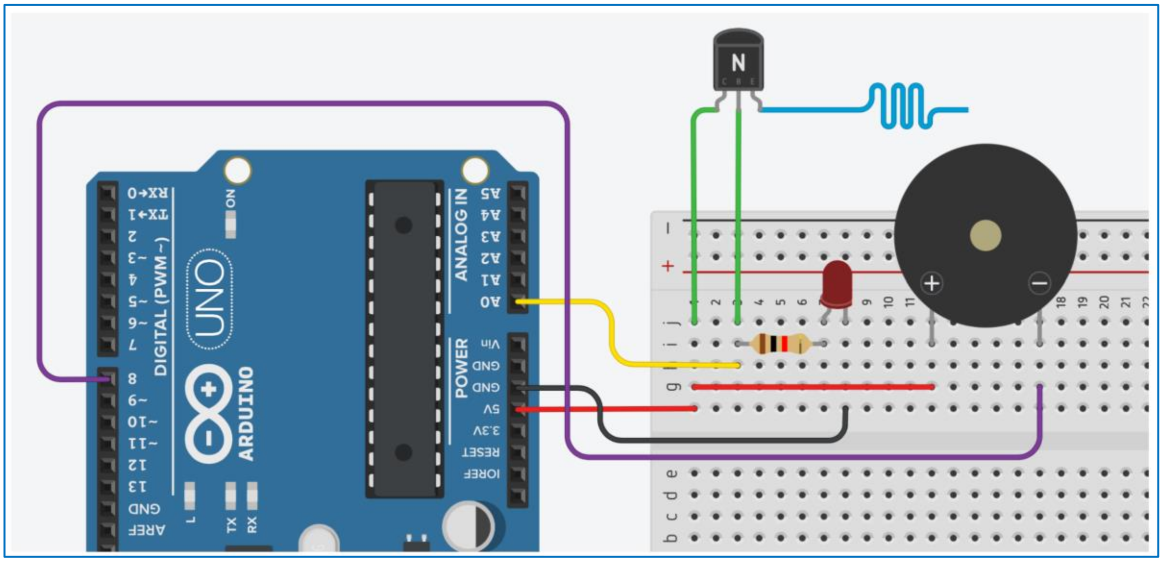
```
void setup() {
  Serial.begin(9600);
}

void loop() {
  int sensorValue = analogRead(A0);
  Serial.println(sensorValue);
  delay(100);
}
```

Load the program into the microcontroller and click on the button in the upper right corner, called Serial Monitor.

A serial monitor will be displayed in front of you showing the sensor readings. Under normal conditions, expect values around 900.

Let's enhance our circuit by incorporating a speaker to audibly represent the electrostatic field. Locate the positive (+) and negative (-) terminals on the piezo speaker. Connect the positive terminal to 5 volts and the negative terminal to pin 8 of the Arduino.

Arduino/Breadboard Diagram



Now let’s modify the code slightly to activate the speaker.

```
int speaker = 8;
void setup() {
  Serial.begin(9600);
  pinMode(speaker, OUTPUT);
}

void loop() {
  int sensorValue = analogRead(A0);
  Serial.println(sensorValue);
  delay(100);
 if(sensorValue <= 500){
   digitalWrite(speaker, LOW);
 }
 else
  digitalWrite(speaker, HIGH);
}
```

Sensor reading

500 represents the value of the sensor that will trigger the activation of the speaker. You can experiment and change these values either up or down, changing the sensitivity of the trigger.

Troubleshooting

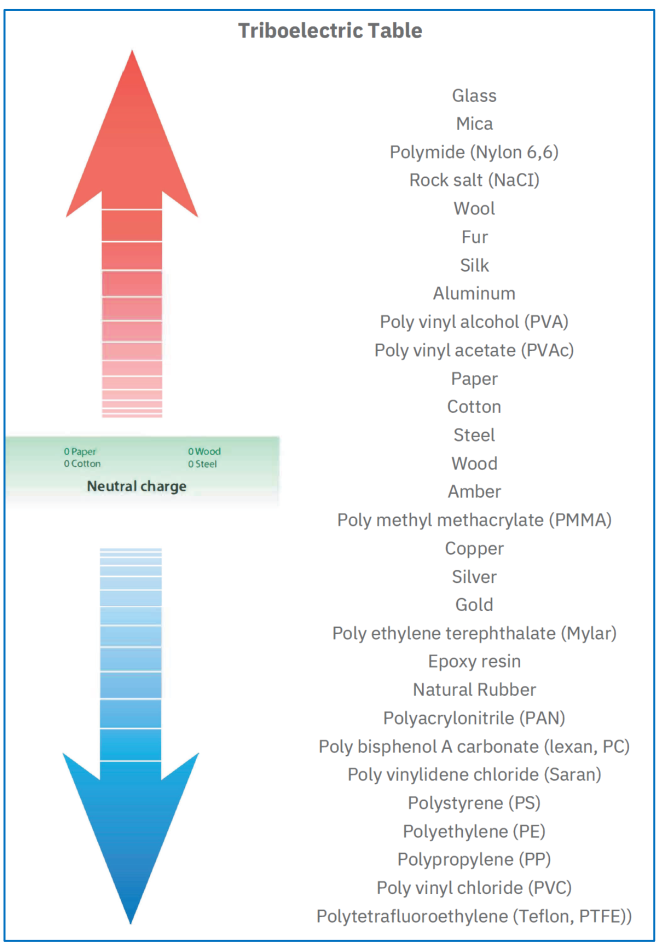
Here are some potential issues you might encounter with the circuit:

- Incorrect LED installation: Ensure that the LED is installed correctly.
- LED not lighting up initially: If the LED doesn't light up when the circuit is first turned on, you can troubleshoot by gently touching the antenna of the J310 transistor. This can help activate the circuit and make the LED glow.

Part 2 – Investigating the Electrostatic Force

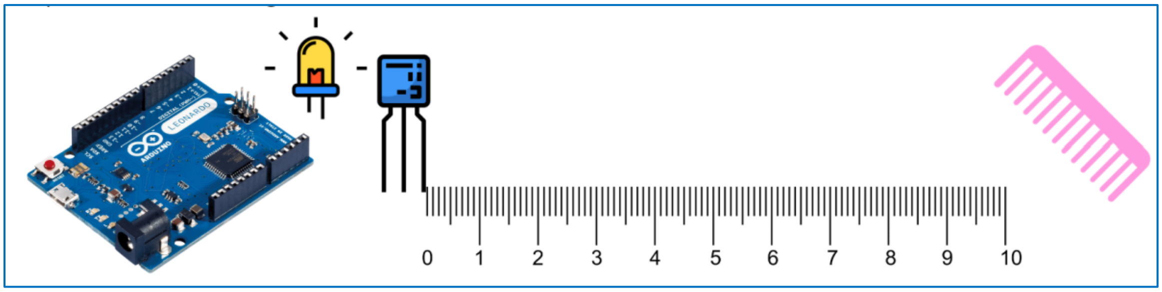
Triboelectric series tables illustrate how charges are generated on various materials. When two materials come into contact and then separate, the one positioned higher on the series acquires a positive charge, while the other gains a negative charge due to friction.

Materials that are further apart in the table generally exhibit a greater potential difference than those positioned closer together. However, it's important to note that these tables should be used as references, as achieving equal potential with some materials can be challenging. A typical triboelectric series is displayed below.



The activity involves analyzing various materials using the sensor. To conduct this experiment, we need to position the sensor on the table and place a ruler near the sensor. Use tape to secure the ruler and sensor to the table. Make sure the sensor is positioned at the 0 marking on the ruler.

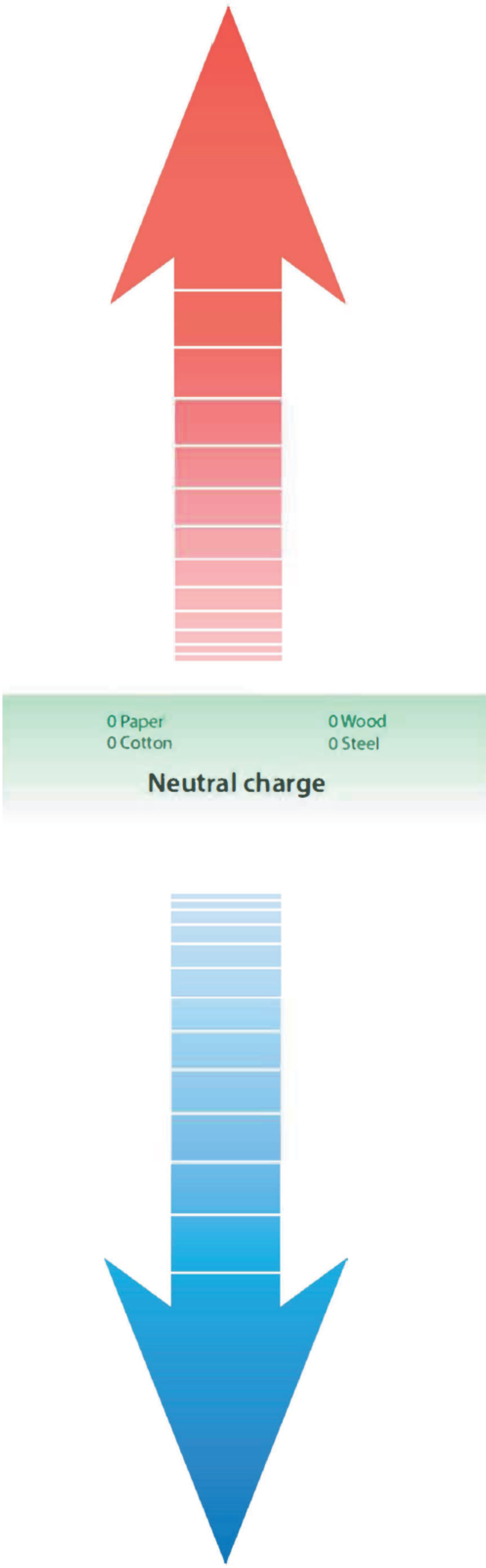
Ruler/Sensor Setup



Now we will proceed with testing a variety of different material combinations. Follow the given process:

1. Select the material (Material 1) that you are going to rub. Verify that there is zero charge on the material by bringing it towards the sensor.
2. Select another material (Material 2) with opposite polarity and rub against Material 1.
3. Place Material 1 at a designated starting position and verify if the sensor was triggered. Record the position on the table as Starting Distance.
4. Since charge may dissipate quickly, rub Material 2 against Material 1 again to recharged it.
5. If the sensor was triggered at the starting position, place Material 1 at a distance further than the starting position. Otherwise, place it at a distance closer to the sensor.
6. Repeat step 5 until the maximum distance that triggers the sensor is located. Record this value on the table as Final Distance.
7. Perform steps 1 through 6 for different materials and combinations.
8. Once enough material combinations have be tested, organize the materials based on the ease at which they accept or donate charges. Compare your table with the Triboelectric Table.

Triboelectric Table



Glass
Mica
Polymide (Nylon 6,6)
Rock salt (NaCI)
Wool
Fur
Silk
Aluminum
Poly vinyl alcohol (PVA)
Poly vinyl acetate (PVAc)
Paper
Cotton
Steel
Wood
Amber
Poly methyl methacrylate (PMMA)
Copper
Silver
Gold
Poly ethylene terephthalate (Mylar)
Epoxy resin
Natural Rubber
Polyacrylonitrile (PAN)
Poly bisphenol A carbonate (lexan, PC)
Poly vinylidene chloride (Saran)
Polystyrene (PS)
Polyethylene (PE)
Polypropylene (PP)
Poly vinyl chloride (PVC)
Polytetrafluoroethylene (Teflon, PTFE))

Material 1	Material 2	Starting Distance (cm)	Final Distance (cm)