

- Instructor Copy -

Series Circuit Experiment Worksheet

Objective: Explore how series circuits function and understand the relationship between voltage, current, and resistance in a series circuit.

Materials Needed:

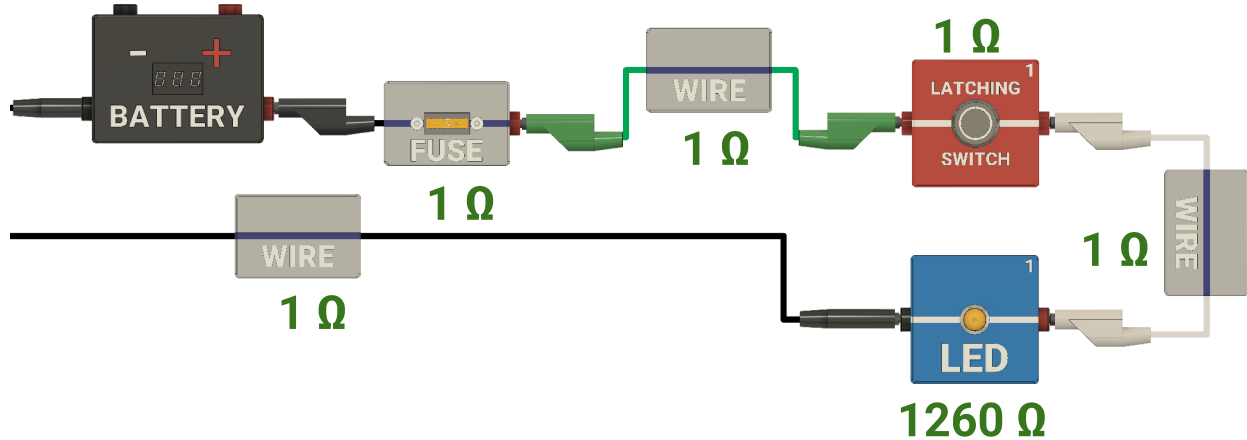
- Series Circuit Magnetic Trainer
- A multimeter (Recommend a Fluke 87)
- Power Supply: Instructors can utilize the one provided in the kit, or use a bench-top power supply. Ensure that the calculations match the voltage being supplied by your power supply.

Safety Precautions:

- Instructors: ensure your students are following all appropriate safety regulations based on your location.
- Recommend students double-check the circuit connections before powering it on. Ensure no short to ground connections.
- Never handle electrical components with wet hands.
- Ensure the power supply voltage is approximately 12VDC to avoid damaging the components or the multimeter.

Background

In a series circuit, components are connected one after the other, so the same current flows through each component. The total voltage across the circuit is the sum of the voltages across each component. The resistance adds up, too – the total resistance in a series circuit is the sum of each resistor's resistance.



Total Circuit Resistance = 1265 Ω

Figure 1: Total Circuit Resistance in a Series Circuit

Ohm's Law and LED Behavior in Circuits

The FUSE, WIRE, and LATCHING SWITCH in our circuit each have a measurable resistance. These components follow ohmic behavior, meaning their resistance stays the same even when the voltage applied to them changes. According to Ohm's Law, the current, measured in amperes (A), that flows through a component is directly related to the voltage (V) across it, and inversely related to its resistance (R). We write this important relationship as

$$A = V/R$$

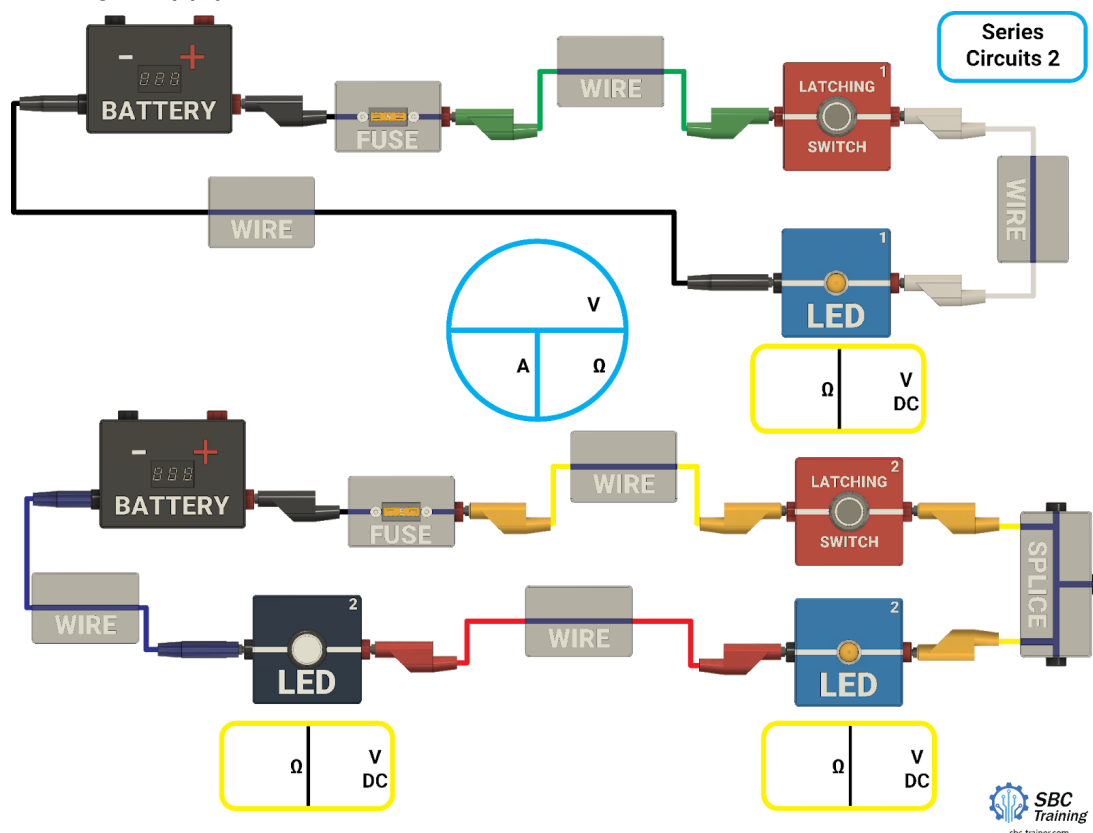
Non-Ohmic LEDs:

The LED in our circuit does not follow the same rules as the FUSE, WIRE, and SWITCH. The key difference is in how the resistance of an LED changes. Unlike the consistent resistance found in ohmic components, an LED's resistance varies with the voltage applied to it. This is closely related to a concept known as the forward voltage (Vf) of an

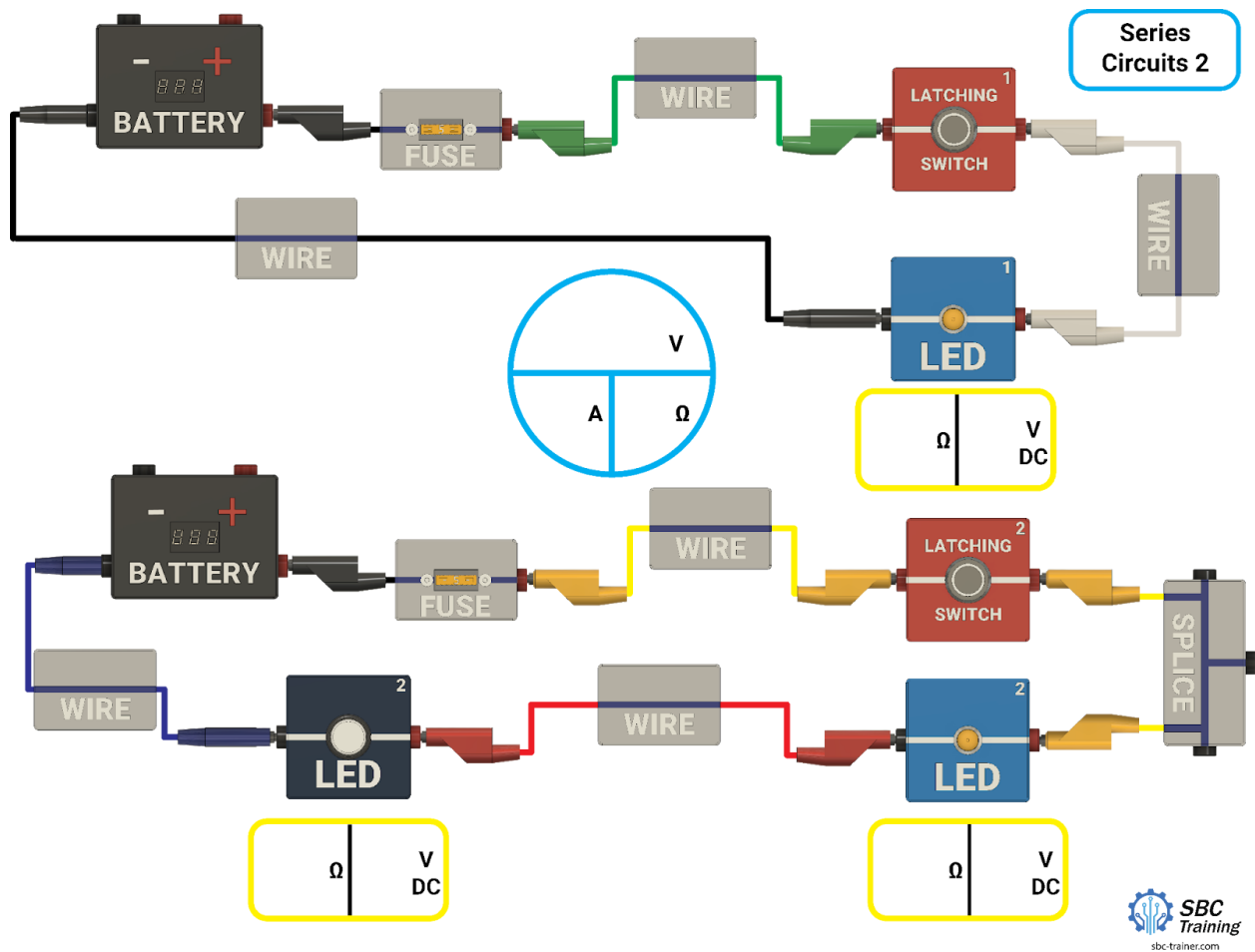
LED, which is essentially the minimum voltage needed to illuminate the LED. When the applied voltage is under this threshold, the LED behaves as if it has very high resistance, letting through barely any current – a fact that might be misleading when measured with a multimeter, which typically applies around 3 volts for such measurements.

In our experiments, where the circuit's voltage is around 12 VDC, the behavior of the LED shifts significantly once the applied voltage surpasses its V_f . Beyond this point, the LED allows current to pass through much more freely, and we observe a sharp increase in current with only slight increases in voltage. This illustrates how LEDs require a specific voltage to operate effectively, after which their response to voltage changes is much more sensitive than that of ohmic components.

In our circuit, we've determined specific resistance values for the LEDs based on our measurements. For light blue small LEDs 1 and 2, we calculated a resistance of 1260 ohms (Ω) each. For the dark blue large LED 2, the calculated resistance is 2800 ohms (Ω). These calculations were made by measuring the current flowing through the circuit with a voltage supply of 12V



Series Circuits LAB

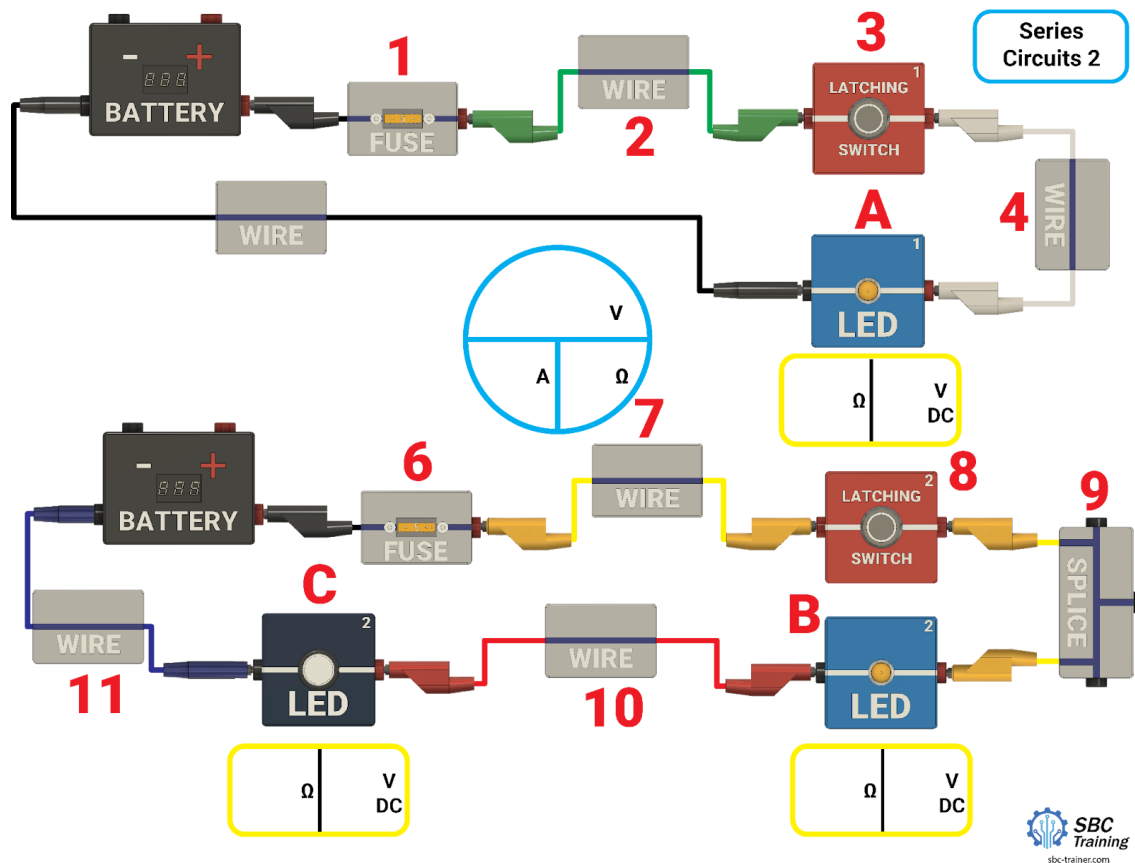


Setup

Complete the following steps to set up for testing:

1. Place all of the electrical nodes on the Series Circuits Sheet
2. Do not connect the Power Supply to the circuit until instructed to do so.

Testing



Resistance Measurements

1. Set the multimeter to measure Resistance
2. Ensure that the Power Supply is turned "off". When measuring resistance of a component or circuit with a multimeter, the circuit must be unpowered.
3. Place the multimeter probes on the terminals of each node.
4. Record the resistance measured for each node, 1-11.
5. Add up all the resistances in the circuit to determine the total resistances.

The numbers on the nodes may vary by around 1 ohm

TOP CIRCUIT			BOTTOM CIRCUIT	
Node 1	0.3Ω		Node 6	0.3Ω
Node 2	0.8Ω		Node 7	0.8Ω
Node 3	0.8Ω		Node 8	0.8Ω
Node 4	0.8Ω		Node 9	1.2Ω
LED A	1260 Ω		LED B	1260 Ω
Node 5	0.8Ω		Node 10	0.8Ω
TOTAL RESISTANCE	1263.5 Ω		LED C	2800 Ω
			Node 11	0.8Ω
			TOTAL RESISTANCE	4064.7 Ω

Current Measurements

1. Set the multimeter to measure DC Amperage
2. Connect the POWER SUPPLY to each battery using the red and black POWER SUPPLY WIRES
 - Connect the POWER SUPPLY WIRES to the jacks of the POWER SUPPLY as shown in Figure 6
 - Attach one set of wires to the positive (red) and negative (black) terminals at the top of BATTERY A, and connect another set to the positive (red) and negative (black) terminals at the top of the BATTERY B. See figure 7

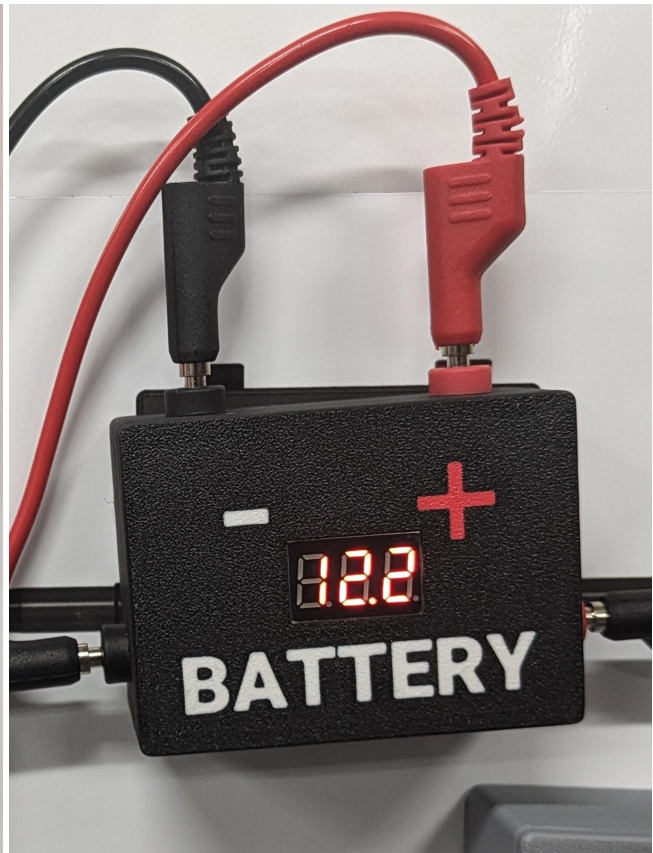


Figure 6: POWER SUPPLY Connection Figure 7: BATTERY Connection

3. Turn on the POWER SUPPLY by pushing up on the switch located at the top left side of the POWER SUPPLY
4. Ensure that the circuit is on by verifying that the LED is illuminated in both the TOP circuit and the bottom circuit

5. Unplug the green wire going into the fuse of the top circuit
6. Unplug the yellow wire going into the fuse of the bottom circuit
7. Review Figure 8 below before proceeding

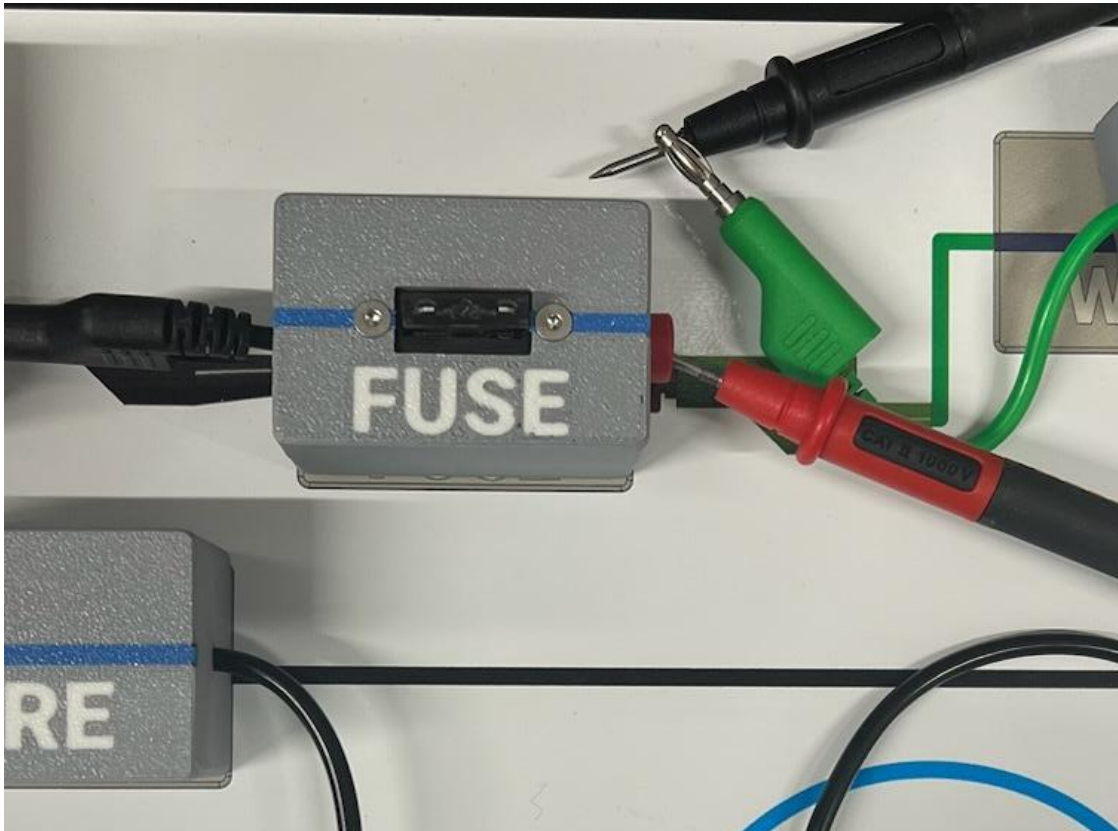


Figure 8: Measuring Current in a circuit

8. Place the red meter lead in the red jack of the top circuit fuse
9. Place the black meter lead on the banana plug of the green wire that you disconnected
10. Record the amperage measured for top circuit.
11. Repeat the amperage measurement for the bottom circuit

This value will vary depending on the actual voltage on your power supply and the accuracy of your meter. The important thing for them to learn is that more resistance = less current

Top Circuit Amperage: 9.6 mA
Bottom Circuit Amperage: 2.95 mA

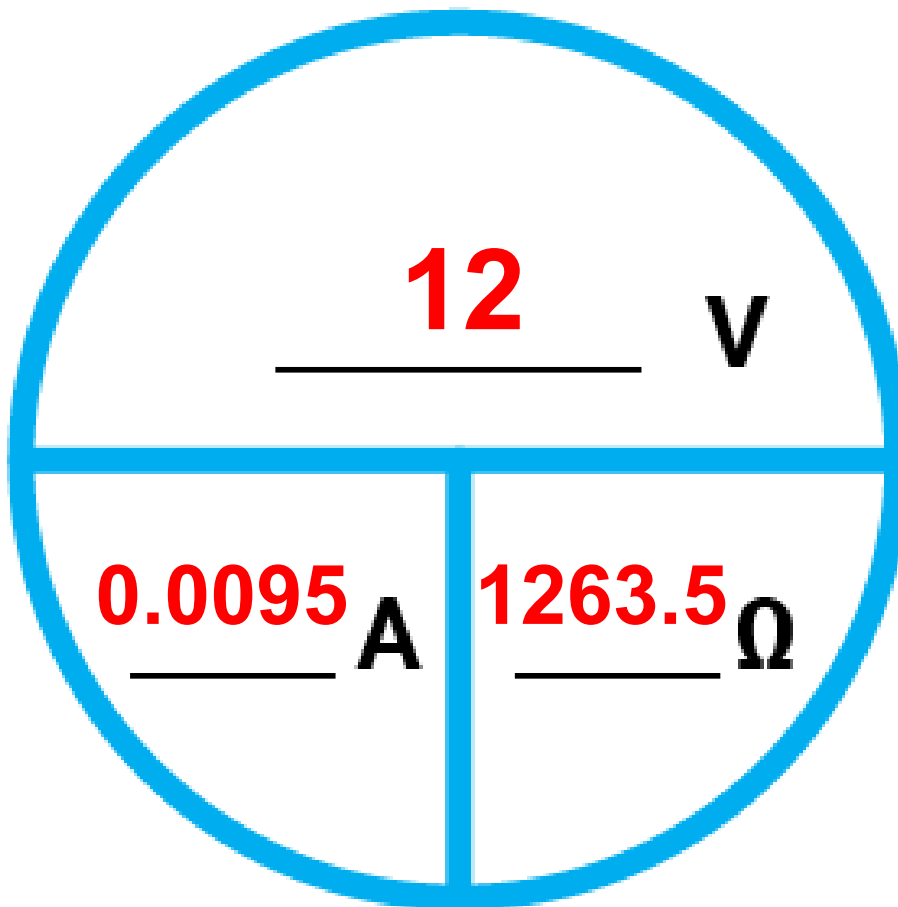
Calculations

1. Refer to the Ohm's Law Circle below to calculate the TOTAL RESISTANCE in the top circuit. Use the voltage measurement from the BATTERY and the current measurement from the circuit for your calculation.

Note on Discrepancies:

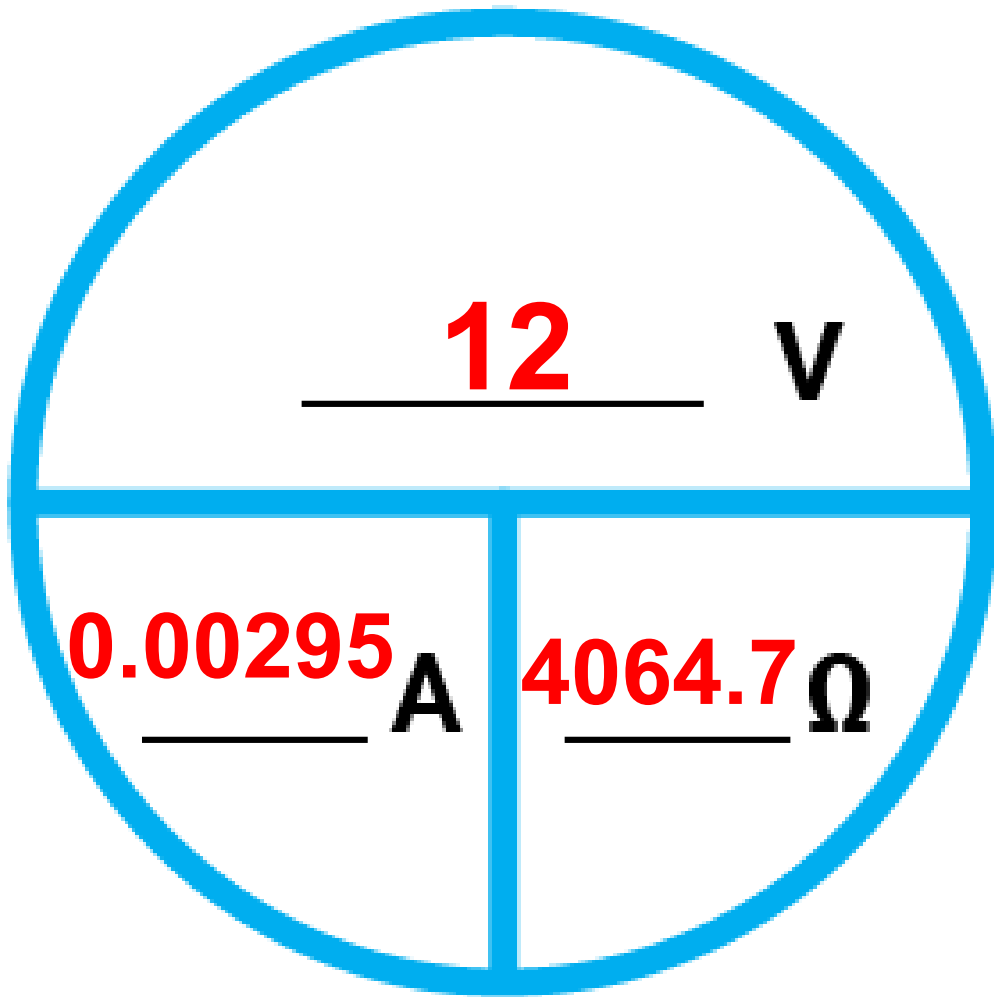
You might notice that the calculated total resistance doesn't exactly match the measured resistance. This discrepancy can occur due to the heat generated when current flows through wires and components. Heat tends to increase the resistance of these components, which in turn can reduce the current flow.

However, components like LEDs typically generate less heat when activated, leading to a less pronounced change in resistance compared to other electrical elements. Therefore, the impact of heat on the resistance of LEDs may not be as significant, affecting the current to a lesser extent.



Total Resistance Calculation Top Circuit

2. Using the Ohm's Law Circle below calculate the TOTAL RESISTANCE in the bottom circuit using the voltage measurement from the BATTERY and the current measurement



Total Resistance Calculation Bottom Circuit

3. Which circuit has the highest current?
 - a. Top circuit **Correct**
 - b. Bottom circuit
4. Which circuit has the highest total resistance?
 - a. Top circuit
 - b. Bottom circuit **Correct**
5. If the voltage in the circuit is the same what can be said about the relationship between the total resistance in a circuit and current? **(SELECT ALL THAT APPLY)**
 - a. As the total resistance in the circuit increases the current decreases **Correct**
 - b. As the total resistance in the circuit decreases the current decreases **Incorrect**
 - c. As the total resistance in the circuit increases the current increases **Incorrect**
 - d. As the total resistance in the circuit decreases the current increases **Correct**
 - e. There is not a relationship between the total resistance and current in the circuit **Incorrect**