Phys 132L
Fall 2018

Laboratory 6: Series and Parallel Circuits – Prelab

1 Resistors in Series

Consider the circuit with two resistors in series as illustrated in Fig. 1. Determine the current that flows through the battery.

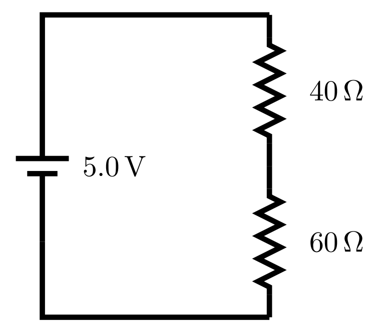

Figure 1: Resistors in series.

2 Resistors in series

Consider the circuit with two resistors in series as illustrated in Fig. 2 (the same as that of Fig. 1 but with the order of the resistors reversed). Will the current through the circuit be the same as, larger than or smaller than that of the circuit of Fig. 1? Explain your answer.

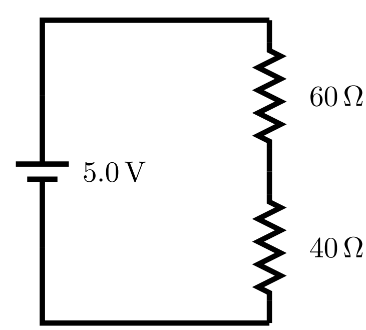

Figure 2: Resistors in series.

Laboratory 6: Series and Parallel Circuits – Activity

This laboratory investigates bulbs and resistors connected in series and parallel; these arrangements are common in many electrical devices.

1 Series Resistors

One method of connecting more than one device to a single battery or power supply is to arrange for the current to flow through the devices in succession. This is a "series" circuit; an example is illustrated in Fig. 3.

a) Consider the circuit with two resistors in series as illustrated in Fig. 3. Here R_1 has a larger resistance than R_2. Predict how the current through R_1 will compare (same, larger, smaller, ...) to that through R_2. Explain your answer.

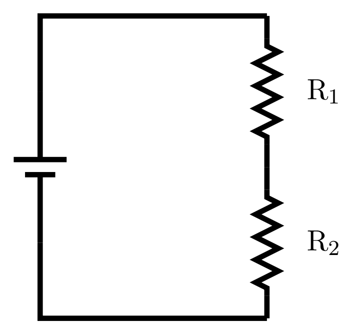

Figure 3: Resistors in series.

Predict how the voltage across R_1 will compare (same, larger, smaller, ...) to that across R_2. Explain your answer.

Predict how the voltage across R_1 will compare (same, larger, smaller, ...) to that across the power supply. Explain your answer.

b) You will be given two resistors. The instructor will show you how to use the resistance setting ("Ω") of the digital multimeter to measure resistance. Measure and record the resistance of each (approximate resistances are encoded in the color bands on the resistors) resistor.

c) Connect the circuit of Fig. 3. Measure and record the current that passes through each resistor. Does your measurement agree with your prediction of part 1 a)?

Measure and record the voltage across the power supply and the voltage across each resistor. Do the measurements agree with your predictions?

In a series circuit of this type, the current and the potential difference across the power supply are related by

$$\Delta V = IR_{\text{eff}}$$

where the effective resistance is

$$R_{\text{eff}} = R_1 + R_2.$$

d) Calculate the effective resistance for your circuit.

Use the measured potential difference across the power supply to calculate the current flowing through the resistors. Does the calculated value agree with your measured value?

Note that Ohm's law applies to each resistor individually. Use the calculated current to determine the voltage across each resistor. Do these values agree with your measured values?

e) Suppose that the circuit of Fig. 3 was modified by connecting a wire across the second resistor as illustrated in Fig. 4. This is called "shorting the resistor." This has the same effect as removing the second resistor and replacing it with a piece of wire. **Predict** how the current provided by the power supply with the resistor shorted will compare (same, larger, smaller, ...) to the current with the resistor included. Explain your answer.

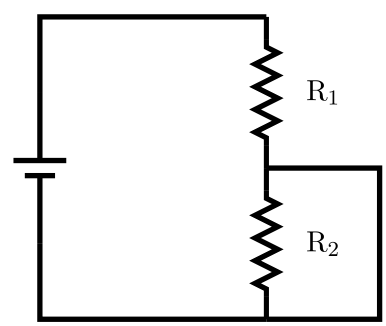

Figure 4: Shorted resistor.

Check your prediction using the circuit that you have constructed. Was it correct? If not, explain why.

2 Parallel Circuits

Another method of combining devices is to connect them"in parallel," so that there are alternative paths through which current can flow. The following exercises and demonstrations consider circuits which contain bulbs connected in such parallel arrangements. Your predictions will rely on the fact that, for identical bulbs, the brightness increases when the current through the bulb increases. Assume that all the bulbs involved in the following circuits are identical.

a) The bulbs in Fig. 5 are said to be **in parallel**. Predict how the brightness of bulb A compares (brighter, dimmer, the same) to that of bulb B. Explain your answer.

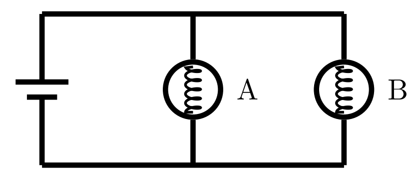

Figure 5: Bulbs in parallel.

Predict how the voltage across bulb A compares (same, smaller, larger) to that across bulb B and also to that across the power supply.

Measure and record the voltage across bulb A and the voltage across bulb B. Were you predictions correct?

b) Now consider the same circuit but with a switch placed before bulb B. Predict how the brightness of bulb A with the switch open compares to that of bulb A with the switch closed. Explain your prediction.

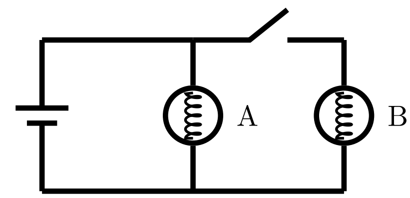

Figure 6: Parallel bulbs and a switch.

Build the circuit and check whether your prediction is correct.

Measure and record the voltage across bulb A with the switch open and with the switch closed. Does closing the switch change the voltage much? How do the voltages compare (smaller, larger, same, . . .) to that provided by the power supply? What effect does the inclusion of bulb B have on the voltage provided by the power supply?

The power supply indicates the current that is delivered to the entire circuit. Observe and record this with the switch open and the switch closed. What effect does the inclusion of bulb B have on the total current delivered?

c) Your household wall outlets are connected in parallel. As you plug in more and more devices what happens to the voltage provided to your household? What happens to the current that flows into your household?

3 Resistors in Parallel

a) Consider the circuit of Fig. 7 where two resistors are connected in **parallel** with R_1 having a larger resistance than R_2. Predict how the current through R_1 will compare (same, larger, smaller, …) to the current produced by the power supply. Explain your answer.

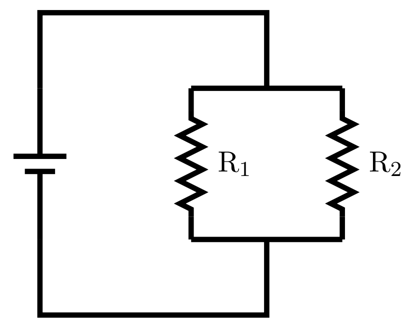

Figure 7: Parallel resistors.

Predict how the current through R_2 will compare (same, larger, smaller, …) to the current produced by the power supply. Explain your answer.

Predict how the current through R_1 will compare (same, larger, smaller, …) to the current through R_2. Explain your answer.

b) Connect the circuit of part Fig. 7. Measure and record the current that passes through each resistor and the current produced by the power supply. Measure and record the potential difference across the power supply. Do your measured currents agree with your predictions from part 3 a)? How is the current produced by the power supply relate to the currents through the resistors?

In a parallel circuit of this type, the current and the potential difference across the power supply are related by

$$\Delta V = IR_{\text{eff}}$$

where the effective resistance is determined using

$$\frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2}.$$

c) Determine the effective resistance of your parallel combination and use this to calculate the current produced by the power supply. Does this agree with the current that you measured?

d) Measure and record the potential difference across each resistor and the power supply. How are these related?

e) Suppose that a resistor were removed from the parallel circuit as illustrated. Predict how the current through the remaining resistor will compare (same, larger, smaller, ...) to what it was when the other resistor was present. Explain your answer.

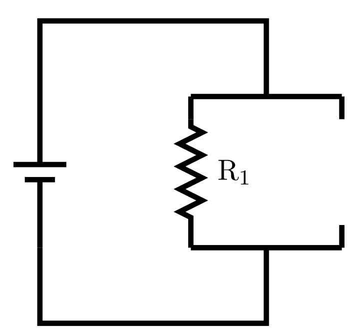

Figure 8: "Broken" parallel resistors.

f) Use the circuit of part 3 a). Measure and record the current that passes through resistor 1 while resistor 2 is present. Then remove resistor 2 and measure the current passing through resistor 1. Does your prediction of part 3 e) agree with your measurements?

Reconnect the circuit of part 3 a). Measure and record the voltage across resistor 1 while resistor 2 is present. Then remove resistor 2 and measure the voltage across resistor 1. Does removing resistor 2 change the voltage across resistor 1?

4 Conclusion

a) For resistors connected in series do your observations suggest that the current split? Does the voltage split?

b) For resistors connected in parallel do your observations suggest that the current split? Does the voltage split?

Equipment Set Up: Ammeter and Voltmeter

A variety of meters are available for reading currents (ammeter) and electric potential differences (voltmeter). The precise methods of setting these up vary from one device to another but the way in which they are connected is always the same.

a) **Voltmeter:** The voltmeter is always connected in parallel across the device for which the potential difference is to be measured. Figure 9 illustrates an example where the voltmeter measures the potential difference across the bulb.
The voltmeter reading is equivalent to the electrostatic potential at the V terminal minus that at the COM terminal.

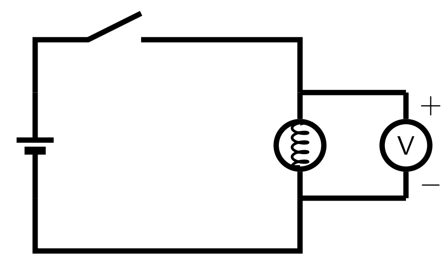

Figure 9: Voltmeter connection

b) **Ammeter:** The ammeter is always connected in series with the components through which it measures current. Figure 9 illustrates an where the ammeter measures the current in the portion of the circuit prior to the bulb.

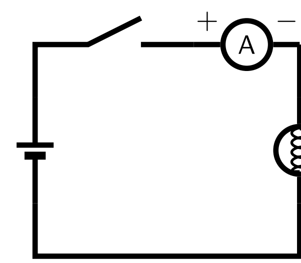

Figure 10: Ammeter connection