Kirchhoff's Circuit Laws
Spring 2017

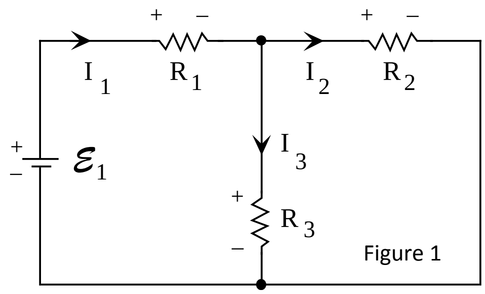


Figure 1

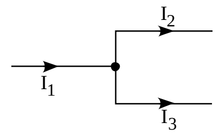
Introduction

This experiment will allow you to examine Kirchhoff's current law and voltage law. Short and open circuits will also be examined. *Be sure to set your multimeters to get as much measurement precision as possible!*

Experiment

1. *Kirchhoff's Current Law (the Node Rule)*

Kirchhoff's current law states that the current that enters a junction equals the current that exits the junction: $I_{in} = I_{out}$. If the current splits as shown at right, then $I_1 = I_2 + I_3$.



a. Make a *large, neat* sketch of the circuit shown in Figure 1 above. Make sure you see the correlation between this diagram and the circuit board you are using.

b. Create a table in your report as shown below; note that the ammeter will display currents in units of *mA*:

Resistor	R (*Ω*)	I (*A*)	$V_{calculated}$ = R·I (*v*)	$V_{measured}$ (*v*)
R_1				
R_2				
R_3				

c. ***Before connecting any wires to the circuit***, set one multimeter to be used as an ohmmeter and measure each resistor on your board; record the value of each resistance in the data table.

d. Two jumper wires will be used in this experiment to complete the circuit. Connect jumper wire **J₂** on the right side of the circuit as shown below; this jumper will be in place for the first two experiments.

e. Connect the ammeter and jumper wire **J₁** as shown in Figure 2 below:

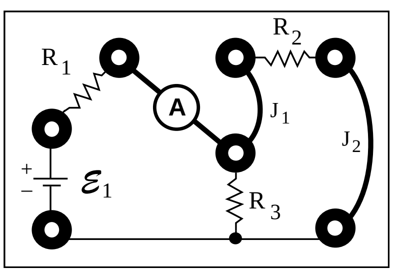


Figure 2

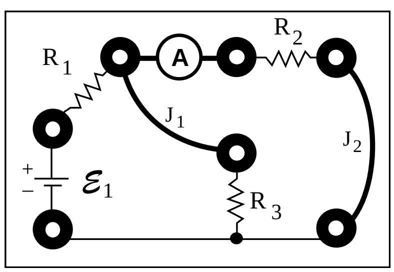


Figure 3

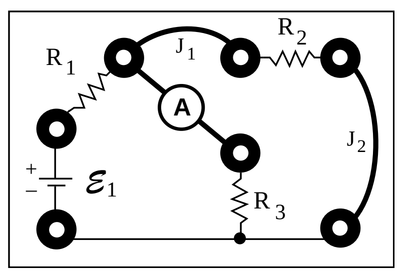


Figure 4

f. Connect the *DC* power supply to your circuit board, set the voltage of $\mathcal{E}_1$ to 15.0 volts (as measured on the voltmeter connected across the circuit board terminals), then measure and record I_1, the current through R_1 (be sure that the ammeter is adjusted to display with as much precision as possible). Move the ammeter and jumper wire J_1 to the positions shown in Figures 3 and 4 to measure I_2, and I_3, respectively. The jumper wire ensures that the entire circuit is powered at all times.

g. Kirchhoff's current law states that the total current flowing *into* a junction is equal to the total current flowing *out* of the junction ($I_{in} = I_{out}$). Check your measurements to see if $I_1 = I_2 + I_3$ (*how can you compare how well two values agree with each other? % difference!*)

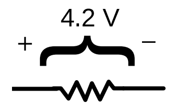
2. *Kirchhoff's Voltage Law (the Loop Rule)*

Kirchhoff's voltage law states that the sum of the voltages in *each loop* of the circuit will be zero:

$$\sum_{\substack{around\\loop}} \Delta V = 0$$

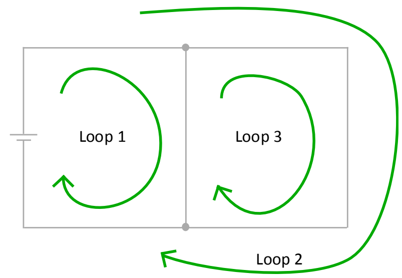
The following sign conventions are used as you move through circuit elements around a loop: the voltage is *negative* when following in the direction of current through a resistor; the voltage is *positive* when following in the direction of current through a source of $\mathcal{E}mf$.

a. Measure the voltage across each resistor. Record the measured voltage in your data table, and on your circuit sketch; use a curly bracket on the circuit sketch to denote the magnitude and polarity of the voltage, as shown at right. Some things to consider:



i. It is important that current flows through the *entire circuit* during your voltage measurements. Which configuration of $\mathbf{J_1}$ and the ammeter (Figure 2, 3, or 4) should you use? Does it matter?

ii. You don't need to switch the position of $\mathbf{J_1}$ and the ammeter for each voltage measurement!



b. The figure at right shows the three loops you will follow for your circuit. Identify which resistors are contained in each loop. Is the voltage source included in each loop?

c. Moving *clockwise* around the left loop ("Loop 1") of your circuit diagram, determine the sum of the measured voltages and the voltage source.

d. Repeat your calculations for the outside loop ("Loop 2"), and then the right loop ("Loop 3"). Are the sums consistent with Kirchhoff's voltage law?

THE EFFECTS OF SHORT AND OPEN CIRCUITS ON BULBS IN SERIES AND PARALLEL:

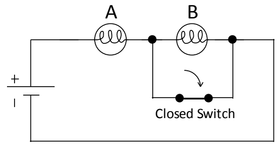
3. *Open circuits:*

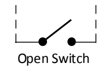
a. Connect two light bulbs (of the same wattage) in *series* (*no meters are necessary for this circuit*). Draw a circuit diagram, and turn up the power supply until the built-in meter reads 7.0 *V*. Unscrew one of the bulbs and remove it. What happens? Screw this bulb back in, then unscrew the other. Use your circuit diagram to briefly explain what you observed and why it happened (represent the bulb that was unscrewed by omitting it from the diagram and leaving a gap in its place).

b. Turn off the DC power supply using the power button, leaving the voltage set to 7.0 *V*. Connect the two bulbs in *parallel*, draw a circuit diagram, and turn on the DC power supply. Repeat the experiment above, record your observations, and use your circuit diagram to explain your observations. Describe the appearance of the bulbs at each step

c. Which connection (series or parallel) results in brighter bulbs? Based upon your observations, explain whether you think the light bulbs in your house are wired in parallel or series.

4. *Short circuits – Bulbs in series:*





Important Note: Have your instructor check your circuit before turning on the DC power supply!

a. Connect two light bulbs in series, as shown in the circuit diagram (again, no meters are required). Your instructor will show you how to connect a knife switch across one of the bulbs. Make sure the switch is open, turn on the DC power supply (set to 7.0 *V*), and observe the results. Close the switch, and record your observations. Use your circuit diagram to briefly explain what you observed (draw a *closed* switch!).

5. *Short circuits – Bulbs in parallel:*

Important Note: This experiment cannot be performed when the bulbs are connected in parallel! Unplug the DC power supply from the AC power before proceeding!

a. **Unplug the DC power supply's power cord before connecting this circuit.** Connect the two bulbs in parallel, and include a switch to short out one of the bulbs. Draw a circuit diagram, and use it to explain why we can't turn the DC power supply on without disastrous results.

Discussion

- Summarize your numerical results (calculated and measured, and current and voltage sums) from the three parts of this experiment.
- Discuss whether or not your numerical results are consistent with Kirchhoff's node and loop rules.
- Briefly summarize your observations for connecting bulbs in parallel and series. Explain why the bulbs are brighter when connected one way versus the other.