PHYS 1106 **Last edit: September 16, 2017**
SMU Physics Dept.

DC Circuits and Kirchhoff's Laws

Goal

- To become familiar with the behavior of currents and voltages in DC circuits with regard to Kirchhoff's junction and loop rules.

Equipment

Breadboard, wires, resistors, multimeter.

The Big Picture

In this experiment you will explore two ways of connecting circuit elements. One method, called a **series** connection, is characterized by the same current running through each element. The other method, called a **parallel** connection, is characterized by the same voltage across each element. (It is possible for a collection of circuit elements to be in neither the series nor the parallel configuration.)

Theory

A **junction** is a location where three or more wires meet.

Kirchhoff's Junction Rule: the sum of the currents entering any junction must equal the sum of the currents leaving that junction. This is a consequence of conservation of electric charge; electric charge entering a junction must leave that junction, otherwise charge would build up at the junction.

Kirchhoff's Loop Rule: The sum of the changes in potential (voltage) encountered in a complete traversal of any loop of a circuit must be zero. This is a consequence of conservation of energy; an electric charge (like an electron) will gain or lose energy when it

travels through a potential difference, but if the charge ends up in the same place that it began then the net change in energy must be zero.

Procedure: Series

1. Choose three resistors with identical coded resistance. The bands should be the same; the color and shape of the resistor body may vary.
2. Connect the three resistors in the series circuit shown below.

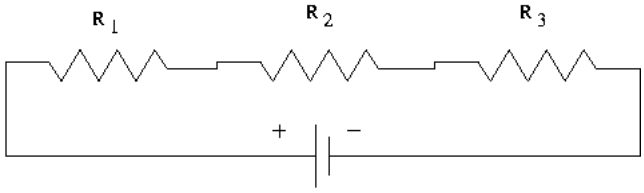

Figure 1:

3. Measure the voltage across each of the resistors in turn and record your measurements (with units and errors). Measure the voltage across the battery.

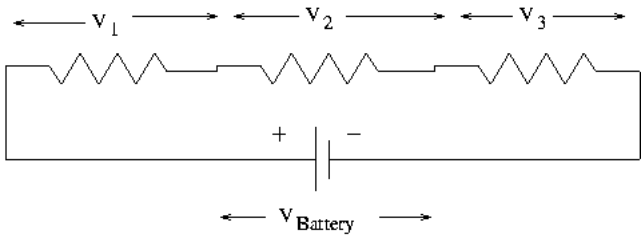

Figure 2:

4. Review the precautions for using a multimeter as an ammeter. **Note that measuring current incorrectly will blow the fuse in the meter.**
5. Break the circuit open at the point indicated in the figure below. Measure the current I_1 flowing through the wire between the positive terminal of the battery and resistor 1. Record your measurements (with units and errors).

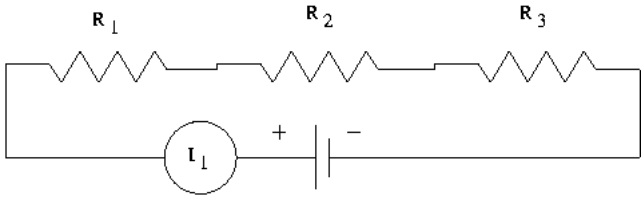

Figure 3:

6. Remove the ammeter, reconnect the circuit, and break the circuit open between resistor 1 and resistor 2. Measure the current I_2 flowing through that piece of wire. Record your measurements (with units and errors)
7. Repeat for current I3 flowing between resistor 2 and resistor 3, and current I4 flowing between resistor 3 and the battery.
8. What is the apparent rule for voltage in a series circuit?
9. What is the apparent rule for current in a series circuit?
10. Repeat this exercise with three non-identical resistors.
11. Do the apparent rules still hold? Explain.

Procedure: Parallel

1. Choose three resistors with identical coded resistance.
2. Connect the three resistors in the parallel circuit shown below.

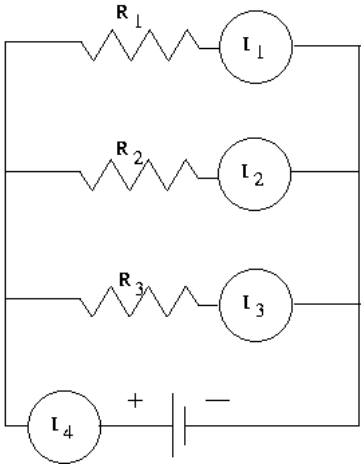

Figure 4:

3. Record the voltages across each resistor (1,2,3) and the battery.
4. Measure the currents through each resistor (1,2,3) and the current flowing out of the battery (4). **Remember to break the circuit open and insert the ammeter in series.**
5. What is the apparent rule for voltage in a parallel circuit?
6. What is the apparent rule for current in a parallel circuit?
7. Repeat this exercise with three non-identical resistors.

8. Do the apparent rules still hold? Explain.

Procedure: Kirchhoff's Rules

1. Connect the circuit shown below, using
   R1 = 1000 ohm (upper left)
   R2 = 2200 ohm (upper right)
   R3 = 560 ohm (lower left)
   R4 = 330 ohm (lower right)
   R5 = 1000 ohm (middle resistor)

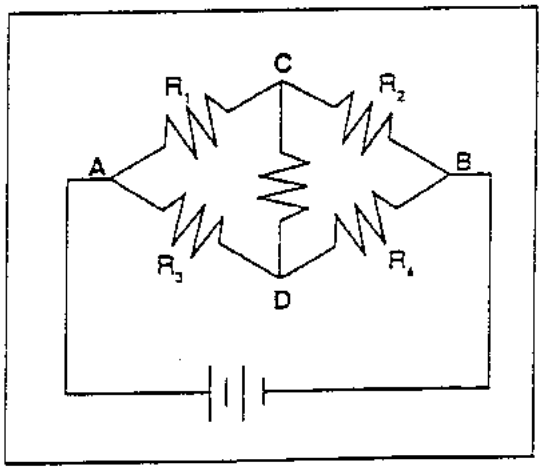

Figure 7.1b

Figure 5:

2. Are any resistors in series or parallel?
3. Measure the voltage across each resistor and across the battery.
4. Measure the current flowing through each resistor. Also measure the current flowing out of the battery. **Remember to break the circuit open and insert the ammeter in series.**
5. Determine the net current flow into each of the four junctions. If current is flowing out of the junction then it is negative.
6. Determine the net voltage drop around any two of the seven closed loops in the circuit. Diagram which loops you are using.
7. Do Kirchhoff's two rules hold experimentally for this circuit? Explain.

Analysis

1. Summarize the rule for voltage in a series circuit.
2. Summarize the rule for current in a series circuit.
3. Summarize the rule for voltage in a parallel circuit.
4. Summarize the rule for current in a parallel circuit.
5. List two random and two systematic error sources.

Literature

1. Halliday, Resnick, & Walker, *Fundamentals of Physics* Vol. 1 (10th ed.), Ch 27: Circuits, Wiley, 2014.