LAB SECTION: ______________________________ NAME: ______________________________

EXPERIMENT 9: OHM'S LAW

Introduction: In this lab, you will use a variable power supply to subject a resistor (of known resistance) to a variety of voltages. Your objective will be to test Ohm's Law, which asserts that the resulting current through the resistor (as well as the rest of the circuit) is proportional to the applied voltage. Once you have established that Ohm's Law is, in fact, valid over the ranges of voltage and current in your experiment, you will use the knowledge gained to determine the value of an unknown resistance.

IMPORTANT: Special concerns for Ohm's law experiment

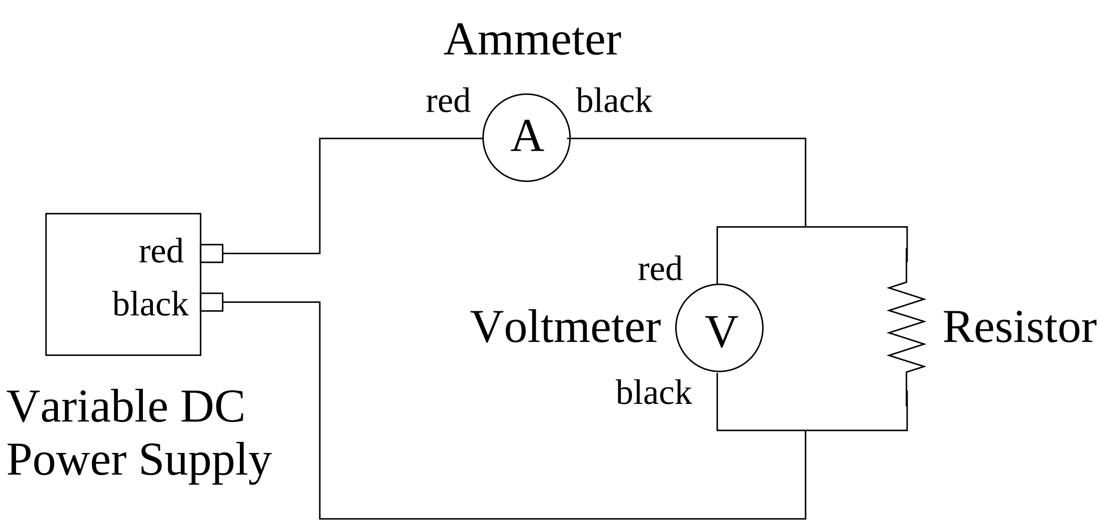
1. If your circuit is not properly connected, it is possible to damage the electronic equipment used in this lab. Set up your circuit with the power supply OFF and the output voltage turned DOWN TO ZERO. Do not proceed with your experiments until your TA has checked the circuit.

For many students, the concepts of voltage and current in an electric circuit are most easily understood by means of an analogy with a flow, driven by gravity, through a pipe. Consider a simple circuit consisting of a battery and a wire having significant resistance. For the wire, imagine a long flexible pipe (a very large hose) laid out on a hill; one end of the pipe is at the top of the hill and the other end at the bottom. The pipe doesn't come straight down the hill, but is laid out in a meandering fashion; however, the steepness of the pipe is constant. If you were to walk alongside the pipe you might find, for example, that for every ten steps you descend by 1.0 m. The actual amount of descent for ten steps would depend on the height of the hill and the length of the pipe; however, in our analogy, the steepness of the descent must be constant everywhere along the meandering pipe.

The actual current in most metal wires is carried by conduction electrons, electrons that are free to move about within the conducting material; however, our analogy will be easier to complete if we imagine that currents are carried by hypothetical positive charges moving through the metal wires (in the opposite direction of the actual conduction electron movement). In our analogy, the hypothetical moving positive charges are represented by honey. Our pipe is filled with honey, and gravity is continually driving the honey down the hill. The battery in the circuit is represented by a pump; the function of the pump is to remove any honey that exits the pipe at the bottom of the hill and to transport that honey back to the top of the hill. At the hilltop, the pump puts the honey back into the pipe, keeping the pipe always full. The "current" in our analogy is simply the amount of honey per second that exits the lower end of the pipe, or that is put back into the upper end of the pipe, in units of kilograms per second.

We are now ready to apply our analogy to the concept of voltage. Voltage IS, by definition, a difference in electric potential energy per unit charge. In our analogy, the "voltage" is the height of the hill (or more precisely, the height of the hill times the acceleration due to gravity, *i.e.* the gravitational potential energy per unit mass). If the hill in our analogy were made higher, the meandering pipe would everywhere be steeper, and therefore the flow of honey would be increased (more kg per second would come out of the lower end and would need to be replaced at the upper end). In other words, more voltage would result in proportionally more current.

Ohm's Law, applied to our analogy, may seem rather obvious; it asserts simply that the resistance of the pipe to the flow of honey depends only on the geometry of the pipe (the length and cross-sectional area) and not in any way on the flow rate of the honey. It is easy to see why the geometry of the pipe matters. If the height of the hill were not changed, and the pipe were made twice as long, then the pipe would be everywhere half as steep, and the flow of honey would be cut in half. On the other hand, if the pipe length were not changed but the area of the pipe were doubled, then the flow rate of honey would also double. But it is difficult to see how the flow rate of honey might possibly affect some property of the pipe and thereby affect the resistance. In fact, it is at this point that our analogy fails; for an electrical circuit, the amount of current can, and sometimes does, affect the material of the wire through which the current is passing. Large currents heat the wires through which they pass, causing increased thermal motion of the atoms in the wires and making it more difficult for the moving charges to pass (thereby increasing resistance to the flow of charge). However, for the range of currents and voltages that we will use in this experiment, the resistors in your circuits should not heat significantly, and thus Ohm's Law (and our analogy) should be valid.



Procedure

Part A: Known Resistance

1. Make sure that the DC variable power supply is OFF, AND THE VOLTAGE KNOB IS TURNED DOWN TO ZERO. Set up the circuit shown in the figure at the bottom of page 2. Use one of the resistors of known resistance provided with your lab equipment; record the value of the resistor in Data Table 9.1. Ask your TA to check your circuit before beginning the experiment.
2. Adjust the output voltage from the variable power supply to produce six different values on the voltmeter. Your TA will indicate the appropriate range of voltage values for your experiment. For each value of voltage, record the voltage and the resulting current, as read on your ammeter, in Data Table 9.1.

Part B: Unknown Resistance

1. Repeat the steps of Part A with a resistor of unknown resistance. Record your voltages and the currents produced by those voltages in Data Table 9.2.

Results

1. Make a graph of your data for the known resistance, with voltage on the x-axis and current on the y-axis. Draw a best fit line. Are you able to conclude that the amount of current is proportional to the applied voltage? Why or why not?

2. Find the slope of your best fit line from question 1, with proper units. Show your calculation here and on your graph.

3. When Ohm's Law is valid, the definition of resistance is the ratio of applied voltage to the amount of current produced by that voltage, in units of volts/amperes or Ohms (Ω). What is your measured value of resistance based upon your graph from question 1? Calculate the percent error between your measured value and the given value of your known resistance and show that calculation at the top of page 5.

Data Table 9.1 Known Resistance of ________ Ω

Trial	Voltage (V)	Current (A)
1		
2		
3		
4		
5		
6		

Data Table 9.2 Unknown Resistance

Trial	Voltage (V)	Current (A)
1		
2		
3		
4		
5		
6		

4. To determine the unknown resistance, make a graph of your data for that resistor, but with current on the x-axis and voltage on the y-axis. Draw a best fit line and calculate the slope of that line; show your calculation here and on the graph. What is the value of your unknown resistance?

5. Select three values of voltage which were not among the six values you used for the unknown resistor. For each of those three values, predict the current which will be produced by that value of voltage (HINT: use your answer to Part 4). Enter your voltages and predicted currents in Data Table 9.3, and show one example of the calculation that you have done to make the predictions. Test your three predictions with the lab equipment. Enter your measured values of current in Data Table 9.3 and calculate the percent error for each case. Show one calculation of percent error.

Data Table 9.3 Previously unknown resistance now determined to be _____ Ω

Voltage (V)	Predicted Current (A)	Measured Current (A)	Percent Error

Going Further

1. Connect three different resistors end-to-end (in series) and subject the combination of resistors to four different input voltages (for example, 2 V, 4 V, 6 V, and 8 V). Use what you have learned to find the total resistance of the combination from a graph of voltage versus current (*i.e.* voltage on the y-axis). Show your data table below (with proper labels and units) as well as your calculation of slope for the best fit line on your graph. Be sure to state what three known resistances you have used.

2. Connect the same three resistors side-by-side (in parallel) and subject the combination of resistors to four different input voltages (for example, 0.2 V, 0.4 V, 0.6 V, and 0.8 V). Use what you have learned to find the total resistance of the combination from a graph of voltage versus current (*i.e.* voltage on the y-axis). Show your data table below (with proper labels and units) as well as your calculation of slope for the best fit line on your graph. Be sure to state what three known resistances you have used.