Ohm's Law
Spring 2008

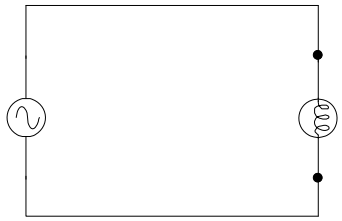
Introduction

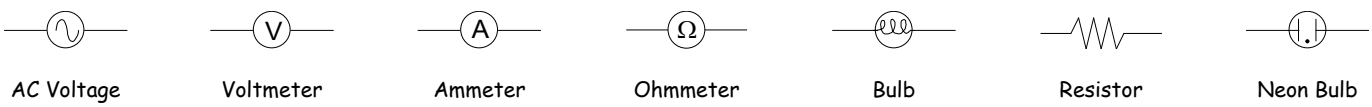
In this experiment, you will practice connecting simple circuits and measuring the *voltage across* and the *current through* a component of the circuit. You will also examine the current-voltage relation for a resistor, an incandescent light bulb, and a neon bulb. Before beginning this experiment, you should reread the "Using a Digital Multimeter" document you printed last week.

> ***Important note:*** Circuit components will become **hot**! Be sure to turn off the power supply when you have completed taking your measurements. Always connect your wires to the power supply *after* your components are connected; never leave bare wires hanging from the power supply. And never pull on the wire, only on the end connector.

Experiment

1. *Direct measurement of resistance:* Before connecting the circuit, use the multimeter labeled "Voltmeter" to measure the resistance of each component. Insert *two* wires into the voltmeter, one in the "COM" port, the other in "V/Ω", then set the dial to measure resistance ("Ohm"). Record this value for the resistor and the incandescent bulb. You won't be able to measure the resistance of the neon bulb with the meter, but you should try it anyway!
2. *Setting up the voltmeter and ammeter:* You will be using two identical multimeters, one labeled as an *ammeter* (for measuring current), the other a *voltmeter* (for measuring voltage). It is important that you connect each meter correctly to the circuit, to prevent blowing a fuse in the meter or power supply.
   a. The **ammeter** measures the *current through* the circuit, and gets inserted into the circuit just like another component. Insert *one* wire into the ammeter in the "A" port, and be sure that the dial is set to an "ACA" setting. This will remind you that the circuit needs to be opened up in order to measure current (the "free" wire from the opened circuit will be connected to the "COM" port).
   b. The **voltmeter** measures the *voltage across* a component (light bulb, battery, etc.); insert *two* wires into the voltmeter, one in the "COM" port, the other in "V/Ω" (this is the same setup as used in step 1), and set the dial to a "ACV" setting. This will remind you that the voltmeter is used to "touch" both sides of a component. The voltmeter should always be connected to the circuit *after* the ammeter.
3. *Assembling the circuit*: Be sure to **turn the knob on the variac (the "battery") counterclockwise to zero, and turn the variac off with the switch each time you make a change to your circuit**.
   a. Sketch the circuit at right in your report. The symbols that will be used in circuit diagrams are found below.

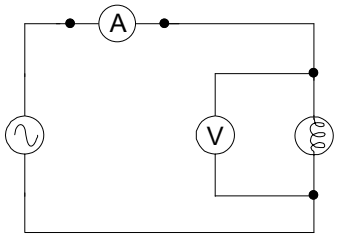




   b. Connect the bulb socket to the variac with two wires to make this circuit. Screw in the light bulb, turn the variac on and slowly turn the variac knob clockwise. The bulb will slowly increase in brightness; if not, have your instructor check your circuit.

c. *Turn the variac off* by turning its knob to zero and pressing the button. To measure **I**, the ***current through*** the bulb, disconnect one wire from the variac, and insert it in the "A" port of the **ammeter**; the other wire previously inserted in the "COM" port of the ammeter is then connected to the variac to complete the circuit. (Keep the variac turned off!!)

d. You will measure **V**, the ***voltage across*** the light bulb, by plugging the wires from the **voltmeter** into the connectors on both sides of the light bulb – don't remove the wires connected to the bulb. (The variac is *still* off!!). Sketch the circuit at right in your report.



e. When both meters are connected, turn on the switch, and raise the voltage *slowly* until the **voltmeter** reads the voltage rating printed on the bulb (typically 120*v*). Record the voltage and current in your report.

f. The power output of the bulb, in Watts, is the product of the voltage across the bulb (volts) and the current through it (amperes): $\mathbf{P = I \cdot V}$. Calculate the power of the bulb, and compare it to the published value.

4. *Ohm's Law*: Ohm's Law states that certain types of circuit components exhibit a linear relationship between current and voltage: $\mathbf{V = I \cdot R}$. Components that obey Ohm's law will produce a straight line *through the origin* when plotting I vs. V, and the resistance of the component can be determined from the inverse-slope of the line. If a component produces a non-linear graph, than its resistance cannot be accurately determined with this method.

a. Create a data table in your report to record measurements of I and V. Adjust the variac so that the reading on the voltmeter is 100 *v* (the maximum you will use). Decrease the voltage in 10 *v* increments and measure the current; collect *one additional measurement* when the voltage is 5 *v*. Create a graph of current as a function of voltage *as you collect your data*.

b. What is the voltage when the incandescent bulb turns off completely? What is the current at this point?

c. Turn off the variac, and replace the incandescent bulb (careful – it's hot!) in the circuit with a special neon bulb. Draw a new circuit diagram (the neon bulb symbol appears on the previous page). Again adjust the variac so that the reading on the voltmeter is 100 *v*, and measure and plot I vs. V (on a *second* graph), decreasing the voltage in 10 *v* increments. The current is very small in this circuit, so you'll want to change the ammeter setting to read more significant figures.

d. What is the voltage when the neon bulb turns off completely? What is the current at this point?

e. Replace the neon bulb with the resistor, and set the voltage to 75 volts (this will keep the resistor from heating up too much). On a *third* graph, again plot I vs. V, decreasing the voltage in 10 *v* increments. When you get down to 25 *v*, continue to decrease the voltage in 5 *v* increments; this will give you more interesting results in the graphs you will plot in step *i* below.

f. Which component(s) obeys Ohm's Law (linear points *through the origin*)? Draw the best straight line through these points, and find the value of resistance from the *reciprocal* of the slope (*why the reciprocal?*). Don't use data points to calculate slope!

g. Compare the resistance calculated from the graph of this component to the resistance as measured using the multimeter in step 2. How well do these values agree with each other?

h. If you haven't done so already, enter your current and voltage measurements for the three components into an Excel spreadsheet (put the data for each component on a separate worksheet). Create a third column for the resistance, and have Excel calculate these values.

i. Create two graphs for each component: I vs. V, and R vs. V (put the graphs on the same worksheet as the data). Resize the graphs so that the data and both graphs for each component will print on a single page. Print these graphs for your report.

Discussion

- Comment on the measured power output of the incandescent bulb as compared to its expected value – calculate the percent difference!
- Summarize your resistance measurements and calculations, and comment on the components that did or did not behave as predicted by Ohm's Law (support your argument by discussing your graphs).
- Briefly describe the difference in the behavior of the incandescent and neon bulbs, as observed visually and in the appearance of their respective I vs. V graphs.
- Discuss the different behaviors of each component by analyzing their R vs. V graphs.

Please unplug all the wires from your circuit,
and turn off the multimeters.