OHM'S LAW

(L-20)

Resistors are circuit elements designed to limit current flow while dissipating energy (the energy is usually converted into heat or light). Experimental observation culminating in what is called OHM'S LAW states that the *voltage difference across a resistor is proportional to the current through the resistor*, with the proportionality constant between the two variables being called the resistance *R* of the resistor. In other words, Ohm's Law state V = iR.

The goal of this lab is two-fold. First, it will give you a chance to play around with the equipment (respectfully), and second it will allow you to verify Ohm's Law.

PROCEDURE--DATA

Part A: (series circuit)

a.) On your table (or at the front of the room), you will find a very sensitive ammeter called a *galvanometer*, a power supply, a circuit box in which there will be two resistors, a container of wires and leads to the computer. Make sure you and your partner have everything you need.

b.) Before getting into the wiring, you might as well set up your computer. To do so:

1.) Plug a voltage probe into the CH 1 of the LabPro interface, and open up the Logger Pro program. The window will give you a *voltage versus time* graph.

2.) Go to EXPERIMENT (this is a pull-down on the top ribbon), then DATA COLLECTION (this is a pull-down). From MODE, select the EVENTS WITH ENTRY option. When the window opens, write CURRENT, then "i," then AMPS in the appropriate boxes.

3.) Double click on the graph window. Click on the GRAPH TITLE option, the put your name, your partner's name, and some shorthand way to tell which graph you are looking at (for the first graph, use SERIES; for the next part, you'll label it PARALLEL).

4.) Click on the vertical graph scale (this should be labeled POTENTIAL). Check the AUTOSCALE FROM ZERO option.

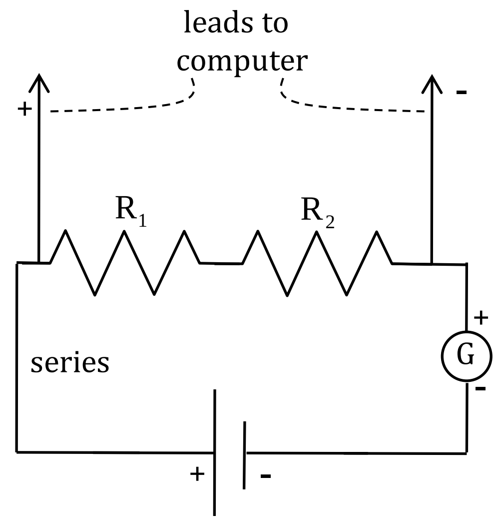
5.) Double click on the CURRENT DATA TABLE. In the window that pops up, click on OPTIONS, then DISPLAY PRECISION. In that box, put a "4" (that will allow for data that looks like ".0001").

c.) At some point during the lab (i.e., after you are comfortable with the idea of a series combination of resistors), use the IMPEDANCE BRIDGE (this is pronounced *im-pE-dance*, not *IM-pe-dance*) provided to determine values for the following three parameters:

--R_1 (call this $R_{1,\,imp}$) and R_2 (call this $R_{2,\,imp}$);

--The net resistance of R_1 *and* R_2 in a series combination--call this equivalent resistance $R_{s,imp}$;

--The net resistance of R_1 *and* R_2 in a parallel combination--call this equivalent resistance $R_{s,para}$;



d.) Wiring a circuit is a lot like making a cake. In other words, it's a process that requires you to FOLLOW THE DIRECTIONS as they are presented on schematic form. As such, look at the circuit diagram shown to the right, ask questions if you are confused, but if not, wire the circuit.

e.) When you are ready to take data, if you are the first, call me so I can show everyone how to do the data taking.

In summary of what you will see: To start taking data, click on COLLECT, then use the Vernier knob on the power supply to bring the galvanometer's current reading up to the number "1" on the scale.

Although it is not obvious by looking at it, the GALVANOMETER an ammeter that is calibrated so that a *full deflection reading* corresponds to a current through the device of $.5\text{x}10^{-3}$ amps (i.e., a half milliamp), or $5\text{x}10^{-4}$ amps. That means that when the galvanometer reads "1", you are really registering a current of $1x10^{-4}$ *amps*, or *.0001 amps*.

Once the reading has stabilized, click on the KEEP icon (it is just to the right of the COLLECT button) and a window will appear asking what current should be associated with the voltage the computer has recorded. In the box, type in "*.0001*." Hit ENTER when done.

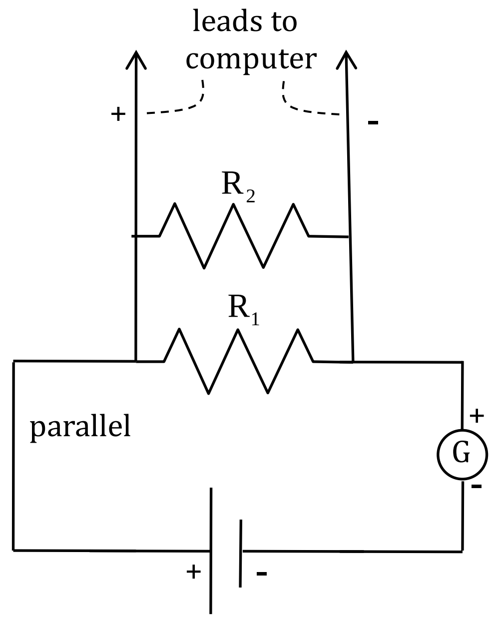
Use the vernier to put the current at the number "2" on the galvanometer, then click on KEEP. When the box appears, write in "*.0002*." Hit ENTER.

Continue following this procedure until you have recorded data for 1, 2, 3, 4, and $5\text{x}10^{-4}$ amp readings.

When done, hit STOP, graph the window and PRINT a copy of the graph for each member of the group.

f.) It is now time to do a little evaluation. At the end of this lab, you will find a series of questions under *Questions for Part A*. If it looks as though you will have time during the lab to answer those, do so now. If not, put them off until later.

Part B: (parallel circuit)



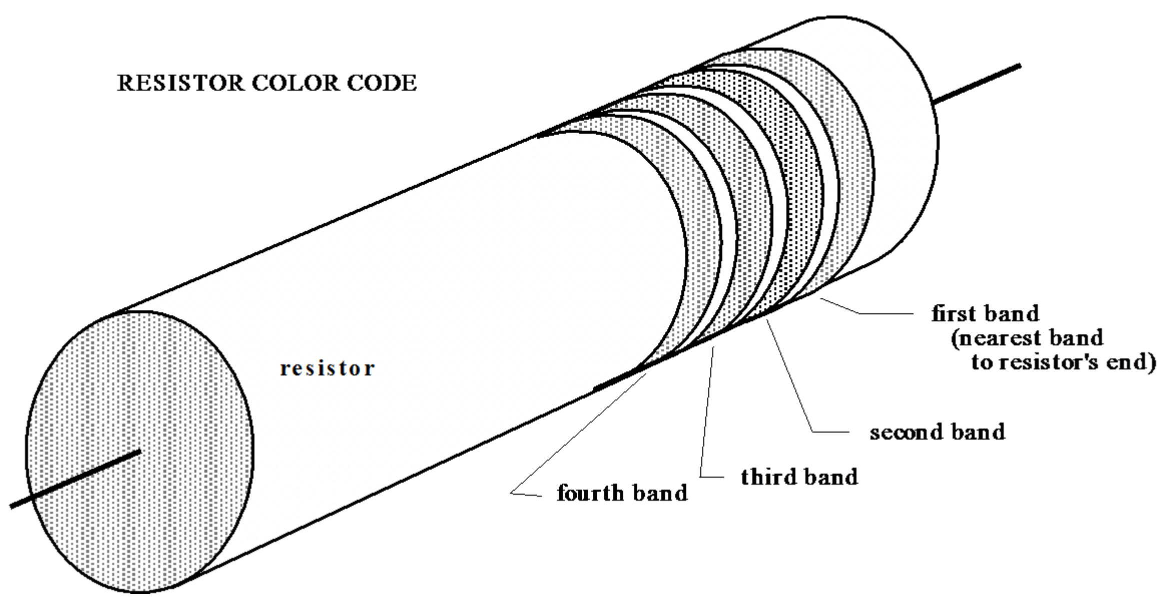
g.) Re-wire the circuit as a *parallel combination* of R_1 *and* R_2.

h.) Use the technique outlined in *Part A* to generate a *Voltage versus Current* graph for this part by taking data for currents of 1, 2, 3, 4, and 5×10^{-4} amps. (Note that you will have to modify your graph's title.) Print this graph as well.

Part C: (color code information)

n.) Most resistors are marked at the factory with a four-band *color-code* to identify their approximate size (this is called "the factory value"). A brief explanation of what each band signifies and which color is assigned to what number follows, along with a sketch of a sample resistor (next page). Study the information, then use it to determine the *color-code value* of your resistor R_1 (call this $R_{1,cc}$).

--To begin with, the "first band" starts at the far edge of the resistor (see sketch) while the "last band" is located somewhere in the middle of the resistor.



--The number assigned to each color is shown in the chart below:

COLOR VALUES

black	0	violet	7
brown	1	gray	8
red	2	white	9
orange	3		
yellow	4	last band gold	$\pm$ 5%
green	5	last band silver	$\pm$10%
blue	6	last band blank	$\pm$20%

--Color-coded resistance values always have the form:

$$\boldsymbol{a}\ \boldsymbol{b}\ x\ 10^{\boldsymbol{c}} \pm \boldsymbol{d}\%,$$

where the ***ab*** term is not the product of *a* and *b* but rather individual numbers. In fact, ***a***, ***b***, and ***c*** are the number equivalents to the colors of the first, second, and third bands respectively. The fourth band (designated ***d*** above) gives the factory tolerance.

Example: If a resistor's value is $52\text{x}10^6 \pm 10\%$, the bands will be (according to the table):

--first band *green* (for *5*),
--second band *red* (for *2*),
--third band *blue* (for *6*),
--fourth band *silver* (to show a tolerance of *10%*),

In other words, if you come upon a resistor whose bands (starting from the edge of the resistor) are *green, red, blue, silver*, you will know that the resistor's factory value is:

$$52\text{x}10^6 \pm 10\%.$$

QUESTIONS

Part A: (Ohm's Law and resistors in series)

1.) Look at your graph. Is it linear? That is (briefly), is the voltage difference across the resistor proportional to the current through the resistor? What does this tell you about whether Ohm's Law holds for your circuit?

2.) Even if we haven't talked about this in class, using your head, what do you think the equivalent resistance of two resistors in series is going to be? You have Impedance Bridge values for both resistors individually. Use these values to determine what the equivalent resistance should be for your series circuit.

3.) You actually measured the equivalent resistance of your two resistors in series using the Impedance Bridge. Do a % comparison between those two values. Comment briefly.

4.) From your graph, determine the equivalent resistance of your circuit. Explain how you did this, and compare (qualitatively) to your results to #2 and #3 above.

Part B: (parallel resistor circuit)

5.) It probably isn't obvious right now (we will derive it later in class), but the equivalent resistance of two resistors in parallel is such that $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$. Use your Impendence Bridge values in this relationship to determine the theoretically expected value for that combination.

6.) Pick a point on your graph and take the ratio of its voltage to current. What does this give you?

7.) The value you got in #6 should match up with the value you got in #5. Do a % deviation between the values. Comment briefly.

Part C: (color code)

8.) As was explained in previous pages, manufacturers used to identify the size of their manufactured resistors using a color code. Use the color code to determine the size of your resistor R_1. Is that value within the stated deviation of your actual, Impedance Bridge value? Comment briefly.