Interpreting Last Week's Results: Finding the Systematic Error
Spring 2009

Introduction

When the results from last week's experiment on Ohm's Law were assembled, it was clear that there was a *systematic error* in the experiment. In every case, $R_1 + R_2 \leq R_{set}$. The purpose of this lab is to figure out *why* the sum of resistances measured separately was less than the measured combined resistance. *Be sure to use the same resistor set as last week!*

Experiment 1

1. Your instructor will perform a demonstration using resistors and liquid nitrogen (T = 77 K = -321 °F). Briefly describe the demonstration and the results.

Experiment 2

1. Set up your multimeter as an ohmmeter to measure resistance (refer to the document "Using a Digital Multimeter"). *Without connecting the resistors to a power supply*, use the ohmmeter to measure R_1, R_2, and R_{set}. Report your results.
2. How do the direct measurements of resistance with the ohmmeter compare to the values you calculated last week from your *I* vs. *V* graph?
3. Calculate $R_1 + R_2$ from the individual ohmmeter measurements, and compare to the *direct* ohmmeter measurement of R_{set}; how do they compare with each other? Were the ohmmeter measurements higher, lower or the same as the values calculated last week? What conclusion can you draw? Be sure to state your results from last week!

Experiment 3

1. Open your KaleidaGraph plot from last week, and click on the "grid" icon in the upper right corner of the window to extract your data from the plot. (If you chose not to follow the instructions, create a plot of *I* vs. *V*, and make linear curve fits for R_1, R_2, and R_{set}).
2. Follow the instructions in "Graphing & Curve Analysis Using KaleidaGraph" to calculate the *residuals*. Recall that the residuals are the difference between the *predicted* y-value of a data point (as indicated by the best-fit line) and the *measured* y-value. They show how much the best-fit line misses the data points.
3. Graph the residuals vs. voltage on KaleidaGraph (you can put all three sets of residuals on *one* plot). Do you notice any pattern in the residuals? If so, describe it. (Fitting a 2nd order polynomial curve to each residual set might help you visualize the pattern. Don't display the equations; they aren't important here).

Experiment 4

1. Again measure the resistance of *one* of the resistors with an ohmmeter. These resistors are rated for $^1/_4$ watt of power output. Calculate the rated *current* for the resistor, i.e., find the amount of current that will produce $^1/_4$ watt of power dissipation (recall $P = I^2R$). How much voltage is needed to produce this current? Call this voltage V_{max}.
2. Connect a circuit with a voltmeter, ammeter, and the single resistor, the same as last week. Draw a circuit diagram in your report. Measure the current (to 0.01 *mA*) through the resistor as a function of the voltage, but don't go higher than V_{max} at first. Then increase the voltage higher than V_{max} until you can feel the

resistor getting warm to the touch. Turn the power supply up to its maximum value (40 to 50 volts); record at least 6 data points above V_{max}. Be sure to graph the data as you collect your measurements.

3. Draw a best fit line for the points *below* V_{max}, and extend this line across your graph. Do the data points above V_{max} lie on this best-fit line? Explain what is occurring in this graph. Your instructor can show you how to graph these points in KaleidaGraph so that a linear fit can be applied to those points below V_{max}.
4. Plot the resistance vs. the voltage (use the "Formula Entry" window to calculate the resistance – see your KaleidaGraph instructions). What do you notice happening to the resistance as the voltage increases?

Discussion

- Using what you have learned today, and your *I vs. V* graph from last week, explain the cause of the systematic error in last week's lab; specifically, why was $R_1 + R_2 \leq R_{set}$? *Be sure to site specific examples from **each experiment** performed today to support your explanation.*