PHY 252 Spring 2010 Practical Lab #1
Ohm's Law

Objectives

- Construct a circuit using resistors, wires and a breadboard from a circuit diagram.
- Test the validity of Ohm's law

Apparatus

A DC power supply, a resistor, a breadboard, 2 digital multimeters and 5 banana plug cables.

Theory

According to Ohm's law, there is a linear relationship between the voltage drop across a circuit element and the current flowing through it. This means that the resistance R is viewed as a constant independent of the voltage and the current. In equation form, Ohm's law is:

$$V = IR \qquad (1)$$

Here, V = voltage applied across the circuit and has SI units of volts (V)
I = current flowing through the circuit and has SI units of amperes (A)
R = resistance of the circuit and has SI units of ohms (Ω)

Equation (1) implies that, for a resistor with constant resistance, the current flowing through it is proportional to the voltage across it.

In a series connection between two known resistors, R_1, and R_2, the current flowing through both, I, is the same. If the voltage across either resistor is known, the current can be determined from Ohm's law. The voltage across the other resistor can then be calculated using Ohm's law.

Procedure

When you arrive to do the practical lab, you will be told which color of (unknown) resistor to use in your circuit.

1. Using the five banana plug cables, the digital multimeters, the power supply, your resistor, and the breadboard, construct the circuit shown in Figure 1 below (V represents the voltmeter and A represents the ammeter). **Do not turn the power supply on until your Instructor has approved your circuit.** You will be awarded 4 of the 20 total points, for a correctly wired circuit. If the circuit is not correctly wired, your Instructor will wire it for you, and then you can proceed with the rest of the lab.

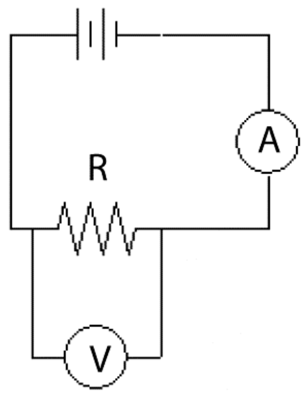

Figure 1

2. Turn on the power supply and increase the voltage until your voltmeter (one of the two digital multimeters) reads $V = 3.0$ volts. Record the current in Data Table 2.
3. Repeat step 3 for $V = 6.0$ volts, 9.0 volts, 12.0 volts and 15.0 volts.
4. Import your data into Kaleidagraph and construct a graph of voltage versus current. Fit your graph with a best fit line that includes the uncertainties in the slope and intercept. You do NOT have to include error bars on this graph.

Questions

1. From the linear fit to your data as shown in the graph, what is the resistance, R, and its uncertainty, δR?
2. From a table of resistance values that will be provided, which resistance value (and uncertainty) is nearest to your measured resistance?
3. Show that the measured resistance and the tabularized resistance value nearest to it are (or are not) consistent with each other.
4. Is the ammeter in series or parallel with your resistor?
5. The ammeter has an internal resistance of $R_{Int} = 6\,\Omega$, and the value of your resistor is obtained from the graph. When the voltage across your resistor is adjusted to $V_R = \text{value given}$, what is the voltage drop across the internal resistance of the ammeter?

<u>CHECKLIST</u>

1) the spreadsheet with your data and formula view of your spreadsheet
2) graph with best-fit line, slope and intercept of best-fit line, and their uncertainties
3) answers to the questions
4) other than specified in the questions, NO sample calculations are required

USING UNCERTAINTIES TO COMPARE DATA AND EXPECTATIONS

One important question is whether your results agree with what is expected. Let's denote the result by r and the expected value by e. The ideal situation would be $r = e$ or $r - e = 0$. We often use Δ (pronounced "Delta") to denote the difference between two quantities:

$$\boxed{\Delta = r - e} \qquad \textbf{(1)}$$

The standard form for comparison is always *result - expected*, so that your difference Δ will be negative if your value is lower than expected, and positive if it is higher than expected.

This comparison must take into account the uncertainty in the observation, and perhaps, in the expected value as well. The data value is $r \pm \delta r$ and the expected value is $e \pm \delta e$. Using the addition/subtraction rule for uncertainties, the uncertainty in $\Delta = r - e$ is just

$$\boxed{\delta\Delta = \delta r + \delta e} \qquad (2)$$

Our comparison becomes, "is zero within the uncertainties of the difference Δ?" Which is the same thing as asking if

$$\boxed{|\Delta| \leq \delta\Delta} \qquad (3)$$

Equation (2) and (3) express in algebra the statement "*r* and *e* are compatible if their error bars touch or overlap." The combined length of the error bars is given by (2). $|\Delta|$ is the magnitude of the separation of r and e . The error bars will overlap (or touch) if r and e are separated by less than (or equal to) the combined length of their error bars, which is what (3) says.