PHY 252 Summer 2014 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, two digital multimeters and five banana plug cables.

Theory

One of the fundamental laws describing how electrical circuits behave is Ohm's law. According to Ohm's law, there is a linear relationship between the voltage drop across a circuit element and the current flowing through it. Therefore the resistance R is viewed as a constant independent of the voltage and the current. In equation form, Ohm's law is:

$$V = I \times R \qquad (1)$$

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. If the voltage is held constant, then the current is inversely proportional to the resistance.

Procedure

1. At the beginning of your practical lab, you will be told which resistor to use along with its color code. Record the color code in Data Table 1 and use Table 1 below to find the four numerical values corresponding to your color code. Record these four numerical values in Data Table 1. Then, use Excel to calculate the resistance and uncertainty (δR) of your resistor. If the numerical values corresponding to your resistors color code are A, B, C and D then,

$$R = AB \times 10^{C} \quad \text{and} \quad \delta R = R \times \frac{D}{100}$$

Table 1 Resistor Color Codes

Color	1st Digit	2nd Digit	Power of 10	Multiplier	Tolerance
Black	0	0	0	1	-
Brown	1	1	1	10	-
Red	2	2	2	100	-
Orange	3	3	3	1,000	-
Yellow	4	4	4	10,000	-
Green	5	5	5	100,000	-
Blue	6	6	6	1,000,000	-
Violet	7	7	7	10,000,000	-
Gray	8	8	8	100,000,000	-
White	9	9	9	1,000,000,000	-
Gold	-	-			5%
Silver	-	-			10%
None	-	-			20%

2. 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 which should be on and in the DC voltage setting, and A represents the ammeter, which should be on and in the DC mA setting, both appropriately connected). **Do not turn the power supply on until your TA has approved your circuit and your meters.** Four of the twenty points on this lab are assigned to correctly wiring this circuit and connecting the V and A meters. Points here are all or none, if anything is incorrect, zero points for this part; this includes the wires the resistor in place, the wires properly connected, the meters turned on (not the power supply), set to measure DC current for the ammeter and DC voltage for the voltmeter. If the circuit is not correctly wired, your TA will wire it for you and then you can proceed with the rest of the lab.

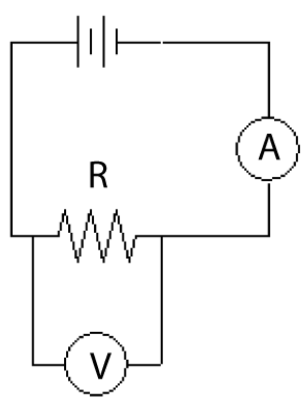

Figure 1

3. Turn on the power supply and increase the voltage until the voltage on the power supply reads 3.0 volts Record the voltage on the voltmeter (one of the two digital multimeters) and the current on the ammeter (the other multimeter) in Table 2.

4. Repeat step 3 for V= 6.0 volts, 9.0 volts, 12.0 volts and 15.0 volts.
5. Import your data into Kaleidagraph and construct a graph of the voltmeter 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 or comments on this graph.

Questions

1. What is the nominal resistance of your resistor that you obtained from the color code and its uncertainty?
2. From the slope of your graph, what is the resistance of your resistor and its uncertainty?
3. Discuss the consistency of the resistance obtained from the color code with the resistance obtained from your graph.
4. The digital multimeter when used as a voltmeter has an internal resistance of 10 MegaOhm (10^7 Ω). If the current through the resistor in your circuit is 1 mA, what is the voltage drop across the voltmeter? What is the current through the voltmeter? (To answer this problem, use the value of your resistance obtained from your graph.)

<u>CHECKLIST</u>

1) The spreadsheet with your data and formula view of your spreadsheet.
2) Graph with best-fit line, equation of best-fit line and uncertainties. NO comment on graph is required.
3) Answers to the questions.
4) Other than specified in the questions, NO sample calculations are required.

Any formulae, definitions or errors needed for the practical lab are provided for you. No notes or other aids (such as the internet) may be used during the practical.

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 use D to denote the difference between two quantities:

$$\boxed{\mathbf{D} = \boldsymbol{r} - \boldsymbol{e}} \tag{1}$$

The standard form for comparison is always *result - expected*, so that your difference D 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

$$\boxed{\delta \mathbf{D} = \delta \mathbf{r} + \delta \mathbf{e}} \tag{2}$$

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

$$\boxed{|\mathbf{D}| \leq \delta \mathbf{D}} \tag{3}$$

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). $|D|$ 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.