PHY252 Spring 2014 Practical Lab #1: Ohm's Law

Objectives

- Construct a DC circuit 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.

Documents

- This document of instructions (a copy will be provided at the lab).
- A preformatted spreadsheet on the lab computer for data entry (a copy is reproduced for you at the end of this document).
- A worksheet containing the questions (a copy will be provided at the lab).

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. Then, use Excel to calculate the resistance and uncertainty (δR) of your resistor. If the numerical values corresponding to your resistor's color code are A, B, C and D then,

$$R = (10 * A + B) \times 10^C \quad \text{and} \quad \delta R = R \times \frac{D}{100}$$

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 banana plug cables, digital multimeters, power supply, resistor and breadboard, construct the circuit shown in Figure 1 below. The V represents the voltmeter, which should be in the DC voltage setting, and the A represents the ammeter, which should be in the DC mA setting. **Do not turn the power supply on until your TA has approved your circuit and your meters.** Four out of 20 points on this lab are assigned to wiring this circuit. If the circuit is not correctly wired, your TA will deduct points (up to a maximum of 4) and then wire it for you so you can proceed with the rest of the lab.

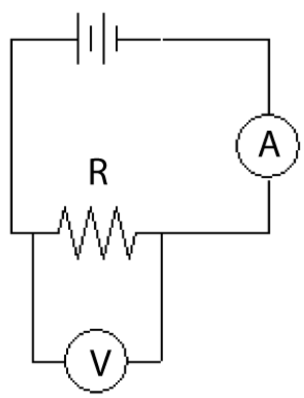

Figure 1

3. Turn on the power supply and increase the voltage until the voltmeter (one of your multimeters) reads 3.0 V. Record the current on the ammeter (the other multimeter) in Data Table 2.
4. Repeat step 3 for voltages of 6.0 V, 9.0 V, 12.0 V and 15.0 V.
5. Import your data into Kaleidagraph and construct a graph of the 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.
6. Answer the questions on the worksheet.

Questions

1. What is the nominal resistance and uncertainty of your resistor that you obtained from the color code?
2. From the slope of your graph, what is the measured resistance and uncertainty of your resistor?
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 MΩ (10^7 Ω). (Use the resistance obtained from your graph to answer the following questions.)
    a. If the current through the resistor in your circuit is 1 mA (10^{-3} A), what is the voltage drop across the voltmeter?
    b. What is the current through the voltmeter?

CHECKLIST

1) The spreadsheet with your data and formula view of your spreadsheet.
2) Graph with best-fit line and equation of best-fit line with uncertainties.
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 often use Δ (pronounced "Delta") to denote the difference between two quantities:

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

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

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

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

$$|\Delta| \leq \delta\Delta \qquad (3)$$

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.

Copy of the Ohm's Law practical lab spreadsheet:

Ohm's Law

Measured Quantities:
Calculated Quantities

Data Table 1

	A	B	C	D (%)
Resistor labels from table				
Resistance from color code R =		±		(insert units)

Data Table 2

Voltage (insert units)	Current (insert units)

Results from graph

Slope =	±	(insert units)