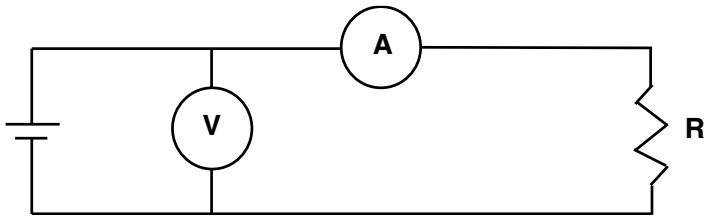
Ohm's Law

Introduction

The purpose of this lab is to make measurements which can be compared with the predictions of Ohm's law. Ohm's law relates the current through a device to the voltage across it. Ohm found that, for many materials, the current is directly proportional to the voltage. Ohm's law is usually expressed in the following form:

$$V = IR$$

Here, V is the voltage (also called the potential difference) between the ends of the device, and I is the current through it. The proportionality constant R is called the resistance. You will make voltage – current measurements on several objects called resistors to see if the voltage and current can be related by Ohm's Law.



Procedure

The circuit above, consisting of a power source, a voltmeter, an ammeter, and a resistor, will be used to make the measurements. The power source (indicated as a battery in the diagram) is a variable voltage power supply. The voltmeter (the circle with the V in it) is an analogue voltmeter that can make voltage measurements in two ranges: 0-8 volts, and 0-100 volts. The ammeter (the circle with the A) is a digital multimeter (DMM).

First, turn off the power supply and turn both voltage knobs fully counterclockwise (zero voltage). Select one of the resistors (R1, R2, or R3), write down the one you used, and use the digital multimeter to measure its resistance – look for the Ω measurement modes. Record the resistance, as you will need it later.

Next, connect the components together to form the circuit as shown above. Connect the analogue voltmeter to make measurements below 8 volts. Use the milliamp input on the DMM and set it to the 2 mA mode or the closest available mode - some meters may have different modes. Your instructor will be able to help you with making connections and configuring the DMM. **Have your circuit checked by the instructor before turning on the power supply!**

Turn the power supply and DMM on. Set the power supply to zero volts and record the current read out by the DMM and the voltage read out by the voltmeter. Since the voltmeter is analog, be sure to estimate the voltmeter to the nearest one-tenth of the smallest scale division. Increment the voltage on the power supply by 1.0 volts and record the new voltage read out by the voltmeter and new current read out by the DMM. Continue incrementing the power supply voltage by 2.0 volts and recording data until you reach 20.0 volts. As you increase the voltage,

you will eventually have to switch the voltmeter to the 200 volt range and switch the DMM to measure larger currents (likely the 20 mA or 40 mA mode). Organize your data in a table.

Repeat this procedure for the other two resistors - be sure to turn off the DMM and the power supply before changing connections. Make a separate data table for each configuration.

Analysis and Results

Make a scatter plot (don't connect the data points) of I (the dependent variable - on the y axis) vs. V (the independent variable - on the x axis) for each resistor. Ohm's law says these plots should be straight lines with slope equal to $1/R$. Do a linear fit on each plot and record the slope and y-intercept and their standard errors (this information is given by the LINEST function in Excel or Google Sheets). Determine the value of R from the slope of your plot and do an error propagation to determine the uncertainty. In your report, clearly state whether your data is consistent with Ohm's Law (that is, to the best of your judgement, state whether the data is consistent with a linear trend). Also, clearly report both resistance measurements for each resistor – the measurement made directly with the DMM and the measurement from the slope of the plot. Discuss whether the resistance measurements are consistent within uncertainties.

Formal Lab Report Guidelines

You will write a formal lab report for this lab. Below, I will list the sections required in the report and the data, plots, and calculations that you need to include. Refer to the general lab report guidelines on Brightspace for more details on what to include in each section.

Heading: Your full name, your partners' full names, the date, and a title which includes the name of the experiment.

Introduction: Describe the goal(s) of the lab and introduce any theory or models that you will use or test to achieve those goals.

Procedure: Describe the apparatus and how you collected the data. Be sure to include any important details specific to your data collection that are not described in the lab handout.

Raw Data: Three organized data tables, one for each resistor configuration, of current and voltage measurements. Voltages should be in 2.0 V increments from 0 V up to about 20 V. Also include the DMM resistance measurement for each resistor.

Plots: Include the three I vs. V plots you made. Be sure they have titles, axis labels with units, and linear trendlines.

Data Analysis: Explain how you calculated the value of R and its uncertainty from the slope measurement. Show a sample calculation for one of the resistors.

Results and Discussion: Clearly report both measurements of R with uncertainties for each resistor. Discuss whether the resistance measurements are consistent. State whether each resistor behaved consistently with Ohm's Law.

Conclusions: One paragraph that summarizes the important results and discoveries made in this lab.