

Ohm's Law

Purpose

In this lab we will quantitatively investigate Ohm's Law.

Equipment Needed

| | |
|-----------------------------|-------------------|
| Pasco AC/DC Electronics Lab | Computer |
| Digital Multi-Meter (2) | Lead, Banana Jack |
| Battery Eliminator | |

Introduction

The German physicist Georg Simon Ohm made the discovery that for certain materials – known as Ohmic materials- that there is a simple relationship between the potential difference across the material and the current that flows through the material. This relationship –known as Ohm's Law- says that the current is proportional to the potential difference across the material. If we let the potential difference be denoted by V and let the current be denoted by I , then we can write Ohm's Law as

$$I = \left(\frac{1}{R} \right) V .$$

More typically Ohm's Law is written as

$$V = IR .$$

The quantity R is called the resistance of the material. It gives a measure of how easily current flows through the circuit. The lower the resistance for a given potential difference, the more current that will flow in the material. In the experiment we will apply varying potential differences across several carbon film resistors and measure the resulting current. A graph of current versus potential difference should yield a straight line.

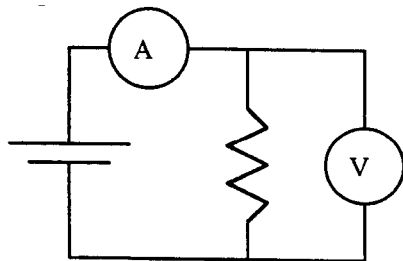
Procedure

Begin by measuring with the digital multimeter the value of each of the three resistors that you have chosen. Don't assume that any values indicated by the colored ring codes on the resistors are correct. No resistor should be less than 80Ω . Be sure to record your values so that you know which value corresponds to which resistor and keep them separated so that you can tell them apart. These will be your measured resistor values R_{meas} .

Next, construct the circuit shown in Figure 1. Note that the ammeter needs to be included as an integral element of the circuit. Be sure to make your resistance measurements **before** connecting the circuit.

1. Make sure at this point that the power supply is unplugged and also that the switch on the power supply is in the off position.
2. Set the voltmeter on the 20 VDC scale and set the ammeter on the 200mA scale.
3. Run a wire from the (+) terminal of the power supply to the (+) side of the ammeter.
4. Run a second wire from the (-) side of the ammeter to the resistor on top of the circuit board.
5. Run one more wire from the other side of the resistor to the (-) terminal of the power supply.

Figure 1 Circuit schematic for verification of Ohm's Law



6. Plug in the power supply, set the voltage to the lowest setting. Do a rough calculation of the current expected. (Watch the decimal points.)

Caution: If you set the ammeter in too low a range you will blow the fuse. If your not sure as your instructor.

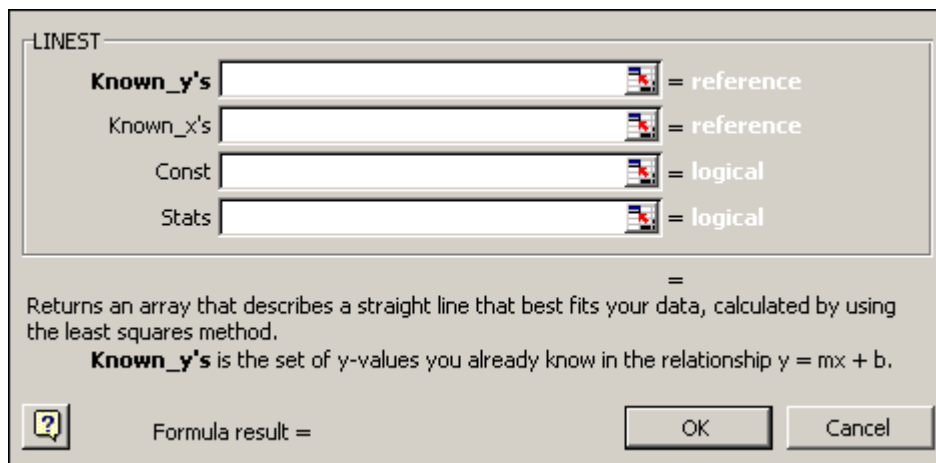
7. Turn on the switch on the power supply.
8. Use the DMM set in the 20 VDC setting and measure the potential drop across the resistor. Record the potential difference across the resistor
9. Measure the corresponding current flowing through the circuit in a data table.
The voltage drop across the resistor should be approximately equal to the setting on the power supply. If it isn't or if the ammeter indicates no current flow, contact your instructor.
10. If the circuit appears to be operating correctly, then switch the power supply to the next higher setting and measure the potential drop across the resistor and record it along with the corresponding current in your data table.
11. Repeat your procedure for the three more settings on the power supply, for a total of five data points.
12. TURN OFF THE P.S. and swap out the 1st resistor for your 2nd resistor.
13. TURN THE P.S. BACK ON and repeat the same set of measurements of voltage and current that you have just made for the 1st resistor.
14. Be sure to record your values in a separate data table from the previous set of measurements.
15. Finally, swap out the 2nd resistor for your 3rd resistor. Remembering to TURN OFF THE P.S. before hand.
16. Take a complete set of data points of voltage and corresponding current for this final resistor and record it in a separate data table.

Data Analysis

We would like to verify that each of the resistors obeyed Ohm's Law. On coordinate systems we will construct separate graphs for each of the sets of data points we have recorded for the three resistors. Graph the **voltage** vs. the **corresponding current**. Remember, it is always y vs. x . Writing Ohm's Law in the form $V = RI$ (as $y = mx$ where slope m is synonymous with R) we see that our data should lie on a straight line and that the slope of our line should be the resistance of the resistor. This will be the

experimental value of your resistance R_{exp} . From Ohm's Law, we expect the best fit line to pass through the origin because the y-intercept is 0. Experimentally, we may not observe this due to our neglecting of things such as contact resistance and internal resistance. For each set of data points, use MS Excel to draw the best-fit line (trendline) that goes through your data, and determine the slope of the line from the program. **Do not** force it to go through the origin. Be careful about the units you use.

To clarify, at this point you should have three (3) graphs, each with separate sets of data points on it. Individual trendlines should be drawn through each set of data points on your graphs, and Excel will calculate the slope for each of the three trendlines. We also desire to estimate the uncertainty in these R_{exp} values (i.e. the slopes). To calculate these values we will need to use the Excel LINEST Worksheet function. This can be called by clicking on the menu item Insert > Function. If it doesn't show up under the "Most Recently Used" list then search under the Statistics section.



The image shows the 'LINEST' dialog box in Microsoft Excel. The dialog box has a title bar 'LINEST'. Inside, there are four input fields with labels to their left: 'Known_y's', 'Known_x's', 'Const', and 'Stats'. Each field has a small icon to its right. To the right of each field is an equals sign followed by a label: '= reference' for 'Known_y's', '= reference' for 'Known_x's', '= logical' for 'Const', and '= logical' for 'Stats'. Below these fields, there is a line with an equals sign followed by a text description: 'Returns an array that describes a straight line that best fits your data, calculated by using the least squares method.' Below this, there is a line with the text: 'Known_y's is the set of y-values you already know in the relationship $y = mx + b$.' At the bottom left, there is a question mark icon. At the bottom center, there is a label 'Formula result =' followed by a blank space. At the bottom right, there are two buttons: 'OK' and 'Cancel'.

Compare measure and experimental values of the resistance of each resistor by calculating the percent difference between the two (using the average value of the two for the denominator).

Report Format

Your lab report should include your graph (either on graph paper or computer generated), the resistance for each resistor determined from your graph, and a calculation of the percent difference between the value of the resistor measured by the DMM and the value determined from the slope. You should also answer with complete sentences any questions posed in the hand out and discuss any sources of error.