General Physics II Lab (PHYS-2021)
Experiment ELEC-2:
Ohm's Law

1 Equipment

	Included:	
1	Resistive/Capacitive/Inductive Network	UI-5210
1	Short Patch Cords (set of 8)	SE-7123
1	850 Universal Interface	UI-5000
1	PASCO Capstone	

2 Introduction

The purpose of this experiment is to verify Ohm's Law. This experiment requires a formal Lab Report as described in the "Lab Report Format" document.

3 Theory

In metals and some other materials (in particular, commercially manufactured resistors), one finds experimentally that the voltage drop, V, across the material is directly proportional to the current, I, through the material (provided the temperature remains relatively constant):

$$V \propto I\,,$$

which is referred to as Ohm's Law. It is convenient to define a proportionality constant called the resistance (unit: Ohm [Ω] = V/A) such that

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

A resistor generally means a device that obeys Ohm's Law (many devices do not) and has a resistance R. Two (or more) resistors can be connected in series (as in Figure 1), or in parallel (as in Figure 2). Resistors could also be connected in a series/parallel circuit like Figure 3. Resistor circuits will be explored in Experiment ELEC-3 next week.

In the circuit figures on the next page, the resistor labels (R_1, R_2, and R_3) do not correspond to the resistor labels on the circuit boards. On your circuit resistor boards, the 3.3 kΩ resistor is R2, and the 1.0 kΩ resistors are R3 and R4.

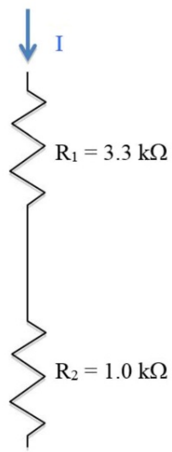


Figure 1: Series

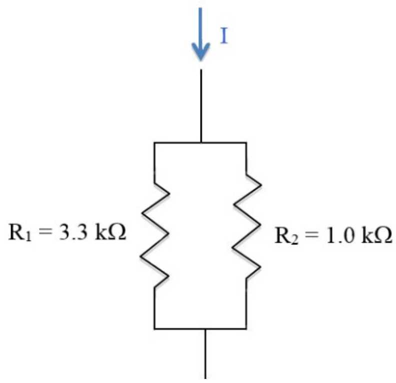


Figure 2: Parallel

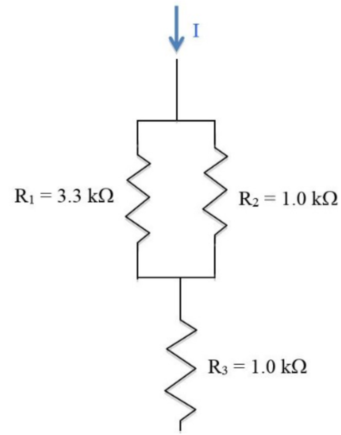


Figure 3: Series/Parallel

4 Setup/Procedure

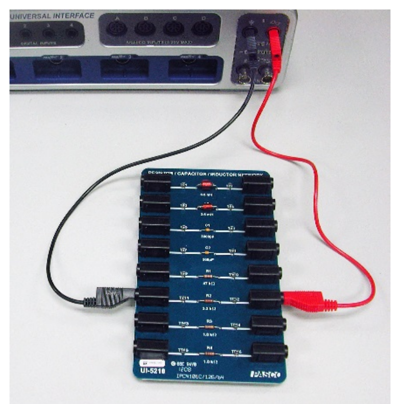


Figure 4: Ohm's Law Setup

1. Setup the circuit shown in Figure 4 using the 3.3 kΩ resistor.
2. In PASCO Capstone, open the Hardware Setup and click on Signal Generator #1 and select the Output Voltage Current Sensor. Set the Common Sample Rate to 100 Hz.
3. Click open the Signal Generator at the left of the screen. Set Output 1 for a DC Waveform with a DC Voltage of 1V. Click On.
4. Open the Calculator and create the following calculations:

```
Iavg = avg([Output Current])*1000
     Units of mA
```

5. Create two digits displays and select the Output Voltage and the Average Current (i.e., `Iavg`).
6. Create a table with four columns: Create user-entered data sets called "Voltage" with units of V, "Zero Current" with units of mA, and "Measured Current" with units of mA.
7. Then, go to the calculator and define True Current as:

```
True Current = [Measured Current]-[Zero Current]  Units of
mA
```

8. Following this, go to the 4th column of your table and select "True Current" from your options. The order is important. Your table should look like the one on the next page:

Table I: Voltage vs. Current

Voltage (V)	Zero Current (mA)	Measured Current (mA)	True Current (mA)

9. The 850 Universal Interface can read currents with a resolution of about 0.01 mA. However, this is a small current and the instantaneous value fluctuates quite a bit. Fortunately, by taking an average over several seconds, we get a value with a precision of 0.01-0.02 mA. However, the noise can produce a systematic error up to about 5 mA with a variation across the range of almost 1 mA, so we must calibrate the system to get accurate values (±0.1 mA due to variation in zero noise).
10. Calibration Run: Unplug the red lead from the 850 Universal Interface. The current should now be zero for all voltage, but is not. Click RECORD. Wait a few seconds until the Average current reading stop drifting. Record the Average Current value in the Zero Current column of Table I. If the Actual Voltage is different from the Voltage shown in the first column of the table, change the table to match the actual voltage. Click STOP.
11. Change the Signal Generator to 3V and repeat Step 10. Repeat again for voltages of 6 V, 9 V, 12 V, & 15 V.
12. Set the Signal Generator back to 1 V.
13. Experiment Run: plug the red lead back into the 850 Output 1 jack. Repeat Steps 10 & 11 except record the values for Average current in the Measured Current column. The True Current is the difference between the Measured Current and the Zero Current.
14. Turn off the Signal Generator.

GENERAL COMMENTS:

a. Using "`Iavg`" for the Average Current provides a relatively constant value.

b. Subtracting off the Zero Current is important. It cannot be neglected. Due to the systematic error in the current, it can actually sometimes read negative. If you subtract off the Zero Current, you will get a True Current that is positive, and that scales properly with Voltage.

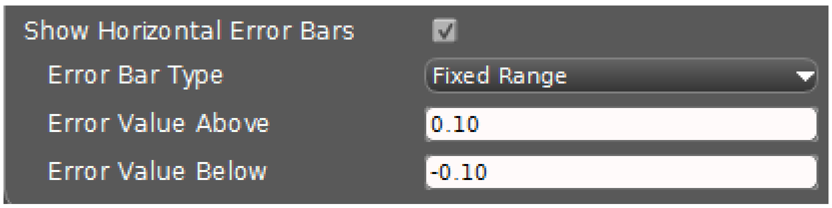
c. When making the plot, to put in the horizontal error bars, you will select the gear and then click on Active Data appearance, and then scroll down to the Show Horizontal Error

Bars Entry reproduced in the writeup (don't forget to check the Show Horizontal Error Bars box).

d. You have the option of either copying the data presented on the computer screen by hand, or sending the data table to the Departmental Printer in Brown Hall 262. If you plan to send any output to this printer, you will have to first log in to the wireless on the laptop. Your instructor will show you how to do that.

5 Analysis

1. Create a graph of Voltage (user-entered data) vs. True Current.
2. Select a Linear fit.



3. Open the properties on the graph and select to show horizontal error bars for a fixed range of ± 0.1 mA. This is the uncertainty in the True Current which was achieved by calibrating the system. The uncertainty in the Voltage is much too small to show.
4. The uncertainties in the slope and intercept arise from the spread of the data points but do not include the uncertainty in the True Current. This means that the quoted uncertainties are too small. You can get a good approximation to the actual uncertainties in slope and intercept (without elaborate math) by holding a transparent ruler up to the screen (or printing off the graph) and seeing how much you can vary the slope and intercept with a straight line that still fits the data (including error bars) reasonably well.

6 Conclusions

1. How well does your data support Ohm's Law? Explain fully!
2. What is the physical meaning of the slope of the Linear Fit to the data on the Ohm's Law graph? Hint: What are the units of the slope?