

# PHYSICS 1040L LAB

## LAB 2: OHMS LAW LAB

Print 1 copy of the report page to start your lab report. Print 2 copies of the data page.

**OBJECT:** To study Ohm's law for DC circuits, to learn basic construction and measurement of electric circuits, to learn curve fitting and basic error analysis.

**APPARATUS:** Variable DC voltage supply, resistor, connecting wires, analog ammeter, digital multimeter, and computer with current/voltage probes.

**THEORY:** Electrical current is the amount of charge passing by a given point in a conducting path (circuit) per unit time:

$$I = \Delta Q / \Delta t \quad (1)$$

The unit of current is the Ampere, which is equal to a (Coulomb/second) and, although it is defined by other relations, a current of one ampere exists in a wire if approximately  $6.28 \times 10^{18}$  or **6,280,000,000,000,000** electrons (charge of one Coulomb) flow through a given cross-section of wire in one second.

It is agreed for convenience that the direction of the current is the same as the direction of movement of positive charges in electric field. In a metallic conductor, such as a wire, the only mobile particles are negatively charged electrons, which move in a direction opposite to that chosen for the conventional current.

The fundamental relationship among the three important electrical quantities current, voltage, and resistance was discovered by Georg Simon Ohm.

Georg Simon Ohm (16 March 1789 – 6 July 1854) was a [Bavarian](#) (German) [physicist](#) and [mathematician](#). As a high school teacher, Ohm began his research with the new [electrochemical cell](#), (Is a device used for generating an [electromotive force](#) [\(voltage\)](#) and current from [chemical reactions](#) (A Battery), invented by Italian scientist [Alessandro Volta](#).

Using equipment of his own creation, Ohm found that there is a direct proportionality between the potential differences ([voltage](#)) applied across a conductor and the resultant [electric current](#). This relationship is known as [Ohm's law](#).

The relationship and the unit of electrical resistance were both named for him to commemorate this contribution to physics.

These electrical quantities can be difficult to understand, because they cannot be observed directly. To clarify these terms, some people make the comparison between electrical circuits and water flowing in pipes. Here is a chart of the three electrical units we will study in this experiment.

Electrical Quantity	Description	Units	Water Analogy
Voltage or Potential Difference	A measure of the Energy difference per unit charge between two points in a circuit.	Volts (V) Unit is named after <a href="#">Alessandro Volta</a>	Water Pressure
Current	A measure of the flow of charge in a circuit.	Amperes (A) It is named after <a href="#">André-Marie Ampère</a> (1775–1836), French mathematician and physicist, considered the father of electrodynamics.	Amount of water flowing
Resistance	A measure of how difficult it is for current to flow in a circuit.	Ohms ( $\Omega$ ) Unit named after Ohm.	A measure of how difficult it is for water to flow in a pipe.

**Ohm's law states as follows: If the temperature and other physical conditions of a metallic conductor are unchanged, the ratio of the potential difference across the conductor (V) to the current (I) is a constant. This constant ratio (R) is the resistance of the conductor.**

$$R = V/I \quad (2)$$

**If potential difference is measured in Volts and current is in Amperes, resistance will be in Ohms (unit of resistance, equal to one Volt per Ampere).**

**The resistance of a metallic conductor depends only on its length, the area of cross-section, the material of the conductor and its temperature. It does not depend on either V or I. At a given temperature**

$$R = \rho L/A, \quad (3)$$

**where  $\rho$ , L and A are, respectively, resistivity, the length, and cross sectional area of the resistor. A resistor is called a "linear device", as opposed to a "non-linear device" such as diode. A diode is a device that does not obey the linear Ohm's law even without significant change in temperature. In this experiment we will study a regular resistor with constant resistance only.**

## PROCEDURE

1. Connect a circuit as shown in Fig.1 or Fig. 12

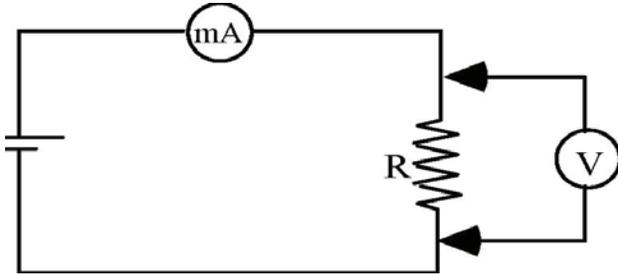


Figure 1 Circuit Diagram

Note: The voltmeter does not have to be connected to the circuit. You can measure the voltage across any two points by touching the points with the two leads of the voltmeter. See Figure 2.

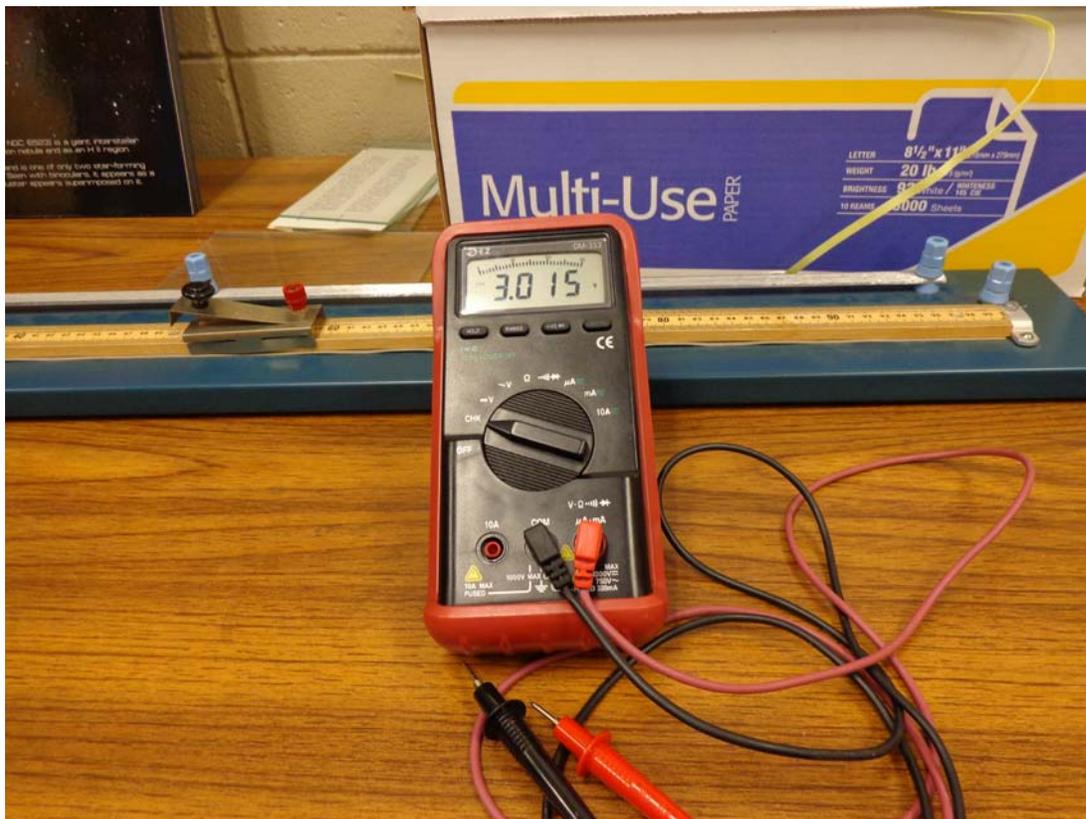


Figure 2: CE Brand Multimeter.

Note: The Multimeter can be used to measure many electrical quantities including AC and DC Voltages, AC and DC currents and resistance. We will be using the multimeter to measure DC voltages in the manual part of this experiment.

Figure 3: Symbol for DC Voltage setting on the front of the multimeter.



**2. Manual experiment: Record the value of the resistor in the data table. Measure the current for 12 different voltages, with the increment of 1V (See Fig. 8). Record the current and voltage in your data table. Record the instrumental error in your measurements. The instrumental error is taken as  $\pm 1/2$  of the smallest division on the scale of the analog device, and  $\pm 1$  in the lowest digit for the digital device.**



Figure 4: Three Range Ammeter. Note the three different Red (+) connectors and the Black (-) output. Also note the three different scales that match the three Red connectors.

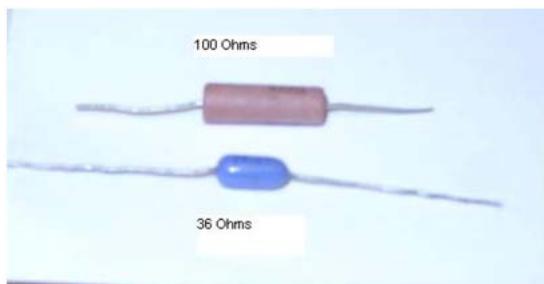
Figure 5: 2 of these Alligator Clips are used to connect the resistor into the circuit.



Figure 6: Banana Plug wires. Note how they can be plugged into the connectors on the ampmeter as well as into the alligator clips.



Figure 7: Example of some resistors. Yours might not look like the ones here, but the format is the same.



**Figure 8: PASCO Variable voltage Power Supply**

**3. Computerized experiment: Use a computer with a voltage sensor and a current sensor in place of the voltmeter and the current meter to perform the same experiment outlined above. The data will be automatically taken and plotted (See computer set-up). Use curve fit to obtain the resistance. Your instructor will tell you about the most recent version of the software in operation, and where to find the program for this experiment. The software is frequently updated, but should be pretty much self explanatory. You need to collect data and use the computer program to plot your data and do a curve fit. Each person in the Lab Group will print out a copy of the graph to include in their lab report. Also record the fitting parameters on your data page.**

**Computer set-up (as of FALL 2011 – Vernier 3.8.\*)**

- 1. On the desktop OPEN Vernier 3.8.3.**
- 2. In the program menu click FILE – OPEN –**
- 3. Choose Physics with VERNIER – Exp 22 Ohm's Law from the list of experiments.**
- 4. A graph of potential vs. current will be displayed. The Meter window displays potential and current readings.**
- 5. 2. The program will tell you where to plug the current probe and the voltage probe into the blue LabPro interface box. Current probe should go into Channel 1; voltage probe should go into channel 2.**

Figure 9: Vernier Differential Voltage probe. Note: you might have the simpler voltage probe. See Figure 10



Figure 10: Vernier Voltage Probe



Figure 11: Vernier Current Probe. Note Red and Black connectors

6. With the power supply turned off, connect the power supply, resistor, wires, and clips as shown in Figure 1. Take care that the positive lead from the power supply and the red terminal from the Current & Voltage Probe are connected as shown in Figure 1 and 12. Note: Attach the red connectors electrically closer to the positive (RED) side of the power supply.

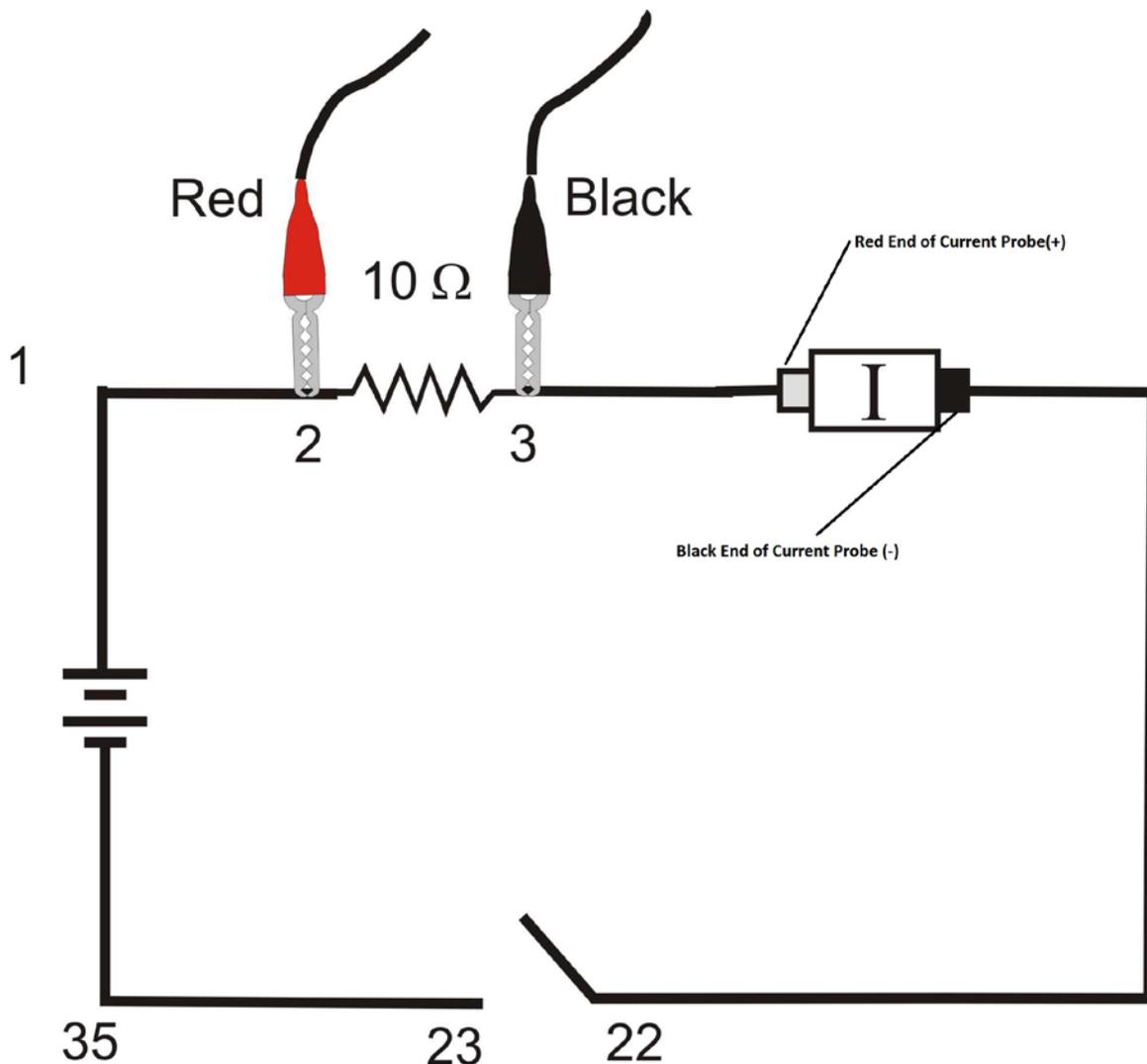


Figure 12: Circuit Diagram No. 2. However will not be using a switch {22 & 23}

7. With the power supply turned off you need to zero all sensors.
8. Click ZERO button on the toolbar.
9. A dialog box will appear. Click Zero all sensors.
10. This sets the zero for both probes with no current flowing and with no voltage applied.
11. . Make sure the power supply is set to 0 V.
12. Turn the power supply on and set the voltage to 0.5V
13. Click COLLECT button on the toolbar.
14. Monitor the voltage and current.
15. When the readings are stable click the KEEP button.
16. Increase the voltage on the power supply by approximately 0.5 V to 1.00V.

17. When the readings are stable click KEEP button.
18. Repeat this process until you reach a voltage of 5.0 V. **DO NOT GO OVER 5V**
19. Click STOP button and set the power supply back to 0 V.
20. Look at the graph. Are the voltage and current proportional? Adjust the scale, so the line is more or less diagonal.
21. Click the “ANALYZE” menu.,
22. Choose “CURVE FIT”.
23. Choose a Linear fit  $\{y = mI + b\}$  for your data.
24. Click on the button “Try Fit” and the fitting parameters will appear in the little white boxes.
25. Click on the OK Button and a window will pop up over the Voltage vs. Current graph giving the parameters for the best fit equation to your data. The best fit straight line graph from the collected data will display on the screen.
26. Record the slope and y-intercept of the regression line in the data table, along with their units and uncertainties.

#### DATA ANALYSIS:

1. Plot the voltage versus current data **BY HAND**. Use linear graph paper. (The green graph paper you have seen in previous labs or something similar). The data is from the data table for part 1.
2. Find the slope, which is experimental value for the resistance.
3. Fill out your data table: Calculate the resistance for each trial, the average resistance  $R_{avg}$  and the deviation for each trial  $\Delta i = |R_i - R_{avg}|$
4. Calculate standard deviation  $\sigma = [\sum (\Delta i)^2 / (n-1)]^{1/2}$  where n is the number of data points, and  $\sigma$  is the random error.
5. As you can see, the random error can be reduced to as small as your time allows.
6. You can make  $\sigma$  smaller if you to increase the number of measurements. Note: Average resistance and its standard deviation can be computed using EXCEL or using your calculator if it has statistics capabilities
7. . Compare you results with the results of computerized experiment. Are they reasonably close?
8. Show the difference between the two results by calculating a % difference.

**Reminder: Check you math, check the units, check your graph, do not forget to follow the format for your lab report (see syllabus).**