

Lab 3

Ohm's Law and Resistors

What You Need To Know:

The Physics One of the things that students have a difficult time with when they first learn about circuits is the electronics “lingo”. The lingo and the circuit concepts can be very intimidating at first. It’s almost like learning a new language. So, as the concepts are discussed below, some of the associated lingo will be thrown in as well.

In the Equipotential Surfaces lab that you did last week, you were using a voltmeter to measure the potential on the conductive paper. Actually, you were measuring the *potential difference* between a point on the conductive paper and the negative pushpin. Another word for potential difference is *voltage*. When you measure the voltage, it is always the *difference* in potential between one point in a circuit and another point. You can use a voltmeter to measure the voltage of an element [a resistor, a battery, etc.] in a circuit. A voltmeter has two wires, or leads, that come from it. One lead is placed on one side of the circuit element and the other lead is placed on the other. You can then measure the potential difference, or the voltage, or the potential “drop” of the element. This is the reason why, in electronics lingo, the voltage is said to be measured “across” a circuit element.

A potential difference in a circuit will cause the free electrons in the metal of the wires to flow. The electrons will always move towards a higher potential. A high potential can be thought of as positive charge. Since electrons are negative they will be attracted to the high potential and flow. This flow of electrons is called a *current*.

To control the flow of the current in a circuit, you use circuit elements called *resistors*. Current is said to flow “through” the resistors. When current flows through a resistor it causes a voltage *across* the resistor. Another way to state this is that the current causes a difference in potential from one side of the resistor to the other. A common mistake that students make is in thinking that the **voltage** flows around the circuit. This is incorrect. It is the **current** that flows around the circuit. The voltage is a comparison between two points in the circuit.

There is a very specific relationship between the voltage and current of a resistor. This relationship is defined by an equation called Ohm’s Law ...

$$V = IR$$

V is the voltage across the resistor (in volts, V)
I is the current through the resistor (in amperes or amps, A)
R is the resistance of the resistor (in ohms, Ω)

Ohm’s Law says that the voltage is directly proportional to the current in a resistor. If you were to make a graph of Voltage vs. Current for a resistor, you would get a straight line with a slope. If a circuit element follows this behavior, then it is said to be Ohmic. If the graph is not linear, then it is Non-Ohmic.

Color Bands Most resistors have four color bands around them. Each color represents a number that signifies the resistance of the resistor. **See the Color Band Chart.** There are many mnemonics to help you memorize the chart but most are crude and will not be repeated in the family-style environment of this lab manual.

Color Band Chart

BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
GRAY	8
WHITE	9
RED	2%
GOLD	5%
SILVER	10%

The way you decipher the bands is as follows: The first three bands tell you the value of the resistor and the last band tells you the tolerance, or accuracy, of the resistor. The easiest way to explain this is by example. **Figure 1** will be used as an example.

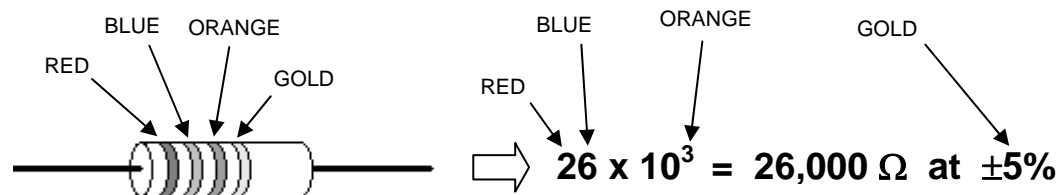


FIGURE 1 - A resistor and its value

The first two colors give you the first two digits of the resistor's value. The third number tells you the power of ten by which the first two numbers will be multiplied. The tolerance tells you that the resistor's real value will lie somewhere in between a certain percentage of the color band value.

Note: It is sometimes difficult to determine the color of a band. For example, some grays actually look brown. If you are not sure on a color, utilize the vast experience of your lab TA and ask.

What You Need To Do:

Equipment List

POWER SUPPLY
3 WIRES
2 ALLIGATOR CLIPS
2 RESISTORS
LIGHT BULB
VOLTAGE PROBE
CURRENT PROBE
DUAL CHANNEL
AMPLIFIER

Part 1 – The Setup Verify that every item on the **Equipment List** is on your lab table. Note that there are FOUR alligator clips; two coming from the voltage probe and two stand-alone ones. The first thing you are going to do is hook up your own circuit. Before you begin, make sure that the power supply is **TURNED OFF**. You'll be using **Figure 2** on the next page as a guide to set up the circuit. Do the following ...

A) The first thing you should do is set up the main line which starts at the power supply and ends at the power supply. (Worry about the alligator clips for the voltage probe **LAST**. See **Figure 2**.) To set up the main line, use the three wires, the two stand-alone alligator clips (**NOT** the alligator clips for the voltage probe coming from the Dual Channel Amplifier), the brown-bodied resistor, and the small box that has the plus and minus on it (current probe). **See Figure 2**. Use the stand-alone alligator clips on the ends of your wires and then attach the clips to either side of the resistor. [NOTE: It does not matter what color wire you use in any part of the circuit.]

B) Now attach the alligator clips for the voltage probe that are coming from the Dual Channel Amplifier. See **Figure 2**. Notice that the voltage probe is attached "across" the resistor and that the current probe is attached so the current will flow "through" the resistor first and then through the probe.

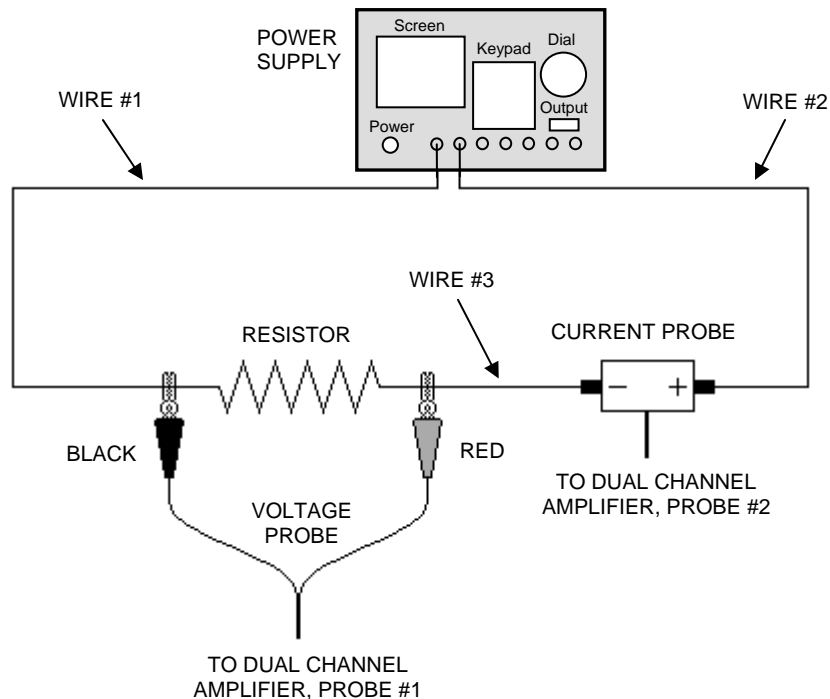


FIGURE 2 - Circuit diagram

C) Before continuing with the lab please have your TA check to make sure that the circuit is hooked up correctly. There is a chance that the equipment could be damaged if it is set up incorrectly.

NOTE: As a prelude to next week's lab, we would say that the voltage probe is in *parallel* with the resistor and that the current probe is in *series* with the resistor.

D) The Dual Channel Amplifier is hooked up to an interface that is connected to your computer. You will use the computer to measure the resistance of the resistor in the circuit. Open the file called **Ohm's Law** on the desktop of the computer. If any extra windows pop up about the connections make sure you push OK (not cancel). At this point, if you don't see a Potential vs. Current graph on your screen then grab your TA.

E) Your TA should go over how to use the power supply but here are the basics. Turn on the power supply using the lower left button called **Power**. See **FIGURE 2**. Give it a second for the software to boot. In order for the power supply to output a voltage, you have to push the **Output** button. See **FIGURE 2**. You can control the output voltage by using the **Dial** or by typing it on the **Keypad**. If you use the **Keypad**, push the **Vset** button, enter your voltage on the keypad, and then push **Enter**. If you are having trouble then grab your TA.

F) While increasing the voltage from the power supply, monitor the voltage and current values on the computer screen. You can find the meter window at the very bottom left-hand side of the screen. The voltage can be read where it says **Potential**. Make sure the meter values are increasing and decreasing as you increase and decrease the power supply voltage. If this is not the case, then grab your TA.

Part 2 – Finally, You Can Begin The first thing you should do is to make a copy of **Chart 1** on your paper. Using the **Color Band Chart** on the left, record the value of the resistance in the chart under Resistance Value.

Color Band Chart

BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
GRAY	8
WHITE	9

RED	2%
GOLD	5%
SILVER	10%

Resistor	Resistor Value	Trial #1 R-Value	Trial #2 R-Value	Average
Brown Body				
Blue Body				

CHART 1

- A)** Set the power supply to 0 V.
- B)** With the mouse, push the **Zero** button (a zero with a slash through it) on the computer screen. It is the button just to the left of the big green **Collect** button. Now click OK. This ensures that you have a zero baseline for your values.
- C)** Do the following ... click on the graph area then, **OPTIONS** → **GRAPH OPTIONS** → **AXES OPTIONS**. In this mode you can change the axis values on the graph.
- D)** For the X-Axis section set the Left to 0.0 and set the Right to 0.05. Press **DONE**. Feel free to adjust the axes throughout the lab so that you have a graph that is spread out across the screen.
- E)** Now you can start taking data. Push the green **Collect** button.
- F)** Increase the voltage on the power supply to 0.5 V. The voltage that shows on the meter on the computer screen might be a little different but just go with it.
- G)** When the reading is relatively stable (sometimes it jumps) push the **Keep** button which is to the right of the big red button (formerly green). The reading might still be jumping around but go ahead and push **Keep** anyway. A red dot will appear on the graph that corresponds to the voltage and current reading.
- H)** Repeat this process in increments of 0.5 V until you reach 5.0 V. **NOTE:** You do not have to push **Stop** and **Collect** each time you change your voltage. **NOTE²:** Make sure you take the data in numerical order. (i.e. don't go back and take data that you missed) You won't be able to use the Linear Fit option (coming up soon) if you jump around with your data.
- I)** Once you are done taking data, push the **Stop** button. **ALSO,** set the power supply to 0 V.

Question 1 Upon examining your graph, does a resistor follow Ohm's Law? How can you tell?

Part 3 – Slopes And Such Now you are going to analyze your graph. Push the Linear Fit button. It is one of the buttons at the top of the screen. The button has a slope line in it as well as a $R=$. This will analyze the graph for you and show the result in a little window. The window will show values for "m" and "b" which are, respectively, the slope and the y-intercept of the plot. Record the slope of the plot in the Trial #1 column in your chart.

Question 2 Explain in detail why the slope should be equal to the resistance value.

Part 4 – A Small Repeat Using the same resistor, take another set of readings. Start by hitting the big green button [this will also erase the last set of data for you] and then follow the same procedure that you did before.

Use the Linear Fit button to find the slope of the graph. Place this value in the chart under Trial #2. Also take your two Trial values, average them and put it in the chart.

Part 5 – A Big Repeat Now you will do the same process with a different resistor. Turn OFF the power supply. Remove the brown-bodied resistor and replace it with the light blue resistor. Repeat the entire process you just completed. Change the axis with the current to fit your data. Do two trial runs. Average the two trial values and put these values in the appropriate boxes in the chart.

Part 6 – Tolerance Now you are going to see if your average calculated resistance value falls within the specified tolerance of the resistor. Make a chart like **Chart 2**. Fill in the columns for which you already have data. Now, calculate the upper and lower limits of the range of values for the resistor. For example, if you have a gold banded resistor then take 5% [See Color Band Chart] of the color band value and add it back to the same color band value to calculate the upper limit. Does the average calculated value fall within the range? Answer in the appropriate box.

Color Band Chart

BLACK	0
BROWN	1
RED	2
ORANGE	3
YELLOW	4
GREEN	5
BLUE	6
VIOLET	7
GRAY	8
WHITE	9

RED	2%
GOLD	5%
SILVER	10%

Color Band Value	Lower Limit	Upper Limit	Calculated Value	Fall in Range?

CHART 2

Question 3 Resistors, especially if they are old, tend to not have the resistance value that their color bands say that they do. The light blue resistor is newer than the brown resistor. Does your data reflect this?

Part 7 – A Bright Idea? Now you are going to make a graph for a light bulb and analyze it.

A) Turn off the power supply.

B) Replace the light blue resistor with the light bulb. Just take the alligator clips from each end of the resistor and attach them to the flat loops of metal on the red light bulb platform. Check with your TA if you are not sure about how to do this.

C) You are going to follow the same procedure as **Part 2** with only a few exceptions. Instead of using 0.5 V increments, use 0.3 V increments. Also, this time start at 4.8 V and work your way backwards in 0.3 V increments. **Make sure you do not exceed 5.0 V.** If you do, then the light bulb may burn out.

D) Once you are done taking data, push the **Stop** button. **ALSO**, set the power supply to 0 V.

Question 4 According to the graph, does a light bulb seem to be an Ohmic device? Explain.

First Slope	Second Slope

CHART 3

Part 8 – Analyze Now you are going to analyze the graph that you made for the light bulb. Copy the above **Chart 3** into your lab report.

A) With the mouse, click and hold on the first data point. Slide the mouse over to the 6th data point and unclick.

B) Press the Linear Fit button and record the slope in the First Slope box in **Chart 3**.

C) Highlight the **LAST** six data points and record the slope in the Second Slope box. Note that two different slopes imply a Non-Ohmic device.

Question 5 Why do you think that the light bulb is a Non-Ohmic device? You may need to refer to your lecture notes (and an equation) to answer this. **Hint:** Think heat.

D) Please disconnect your circuit for the next lab group. Thanks!!

What You Need To Turn In:

Turn in all of your charts and the answers to the questions.