

## E4b: Simple D.C. Circuits

### Introduction:

An oft unexplored, but extremely important component of modern life is the resistor. The resistor is an integral part of nearly every electronic device made use of today, including the computer and printer that printed this lab report. Resistors function by provided resistance to the voltage and current of electricity as they flow through the different electronic components.

This experiment is designed to examine the relationship between Voltage, Current and Resistance. Simple D.C. circuits will be constructed where voltages, currents, and resistances can be measured. The measured values will be first utilized to verify Ohm's law in a simple one resistor circuit, and then to examine the voltage, current, resistance behavior when resistors are connected in series and in parallel.

### Apparatus:

- 3 Resistors (ranging from 800 Ohms to 10000 Ohms)
- 2 digital multimeters (DMM)
- 1 D.C. power supply
- 1 breadboard
- hook-up wire

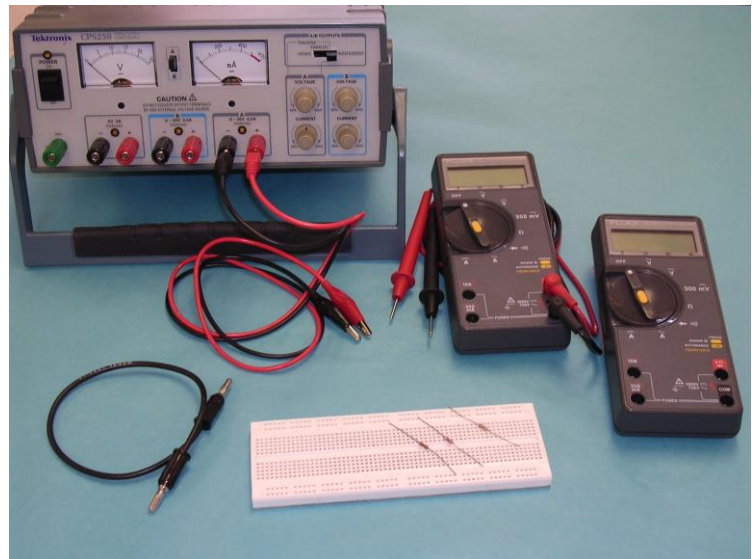
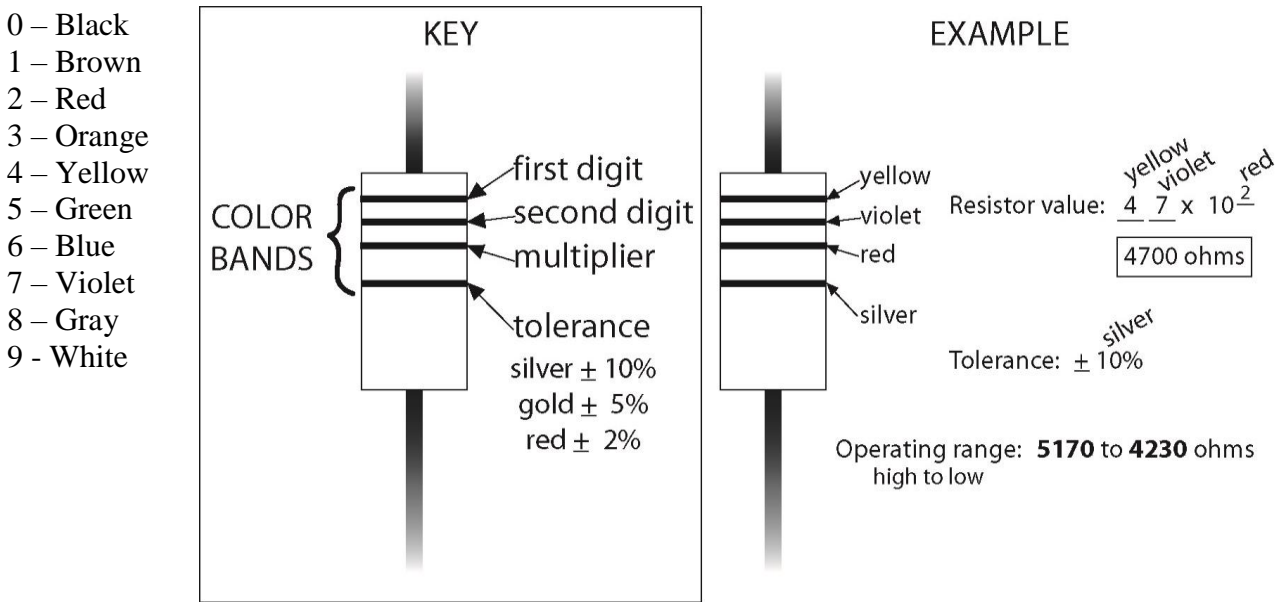


Figure 1

### Discussion:

When working with resistors, it is important to realize that each resistor has a specific resistance associated with it, and an acceptable range the resistor possesses. Both the resistance and the range for the resistor are coded onto the side of each resistor in a special color dependent coding system. In order to proceed with the experiment at hand, it is necessary to first understand and be able to read the color coding.

**COLOR CODED RESISTORS:** The value of resistance associated with a particular resistor is indicated by an arrangement of color bands on the body of the resistor. The diagram shown below demonstrates how the resistance value can be determined from this color band arrangement.



**Figure 2**

An even more important portion of today’s experiment is the law that governs the relationship between voltage, current, and resistance: Ohm’s Law. By making use of Ohm’s Law, it becomes possible to better explore the different aspects of resistance, current, and voltage.

**OHM’S LAW:** Ohm’s law expresses the relationship between the current through a conductor and the potential difference across the conductor. For a constant resistance the potential difference is directly proportional to the current flow.

Symbolically this relationship is:

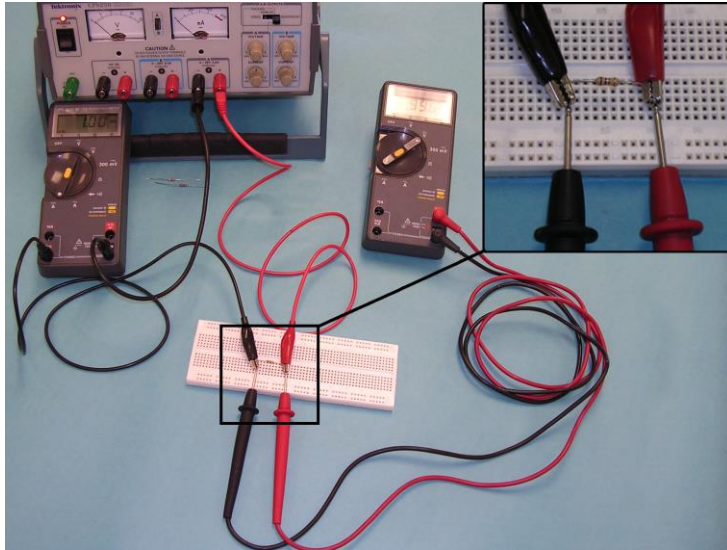
$V = I R$	<p>V = Potential across the conductor I = Current Flow through the conductor R = Resistance of the conductor</p>
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**Procedures:**

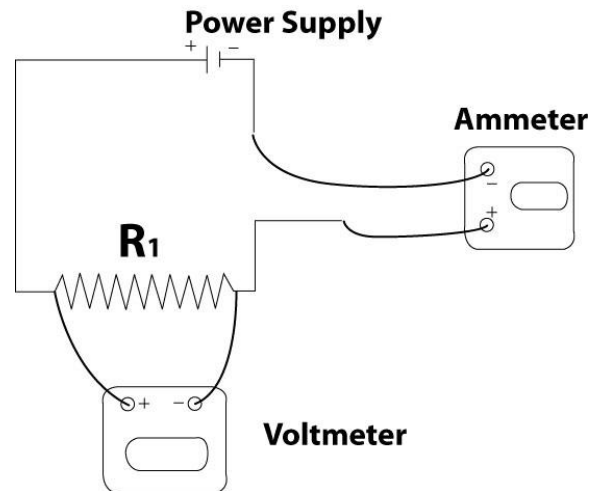
This experiment consists of three separate and distinct parts: Part I, which examines the relationship between current, voltage, and resistance for a single resistor; Part II, which examines the relationship for the three quantities using three resistors in series; and Part III which examines these relationships using three resistors in parallel configuration.

## Part I

1. Locate the 1000 ohm resistor using the color code as a reference. Based upon the tolerance band calculate the operational range specified by the manufacturer. Record this information in the Ohm's law data table. Measure the resistance of the 1000 ohm resistor with the digital multimeter (DMM) and record it in the data table.
2. Assemble the circuit in **Figure 3**.



**Figure 3**

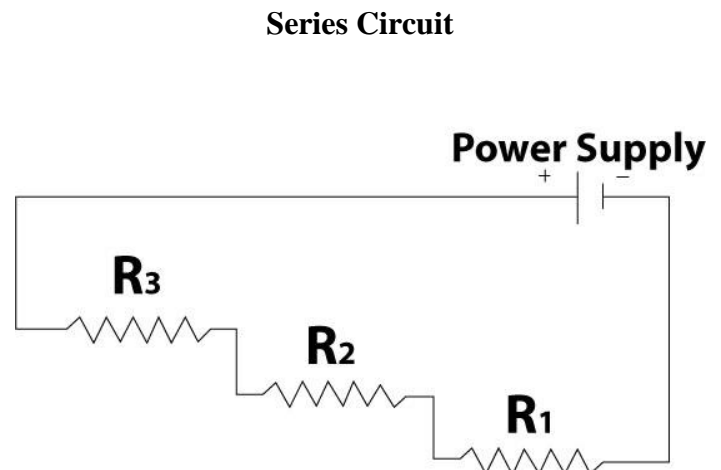
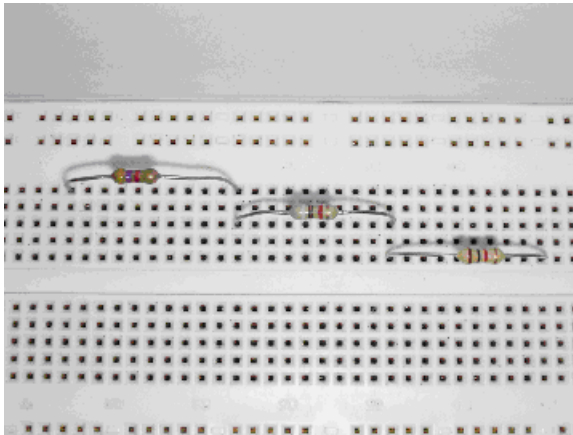


3. If unsure of the circuit connections, have the lab instructor check them before applying power to the circuit.
4. Turn the power supply on and adjust it while watching the ammeter until one milliamp is read on the scale. Record this measurement and the voltage measurement in the data table. Divide the voltage by the current to calculate the resistance value.
5. Increase the current through the resistor by 1mA and again measure the voltage and calculate the resistance.
6. Repeat these steps of increasing the current by 1mA, measuring the voltage and calculating the resistance until completing 10 trials.
7. Turn the power supply off after completing all of the measurements.
8. Make a graph of the voltage as a function of current (voltage on y-axis, current on x-axis). Calculate the slope of the best fit line.
9. Compare the slope of the line to the measured resistance value.

## Part II:

**SERIES D.C. CIRCUITS:** When resistors are series connected across a potential source, the total circuit current passes through each resistor. It follows from Ohm's law that the sum of the potential drops (equivalent to current times resistance) across each resistor around the series circuit will equal the source potential.

1. Assemble the circuit shown in **Figure 4**.



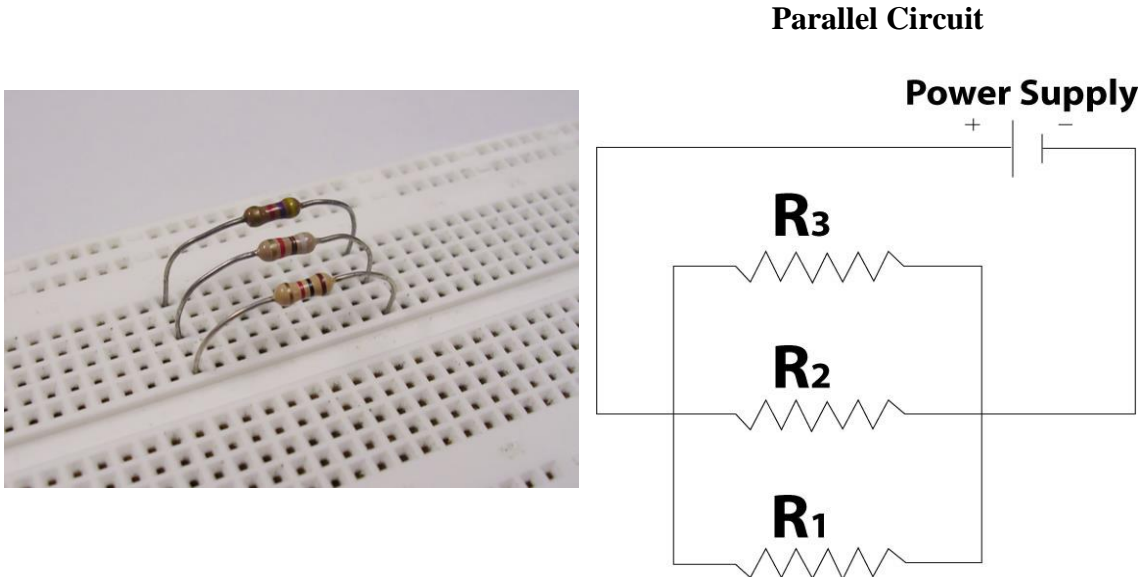
**Figure 4**

2. Measure the individual values of the three resistors to be used in the series circuit prior to connecting the supply voltage. Record these values on the series circuit data sheet. Also measure the total resistance of the three resistors in series and record its value.
3. Complete the circuit by connecting the power supply. Adjust the power supply for about a 15 volt output (it is necessary to measure this with the DMM while adjusting the power supply).
4. Measure the voltage drop across each of the three resistors individually using the DMM. Also measure the voltage drop across the three resistors in series. Record the readings in the data table.
5. Measure the current at each connection point in the circuit using the DMM. Record the readings in the data table.
6. Turn the power supply off after completing all of the measurements.
7. Calculate the resistance of each resistor by dividing the voltage drop across the resistor by the measured current value. Also calculate the total series resistance by dividing the voltage drop across the series of resistors by the measured current. Compare the calculated resistance values to the measured resistance values.
8. Examine the data taking note of the following conditions:
  - a. Is the current approximately the same through all locations?
  - b. Does the voltage drop across the individual resistors add up to be equal to the voltage supplied by the power supply?
  - c. Do the individual resistance values add up to be equivalent to the total resistance of the series? Derive this relationship using Ohm's law.

### Part III:

**PARALLEL D.C. CIRCUITS:** If a source of potential is connected across a bank of resistors (resistors connected in parallel), each resistor offers a path through which current can flow from the positive terminal to the negative terminal of the potential source. As more current paths are introduced (more resistors in parallel), the total current drawn from the potential source is increased. The end result is that the effective resistance of the resistor bank is reduced.

1. Assemble the circuit shown in **Figure 5**.



**Figure 5**

2. Measure the individual value of the three resistors to be used in the parallel circuit prior to connecting the supply voltage. Also measure the value of the three resistors in parallel for the total resistance. Record all values in the parallel circuit data table
3. Connect the power supply as shown in the schematic. Adjust the power supply voltage for approximately a 15 volt output (again this must be measured with the DMM while adjusting the power supply).
4. Using the DMM measure the voltage drop across each of the three individual resistors and the bank of resistors. Record the values in the data table.
5. Measure the current through each resistor using the DMM. Also measure the total current entering the junction before the branch. Record the values in the data table.
6. Turn the power supply off after completing all of the measurements.
7. Calculate the resistance of the individual resistors by dividing the voltage drop across the resistors by the measured current. Also calculate the total resistance through the circuit by dividing the voltage drop across the parallel bank of resistors by the total current entering before the branch point. Compare the calculated resistance to the measured resistance.
8. Examine the data taking note of the following conditions:
  - a. Do the voltage drops across each of the individual resistors and across the bank of resistors all equal the voltage rise from the power supply?
  - b. Is the sum of the currents through each of the individual resistors equivalent to the current entering the total bank of parallel resistors coming from the power supply?
  - c. How does the total resistance of the parallel bank of resistors compare to any of the individual resistors in that bank? Derive the expression for the total resistance using Ohm's law and verify it by using your data.

## Experiment E4b: Ohm's Law

Student Name \_\_\_\_\_

Lab Partner Name \_\_\_\_\_

Lab Partner Name \_\_\_\_\_

Physics Course \_\_\_\_\_

Physics Professor \_\_\_\_\_

Experiment Start Date \_\_\_\_\_

<i>Lab Assistant Name</i>	<i>Date</i>	<i>Time In</i>	<i>Time Out</i>

Experiment Stamped Completed

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# Data Sheets: E4b: Ohm's Law

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

Color Coded Resistance \_\_\_\_\_

Operating Range \_\_\_\_\_

Measured Resistance \_\_\_\_\_

Slope of Graph \_\_\_\_\_

<b>Trial #</b>	<b>Current (measured) Amps</b>	<b>Voltage (measured) Volts</b>	<b>Resistance (calculated) Ohms</b>

## Data Sheets: E4b: Series Circuit

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

Power Supply Voltage  $E =$  \_\_\_\_\_

	Resistor # one R1	Resistor # two R2	Resistor # three R3	Series of Resistors Rt
Color Coded Resistance (Ohms)				
Operating Range high low				
Measured Resistance (Ohms)				
Calculated Resistance				
Measured Voltage (Volts)	V1=	V2=	V3=	Vt=
Measured Current (Amps)	I1=	I2=	I3=	It=



## Data Sheets: E4b: Parallel Circuit

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

Power Supply Voltage      E = \_\_\_\_\_

	Resistor # one R1	Resistor # two R2	Resistor # three R3	Parallel Bank of Resistors Rt
Color Coded Resistance    (Ohms)				
Operating    high Range        low				
Measured Resistance    (Ohms)				
Calculated Resistance				
Measured Voltage        (Volts)	V1=	V2=	V3=	Vt=
Measured Current        (Amps)	I1=	I2=	I3=	It=