# 4 Ohm's Law

**OBJECTIVES:**

After performing this experiment, you will be able to:

1. Measure and plot the current-voltage relationship for a resistor.
2. Construct a graph of the data from objective 1.
3. Given a graph of current-voltage for a resistor, determine the resistance.

**READING:**

Floyd and Buchla, *Principles of Electric Circuits,* Sections 3–1 through 3–5

**MATERIALS NEEDED:**

Resistors:

One 1.0 kΩ, one 1.5 kΩ, one 2.2 kΩ

One dc ammeter, 0–10 mA

For Further Investigation: One 5 V zener diode

1.0 kΩ brown black red gold

1.5 kΩ brown grn red gold

2.2 kΩ Red Red Red Gold

**SUMMARY OF THEORY:**

The flow of electrical charge in a circuit is called *current.* Current is measured in units of *amperes,* or amps for short. The ampere is defined as one coulomb of charge moving past a point in one second. Current is abbreviated with the letter *I* (for *Intensity*) and is frequently shown with an arrow to indicate the direction of flow. Conventional current is defined as the direction a positive charge would move under the influence of an electric field. When electrons move, the direction is opposite to the direction defined for conventional current. To clarify the difference, the term *electron flow* is frequently applied to current in the opposite direction of conventional current.

The relationship between current and voltage specifies the characteristics of an electrical device. One convenient way to represent these quantities is with a graph. In order to construct the graph, one of the variables is changed and the response of the other variable is observed. The variable that was initially moved is called the independent variable; the one that responds is called the dependent variable. By convention, the independent variable is plotted along the *x*-axis (the horizontal axis) and the dependent variable is plotted along the *y*-axis (the vertical axis). In this experiment, the voltage will be controlled (independent) and the current will respond (dependent).

Fixed resistors have a straight-line, or *linear,* current-voltage curve. This linear relationship illustrates the basic relationship of Ohm's law—namely, that the current is proportional to the voltage for constant resistance. Ohm's law is the most important law of electronics. It is written in equation form as

$$I = \frac{V}{R}$$

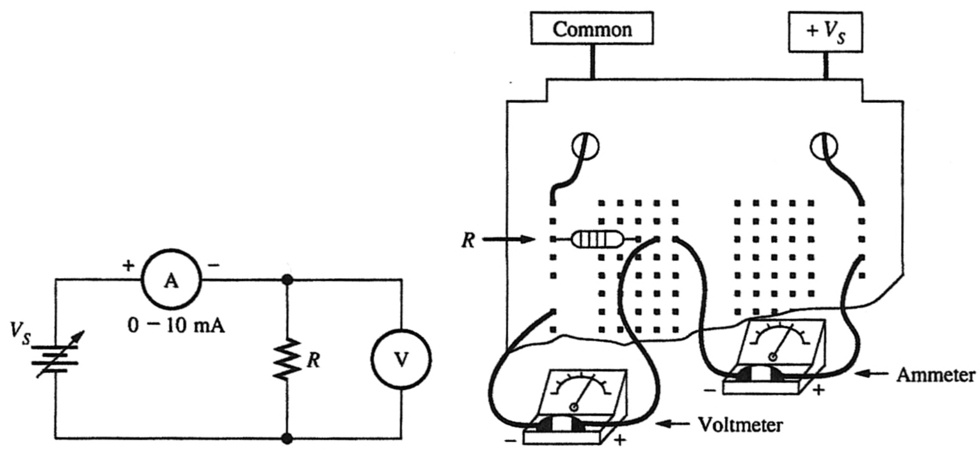
where *I* represents current, *V* represents voltage, and *R* represents resistance.

## PROCEDURE:

1. Measure three resistors with listed values of 1.0 kΩ, 1.5 kΩ, and 2.2 kΩ. Record the measured values in Table 4–1.

2. Connect $R_1$ into the circuit shown in Figure 4–1. The schematic diagram and an example of the protoboard wiring is shown.

| |
|---|
| Caution! Current meters can be easily damaged if they are incorrectly connected. Have your instructor check your connections before applying power. |




(a) Schematic

(b) Protoboard wiring

**Figure 4–1**

3. Adjust the power supply for a voltage of 2.0 V. Measure the current that is through the resistor and record it in Table 4–2.

4. Adjust the power supply for 4.0 V and measure the current. Record the current in Table 4–2. Continue taking current readings for each of the voltages listed in Table 4–2.

5. Replace $R_1$ with $R_2$ and repeat steps 3 and 4. Record the data in Table 4–3.

6. Replace $R_2$ with $R_3$ and repeat steps 3 and 4. Record the data in Table 4–4.

7. On Plot 4–1, graph all three *I*-*V* curves using the data from Tables 4–2, 4–3, and 4–4. Plot the dependent variable (current) on the *y*-axis and the independent variable (voltage) on the *x*-axis. Choose a scale for the graph that spreads the data over the entire grid. Label the three resistance curves with the resistor value.

## FOR FURTHER INVESTIGATION:

Not all devices have a linear current-voltage relationship. (This is what makes electronics interesting!) Investigate a zener diode *I-V* curve. The circuit is shown in Figure 4–2. The 1.0 kΩ resistor is used to limit the total current in the circuit. Notice the polarity of the zener diode. Measure the voltage across the zener diode as the power supply is varied and enter the measured zener voltage in Table 4–5. The circuit is a series circuit so the zener current is the same as the current read by the ammeter. Summarize your results with a graph of the *zener current* as a function of the *zener voltage.*

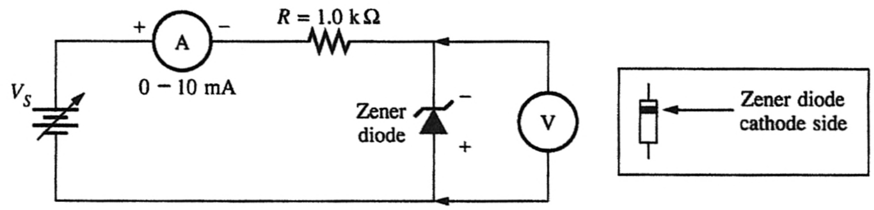



**Figure 4–2**

## APPLICATION PROBLEM:

A student decides to set up switches for testing the resistors in this experiment. The student has only two double-pole, single-throw switches. A partial schematic is drawn in Figure 4–3 of the report. The two switches are to be wired in a way that connects only one resistor at a time to the voltage source. When $S_1$ is in position **B,** only $R_1$ is in the circuit; when $S_1$ is moved to position **A** and $S_2$ is in position **C,** only $R_3$ will be in the circuit; when $S_2$ is now moved to position **D,** only $R_2$ is in the circuit. Complete the schematic shown in Figure 4–3.

# Report for Experiment 4

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Class EET 110

**ABSTRACT:**

**DATA:**

**Table 4–1**

| Component | Listed Value | Measured Value |
|---|---|---|
| $R_1$ | 1.0 kΩ | 0.991kΩ |
| $R_2$ | 1.5 kΩ | 1,495kΩ |
| $R_3$ | 2.2 kΩ | 2,172KΩ |

**Table 4–2 ($R_1$)**

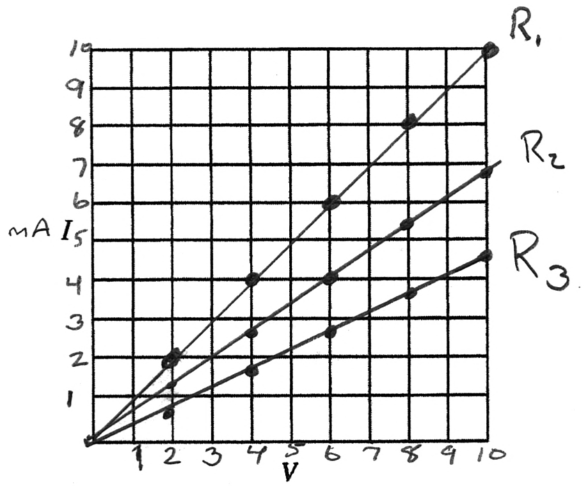
| $V_S =$ | 2.0 V | 4.0 V | 6.0 V | 8.0 V | 10.0 V |
|---|---|---|---|---|---|
| $I =$ | 2.023mA | 4,003mA | 6.009 mA | 8,006 mA | 9.98mA |

**Table 4–3 ($R_2$)**

| $V_S =$ | 2.0 V | 4.0 V | 6.0 V | 8.0 V | 10.0 V |
|---|---|---|---|---|---|
| $I =$ | 1,346 mA | 2.689 mA | 4,001 mA | 5.328 mA | 6.646 mA |

**Table 4–4 ($R_3$)**

| $V_S =$ | 2.0 V | 4.0 V | 6.0 V | 8.0 V | 10.0 V |
|---|---|---|---|---|---|
| $I =$ | 0.939 mA | 1,850 mA | 2.768 mA | 3.679 mA | 4,597 mA |



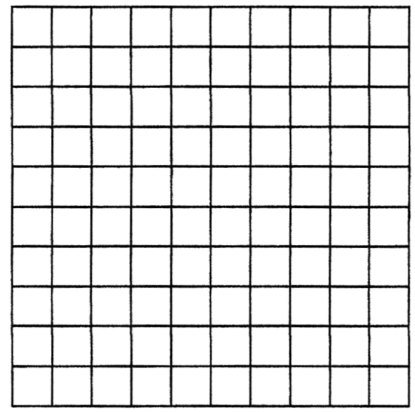

**Plot 4–1**

## RESULTS AND CONCLUSION:

## FURTHER INVESTIGATION RESULTS:

**Table 4–5** (Zener diode)

| $V_S =$ | 2.0 V | 4.0 V | 6.0 V | 8.0 V | 10.0 V |
|---|---|---|---|---|---|
| $V_Z =$ | | | | | |
| $I_Z =$ | | | | | |



**Plot 4–2**

## APPLICATION PROBLEM RESULTS:

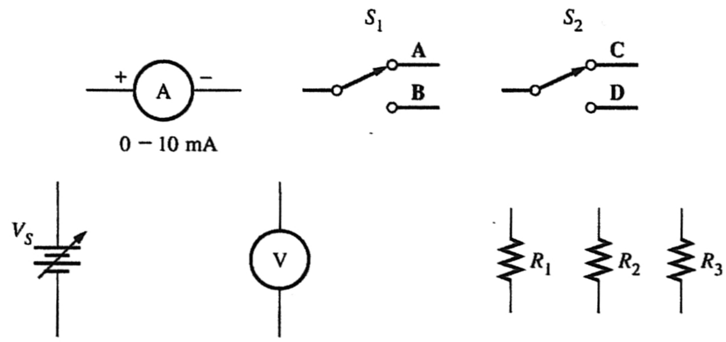
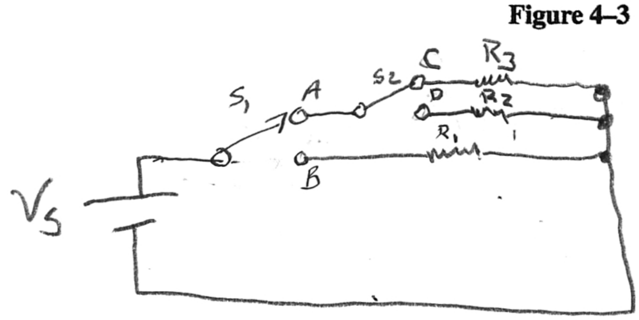



**Figure 4–3**



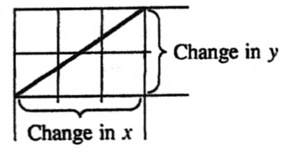
## EVALUATION AND REVIEW QUESTIONS:

1. The slope of a line is the change in the *y* direction divided by the change in the *x* direction. The definition for slope is illustrated in Figure 4–4. Find the slope for each resistor on Plot 4–1. Note that the slope for a resistor has units for conductance, the siemens.

$$R_1 = \left(\frac{4.003 - 2.023}{4-2}\right) = 0.990$$

$$R_2 = \left(\frac{2.689 - 1.346}{4-2}\right) = 0.672$$

$$R_3 = \left(\frac{1.850 - 0.939}{4-2}\right) = 0.456$$




$$\text{Slope} = \frac{\text{Change in } y}{\text{Change in } x} = \frac{2}{3}$$

**Figure 4–4**

2. What happens to the slope of the *I-V* curve for larger resistors?

As the resistor increases, the slope decreases.

3. (a) If the resistance is halved and the voltage is not changed, what will happen to the current in a resistive circuit?

$I = \frac{V}{R}$ If the resistance is halved, the current is doubled.

(b) If the voltage is doubled and the resistance is not changed, what will happen to the current in a resistive circuit?

If the voltage is doubled, the current is doubled.

4. If the current in a resistive circuit is 24 mA and the applied voltage is 48 V, what is the resistance?

$R = \frac{V}{I}$ $\frac{48V}{24mA} = 200\Omega$

5. What current is in a 10 Ω resistor with 5.0 V applied?

$I = \frac{V}{R}$ $\frac{5V}{10\Omega} = 0.5A$

6. The resistance of a tungsten bulb increases as it gets hotter. How does this help explain why many bulbs burn out when they are first turned on?

As the resistance approches zero, the full possible amp value of a circuit is reached. On a 110V American outlet, this could be near 15A8