CHAPTER 9

9 Voltage, Current, Resistance

In this experiment, you will investigate the mathematical relationships between voltage and current and between resistance and current. There are more than 2 variable in the experiment that is voltage, current and resistance. You will have to control all the variable except the two variable whose relationship you want to investigate. In this process you will collect data and make graphs to help you analyze.

QUESTIONS ***What are the relationships between voltage and current and resistance and current?***

Objectives

Describe the relationship between voltage and theotal current flowing through a circuit through a circuit.

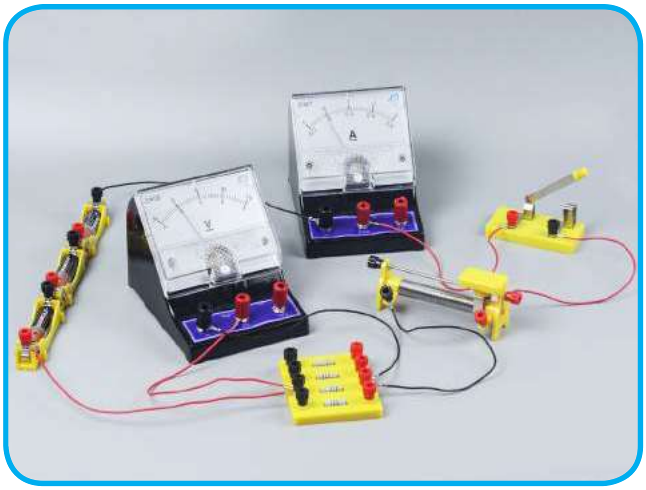
Describe the relationship between the resistance of a circuit and the total current.

Make and use **graphs** to show the relationships between current and resistance and between current and voltage.

Precautions

Resistors and circuits will become hot.

Recall from *Chapter 5* that resistance can be affected by temperature. Resistance of the resistor increases while its temperate increase, so you need to do the measurement in a short time to make sure the resistance do not change over time.



Materials

three 1.5-V batteries, one Ammeter, one Voltmeter, one 5-Ω resistor, one 10-Ω resistor, one 20-Ω resistor, one Potentiometer, one Switch, Some wires

Procedures

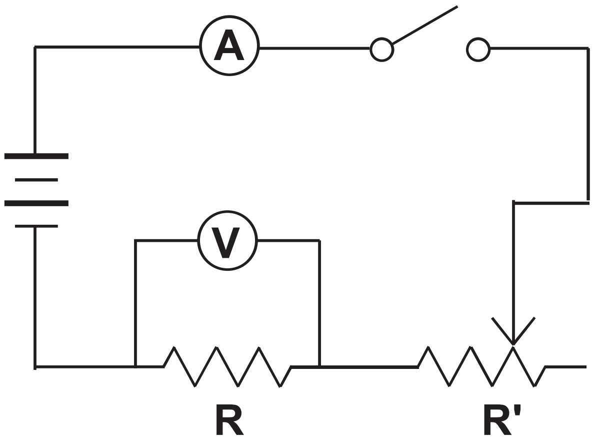


Figure 9-1

Experiment A

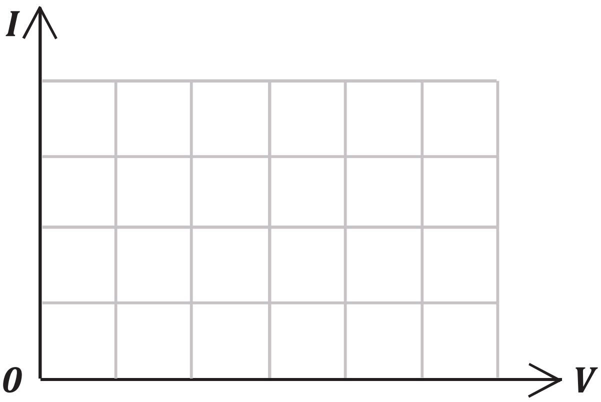
1. Hook up a circuit according to the diagram in *Figure 9-1*.
   (Using three 1.5-V batteries and a 5-Ω resistor)
2. Slide the slider of the potentiometer after close the switch.
3. Measure and record the current flowing through the resistor and voltage across it.
4. Turn off the switch.
   ⚠ Make sure you do step 2-4 in a short time to prevent the temperature of the resistor from increasing too much.
5. Repeat step 2-4 and collect data into *Data table 1*.

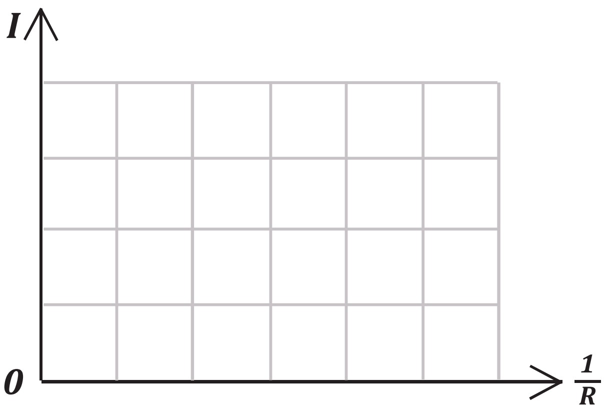
	I	*V*
1		
2		
3		
⋮		

Data Table 1

	I	*R*	$\frac{1}{R}$
1			
2			
3			
⋮			

Data Table 2





Experiment B

6. Hook up the circuit again according to the diagram in *Figure 9-1*.
   (Using three 1.5-V battery and a 5-Ω resistor)
7. Close the switch and slide the slider of the potentiometer so that the voltmeter shows a certain value (2.5 V, for example)
8. Measure and record the current flowing through the resistor and then turn off the switch.
   ⚠ Make sure you do step 7-8 in a short time.
9. Hook up the circuit again but replace the 5-Ω resistor with a 10-Ω resistor.
10. Close the switch and slide the slider of the potentiometer so that the voltmeter shows the same value (2.5 V, for example)
11. Measure record the current flowing through the resistor and then turn off the switch.
12. Repeat again with a 20-Ω resistor and collect data into the *Data Table 2*.

Analyze

1. Which is the **control variable** in each of the experiment?
2. **Make and Use Graphs**
   Graph the current versus the voltage. Place voltage on the x-axis and current on the y-axis.
3. **Make and Use Graphs**
   Graph the current versus the reciprocal of resistance 1/R. Place the reciprocal of resistance on the *x-axis* and current on the *y-axis*.

Conclude and Apply

1. Looking at the first graph that you made, how would you describe the relationship between voltage and current?
2. Why do you suppose this relationship between voltage and current exists?
3. Looking at the second graph that you made, describe the relationship between resistance and current?
4. Why do you suppose this relationship between resistance and current exists?

Chapter 9

Going Further

1. What would be the current in a circuit with a voltage of 5.0 V and a resistance of 50 kΩ? How did you determine this?
2. Could you derive a formula from your lab data to explain the relationship among voltage, current, and resistance?

Voltage, Current, and Resistance

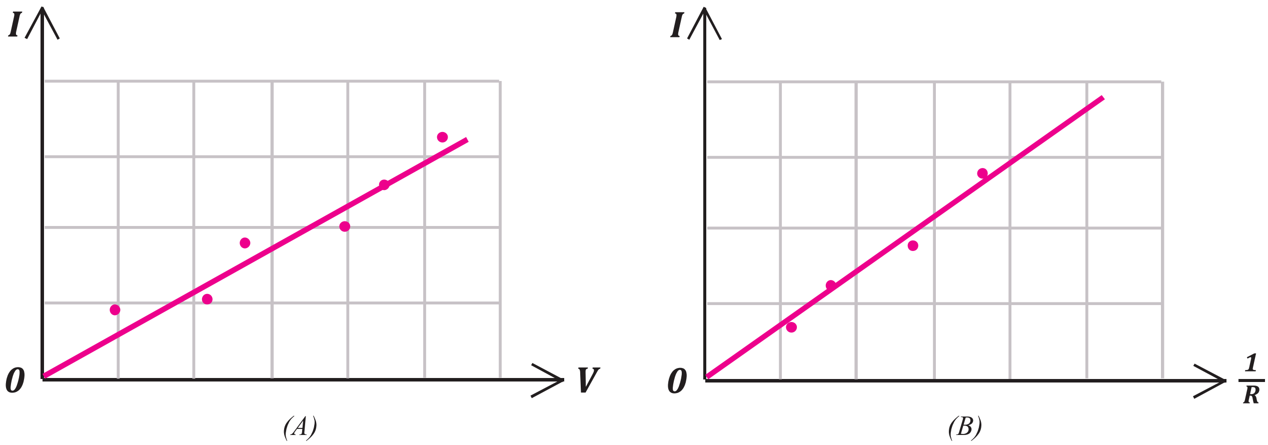


Figure 9-2
The current is proportional to the voltage(A).
The current is proportional to the reciprocal of resistance(B).

From the *Experiment A*, we can obtain some data points on a graph of current versus the voltage. Then we can draw a best-fit line through data points on the graph like it is shown in the *Figure 9-2*. There are errors in the experiment, however, we can still conclude that it should be a straight line that goes through the origin. This indicates that current is directly proportional to the voltage:

$$I \propto V$$

Current is **directly** proportional to the voltage.

From the *Experiment B*, we should also obtain a straight line that goes through the origin, which indicates that current is directly proportional to the reciprocal of resistance ***1/R***:

$$I \propto \frac{1}{R}$$

Current is directly proportional to the **reciprocal of** resistance

From both experiments, we can derive a formula that arrives at the usual mathematical equation that describes the relationship between voltage, current, and resistance:

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

The resistor's current ***I*** in amps (A) is equal to the resistor's voltage ***V*** in volts (V) divided by the resistance ***R*** in ohms (Ω).

In fact, this equation is one of the *Ohm's law formula*.

Ohm's law formula

When we know the voltage and the resistance, we can calculate the current.

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

When we know the voltage and the resistance, we can calculate the current.

$$V = I \times R$$

When we know the voltage and the resistance, we can calculate the current.

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

Most metallic conductors obey *Ohm's law*, at least over a limited range of voltages. Many devices such as filament lightbulbs, however, do not, that is, their relationship between current and voltage (their ***I–V*** curve) is nonlinear.

Recall from *Chapter 2* that a filament lightbulb produces light as it heats up when an electric current passes through it. The resistance of a filament lightbulb will increase as the temperature of its filament increases. As a result, the current flowing through a filament lightbulb is not directly proportional to the voltage across it, in other words, current does not vary linearly.

In *Figure 9-3* is the graph of current against voltage for a filament lamp. Diodes, transistors, mosfets, thyristors, etc do not obey *Ohm's law* too.
In *Figure 9-4* is the graph of current against voltage for a diode. So a radio and a pocket calculator contain many devices, such as transistors and diodes, do not obey *Ohm's law*.

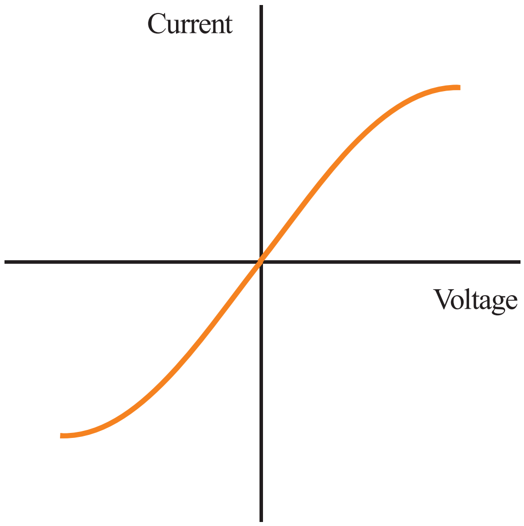


Figure 9-3
(Relationship between current and voltage for a filament lightbulb.)

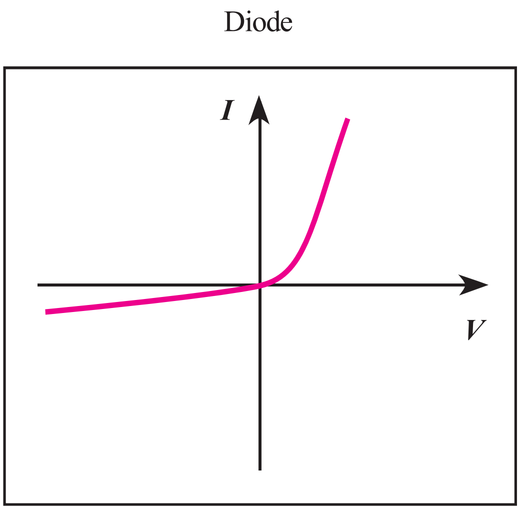


Figure 9-4
(Diodes do not obey Ohm's law.)