CHAPTER 2

2 Series Circuits & Parallel Circuits

There is a series circuit and a parallel circuit in the Figure below. Could you tell the difference between them? In this experiment you will learn about Series Circuits and Parallel Circuits.

QUESTIONS ***What will happen if you turn on and off a switch in a series circuit and a parallel circuit?***

Objectives

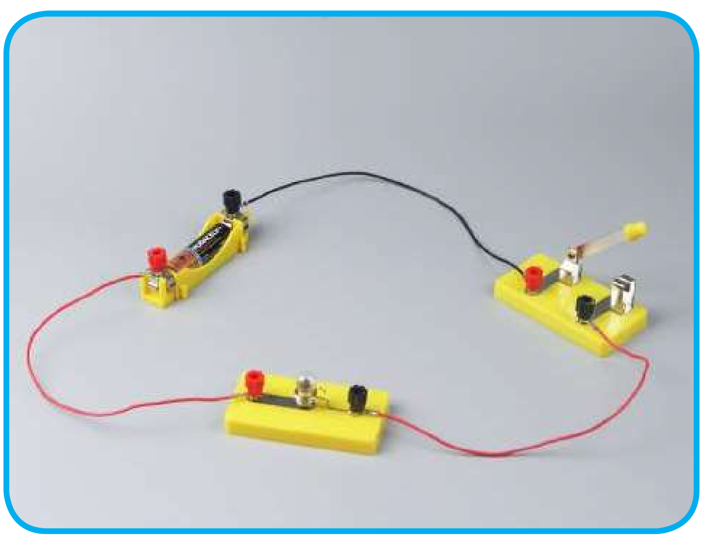
Define series circuits and parallel circuits.
Describe how switches affect the series circuits and parallel circuits.

Precautions

Wire and lightbulbs can be hot if connected across the battery for a long time.

Materials

one 1.5-V battery
two Lightbulbs
two Lightbulb sockets
two Switches
some Wires



Procedures

Experiment A

1. Connect the positive terminal of a battery to one terminal of a lightbulb.
2. Connect the other terminal of the lightbulb to one terminal of a switch.
3. Connect the other terminal of the switch to the negative terminal of the battery.
4. **Observe** Make observations of the lightbulb when the switch is turned on and off.

Experiment B

5. Hook up a circuit in the *Experiment A* by repeating step 1~3.
6. Connect one terminal of a lightbulb A to the one terminal of another lightbulb B.
7. Connect the other terminal of the lightbulb B to a terminal of another switch B.
8. Connect the other terminal of the switch B to the other terminal of the lightbulb A.
9. **Observe** Make observations of the lightbulbs when the switches are turned on and off in the experiments.

Analyzes

10. Which kind of circuit you were hooking up in each of the experiments? A series circuit or a parallel circuit?
11. How did the current flow in each circuit in the experiments?
12. What happened to the lightbulbs when the switches are turned on and off? Try to explain.

Conclude & Apply

Summarize the difference between series circuits and parallel circuits.

Going Further

Try to list some applications of the series circuit and parallel circuit in daily life.

Chapter 2

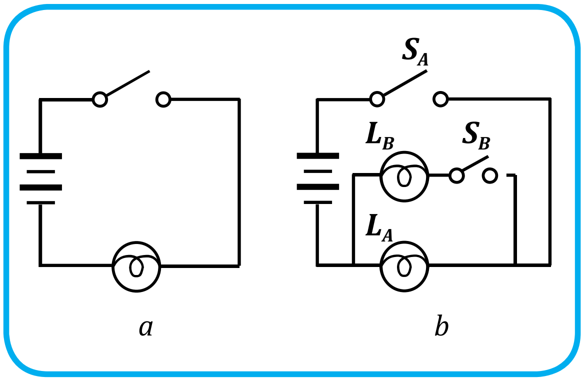


Figure 2-1

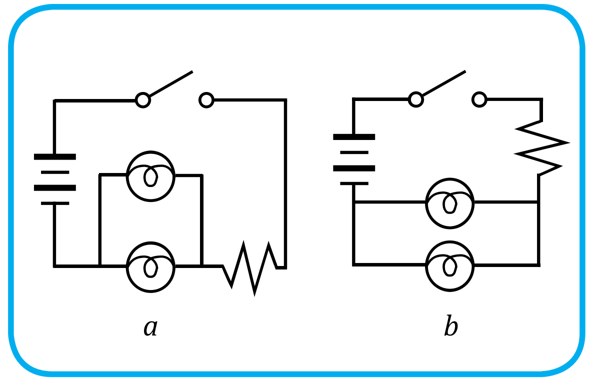


Figure 2-3

Series Circuits

A circuit like the one in *Figure 2-1a*, in which all current travels through each device, is called a series circuit. If the circuit become open when the switch is turned off or the filament inside the lightbulb get burned and become no longer connected, the current stops flowing.

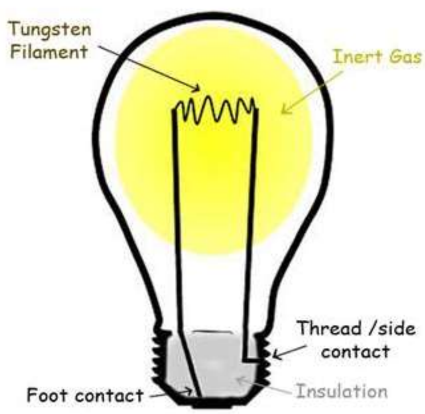


Figure 2-2
(Filament heats up when an electric current passes through it and produces light as a result.)

Parallel Circuits

A circuit like the one in *Figure 2-1b*, in which there are several current paths is called a parallel circuit. The current from power supply goes through both lightbulbs. When you turn off the switch B, the current through the lightbulb B stop flowing, which cause the lightbulb B not working anymore. On the other hand, the lightbulb A will still be lighting because it is still a close loop and the current through it didn't stop flowing.

Can you tell whether the circuit in *Figure 2-3a* is a series circuit or a parallel circuit? There are two lightbulbs connected in parallel while a third lightbulb is in series with the parallel circuit. Such a circuit, which includes series and parallel branches, is called a combination series-parallel circuit. The diagram of this circuit can also be drawn as *Figure 2-3b*.

Real-World Physics

The lightbulbs on a Christmas tree are usually in series.

Street lights are usually in parallel.

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.

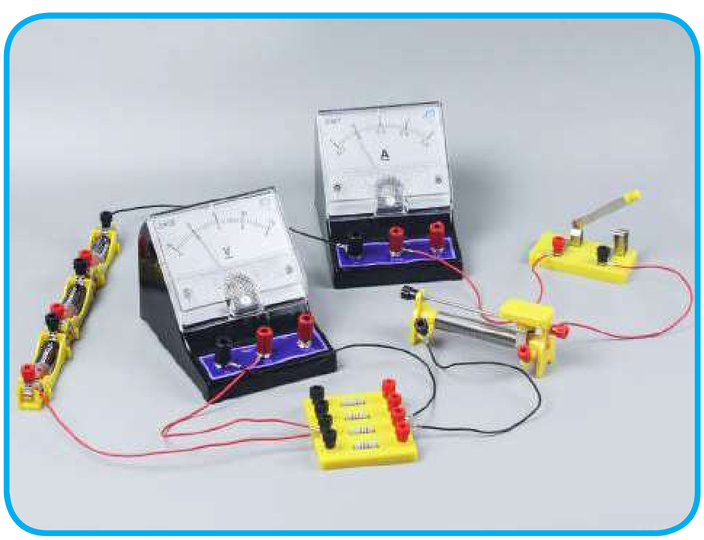
Describe the relationship between the resistance of a circuit and the total current.

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

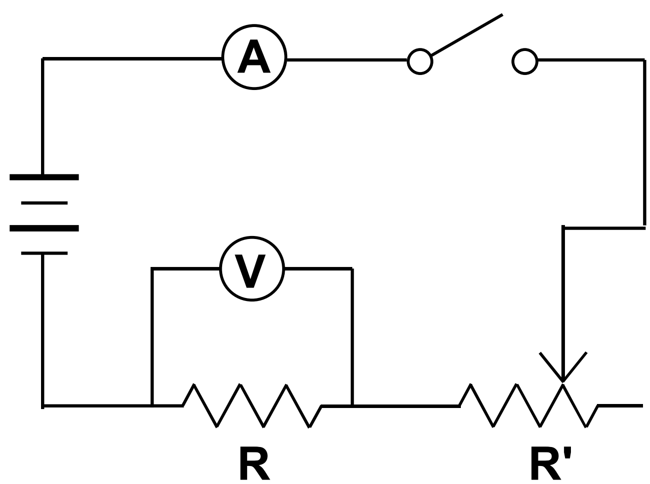


Figure 9-1

Experiment A

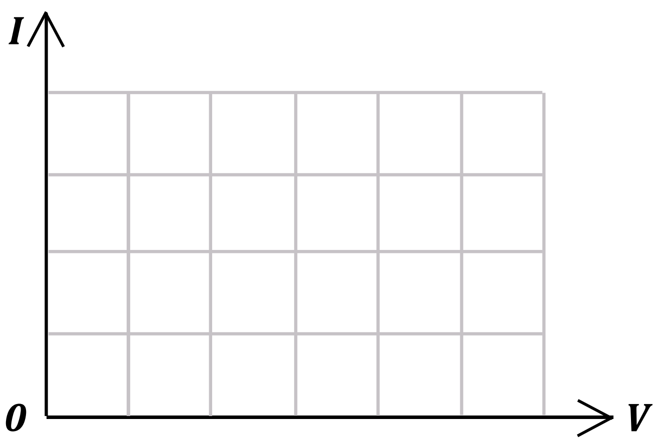
1. Hook up a circuit according to the diagram in *Figure 9-1*.
   (Using three 1.5-V batteries and a 5-Ω resistor)
2. Slide the slider of the potentiometer after close the switch.
3. Measure and record the current flowing through the resistor and voltage across it.
4. Turn off the switch.
   ⚠ Make sure 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.*

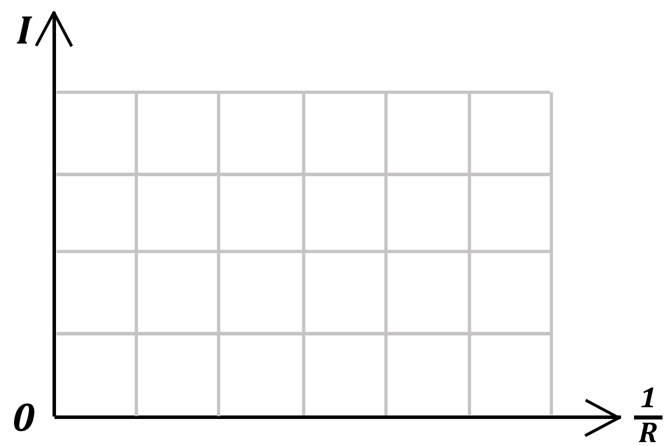
	I	V
1		
2		
3		
⋮		

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

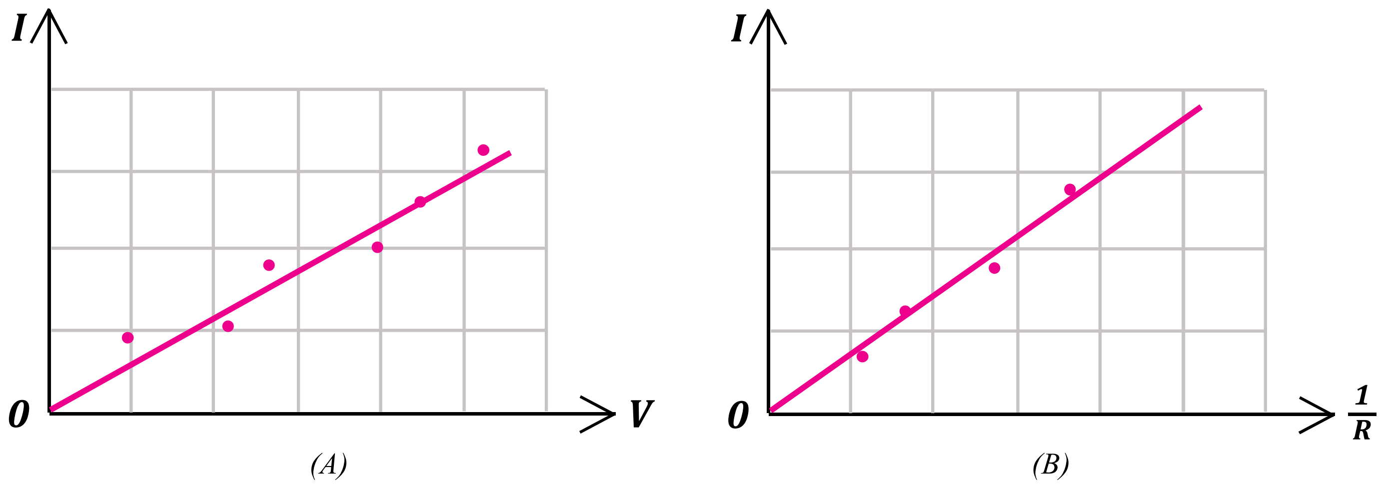


Figure 9-2
The current is proportional to the voltage(A).
The current is proportional to the reciprocal of resistance(B).

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*.

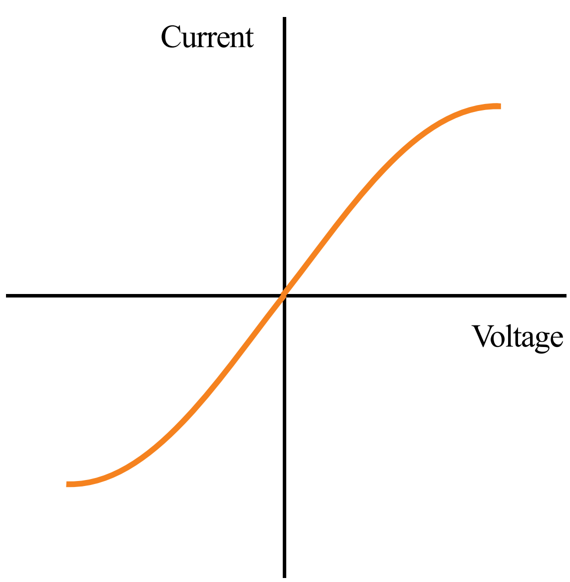


Figure 9-3
(Relationship between current and voltage for a filament lightbulb.)

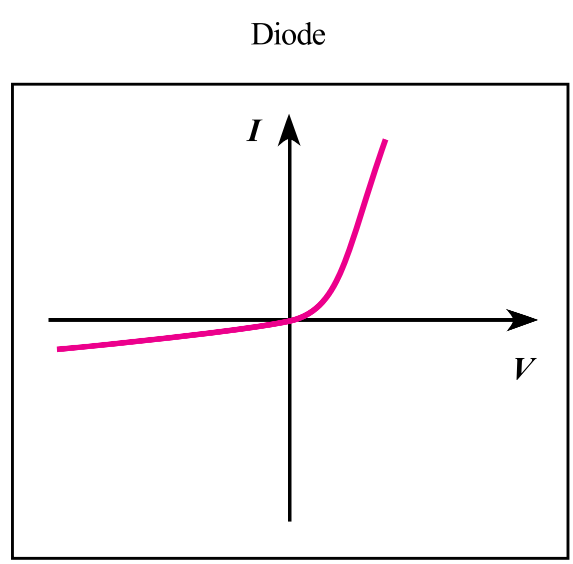


Figure 9-4
(Diodes do not obey Ohm's law.)