Series and Parallel Circuits

Textbook pages 306-319

Before You Read

A circuit is a complete pathway like an electric circuit or a school running track. What other examples of circuits can you list?

What is a series circuit?

A series circuit is an electric circuit that has only one pathway for electric current to take. You can think of a series circuit as a set of parts that are connected end to end. The charges pass through each load before they return to a battery or other energy source. All the moving charges travel through each part of the circuit.

What is a parallel circuit?

A parallel circuit is an electric circuit that has two or more pathways for electric current to take. Some of the moving charges travel through one pathway of the circuit, and other moving charges travel through other pathways of the circuit. All the charges return to the source after moving through the pathways. The place where pathways separate or join in a parallel circuit is called a junction point.
What happens to the current, voltage, and resistance in series and parallel circuits?

The table below summarizes the effects that series circuits and parallel circuits have on the current, the voltage, and the resistance of the circuits.

<table>
<thead>
<tr>
<th>Series circuit</th>
<th>Parallel circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Series Circuit Diagram]</td>
<td>![Parallel Circuit Diagram]</td>
</tr>
</tbody>
</table>

**Current**
The current through the whole circuit is the same throughout and is equal to the total current supplied by the source.

**Current**
The current through each pathway of the circuit adds up to the total current supplied by the source.

**Voltage**
The voltages across each of the loads in the circuit add up to the voltage supplied by the source.

**Voltage**
The voltages across each of the loads in the circuit are equal to each other and to the voltage supplied by the source.

**Resistance**
Resistors placed in series increase the total resistance of the circuit. As a result, the total current throughout the circuit decreases.

**Resistance**
Resistors placed in parallel decrease the total resistance of the circuit. As a result, the total current through the circuit increases.
Series or parallel?

For each of the following statements, identify whether it applies to a series circuit or a parallel circuit.

1. The current is the same throughout the circuit.

2. Adding a resistor will decrease the total resistance of the circuit.

3. The voltage across each resistor in the circuit is the same.

4. There is only one pathway for electrons to flow.

5. Adding a resistor will increase the total resistance of the circuit.

6. There is more than one pathway for current to flow.

7. As more cells are added to the circuit, the brightness of the light bulb increases.

8. There are junction points in the circuit.

9. If the current through one load in the circuit goes to 0 A, the current through all other loads remains the same.

10. The sum of voltages across the loads equals the total voltage supplied by the battery.

11. The total current entering a junction point equals the sum of the current leaving the junction point.
Use with textbook pages 306-313.

Is it in series or in parallel?

Match each description on the left with the correct circuit on the right.

<table>
<thead>
<tr>
<th>Description</th>
<th>Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. _____ 3 resistors in series</td>
<td>A.</td>
</tr>
<tr>
<td>2. _____ 3 resistors in parallel</td>
<td>B.</td>
</tr>
<tr>
<td>3. _____ 2 light bulbs in series</td>
<td>C.</td>
</tr>
<tr>
<td>4. _____ 2 light bulbs in parallel</td>
<td>D.</td>
</tr>
</tbody>
</table>

Draw circuit diagrams as directed below.

5. Draw a circuit diagram showing one resistor and one light bulb in series.

6. Draw a circuit diagram showing one resistor and one light bulb in parallel.
Use with textbook pages 306-313.

**Calculations with series circuits**

Use the diagrams to answer the questions below.

1. **(a)** What is the total resistance in the circuit?

   **(b)** What is the amount of current flowing through Resistor 2?

   **(c)** Using Ohm's Law \( V = IR \), determine the voltage drop across Resistor 2.

   **(d)** What is the voltage drop across Resistor 1?

2. **(a)** What is the total voltage in the circuit?

   **(b)** What is the amount of current flowing through Resistor 2?

   **(c)** Ohm's law is \( R = \frac{V}{I} \). Use Ohm's law to determine the resistance of Resistor 3.
Use with textbook pages 306–313.

Series and parallel circuits

Match each Description on the left with the Circuit on the right. Each Circuit may be used more than once.

<table>
<thead>
<tr>
<th>Description</th>
<th>Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ______ Resistor decrease the total resistance of the circuit.</td>
<td>A. series circuit</td>
</tr>
<tr>
<td>2. ______ Resistors increase the total resistance of the circuit.</td>
<td>B. parallel circuit</td>
</tr>
<tr>
<td>3. ______ The voltages across each of the loads in the circuit add up to the voltage supplied by the source.</td>
<td></td>
</tr>
<tr>
<td>4. ______ The voltages across each of the loads in the circuit are equal to each other and to the voltage supplied by the source.</td>
<td></td>
</tr>
<tr>
<td>5. ______ The current through the whole circuit is the same throughout and is equal to the total current supplied by the source.</td>
<td></td>
</tr>
<tr>
<td>6. ______ The current through each pathway of the circuit adds up to the total current supplied by the source.</td>
<td></td>
</tr>
</tbody>
</table>

Circle the letter of the best answer.

Use the following diagram to answer questions 7 and 8.

7. The light bulbs are connected in parallel.
   A. The statement is correct.
   B. The statement is incorrect.
   C. The diagram does not show whether the statement is correct or incorrect.

8. The current is the same throughout the entire circuit.
   A. The statement is correct.
   B. The statement is incorrect.
   C. The diagram does not show whether the statement is correct or incorrect.

9. Which of the following statements applies to a series circuit?

   | I. | There are junction points in the circuit. |
   | II. | There is only one path for electrons to flow. |
   | III. | The total resistance is equal to the sum of the individual resistances. |

   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II, and III

10. Which of the following applies to a parallel circuit?

   A. There is only one path for electrons to flow.
   B. Adding a resistor to the circuit increases the total resistance.
   C. The sum of the voltages lost on the resistors equals the total voltage supplied by the battery.
   D. The total current entering a junction point must equal the sum of the current leaving the junction point.
The Power of Electricity

Textbook pages 320-329

Before You Read

What does the word power mean to you? Write a sentence using this word on the lines below. As you read about the power of electricity in this section, think about how the common meaning of power differs from the scientific meaning.

Mark the Text

Summarize

As you read this section, highlight the main point in each paragraph. Then write a short paragraph summarizing what you have learned.

What is electrical power?

Power is the rate of change in energy. The symbol for power is P. The units for measuring power are joules per second. A joule (J) is the unit for measuring energy. One joule per second is also called one watt (W).

Electrical power is the rate of change of electrical energy. In other words, electrical power is the amount of electrical energy that is changed into other forms of energy each second. For example, a 100 W light bulb changes 100 W of electrical energy into light and heat each second.

How is electrical power calculated?

You can calculate electrical power if you know the voltage and current in a circuit:

\[ \text{Power (in watts)} = \text{current (in amperes, symbol } I) \times \text{voltage (in volts, symbol } V) \]

or \[ P = IV \]

By rearranging the terms in this equation, you can find the current or the voltage of the circuit, too.

\[ \text{Current} = \frac{\text{Power}}{\text{Voltage}} \quad \text{or} \quad I = \frac{P}{V} \]

\[ \text{Voltage} = \frac{\text{Power}}{\text{Current}} \quad \text{or} \quad V = \frac{P}{I} \]
What is a power rating?
You have likely seen a light bulb with a power in watts marked on it, such as 40 W, 60 W, or 100 W. You may have noticed a similar power in watts on devices such as hair dryers, kettles, or MP3 players. These power ratings tell you how many joules of energy the device uses each second of operation. (Recall that 1 W is 1 J/s.)

How is amount of electrical energy calculated?
You can use a power rating to calculate the amount of electrical energy that a device uses. The mathematical equation that defines power is:

\[ \text{Power (in watts)} = \frac{\text{energy (in joules)}}{\text{time (in seconds)}} \quad \text{or} \quad P = \frac{E}{t} \]

By rearranging the terms in this equation, you can find the amount of electrical energy that a device uses by multiplying its power rating by the amount of time it was used:

\[ \text{Energy (in joules, J)} = \text{Power (in watts, W)} \times \text{Time (in seconds, s)} \]
\[ \text{or} \quad E = P \times t \]

What is a kilowatt-hour?
A joule is a small amount of energy. You use about one joule of energy to lift a medium-sized apple a distance of one metre. Electrical devices use fairly large amounts of energy, so a larger unit of energy is used to describe them. A kilowatt-hour (kW·h) is the same amount of energy as 1000 W used over a period of 1 h.
## Power calculations

State the formula that you will be using for each question. Show all your work below. Write down your answer with the correct units.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The current in a clothes dryer is 20 A when it is plugged into a 240 V outlet. What is the power rating of this clothes dryer?</td>
<td></td>
</tr>
<tr>
<td>2. A countertop convection oven is plugged into an outlet that provides a potential difference of 120 V. What is the power rating of the oven if the current is 12 A?</td>
<td></td>
</tr>
<tr>
<td>3. A DVD player that is not being used still uses energy at a rate of 15 W. What current is passing through it if the DVD player is plugged into a 120 V electrical outlet?</td>
<td></td>
</tr>
<tr>
<td>4. Determine the amount of current flowing into a 210 W computer plugged into a 120 V outlet.</td>
<td></td>
</tr>
<tr>
<td>5. A flashlight bulb has 2.4 W of power when the current in the bulb is 0.8 A. What is the voltage drop across the bulb?</td>
<td></td>
</tr>
<tr>
<td>6. Calculate the power of the light bulb in the circuit shown below.</td>
<td><img src="image" alt="Circuit Diagram" /> 3 I = 2.0 A 30 V</td>
</tr>
</tbody>
</table>
## Energy calculations

State the formula that you will be using for each question. Show all your work below. Write down your answer with the correct units.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A microwave oven operates on 1200 W of power and is used for 30 minutes. How much electrical energy is used by the microwave oven?</td>
<td></td>
</tr>
<tr>
<td>2. A refrigerator operates on average for 12 hours a day. If the power rating of the fridge is 700 W, how much electrical energy does the fridge use in one day?</td>
<td></td>
</tr>
<tr>
<td>3. A kitchen light is left on for 6 h. If the amount of electrical energy used is 0.6 kWh, what is the power of the light bulb?</td>
<td></td>
</tr>
<tr>
<td>4. A hair dryer that has a power rating of 1000 W uses 1.75 kWh in one week. For how many hours (3 minutes) is the hair dryer used daily on average?</td>
<td></td>
</tr>
<tr>
<td>5. How much energy did the light bulb in the circuit below use if it was left on for 2 hours?</td>
<td></td>
</tr>
</tbody>
</table>
Use with textbook pages 320-325.

Paying for electricity

Show all your work below.

1. Assume that the electric utility company charges $0.09 for every kW·h of energy. How much does it cost to:

(a) operate a dryer that uses 15 A of current at 240 V for 1.5 hours?

(b) operate six 100 W light bulbs for an average of 5 hours per day?

(c) operate a refrigerator for a week if it draws 2.0 A of current from a 120 V source that turns on for 15 minutes every hour?

2. If your computer uses 2.5 A at 120 V, how much will it cost to use the computer for 4 hours a day, seven days a week for two weeks? Assume that the cost of electricity is $0.09 for every kW·h of energy.

3. A clothes dryer has a power rating of 4000 W. How long did it take to dry a load of laundry if electric power costs $0.09/ kW·h and the cost of using the dryer was $0.54?
The power of electricity

Use the following table showing power ratings of some appliances to answer questions 1 to 3.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>stereo</td>
<td>250</td>
</tr>
<tr>
<td>toaster</td>
<td>1100</td>
</tr>
<tr>
<td>computer</td>
<td>350</td>
</tr>
<tr>
<td>colour TV</td>
<td>200</td>
</tr>
<tr>
<td>microwave</td>
<td>900</td>
</tr>
</tbody>
</table>

5. A calculator uses a 9 V battery and draws 0.2 A of current. What is its power rating?
   A. 0.02 W  
   B. 1.8 W   
   C. 18 W    
   D. 45 W

6. The current flowing in an appliance connected to a 120 V source is 2 A. How much electrical energy does the appliance use in 6 h?
   A. 1.44 kW·h  
   B. 40 kW·h    
   C. 240 kW·h   
   D. 1440 kW·h

7. An electric space heater draws 15 A from a 120 V source. If it is used for 6 hours, how much electrical energy does it use?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>10.8 kW·h</td>
</tr>
<tr>
<td>II.</td>
<td>648 000 kW·h</td>
</tr>
<tr>
<td>III.</td>
<td>38 880 000 J</td>
</tr>
</tbody>
</table>

A. I and II only  
B. I and III only  
C. II and III only  
D. I, II, and III

8. A self-cleaning oven operates on 5400 W of power when cleaning itself. It takes 2 h to clean. At a cost of $0.09 per kW·h, how much does it cost to clean the oven?
   A. $0.49  
   B. $0.97  
   C. $10.80  
   D. $970.00