# 16-3 Power

*Vocabulary* **Power:** The amount of work done in a given unit of time.

As seen in the previous chapter, electrical work is done when an amount of charge, $\Delta q$, is transferred across a potential difference, $V$, or $W = \Delta qV$. The faster this transfer of charge occurs, the more power is generated in the circuit.

$$\textbf{Power} = \frac{\textbf{work}}{\textbf{elapsed time}} \quad \text{or} \quad P = \frac{W}{\Delta t} = \frac{\Delta qV}{\Delta t} = IV$$

Therefore, as current is drawn in a circuit to power an appliance, a potential difference occurs across the appliance.

The SI unit for electrical power is the **watt (W),** which equals one **joule per second (J/s).**

## Solved Examples

**Example 5:** The lighter in Bryce's car has a resistance of 4.0 Ω. a) How much current does the lighter draw when it is run off the car's 12-V battery? b) How much power does the lighter use?

**a.** *Given:* $R = 4.0\ \Omega$
$V = 12\ \text{V}$

*Unknown:* $I = ?$
*Original equation:* $V = IR$

*Solve:* $I = \frac{V}{R} = \frac{12\ V}{4.0\ \Omega} = \mathbf{3.0\ A}$

**b.** *Given:* $I = 3.0\ \text{A}$
$V = 12\ \text{V}$

*Unknown:* $P = ?$
*Original equation:* $P = IV$

*Solve:* $P = IV = (3.0\ \text{A})(12\ \text{V}) = \mathbf{36\ W}$

**Example 6:** A 120.-V outlet in Carol's college dorm room is wired with a circuit breaker on a 5-A line so that students cannot overload the circuit. a) If Carol tries to iron a blouse for class with her 700-W iron, will she trip the circuit breaker? b) What is the resistance of the iron?

**Solution:** A circuit breaker is a switch that automatically turns a circuit off if the current is too high.

**a.** *Given:* $P = 700.\ \text{W}$
$V = 120.\ \text{V}$

*Unknown:* $I = ?$
*Original equation:* $P = IV$

*Solve:* $I = \frac{P}{V} = \frac{700.\ \text{W}}{120.\ \text{V}} = \mathbf{5.83\ A}$

Yes, she will!

It may be difficult to see how a watt/volt equals an amp until you begin to break down the units.

$$\frac{\text{watt}}{\text{volt}} = \frac{\text{joule/second}}{\text{joule/coulomb}} = \frac{\text{coulomb}}{\text{second}} = \text{amp}$$

**b.** Now find the resistance using $V = IR$.

*Given:* $V = 120.\ \text{V}$
$I = 5.83\ \text{A}$

*Unknown:* $R = ?$
*Original equation:* $V = IR$

*Solve:* $R = \frac{V}{I} = \frac{120.\ \text{V}}{5.83\ \text{A}} = \mathbf{20.5\ \Omega}$

**Example 7:** The Garcias like to keep their 40.0-W front porch light on at night to welcome visitors. If the light is on from 6 p.m. until 7 a.m., and the Garcias pay 8.00¢ per kWh, how much does it cost to run the light for this amount of time each week?

**Solution:** First, convert the power units to kilowatts, kW, because the cost of household energy is measured in kWh. 40.0 W = 0.0400 kW

Next, determine how long the light is left on each week. From 6 P.M. until 7 A.M. is 13 h. Operating 7 days a week means that the light is on for a total of 91.0 hours.

*Given:* $P = 0.0400\ \text{kW}$
$\Delta t = 91.0\ \text{h}$

*Unknown:* $W = ?$ Cost = ?
*Original equation:* $P = \frac{W}{\Delta t}$

*Solve:* $W = P\Delta t = (0.0400\ \text{kW})(91.0\ \text{h}) = \mathbf{3.64\ kWh}$

$$\text{Cost} = \frac{8.00¢}{1.00\ \text{kWh}}(3.64\ \text{kWh}) = \mathbf{29.1¢}$$

Therefore, it costs the Garcias about 29¢ to run the light all night for an entire week, or a little over $15 per year.

## Practice Exercises

**Exercise 10:** How much power is used by a contact lens heating unit that draws 0.070 A of current from a 120-V line?

Answer: ____________________

**Exercise 11:** Celeste's air conditioner uses 2160 W of power as a current of 9.0 A passes through it. a) What is the voltage drop when the air conditioner is running? b) How does this compare to the usual household voltage? c) What would happen if Celeste tried connecting her air conditioner to a usual 120-V line?

Answer: **a.** ______________________

Answer: **b.** ______________________

Answer: **c.** ______________________

**Exercise 12:** Which has more resistance when plugged into a 120.-V line, a 1400.-W microwave oven or a 150.-W electric can opener?

Answer: ______________________

**Exercise 13:** Valerie's 180-W electric rollers are plugged into a 120-V line in her bedroom. a) What current do the electric rollers draw? b) What is the resistance of the rollers when they are heated? c) Combining the equations just used, derive an equation that relates power to voltage and resistance.

Answer: **a.** ______________________

Answer: **b.** ______________________

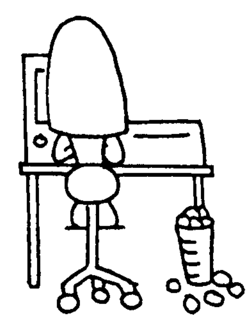
Answer: **c.** ______________________

**Exercise 14:** Mrs. Olsen leaves her 0.900-kW electric coffee maker on each day as she heads off to work at 6 A.M. because she likes to come home to a hot cup of coffee at 6 P.M. a) If the electric company charges Mrs. Olsen $0.100 per kWh, how much does running the coffee maker cost her each day? b) What is the yearly cost to run the coffee maker?

Answer: **a.** ____________________

Answer: **b.** ____________________

**Exercise 15:** While writing this book, the author spent about 1000 h working on her personal computer that has a power input of 60.0 W. Seventy additional hours were spent with the 60.0-W computer and the 240.-W printer running. How much did it cost for the energy use of these two devices, at a cost of $0.100 per kWh?



Answer: ____________________

11. a) 240 V
    c) 18 A
13. a) 1.5 A
    b) 80 Ω
15. $8.10