KEY CONCEPT

12.3 Magnetism can produce current.

BEFORE, you learned
• Magnetism is a force exerted by magnets
• Electric current can produce a magnetic field
• Electromagnets can make objects move

NOW, you will learn
• How a magnetic field can produce an electric current
• How a generator converts energy
• How direct current and alternating current differ

EXPLORE Energy Conversion

How can a motor produce current?

PROCEDURE
1. Touch the wires on the motor to the battery terminals to see how the motor operates.
2. Connect the wires to the light bulb.
3. Roll the shaft, or the movable part of the motor, between your fingers. Observe the light bulb.
4. Now spin the shaft rapidly. Record your observations.

WHAT DO YOU THINK?
• How did you produce current?
• What effect did your motion have on the amount of light produced?

MATERIALS
• small motor
• AA cell (battery)
• light bulb in holder

Magnets are used to generate an electric current.

In the 1830s, about ten years after Oersted discovered that an electric current produces magnetism, physicists observed the reverse effect—a moving magnetic field induces an electric current. When a magnet moves inside a coiled wire that is in a circuit, an electric current is generated in the wire.

It is often easier to generate an electric current by moving a wire inside a magnetic field. Whether it is the magnet or the wire that moves, the effect is the same. Current is generated as long as the wire crosses the magnetic field lines.

CHECK YOUR READING
What must happen for a magnetic field to produce an electric current?
How a Cell Phone Generator Works

An emergency cell phone charger uses a generator to produce electric current.

1. Turning the handle provides kinetic energy to the generator, making the gears rotate.
2. The turning motion rotates coils of wire inside a magnet. This rotation produces electric current.
3. Electric current recharges the phone's battery.

What function does the magnet in the generator serve?

Generating an Electric Current

A generator is a device that converts the energy of motion, or kinetic energy, into electrical energy. A generator is similar to a motor in reverse. If you manually turn the shaft of a motor that contains a magnet, you can produce electric current.

The illustration below shows a portable generator that provides electrical energy to charge a cell phone in an emergency. The generator produces current as you turn the handle. Because it does not need to be plugged in, the generator can be used wherever and whenever it is needed to recharge a phone. The energy is supplied by the person turning the handle.

1. As the handle is turned, it rotates a series of gears. The gears turn the shaft of the generator.
2. The rotation of the shaft causes coils of wire to rotate within a magnetic field.
3. As the coils of the wire cross the magnetic field line, electric current is generated. The current recharges the battery of the cell phone.

What is the source of energy for a cell phone generator?
Direct and Alternating Currents

Think about how current flows in all of the circuits that you have studied so far. Electrons flow from one end of a battery or generator, through the circuit, and eventually back to the battery or generator. Electrons that flow in one direction produce one of two types of current.

- A **direct current** (DC) is electric charge that flows in one direction only. Direct current is produced by batteries and by DC generators such as the cell phone generator.
- An **alternating current** (AC) is a flow of electric charge that reverses direction at regular intervals. The current that enters your home and school is an alternating current.

**CHECK YOUR READING** What is the difference between direct current and alternating current?

Direct currents and alternating currents are produced by different generators. In an AC generator, the direction in which charge flows depends upon the direction in which the magnet moves in relation to the coil. Because generators use a rotating electromagnet, the poles of the electromagnet alternate between moving toward and moving away from the magnet. The result is a current that reverses with each half-rotation of the coil.

The illustration on the right shows a simple DC generator. DC generators are very similar to AC generators. The main difference is that DC generators have a commutator that causes the current to flow in only one direction.

Many things in your home can work with either direct or alternating currents. In light bulbs, for instance, the resistance to motion of the electrons in the filament makes the filament glow. It doesn’t matter in which direction the current is moving.

Some appliances can use only direct current. The black box that is on the plug of some devices is an AC–DC converter. AC–DC converters change the alternating current to direct current. For example, laptop computers use converters like the one shown in the photograph on the right. In a desktop computer, the converter is part of the power supply unit.
The energy that powers a car comes from burning gasoline, but the car also contains many devices that use electrical energy. Some of them are familiar—the headlights, turn signals, radio, power windows, and door locks. Others may be less familiar, such as the spark plugs that ignite the gasoline, the fuel and oil pumps that move fluids in the engine, and the air conditioner.

A car’s engine includes a generator to provide current to its electrical devices. As the engine runs, it converts gasoline to kinetic energy. Some of that energy is transferred to the generator by a belt attached to its shaft. Inside the generator, a complex coil of copper wires turns in a magnetic field, generating a current that operates the electrical devices of the car.

The generator also recharges the battery, so that power is available when the engine is not running. Because the generator in most cars supplies alternating current, a car generator is usually called an alternator.
Magnets are used to control voltage.

A transformer is a device that increases or decreases voltage. Transformers use magnetism to control the amount of voltage. A transformer consists of two coils of wire that are wrapped around an iron ring.

An alternating current from the voltage source in the first coil produces a magnetic field. The iron ring becomes an electromagnet. Because the current alternates, the magnetic field is constantly changing. The second coil is therefore within a changing magnetic field. Current is generated in the second coil. If the two coils have the same number of loops, the voltage in the second coil will be the same as the voltage in the first coil.

A change in the voltage is caused when the two coils have different numbers of loops. If the second coil has fewer loops than the first, as in the illustration, the voltage is decreased. This is called a step-down transformer. On the other hand, if the second coil has more loops than the first, the voltage in the second circuit will be higher than the original voltage. This transformer is called a step-up transformer.

Transformers are used in the distribution of current. Current is sent over power lines from power plants at a very high voltage. Step-down transformers on utility poles, such as the one pictured on the right, reduce the voltage available for use in homes. Sending current at high voltages minimizes the amount of energy lost to resistance along the way.

KEY CONCEPTS
1. What is necessary for a magnetic field to produce an electric current?
2. Explain how electric generators convert kinetic energy into electrical energy.
3. Compare and contrast the ways in which direct current and alternating current are generated.

CRITICAL THINKING
4. Apply Many radios can be operated either by plugging them into the wall or by using batteries. How can a radio use either source of current?
5. Draw Conclusions Suppose that all of the electrical devices in a car stop working. Explain what the problem might be.

CHALLENGE
6. Apply European power companies deliver current at 220 V. Draw the design for a step-down transformer that would let you operate a CD player made to work at 110 V in France.