SECTION 1

What Is Light?

You can see light. It's everywhere! Light comes from the sun and from other sources, such as light bulbs. But what exactly is light?

Scientists are still studying light to learn more about it. A lot has already been discovered about light, as you will soon find out. Read on, and be enlightened!

What You Will Learn

- Describe light as an electromagnetic wave.
- Calculate distances traveled by light by using the speed of light.
- Explain why light from the sun is important.

Vocabulary

electromagnetic wave
radiation

READING STRATEGY

Brainstorming The key idea of this section is light. Brainstorm words and phrases related to light.

Light: An Electromagnetic Wave

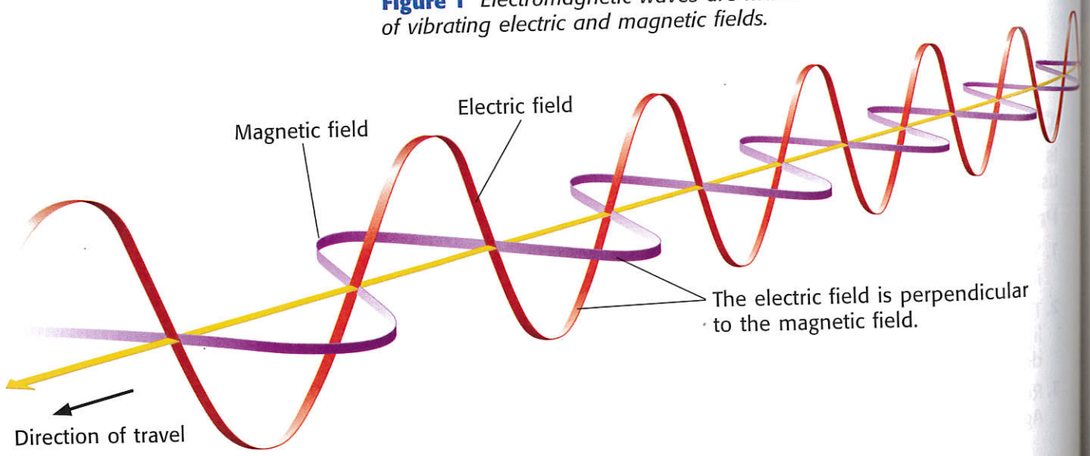
Light is a type of energy that travels as a wave. But light is different from other kinds of waves. Other kinds of waves, like sound waves and water waves, must travel through matter. Light does not require matter through which to travel. Light is an electromagnetic wave (EM wave). An **electromagnetic wave** is a wave that can travel through empty space or matter and consists of changing electric and magnetic fields.

Fields exist around certain objects and can exert a force on another object without touching that object. For example, Earth is a source of a gravitational field. This field pulls you and all things toward Earth. But keep in mind that this field, like all fields, is not made of matter.

Figure 1 shows a diagram of an electromagnetic wave. Notice that the electric and magnetic fields are at right angles—or are *perpendicular*—to each other. These fields are also perpendicular to the direction of the wave motion.

electromagnetic wave a wave that consists of electric and magnetic fields that vibrate at right angles to each other

Figure 1 *Electromagnetic waves are made of vibrating electric and magnetic fields.*



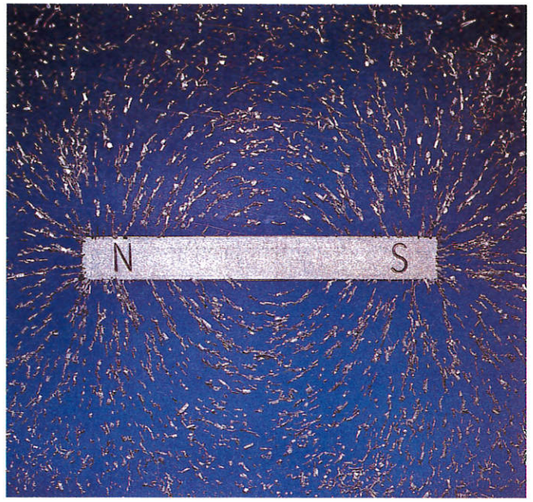


Figure 2 *The hair on the girl's head stands up because of an electric field and the iron filings form arcs around the magnet because of a magnetic field.*

Electric and Magnetic Fields

Electromagnetic waves are changing electric and magnetic fields. But what are electric and magnetic fields? An *electric field* surrounds every charged object. The electric field around a charged object pulls oppositely charged objects toward it and repels like-charged objects. You can see the effect of electric fields whenever you see objects stuck together by static electricity. **Figure 2** shows another effect of an electric field.

A *magnetic field* surrounds every magnet. Because of magnetic fields, paper clips and iron filings are pulled toward magnets. You can feel the effect of magnetic fields when you hold two magnets close together. The iron filings around the magnet in **Figure 2** form arcs in the presence of the magnet's magnetic field.

Reading Check **Where can electric fields be found?**
(See the Appendix for answers to Reading Checks.)

How EM Waves Are Produced

An EM wave can be produced by the vibration of an electrically charged particle. When the particle vibrates, or moves back and forth, the electric field around it also vibrates. When the electric field starts vibrating, a vibrating magnetic field is created. The vibration of an electric field and a magnetic field together produces an EM wave that carries energy released by the original vibration of the particle. The transfer of energy as electromagnetic waves is called **radiation.**

CONNECTION TO Social Studies

WRITING SKILL **The Particle Model of Light**

Thinking of light as being an electromagnetic wave can explain many properties of light. But some properties of light can be explained only by using a particle model of light. In the particle model of light, light is thought of as a stream of particles called *photons*. Research the history of the particle model of light. Write a one-page paper on what you learn.

radiation transfer of energy as electromagnetic waves

Figure 3 *Thunder and lightning are produced at the same time. But you usually see lightning before you hear thunder, because light travels much faster than sound.*

The Speed of Light

Scientists have yet to discover anything that travels faster than light. In the near vacuum of space, the speed of light is about 300,000,000 m/s, or 300,000 km/s. Light travels slightly slower in air, glass, and other types of matter. (Keep in mind that even though electromagnetic waves do not need to travel through matter, they can travel through many substances.)

Believe it or not, light can travel about 880,000 times faster than sound! This fact explains the phenomenon described in **Figure 3.** If you could run at the speed of light, you could travel around Earth 7.5 times in 1 s.

Reading Check **How does the speed of light compare with the speed of sound?**

MATH FOCUS

How Fast Is Light? The distance from Earth to the moon is 384,000 km. Calculate the time it takes for light to travel that distance.

Step 1: Write the equation for speed.

$$speed = \frac{distance}{time}$$

Step 2: Rearrange the equation by multiplying by time and dividing by speed.

$$time = \frac{distance}{speed}$$

Step 3: Replace *distance* and *speed* with the values given in the problem, and solve.

$$time = \frac{384{,}000 \text{ km}}{300{,}000 \text{ km/s}}$$

$$time = 1.28 \text{ s}$$

Now It's Your Turn

1. The distance from the sun to Venus is 108,000,000 km. Calculate the time it takes for light to travel that distance.

Light from the Sun

Even though light travels quickly, it takes about 8.3 min for light to travel from the sun to Earth. It takes this much time because Earth is 150,000,000 km away from the sun.

The EM waves from the sun are the major source of energy on Earth. For example, plants use photosynthesis to store energy from the sun. And animals use and store energy by eating plants or by eating other animals that eat plants. Even fossil fuels, such as coal and oil, store energy from the sun. Fossil fuels are formed from the remains of plants and animals that lived millions of years ago.

Although Earth receives a large amount of energy from the sun, only a very small part of the total energy given off by the sun reaches Earth. Look at **Figure 4.** The sun gives off energy as EM waves in all directions. Most of this energy travels away in space.

Figure 4 *Only a small amount of the sun's energy reaches the planets in the solar system.*

SECTION Review

Summary

- Light is an electromagnetic (EM) wave. An EM wave is a wave that consists of changing electric and magnetic fields. EM waves require no matter through which to travel.
- EM waves can be produced by the vibration of charged particles.
- The speed of light in a vacuum is about 300,000,000 m/s.
- EM waves from the sun are the major source of energy for Earth.

Using Key Terms

1. Use the following terms in the same sentence: *electromagnetic wave* and *radiation*.

Understanding Key Ideas

2. Electromagnetic waves are different from other types of waves because they can travel through
   a. air. c. space.
   b. glass. d. steel.
3. Describe light in terms of electromagnetic waves.
4. Why is light from the sun important?
5. How can electromagnetic waves be produced?

Math Skills

6. The distance from the sun to Jupiter is 778,000,000 km. How long does it take for light from the sun to reach Jupiter?

Critical Thinking

7. **Making Inferences** Why is it important that EM waves can travel through empty space?
8. **Making Comparisons** How does the amount of energy produced by the sun compare with the amount of energy that reaches Earth from the sun?
9. **Applying Concepts** Explain why the energy produced by burning wood in a campfire is energy from the sun.

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