Guide for Reading

Focus on this question as you read.

▶ *What is an electromagnetic wave?*

3–1 Electromagnetic Waves

What does sunlight have in common with the X-rays used in a doctor's office? Are you surprised to learn that they are both waves? They're not matter waves that you can feel or hear. They are electromagnetic waves. You may remember reading about electromagnetic waves in Chapter 1. Although you might not realize it, you are constantly surrounded by thousands of electromagnetic waves every day. Sunlight (visible light) and X-rays are only two types of electromagnetic waves. Other types are radio waves, infrared rays, ultraviolet rays, and gamma rays.

Nature of an Electromagnetic Wave

An electromagnetic wave, as its name suggests, is both electric and magnetic in nature. An electromagnetic wave consists of an electric field and a magnetic field. These fields are not made up of matter like that in a football field or a soccer field. Electric and magnetic fields are the regions through which the push or pull of charged particles and magnets is exerted. (Charged particles and magnets can push or pull certain other objects without even touching them.) **An electromagnetic wave consists of an electric field and a magnetic field positioned at right angles to each other and to the direction of motion of the wave.** See Figure 3–2. Because the electric and magnetic fields are at right angles to the direction of motion of the wave, electromagnetic waves are transverse waves.

Like other waves, such as water waves and waves on a rope, electromagnetic waves carry energy from one place to another. But unlike other waves, electromagnetic waves do not carry energy by causing matter to vibrate. It is the electric and magnetic fields that vibrate. This explains why electromagnetic waves can travel in a vacuum (where there is no matter). But it does not mean that electromagnetic waves cannot travel through a medium. They certainly can. Light, for example, can be transmitted with a medium—as through the atmosphere—or without a medium—as through space.

Figure 3–1 *The colors of light produced by fireworks are one familiar form of electromagnetic waves. What type of wave is light?*

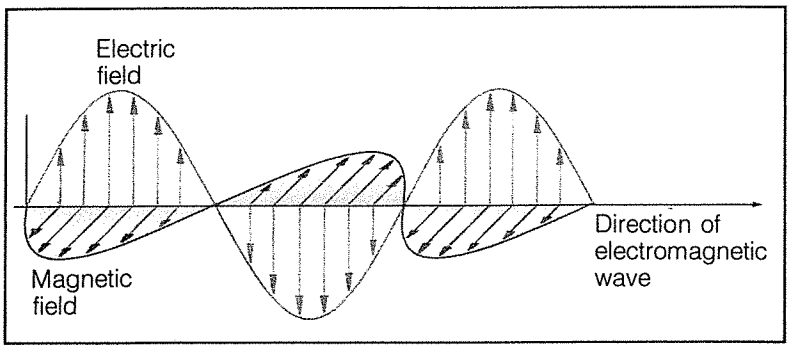


Figure 3–2 *In a transverse wave, the direction of the wave energy is at right angles to both the electric and the magnetic fields.*

Production and Transmission of Electromagnetic Waves

When you first started studying waves, you learned that the source of any wave is a vibration. For example, a vibrating bell causes air particles to move back and forth, producing a sound wave. This same idea about a vibrating source is true for electromagnetic waves as well. However, rather than a source setting up vibrations in a medium, the source of an electromagnetic wave sets up vibrating electric and magnetic fields.

To understand how electromagnetic waves are produced, you must first become familiar with the **atom.** Atoms are the building blocks of matter. An atom consists of a central core, or nucleus, surrounded by tiny particles called electrons. Electrons do not have set positions. Instead, they constantly move about the nucleus.

Electrons are charged particles that can produce electric and magnetic fields. But in order to create the vibrating electric and magnetic fields that are characteristics of an electromagnetic wave, electrons must move. A charged particle, such as an electron, moving back and forth creates electric and magnetic fields that move back and forth, or vibrate. **The source of all electromagnetic waves is charge that is changing speed or direction.** Visible light, for example, is produced by electrons jumping between different positions in an atom. According to modern theories used to describe atoms, electrons move at different distances from the nucleus according to the amount of energy they have. But an electron can absorb more energy and thereby move to another

ACTIVITY THINKING

Electromagnetic Waves in Your Life

1. Look around your home at the devices and appliances you use every day. Name four objects in your home that produce electromagnetic waves.

2. Describe the type of electromagnetic wave that each object produces.

What type of electromagnetic wave is most common on your list?

Do electromagnetic waves play an important role in your life?

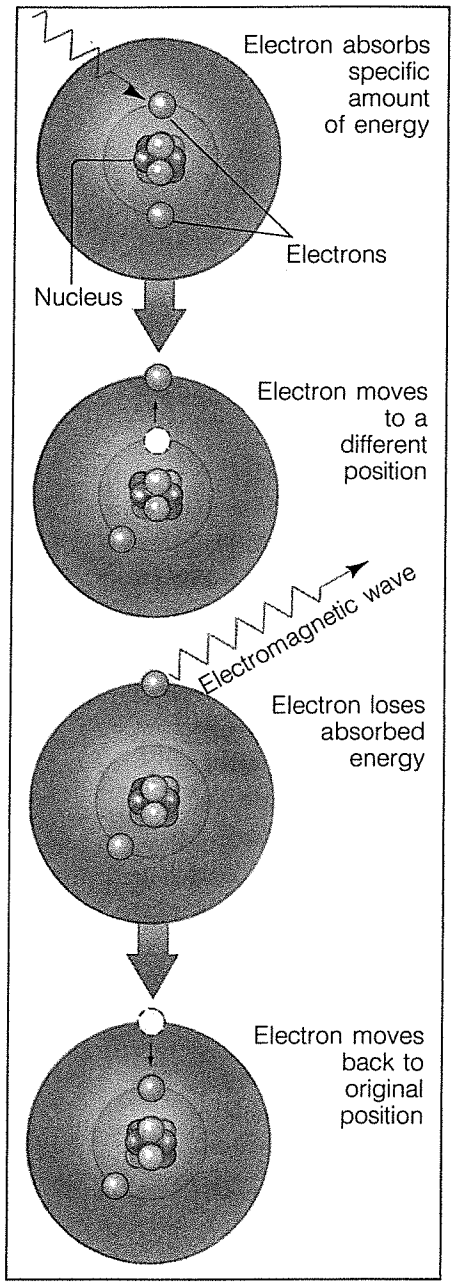


Figure 3–3 *All forms of electromagnetic waves have their source in the atom. In particular, visible light is produced when an excited electron returns to its normal position, releasing energy in the form of an electromagnetic wave.*

position. This move, however, is not a stable one. That is, the electron will not remain in its new position for long. Eventually, it will lose the extra energy and fall back to its original position. As it falls back, it creates vibrating electric and magnetic fields. These fields form the electromagnetic waves that carry the released energy.

Other types of electromagnetic waves are also created in atoms. For example, electrons moving back and forth in an antenna create radio waves. X-rays are produced when electrons slow down abruptly as they collide with a target in an X-ray tube. Gamma rays are produced when the nucleus of an atom gives up extra energy.

The speed of all electromagnetic waves is the same—300 million meters per second in a vacuum. This speed is usually referred to as the speed of light. The speed is slightly slower in air, glass, and any other material. To appreciate just how great this speed is, consider the following: Light from the sun travels 150 million kilometers to Earth in about 8 minutes! Nothing known in the universe travels faster than the speed of light.

Figure 3–4 *Electromagnetic waves carry light from distant stars. If light required a medium for transmission, it would not be able to travel through space to Earth.*

3–1 Section Review

1. What is an electromagnetic wave?
2. What are the physical characteristics of an electromagnetic wave?
3. What is an electric or magnetic field?
4. How is visible light produced?

Critical Thinking—*Relating Concepts*

5. How are sound and light alike? How are they different?

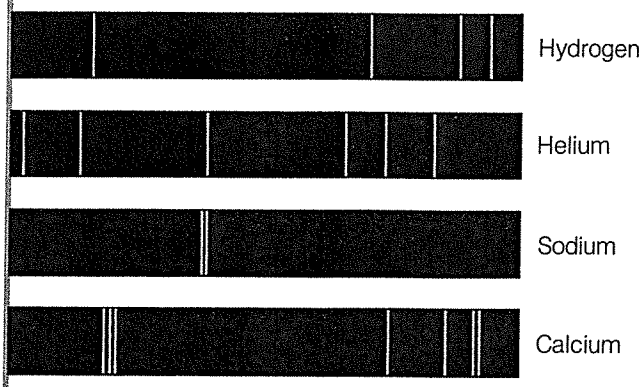
PROBLEM Solving

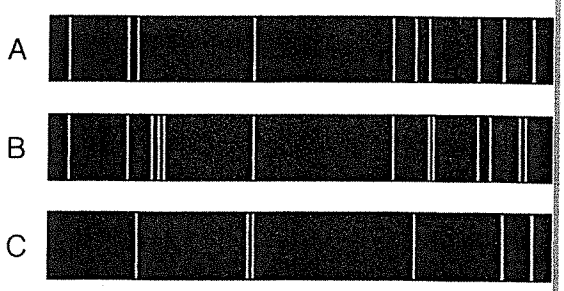
Reaching for the Stars

Suppose you have been given the following assignment: Determine the composition of three distant stars. How can you possibly do it? After all, you cannot travel billions of kilometers to get a sample of each. And, what's more, all you have been given is a few strips of paper with what seem like some silly lines on them. Whatever will you do?

Luckily for you, those strips of paper are all you need. All elements produce a characteristic set of lines when they are heated, and the light given off is passed through a device known as a spectroscope. The lines are called spectral lines. Every element has its own set of spectral lines—much like a fingerprint.

Examine the spectral lines of the following elements. Compare them with the spectral lines labeled A, B, and C. Determine which elements are in the stars that produced A, B, and C.





Waves Activity 6 Name:_____

6-1-20 to 6-8-20 - Final Activity

Read the attached textbook pages (Prentice Hall: chapter 3, section 1.)

Answer the section review questions

1. What is an electromagnetic wave?

2. What are the characteristics of an electromagnetic wave?

3. What is an electric or magnetic field?

4. How is visible light produced?