



Electromagnetic Waves

section 1 The Nature of Electromagnetic Waves

● Before You Read

What do you think of when you hear the word *wave*?

What You'll Learn

- how electromagnetic waves are made
- what electromagnetic waves are like

● Read to Learn

Waves in Space

When you are at the beach, you may enjoy swimming or surfing in the ocean waves. Did you know that you are also enjoying another type of wave when you are at the beach? You can feel the warmth of the Sun on your skin. You can see its brightness with your eyes. The energy from the Sun that you can feel and see comes to you in the form of waves. These waves are a lot like those that bring you TV and cell phone signals. These are the same type of waves that a dentist uses to take X rays.

How is energy moved by waves?

A wave moves or transfers energy from one place to another without transferring matter. How do waves transfer energy? Waves, like water or sound waves, transfer energy by making particles of matter move. Energy passes from particle to particle when the particles bump into each other. Waves that use matter to transfer energy are called mechanical waves.

The space between the Sun and Earth is almost empty. How can the Sun's energy reach Earth if there is no matter to transfer the energy? A different type of wave called an electromagnetic wave is what carries energy from the Sun to Earth. An electromagnetic wave is a wave of charged particles that can travel through empty space or through matter.

Mark the Text

Underline New Ideas

Look for words or sentences that you do not understand. Underline them. When you finish reading, ask a classmate or your teacher to help you understand the things you underlined.

✓ Reading Check

1. **Explain** What does a force field do?

Forces and Fields

Electromagnetic waves are made of two parts—an electric field and a magnetic field. These fields are force fields. A force field is what lets one object put forces on another object without the objects touching. Earth is surrounded by a force field called the gravitational field. This field exerts or puts the force of gravity on all objects that have mass. ✓

How does Earth's force field work? When you throw a ball into the air, it always falls back to Earth. That is because the force of gravity pulls down on the ball. Gravity pulls on the ball when it is still in your hand. It pulls on the ball when it is flying through the air. Earth's gravitational field even goes out into space. Earth's gravitational field is what keeps the Moon orbiting Earth.

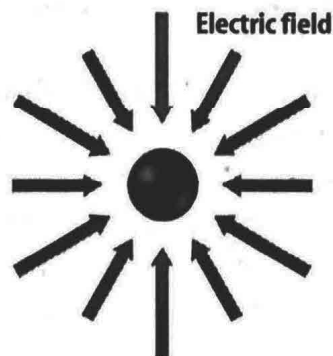
What are magnetic fields?

Have you ever played with magnets? You may know they come together, or attract each other, without touching. They also push each other apart, or repel, without touching. Two magnets put forces on each other without touching because they are surrounded by a force field called a magnetic field. Remember how a gravitational field exerts a force on anything with mass? A magnetic field exerts a force on another magnet or magnetic materials. Magnetic fields cause other magnets to line up along the direction of the magnetic field.

What are electric fields?

Remember that atoms contain protons, neutrons, and electrons. Protons and electrons have a property called electric charge. Protons have a positive electric charge. Electrons have a negative electric charge.

A particle with electric charge is surrounded by an electric field, just like a magnet is surrounded by a magnetic field. The figure shows a charged particle. The arrows show the force put on the particle by the electric field.



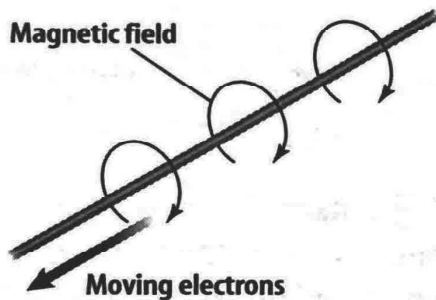
Picture This

2. **Identify** Which of these could be the charged particle in the figure?
- a. a neutron
 - b. a wave
 - c. a field
 - d. an electron

Making Electromagnetic Waves

An electromagnetic wave is made of electric and magnetic fields. How is this kind of wave produced? Think about a wave on a rope. You can make a wave on a rope by shaking one end of the rope up and down. An electromagnetic wave is produced when charged particles, such as electrons, move back and forth or vibrate.

You know that a charged particle is surrounded by an electric field. But, a charged particle that is moving also is surrounded by a magnetic field. For example, electrons flow in a wire that carries an electric current. Because of this, the wire is surrounded by a magnetic field as shown in the figure below. So, a moving charged particle is surrounded by an electric field and a magnetic field.

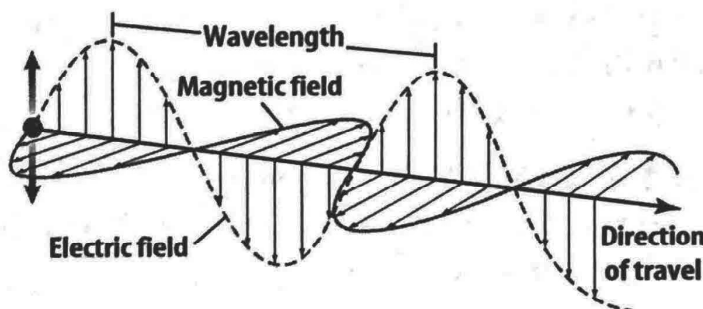


Picture This

3. **Identify** Highlight the direction the electrons are moving in the figure. Use another color to highlight the magnetic field.

How are electromagnetic waves produced?

When you shake a rope up and down, you make a wave that moves away from your hand. When a charged particle vibrates up and down, it makes changing electric and magnetic fields that move away from the vibrating charge in many directions. These changing fields form an electromagnetic wave. The figure below shows how electric and magnetic fields change as they move along one direction.



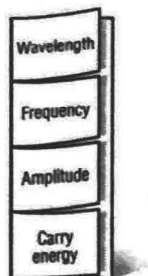
Picture This

4. **Interpret Data** What fields produce electromagnetic waves?

FOLDABLES™

A Organize Information

Make the following Foldable to help you organize information about electromagnetic waves.

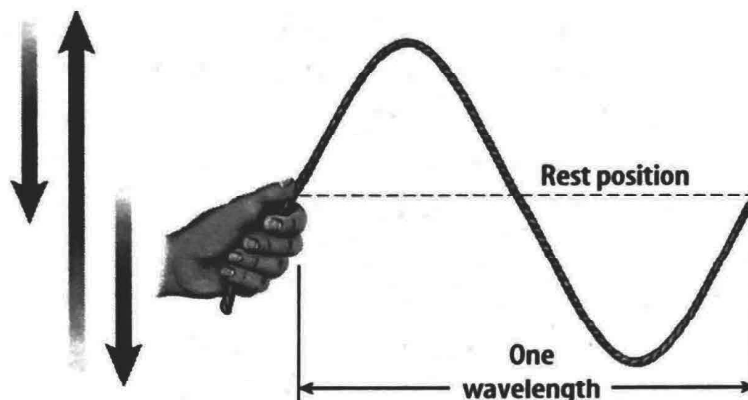


Picture This

5. **Label** a crest and a trough on the wave in the figure.

Properties of Electromagnetic Waves

Like all waves, an electromagnetic wave has a wavelength and a frequency. You can make a wave on a rope when you move your hand up and down while holding the rope. Look at the figure. Frequency is how many times you move the rope up and back down in 1 s. Wavelength is the distance from one crest to the next or from one trough to the next.



Wavelength and Frequency An electromagnetic wave is made by a vibrating charged particle. When the charged particle makes one complete vibration, one wavelength is made. Look at the figure on the previous page. The frequency of an electromagnetic wave is the number of wavelengths that pass by a point in 1 s. This is the same as the number of times the charged particle makes one complete vibration in 1 s.

Energy The energy carried by an electromagnetic wave is radiant energy. What happens if an electromagnetic wave hits a charged particle? The electric field part of the wave exerts a force on the particle and causes it to move. Some of the radiant energy carried by the wave is transferred into the energy of motion of the particle. ✓

How much energy an electromagnetic wave carries depends on its frequency. The higher the frequency of an electromagnetic wave, the more energy it has.

The Speed of Light All electromagnetic waves travel through space at the same speed, about 300,000 km/s. This speed sometimes is called the speed of light.

✓ Reading Check

6. **Describe** What causes a charged particle to move when it is struck by an electromagnetic wave?

● After You Read

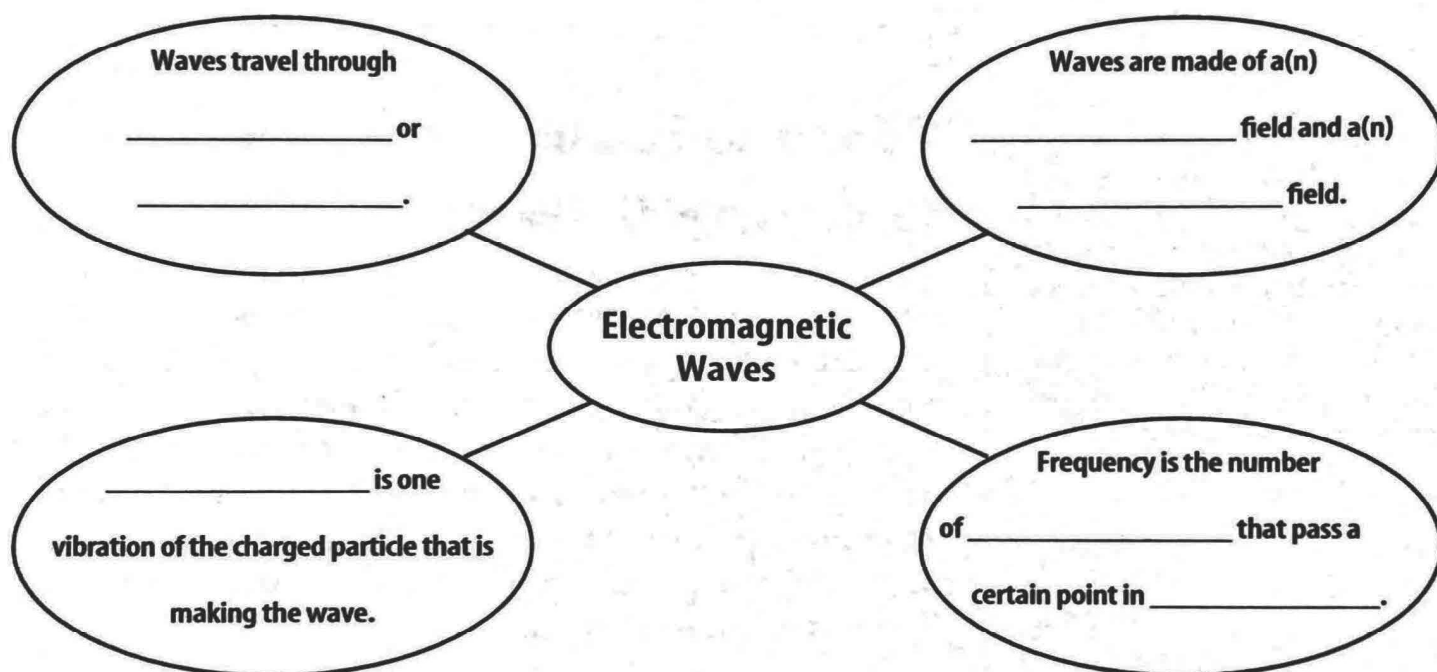
Mini Glossary

electromagnetic wave: a wave of moving charged particles that can travel through empty space or through matter

radiant energy: the energy carried by an electromagnetic wave

1. Review the terms and their definitions in the Mini Glossary. Use the terms *radiant energy* and *electromagnetic wave* to describe why you can feel the warmth of the Sun.

2. Fill in the blanks in the concept map below to describe electromagnetic waves.



3. At the beginning of the section, you were asked to underline words or sentences that you did not understand. How did this help you learn the material?
