Chapter 11 Refraction

What You Will Learn

In this chapter, you will learn how to...

- **explain** refraction and the conditions that are required for partial reflection, partial refraction, and total internal reflection
- **identify** factors that affect the refraction of light as it passes from one medium to another
- **explain** natural effects of refraction, such as apparent depth, mirages, and rainbows, using the ray model of light

Why It Matters

Many modern technologies used in communications and medicine depend on how light behaves when travelling from one substance to another. Also, many of the mysteries of atmospheric phenomena, such as sundogs and rainbows, have been solved by applying our knowledge of how light behaves.

Skills You Will Use

In this chapter, you will learn how to...

- **investigate** the refraction of light and total internal reflection
- **calculate** the velocity of light in a variety of media
- **analyze** how the angles of refraction and incidence change in materials with different indices of refraction

On a cold, crisp day, when the Sun is shining brightly, you might see a halo around the Sun similar to the one shown here. The bright spots beside the Sun are called sundogs. They are created when ice crystals in the air refract the sunlight. Sundogs are just one of the many natural effects of refraction that you will learn about in this chapter.

Activity 11-1

The Re-appearing Coin

For you to see an object, light must reflect from the object and reach your eyes. Sometimes, after reflecting off the object, light will change direction before it reaches your eye, and this will trick your brain. In this activity, you will demonstrate and try to explain this phenomenon.

Use this diagram for question 1.

Safety Precaution

- Be careful not to splash the water on the floor. Wet floors are slippery and dangerous.

Materials

- cup or another container with opaque sides
- coin
- water

Procedure

1. Work with a partner. Place the coin at the bottom of the empty cup, in the middle. Cover one eye with your hand, and look down at the coin with the other eye. Lower your head until the edge of the cup just blocks your view of the coin. Keep your head in this position.
2. Your partner will slowly pour water into the cup. If the coin starts to move, your partner should hold it in place with the end of a pencil. Your partner will continue to pour water into the cup until you can see the coin again.
3. Empty the water in a sink. Be careful not to lose the coin.
4. Change places so that your partner can watch the coin while you pour water into the cup.

Questions

1. Copy the diagram above. Note that the ray in the diagram shows that light from the coin cannot reach your eye if the cup is empty.
2. Sketch a ray diagram to illustrate how light reflects off the coin, travels through the water, and then reaches your eye.
3. How has your brain been tricked by the water?

Study Toolkit

These strategies will help you use this textbook to develop your understanding of science concepts and skills.
To find out more about these and other strategies, refer to the Study Toolkit Overview, which begins on page 560.

Organizing Your Learning

Summarizing

A summary restates the main ideas of a text concisely, using your own words. It can be in sentence form, paragraph form, point form, or graphic form. The table below shows one way to summarize the "Describing Refraction Using Rays" section on page 451.

Summarizing Text

Section of Text	Main Topic	Main Ideas About the Topic	Supporting Details
page 451, third paragraph	how to describe refraction using rays	**1.** Use the same terms to describe refraction as you use to describe reflection. **2.** Use two new terms: the *refracted ray* and *angle of refraction*.	**1.** *Incident ray, normal,* and *angle of incidence* are all used to describe refraction. **2.** Capital *R* is used for refraction, and lower-case *r* is used for reflection.
Summary sentence: The terms used to describe refraction include *incident ray, normal, angle of incidence, refracted ray,* and *angle of refraction* (labelled *R*).			

Use the Strategy

Read the first paragraph under "Partial Reflection and Refraction" on page 458. Summarize the paragraph using a table like the one above. Compare your work with that of a partner and revise as necessary.

Reading Effectively

Making Inferences

Making inferences means figuring out the implied meaning of a text. It involves connecting your prior knowledge with information from the text and, often, from visuals. The second paragraph on page 457 says, "The objects outside the area directly above you are not visible because no light from these objects is penetrating the surface of the water." Here is an example of an inference you might make about this information:

- prior knowledge: To see an object, light must reflect from the object and go to my eyes.
- inference: Light is not reflecting from objects to the side and above the water, so I cannot see the objects.

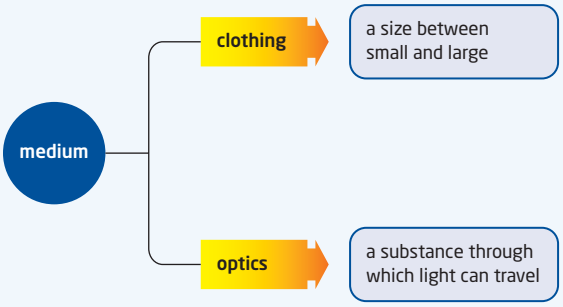
Use the Strategy

Read the first paragraph of Section 11.2 on page 457. Think about your prior knowledge, combine it with the text and the visual on the page, and then make an inference.

Word Study

Multiple Meanings

To reinforce your understanding of a word's multiple meanings, draw a word map like the one on the right. It shows the meaning of *medium* in two different contexts.



Use the Strategy

What does *incident* mean in the context of a police report? in the context of a science chapter about light rays? Draw a word map to show the word's multiple meanings. Use a dictionary if you wish.