Chapter 11 Refraction

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-31 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Collect opaque cups, coins, glass blocks, clear rectangular and semicircular plastic blocks, ray boxes, protractors, 2 L plastic bottles, thumbtacks, duct tape, buckets, flashlights, cardboard, straight pins, stir sticks, non-dairy creamer or chalk dust, ethyl alcohol, glycerol, and masking tape.
- Inspect and repair light sources including flashlights and lamps. Make copies of polar graph paper.
- Have a spill kit and sharps container on hand.

In this chapter, students investigate the refraction of light by various media, predicting light's behaviour, including total internal reflection.

Using the Chapter Opener (Student textbook pages 446 and 447)

- As a class, view the image and read the text of the chapter opener. Tell students that the sundogs are the coloured patches along the halo encircling the Sun (left and above). Ask if anyone has seen a sundog. Sundogs have long been considered to predict a dramatic weather change. Ask what other illusions students have seen. For example, a huge Sun or Moon at the horizon, or a rainbow either in the sky or created by a sun-catcher.
- Tell students that sundogs and halos are just two of over 200 different optical effects generated in the atmosphere. Any optical effects associated with the Sun can also be associated with the Moon. However, lunar effects tend to be less bright and appear in black and white due to the nature of low-light detectors in our eyes. Thus, a sundog has the colours of a rainbow and a moondog appears as a grey patch of light.
- Share several optical illusions caused by refraction and ask students to explain what they see. For example, a straw "severed" by a glass of water, text enlarged by a glass paper weight (or thick-bottomed glass cup), and a rainbow made by a prism or by shining a flashlight on mist from a spray bottle.

Alternative Context

Tell students about the invisibility cloaks in development at Lawrence Berkeley National Laboratory and Cornell University and light bending materials created at the University of California at Berkeley. They may be familiar with imaginary cloaking devices from stories such as *Star Trek*, *Lord of the Rings*, or *Harry Potter*. The technology in development tries to make use of light refraction to "bend" light rays around an object, so that only the background is visible. Tell students that this chapter will examine the properties of light and refraction that make these technologies possible. Go to **www.scienceontario.ca** for more information and links.

Activity 11-1 The Re-appearing Coin (Student textbook page 447)

Pedagogical Purpose

This activity illustrates that light changes direction in a new medium, making a once obstructed object visible.

Planning	
Materials	Cup with opaque sides Coin 250 mL water The day before, collect cups and coins.
Time	10 min
Safety	Spills can make floors dangerously slippery.

Background

Light travels differently (slower, and in a direction closer to the *normal*) through the dense medium of water than it does through the less dense medium air. Thus, though the viewer positions him or herself so the coin is not visible in air, in water light reflects off the coin at a different angle so the image reaches the water's surface at a point where it can be seen. (Refracting [changing direction] at the surface of the water, the boundary between the two media.)

Activity Notes and Troubleshooting

- Any container with opaque sides will work.
- Water could be reused for each trial rather than discarded.
- View the illustration and explain for question 1 that *ray* means the arrow.
- Wrap up the activity by surveying the class for answers to the questions. Create a master diagram of what is happening based on students' analysis.
- Use **BLM A-7 Scientific Drawing Checklist** or **BLM A-40 Scientific Drawing Rubric** to assess student's diagrams.

Additional Support

- DI ELL This is an excellent activity for many learning styles, especially bodily-kinesthetic, visual, and English language learners.
- Students with a visual impairment can receive additional support, using sound to simulate light. Tap the bottom of the cup with a spoon and ask the visually impaired student to point at the sound.
- Without water in the cup, have students explore the different view from each eye, adjusting their position until the coin is visible through one eye but not the other. Use string to create a path from the coin to each eye, making concrete the different path light travels to each eye. Link this to the change in angle caused by the water.
- Set up a scale model of the activity including a doll and string to show the different rays (paths) light travels with and without water in the cup.

Answers

1. Diagrams should be accurate copies of the one in the student textbook.
2. Diagrams should show a ray travelling up from the coin and bending at the water's surface to reach the eye.
3. Example: The brain thinks the coin is where the image appears on the water.

Study Toolkit

Strategy	Page Reference	Additional Support
Summarizing	After reading page 464, have students summarize the main points.	Refer students to Study Toolkit 4, on page 565 of the student textbook.
Multiple Meanings	As students read page 452, have them create a word map for *index* as it relates to both optics and the everyday. They may also wish to evaluate the terms *vacuum* and *medium*.	Refer students to Study Toolkit 4, in particular the Spider Map section on page 565 of the student textbook.
Making Inferences	Before students read pages 457 and 466, have them jot notes about what they already know relating to the headings, then have them examine the figures for additional information.	Refer students to Study Toolkit 1, in particular the Preparing for Reading: Previewing Text Features section on page 562 of the student textbook.