

## INQUIRY LABS – OPEN

# Reflection and Refraction

**How can you model the behavior of light waves, and describe what they do when they bounce off of objects or pass from one medium into another?**

Visible light is a form of energy that is given off by natural or human-made objects such as the Sun or a lightbulb. Other objects may reflect light, enabling them to be seen. Light waves change direction as they are reflected by other objects, and may also change speed and direction as they pass from one transparent medium into another. Explore the principles of reflection and refraction as these properties of visible light are investigated.

## Focus on Science Practices

**SEP 2** Develop and Use Models

**SEP 7** Engage in an Argument from Evidence

**SEP 8** Obtain, Evaluate and Communicate Information

## Materials Per Group

- Cork
- Mirror, plane
- Mirror, support
- Protractor sheet
- Pin
- Semicircular lens, 1
- Water, 100 mL

## Safety

*Optics materials are considered safe. Do not look through lenses at bright light objects especially the sun, as it can be harmful to the eyes. Follow all laboratory safety guidelines.*

## Procedure

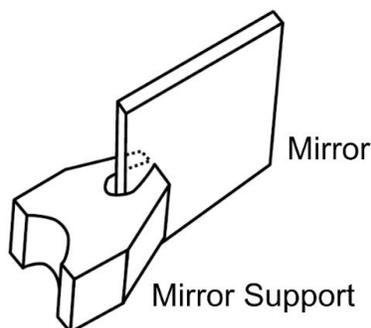
### Part I: Reflection

*What is the relationship between the angle of incidence and the angle of reflection?*

**SEP Develop a Model** Use the following procedure to explore the relationship between the angle of incidence and the angle of reflection for visible light. The procedure provides directions on how to set up the available equipment and supplies, but does not stipulate how their use might yield pertinent data. Once you have set up the equipment you will be directed to develop a procedure that can help you model the relationship between the angle of incidence and the angle of reflection.

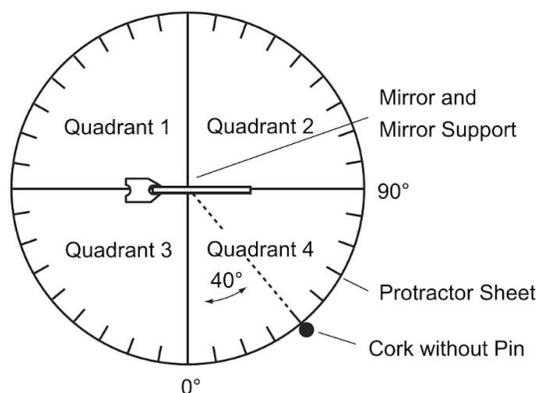
1. Insert the pin into the narrow end of one cork and set aside for step 7.
2. Place the mirror in the mirror support as shown in Figure 1. Note: Make sure the bottom of the mirror support is flat against the work surface so the mirror stands upright without leaning forward or back.

**Figure 1**



3. Place the mirror in the center of the protractor sheet as shown in Figure 2. The mirror should be on the horizontal line ( $90^\circ$ ) on the protractor sheet.

**Figure 2**



4. Place the cork without the pin at the 40° mark in Quadrant 4 on the protractor sheet as seen in Figure 2.
  5. Close one eye and look at the reflection of the cork in the mirror from Quadrant 3.
  6. Adjust your line of sight so the image of the cork is in line with the center of the protractor. Note the angle on the protractor corresponding to your eye position (line of sight). Record the angle and Quadrant number in the data table.
1. Develop a procedure to explore the relationship between the angle of incidence and the angle of reflection, using the apparatus you have set up. Record your detailed procedure; and identify the independent variable(s), the dependent variable(s) and the control variable(s).

**Table 1**

Reflection						
Cork Position		Eye Position		Position of Cork with Pin		Observations
Quadrant	Angle	Quadrant	Angle	Quadrant	Angle	

4	40°					
4						
3						

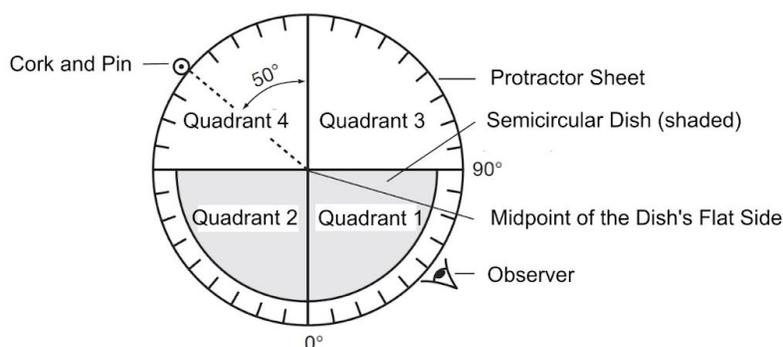
## Part II: Refraction

*What happens to the direction of light as it moves from one medium into another, does it change?*

**SEP Develop a Model** Use the following procedure to explore whether and how light changes direction when it travels from one medium into another. The procedure provides directions on how to set up the available equipment and supplies, but does not stipulate how their use might yield pertinent data. Once you have set up the equipment you will be directed to develop a procedure that can help you understand what occurs when light passes from one medium into another.

7. Fill the semicircular dish  $\frac{3}{4}$ -full with water (approximately 100 mL.)
8. Place the protractor sheet on the work surface so Quadrants 1 and 2 are toward the observer.
9. Carefully place the dish on the protractor sheet so the flat side faces Quadrants 3 and 4, the midpoint line on the dish is centered at the intersection of the quadrants, and the curved section is in Quadrants 1 and 2 as shown in Figure 3.

**Figure 3**



10. Insert the pin into the narrow end of the cork.
11. Place the cork at the  $50^\circ$  mark in Quadrant 4 on the protractor sheet.
12. Close or cover one eye and look through the water-filled dish from Quadrant 1 so your line of sight is from the  $50^\circ$  mark to the center vertical line on the dish. Note: For best results, keep your eye level at the same height as the tabletop.
13. Are you able to see an image of the cork and pin in the water? Record your observations for  $50^\circ$  in the data table.
14. Keeping one eye closed, move your head and line of sight along the curved part of the dish until the cork-and-pin image appears in the water.

Which way did your line of sight move with respect to the normal line ( $0^\circ$ )?  
Add to your observations for  $50^\circ$  in the data table.

15. Continue to move your head and line of sight along the curved part of the dish until the cork-and-pin image in the water lines up with the vertical line on the flat side of the dish.
16. With the image of the pin and vertical line aligned, take the toothpick and place it vertically along the outside of the curved part of the dish so it is aligned with the vertical line and the image of the pin. This will mark your line of sight.
17. Note the angle on the protractor where the toothpick is placed and record the angle and Quadrant number in the data table.
18. Develop a procedure to further explore how light bends as it transitions from air into water. Record your detailed procedure; and identify the independent variable(s), the dependent variable(s) and the control variable(s).

**Table 2**

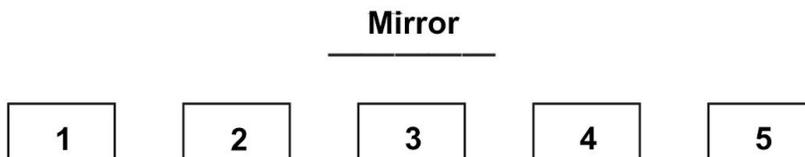
<b>Refraction</b>
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Light Transmission	Observations	Pin Quadrant	Pin Angle	Toothpick Quadrant	Toothpick Angle
Air to Water		4	50°		
Air to Water		4	30°		
Air to Water		4	70°		

### Analyze and Interpret Data

- 1. SEP Communicate Scientific Information** The relationship between the angle of incidence and the angle of reflection is known as the Law of Reflection. Based on your observations, write the Law of Reflection.

2. **SEP Evaluate Evidence** Five students are seated at their desks, which are spaced equally apart, in the front row of a classroom (see diagram). The instructor places a large plane mirror on the board directly in front of the middle student. When student 1 looks at the center of the mirror, which student's image will be seen? Use observations from the lab to support your explanation.



3. **SEP Evaluate Evidence** The archer fish captures its prey by knocking insects off a branch with a stream of water from its mouth. To compensate for the refraction of light as it is transmitted from air into water, would the fish aim above or below the image of the insect it sees? Use observations from the lab to support your explanation.

