Refraction & Total Internal Reflection Teacher's Notes

Main Topic	Light
Subtopic	Refraction
Learning Level	High
Technology Level	Low
Activity Type	Student

Description: Investigate refraction from water to air and back. Observe total internal reflection and determine the critical angle.

Required Equipment	Refraction Cup, Light Box or other source of light rays, Water, Protractor
Optional Equipment	Other liquids such as vegetable oil

Educational Objectives

- Find the index of refraction for water.
- Observe total internal reflection and find the critical angle.

Concept Overview

Refraction is a common phenomenon that we see each day in many different places. Each time we look out a window or into water we are seeing light refract. This activity will have your students discover some of the basic concepts related to refraction. Students will be able to observe that refraction (bending) always takes place at the interface between two different transparent materials and that the angle of refraction in plastic is smaller than the angle of incidence in air. The light is directed at the center of the semicircular cup where it is bent along a radius and exits the element without bending a second time. (It exits along a normal to the surface.) Careful measurement of the incident angle and the refracted angle will produce data which may be used to compute a constant (within experimental error) ratio of the sines of the angles.

Light is refracted as it moves from water to air. However, the angle of refraction (the light in the air) is larger than the angle of incidence (the light in the plastic). The angle of refraction will increase in size faster than the angle of incidence increases in size. The refracted angle will reach 90° before the angle of incidence does. This incident angle is called the critical angle when the refracted angle is 90°. If the incident angle is greater than the critical angle, all the light will be reflected at the water/air interface. Your students will observe that some light is reflected and some is refracted when the incident angle is less than the critical angle. But, all light will be reflected when the incident angle is greater than the critical angle.

Lab Tips

If time allows, students can find the index of refraction for other liquids, such as vegetable oil.

Refraction & Total Internal Reflection

Name: ____________________
Class: ______________________

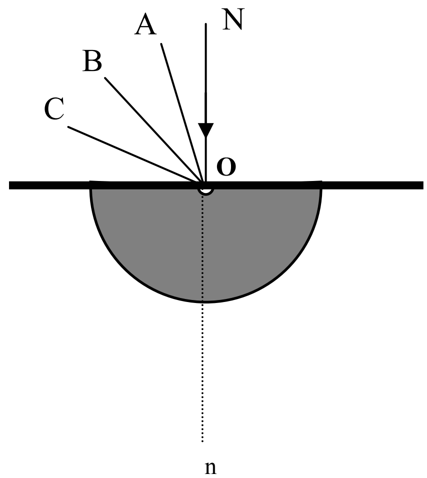
Goal:

Find the index of refraction for water.
Observe total internal reflection and find the critical angle.

Materials:

Refraction Cup, Light Box or other source of light rays, Water, Protractor

Procedure:



1. On a separate page, trace the refraction cup and draw lines N, A, B, and C as shown in the diagram to the right. N must be perpendicular to the flat side of the cup, and extended (as a dotted line) through and past the curved side. The exact angles of A, B, and C are not important. You will measure them later.
2. Fill the cup with water and place it carefully on your digram.
3. Shine a light ray straight down Line A, into the cup.
4. Where does the bending of the light ray take place?

   ____
5. Find the light ray that exits the curved side of the cup. Use a pencil to mark a few dots along the line.
6. Remove the cup, and use a straight edge to connect the dots and the origin, O. Label this refracted ray "a" (lowercase).
7. Repeat steps 3-6 for lines B and C, labeling the refracted rays "b" and "c."
8. Measure each angle of incidence and the corresponding angle of refraction for each ray. Record your measurements in the data table below.

Ray	Angle of Incidence θ_i	Angle of Refraction θ_r	Sine of the angle of Incidence	Sine of the angle of Refraction	Ratio of $\sin\theta_i/\sin\theta_r$
AO					
BO					
CO					

9. Use the data above to make a general statement about refraction of light as it moves from air into water. (Which way does the ray bend?)

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   ____
10. Make a general statement about the ratio of $\sin\theta_i/\sin\theta_r$.

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    ____

Refraction & Total Internal Reflection

Name: ____________________

Class: ______________________

Total Internal Reflection

11. Use the same diagram. Move the light source so that it shines on the line labeled "a" and strikes the curved side of the cup. Where is the refracted ray now? ____
12. Move the light source to line "b," observing the refracted ray, and then to line "c." Describe the trend you are observing in the refracted ray. (Is the angle of refraction getting larger or smaller?) ____
13. Keep moving the light source in the same direction (keeping it aimed at the center point O) until the angle of refraction is 90 degrees, and the refracted ray corresponds to the straight edge of the cup. Use dots to mark the incident ray. Move the cup away and connect the dots and the center point O. Label this ray "d."
14. Measure the angle between the ray "d" and the normal "n." ________________ This is the Critical Angle.
15. Replace the cup. Place the light ray again on "d." Move it on beyond this line, closer to the straight edge of the cup. Describe what you observe.
16. The phenomenon you observed is called Total Internal Reflection. Total, because there has actually been some internal reflection all along. Move the incident ray back to line "c." Observe and describe any internal reflection that occurs. Does this reflection follow the rules of reflection that you have learned about mirrors?