A Critical Lab

Teacher's Guide

Topic:

Refraction and Lenses

The following information is provided to the student:

Question:
At what angle does refraction cease to occur in such a manner that light undergoes total internal reflection?

Purpose:
To determine the critical angle for the water-air boundary and for the Lucite-air boundary.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. The Data section should include two diagrams - one for each boundary. The diagram should display a light ray approaching the boundary at the critical angle and the refracted ray at the appropriate angle. Critical angles should be recorded. The Conclusion should respond to the question raised in the Purpose. The Discussion of Results section should include a short error analysis and include percent error calculations for the two critical angle values.

Materials Required:

Laser; hemicylindrical plastic dish; water; hemicylindrical Lucite block; polar coordinate graph paper (or two protractors).

Description of Procedure:

A hemicylindrical dish is filled three-fourths full of water. It is placed upon a sheet of polar coordinate graph paper and aligned such that its flat edge runs from the 90° mark to the 270° mark of the graph paper. A trace of the dish is made using a pencil. A leveling laser is set to LINE setting and placed with its flattest edge on the graph paper such that the light path is projected onto the paper. The light path is directed at the curved side of the hemicylindrical dish, entering the water at the midpoint of the curved edge and approaching the boundary with the flat side at an angle of incidence of 0°. Gradually the laser path is altered so that the angle of incidence at the flat side increases. For each angle, the laser is set to exit the hemicylindrical dish at the midpoint of the flat side. As the angle of incidence is increased, observations are made of the angle of refraction and of the refracted ray. The minimum angle (in the water) which results in no refraction is observed. Results of the observations are documented. The procedure is repeated for a hemicylindrical Lucite block. Class results are pooled and class averages of the angle are calculated for the two materials.

Alternative Materials and Procedure:

Alternative materials and procedures are not recommended.

Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as

safe as possible. Light from lasers should never be pointed into a person's eye. Caution should be taken to avoid such mishaps. Student *horseplay* and off-task behaviors should not be tolerated.

Suggestions, Precautions, Notes:

1. Inexpensive leveling lasers can be purchased at a home store. They often go on sale for $5 during the Christmas season. They possess the capability of projecting the laser as a line or a beam. If the price is right, consider picking up a class set for use in both reflection and refraction activities.
2. Polar coordinate graph paper can be downloaded from many internet sites. For instance, try

   http://www.analyzemath.com/free_graph_paper/free_graph_paper.html
3. The hemicylindrical plastic dishes described in the Materials and Procedure section are commonly available from science supply houses. As an example, consider the dish advertised by Arbor Scientific:

   http://www.arborsci.com/detail.aspx?ID=308
4. Warn students in advance of the lab of the need to never direct laser light at another person's eye. Students who do not heed your warning should immediately be dismissed from the lab.
5. This activity can be performed without having discussed the mathematics of critical angle. Pooling class results for the water and the Lucite yields very accurate results. The activity makes for a good introduction to the mathematics of the critical angle.

Auxiliary Materials:

None

Scoring Rubric:

RL7.	**A Critical Lab**	**Score**
____	Included, labeled and organized all parts of the lab report.	____/____
____	Data section includes two diagrams (one for each boundary) with an incident ray in the appropriate medium and at the critical angle; corresponding refracted ray is correctly shown. The critical angle is labeled on the diagram.	
____	Conclusion states the critical angles for the two boundaries; values are reasonably accurate.	
____	Discussion of Results includes an error analysis evaluating the reliability of the critical angle values. The theoretical value is calculated (work is shown) and a percent error analysis is included for both boundaries. The work is shown and organized.	

Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

http://www.physicsclassroom.com/Class/refrn/u14l2b.cfm

http://www.physicsclassroom.com/Class/refrn/u14l2c.cfm

Connections to Minds on Physics Internet Modules:

Sublevel 6 of the Refraction and Lenses module is a suitable accompaniment to this lab:

http://www.physicsclassroom.com/mop/module.cfm