Snell's Law

Name:	Teammates:

Introduction

Whenever a wave encounters a different medium, if its speed in the new medium is different, part of the wave is reflected and the other part is refracted (transmitted) into the new medium. The principles governing reflection are quite simple. The angle at which the wave hits the surface is equal to the angle at which it reflects, albeit on the opposite side of the normal to the surface.

Refraction occurs when the wave is able to travel through the interface into the second medium. If the wave comes in at a zero incidence angle, then it refracts at zero angle. However, if it comes in at some angle, then it will transmit into the second medium at an angle that depends upon the speed of the wave in both media. The rule that governs how waves are refracted is known as Snell's law.

$$n_i \sin \theta_i = n_t \sin \theta_t$$

where n is the index of refraction, θ is the angle of the light ray, the i subscripts refer to the incident medium, and the t subscripts refer to the medium into which the light was refracted. As this relationship shows, if the index of refraction of the transmitted medium (n_t) is larger than the index of refraction of the incident medium (n_i), then the transmitted angle (θ_t) will be smaller than the incident angle (θ_I).

It also shows that if ($n_i > n_t$), then the transmitted angle will be larger than the incident. This is true unti the transmitted angle reaches 90 degrees. Beyond that, the light is not transmitted. The angle at which light stops from being transmitted is known as the Critical angle, it is given by

$$\theta_C = \theta_i = \sin^{-1}\left(\frac{n_t}{n_i}\right)$$

For angles greater than this incident angle, we have total internal reflection. This is the basis for such devices as fiber optic cable that more and more often used in telecommunications.

Procedure part 1

To study Snell Law, we will investigate light passing through two different apparatii: a semicircular acrylic solid and a trapezoid-shaped acrylic solid. In the first part of this experiment, we will change the incident angle of a light beam on the middle of the flat face of the semicircular solid. The beam will refract inside of the acrylic, moving at a new angle. However, as the backside of the solid is circular, the beam leaving it will be normal to the surface, and will not refract at a new angle as it re-enters the air. Thus, the angle of refraction for traveling through the acrylic solid can be measured from the beam exiting the backside.

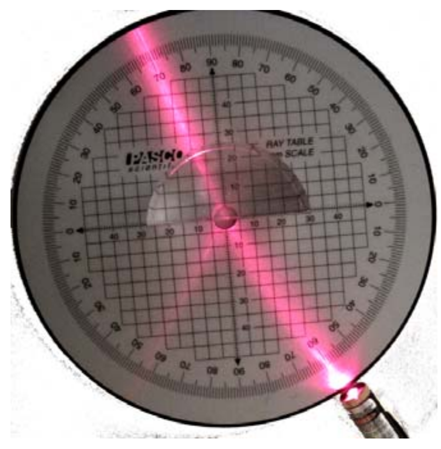


Fig. 1: Experimental set up for first part

1. Set-up the equipment as in Figure 1. Before placing the acrylic semicircle on the table, position the laser so that the laser light beam is traveling down the center of the table, (Note: it might help to have the lights in the room turned off for this experiment). Place the acrylic semicircle so that it is aligned with the center line and has its midpoint at the center of the table.
2. To view the light beam, spray a little baby powder on your hand and lightly blow some of it in the path of the laser beam. Avoid spraying (blowing) too much baby powder.
3. Position the laser until the beam strikes the flat surface of the acrylic semicircle in the center and at a 5 degree angle relative to the perpendicular to surface.

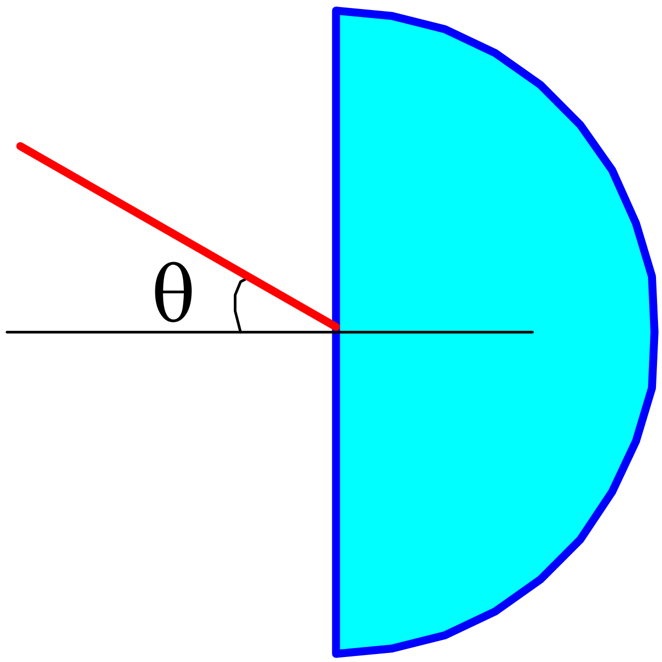
Incident Angle	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	Avg.
Refracted Angle													
Index of refraction													

4. Measure the angle at which the beam leaves the semicircle acrylic solid by noting the angle at which the refracted light ray strikes the optical table.
5. Turn the optical table 5 degrees and repeat the measurement.
6. Continue to do this until you reach an incidence angle of 60 degrees.

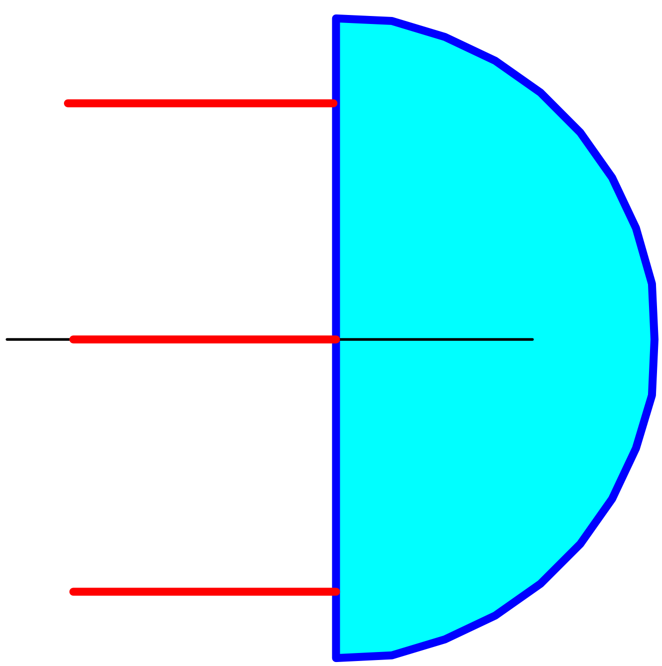
A. How close is your measured value for the index of refraction to the theoretical value of 1.5?

B. What are the sources of error for this measurement?

C. Use the diagram below and the index of refraction that you have measured, to trace the path of the laser beam when inside the circular block and as it exits back into the air. The initial angle θ shown is 30°.

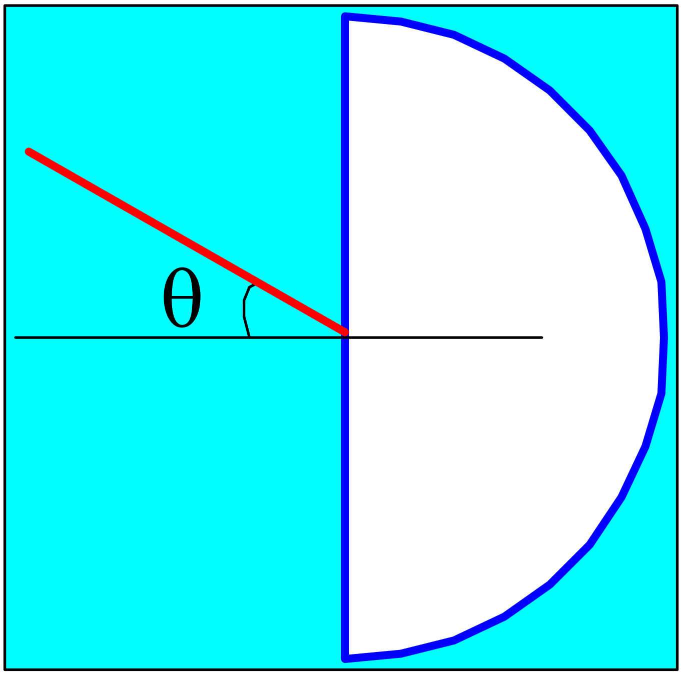


D. Use the diagram below and the index of refraction that you have measured, to trace the path of the three laser beams shown.

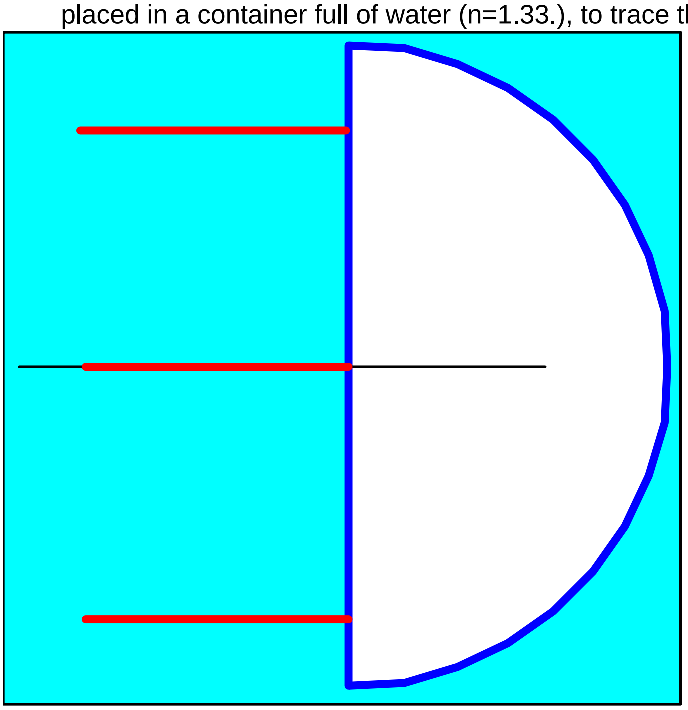


E. What do you conclude about the effects of the semicircular slab on parallel light beams?

F. Repeat the same procedure as in part C but assuming that the block is in this case full of air (n=1.00) and is placed in a container full of water (n=1.33.) The laser beams moves from water into air and back into water as it exits the block.



G. Repeat the same procedure as in part D but assuming that the block is in this case full of air (n=1.00) and is placed in a container full of water (n=1.33.), to trace the path of the three laser beams shown.



H. What do you conclude about the effects of the semicircular block of air on parallel light beams?

Procedure part 2

1. Set-up the equipment as in Figure 2 placing the acrylic trapezoid such that the laser light beam hits the angled side of the trapezoid at an angle of 30 degrees relative to the normal of that side (as shown in the diagram below). Note that the smallest angle of the trapezoid is 45 degrees.
2. Use a white sheet of paper to identify the position of all laser beams that exit the acrylic block.
3. Assuming an index of refraction of 1.5, use the diagram below, a ruler and a protractor, to trace the path of the laser beam when inside the block and as it exits back into the air. Account for all possible reflections and refractions so that you can account for all beams observed in the previous step.
4. Label each of the beams that you have traced and use the label to provide the logic you have used in tracing that beam.

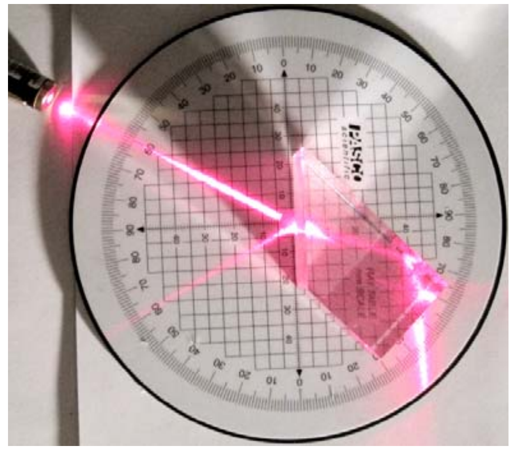


Fig. 2: Experimental set up for part 2