Refraction

BACKGROUND: The bending of light rays in passing from one medium to another is called refraction. In Fig. 10.1. light is traveling in media 1 with index of refraction n_1, and is incident on medium 2 which has an index of refraction of n_2. The light ray in medium 1 is referred to as the incident ray, and that in medium 2 is referred to as the refracted ray. The angle of incidence is defined as the angle that the incident ray makes with the normal to the surface. Similarly the angle of refraction is the angle that the refracted ray makes with the normal to the surface.

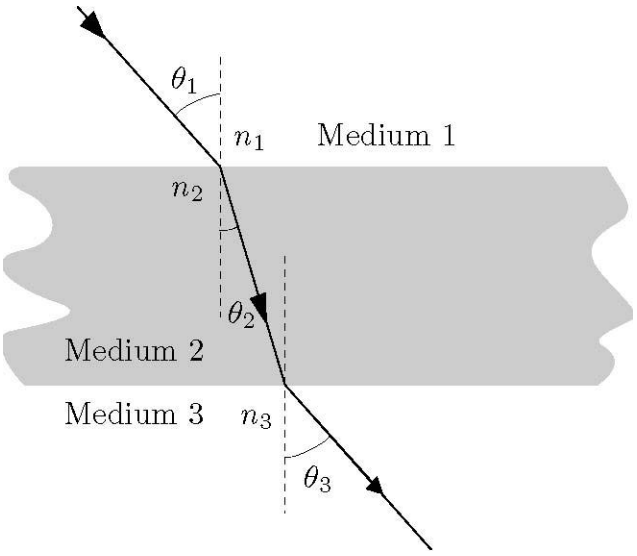

Figure 10.1: Double Refraction.

The angles of incidence and refraction are related to the indices of refraction of the two media through Snell's Law:

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2) , \quad (1)$$

or, more conveniently for us:

$$n_2 = n_1 \sin(\theta_1) / \sin(\theta_2) . \quad (2)$$

From Eq. (2), it can be seen that the index of refraction of the second medium, with index of refraction n_2, can easily be determined from measurements of the angles θ_1 and θ_2 if the index of refraction in thefirst medium, n_1, is known. For this laboratory exercise the first medium will be air, so that $n_1 \approx 1$.

OBJECT: To investigate Snell's Law and determine the index of refraction of liquid media.

APPARATUS: HeNe Laser, Refraction Tank-Protractor Unit.

WARNING: Never look directly into a laser beam.

PROCEDURE:

1. Locate the glass side of the tank that has a clearly etched vertical line. Arrange the tank on the base so that the etched lined is over the axis of rotation of the protractor arm. It may be necessary to disassemble the tank from the base to obtain the proper orientation.
2. Partially fill the tank with water. Be certain to clear any residue material from the tank before filling it. With the laser turned off, arrange the tank and laser so that the laser is away from the side of the tank that contains the etched line.
3. Turn the laser on and direct the beam through the tank of water so that the refracted beam strikes the etched line on the opposite side of the tank.
4. Rotate the protractor arm until the emergent beam strikes the center of the protractor arm. The angle specified by the arm is θ_1.
5. Place the movable slits on the sides of the tank so that the beam passes through them. Sight over the surface of the water to align the protractor arm with the slit. The angle specified by the arm in this configuration is θ_2.
6. Reposition the laser so the angle of incident is changed. Note that best results occur when the angle of incidence is large, at least 45^0. Repeat the procedure for five different angles.
7. Add the prepared salt solution to the water tank, and again obtain measurements for five different angles.
8. Enter all data in the data tables and determine the average value for the index of refraction of water and for the index of refraction of the water-salt mixture.
9. Determine the percentage of error in the measured index of refraction for water using 1.33 as the accepted value.

QUESTIONS:

1. Why does light bend when it travels from one medium to another?
2. For what incidence angle would light not bend when passing from water to glass?
3. Explain the differences in the values that you obtained for the index of refraction for water and for the water-salt mixture. Where there significant differences in the two answers? What would you guess the difference in these two values to be? Explain.

Data to determine the index of refraction of water.					
Trial	θ_1	$\sin(\theta_1)$	θ_2	$\sin(\theta_2)$	n_2
1					
2					
3					
4					
5					
Average					
% of error					
Data to determine the index of refraction of water-salt mixture.					
Trial	θ_1	$\sin(\theta_1)$	θ_2	$\sin(\theta_2)$	n_2
1					
2					
3					
4					
5					
Average					