4C Lab – Reflection and Refraction

Goal: To examine the optical properties of reflection and refraction and calculate the index of refraction of a plastic block.

Equipment List:

Optics bench
Angular translator
Laser
Mirror, plastic block, plastic triangle, screen
Component holders

Pre-lab Exercise: Using Snell's Law, derive an equation for the index of refraction for the plastic block

Background:

The law of reflection says that the angle of incidence is equal to the angle of reflection, or:

$$\theta_{in} = \theta_{out}$$

Snell's Law relates the angle of incidence to the refracted angle depending on the index of refraction in the two media, or:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

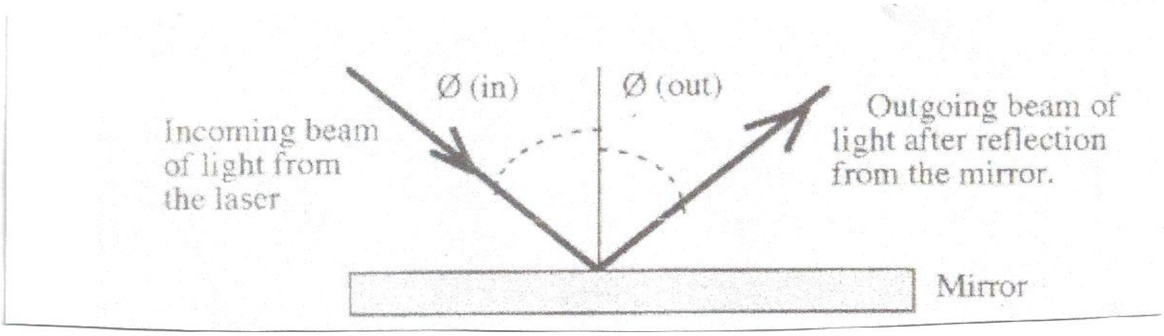
Total internal reflection occurs when the critical angle is given by:

$$\text{Sin } \theta_c = n_2/n_1$$

Part 1: The law of reflection

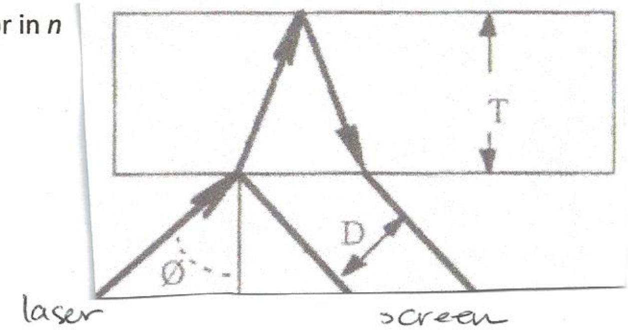
1. Align the laser, angular translator, screen and mirror. First, put the mirror on the center of the translator perpendicular to the light from the laser. Try to get the beam to go exactly back into the opening.
2. Put the screen on the rotatable arm and try to align it with the beam. Note the position of the ray when no mirror is blocking the light.
3. Now, carefully rotate the mirror through some angle and move the screen to find the outgoing ray. What is the angle between incoming and outgoing rays?
4. If you rotated the mirror to angle θ on the right (say at 20°), check the opposite rotation (for example, 340°). Are the values (of the reflection angles) the same, rotated to the right and to the left? If not, try to center the mirror again.
5. Repeat for six angles total, three left, three right. Determine the ratio of mirror rotation to the angle between incoming and outgoing rays. Calculate the average and standard deviation.

And, by the way! Do not shine the laser in anyone's eyes, including your own. Do not look directly at the laser.



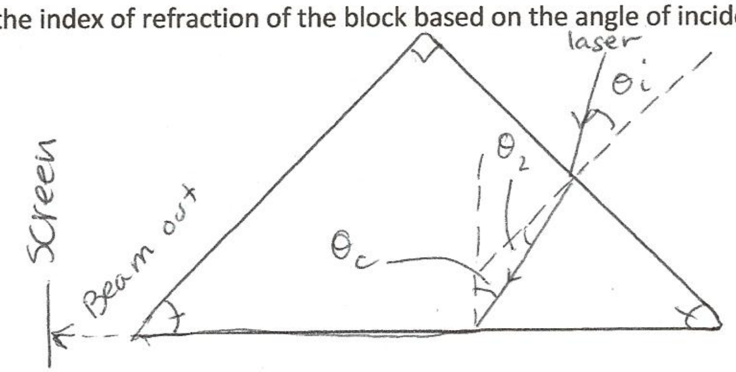
Part 2: Snell's Law

1. With the rectangular plastic block front surface on the center of the rotating platform, check that the beam is reflected back into the opening to find the zero position.
2. Rotate the block through some angle and look for the double dot outgoing reflection. Now there is a reflection off of the front surface and the back surface. Measure are the angle through which the block rotates and the distance between the two dots on the screen.
3. Take 10 measurements, five at each angle left and right. Average the left and right values of *D* for 5 values of *D*.
4. Measure *t,* the thickness of the block.
5. Derive, as in the pre-lab exercise, the index of refraction based on your measurements, θ_{in}, *D* and *t*
6. Calculate *n* for each value of *D*, $n_{average}$ and the standard error in *n*



Part 3. Total internal reflection

1. Center the prism with the one of the short side's front edge at the center of the rotating platform with the laser hitting the side at normal incidence. Move the white screen around the platform and notice that no light escapes from the hypotenuse side of the prism. Since the prism is an isosceles right triangle, the beam is hitting the hypotenuse at 45o and is totally internally reflected.
2. Place the screen so that the center of it lies along the line of the hypotenuse. Now rotate the prism so that the laser is no longer incident normally. Rotate the prism so that the angle of the beam on the inside of the prism at the hypotenuse face grows smaller.
3. You will see the critical angle when the beam is traveling along the face of the hypotenuse and there is a dot on the screen. Check that this is the critical angle by rotating the prism slightly to see the beam appear and disappear. Measure the angle of incidence.
4. Using your knowledge of geometry, Snell's Law and the condition for total internal reflection, calculate n, the index of refraction of the block based on the angle of incidence.



Conclusion:

Does your data from part 1 verify the law of reflection?

What is the index of refraction of your block from part 2 and part 3? Does it fall within uncertainty of the accepted value?