SAINT JOSEPH'S PREPARATORY SCHOOL
PHYSICS LAB EXERCISE
SNELL'S LAW

NAME: _____ DATE:_____ PERIODS: _____

COLLABORATORS:_____

DATE REPORT IS DUE:_____

Light travels at different speeds in different media. When light rays pass at an angle from one medium to another, they are ***refracted*** or bent at the boundary between the two media. If a ray of light enters a medium in which it moves less quickly and at an angle, it is bent toward the normal line. If a ray of light enters a medium in which it moves more quickly and at an angle, it is bent away from the normal line. This change in direction or bending of light at the boundary at two media is called ***refraction***. Refraction is one of the wave characteristics of light an does not involve an energy change.

The *index of refraction* of a substance, n_s, is defined as the ratio of the speed of light in a vacuum, c, to its speed in the substance, v_s:

$$n_s = \frac{c}{v_s}$$

All indices of refraction are greater than one, because light always travels slower through matter than through a vacuum. The index of refraction can be measured by using Snell's law, which states that a ray of light passing from one medium to another bends in such a way that the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for any two media. Snell's law can be written:

$$n = \frac{\sin\theta_i}{\sin\theta_r} = \frac{v_i}{v_r}$$

It is more useful to write Snell's law as:

$$n_i \sin\theta_i = n_r \sin\theta_r$$

where n_i is the index of refraction of the first medium and n_r is the index of refraction of the second medium. The angle of incidence is θ_i, and the angle of refraction is θ_r.

You are to construct ray diagrams to analyze the path of light as it passes through plate glass. For each angle of incidence, you will measure the angle of refraction to find the index of refraction of plate glass and or transparent plastic. The results of this exercise depend on the fact that the difference between the speed of light in air and its speed in a vacuum is negligible.

Materials

glass plate and/or Lucite® block
metric ruler
protractor
sheet plain white paper

Procedure

1. Place the glass plate in the center of a sheet of plain white paper. Use a pencil to trace an outline of the plate.
2. Remove the glass plate and construct a normal $\mathbf{N_1B}$ at the top left of the outline, as shown in Figure 1 on the next page.
3. Use your ruler and protractor to draw a heavy line **AB** at an angle of 30° with the normal. Angle **ABN**, is the angle of incidence, θ_i.

4. Replace the glass plate over the outline on the paper. With your eyes on a level with the glass plate, sight along the edge of the glass plate opposite the line **AB** until you locate the heavy line through the glass as shown in Figure 2. Sight your ruler at the line until its edge appears to be a continuation of the line. **DO NOT MOVE THE GLASS!** Draw the line **CD** as shown in Figure 1.
5. Remove the glass plate and draw another line **CB** connecting lines **CD** and **AB.** Extend the normal $\mathbf{N_1B}$ through the rectangle, forming a new line $\mathbf{N_1BN_1'}$.
6. Use a protractor to measure angle $\mathbf{CBN_1'}$**.** This is the angle of refraction, θ_r. Record the value of this angle. Record the sines corresponding to the measured angles of incidence and refraction. Determine and record the ratio of $\frac{\sin\theta_i}{\sin\theta_r}$. This is the index of refraction, *n* of the glass or plastic.
7. Construct a normal $\mathbf{N_2}$ at point **C**. Measure angle $\mathbf{DCN_2}$**,** which will be called $\theta_{r'}$, and record this value.
8. Turn the paper over and repeat Steps 1 through 7, using an angle of incidence of 45°. Again, determine the index of refraction from your data.

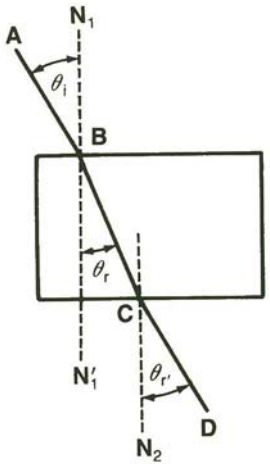

Figure 1: Construct normal lines at points **B** and **C.**

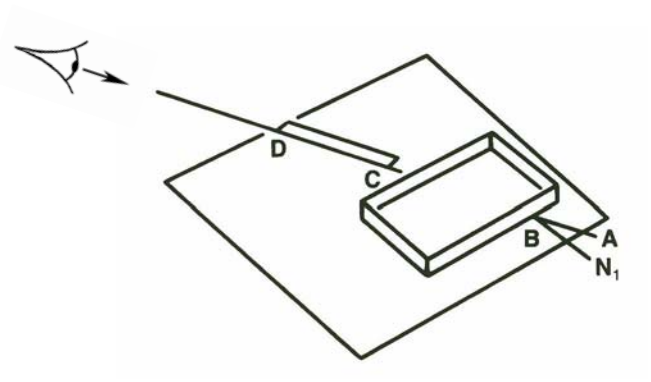

Figure 2: Sight through the glass or plastic and align the ruler with line **AB**.

Analysis

1. Is there good agreement between the two values for the index of refraction of plate glass?
2. According to your diagrams, are light rays refracted away from or toward the normal as they pass at an angle from an optically less dense medium into an optically more dense medium?
3. According to your diagrams, are light rays refracted away from or toward the normal as they pass from an optically more dense medium into an optically less dense medium?
4. Compare θ_i; and $\theta_{r'}$. Is the measure of $\theta_{r'}$ what you should expect? Explain.
5. Use your results to determine the approximate speed of light as it travels through glass. By what percent is the speed of light traveling in a vacuum faster than the speed of light traveling in glass?