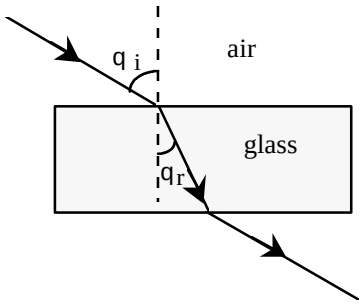
Refraction and Snell's Law

Introduction:

While the speed of light is constant in a vacuum, the speed of light in air and in transparent solids is somewhat less. The ratio of the speed of light in a vacuum *(c)* to the speed of light in a solid *(v)* is called the **index of refraction** *(n)* of the solid:

$$n = \frac{c}{v}$$

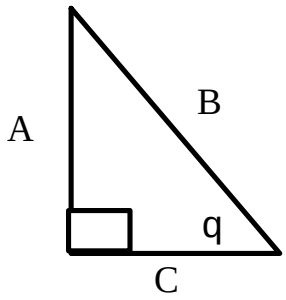
When a beam of light travels between substances with different indices of refraction such as from air (n = 1.00026) into glass (n = 1.52), the change in wave velocity which occurs is accompanied by a change in the direction of the beam. This is the principle of **refraction**.



The **law of refraction** or **Snell's law** describes the amount of refraction which will take place. This law states that the index of refraction of the incident medium multiplied by the sine of the incident angle is equal to the index of refraction of the refracting medium multiplied by the sine of the refracted angle.

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

The sine function is a trigonometric function which relates an angle in a right triangle to the ratio of the lengths of two of its sides. Specifically, the sine of an angle θ for a right triangle is defined as the ratio of the length of the side opposite to the angle and the length of the hypotenuse.



For the right triangle A-B-C, the sine of q is defined as follows:

$$\sin q = \frac{A}{B}$$

The objective of this experiment is to use Snell's law to determine the index of refraction of a glass plate. We will be measuring the angles of incidence and refraction and substituting into Snell's law to solve for the index of refraction of glass. In addition, we will be measuring various lengths in order to demonstrate the utility of the sine function.

Procedure:

1. Use masking tape to secure the paper to the Styrofoam and place the glass plate near the center of the page, also using the tape to secure the glass plate to the paper. The glass plate may have only two edges which are polished for the transmission of light. If so, place these edges facing the short sides of the paper.
2. Put a pin against one of the polished edges of the glass so that it is off-centered to the right.
3. Place an eye at the level of the plate in order to see the image of this first pin. Align a second pin with the image to establish the path of the *incident ray*.
4. Now look through the glass at the two pins. Place a third and fourth pin on the other side of the glass so that they align with the two pins on the other side of the glass. Place one of these pins in contact with the other polished surface of the glass.
5. Make marks along the incident and emergent edges of the glass plate.
6. Repeat steps 2-5 for another ray with a different incident angle.
7. Remove the plate from the page. Construct the incident, refracted, and emergent rays. Using a drafting triangle, construct a normal (perpendicular) to the surface at the incident and emergent points of the glass.
8. Using a ruler, construct right triangles using the normal and the incident and refracted beams. The beam will serve as the hypotenuse, the normal as the adjacent side. Locate the opposite side and determine the ratio of the length of the opposite side to the hypotenuse. Do this both for the right triangle of the incident and refracted beams.

9. Using a protractor, measure and record the angle of incidence and the angle of refraction at each of the incident and emergent points. Use a calculator to find the sine of these angles. Are they equal to the ratios calculated above?

Analysis:

Assuming the index of refraction of air is $n_i = 1.00$, use Snell's law and the sines determined above to find the index of refraction of the glass plate. The accepted value is $n_{glass} = 1.52$. Calculate the percent error of your measured value. Report both the value obtained from the ratios and that obtained with the protractor and the sine function.

Conclusions:

1. Summarize your results for this experiment.
2. What units does the index of refraction have? Why?
3. If the index of refraction of air was greater than that of the glass, how would your data look? (Draw a picture.)
4. Now consider a cylindrical piece of glass, which is a circle as seen from above. Draw the path of a ray incident on such a solid. Remember that the incident angle is measured from a perpendicular to the surface at the point of incidence.

Error Analysis:

Describe any significant sources of error.

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Data Collection Sheet

Name:_____Section:_____

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Name:_____ Section:_____

Abstract:

Conclusions:

Error Analysis: