Laboratory #8
The Index of Refraction

It is useful this week to have a calulator with trig. functions on it. If you don't, I am sure there are enough to share.

Light in a vacuum travels approximately 300,000,000 m/s. Light in air travels at almost that same speed. However, when light goes from air to glass it slows down. The ratio of the speed of light in a vacuum to that in a substance is called the refractive index and is given the symbol n. We take $n = 1$ for air in most cases. In this laboratory you measure the index of refraction, n, of a piece of glass and test Snell's law, which relates n to the angle of incidence and the angle of reflection. This process is more data intensive than the previous laboratories and a simple graph is required. Try to move promptly through the data taking stage of the lab to leave plenty of time for the analysis.

Place the large, solid block of glass in the square on the graph paper. If it does not fit exactly, line it up with the bottom line and allow the top to be off some. Now stick a pin right up to the top side of the block. In principle this is where position 1 is marked, but if your glass does not fit, it might be a bit off. This pin remains in place throughout the laboratory and is not to be removed.

Now place one pin at position $2a$ and a second pin on line 3 which is aligned with pin $2a$ and the image of pin 1. Put a small circle around pinhole $3a$, label its location with an a and remove pins $2a$ and $3a$. The locations of the three pins indicate the path of a ray of light which travels through the block of glass (pin 1 to $2a$) and is then refracted when it enters the air (pin $2a$ to $3a$).

Repeat this entire procedure with each of the locations labeled $2b$, $2c$ and $2d$.

Remove the block of glass and all of the pins. Use a ruler to draw the light paths in the glass from pin 1 to pin 2 and the path in the air from pin 2 to pin 3 for each of the four cases. It is useful to extend the line from point 2 to point 1 up to the top of the graph paper as it makes it easier to measure the angles. Now measure θ_g (the angle in the glass) and θ_a (the angle in the air) while putting all of the data in a table. And include the sine of each angle that is measured. Remember that these angles are measured with respect to the normal of the glass=air interface.

To analyze the data make a graph in your lab book by plotting $\sin \theta_a$ vertically against $\sin \theta_g$ horizontally. Make the graph plenty **BIG**—a size of 20 squares by 20 squares seems about right to me. Do the points fall nearly on a straight line? If so, then draw in a single straight line which includes all of the points, to the extent that is possible. Find the slope, $\Delta Y / \Delta X$, of this line—this slope is the index of refraction of the glass.

For a special value of θ_g the refracted ray just skims the surface of the block of glass. In that case θ_a is 90°, and $\sin \theta_a$ is 1. From your graph, first find the value of $\sin \theta_g$ which corresponds to $\sin \theta_a = 1$. Then find the corresponding angle, θ_g; this is the critical angle for total internal reflection.

As part of a conclusion you should explain what feature of your data supports Snell's law.