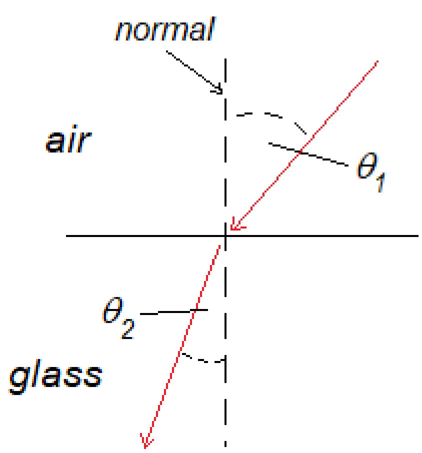
Physics 4C Lab 9: *Snell's Law, Refraction of Light*

The objective of this lab exercise is to observe the refraction of a beam of light through two different media, and use the measured data to determine the index of refraction for both media.

When a beam of light transmits from one medium into another, it will "refract", i.e. change direction due to the difference of the speed of light in the two media. Since the speed of light in air is nearly the same as the speed of light in a vacuum, it's safe to assume that light transmitting from air into any solid medium will slow down. Since the speed in the solid (or liquid) medium is slower, the path of the light in the solid (or liquid) medium will be closer to the "*normal",* the line perpendicular to the boundary between the two media.

We define the *angle of incidence* and *angle of refraction* (with labels θ_1 and θ_2, respectively…) as the angle between the direction of the light beam and the *normal*, i.e. perpendicular, to the surface:



The two angles are related by *Snell's Law*:

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

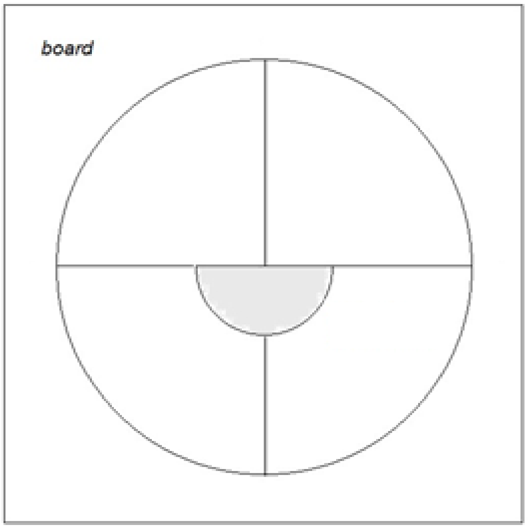
Since the index for air, i.e. n_1, is 1.00, we can simplify this expression to:

$$\sin\theta_1 = n \sin\theta_2$$

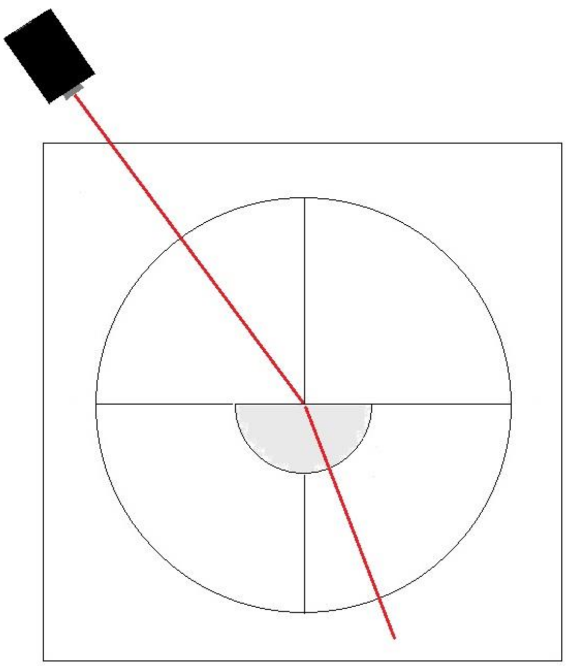
where "n" is the index of refraction of the material.

In practice, measuring angles precisely can be difficult. So for this experiment we will devise an alternate system of measurements that will accomplish our task with the precision we need. Our equipment will include a laser (as the source of the light beam), a dish filled with liquid, and a large circle drawn on a flat board.

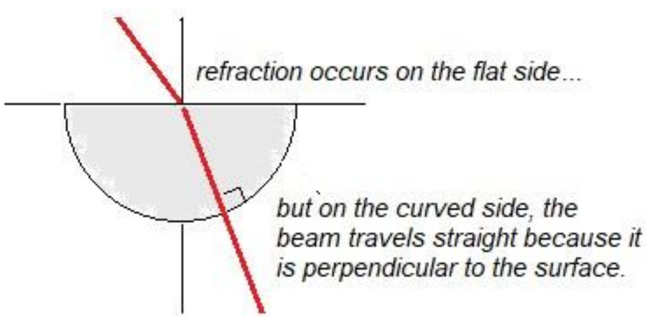
We will place the semi-circular dish on the board so that the center of the semi-circle is exactly at the center of the large circle drawn on the board:



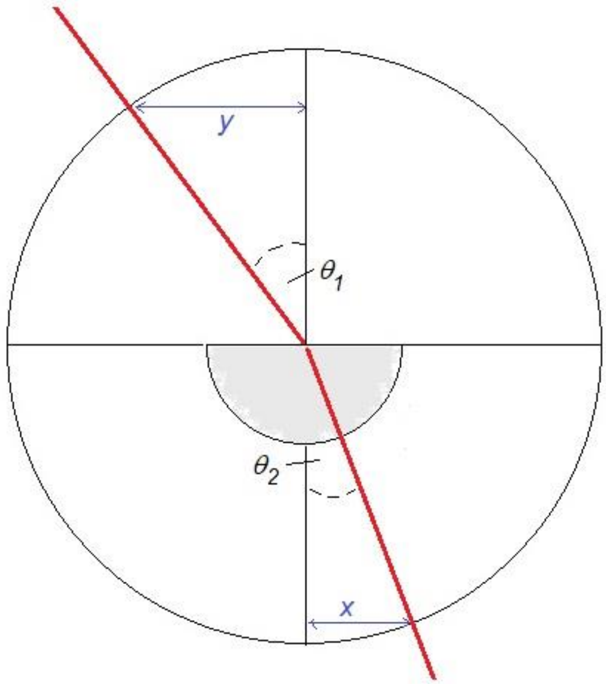
We will direct a beam of light (from the laser) so that it is incident at the exact center of the circle:



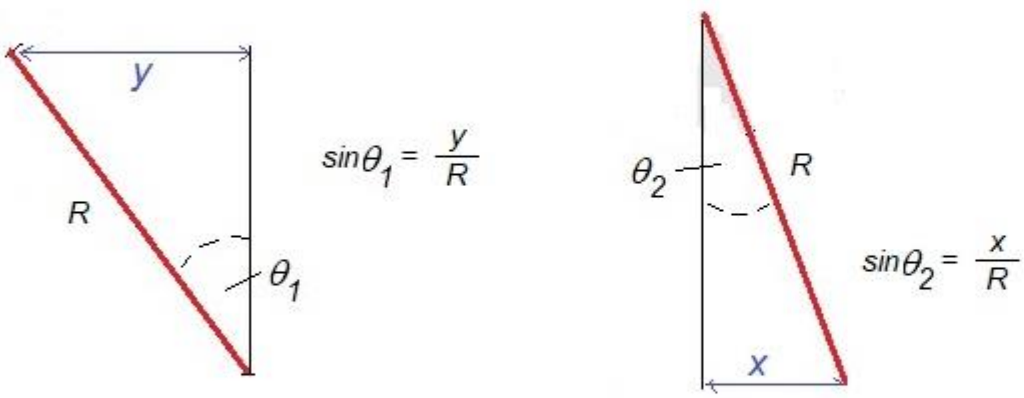
The ray will *refract* at the flat side of the dish, but it will travel straight through the curved side:



We can observe the two angles, θ_1 and θ_2, for the refraction. We can label as “y” the horizontal distance between the center of the large circle point where the incident beam crosses the edge of the large circle. We can label as “x” the horizontal distance between the center of the large circle and the point where the refracted beam crosses the edge of the large circle:



We now have two triangles, one with horizontal side “y” and angle θ_1, and the other with horizontal side “x” and angle θ_2. The hypotenuse of both triangles is the radius of the big circle, which we can label “R”:



We can now use these triangles, and the definition of the “sine” of both angles, to simplify our equation above:

$$\sin\theta_1 = n \sin\theta_2$$

becomes:

$$(y/R) = n\,(x/R)$$

or simply:

$$y = n\,x$$

Procedure

1. Direct the laser at the center of the circle, as shown in the diagram, and mark the location on either side (i.e. incident side and refracted side) where the laser crosses the edge of the big circle.

2. Repeat Step 1 five more times, for a range of incident angles from approximately 10 to 60 degrees.

3. Measure the value of “y” for each of the six points on the “incident” side of the circle, and measure the value of “x” for each of the six points on the “refracted” side of the circle.

> ***Note: measure “x” and “y” in centimeters, to the nearest 0.05 cm. That is, measure to the nearest half-millimeter.***

4. Create a data table for the six values of “x” and “y”, and create a graph, with best-fit straight line, of the “x” and “y” values. From the equation above, the slope of the best-fit line should be the index of refraction of the liquid.

5. Repeat Steps 1 through 4 for the other side of the large circle.

After completing both trials, i.e. both sets of data and both graphs, repeat these steps for the second medium.