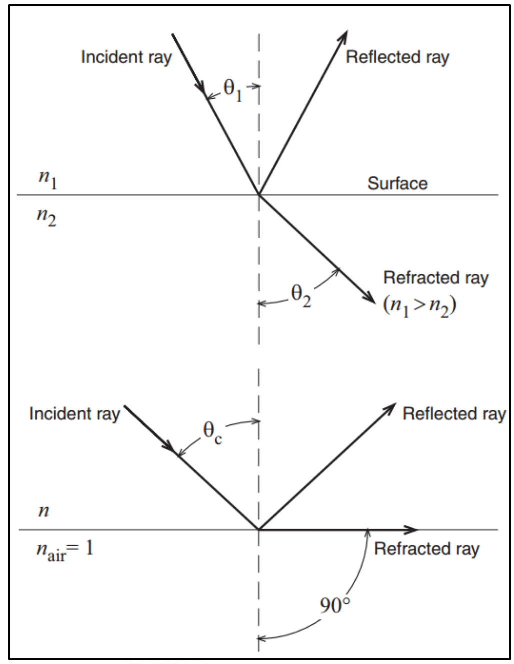
Name: David Gutierrez | Group Members: Claire Zhou, Alvaro Espinosa, Yash Desai, Kenneth Lin

LAB 12. RAY OPTICS: TOTAL INTERNAL REFLECTION

AP PHYSICS II



Driving Question | Objective

We have seen what happens when light goes from low index (fast) to high index (low), but what happens when light goes from high index to low index? What is the maximum refractive angle you can get?

Investigate what happens as light tries to go from slow to fast.

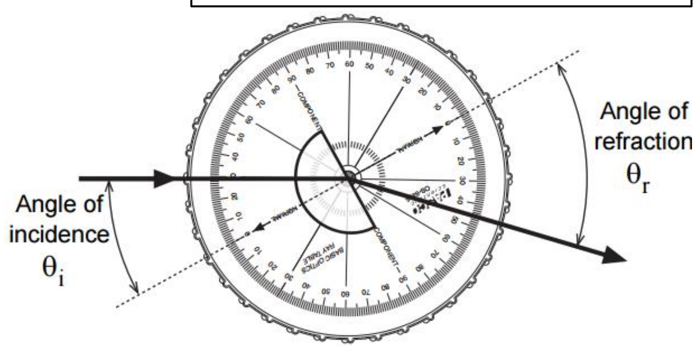
Materials and Equipment

- Light Source
- Protractor
- Ray Table
- Acrylic Block
- Acrylic Semicircle
- Ruler

Procedure

1. Place the acrylic Semicircle on the ray table in the outline provided on the ray table.

2. Place the light source on the table in ray-box mode and aim a ray to the curved side of the acrylic semicircle as seen in the image to the right. Assure that the incident ray is aimed perpendicular to the surface and directly toward the center of the ray table as seen.



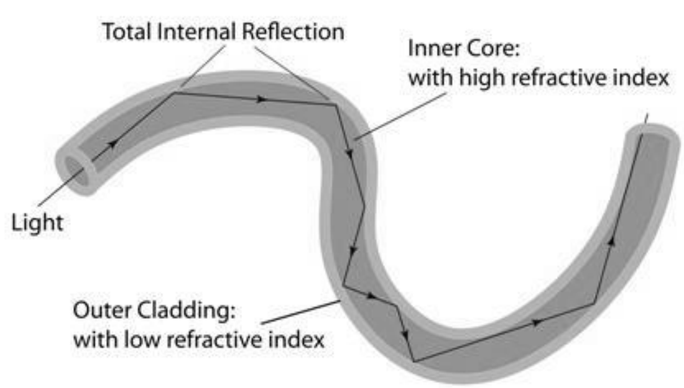
3. Begin rotating the ray table and observe what happens to the refracted light that leaves the flat side of the acrylic semicircle. Describe what you see below.

The angle of refraction decreases as the angle of incidence approaches zero degrees and increases to 90 degrees as the angle of incidence approaches about 45 degrees. After the angle of incidence reaches 45, the primarily visible ray is the reflected one.

4. The incident angle in which this happens is the angle that results in a refracted angle of 90°. Using Snell's Law, we get: $\boldsymbol{n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightarrow n_{acrylic} \sin\theta_{critical} = n_{air} \sin 90°}$.

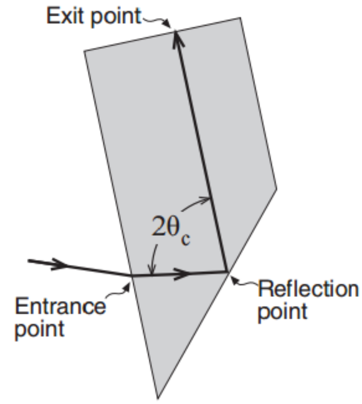
5. Solve for $\theta_{critical}$ in terms of the other variables:
   $\boldsymbol{\theta_{critical}} = sin^{-1}\left(\frac{n_{air}}{n_{acrylic}}\right)$

6. This is known as the critical angle. Note that any angle of incidence greater than this does not result in any refraction at all, but rather a reflection. This is called **total internal reflection** and is widely used in modern appliances such as fiber optics to transmit signals via pulses of light through cables over long distances. Even if the cable bends!



Activity

Now that we know about total internal reflection, lets attempt to determine the index of refraction of our acrylic block using a critical angle.



1. Place the light source in ray-box mode on the lab table.

2. Position the trapezoid in the box below as shown in the figure. Trace the perimeter of the block.

3. Shine a ray into the side of the block and move the position of the light source until you ***just reach*** the point where you achieve total internal reflection.

4. Mark the exact points where light enters, reflects, and exits the block.

5. Remove the block, connect a ray from Entrance to Reflection points as well as a ray from Reflection point to Exit Point.

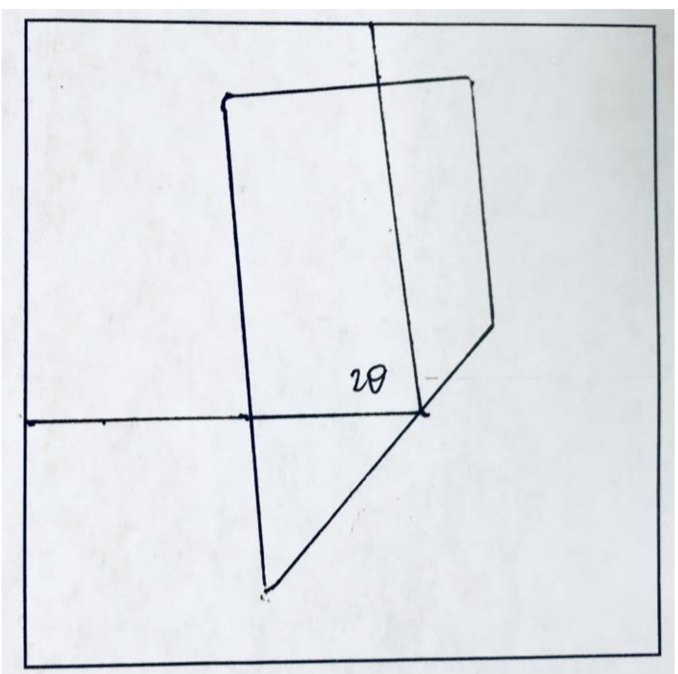
6. Measure the angle between the two rays inside the block with the protractor. This is $2\theta_c$.

   a. What is θ_c? $\boldsymbol{\theta_c} = 42°$

7. Using the equation that you determined on the front of this page for θ_c, calculate the index of refraction of this acrylic block.

   a. $n_{acrylic} = 1.494$

8. The accepted value for the index of refraction of acrylic is $n = 1.5$. What was your % difference?



Calculate your % error

$$\% \text{ difference} = 100 \times \left|\frac{1.494-1.5}{1.5}\right| = \mathbf{.373\%}$$