Brewster's Angle

Equipment

1	Basic Optics Light Source	OS-8470
1	Basic Optics Ray Table	OS-8465
1	Polarizer	OS-8533A

Background

When unpolarized light is incident on a transparent dielectric surface, most of the light is refracted through the transparent medium, but some light is also reflected, as in Figure 1. The amount of light reflected is dependent on the angle of incidence and the polarization of the incoming light.

In this experiment you will explore how the intensity and polarization of light changes when reflected from the surface of a transparent medium, and then compare your experimental results to a theoretical value known as Brewster's Angle.

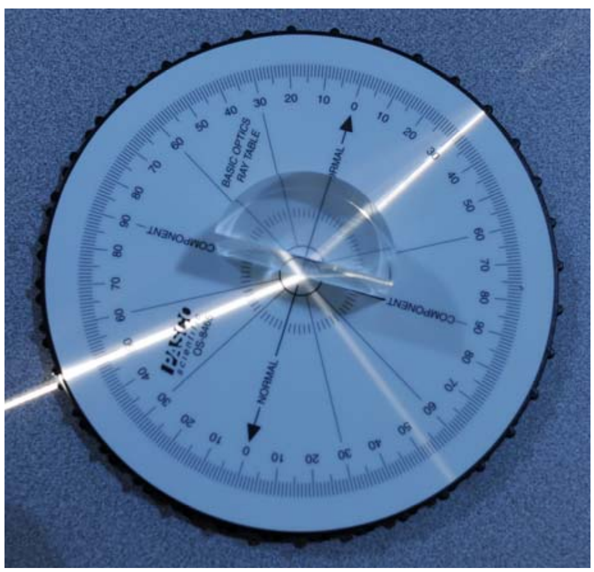

Figure 1: Light Being Reflected and Refracted

Setup

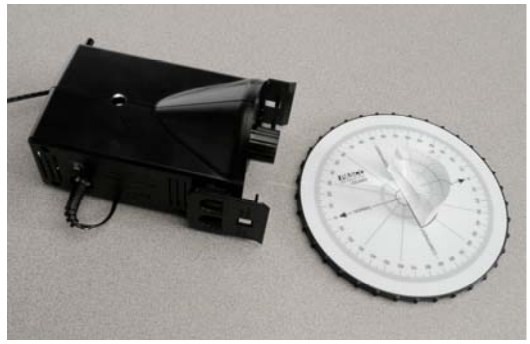

Figure 2: Ray Table Setup

1. Set the Ray table on the lab bench, and place the clear acrylic D-shaped lens within the outline on the top of the ray table.

2. Connect the light source to power, and then adjust the dial on the front of it so that only one ray of light is emitted.

3. Turn off all the lights in the classroom.

4. Place the light source on the lab bench so that the front of it is as close to the ray table as possible without touching it, and the ray of light is incident on the center of the flat side of the D-shaped lens (similar to Figure 2).

5. Making sure to keep the light ray incident on the center of the flat side of the D-shaped lens, adjust the incident angle of the light ray to 25°.

6. Assuming all of the light that is incident on the D-shaped lens is either refracted or reflected, about what percentage of the incident light appears to be reflected?

7. Is the incident light ray polarized? If not, what could you do to make it polarized?

8. Increase the incident angle to several larger angles. What happens to the apparent percentage of incident light that is reflected as the incident angle increases?

9. Adjust the incident angle back to 25°.

Collect Data

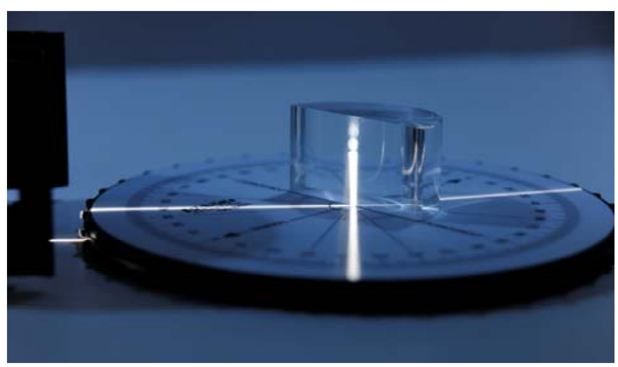

Figure 3: Viewing the Reflected Light

1. Close one eye and look down the path of the reflected light ray (as in Figure 3) observing the intensity of the reflected ray on the surface of the ray table.

   NOTE: Your head should be near the plane of the lab table, and you may need to adjust the position of your head side-to-side to best see the reflected light ray.

2. Place the polarizer disk in front of your open eye and slowly rotate the disk one full revolution. What happens to the intensity of the reflected ray observed on the surface of the ray table as you rotate the polarizer disk?

3. Adjust the incident angle to 40° and repeat the previous steps. What happens to the intensity of the reflected ray observed on the surface of the ray table as you rotate the polarizer disk?

4. What happened to the polarization of the reflected light ray when the incident angle was increased? How does the polarizer disk indicate the polarization of the reflected light ray?

5. Observe the reflected light ray using the polarizer disk for each incident angle between 45° and 75°, using 5° increments. Be sure to rotate the polarizer disk one full revolution for each incident angle and pay close attention to the intensity of the reflected light ray.

6. Describe your observations of the reflected light ray at increasing incident angles. What changed as incident angle increased, and what stayed the same?

7. Use the polarizer disk and ray table to determine the incident angle and polarizer orientation (rotation) that allows none of the reflected light ray to be seen. Record the incident angle.

Theory

As you have observed, when unpolarized light reflects off a nonconducting surface like the acrylic D-shaped lens, it is partially polarized parallel to the plane of the reflective surface depending on the incident angle of the incoming light. As you have also seen, there is a specific incident angle at which the reflected light is 100% polarized. This angle is called Brewster's angle, and it occurs when the reflected ray and the refracted ray are 90° apart.

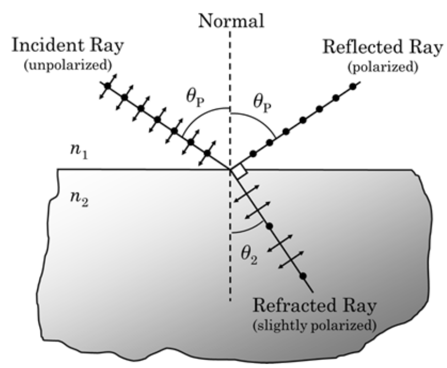

Figure 4: Brewster's Angle

To determine the mathematical relationship that describes Brewster's angle we can start by using Snell's Law:

$$n_1 \sin \theta_p = n_2 \sin \theta_2 \qquad (1)$$

Because $\theta_1 + \theta_2 = 90^o$ or $\theta_2 = 90^o - \theta_p$, an important substitution can be made into Equation 1:

$$n_1 \sin \theta_p = n_2 \sin (90^o - \theta_p) \qquad (2)$$

Substituting $\sin (90^o - \theta_p) = \cos \theta_p$ back into Equation 2 gives:

$$n_1 \sin \theta_p = n_2 \cos \theta_p$$

Therefore

$$\tan \theta_p = n_2/n_1 \qquad (3)$$

Equation 3 describes the relationship between both indices of refraction, n_1 and n_2, and Brewster's angle θ_p.

Analysis

1. Calculate the theoretical value for Brewster's angle using the D-shaped acrylic lens. Assume that the index of refraction of air is 1 and index of refraction for the acrylic lens is 1.49.

2. How does your experimental value for Brewster's angle from the Collect Data page compare to the theoretical? What is the percent error?

$$\%\text{error} = \frac{|\text{Theoretical} - \text{Experimental}|}{\text{Theoretical}} \times 100\%$$

$$\tan \theta_P = \frac{n_2}{n_1}$$

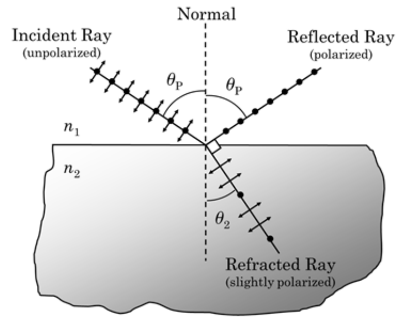

Figure 5: Brewster's Angle Equation