Experiment 2: Prism

Required Equipment from Basic Optics System

Light Source

Trapezoid from Ray Optics Kit

Blank white paper

Purpose

The purpose of this experiment is to show how a prism separates white light into its component colors and to show that different colors are refracted at different angles through a prism.

Theory

When a monochromatic light ray crosses from one medium (such as air) to another (such as acrylic), it is refracted. According to Snell's Law,

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

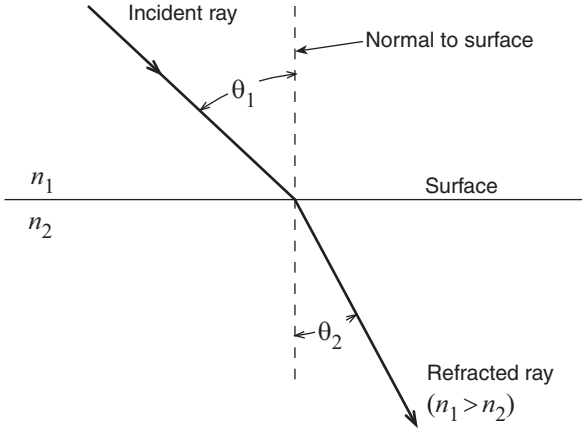

Figure 2.1: Refraction of Light

the angle of refraction (θ_2) depends on the angle of incidence (θ_1) and the indices of refraction of both media (n_1 and n_2), as shown in Figure 2.1. Because the index of refraction for light varies with the frequency of the light, white light that enters the material (at an angle other than 0°) will separate into its component colors as each frequency is bent a different amount.

The trapezoid is made of acrylic which has an index of refraction of 1.497 for light of wavelength 486 nm in a vacuum (blue light), 1.491 for wavelength 589 nm (yellow), and 1.489 for wavelength 651 nm (red). In general for visible light, index of refraction increases with increasing frequency.

Procedure

1. Place the light source in ray-box mode on a sheet of blank white paper. Turn the wheel to select a single white ray.

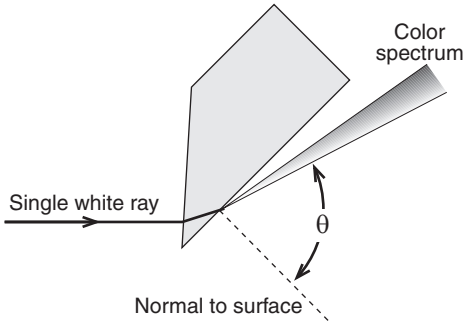

Figure 2.2

2. Position the trapezoid as shown in Figure 2.2. The acute-angled end of the trapezoid is used as a prism in this experiment. Keep the ray near the point of the trapezoid for maximum transmission of the light.

3. Rotate the trapezoid until the angle (θ) of the emerging ray is as large as possible and the ray separates into colors.

(a) What colors do you see? In what order are they?

(b) Which color is refracted at the largest angle?

(c) According to Snell's Law and the information given about the frequency dependence of the index of refraction for acrylic, which color is predicted to refract at the largest angle?

4. Without repositioning the light source, turn the wheel to select the three primary color rays. The colored rays should enter trapezoid at the same angle that the white ray did. Do the colored rays emerge from the trapezoid parallel to each other? Why or why not?

Experiment 4: Snell's Law

Required Equipment from Basic Optics System

Light Source

Trapezoid from Ray Optics Kit

Other Required Equipment

Protractor

White paper

Purpose

The purpose of this experiment is to determine the index of refraction of the acrylic trapezoid. For rays entering the trapezoid, you will measure the angles of incidence and refraction and use Snell's Law to calculate the index of refraction.

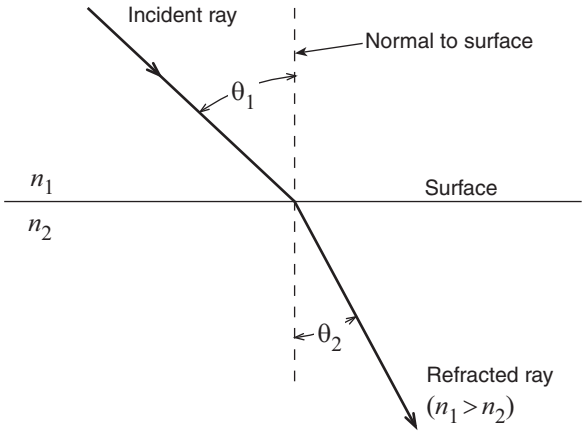

Figure 4.1

Theory

For light crossing the boundary between two transparent materials, Snell's Law states

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

where θ_1 is the angle of incidence, θ_2 is the angle of refraction, and n_1 and n_2 are the respective indices of refraction of the materials (see Figure 4.1).

Procedure

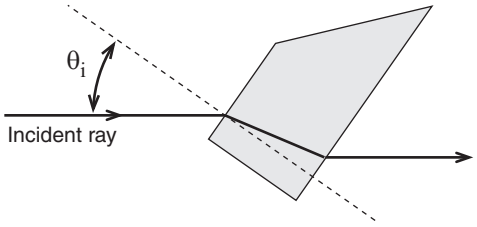

Figure 4.2

1. Place the light source in ray-box mode on a sheet of white paper. Turn the wheel to select a single ray.

2. Place the trapezoid on the paper and position it so the ray passes through the parallel sides as shown in Figure 4.2.

3. Mark the position of the parallel surfaces of the trapezoid and trace the incident and transmitted rays. Indicate the incoming and the outgoing rays with arrows in the appropriate directions. Carefully mark where the rays enter and leave the trapezoid.

4. Remove the trapezoid and draw a line on the paper connecting the points where the rays entered and left the trapezoid. This line represents the ray inside the trapezoid.

5. Choose either the point where the ray enters the trapezoid or the point where the ray leaves the trapezoid. At this point, draw the normal to the surface.

6. Measure the angle of incidence (θ_i) and the angle of refraction with a protractor. Both of these angles should be measured from the normal. Record the angles in the first row of Table 4.1.

7. On a new sheet of paper, repeat steps 2–6 with a different angle of incidence. Repeat these steps again with a third angle of incidence. The first two columns of Table 4.1 should now be filled.

Table 4.1: Data and Results

Angle of Incidence	Angle of Refraction	Calculated index of refraction of acrylic
		Average:

Analysis

1. For each row of Table 4.1, use Snell's Law to calculate the index of refraction, assuming the index of refraction of air is 1.0.

2. Average the three values of the index of refraction. Compare the average to the accepted value (n = 1.5) by calculating the percent difference.

Question

What is the angle of the ray that leaves the trapezoid relative to the ray that enters it?