Experiment 1: Color Addition

Required Equipment from Basic Optics System

Light Source

Convex Lens from Ray Optics Kit

Other Required Equipment

Red, blue, and black pens

Blank white paper

Purpose

In Part 1 of this experiment, you will discover the results of mixing red, green, and blue light in different combinations. In Part 2, you will compare the appearance of red, blue, and black ink illuminated by red and blue light.

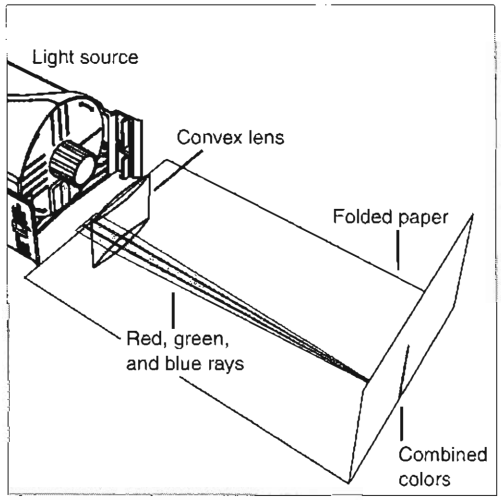

Figure 1.1: Color addition

Part 1: Addition of Colored Light

Procedure

1. Turn the wheel on the light source to select the red, green, and blue color bars. Fold a blank, white sheet of paper, as shown in Figure 1.1. Lay the paper on a flat surface and put the light source on it so that the colored rays are projected along the horizontal part of the paper and onto the vertical part.

2. Place the convex lens near the ray box so it focuses the rays and causes them to cross at the vertical part of the paper.

   Note: The lens has one flat edge. Place the flat edge on the paper so the lens stands stably without rocking.

3. What is the resulting color where the three colors come together? Record your observation in Table 1.1.

4. Now block the green ray with a pencil. What color results from adding red and blue light? Record the result in Table 1.1.

5. Block each color in succession to see the addition of the other two colors and complete Table 1.1.

Table 1.1: Results of Colored Light Addition

Colors Added	Resulting Color
red + blue + green	
red + blue	
red + green	
green + blue	

Questions

1. Is mixing colored light the same as mixing colored paint? Explain.

2. White light is said to be the mixture of all colors. In this experiment, did mixing red, green, and blue light result in white? Explain.

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.

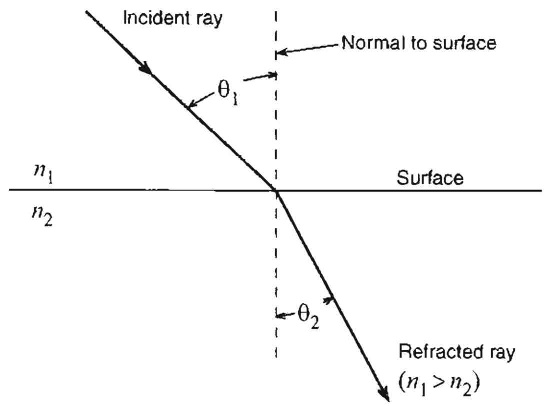

Figure 2.1: Refraction of Light

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,

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

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.

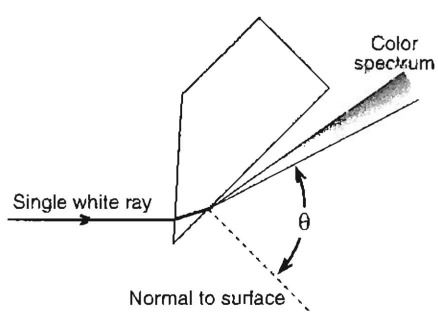

Figure 2.2

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?

→

Experiment 3: Reflection

Required Equipment from Basic Optics System

Light Source

Mirror from Ray Optics Kit

Other Required Equipment

Drawing compass

Protractor

Metric ruler

White paper

Purpose

In this experiment, you will study how rays are reflected from different types of mirrors. You will measure the focal length and determine the radius of curvature of a concave mirror and a convex mirror.

Part 1: Plane Mirror

Procedure

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

2. Place the mirror on the paper. Position the plane (flat) surface of the mirror in the path of the incident ray at an angle that allows you to clearly see the incident and reflected rays.

3. On the paper, trace and label the surface of the plane mirror and the incident and reflected rays. Indicate the incoming and the outgoing rays with arrows in the appropriate directions.

4. Remove the light source and mirror from the paper. On the paper, draw the normal to the surface (as in Figure 3.1).

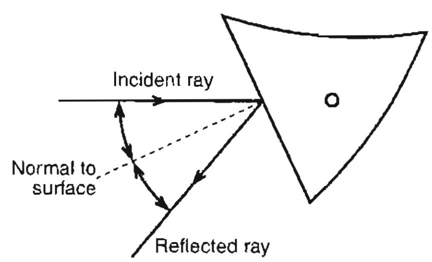

Figure 3.1

5. Measure the angle of incidence and the angle of reflection. Measure these angles from the normal. Record the angles in the first row Table 3.1.

6. Repeat steps 1–5 with a different angle of incidence. Repeat the procedure again to complete Table 3.1 with three different angles of incidence.

Table 3.1: Plane Mirror Results

Angle of Incidence	Angle of Reflection

Questions

1. What is the relationship between the angles of incidence and reflection?

Experiment 4: Snell's Law

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.

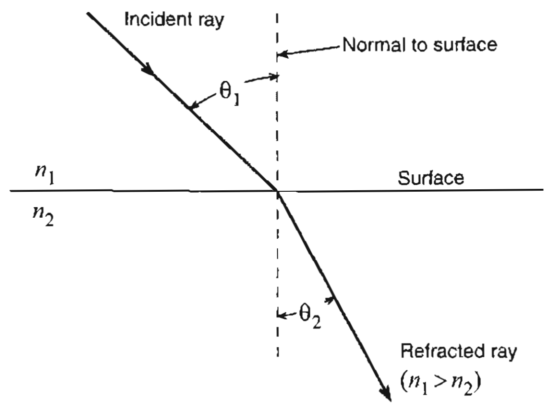

Figure 4.1

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

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.

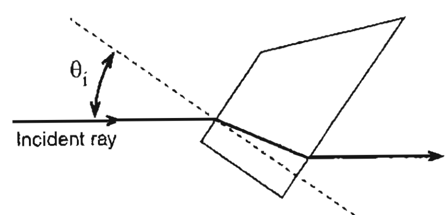

Figure 4.2

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.

END