Experiment 10: Reversibility

Required Equipment from Basic Optics System

Ray Table

D-shaped Lens

Light Source

Purpose

In Trial 1 of this experiment, you will determine the relationship between the angle of incidence and the angle of refraction for light passing from air *into* a more optically dense medium (the acrylic of the D-shaped lens).

In Trial 2, you will determine whether the same relationship holds between the angles of incidence and refraction for light passing *out* of a more optically dense medium back into air. That is to say, if the light is traveling in the opposite direction through the lens, is the law of refraction the same or different? By comparing the results of both trials, you will find the answer to this question.

In Figure 10.1, notice that refraction occurs only at the flat surface of the D-shaped lens, not at the curved surface.

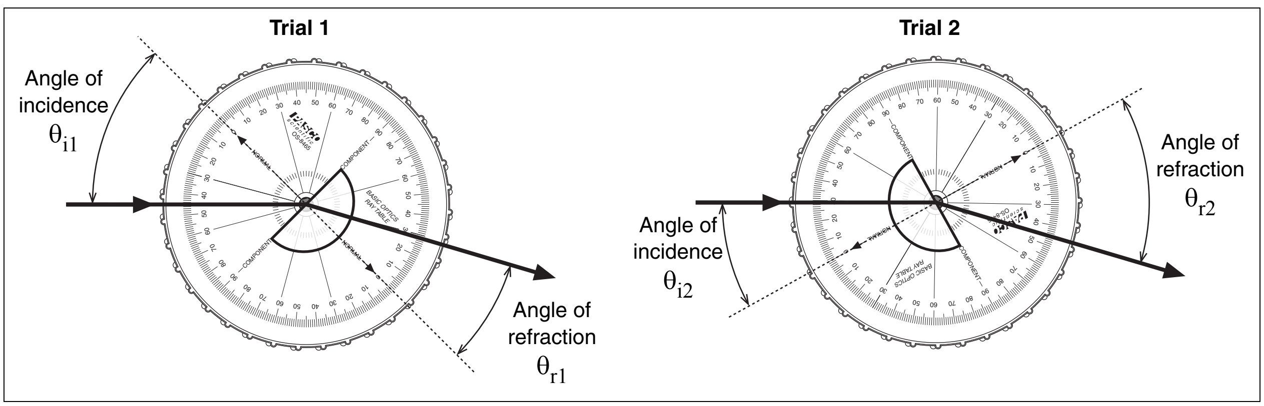

Figure 10.1: Refraction of light passing into the lens (Trial 1) and out of the lens (Trial 2)

Setup

1. Place the light source in ray-box mode on a flat tabletop. Turn the wheel to select a single ray.
2. Put the ray table in front of the light source so the ray from the light source crosses the exact center of the ray table.
3. Put the D-shaped lens on the ray table exactly centered in the marked outline.

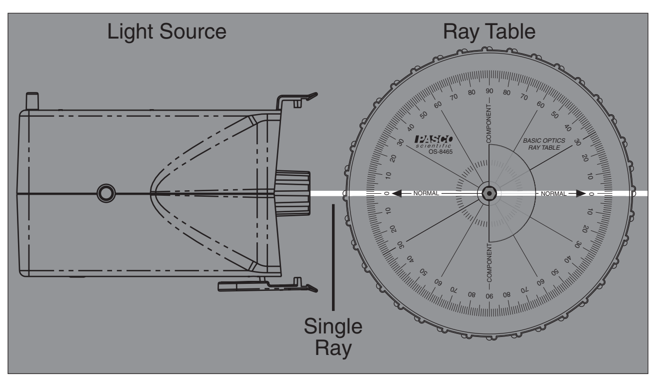

Figure 10.2: Initial setup for Trial 1

Record Data

Trial 1

1. Turn the ray table so the incoming ray enters the lens through the *flat* surface (see Figure 10.2).

2. Rotate the ray table to set the angle of incidence to each of the values listed in the first column of Table 10.1. For each angle of incidence (θ_{i1}), observe the corresponding angle of refraction (θ_{r1}) and record it in the second column of the table.

Table 10.1: Data

Trial 1 Ray Incident on Flat Surface		Trial 2 Ray Incident on Curved Surface	
Angle of Incidence θ_{i1}	Angle of Refraction θ_{r1}	Angle of Incidence θ_{i2}	Angle of Refraction θ_{r2}
0°			
10°			
20°			
30°			
40°			
50°			
60°			
70°			
80°			

Trial 2

1. Copy all of the values in the second column to the third column of the table. (In other words, the angles of refraction that you observe in Trial 1 will be the angles of incidence that you use in Trial 2.)

2. Turn the ray table so the incoming ray enters the lens through the *curved* surface.

3. For the angles of incidence (θ_{i2}) that you wrote in the third column of the table, observe the corresponding angles of refraction (θ_{r2}) and record them in the fourth column.

Analysis

1. Using your values for θ_{i1} and θ_{r1} and Snell's Law (Equation 10.1), determine the index of refraction of acrylic ($n_{acrylic}$). Assume the index of refraction of air (n_{air}) is 1.0.

(eq. 10.1)
$$n_{air}\sin(\theta_{i1}) = n_{acrylic}\sin(\theta_{r1})$$

$n_{acrylic}$ = ___________ (from θ_{i1} and θ_{r1})

2. Determine $n_{acrylic}$ again, this time using your values of θ_{i2} and θ_{r2}.

$n_{acrylic}$ = ___________ (from θ_{i2} and θ_{r2})

Questions

1. Is the law of refraction the same for light rays going in either direction between the two media?

2. Does the principle of optical reversibility hold for reflection as well as refraction? Explain.

Experiment 11: Dispersion

Required Equipment from Basic Optics System

Ray Table

D-shaped Lens

Light Source

Purpose

The purpose of this experiment is to determine the index of refraction of acrylic at two different wavelengths.

Theory

When light crosses the boundary between two transparent media, it is refracted. Snell's Law expresses the relationship between index of refraction of the first medium (n_1), the index of refraction of the second medium (n_2), the angle of incidence (θ_1), and the angle of refraction (θ_2):

(eq. 11.1)

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

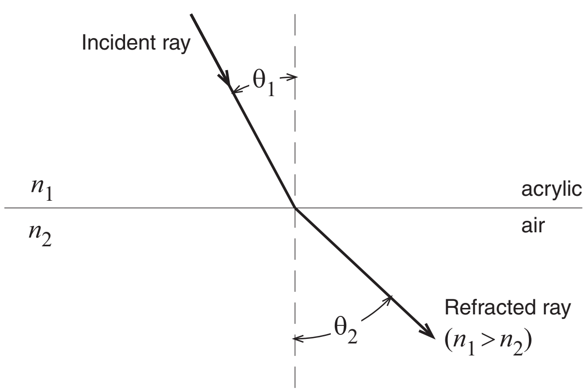

Figure 11.1

We can assume the index of refraction of air (n_2 in this experiment) is always equal to 1.0. However, the index of refraction of acrylic (n_1) depends on the wavelength, or color, of the light. Therefore, the different wavelengths present in an incident ray of white light will be refracted at different angles. The wavelength dependence of a material's index of refraction is known as dispersion.

Setup

1. Place the light source in ray-box mode on a flat tabletop. Turn the wheel to select a single ray.

2. Put the ray table in front of the light source so the ray from the light source crosses the exact center of the ray table (see Figure 11.2).

3. Put the acrylic D-shaped lens on the ray table in the marked outline. Turn the ray table so

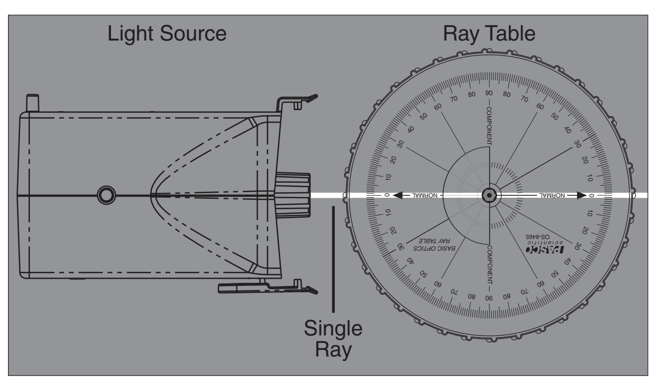

Figure 11.2

the ray enters the lens through the *curved* surface, and the angle of incidence is 0°.

Procedure

1. Hold a piece of white paper vertically near the edge of the Ray Table so the outgoing ray is visible on the paper.
2. Slowly rotate the ray table to increase the angle of incidence. Notice that the ray is refracted only at the flat surface of the lens, not at the curved surface. As you continue to increase the angle of incidence, watch the refracted light on the paper.

Analysis

1. At what angle of refraction do you begin to notice color separation in the refracted light?
2. At what angle of refraction does the maximum color separation occur?
3. What colors are present in the refracted ray? (Write them in the order of minimum to maximum angle of refraction.)
4. Use Snell's Law (Equation 11.1) to calculate the index of refraction of acrylic for red light (n_{red}) and the index of refraction for blue light (n_{blue}).