Experiment 9: Apparent Depth

Required Equipment from Basic Optics System

Light Source

Trapezoid from Ray Optics Kit

Convex Lens from Ray Optics Kit

Mirror from Ray Optics Kit (used to block rays)

Other Required Equipment

Metric ruler

White paper

Very sharp pencil

Purpose

In this experiment, you will use two different methods to measure the apparent depth of the acrylic trapezoid. You will also determine the index of refraction of acrylic by comparing the apparent depth to the actual depth.

Theory

Light rays originating from the bottom surface of a block of transparent material refract at the top surface as the rays emerge from the material into the air (see Figure 9.1). When viewed from above, the apparent depth, d, of the bottom surface of the block is less than the actual thickness, t, of the block. The apparent depth is given by

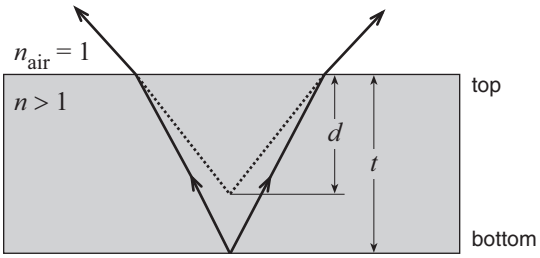

Figure 9.1

(eq. 9.1) $$d = t/n$$

where n is the index of refraction of the material.

Part 1: Parallax Method

Background

Place this page flat on the table in front of you. Hold a pencil horizontally a few centimeters above the paper. With one eye closed or covered, look down at the pencil and move your head side to side (without moving the pencil). Notice how the pencil appears to move relative to the words printed on the paper; this phenomenon is known as *parallax*. Now hold the tip of the pencil on the paper and check for parallax. When there is no parallax between to objects, they are at the same distance from you.

Procedure

1. Place a blank sheet of paper flat on the table. Use a straight edge and pencil to draw a vertical line on the paper. Place the trapezoid on the paper over the line as shown in Figure 9.2.

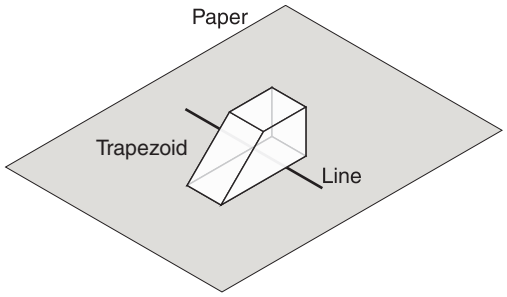

Figure 9.2

2. With both eyes, look down through the top of the trapezoid. Does the line viewed through the trapezoid appear to be closer? Close or cover one eye, and move your head side to side. Do you see parallax between the line viewed through the trapezoid and the line viewed directly?

3. In this step, you will hold a pencil near the trapezoid to determine the position of the apparent line. When the pencil and the apparent line are at the same distance from your eye, there will be no parallax between them.

   While looking down through the trapezoid (with one eye), hold a very sharp pencil as shown in Figure 9.3 so it appears to be lined up with the line inside the trapezoid. Move your head left and right to check for parallax. Move the pencil up or down and check again. When there is no parallax, mark that point. (Hold the trapezoid with your free hand, press the pencil tip gently against the side of the trapezoid and twist the pencil to make a light mark. Erase the mark after you have finished this experiment.)

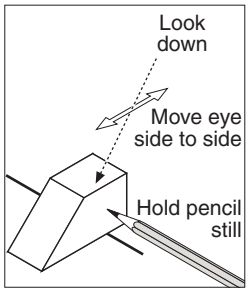

Figure 9.3

Analysis

1. Measure the distance from the *top* of the trapezoid to your pencil mark. Record this apparent depth, *d*, in the first row of Table 9.1.

2. Measure the thickness, *t*, of the trapezoid and record it in Table 9.1.

3. Use Equation 9.1 to calculate the index of refraction and record your result in Table 9.1.

Table 9.1: Results

	d	*t*	*n*
Part 1: Parallax method			
Part 2: Ray-tracing method			

Part 2: Ray-tracing Method

Procedure

1. Place the light source in ray-box mode on a white sheet of paper. Turn the wheel to select five parallel rays. Shine the rays straight into the convex lens. Place the mirror on its edge between the ray box and the lens so that it blocks the middle three rays, leaving only the outside two rays (as in Figure 9.4, but do not put the trapezoid there yet).

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

2. Mark the place on the paper where the two rays cross each other.

3. Position the trapezoid as shown in Figure 9.4. The "bottom" surface of the trapezoid must be exactly at the point where the two rays cross. The crossed rays simulate rays that originate at an object on the "bottom" of the block.

4. Trace the trapezoid and trace the rays diverging from the "top" surface.

5. Remove the trapezoid and light source. Trace the diverging rays back into the trapezoid. The point where these rays cross (inside the trapezoid) is the apparent position of the "bottom" of the trapezoid when viewed through the "top".

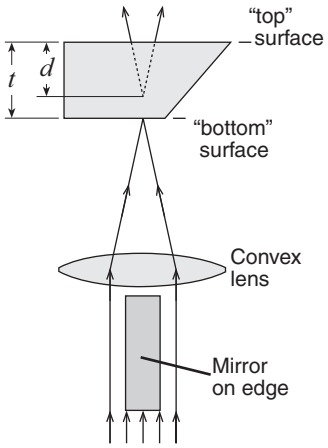

Figure 9.4

Analysis

1. Measure the apparent depth, d, and record it in Table 9.1.

2. Use Equation 9.1 to calculate the index of refraction and record your result in Table 9.1.

Questions

1. Of the two methods that you used to determine d, which one is more precise? Explain.

2. The accepted value of the index of refraction of acrylic is $n = 1.49$. What was the percent difference between the accepted value and each of your two results?