

# Experiment 26

## Reflection and Refraction

### Advanced Reading:

(Serway) Chapter 35, sections 35-4, 35-5 & 35-8.

### Equipment:

- 1 Plexi-Ray set (includes plane mirror, plastic prism, pins)
- 1 cork board
- 1 protractor
- 1 30 cm ruler

### Objective:

The object of this experiment is to study the laws of reflection and refraction.

### Theory:

The **Law of Reflection** states that the angle of incident ray equals the angle of the reflected ray, or  $\theta_i = \theta_r$

The **Law of Refraction (Snell's Law)** relates how a ray of light will behave when passing from one media to the other. It is given by:

$$n_1 \sin \theta_i = n_2 \sin \theta_r$$

where  $n_1$  and  $n_2$  are the indices of refraction for the two different media. Figures 23-2 and 23-3 (*note- figure labeling is off, but correct*) state these two laws pictorially.

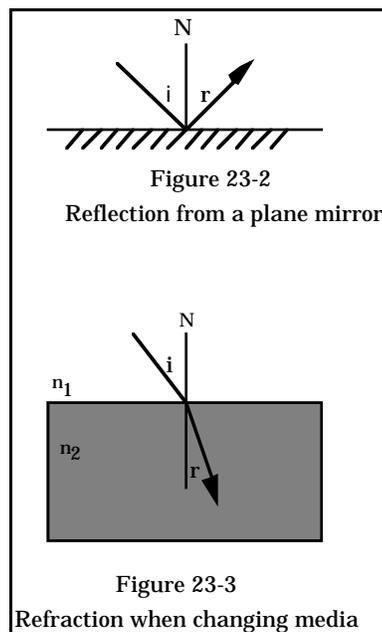
### Procedure:

#### Part 1: Reflection

1. Draw a line approximately 20 cm long at the center of a sheet of clean, white paper. This will be the baseline. Draw another line normal (normal =  $90^\circ$ ) to the first line using the protractor. Place the plane mirror into the slots of the little pieces of cork in the Plexi-Ray kit so that it will stand-up. Next, place the mirror so that the back (the reflecting surface) is on the first line.



figure 26 -1



2. Draw a ray on the left side of the normal line as you face the mirror that is at least 20 cm long from the point where the normal line joins the baseline. Stick two pins vertically on the line, one approximately 20 cm and the other at approximately 10 cm from the mirror along the line. Label these

points  $P_1$  and  $P_2$  respectively. (See figure 24-4)

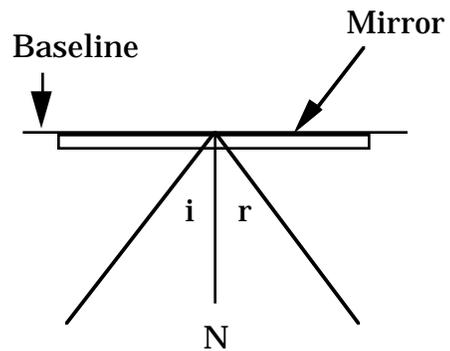


figure 24-4

3. Look at the mirror from the right side of the normal so that you can see the reflection of the first two pins. Stick two pins into the paper so that they appear to be co-linear to the first two pins. Label these two points  $P_3$  and  $P_4$ . **It is important that the mirror not move from the baseline. This will change the angle of reflection.**

4. Draw a line that connects points  $P_3$  and  $P_4$ . Measure the angle of incidence and the angle of reflection and compare to theory.

5. Repeat steps 2-4 for another set of points.

### **Part 2: Refraction.**

6. Place the plexi-glass square at the center of another sheet of clean white paper and trace around it. In the upper-left corner of the traced square, draw a line normal to the square 1 cm from the corner of the

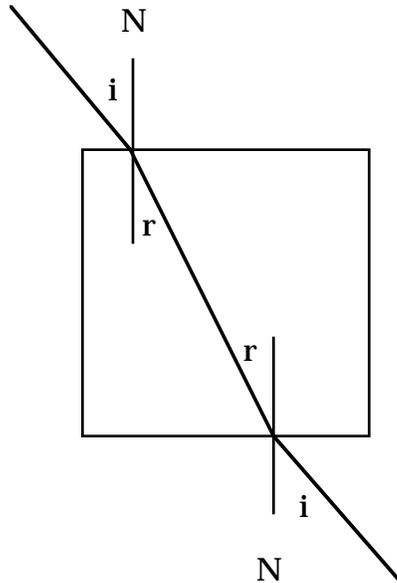


figure 24-5

square that crosses the side of the square. (see figure 24-5)

7. Draw a line left of the normal and place pins on the line as done in part 1 of this experiment. Look through the plexi-glass square from the side opposite pins and place pins two pins in the page so that it appears that all the pins are collinear. Label these two points P<sub>3</sub> and P<sub>4</sub>. Take the pins out and draw a line through the points beginning at the edge of the square. Where the line joins the edge of the square, draw another normal line that crosses the side of the edge of the square.

8. Measure the angle of the incident and the transmitted ray makes to the normals. Measure the angle between the normal lines and the ray when it was inside the plexi-glass. Use these angles to calculate the index of refraction of the material.

9. Repeat for a different set of points.

### Part 3 Total Internal Reflection

10. Place the plexi-glass triangle on a sheet of paper and trace around the edges. Put two pins in the page at points P<sub>1</sub> and P<sub>2</sub>. (see figure 24-6)

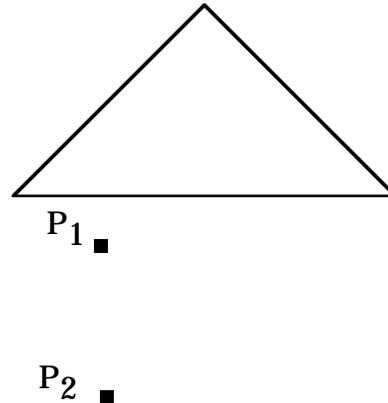


figure 24-6

11. Stick two more pins into the page so that all four pins appear co-linear. Remove the triangle from the page and draw rays showing the path of the light ray. (The result may be surprising.)

### Part 4 Image from a plane mirror

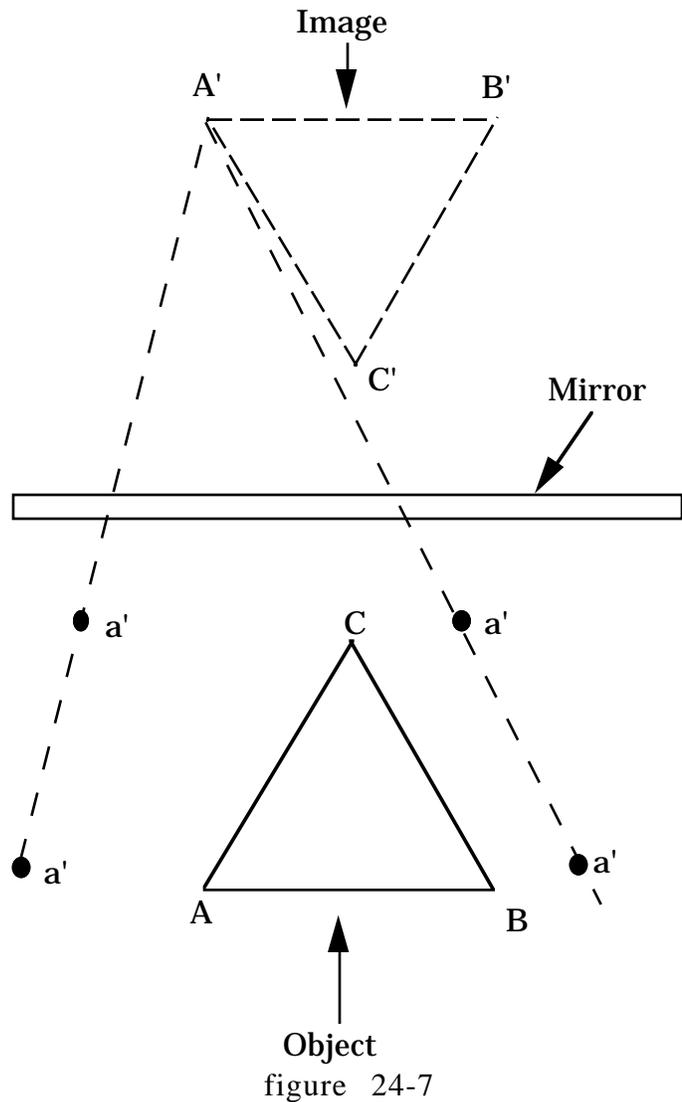
The image seen in any plane mirror does not appear to be at the surface of the mirror, but rather, to be located some distance behind the surface. This image is known as a virtual image. The image appears to be located the same distance behind the mirror as the object is in front of the mirror. (see figure 24-7)

12. Draw a line bisecting a sheet of clean, white paper. Place the triangular plexi glass in the middle of one of the bisected halves and trace around it. Label the vertices A,B,C. Place the mirror on the line bisecting the paper with the silvered surface exactly on the line.

13. Stick a pin into the cork board at the vertex labeled A and from a point of observation, use two more pins to mark a sight line to the image of the point A pin. Remove the sighting pins and mark the pin pricks with an 'a'. Repeat this again from a different observation point. Do this again for the pins at vertices B and C, obtaining two sight lines for each vertex. (see figure 24-7)

14. Remove all the pins and the mirror. Draw a line connecting the first two 'a' pin pricks, extending the line fully across the page. Do this for all pairs of pin pricks. Mark the intersection of the 'a' lines with an A' and the intersection of the 'b' and 'c' lines with a B' and C' respectively.

15. Connect the point A', B', and C'. Measure the dimensions of the virtual image and compare the dimensions with the object triangle.



**Questions/Conclusions:**

1. Does the angle of incidence equal the angle of reflection for the first part of this experiment?
2. What is the index of refraction of the plexi-glass block?
3. What is the smallest plane mirror needed by a person who is 1.5 meters tall to see his or her whole body?