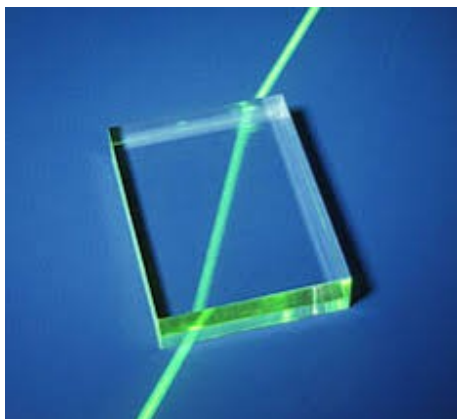


Reflection and Refraction – Laboratory 7



OBJECTIVE

The objective is to observe the reflection and refraction of light, to validate the Law of Reflection, and to calculate the index of refraction of a transparent object.

THEORY

When a light wave strikes an interface separating two transparent materials, the wave is usually partly reflected and partly refracted.

1. Reflection occurs when light is incident on an object and some or all of the light is not transmitted through the object but is propagated away from the object at the same angle that it was incident

2. Refraction can be thought of as the bending of light. When light passes from medium to medium (air to water, air to glass, e.g.), the light's speed changes based on the **Index of Refraction** of each medium. When the light's speed changes, it changes direction in some manner. Optical materials have a characteristic called the Index of Refraction (n). The Index of Refraction is the ratio of the speed of light in a vacuum to the speed of light in the material: $n = c / v$. These two characteristics of light can be translated into laws: the Law of Reflection, and the Law of Refraction.

1. Law of Reflection: $\theta_r = \theta_i$

This law says that the angle of a reflected ray (θ_r), measured from a normal to the surface at the point of contact with the surface to the incident ray, is equal to the angle of the incident ray (θ_i).

2. Law of Refraction: $n_a \sin \theta_a = n_b \sin \theta_b$

This is also known as Snell's Law, and it relates the Index of Refraction and the angle measured from the normal between two materials a and b . If $n_b > n_a$ the refracted ray bends towards the normal. If $n_a > n_b$ the refracted ray bends away from the normal.

PROCEDURE

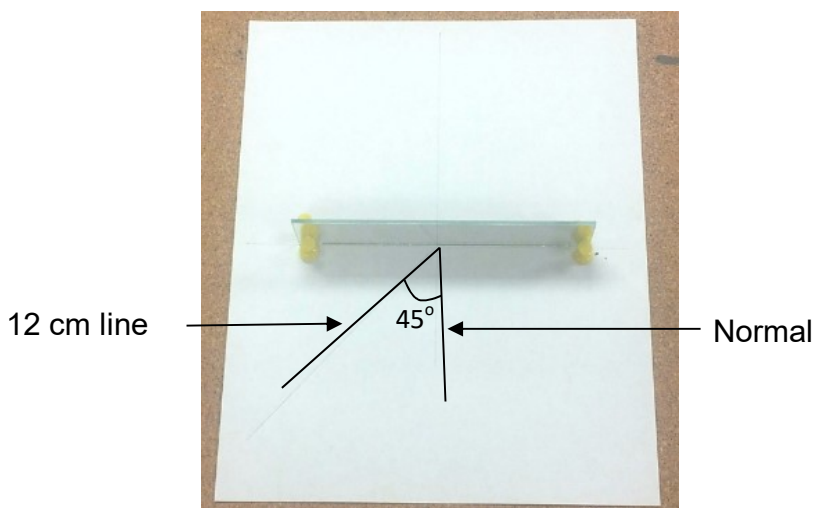
Materials List: 8"x11" sheets of white paper (4), pins (4), 30 cm scale, protractor, plane mirror, Plexiglas block, cork board.

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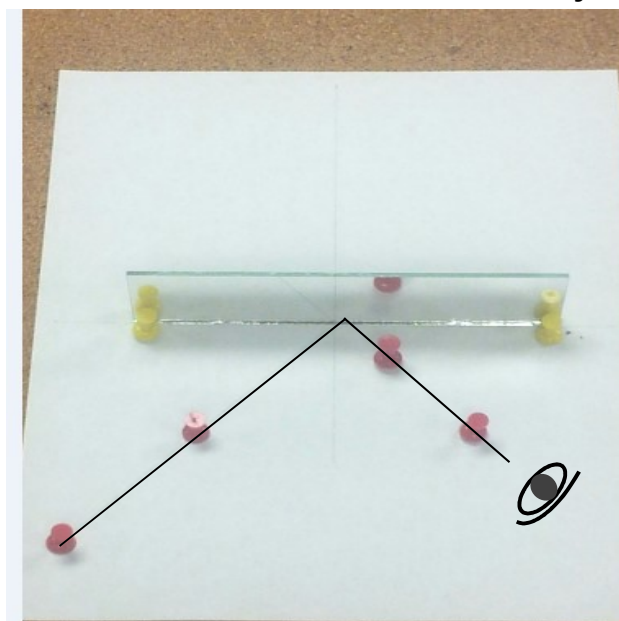
Reflection

1. Place a sheet of paper on the lab table. Draw a baseline about 20 cm long at the center of this white sheet of paper from left to right, parallel to the top edge, with the paper in portrait mode (see picture). At the middle of this line, use your protractor to draw another 20 cm line exactly perpendicular to the first one. This second line will act as your normal. From the center of the first line, draw an approximately 12 cm line at a 45° angle with the normal toward the left side of paper. Record this as the angle of incidence.
2. Place this sheet on your corkboard and stand the plane mirror up, placing it where the reflecting surface is exactly on the first line. It may be difficult to stand the mirror on its edge while on the cork board. You may need to use the Plexiglas block to support it from behind.



3. Stick two of your pins in this line, one at approximately 6 cm and the other at 12 cm. Label the points: p1 and p2.on the paper.
4. Look from the right side of the normal line into the mirror so you see the reflection of the pins. Stick two more pins into that side of the paper, trying to line them up with the reflection. Try not to move the mirror during this process as it will affect the results. Label these points p3 and p4. Remove the mirror, place the paper on the lab table, and draw a line connecting p3, p4. and the midpoint of the 20 cm line. Measure and record the angle of reflection from the normal line to the right-side line.

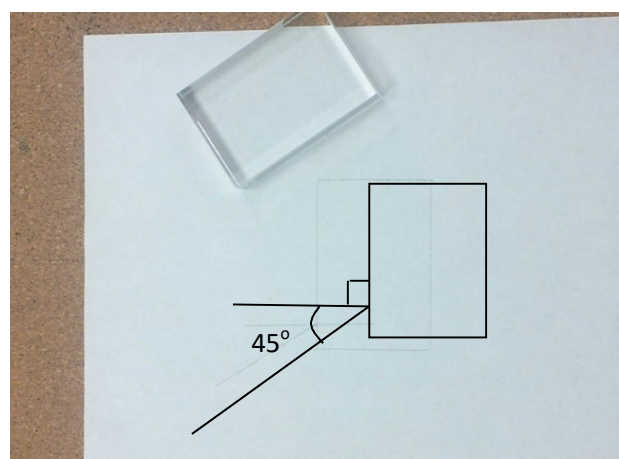
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5. Repeat steps 1 - 4 with a new sheet and with the 12 cm line incident to the mirror at a different angle. For example you might want the incidence angle to be 60° to the normal or perhaps 30° .

Refraction

6. Place the Plexiglas block at the center of a fresh sheet of paper while the paper lies on the table. Trace around the block, remove the block, and draw a 10 cm normal line 2 cm from the bottom left edge of the traced square. Use your protractor to ensure that this line is exactly perpendicular to the side of the block line. Starting from where the normal line and traced block lines meet, draw a line 10 cm down and to the left of the normal and at a 45° angle with the normal as shown below. Put this sheet on the cork board and place two pins in this line, labeling these points p1 and p2.

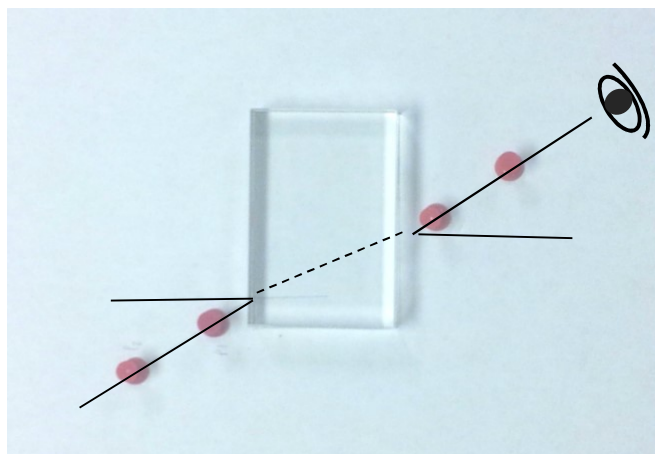


7. Place the Plexiglas block back on its outline and look through the edge of the rectangle that is opposite to the side with the pins (right side as shown below). Place

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two more pins in the paper so they appear to line up exactly with the other two pins. Label these p3 and p4. Remove all pins, place the paper on the lab table and draw lines connecting their holes that start at the edge of the square. Where this line joins the edge of the square draw another 10 cm normal line.



8. Draw a line to connect the two normal lines. This is the path of the light through the block (dotted line above). Your line does not have to be dotted.

9. Extend the two normal lines into the block outline and measure and record the angles the incident and transmitted rays make with both normal lines (outside the block) Are the angles the same? Why or why not? Measure and record the angle the dotted line ray makes with both extended normal lines. Are they the same?

10. With a new piece of paper, repeat steps 6 – 9 for a different incident angle ray. You might want to choose 60° to the normal.

CALCULATIONS

Do your measured angles from the Reflection Procedure agree with the Law of Reflection for both trials?

Calculate the Index of Refraction for the Plexiglas block material using the Law of Refraction (Snell's Law) for both trials (both angles). Are your two Index of Refraction values the same? Assume that the index of refraction of air = 1.00.

At the conclusion of this experiment you will have 4 drawings – 2 for reflection and 2 for refraction. Each lab partner is to include one reflection and one refraction drawing in his/her report.

According to published tables, the index of refraction for Plexiglas at 500 nm (average value for visible light) is 1.496. Calculate a percent error for n for both of your incident angles.