Experiment 18
REFLECTION AND REFRACTION

EQUIPMENT

1 Optics Light Ray Kit
Video tape: "Geometrical Optics"
1 Cork Board
1 Protractor
1 Rectangular Plastic Cell
Ruler
Tap Water
Light Refraction Program

INTRODUCTION

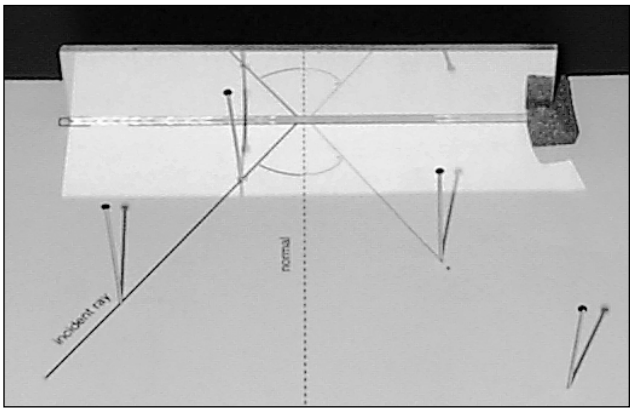
The purpose of this experiment is to investigate the behavior of light at the boundary of two media.

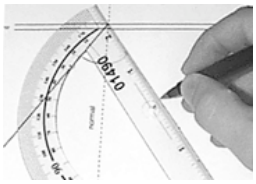
Light ordinarily travels in straight lines. When going from one medium to another, light will take the most efficient path and travel in a straight line. It is this idea which underlies all the formulas that describe light paths. It is referred to as Fermat's principle of least time: light takes the path that requires the least time when it goes from one place to another. If a surface is smooth, an incident (incoming) light ray will be reflected off the surface at the same angle from which it was incident. In other words, the angle of incidence equals the angle of reflection. This is the *law of reflection*. The *law of refraction* describes the path of a light ray which passes from one medium into another. A ray of light entering a transparent medium at an angle will be bent. This bending is caused by the difference in the speed of light in the two media.

In this laboratory exercise you will investigate for yourself the laws of reflection and refraction. Using ray tracing diagrams, pins, mirrors, and various media, you will describe the behavior of incident, reflected, and refracted rays. Through these descriptions you will satisfy yourself of the correctness of these laws.

PROCEDURE

A. Reflection of Light Rays

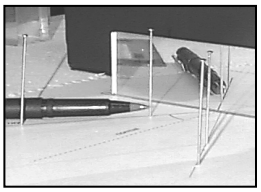




1. Using a protractor, measure the angle between the normal line and the incident ray line on ray diagram worksheet number 1; this is the incident angle. Record its name and value on the diagram.

2. Place the ray diagram on the pin board and place 2 or 3 pins along the incident ray.

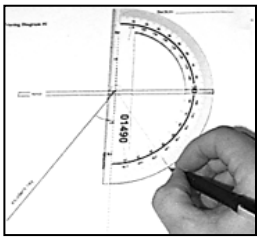
3. Attach a support to the plane mirror and place it in position on the diagram.



4. Position yourself so that you are looking at the mirror and can see the reflected image of the pins. Now place 2 or 3 pins, in line with this image, between your eye and the mirror. You should be able to look down the line of pins and see only one pin. These pins describe the position of the reflected ray.

5. Remove the pins and the diagram from the pin board. Now draw a line connecting the holes left by the reflection ray pins. This is the reflected ray. Label it with its name.

6. Use the protractor to measure the angle between the reflected ray line and the normal line; this is the angle of reflection. Label this angle with its name and value. Your diagram should now look similar to Figure 1.



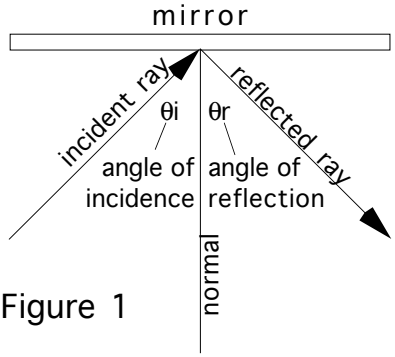


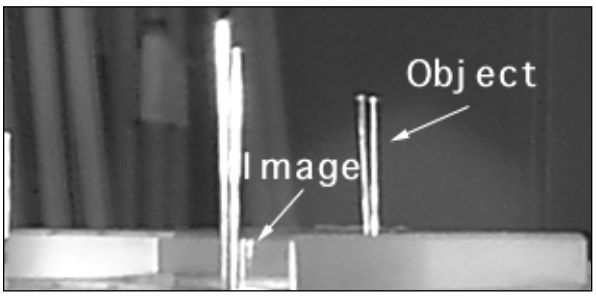
Figure 1

B. Refraction of Light Rays

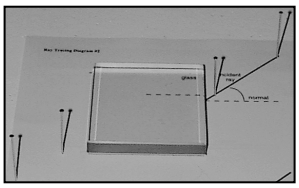
1. Place ray diagram worksheet number 2 on the pin board and place several pins along the pre-drawn incident ray.

2. Place the square plastic medium in the corner outline on the diagram. Be sure that a clear edge of the square is intersected by the incident ray. Complete tracing the outline of the plastic medium on the worksheet.

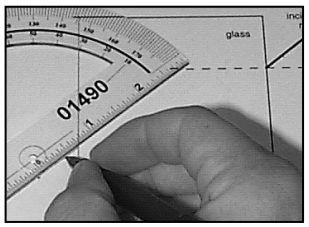
3. Now place 2 pins on the incident ray line. Position yourself on the opposite side of the block from your pins so that you are looking through the other clear edge and viewing the transmitted images of the pins. Find where the pins form a straight line (as you did in part A). Place 2 pins so that they line up with the image in the plastic.



4. Now place pins between your eye and the near edge of the square, in line with this single image.



5. Remove the pins and the diagram from the pin board and draw a line connecting the holes left by the pins you positioned in step 4. Your diagram should now resemble Figure 2.



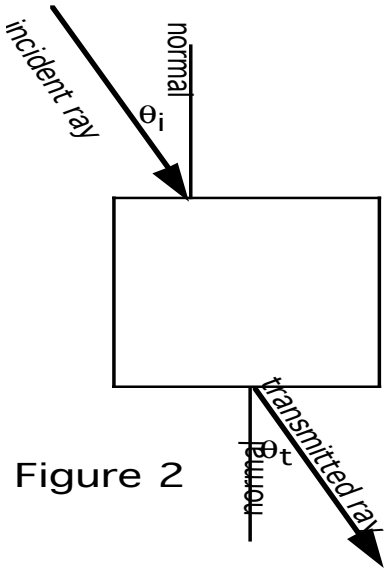
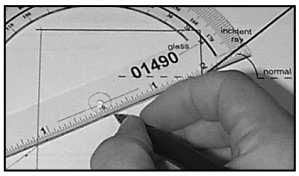


Figure 2

6. From the example of Figure 3, draw a line representing the path of the light ray through the medium.



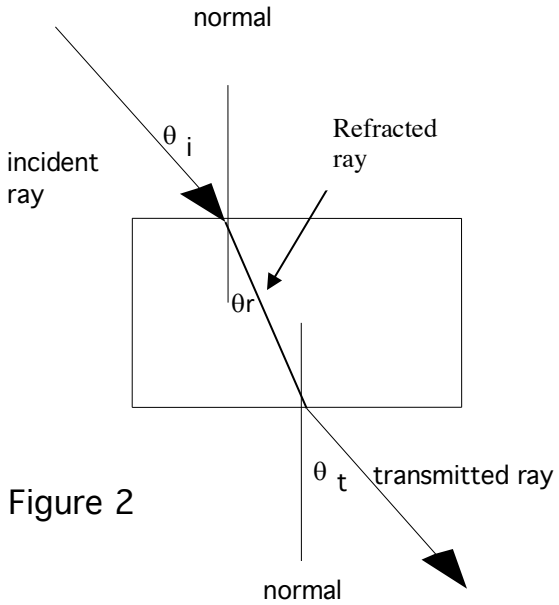
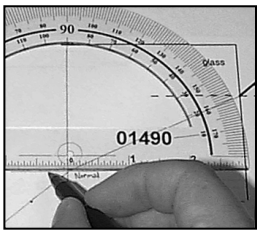


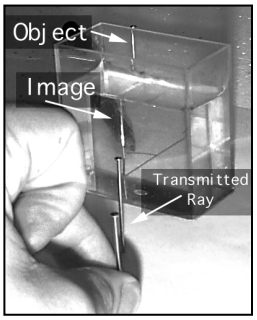
Figure 2

7. Draw the Normal perpendicular line for the Transmitted Ray.



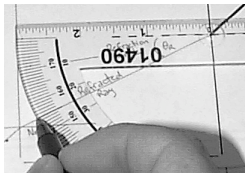
8. Measure all angles — incident, refracted, and transmitted — with the protractor and label them with their names and values.

9. Repeat steps 1 - 8 using the rectangular plastic cell on ray diagram Data Sheet number 3. Then repeat with the cell (empty first, then with water) partly filled with water. Measure all angles and label as appropriate on the diagram.



10. Use the computer program, LIGHT REFRACTION, to find the velocity of light through each medium used in the previous steps. Record the calculated values in the space provided on the diagrams.

11. Using ray diagram sheet number 4 and the triangular plastic medium, place 2 pins in the incident ray. Find the transmitted ray for the incident ray shown. Carefully examine all sides of the triangle for transmitted rays.



Note: The incident and transmitted rays enter and leave the same side of the triangle. This is a case of *total internal reflection.* The light ray is reflected from the inside walls of the triangle, not bent by refraction.

12. Draw the path taken by the ray as it is reflected on the inside of the triangle.

Experiment 18

GEOMETRICAL OPTICS: REVIEW QUESTIONS

Your instructor will present the videotape "Geometrical Optics" for your viewing enjoyment and education. After watching the first section of the tape, you will have several minutes to complete the first ten questions. The tape will continue so that you may check your answers, then you will be required to answer the last five questions on your own

Please be sure to answer the first ten questions BEFORE the answers are given.

1) What is the value of the speed of light in air or free space?

2) What are some common sources of light which make objects visible?

3) What evidence exists to show that light travels in a straight line?

4) What is the law of reflection relating the incident and reflected angles?

   Draw a diagram to illustrate this concept and **label each angle**.

5) When light is refracted, what changes that causes its path to bend?

   Is light bent *away from* or *toward* the normal when passing from water into air?

   Draw a diagram showing the path of light passing from water into air. Be sure to **label** the angles of incidence and refraction, the normal, the names of the two media, and indicate the direction the ray is travelling.

6) What is the difference between diffuse and specular reflection? Give examples of each.

7) What are the two types of lenses discussed? Draw a diagram of each.

8) Define the focal length of a converging lens.

Draw a diagram of parallel rays entering such a lens illustrating their focusing at the focal point. **Label** the focal point and focal length.

9) Draw a diagram that shows how the converging lens of the eye focuses light on the retina.

10) Draw an additional diagram illustrating the type of lens used to correct for myopia or nearsightedness.

STOP THE TAPE AND REVIEW YOUR ANSWERS.
CONTINUE THE TAPE TO REVIEW THE CONCEPT OF SIMPLE MAGNIFYING LENSES.

11) Write down the relationship between the image and object distances and magnification. M (magnification) is defined as the ratio of image to object distance.

Draw a diagram that illustrates the meaning of the image and object distances.

12) What is a virtual image and when is a virtual image formed by a converging lens?

13) How can a converging lens be used as a magnifying glass?

Draw a diagram illustrating the position of the eye, lens, and object in this case.

14) What type of converging lens can be used to produce the most effective magnifying glasses?

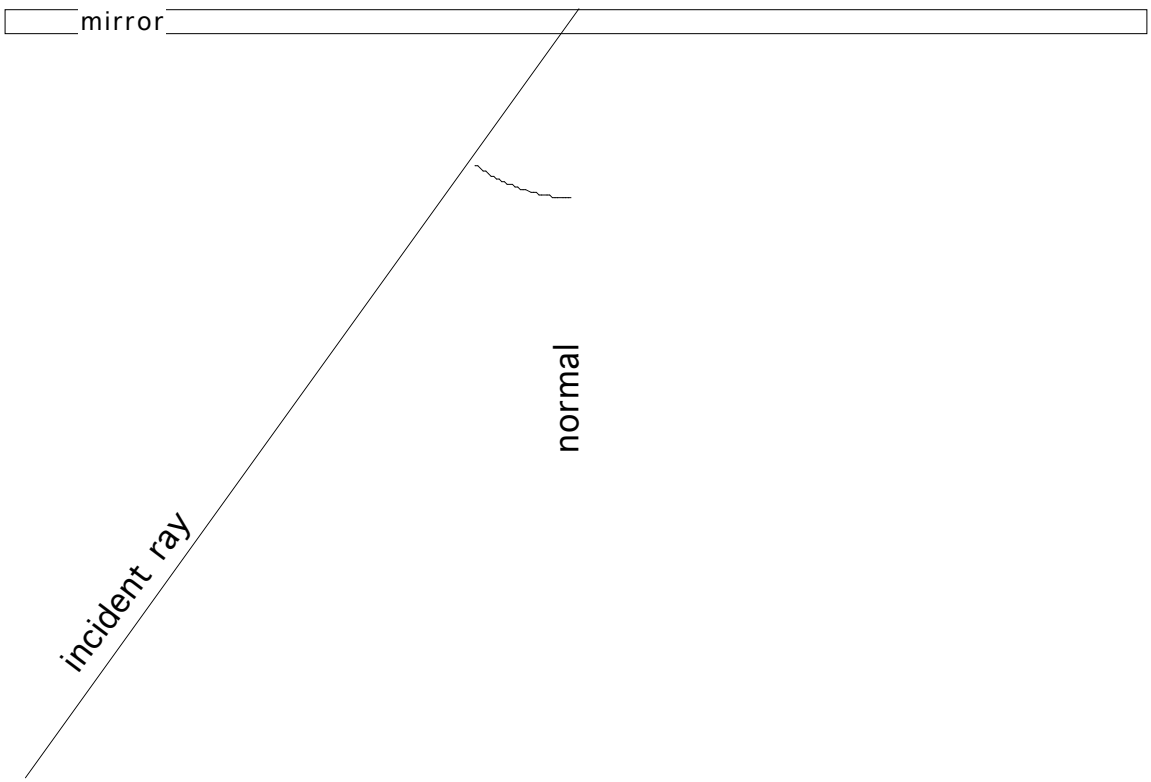
STOP THE TAPE AT THE BEGINNING OF THE DISCUSSION OF A COMPOUND MICROSCOPE. YOU WILL NOT BE RESPONSIBLE FOR THIS INSTRUMENT. INSTEAD WE WILL CONCENTRATE ON THE EYE AS AN OPTICAL INSTRUMENT IN FUTURE LABORATORIES.

Experiment 18
Reflection & Refraction DATA SHEET

Name: _____

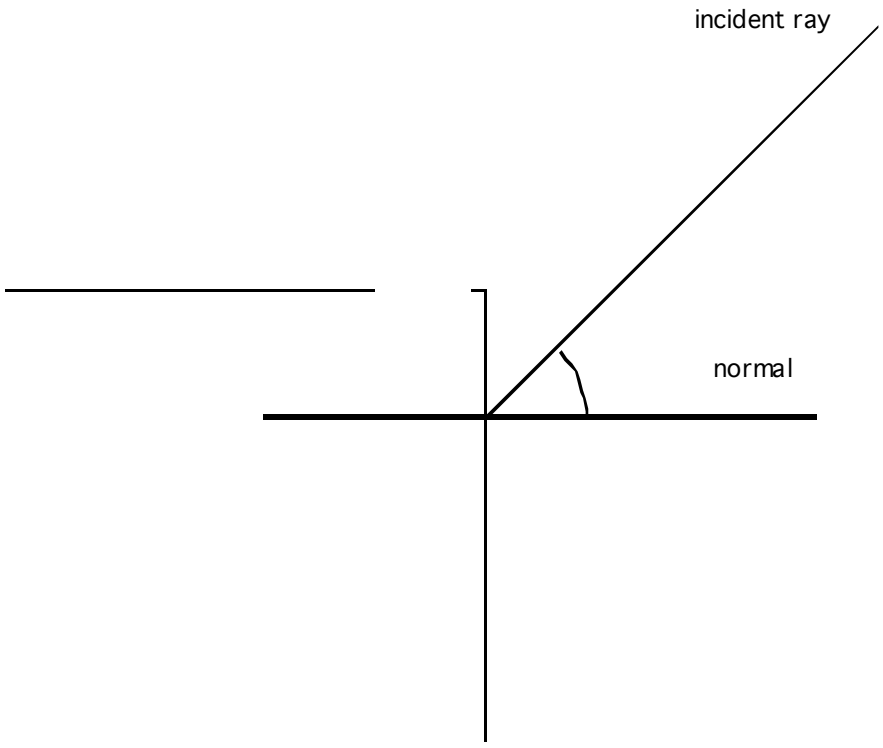
Table: _____ Section: _____

Tracing Diagram #1



Experiment 18
DATA SHEET

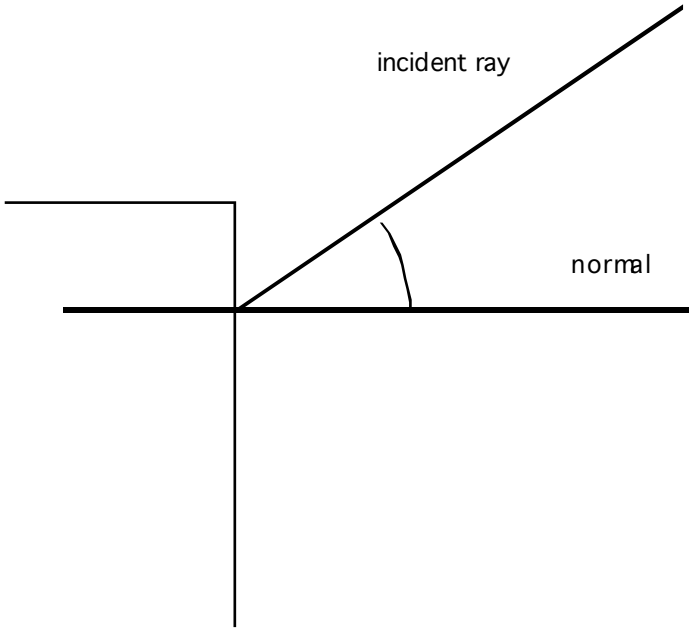
Ray Tracing Diagram #2

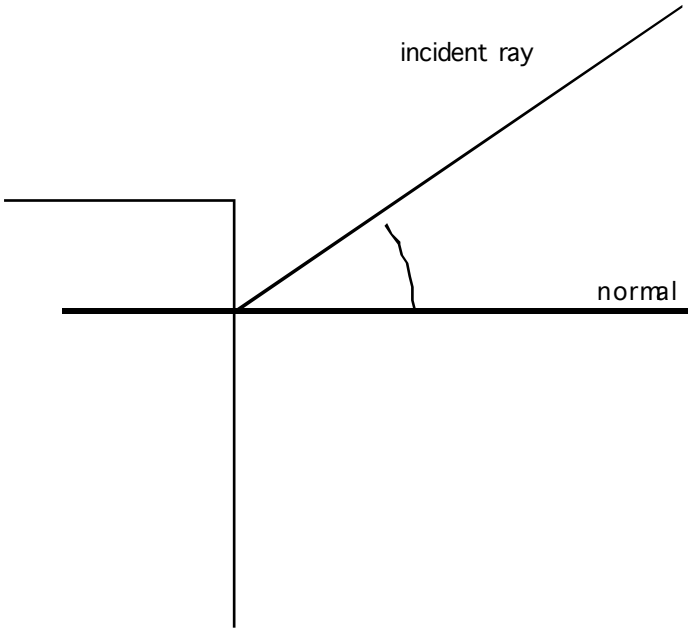


Velocity of light through plastic _____ .

Experiment 18
DATA SHEET

Ray Tracing Diagram #3



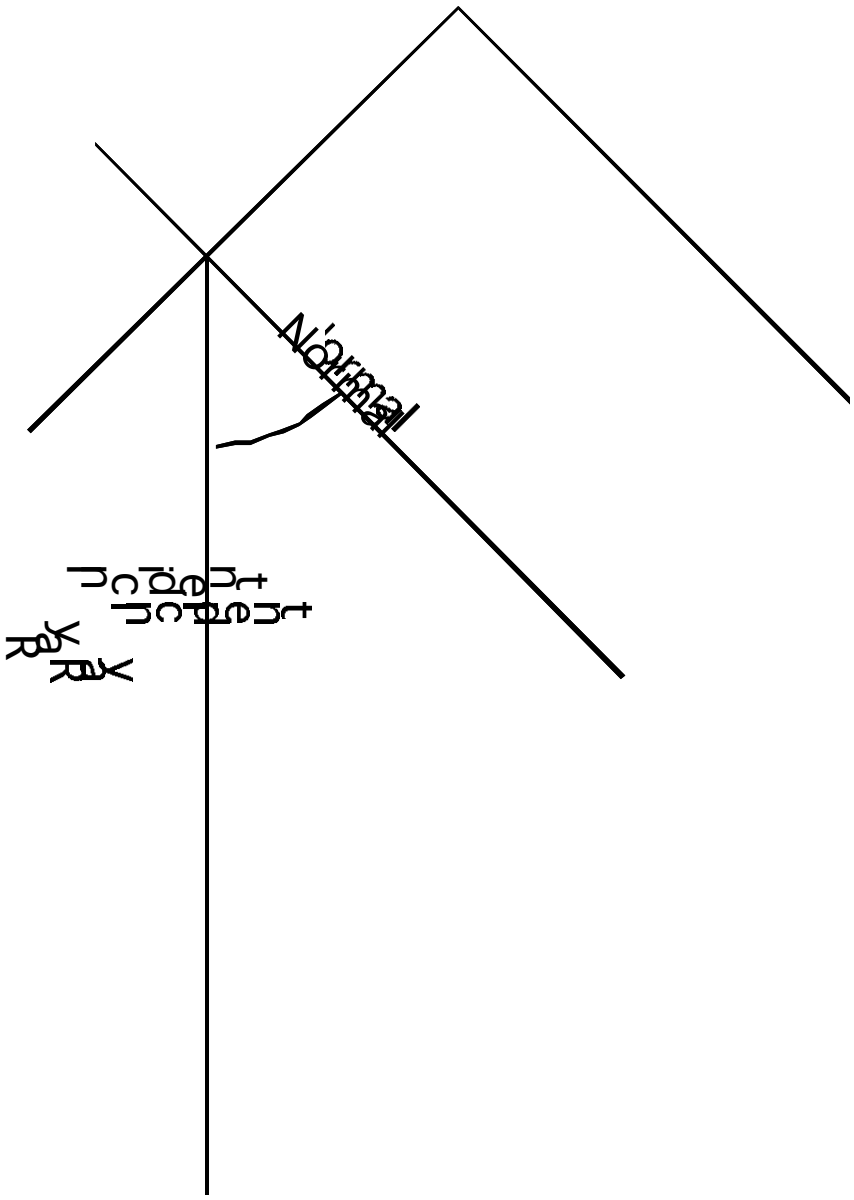


Velocity of light through air _____.

Velocity of light through water _____.

Experiment 18
DATA SHEET

Ray Tracing Diagram #4



QUESTIONS

1) Do your results for Part A support the Law of Reflection as defined in your textbook?

   Fermat's Principle is closely related to the laws of reflection and refraction. What is Fermat's Principle and how does it apply to these laws?

2) State the Law of Reflection.

3) Compare the velocities of light through the three media studied by recording the name of each media in order of slowest to fastest.

4) If you stick a pencil into a glass of water, it appears bent or broken depending on the angle from which it is viewed. Why is this so?