Name _____ Date _____

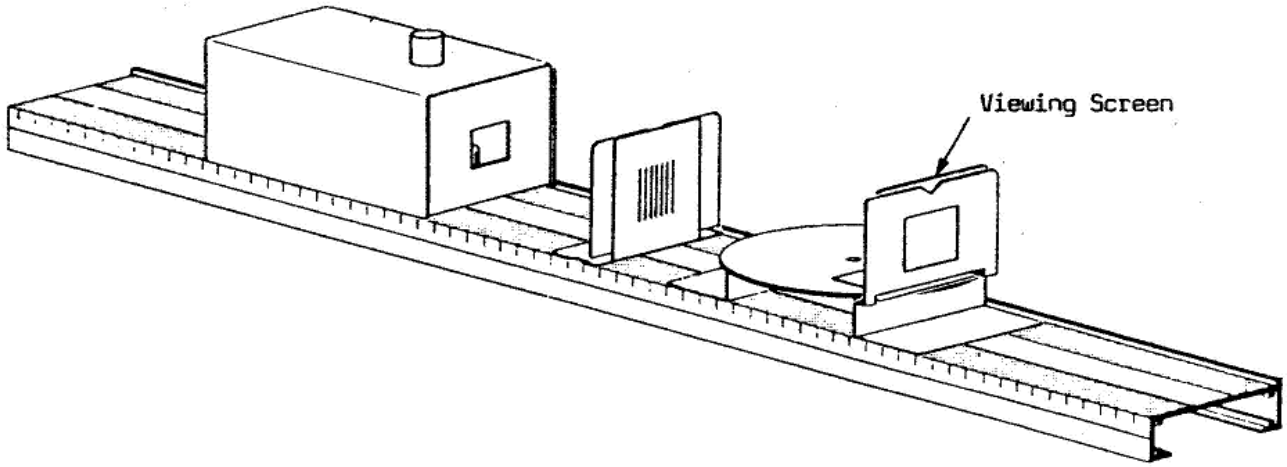
Partners _____

Light Propagation: Lab #11
by Pasco Scientific Company

Objective: to become familiar with physical ray optics

Equipment:

Sketch:



Background:
Define normal:

Procedure:
1. Light Rays

Set up the optical bench with the light source, the slit plate on a holder, and the viewing screen on a holder. Darken the room so that the light rays are easily visible.

Are the rays straight?

As you vary the distance of the viewing screen from the slit plate, how does the width and distinctness of each ray change?

Rotate the slit plate slowly on its holder and watch the slit images on the viewing screen. Describe how the width and distinctness of the images change with slit angle (vertical slits to horizontal slits).

What does this tell you about the orientation of the light source lamp's filament?

2. Ray tracing to locate the lamp's filament

Set up the optical bench with the light source, the slit plate on a holder, and the circular ray table on its base with its lower side toward the light source. Put a piece of white paper on the ray table and put a small circle on the paper at the position of the center of the ray table.

Use a straight edge to trace the edges of several light rays on the paper.

Remove the paper from the ray table. Label the center of the ray table, then use a ruler to extend the rays until they intersect. (You will probably need to tape another piece of paper onto your original sheet.) Label the best intersection point "filament", and measure the distance from this point to the center of the ray table. Estimate its uncertainty also.
Distance from ray table to intersection = _____.

Note the notch on the side of the light source showing the location of the filament. There is a metric scale on the optic bench. Use this scale to measure the distance between the filament and the center of the ray table. Distance = _____.

Which distance measurement do you trust more?

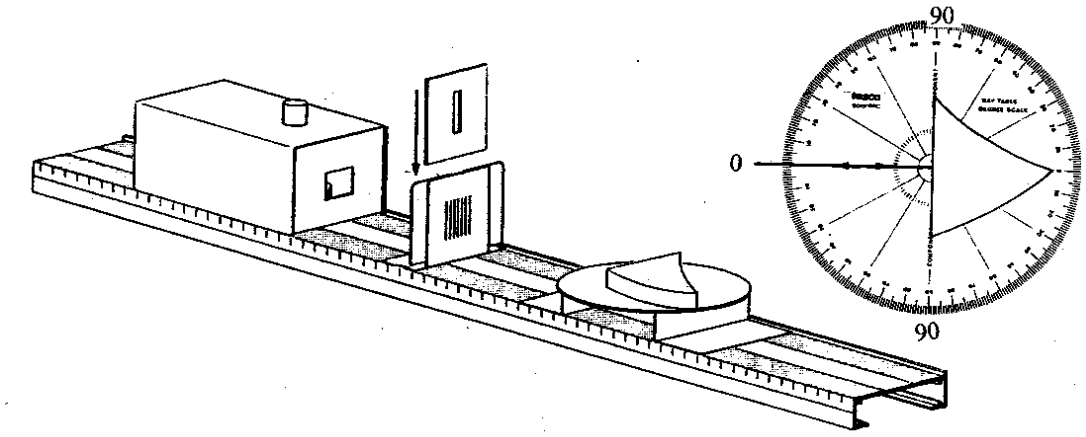
Calculate the percent difference.

How can you explain this amount?

3. The law of reflection

Set up the optical bench with the light source, the slit plate on a holder, and the ray table on its base. Carefully set the ray optics mirror on the ray table such that its flat side is along the line labeled "component" and faces the light source. Add a slit mask to the slit plate assembly so that only one slit passes light, and that it is centered on the mirror. You will observe the reflection of this single ray of light from a plane mirror.

Rotate the ray table and record the angle of reflection for each angle of incidence. The angle is measured relative to the normal to the mirror. Repeat your measurements with the incident ray coming from the opposite side of the normal.



Angle of incidence	Angle of reflection (1)	Angle of reflection (2)
0°		
10°		
20°		
30°		
40°		
50°		
60°		
70°		
80°		

Are the results for the two trials the same?
If not, to what might you attribute the difference?

State the relationship between the angle of reflection and the angle of incidence:

Does the reflected ray lie in the same plane as the incident ray?

Future work: How might the law of reflection be determined to a higher level of accuracy than in the experiment you just performed?

4. Image formation in a plane mirror

Looking into a mirror and seeing an image of yourself is understandable in terms of the principles you have just observed: the straight line propagation of light, and the law of reflection.

Set up the optical bench with the light source, the slit plate on a holder, and the ray table on its base. Carefully set the ray optics mirror on the ray table such that its flat side is along the line labeled “component” and faces the light source. Adjust the slit plate and light source positions for sharp, easily visible rays.

Draw a straight line across a blank piece of paper 7 centimeters from one end. Put the paper on the ray table with your line over the “component” line. Place the flat side of the ray optics mirror on this line. All the rays of light should be reflected from the mirror’s flat side.

Rotate the ray table about 30°. Look into the mirror from the direction of the reflected rays. You should be able to see the image of the slit plate and also the filament of the light source through the slits. Do the rays seem to follow a straight line into the mirror? _____

Have one person hold the ray table steady. With a pencil mark with dots two points along the edge of one of the incident rays. Also mark two points along that ray's reflected ray.
Now pick another incoming ray and mark two little x's on its incoming ray and on its outgoing ray.
Mark the positions of three more ray pairs, each with a different symbol.

Remove the paper from the ray table and reconstruct the rays. You may need to tape additional sheets of paper on. The incoming rays should intersect back at the filament. Label it "filament."
Measure the distance from the paper filament to the paper mirror _____.
What is this distance on the scale on the optical bench? _____
What is your percent difference? _____

The reflected rays should intersect behind the mirror at the image of the filament. Label it.
Measure the distance from the paper image of the filament to the paper mirror _____.
From symmetry, this distance should be the same as the distance on the paper from the filament to the mirror.
What is your percent difference? _____

Application: If one wall of a room is a huge flat mirror, how much larger does the room appear to be than it actually is?

How does the size of an image reflected from a plane mirror relate to the size of the object?

5. The law of refraction

As you have seen, when light encounters a reflective surface it changes its direction abruptly. Light also changes its direction when it passes from one medium of propagation into another medium. In this case it is called refraction.

Set up the optical bench with the light source, the slit plate and slit mask on a holder, and the ray table on its base.
Carefully set the cylindrical acrylic lens on the ray table such that its flat side is along the line labeled "component" and the flat side faces the light source.
Adjust the slit plate and light source positions for one sharp, easily visible ray which goes down the center of the optical bench.

Carefully rotate the ray table and record the angle of the outgoing refracted rays in the following data table.
Repeat the measurements for the incident ray striking from the opposite side of the normal to the lens.

Angle of incidence	Angle of refraction (1)	Angle of refraction (2)
0°		
10°		
20°		
30°		
40°		
50°		
60°		
70°		
80°		

Are your results the same from the two sets of measurements? _____
If not, to what can you attribute the difference?

Draw a graph (Graph #1) of angle of refraction vs. angle of incidence with both sets of measurements on the same graph. Add a linear trendline for each set. Is the relationship a straight line for each set of measurements? _____

Draw a graph (Graph #2) of sin (angle of refraction) vs. sin (angle of incidence). Note that Excel expects angles to be in radians instead of degrees, so calculate SIN(A9/57.29) or some such.
Is this a straight line for each set of measurements? _____

Measure the slope of each line _____, _____. Average = _____.

Look in your book for the law of refraction (Snell's Law):

If the index of refraction of air = 1, then what is your measurement of the index of refraction of acrylic? _____
The accepted value for the index of refraction of acrylic is 1.49. What is your % error?

Conclusions:

Discussion of errors:

Future work in this field: