## Physics Laboratory

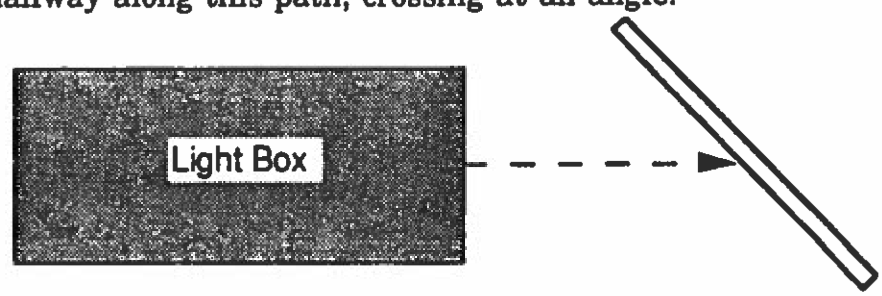
## Reflectors and Ray Tracing

**Set up:** Place the light box with the three point legs down on the table. Insert the desired slit window into the front slide. Project the light from the slits across a sheet of paper. Loosen the top knob and slide the collimating lens to obtain a set of parallel rays. Sometime faint secondary rays emerge from the light box. These sometimes can be eliminated by rotating the lamp holder so that the support wire for the bulb's filament is directly behind the filament.

**Procedure:** Place the object being studied on a sheet of paper. Project the light at the object as desired. To record the light paths, mark the position of the reflector by tracing around the perimeter of the reflector. Then place a mark at either end of the ray being observed. Remove the reflector and rule lines between the points. Place an arrowhead on each ray to indicate direction. If in doubt as to the continuity of any line, replace the reflector in exactly the same position and retrace the ray.

**Experiment 1 -Single Ray reflection of a plane mirror.**

Project a single ray along the paper and mark its two ends. Place the plane mirror halfway along this path, crossing at an angle.




Mark the position of:

(a) The glass front face of the mirror.
(b) The reflecting rear face of the mirror.
(c) The reflected ray (or rays). <u>Explain the second fainter reflected ray.</u>

## Reflectors and Ray Tracing

Draw a line perpendicular to the mirror at the point where the incidence and the reflected rays meet the mirror face. Such a perpendicular is called the NORMAL to the mirror face at this point.

Measure the angle between the INCIDENT RAY and the NORMAL. This angle is called the ANGLE OF INCIDENCE. (Record on your drawing.)

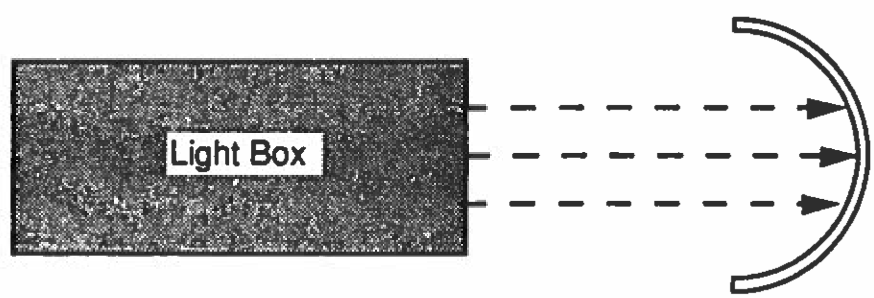
Measure the angle between the REFLECTED RAY and the NORMAL. This angle is called the ANGLE OF REFLECTION. (Record on your drawing.)

These angles are measured from the NORMAL because in later experiments you will be reflecting rays from curved mirrors. Since you cannot measure the angle between the ray and a curved surface, you must first draw a normal to the curved surface, and measure the angles of incidence and reflection from this normal line.

**Experiment 2 -Reflection in a circular, concave mirror.**

Select the semi-circular curved mirror.

Aim a set of parallel rays into the center of the inside curve of the mirror so that the rays are parallel to the axis of symmetry of the mirror.




Record the angle of incident and reflected rays and note where they meet. This is called the FOCUS or FOCAL POINT of the mirror. Draw in normals to these rays. Measure and record on the drawing the angle of incidence and the angle of reflection for each ray.

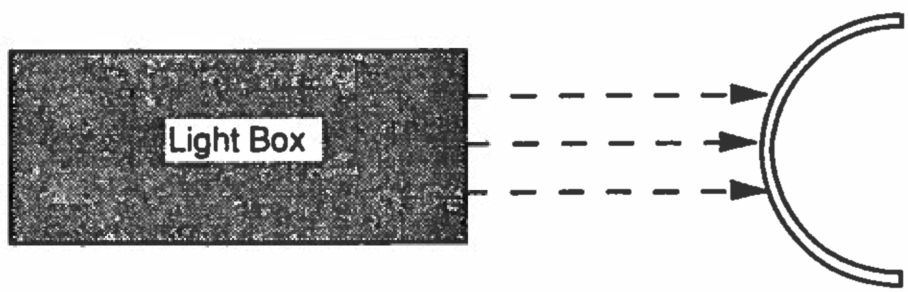
## Reflectors and Ray Tracing

What is the distance of the focal point from the center of the mirror? (Record this length on your drawing.) This distance is called the FOCAL LENGTH of the mirror.

If the focal point appears blurred and broad, with too many rays overlapping through it, block the outer rays as they leave the light box and only use the central ones.

**Experiment 3 -Reflection in a circular, convex mirror.**

Project a number of rays to strike the outside surface of the semi-circular mirror, parallel to its axis.




Record the mirror position and ray paths and indicate the ray directions with arrow heads. Draw in normals to these rays. Measure and record on the drawing the angle of incidence and the angle of reflection for each ray.

Where do the diverging rays appear to come from?

Locate this point by extending the traces of the diverging rays backward through the mirror position. The point where the lines meet is called the VIRTUAL FOCUS of the mirror. This distance is called the VIRTUAL FOCAL LENGTH of the mirror.

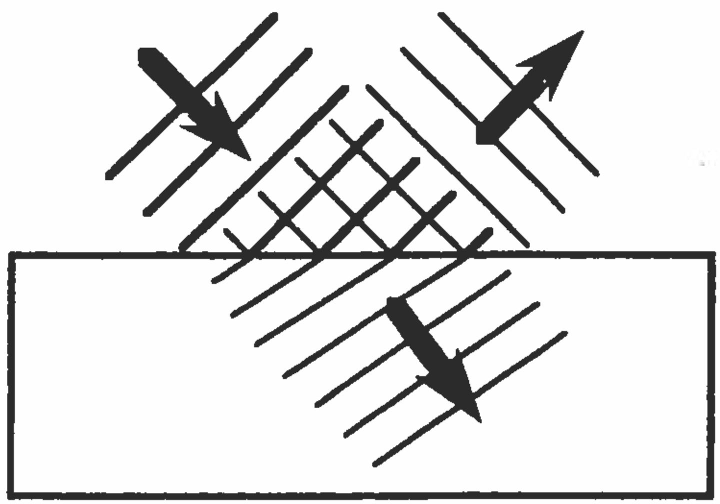
How does this focal length compare to the focal length determined in experiment 2?

## Physics Laboratory

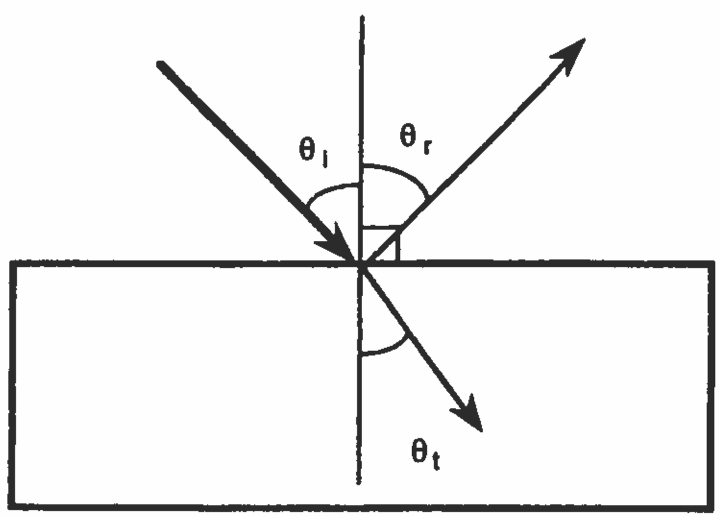
## Refraction and Snell's Law

**Theory:** Light has a dual nature, it propagates through space like a wave and can display particle-like behavior during emission and absorption processes. In the study of optics, the dominate property of light is its wave nature.

When a wavefront is incident on an interface, such as air to glass, part of the wavefront is transmitted or refracted into the glass and part of the wavefront is reflected off the glass back into the air. This process is shown below:



Wave Representation




Ray Representation

## Physics Laboratory

**The laws that apply to the reflection-refraction process are:**

I.) The incident, reflected, and transmitted rays will all lie on the same plane.

II.) The angle of incidence ($\theta_i$) will equal the angle of reflection ($\theta_r$).

III.) Snell's law:

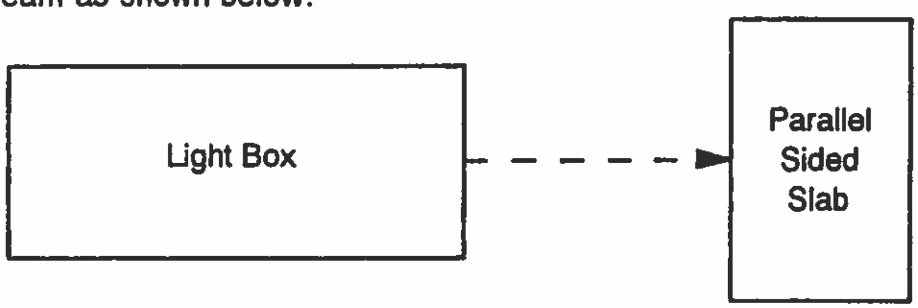
$$n_i \sin \theta_i = n_t \sin \theta_t$$

Where:

$n_i$ = the index of refraction for the incident medium (air = 1)
$\theta_i$ = the angle of the incident ray from the normal to the surface
$n_t$ = the index of refraction for the transmission medium
$\theta_t$ = the angle of transmission from the normal to the surface

**INDEX OF REFRACTION-Clear Acrylic Lens Material**

Place the rectangular slab lens with the long side perpendicular to a single beam as shown below:

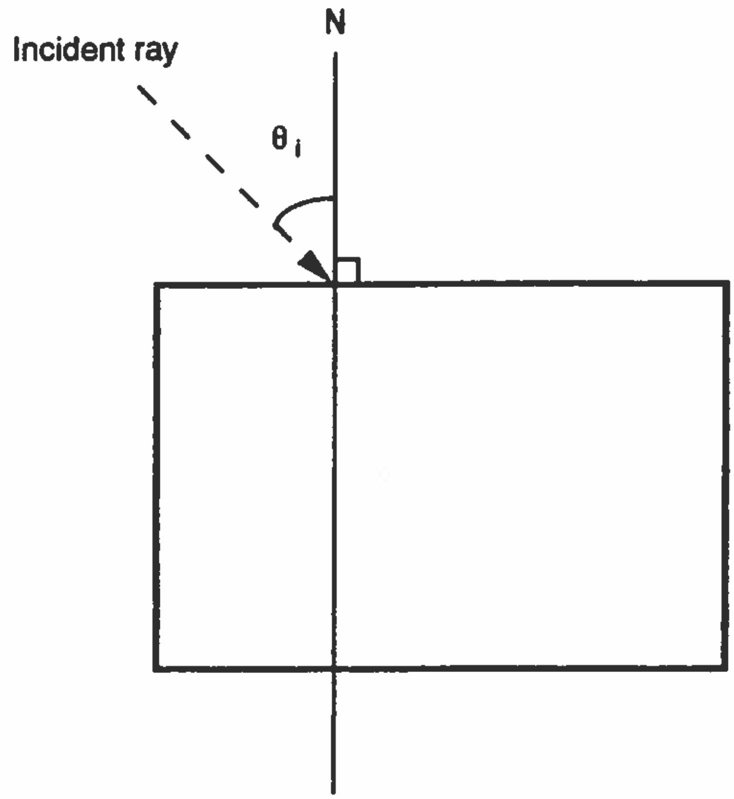



1). Is there any refraction at either incident or emergent faces?

2). What other condition (besides a ray passing from one medium to another) must be present for refraction to occur?

**Physics Laboratory**

Position the light box and the slab on this page as shown:




3). On the above drawing, rule the following lines:

a). The path the incident ray would take without the lens. (dashed line)

b). The reflected ray from the top surface.

c). The transmitted ray. (in the block)

d). The emergent ray. (out the bottom of the block)

e). The normal to the emergent ray.

4). Is the emergent ray parallel to the incident ray and its extension?

5). Label the following angles on the drawing and record their values.

a). $\theta_i$ = the angle of the incident ray = ___________

b). $\theta_t$ = the angle of the transmission ray = _______

c). $\theta_r$ = the angle of the reflected ray = __________

6). Based on the above information, use Snell's Law to determine the index of refraction for the acrylic plastic lens material.

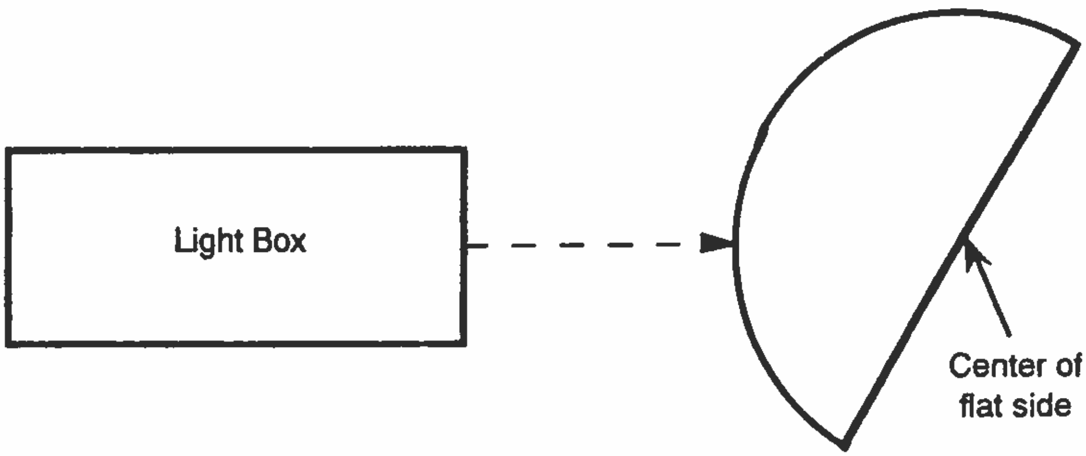
## REFRACTION-Total Internal Refraction.

Arrange the semi-circular lens so that a single light ray strikes the curved surface at the center of the curved side and passes through the center of the flat side.

7). Is there any refraction at either interface? If not, why not?

Determine the critical angle of the acrylic medium. By definition; the critical angle for a material is the angle of incidence beyond which a light ray, passing from a dense to a light medium, is no longer refracted out of the medium, but is totally internally reflected.

Note the position of the center of the flat side. Rotate the lens slightly about this point causing the ray inside to meet the flat side at an angle.




Continue this rotation of the slab until no refracted ray emerges from the flat face. The angle of incidence at which refraction ceases and internal reflection commences is called the CRITICAL ANGLE for this material. Rotate the lens back and forth to find this exact angle.

8). Record the critical angle of the acrylic medium. ________

9). How can the critical angle of a piece of acrylic plastic used to find its refractive index?