Physics Lab Experiments with Simulated Data for Remote Delivery

Department of Chemistry and Physics

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Experiment 2.09: Reflection and Refraction

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I. EXPERIMENT 2.09: REFLECTION AND REFRACTION

A. Abstract

The index of refraction of a glass block is determined using the law of refraction. The relation between focal length and radius of curvature for a spherical mirror is tested.

B. Formulas

$$\theta_{\text{Reflected}} = \theta_{\text{Incident}} \tag{1}$$

$$n_1 \sin\theta_{\text{Incident}} = n_2 \sin\theta_{\text{Refracted}} \tag{2}$$

$$f = \frac{R}{2}, \text{ spherical mirrors} \tag{3}$$

C. Description and Background

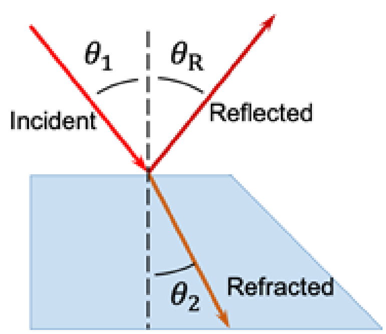

FIG. 1. Reflection and refraction.

Geometrical optics explains light interactions with normal size objects by using simple geometric rules. It is based on two simple principles: (a) When moving between two points, light takes the path that requires the least amount of time, and (b) light propagates as a set of rays, emanating from a source.

Reflection: According to this principle, incident rays of light bounce back from the mirror such that the angle of incidence must equal the angle of reflection (Fig. 1) as specified by Eq. (1).

Refraction: The change in direction and speed that light has when crossing a boundary from one medium to another is called refraction (Fig. 1). The angle a refracted ray makes with the normal is called the angle of refraction. This angle is given by Snell's (Descartes') law as specified by Eq. (2) in which $n_{1/2}$ is the index of refraction in medium 1/2, defined as the ratio between the speed of light in vacuum to that in the medium ($n = c/v$).

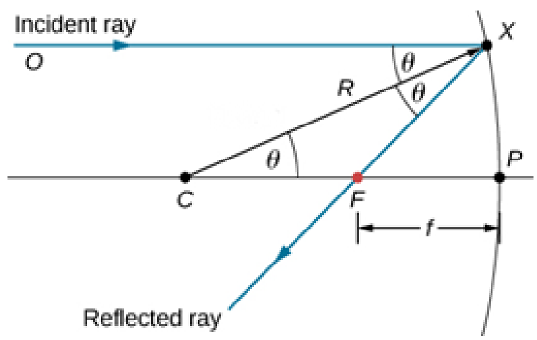

FIG. 2. Spherical mirror.

A spherical mirror, shaped like a section of a sphere, may be reflective on the outside (convex) or the inside (concave). Rays parallel to the optical axis striking a concave spherical mirror converge (in a virtual way in the convex case) at the focal point F (Fig. 2). The focal point is located at the midpoint between the radius of curvature, R, and the mirror surface, hence the focal length is given by Eq. (3).

D. Procedure

1. *Part I*

1. Record the incident, reflected, refracted angles formed when a ray of light obliquely strikes a block of glass. Note that given the boundary line (between glass and air) and any of the rays (*i.e.,* incident, reflected, or refracted), the angle between the two is the complement of the angle with the normal.

2. *Part II*

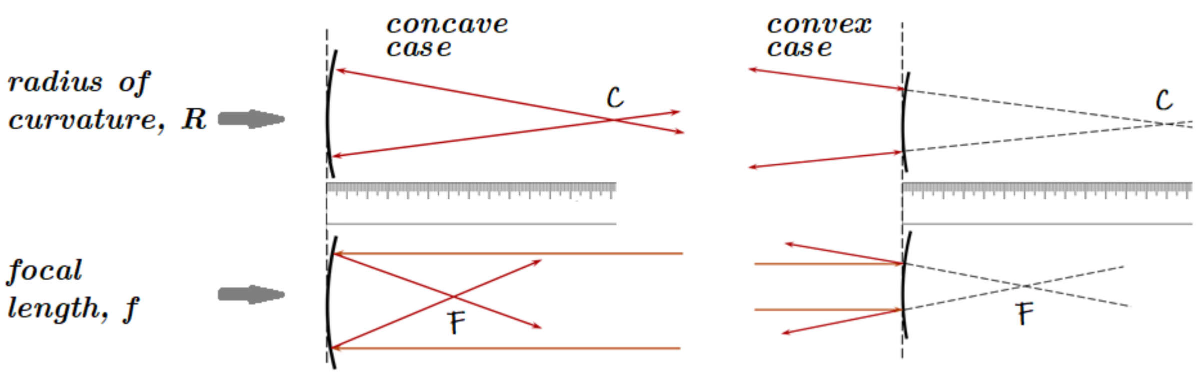

FIG. 3. The measurement process.

1. Independently determine the focal length and radius of curvature of a spherical concave mirror. Note that an incident ray of light passing through the center of curvature, $\mathcal{C}$, will reflect back through the center of curvature (see figure above), so two such rays will intersect at $\mathcal{C}$. Also note that any two rays parallel to the optical axis will intersect at the focal point, $\mathcal{F}$.

2. Independently determine the focal length and radius of curvature of a spherical convex mirror.

E. Measurements

lucite block			
Trial	incident angle, θ_1 [deg]	reflected angle, θ_R [deg]	refracted angle, θ_2 [deg]
1			
2			
3			
4			
5			

mirror	focal length, f [cm]	radius of curvature, R [cm]
concave		
convex		

F. Instructions

1. Calculate the index of refraction of the glass block in each trial, the average, $\bar{n}$, and the standard error, $\delta\bar{n}$.

2. Calculate the percent difference in the incident and reflected angles in each trial.

3. Calculate the percent difference in the focal length and half-radius of the concave and convex mirrors.

G. Calculations

lucite block		
Trial	n	%-Diff (θ_1, θ_R)
1		
2		
3		
4		
5		
$\bar{n}$		N/A
$\delta\bar{n}$		N/A

mirror	%-Diff $(f, R/2)$
concave	
convex	