University of Science and Technology

Faculty of Computer Science and Information Technology

Course Handbook

Physics II

Course Coordinator

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Lecture eight

Reflection of Light

Reflection of Light

LAW OF REFLECTION: A ray is a mathematical line drawn perpendicular to the wavefronts of a lightwave. It shows the direction of propagation of electromagnetic energy. In *specular* (or *mirror*) reflection, the angle of incidence equals the angle of reflection, as shown in Fig. 36-1. Furthermore, the incident ray, reflected ray, and normal to the surface all lie in the same plane, called the *plane-of-incidence*.

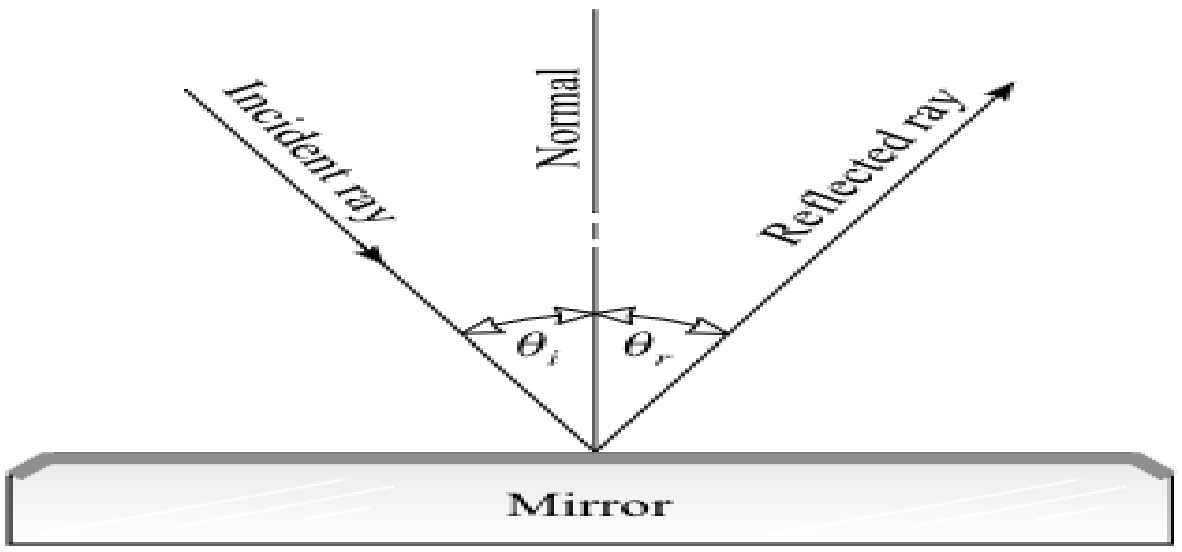
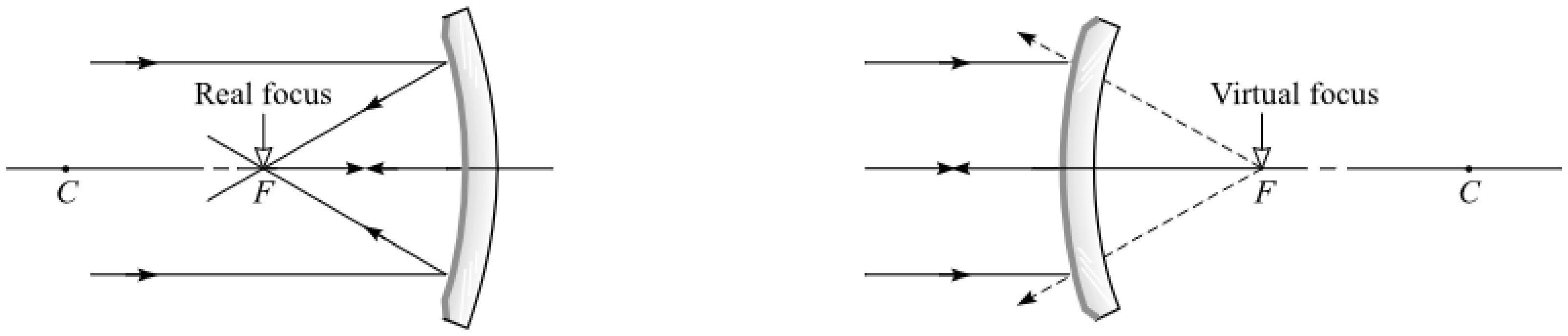


Fig. 36-1

PLANE MIRRORS form images that are erect, of the same size as the object, and as far behind the reflecting surface as the object is in front of it. Such an image is *virtual*; i.e., the image will not appear on a screen located at the position on the image because the light does not converge there.

SPHERICAL MIRRORS: The *principal focus* of a spherical mirror, such as the ones shown in Fig. 36-2, is the point F where rays parallel to and very close to the *central* or *optical axis* of the mirror are focused. This focus is real for a concave mirror and virtual for a convex mirror. It is located on the optical axis and midway between the center of curvature C and the mirror.



(*a*) Concave mirror

(*b*) Convex mirror

Fig. 36-2

Concave mirrors form inverted real images of objects placed beyond the principal focus. If the object is between the principal focus and the mirror, the image is virtual, erect, and enlarged.

Convex mirrors produce only erect virtual images of objects placed in front of them. The images are diminished (smaller than the object) in size.

MIRROR EQUATION for both concave and convex spherical mirrors:

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{2}{R} = \frac{1}{f}$$

where s_o = object distance from the mirror

s_i = image distance from the mirror

R = radius of curvature of the mirror

f = focal length of the mirror = $R/2$.

In addition,

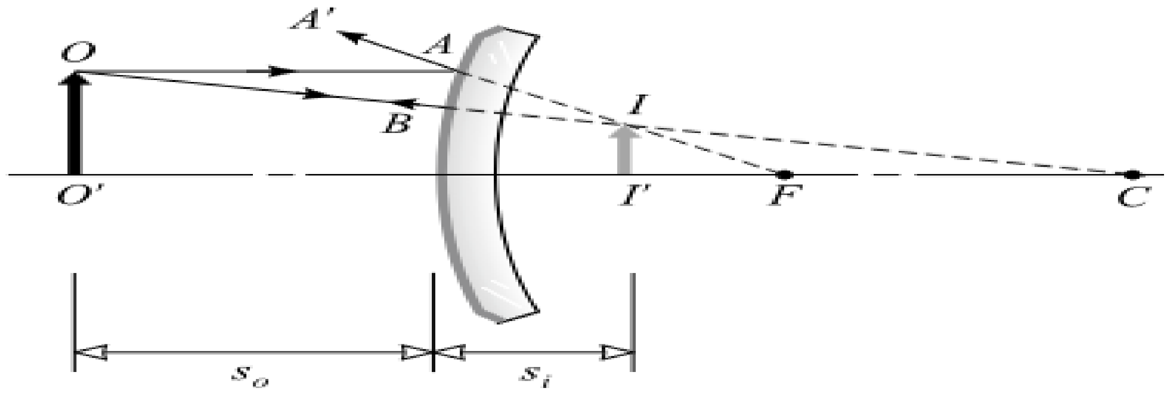
- s_o is positive when the object is in front of the mirror.
- s_i is positive when the image is real, i.e., in front of the mirror.
- s_i is negative when the image is virtual, i.e., behind the mirror.
- R and f are positive for a concave mirror and negative for a convex mirror.

THE SIZE OF THE IMAGE formed by a spherical mirror is given by

$$\text{Linear magnification} = \frac{\text{length of image}}{\text{length of object}} = \frac{\text{image distance from mirror}}{\text{object distance from mirror}} = \left|\frac{s_i}{s_o}\right|$$

Solved Problems

As shown in Fig. 36-8, an object 6 cm high is located 30 cm in front of a convex spherical mirror of radius 40 cm. Determine the position and height of its image,



$$\frac{1}{s_o}+\frac{1}{s_i}=\frac{2}{R} \qquad \text{or} \qquad \frac{1}{30}+\frac{1}{s_i}=-\frac{2}{40} \qquad \text{or} \qquad s_i=-12 \text{ cm}$$

$$\frac{\text{Height of image}}{\text{Height of object}}=\left|\frac{s_i}{s_o}\right|=\frac{12 \text{ cm}}{30 \text{ cm}}=0.40 \qquad \text{or} \qquad \text{height of image}=(0.40)(6.0 \text{ cm})=2.4 \text{ cm}$$

Where should an object be placed, with reference to a concave spherical mirror of radius 180 cm, to form a real image having half its linear dimensions?

The magnification is to be 1/2; hence $s_i = s_o/2$. Then

$$\frac{1}{s_o}+\frac{1}{s_i}=\frac{2}{R} \qquad \text{or} \qquad \frac{1}{s_o}+\frac{2}{s_o}=\frac{2}{180} \qquad \text{or} \qquad s_o = 0.27\ \text{m from mirror}$$

How far must a girl stand in front of a concave spherical mirror of radius 120 cm to see an erect image of her face four times its natural size?

The erect image must be virtual; hence s_i is negative, and $s_i = -4s_o$. Then

$$\frac{1}{s_o}+\frac{1}{s_i}=\frac{2}{R} \qquad \text{or} \qquad \frac{1}{s_o}-\frac{1}{4s_o}=\frac{2}{120} \qquad \text{or} \qquad s_o = 45\ \text{cm from mirror}$$

What kind of spherical mirror must be used, and what must be its radius, in order to give an erect image one-fifth as large as an object placed 15 cm in front of it?

An erect image produced by a spherical mirror is virtual; hence $s_i = -s_o/5 = -15/5 = -3$ cm. As the virtual image is smaller than the object, a convex mirror is required. Its radius is given by

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{2}{R} \quad \text{or} \quad \frac{1}{15} - \frac{1}{3} = \frac{2}{R} \quad \text{or} \quad R = -7.5\ \text{cm (convex mirror)}$$

A dental technician uses a small mirror that gives a magnification of 4.0 when it is held 0.60 cm from a tooth. What is the radius of curvature of the mirror?

Because $|s_i/s_o| = 4$ and $s_o = 0.60$ cm, the mirror equation becomes (in cm)

$$\frac{1}{0.60}+\frac{1}{\pm 2.4}=\frac{2}{R} \quad \text{or} \quad 1.667 \pm 0.417=\frac{2}{R}$$

Supplementary Problems

Describe the image of a candle flame located 40 cm from a concave spherical mirror of radius 64 cm.
Ans. real, inverted, 0.16 m in front of mirror, magnified 4 times

Describe the image of an object positioned 20 cm from a concave spherical mirror of radius 60 cm.
Ans. virtual, erect, 60 cm behind mirror, magnified 3 times

How far should an object be from a concave spherical mirror of radius 36 cm to form a real image one-ninth its size? *Ans.* 0.18 m

An object 7.0 cm high is placed 15 cm from a convex spherical mirror of radius 45 cm. Describe its image.
Ans. virtual, erect, 9.0 cm behind mirror, 4.2 cm high

What is the focal length of a convex spherical mirror which produces an image one-sixth the size of an object located 12 cm from the mirror? *Ans.* –2.4 cm