Al-Mustaqbal University

Department of Optics Techniques

Medical and optical physics 1

First stage

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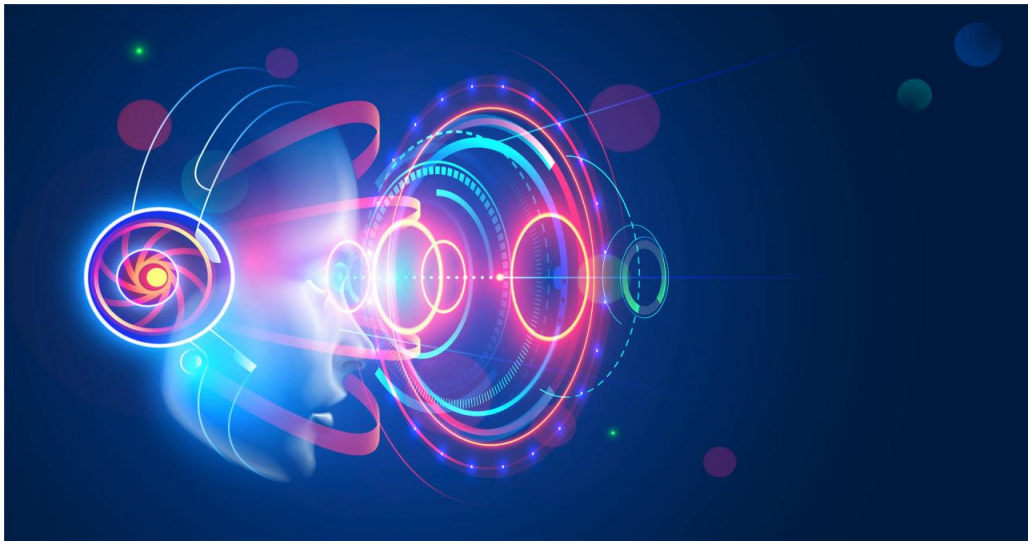


➢ Lecture 5 Mirror Formula and Magnification

Introduction: The mirror formula and magnification are concepts commonly used in optics, specifically in the study of mirrors. There are two types of mirrors: concave mirrors and convex mirrors. The mirror formula and magnification are particularly applicable to both concave and convex mirrors.

Mirror Formula: The mirror formula relates the object distance (denoted as d_o), the image distance (denoted as d_i), and the focal length (denoted as f) of a mirror. It is expressed as:

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$$

where

d_o = object distance.

d_i = image distance.

f = focal length of mirror.

f = is the Focal Length given by: $f = \frac{R}{2}$

R = is the radius of curvature of the spherical mirror.

This formula is applicable to both concave and convex mirrors. In the case of concave mirrors, the focal length is considered positive, while for convex mirrors, the focal length is considered negative.

Magnification: Magnification (M) is a dimensionless quantity that describes how much larger or smaller an image is compared to the object. It is given by the formula:

$$M = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

Where:

M: Magnification

h_i = high of image

h_o = high of object

Sign convention for mirrors:

The d_o and d_i signs determine whether the object or image is real or virtual, while the magnification sign determines whether the image is upright or inverted, as follows:

d_o	+	When the object is in front of the mirror	Real Object
d_o	-	When the object is in behind of the mirror	Virtual Object
d_i	+	When the image is in behind of the mirror	Real Image
d_i	-	When the image is in front of the mirror	Virtual Image

As for the signs for both **f** and R, they are as follows:

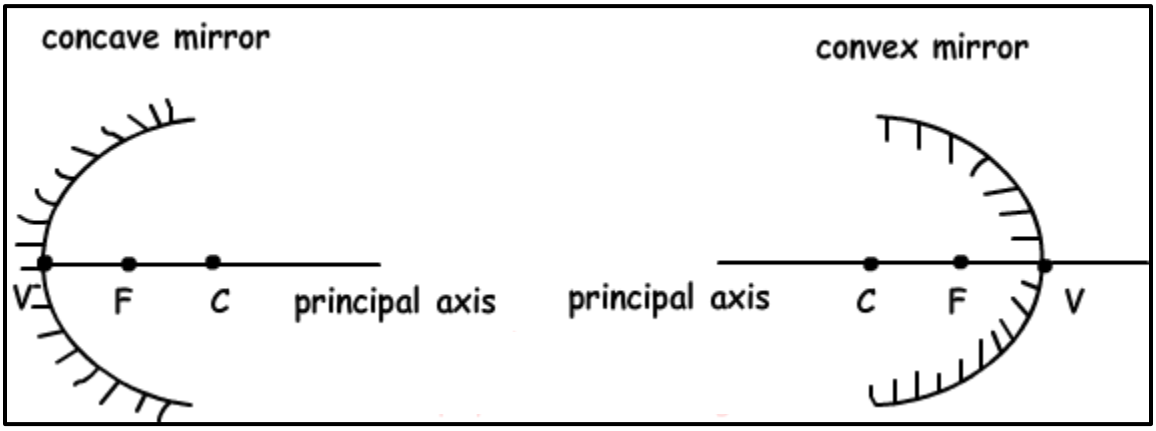
f & R	+	When the focal length is in front of the mirror	Concave mirror
f & R	-	When the focal length is in behind of the mirror	Convex mirror

As for the magnification signs **M :**

M	**+**	The image is upright
M	**-**	The image is inverted

Definition of :-

- **Focal length(f)** : The distance between the mirror and its focal point.
- **Center of curvature (point C) :** is defined as the center of the sphere of which a curved mirror forms a part.
- **Radius of curvature (R)** : is defined as the radius of the sphere of which a curved mirror forms a part.
- **Vertex (Point V)** : is defined as the point at the center of the mirror.
- **Principle axis** : is defined as the straight line through the center of curvature C and vertex V of the mirror.



Solved Examples on Concave and Convex Mirrors

Example: A concave mirror forms a real image at a distance of 4 cm of an object placed at a distance of 20 cm. Find the focal length of the mirror and the radius of its curvature.

Solution:

$d_o = 20$, $d_i = +4$ (real image)

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{d_i}} + \frac{\mathbf{1}}{\boldsymbol{d_o}} \rightarrow \frac{1}{f} = \frac{1}{4} + \frac{1}{20}$$

f = 3.33cm

$$f = \frac{R}{2} \rightarrow R = 2f$$

$$R = 2(3.33) = 6.66cm$$

Example: An object is 10 cm away from a concave mirror with a radius of curvature of 15 cm. Find the distance of the image.

Solution:

$d_o = 10$, $R = 15$

$$f = \frac{R}{2} \rightarrow f = \frac{15}{2} = 7.5\ cm$$

$$\frac{\mathbf{1}}{\boldsymbol{f}} = \frac{\mathbf{1}}{\boldsymbol{d_i}} + \frac{\mathbf{1}}{\boldsymbol{d_o}} \rightarrow \frac{\mathbf{1}}{\mathbf{7.5}} = \frac{\mathbf{1}}{\boldsymbol{d_i}} + \frac{\mathbf{1}}{\mathbf{10}} \rightarrow \frac{\mathbf{1}}{\boldsymbol{d_i}} = \frac{\mathbf{1}}{\mathbf{7.5}} - \frac{\mathbf{1}}{\mathbf{10}}$$

$\boldsymbol{d_i = 30\ cm}$ **Real image, inverted**