

PHYSICS

CHAPTER -4 REFLECTION OF LIGHT

Light

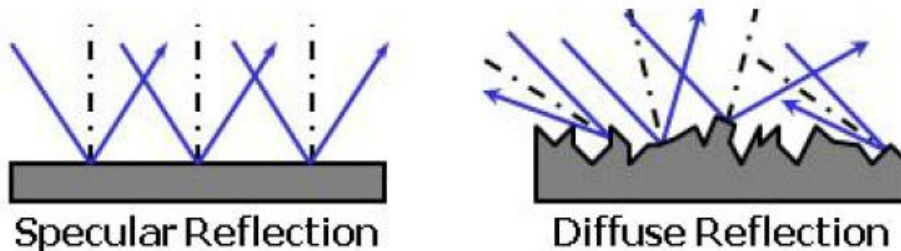
An object reflects light that falls on it. This reflected light when received by our eyes, enables us to see things.

Reflection of Light

- It is the phenomenon of bouncing back of light in the same medium on striking the surface of any object
- There are two types of reflection
 1. Regular / specular reflection
 2. Irregular / diffuse reflection

Regular Reflection: When the reflecting surface is smooth and well polished, the parallel rays falling on it are reflected parallel to one another, the reflected light goes in one particular direction. This is Regular reflection or Specular reflection see below figure.

Irregular reflection: When the reflecting surface is rough, the parallel rays falling on it are reflected in different directions, as shown in below fig. Such a reflection is known as diffuse reflection or irregular reflection.



Law of Reflection

When light is reflected from a smooth surface, the angle of incidence and angle of reflection are equal. The incident ray, reflected ray and normal to the surface are in the same plane.

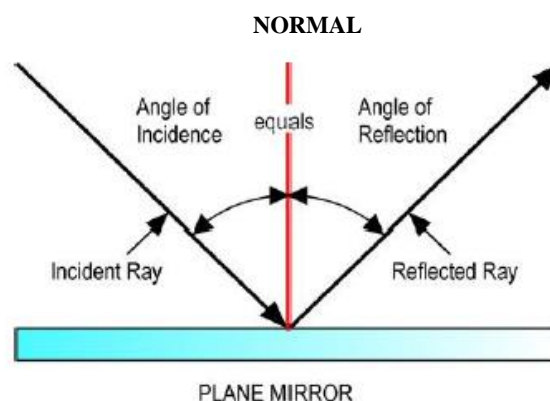


Image formation by a Plane Mirror

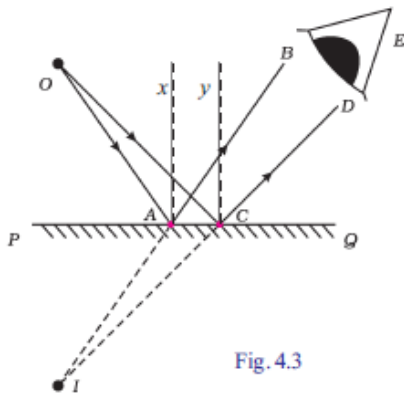
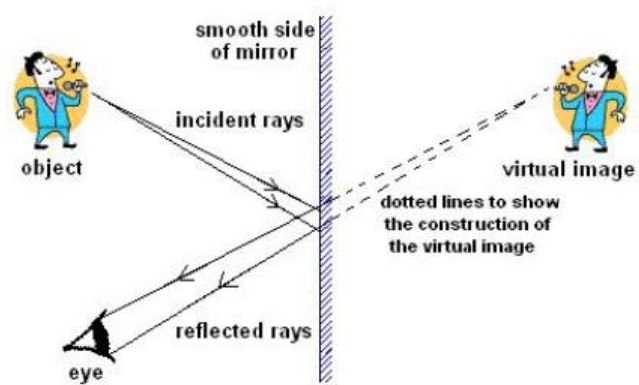


Fig. 4.3



Characteristics of image formation by a plane mirror

1. The image of real object is always virtual. Such image cannot be taken on a screen.
2. The image formed in a plane mirror is always erect.
3. The size of the image in a plane mirror is always the same as the size of the object.
4. The image formed in a plane mirror is as far behind the mirror, as the object is in front of the mirror.
5. The image formed in a plane mirror is laterally inverted i.e. the left side of the objects becomes the right side of the image and vice-versa.

Multiple Reflection and Image Formation

Angle (θ)	Number of images (n)
45	7 images
60	5 images
90	3 images
120	2 images
180	1 image

Table 4.1

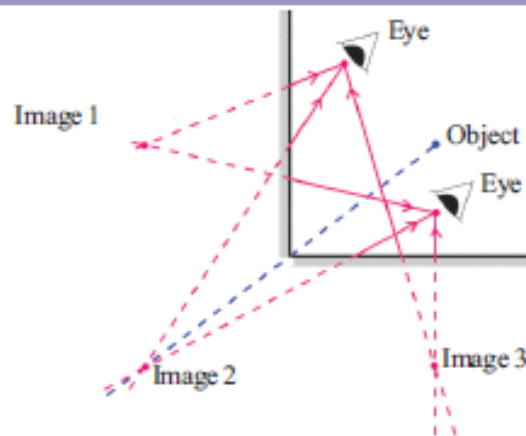


Fig. 4.4

When an object is placed in between two mirrors at an angle of θ the number of images (n) formed is given by

$$\text{Number of images } n = \frac{360}{\theta} - 1$$

e.g if angle between the mirror is 90° , number of images $n = \frac{360}{90} - 1 = 4 - 1 = 3$ (as shown in the figure)

NOTE: if n is any fraction then round the number into next digit

example if angle between the mirror is 50° then

$$n = \frac{360}{50} - 1 = 7.2 - 1 = 6.2 \text{ so the total number of images formed is taken as 7 not as 6}$$

Field of View of Mirrors

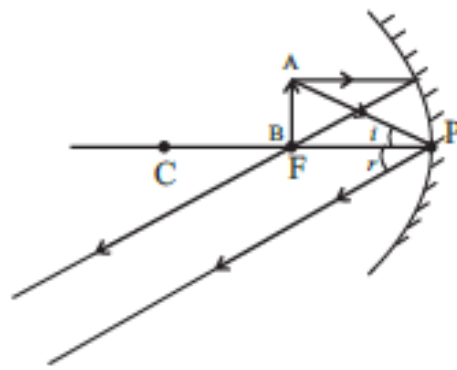
The field of view of a mirror is the maximum range of the vision through the mirror

Note: convex mirror has maximum field of view, concave mirror has the least field of view that is why convex mirror is used as a rear-view mirror in vehicles.

IMAGE FORMATION BY A SPHERICAL MIRROR

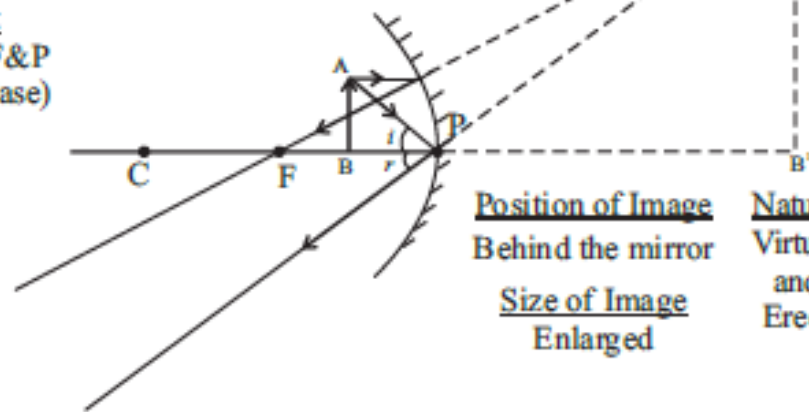
1. <u>Object</u> At infinity		<u>Position of Image</u> At focus	<u>Nature</u> Real and Inverted
		<u>Size of Image</u> Highly diminished (point size)	
2. <u>Object</u> Beyond C		<u>Position of Image</u> Between F&C	<u>Nature</u> Real and Inverted
		<u>Size of Image</u> Small	
3. <u>Object</u> At C		<u>Position of Image</u> At C	<u>Nature</u> Real and Inverted
		<u>Size of Image</u> Same Size of object	
4. <u>Object</u> Between C&F		$i = r$ <u>Position of Image</u> Beyond C	<u>Nature</u> Real and Inverted
		<u>Size of Image</u> Enlarged	

5. Object
At F



$i = r$
Position of Image
At (infinity)
Size of Image
Highly enlarged
Nature
Real and Inverted

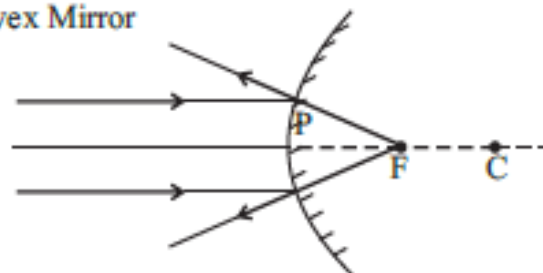
6. Object
Between F & P
(Special Case)



Position of Image
Behind the mirror
Size of Image
Enlarged
Nature
Virtual and Erect

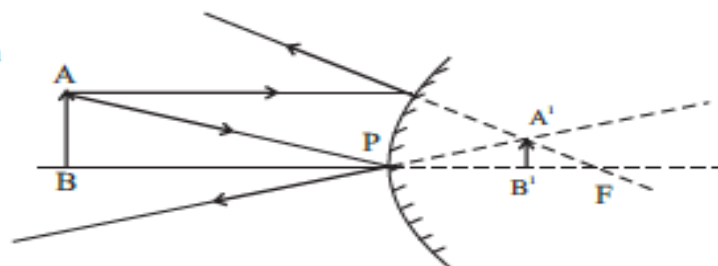
Image formation by Convex Mirror

1. Object
At infinity



Position of Image
At focus
Size of Image
Highly diminished
Nature
Virtual & erect

1. Object
Anywhere between
infinity and pole
of the mirror



Position of Image
Between P & F
Size of Image
Very small
Nature
Virtual & erect

USES OF CONCAVE MIRRORS

1. Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
2. Concave mirrors are used as shaving mirrors to see a larger image of the face.
3. The dentists use concave mirrors to see large images of the teeth of patients.
4. Concave mirrors are used as doctor's head mirrors to focus light coming from a lamp on to the body parts of a patient to be examined by the doctor.
5. Concave dishes are used in TV dish antennas to receive TV signals from the distant communications satellite.
6. Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

USES OF CONVEX MIRRORS

Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles. These mirrors are fitted on the sides of the vehicle, enabling the driver to see traffic behind him/her to facilitate safe driving. Convex mirrors are preferred because they always give an erect, though diminished, image. Also, they have a wider field of view as they are curved outwards. Thus, convex mirrors enable the driver to view much larger area than would be possible with a plane mirror.

Note: only concave mirror can produce real image i.e, the image can be produced in a screen. Both convex and plane mirror will produce virtual and erect images.

MIRROR EQUATION

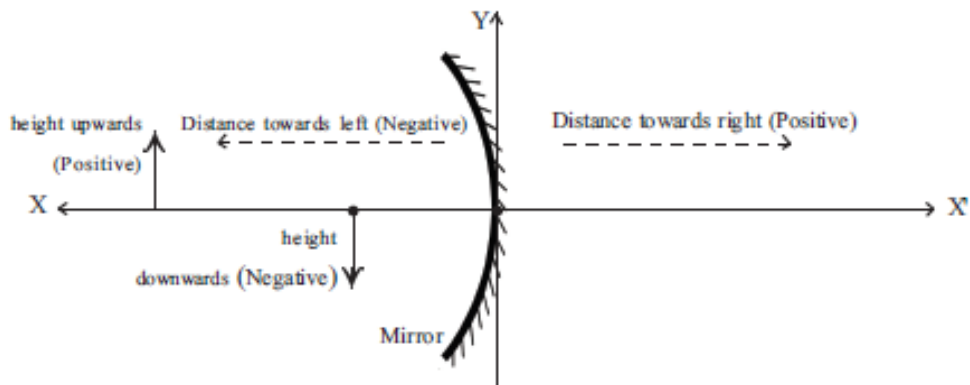
$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, f – focal length, v – distance to image from pole, u – distance to object from pole.

- For convex mirror f is +ve
- For concave mirror f is -ve
- Plane mirror have no focal length

$$v = \frac{uf}{u-f}$$

$$u = \frac{vf}{v-f}$$

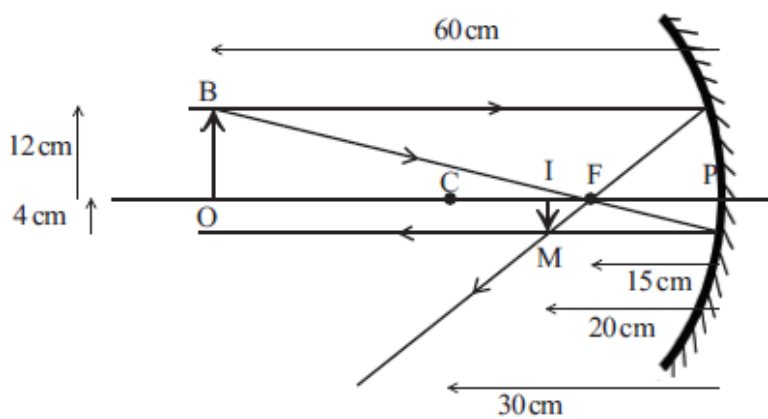
New Cartesian Sign Convention



In all experiments related to lenses and mirrors the distances are measured in the same way as in graphs.

- Distances are measured considering the Pole of the mirror as the origin (O).
- Those measured to the right from O are positive and those in the opposite direction are negative.
- Distances measured upwards from X axis are positive and those downwards are negative. The incident ray is to be considered as travelling from left to right.

Example



Focal length = -15 cm

Distance of object, $u = -60\text{cm}$

Distance of image, $v = -20\text{ cm}$

Radius of curvature, $R = 2f = -30\text{ cm}$

Height of object, $h_o = +12\text{cm}$

Height of image, $h_i = -4\text{ cm}$

Magnification of Image Formation by Mirror

$$\text{Magnification, } m = \frac{\text{height of image}}{\text{height of object}} = \frac{h_i}{h_o} = -\left(\frac{v}{u}\right)$$

Note:

- When magnification is 1 the size of the image and size of the objects are equal
- When magnification is more than 1 size of image is greater than size of object
- When magnification is less than 1 size of image is smaller than size of object
- When magnification is +ve, image is virtual and erect
- When magnification is -ve, image is real and inverted
- When magnification is -1, concave mirror is used, position of object is at C

Practice Questions

1. A dental doctor uses a mirror of focal length 8 cm. To see the teeth clearly what should be the maximum distance between the teeth and the mirror? Justify your answer. Which type of mirror has been used by the doctor?
2. Imagine that a spherical mirror gives an image magnified 5 times at a distance 5 m. If so determine whether the mirror is concave or convex. How much will be the focal length of the mirror?
3. A motor cyclist observes a car coming from behind with a magnification $1/6$. If the actual distance between the car and the bike is 30 m calculate the radius of curvature of the mirror.
4. A shaving mirror of focal length 72 cm is kept in a beauty clinic. A man uses it standing 18 cm away from the mirror. At what distance will the image be formed? Is the image real or virtual? What is the magnification of the image?
5. Wrap a rubber ball of diameter 12 cm completely with an aluminium foil and make the surfaces smooth. Where will be the image of an object kept 12 cm away from the centre of the ball? Is the image real or virtual?
6. We are able to read a book since light falling on a surface gets reflected from the book and reaches the eye. But on such occasions we cannot see our images like that from a mirror. Explain why?
7. Is the image formed by a plane mirror real or virtual? Write an instance when such a mirror gives an inverted image.

Additional Practice Questions

1. Find the focal length of a convex mirror of radius of curvature 1m.
2. Focal length of a convex mirror is 50 cm. What is its radius of curvature?
3. Radius of curvature of a concave mirror is 25 cm. What is its focal length?
4. A concave mirror produces 10 cm long image of an object of height of 2cm. What is the magnification produced?
5. An object 1 cm high is held near a concave mirror of magnification 10. How tall will be the image?
6. An object 4 cm in size is placed at a distance of 25 cm from a concave mirror of focal length 15 cm. Find the position, nature and height of the image.
7. A converging mirror forms a real image of height 4 cm, of an object of height 1 cm placed 20 cm away from the mirror. Calculate the image distance. What is the focal length of the mirror?
8. A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror.
9. An arrow 2.5 cm high is placed at a distance of 25 cm from a diverging mirror of focal length 20 cm., Find the nature, position and size of the image formed.
10. The image formed by a convex mirror of focal length 20cm is a quarter of the object. What is the distance of the object from the mirror?
11. Which of the following figure is correct

