Light : Reflection and Refraction

Reflection of Light : Regular and Irregular Reflection of Light

a phenomenon of returning the light from the surface of an object, when the light incident on it, is a reflection of light.

The reflection of light takes place in two ways : (i) Regular reflection (ii) Irregular reflection

(i) Regular reflection :

When a parallel beam of light is incident on shining plane or smooth surface, a beam remains parallel after reflection in a specific direction. Such reflection of light is called **regular reflection**. The reflection of light by a mirror is an example of regular reflection (Figure 2.2).

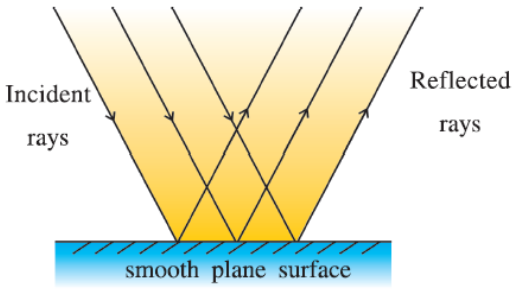


Fig. 2.2 Regular reflection of light

(ii) Irregular reflection : When a parallel beam of light is incident on rough or irregular surface, the beam does not remain parallel but spreads over wide region after reflection. Such a reflection of light is known as an **irregular reflection** (Figure 2.3).The object around us such as book, chair, table etc. can be seen as a result of irreguler reflection of light.

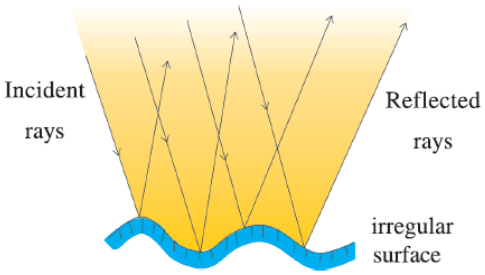
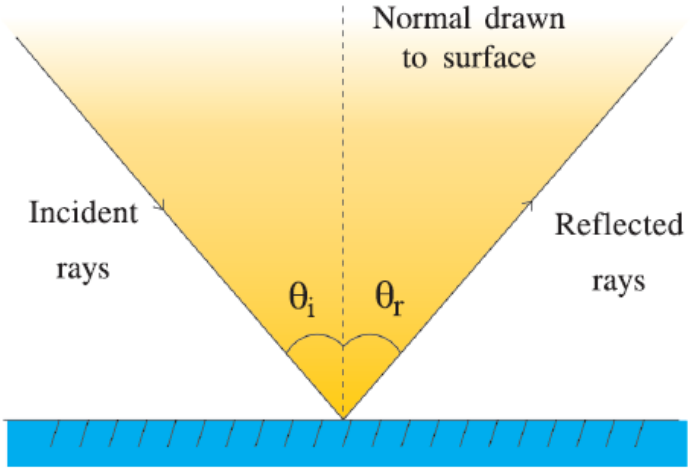


Fig. 2.3 Irregular reflection of light

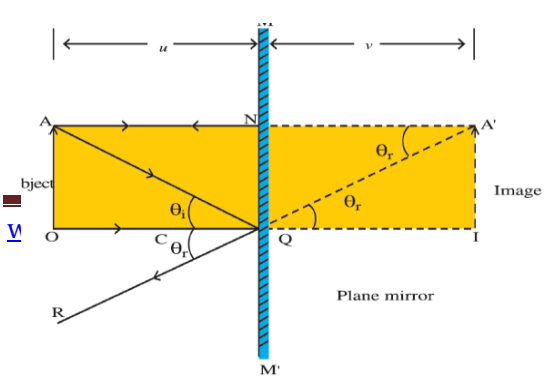


Angle of incidence (θ_i) :

The angle made by an incident ray with the normal drawn at the point of incidence is known as angle of incidence (θ_i).

Angle of reflection (θ_r) :

The angle made by reflected ray with the normal drawn at point of incidence is known as angle of reflection (θ_r).



(1) The angle of incidence is equal to angle of reflection i.e.

(2) The incident ray, the normal to the mirror at the point of in all lie in the same plane.

(1) A plane mirror forms virtual and erect image A'I at a distance v from it.

(2) The image A'I is formed at the same distance

behind the mirror as that of an object AO kept in front of mirror.

(3) The size (height) of an image is same as the object but is laterally inverted.

Reflection by Spherical Mirror

The spherical mirrors are formed by cutting the circular cross section of spherical shell whose inner or outer curved surface are reflecting.

A spherical mirror having inner curved reflecting surface is known as concave mirror.

A spherical mirror having outer curved reflecting surface is known as convex mirror.

Radius of curvature (R) and centre of curvature of mirror (C) : The radius of a spherical shell from which the mirror is made, called radius of curvature (R) of mirror and the centre of this spherical shell is called centre of curvature (C) of mirror.

Pole : A centre of reflecting surface of a spherical mirror is called pole (P) of the mirror.

Principal axis : An imaginary line passing through pole (P) and centre of curvature (C) of mirror is called principal axis of mirror.

Aperture : The diameter of the reflecting suface of the mirror is known as aperture of the mirror.

Principal focus : The point on the principal axis where the parallel rays meet after the reflection from concave mirror or appear to meet after reflection from convex mirror, is called principal focus (F) of the mirror.

Focal length : The distance between pole (P) and principal focus (F) of mirror is called focal length *(f)*.

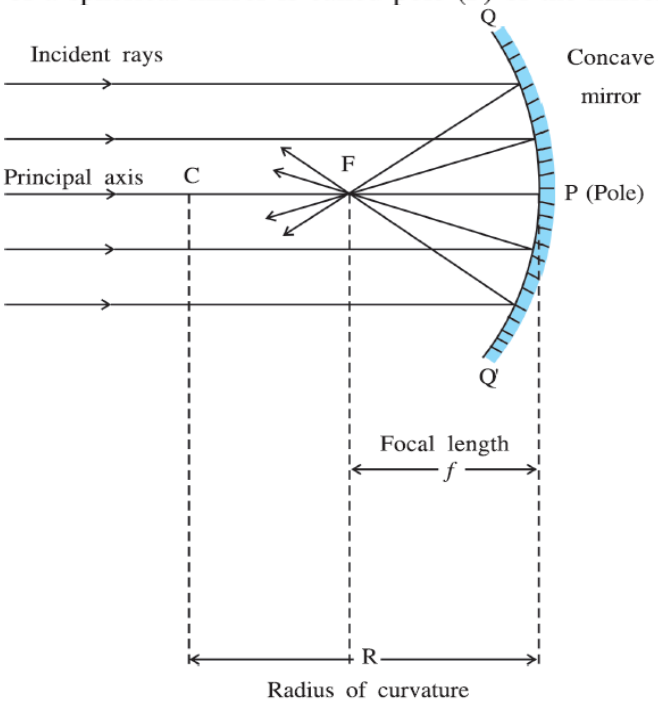


Image Formation by Concave Mirror

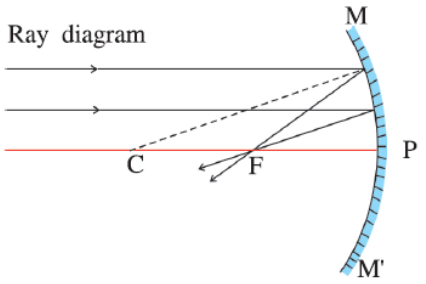
(1) **Position of an object :** At infinity

Position of image : At focus (F)

Nature : Real and inverted

Size : Highly diminished (Pointlike)

Ray diagram



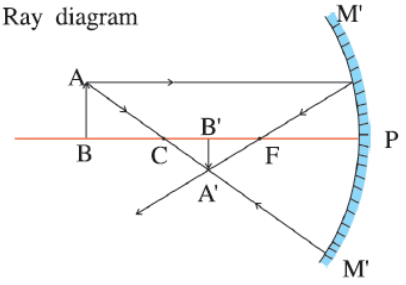
(2) **Position of an object :** Beyond centre of curvature (C)

Position of image : Between centre of curvature (C) and focus (F)

Nature : Real and inverted

Size : Diminished

Ray diagram



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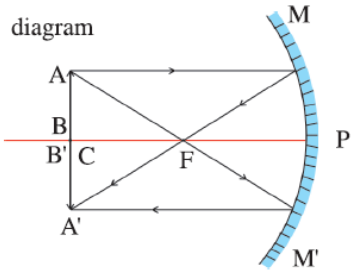
(3) **Position of an object :** At centre of curvature (C)

Position of image : At centre of curvature (C)

Nature : Real and inverted

Size : Same as object

Ray diagram



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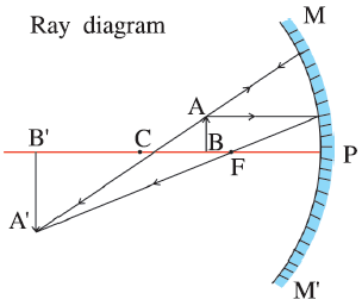
(4) **Position of an object :** Between centre of curvature (C) and principal focus (F)

Position of image : Beyond the centre of curvature (C)

Nature : Real and inverted

Size : Magnified (enlarged)

Ray diagram



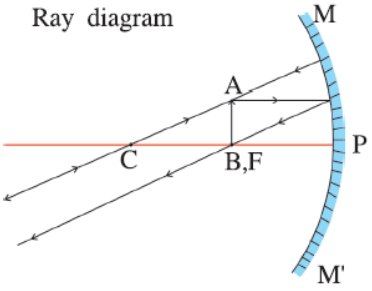
(5) **Position of an object :** At principal focus (F)

Position of image : At infinity

Nature : Real and inverted

Size : Highly magnified

Ray diagram



(6) **Position of an object :** Between pole (P) and principal focus (F)

Position of image : Beyond the mirror

Nature : Virtual and erect

Size : Magnified (enlarged)

Ray diagram

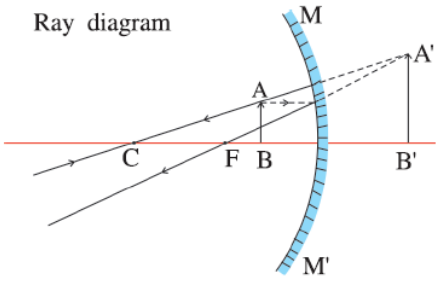


Image Formation by Convex Mirror

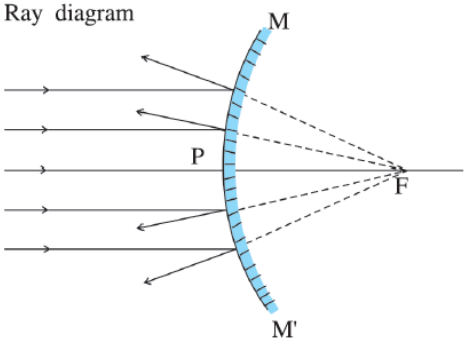
(1) **Position of an object :** At infinity

Position of image : At focus (F) behind mirror

Nature : Virtual and erect

Size : Highly diminished (point like)

Ray diagram



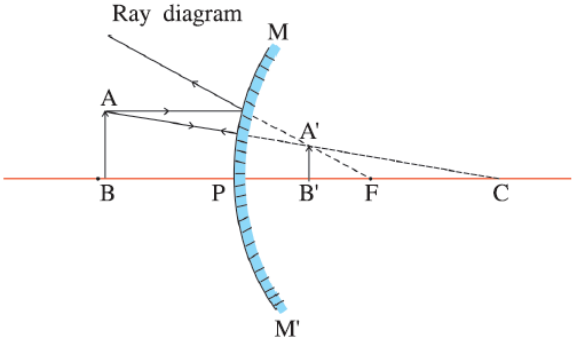
(2) **Position of an object :** Between pole (P) and infinity

Position of an image : Between pole (P) and focus (F) behind mirror

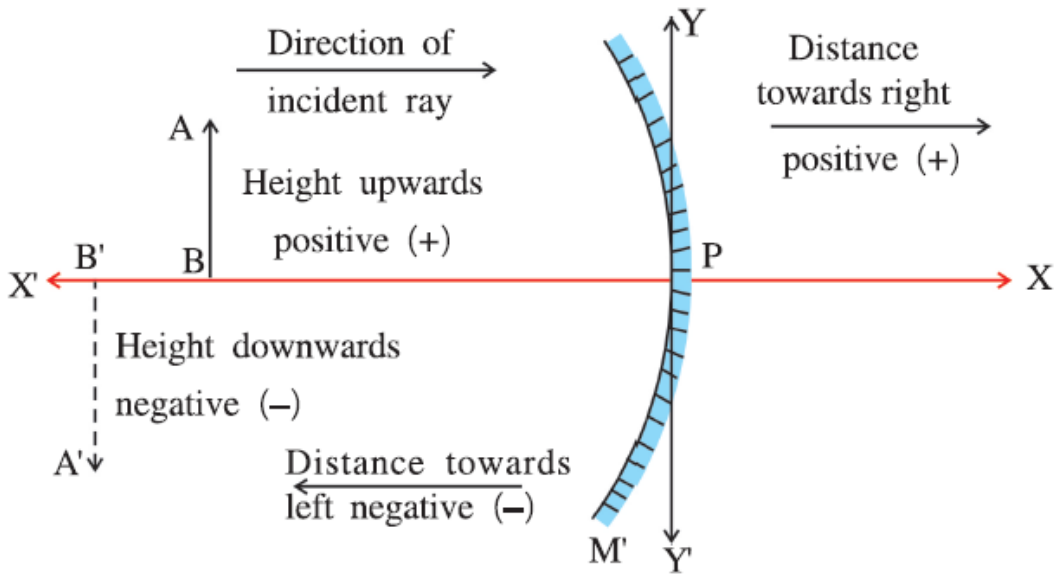
Nature : Virtual and erect

Size : Diminished

Ray diagram



Cartesian Sign Convention for Reflection by Spherical Mirror



$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$$

This equation is known as **mirror formula.**

Magnification of an image

The ratio of height of image to the height of an object is known as magnification of an image which is denoted as m.

$$m=\frac{\text{Image height}}{\text{Object height}}=\frac{h'}{h}$$

$$\therefore \text{ Magnification } \therefore m=\frac{-h'}{h}$$

Note that the object height (h) is always positive.

The image height (h') will be positive in case of erect image, hence its magnification will be positive.

The positive value of magnification represents virtual image of an object.

The image height (h') will be negative in case of an inverted image, hence its magnification will be negative.

The negative value of magnification represents real image of an object.

Now consider the case of a plane mirror.

In this case, Image height (h') = object height (h)

$\therefore m = +1$

Therefore, the image formed by a plane mirror is virtual, erect and of the same size as the object.

magnification $m=-\frac{v}{u}$

$$+1=-\frac{v}{u}$$

$$\therefore v=-u$$

This shows that the image formed by a plane mirror is at the same distance as the object but behind the mirror.

An object of 4 cm height is placed at a distance of 18 cm from concave mirror having focal length 12 cm. Find the position, nature and height of the image.

Solution : Object height $h = 4$ cm

Object distance $u = -18$ cm

Focal length $f = -12$ cm

From mirror formula, $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

$$\therefore \frac{1}{v}=-\frac{1}{12}+\frac{1}{18} \quad \therefore v=-36 \text{ cm}$$

Magnification $m=-\frac{v}{u}=+\frac{36}{-18}=-2$ $\quad \therefore$ From $m=\frac{h'}{h}$

$$h' = m \times h = -2 \times 4 = -8 \text{ cm}$$

This forms real, inverted and enlarged image of an object beyond the centre of curvature (C) at 36 cm from the pole.

A convex mirror is fitted on an automobile with focal length of 3 m. If a vehicle's behind is at a distance of 5 m, determine the position and nature of an image.

Solution : Object distance $u = -5$ m

Focal length $f = 3$ m

From mirror formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\therefore \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{3} + \frac{1}{5}$

$v = \frac{15}{8} = 1.875$ m

Here, v is positive and $v < u$ $\therefore$ $m < 1$.

Therefore, virtual, erect and diminished image behind the convex mirror is obtained at a distance 1.875 m from the mirror.

Solve the following problems :

(1) An object of height 5 cm is placed at a distance of 10 cm from convex mirror of focal length 15 cm. Find the position, nature and size of an image.

(**Ans :** Virtual, erect and diminished image at a distance 6 cm behind the mirror. Height of image = 3 cm)

(2) An object of height 6 cm is placed at a distance of 15 cm from a concave mirror of focal length 10 cm. Find position, nature and height of an image.

(**Ans :** $v = -30$ cm, height = 12 cm, Real, inverted and magnified)