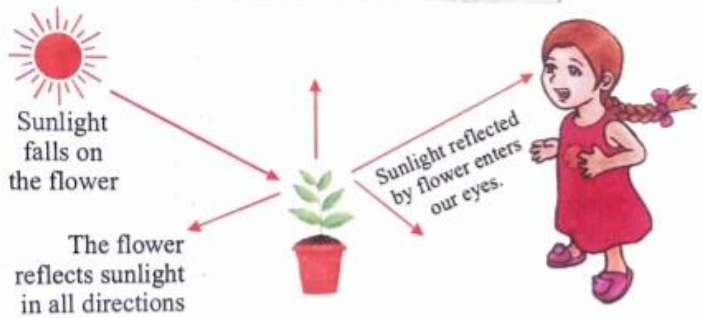
4·2. REFLECTION OF LIGHT

When the rays of light travelling in a homogeneous medium strikes a shining surface, some part of it returns back to the same medium. The rest part of the light energy is either absorbed or transformed into heat or transmitted, if the object is transparent. This phenomenon is called reflection.



(a) We can see the flower during day time because it reflects sunlight falling on it into our eyes.

(b) We can see the chair at night because it reflects bulb light falling on it into our eyes.

Fig. 4·1.

Thus phenomenon in which light comes back (or rebounce back) after getting impact from an opaque surface is known as reflection of light. The mirrors are the glass surfaces polished opaque on one side, hence the other side behaves like a mirror. When light is incident on a mirror it reflects as shown in fig. 4·2.

Let us define some terms before discussing the laws of reflection. In fig. 4·2 a ray of light AO making some angle with the surface of plane mirror (or reflecting surface) falls on the mirror at point O.

The ray AO is known as incident ray. After reflection the ray of light goes along OR. The ray OR is known as reflected ray.

(i) Normal : A perpendicular drawn to the reflecting surface at point 'O' (*i.e.*, point of incidence) is known as the normal to the reflecting surface.

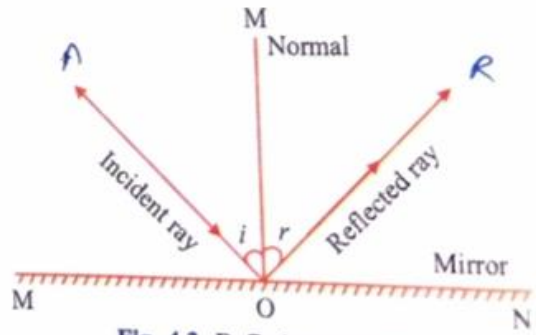


Fig. 4·2. Refletion of light.

2

(ii) Incident Ray : A ray of light falling on reflecting surface is known as incident ray of light.

(iii) Reflected Ray : A ray of light which is reflected back by a reflecting surface is known as reflected ray of light.

(iv) Angle of Incidence : The angle between incident ray and normal at the point of incidence is called angle of incidence it is denoted by 'i'.

(v) Angle of Reflection : The angle between refracted ray and normal at the point of incidence is called angle of reflection. It is denoted by 'r'.

DO YOU KNOW ?

What is reflectance?

The ratio of the amount of light reflected from a surface to the amount of light falling on the surface is called reflectance, i.e.,

$$\text{Reflectance} = \frac{\text{Amount of light reflected from the surface}}{\text{Amount light incident on the surface}}$$

For a surface made of silver the reflectance = 95%
For a surface made of coal the reflectance = 4%.

4-3. LAWS OF REFLECTION

Each light ray while reflected from a mirror surface obeys the two laws these are known as laws of reflection :

(i) Angle of incidence is always equal to the angle of reflection, *i.e.*,

$$i = r$$

where 'i' is angle of incidence and 'r' is angle of reflection.

(ii) Incident ray, reflected ray and normal to the reflecting surface at the point of incidence lie in the same plane.

Explanation : (i) In fig. 4-3 ABCD is mirror surface (or reflecting surface). A light ray AO is incident on it at point O.

OR is reflected ray. The angle between incident ray AO and normal at surface at point O, *i.e.*, OM is $\angle AOM = i$ (angle of incidence). The angle between OM and reflected ray OR is $\angle MOR = r$ (*i.e.*, angle of reflection) by the first law of reflection

$\angle AOM = \angle MOR$ or $i = r$.

(ii) In fig. 4-3 a plane PQRS is taken which is perpendicular to the plane of mirror. The plane PQRS contains the incident ray AO, normal OM and reflected ray OR. Obviously all the three, incident ray, normal and reflected are lying on same plane PQRS which is perpendicular to mirror surface.

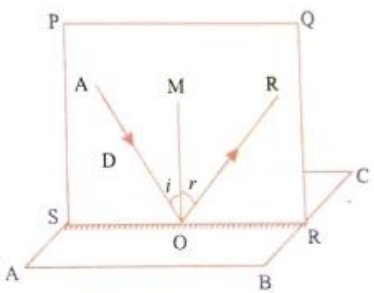


Fig. 4-3. Graphical explanation laws of reflection.

3 In regular reflection if the incident rays are parallel then the reflected rays will also be parallel [Fig. 4·4 (a)].

(ii) Irregular or Diffused Reflection : When the light rays are incident on a rough irregular surface then the light rays are reflected in different direction and diffused. The reason for diffused reflection is that the surface of the objects are uneven. In other words, we can say that they are not optically plane. The phenomenon is called diffused reflection or scattering.

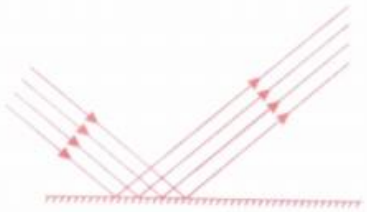


Fig. 4-4 (a). Regular reflection.

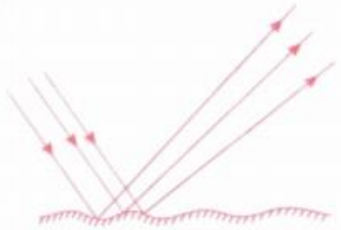


Fig. 4-4 (b). Irregular or diffused reflection.

If the incident rays are parallel then the reflected rays will not be parallel [Fig. 4·4 (b)]. Of course each reflection obeys the laws of reflection.

Uses of Diffused Relection : (i) The rays coming from the Sun undergo diffused reflection from dust particles suspended in air hence general illumination takes place.

(ii) Most of the objects appear visible because of the diffused reflection from the surface.

(iii) Had there been no diffused reflection, object would have been appeared either extremely bright or dark.

4·4. OBJECTS AND IMAGES

Object : In the 'Optics' the term object has special meaning. Anything which gives out light rays (either its own light or the light reflected by it) is known as an object.

While drawing the ray diagram in optics the point objects are represented by a 'dot' and extended objects are represented by drawing an arrow pointing upwards.

Image : The point where the reflected rays or refracted rays meet or it appears to meet is called the image of a point from where the incident light rays are coming.

Actually infinite number of rays emit from a point object but two rays are taken to form an image and to find the position of image.

Real Image : When the reflected rays or refracted rays actually meet at a point, then real image is formed at that point. In the fig. 4·5 (a) A′ is real image of point *A*. Real image is always inverted and can be obtained on the screen.

Virtual Image : When the reflected rays or refracted rays apear to be coming from a point, but actually the rays do not intersect at that point, then virtual image is formed. In the fig. 4·5 (b), I is the virtual image of object 'O'. Virtual images are always erect and cannot be obtained on the screen.

Real image

Virtual image

4

DIFFERENCE BETWEEN REAL AND VIRTUAL IMAGE

REAL IMAGE	VIRTUAL IMAGE
1. Real image are formed due to intersection of refrected or reflected light rays.	1. The light rays appear that they are coming from the image.
2. Real images are inverted.	2. Virtual images are erect
3. These images can be obtained on the screen.	3. These images cannot be obtained on the screen.

Characteristics of Images Formed by Plane Mirror

The following characteristics of the image formed by plane mirror should be remembered :

(i) The image formed by plane mirror is always virtual and equal in size of the object.

(ii) The image lies behind the mirror at a distance equal to the object from the mirror.

(iii) The image formed by a plane mirror at a distance equal to that of object from the mirror.

(iv) The image formed by a plane mirror is laterally inverted, *i.e.*, left hand is seen right hand of the image. Some letters as A, H, I, M, O, T, U, V, W, X and Y do not show lateral inversion.

(v) To see the full image in a mirror, the size of the mirror should be at least half of the length of the object.

(vi) If a man is standing at the centre of room and wants to see the full image of back wall in mirror fixed on front wall then the least size of mirror should be 1/3 of the size of wall.

(vii) Number of images formed by two plane mirrors inclined at an angle θ, then :

(a) $n = \frac{360^\circ}{\theta} - 1$, If $\frac{360^\circ}{\theta}$ is even.

(b) If $\frac{360^\circ}{\theta}$ is odd then there will be two possibilities :

(i) $n = \frac{360^\circ}{\theta} - 1$, if object is placed symmetrically with respect to mirror, *i.e.*,

object is placed on the bisector of $\angle\theta$.

(ii) $n = \frac{360^\circ}{\theta}$, if object is not on the bisector of angle θ.

(c) When the two mirrors are parallel, then infinite images will be formed *i.e.*, $n = \frac{360^\circ}{\theta} = \frac{360^\circ}{0^\circ} = \infty$

(viii) So many images are formed by a thick mirror, in which second image has the maximum intensity.

Uses of Plane Mirror

(i) Plane mirrors are used in dressing table and in bathrooms.

(ii) Plane mirrors are fitted at blind turns of some busy roads so that drivers can see the vehicle coming from other sides.

(iii) Plane mirros are used in periscopes.

4·5. SPHERICAL MIRRORS

When a part of hollow sphere of gas is cut and is polished on it outer surface (bulging surface) or inner surface then the light rays are reflected from the other surface which is not polished. This is called **spherical mirror.**

There are two types of spherical mirrors :

(i) Concave mirror, (ii) Convex mirror.

(i) Concave Mirror : Concave mirror is the part of a hollow sphere whose outer surface (*i.e.*, bulging surface) is silvered and the inner surface (*i.e.*, depressed surface) acts as mirror surface (or reflecting surface) as shown in fig. 4·7 (a).

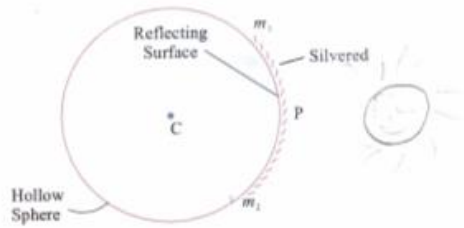


Fig. 4·7 (a). Concave mirror.

(ii) Convex Mirror : Convex mirror is the part of a hollow sphere whose inner surface (*i.e.*, depressed surface) is silvered and the outer surface (*i.e.*, bulging surface) acts as mirror surface (or reflecting surface) as shown in fig. 4·7 (b).

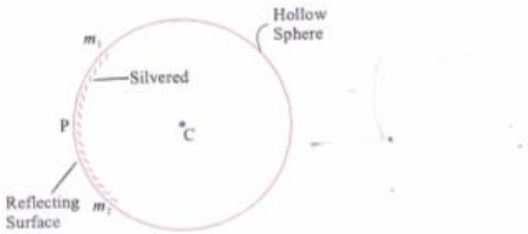


Fig. 4·7 (b). Convex mirror.

SOME DEFINITIONS RELATED TO SPHERICAL MIRRORS

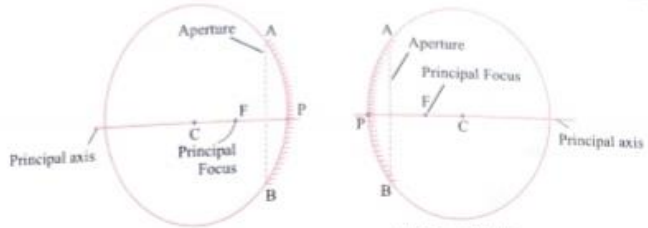
1. Pole : The central point of spherical mirror is called pole. It is denoted by P. [fig. 4·8]

2. Centre of Curvature : Centre of curvature is the centre of the sphere of which the mirror forms a part. It is denoted by 'C'.

3. Radius of Curvature : The radius of the sphere, by which the mirror forms a part is called radius of curvature. It is equal to the distance between pole and focus. It is denoted by 'R'.

4. Principal Axis : The line joining the centre of curvature and pole is called principal axis. In fig. 4·8, PC is principal axis.

5. Aperture : The part of the spherical mirror exposed to the incident light is called the aperture of spherical mirror. In other words the diameter of the circular rim of the mirror is called aperture. In fig. 4-8, the chord AB shows the aperture.

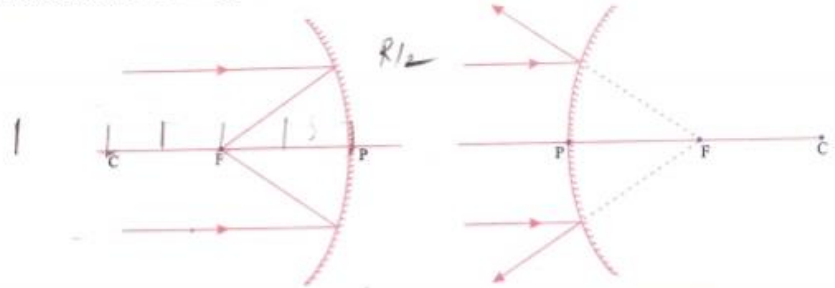


(a) Concave Mirror (b) Convex Mirror

Fig. 4-8.

6. Principal Focus : It is a point on the principal axis where the rays of light parallel to principal axis after reflection from mirror, either converges at that point or appear to diverge from that point. It is denoted by F.

In case of concave mirror, the rays of light which are incident parallel to the principal axis, after reflection actually meet at F [fig. 4-9 (a)] but in case of convex mirror, the rays of light incident parallel principal axis, after reflection from the mirror do not meet at *F*, but appear to come from it, when produced backward. [fig. 4-9 (b)]



(a) For Concave Mirror (b) For Convex Mirror

Fig. 4-9.

7. Focal Length : Distance between the principal focus and pole is called focal length of mirror. It is denoted by *f*.

8. Focal Plane : A plane normal to the principal axis and passing through the principal focus (*F*) of spherical mirror is called focal plane of that spherical mirror.

Convergence of Light : When a parallel beam of light after reflection meets at a point, this is known as convergence of light. The beam reflected is called convergent beam of light. Concave mirror is a convergent mirror.

Divergence of Light: When a parallel beam of light after reflection divergent *i.e.* speard out and appears to came from a point, this is called divergence of light. The beam reflection is called divergent beam of light. Convex mirror is a divergent mirror.

NOTE

1. Concave mirror converges a parallel beam of light falling on it, so concave mirror is also known as convergent mirror.
2. Convex mirror diverges a parallel beam of light falling on it, therefore it is known as divergent mirror.