LIGHT REFLECTION AND REFRACTION ON CURVED SURFACES

REFLECTION:

A highly polished surface, such as a mirror, reflects most of the light falling on it. The phenomenon of bouncing back of light from a surface is known as the reflection of light. An object reflects light that falls on it. This reflected light, when received by our eyes, enables us to see things. We are able to see through a transparent medium as light is transmitted through it.

The laws of reflection of light-

(i)The angle of incidence is equal to the angle of reflection,

(ii)The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane. These laws of reflection are applicable to all types of reflecting surfaces including spherical surfaces.

SPHERICAL MIRRORS

The reflecting surface of a spherical mirror may be curved inwards or outwards. For spherical mirrors of small apertures, the radius of curvature is found to be equal to twice the focal length i.e. **R = 2f**. This implies that the principal focus of a spherical mirror lies midway between the pole and centre of curvature.

1.Concave mirror

A spherical mirror, whose reflecting surface is curved inwards, that is, faces towards the centre of the sphere, is called a concave mirror.

Image formation by a concave mirror

Position of the object	Position of the image	Size of the image
At infinity	At the focus F	Highly dimini point-sized
Beyond C	Between F and C	Diminished
At C	At C	Same size

Uses of concave mirrors

- Used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
- As shaving mirrors to see a larger image of the face.
- The dentists use concave mirrors to see large images of the teeth of patients.
- Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

2.Convex mirror

A spherical mirror whose reflecting surface is curved outwards, is called a convex mirror.

Imageformationbyaconvexmirror

Position of the object	Position of the image	Size of the image
At infinity	At the focus F, behind the mirror	Highly diminishe point-sized
Between infinity	Between P and F	Diminished

Uses of a convex mirror

- 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. It enables the driver to view much larger area than would be possible with a plane mirror.
- In big showrooms and departmental stores, convex mirrors are used to have a view on the customers entering in as well as going out.
-

- **Importantterms-**

  Ray of Light : A line drawn in the direction of propagation of light is called a ray of light.
- **Beam of Light :** A group of rays of light emitted by a source of light is called a beam of light. A light beam is of three types.
- **Real Image :** It is a kind of image which is formed by actual intersection of light rays after reflection.

Virtual Image : It is a kind of image which is formed by producing the reflected rays backward after reflection **Pole:** The centre of the reflecting surface of a spherical mirror is a point called the pole. It lies on the surface of the mirror.

Centre of curvature: The reflecting surface of a spherical mirror forms a part of a sphere. This sphere has a centre. This point is called the centre of curvature of the spherical mirror.

Radius of curvature: The radius of the sphere of which the reflecting surface of a spherical mirror forms a part, is called the radius of curvature of the mirror.

Principal axis: A straight line passes through the pole and the centre of curvature of a spherical mirror. This line is called the principal axis.

Principal Focus: When rays from infinity come in parallel to the optical axis of a spherical mirror, they are bent so that they either converge and intersect in at a point, or they seem to diverge from a point. The point of convergence or divergence is called the focus. It is denoted by letter F.

Focal length: The distance between the pole and the principal focus of a spherical mirror is called the focal length. It is represented by the letter f.

Aperture: The diameter of the reflecting surface of spherical mirror is called its aperture.

Magnification: Magnification produced by a spherical mirror gives the relative extent to which the image of an object is magnified with respect to the object size.

If h is the height of the object and h′ is the height of the image, then the magnification m produced by a spherical mirror is given by:

$$m = \frac{\text{Height of the im}}{\text{Height of the ob}}$$

The magnification m is also related to the object distance (u) and image distance (v):

$$\text{Magnification } (m) =$$

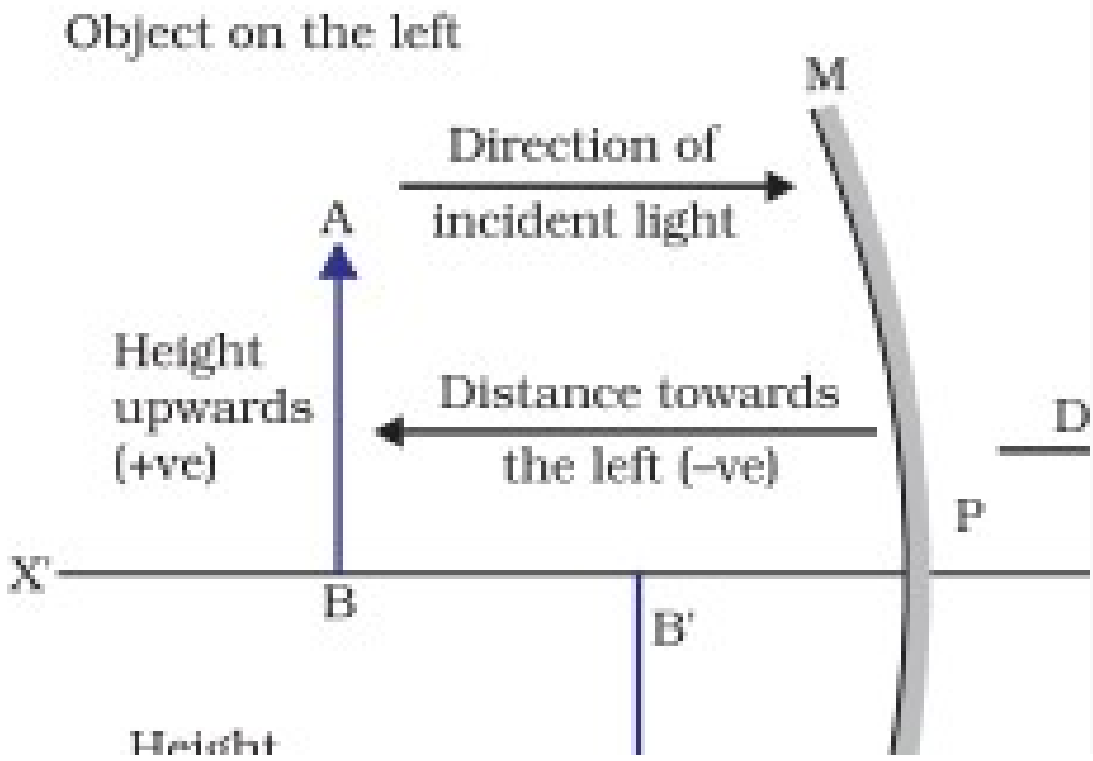
MIRROR FORMULA

In a spherical mirror, the distance of the object from its pole is called **the object distance (u)**. The distance of the image from the pole of the mirror is called **the image distance (v).** The distance of the principal focus from the pole is called **the focal length (f).** There is a relationship between these three quantities given by the mirror formula which is expressed as-

$$\frac{1}{\quad} - \frac{1}{\quad} =$$

Sign Convention for Reflection by Spherical Mirrors

While dealing with the reflection of light by spherical mirrors, we shall follow a set of sign conventions called the **New Cartesian Sign Convention.** In this convention, the pole (P) of the mirror is taken as the origin. The principal axis of the mirror is taken as the x-axis (X'X) of the coordinate system. The conventions are as follows –



(i)The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left-hand side.
(ii) All distances parallel to the principal axis are measured from the pole of the mirror.
(iii)All the distances measured to the right of the origin (along + x-axis) are taken as positive while those measured to the left of the origin (along – x-axis) are taken as negative.
(iv)Distances measured perpendicular to and above the principal axis (along + y-axis) are taken as positive.
(v)Distances measured perpendicular to and below the principal axis (along –y-axis) are taken as negative.

REFRACTION

1. Refraction of Light at Curved Surface:

(i) The centre of the sphere, of which curved surface is a part, is called as the centre of curvature. It is denoted by letter 'C"C'.
(ii) The centre of the curved surface is called the pole (P)P of the curved surface.

(iii) The line that joins the centre of curvature and the pole is called 'principal axis'.

(iv) Focal length of the lens is the distance from the optic centre to the principal focus. This is denoted by the letter ff.
(v) For refraction through a spherical interface (from medium 11 to 22 of refractive index n1n1and n2n2 respectively) n2v−n1u=n2−n1Rn2v-n1u=n2-n1R
(vi) Thin lens formula: 1v−1u=1f1v-1u=1f
(vii) Lens maker's formula: 1f=(n−1)(1R1−1R2)1f=n-11R1-1R2 where R1R1 and R2R2 are the radii of curvature, nn is the refractive index, ff is positive for a converging lens; ff is negative for a diverging lens.

2. Behaviour of light rays incident on a lens:

(i) When a ray of light passes through the optic centre of a thin lens, it does not undergo deviation.

(ii) A ray of light falling parallel to the principal axis of a convex lens passes through the principal focus after refraction.

(iii) A ray incident parallel to the principal axis of a concave lens appears to diverge from the focus on the same side of the lens.

(iv) A ray of light passing through the principal focus of a convex lens passes parallel to the principal axis after refraction.

(v) In the case of a convex lens, magnification of the virtual image is possible only when the object is at the distance less than the focal length of the lens.

Lenses:

• A lens is made up of transparent material.

• Bounded by two surfaces both or one is spherical surface.

• 'A lens is bounded by atleast one curved surface'.

• Lenses are of various types.

Convex Lens:

• It may have two spherical surfaces bulging outside.

• It is called double convex lens or biconvex lens.

• It is thick at the middle and thin at the edges.

Concave lens:

• A double concave lens has two spherical surfaces.

• It is thin at middle and thick at the edges.

• Each curved surface of a lens is a part of a sphere.

Centre of curvature:

• It is the centre of sphere contains lens part.

• It is denoted by C.

• The distance between curved surface and centre of curvature is called “radius of curvature (R)”.

• If the lens contains two curved surfaces, it will have two centres of curvatures namely C1 and C2 .

• The line joining between two centres is called principal axis.

• The mid point of the lens is called optic centre(P).

Image Positions of Convex Lens for various positions of object:

✓ Object at infinity: A point sized image at focal point will be formed.

✓ Object beyond the centre of curvature of Principal axis: Image will be real, inverted and diminished formed on principal axis between the points F1 and 2F1.

✓ Object at the centre of curvature (at 2F2): The image will be on another side at 2F1, and a real, inverted and of same size as the object.

✓ Object between Centre of curvature (2F2) and Focal point(F2): The image will be beyond 2F1 which is real, inverted and magnified.

✓ Object at focal point (F2): Image at infinity.

✓ Object between Focus (F1) and optic centre: Image on the same side.

• Virtual, erect and magnified which can be seen with eyes.

• Cannot be caught on the screen.

• This behaviour of Convex lens is useful to construct a microscope.

For concave lens: The image will be always erect, virtual and diminished in size, irrespective of the position of object.

Lens formula: $1/v - 1/u = 1/f$

For any lens with sign convention.

✓ Focal length of a lens depends upon the surrounding medium.

✓ Focal length of lens increases in water.

Lens maker’s formula: In the air medium, the relative refractive index is the absolute refractive of the lens,

$1/f = (n -1)(1/R1 – 1/R2)$

Where R1 and R2 are radii of curvature, n is the refractive index. This is called lens maker’s formula.

Note: Always use sign convention.

✓ If the refractive index of the medium is less than convex lens, behaves as a convergent lens.

✓ Convex lens behaves as a divergent lens, if the refractive index of the transparent medium is greater than lens.

✓ Air bubble in water behaves as a diverging lens.