29.8 Effect of Rotated Mirror on Angle of Deviation

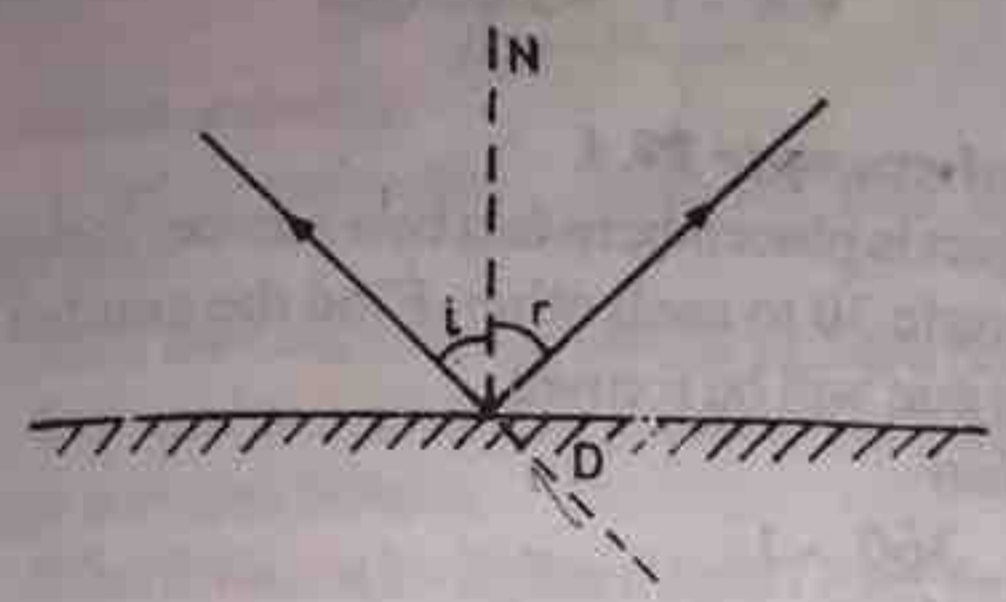

Fig. 29.13(a) Effect of rotating mirror

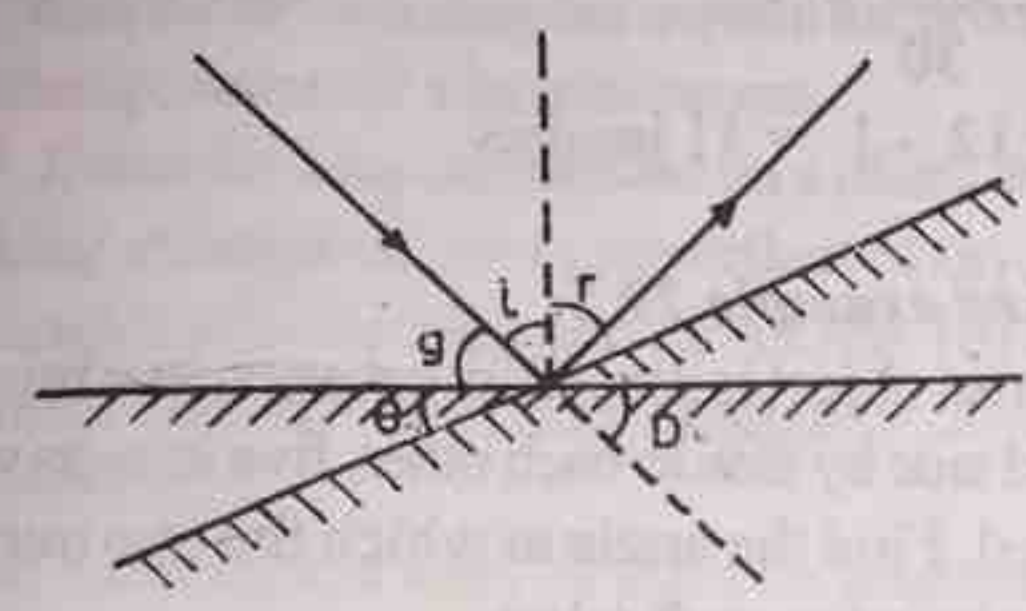

Fig. 29.13(b) Effect of rotating mirror

Suppose the mirror is rotated at angle θ shown, it is observed that the angle of deviation increases under one condition. That is, the incident ray remains the same.

Thus $< d = 2\theta$

29.9 Mirror Galvanometer Deflection

A meter which is very long is placed in front of a rotating mirror. A ray of light is incidented on the mirror normally and reflected back to the source placed some meters backward. When it is switched on, i.e, current flows, the coil rotates through a small angle, θ. Ray of light is incidented on the mirror now that it has rotated. The reflected ray is no more normal, but reflected in another direction to the meter rule; the point is indicated and the distance is obtained by measuring the length from the first reflected ray, to the second reflected ray. The angle is twice the angle of reflection, θ

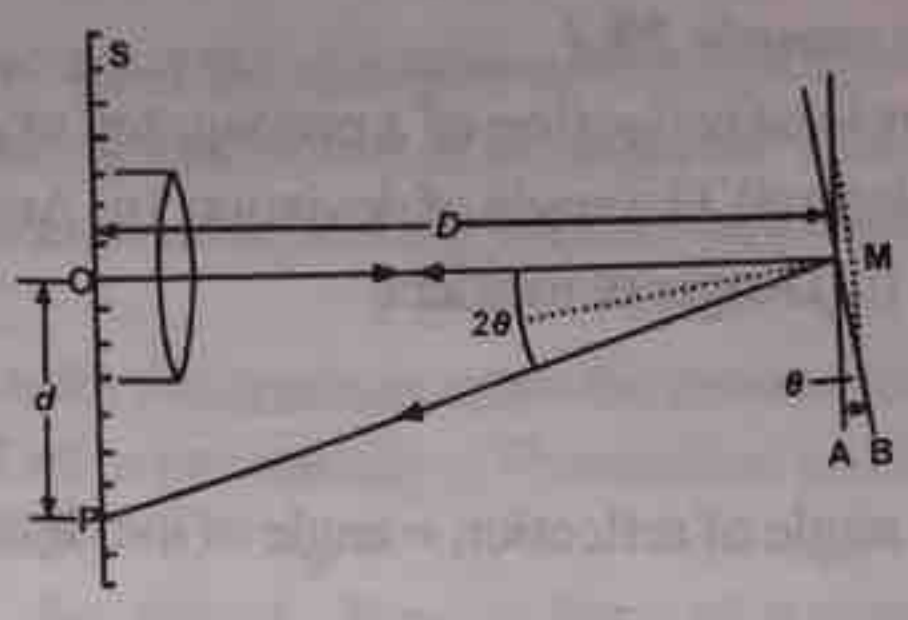

Fig. 29.14 Mirror galvanometer deflection

using trigonometrical analysis,

$$\text{Tan } \theta = \frac{\text{opposite}}{\text{adjacent}}$$

Opposite = y

Adjacent = x

$$\text{tand } 2\theta = \frac{y}{x}$$

$$2\theta = \tan^{-1} \frac{y}{x}$$

29.10 Periscope

Periscope enables one to see over walls and other obstacles. It is also used in tanks to see out above the armour plating. It can be constructed by fixing two parallel plane mirrors inclined at 45° to the line joining them. The principle is based on reflection of rays. The incident ray, oA that strikes the mirror, is placed at 45°. A ray is reflected, turning to the second mirror. The incident ray of the second mirror is reflected into the eye, causing proper vision.

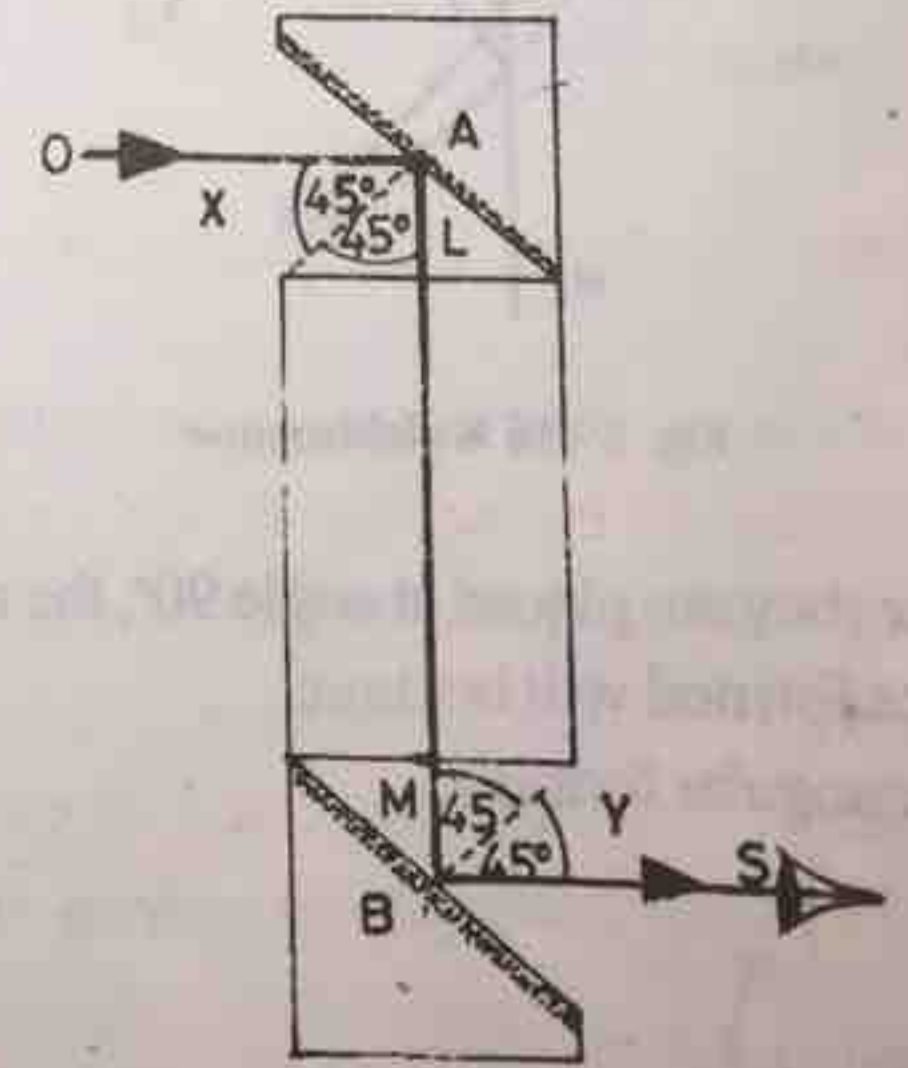

Fig. 29.15 Periscope

Worked example 29.3

If the angle of reflection of a propagated ray is 35°, calculate: (i) The angle of deviation (ii) Angle of glance (iii) Angle of incident.

Solution

Since angle of reflection = angle of incident

$< i = < r$

$< x = < 35$

Angle of incidence $= 35°$

Angle of glance $= (90 - r)$

$= 90° - 35°$

$= 55°$

Angle of deviation $= D = 2g$

$= 2 \times 55°$

$D = 110°$

29.11 Kaleidoscope

Two mirrors placed at angle θ to each other form a kaleidoscope. When an object is placed in a kaleidoscope or between two mirrors inclined at 60°, multiple images are formed by the two mirrors.

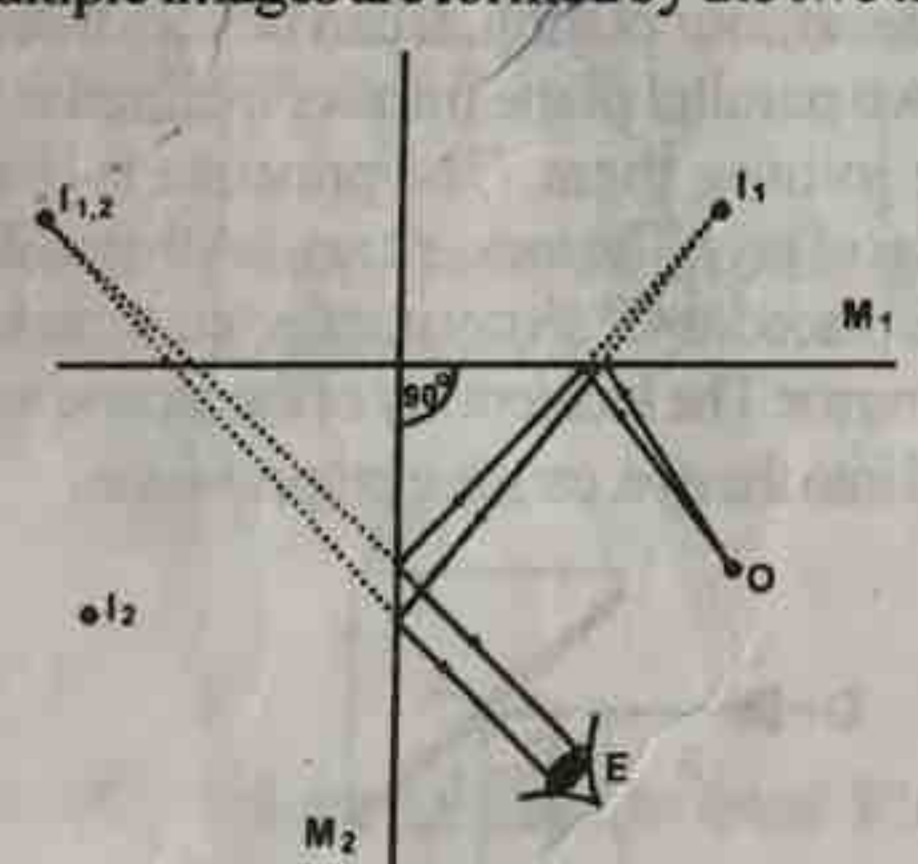

Fig. 29.16 Kaleidoscope

Since they are placed at angle 90°, the number of images formed will be three.

Using the angular formula,

$$\frac{360}{\theta} - 1$$

If $\theta = 90°$

Number of images formed $= \frac{360}{90} - 1$

$= 4 - 1 = 3$ images

Worked example 29.4

An object is placed between two mirrors inclined at an angle 30 to each other. Find the number of images that will be formed.

Solution

$$N_m = \frac{360}{\theta} - 1$$

Where $\theta = 30°$

$$N_m = \frac{360°}{30} - 1$$

$= 12 - 1 = 11$ images

Worked example 29.5

When an object is placed in-between two mirrors placed side by side to each other, five images were formed. Find the angle at which the two mirrors were placed to each other.

Solution

$N_m = 5, \theta = ?,$

using the formula,

$$N_m = \frac{360°}{\theta} - 1$$

$$5 = \frac{360°}{\theta} - 1$$

$5\theta = 360 - \theta$

$5\theta + \theta = 360$

$6\theta = 360$

$$\theta = \frac{360}{6} = 60°$$

29.12 Applications of Plane Mirror

1. Plane mirrors are used in day-to-day activities, as a viewing glass or dressing mirror.
2. It is also used in making periscope.
3. It can be used as sextant device.
4. Plane mirrors are adaptations from which kaleidoscope is made.

30. CURVED SPHERICAL MIRRORS

30.1 Types of Curved Mirrors

There are two types of curved surfaces. These are determined by the size of the curved mirrors while the images produced determine the type of mirrors used.

Types of mirrors

(i) Concave mirror: This is a curved mirror that produces a real image and has the right-hand side of its surface coated. The reflecting surface bends inwards, causing incident rays to converge after reflection.

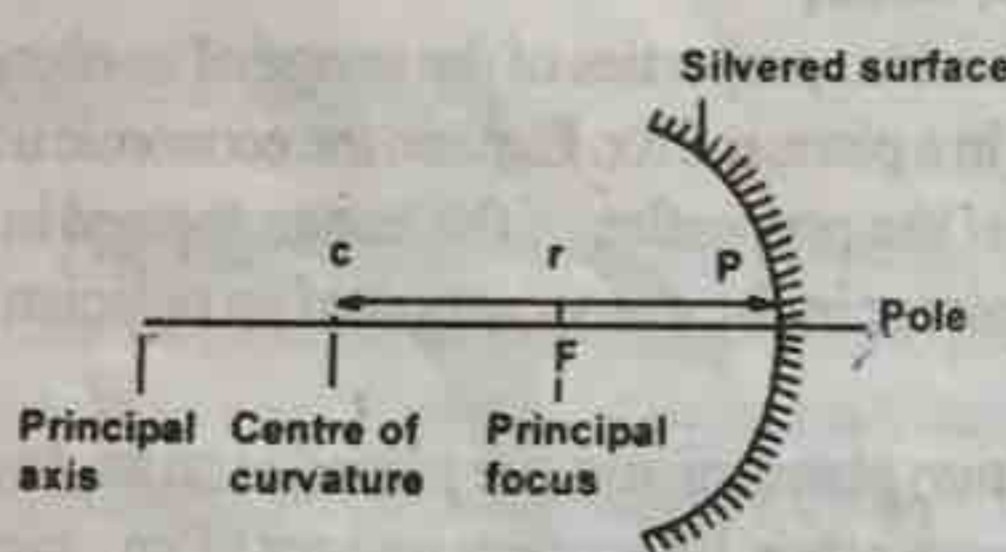

Fig. 30.1 Concave mirror

(ii) Convex mirror: Convex mirror at any point produces virtual images and has its left-hand side (inwards) coated. It causes incident rays to diverge after reflection. The reflecting surface bends outwards.

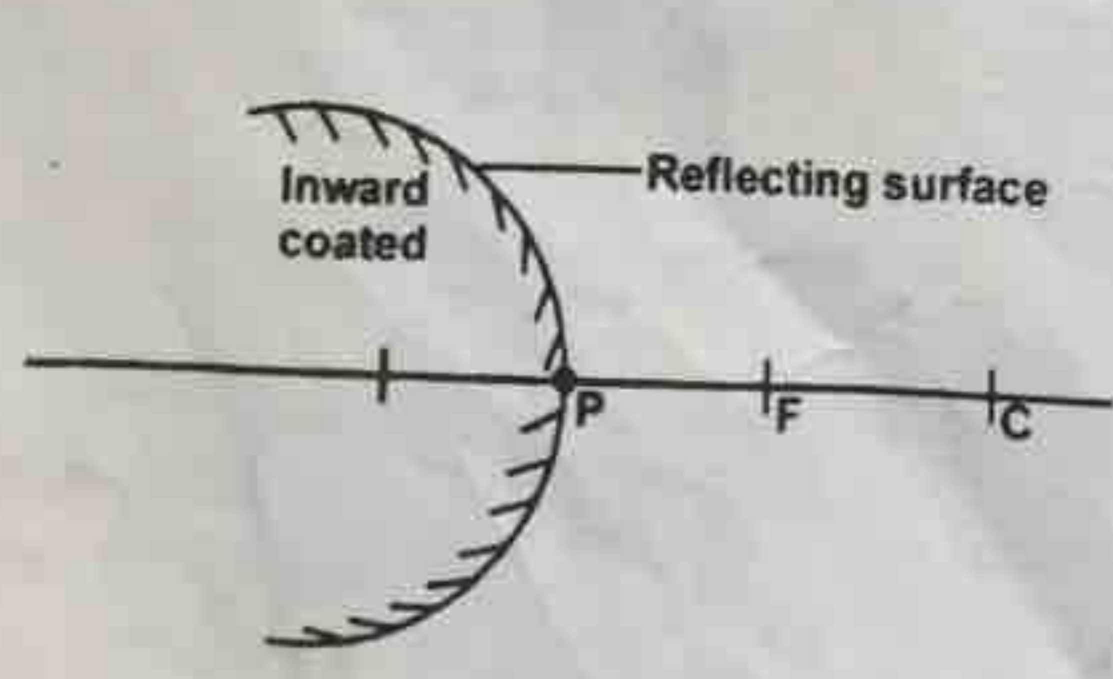

Fig. 30.2 Convex mirror

30.2 Terms Associated with Curved Surfaces

Using a concave mirror as a point of reference, the following terms are associated with curved surfaces.

1. Aperture of a mirror
2. Focus
3. Curvature (radius)
4. Principal axis
5. Pole
6. Focal length

1. **Aperture:** This is a cut-out section from the curved surface, where the rays of light propagated can be incidented. It is the distance between the opposite point on the edge of the mirror.
2. **Focus:** This is the point where the range of light incidented on a curved surface is reflected (to converge at a point). The point is known as *principal focus*. It is also the point F_1 on the principal axis to which rays parallel and close to the principal axis converge or diverge, depending on the nature of the curved mirror, either concave or convex. The principal focus determines whether an image is real or virtual.
3. **Curvature:** This is an imaginary centre assumed to be the centre of the curved surface. It is called *the center of the sphere* of which the mirror is part of the point C which is known as *center of curvature*.
4. **Pole:** This is a centre point produced on an aperture. It is denoted by letter P.
5. **Principal axis:** This is the line joining the pole P to the centre of curvature C. The distance from the centre of curvature to the pole of an aperture is known as *principal axis*.

6. Focal length: The distance from the focus point to the pole is known as *focal length.*

$$\text{Focal length} = \frac{\text{Radius of curvature}}{2}$$

$$f = \frac{r}{2}$$

30.3 Principle of Reversibility

The principle of reversibility agrees with the fact that light incidented and perpendicular to plane surfaces is reflected on the same line of its incident. This is true for every surface.

Experiment to determine the focal length using a concave mirror

Aim: To determine the focal length of a concave mirror

Apparatus: Screen, concave mirror, light force and a ray box

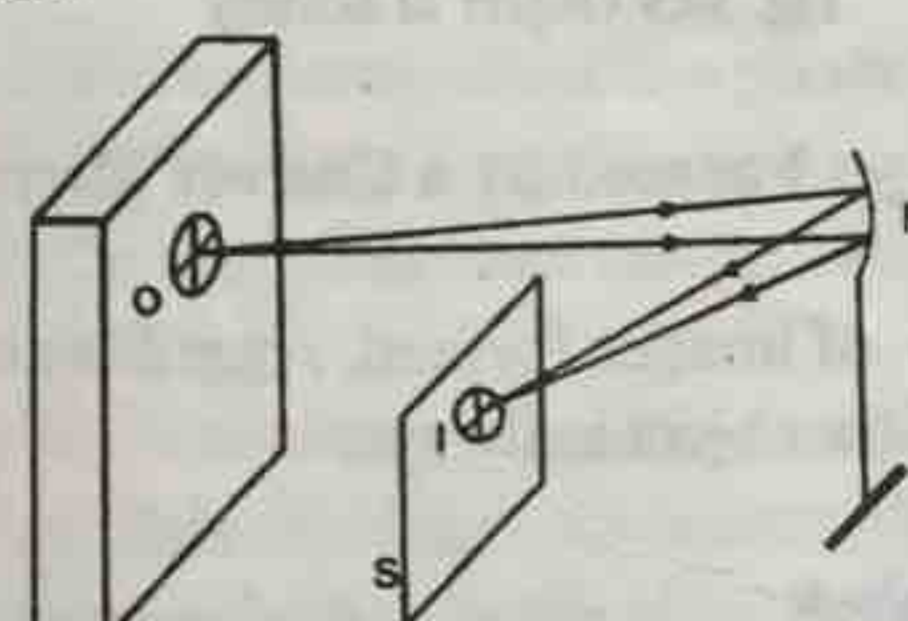

Fig. 30.3 Determining the focal length using a concave mirror

Method: The apparatus set is shown in Figure 30.3 diagram above. The ray box is used to incident ray of light on the curved surface and the reflection is directly focused on the screen. The distance from the ray box to the curve is known as *object distance* [U_d] while from the curve to the screen is known as the *image distance* [V].

Conclusion: A light is formed on the screen as the focus of a concave mirror. Therefore, the real focus is the distance from the principal focus to the pole. It is established by experiment to be equal to half the radius at curvature,

i.e $f = \frac{r}{2}$

30.4 Images Formed on Concave Mirror

Images formed on concave mirrors are produced in six different ways with one exception. It is observed that all the 5 ways produce real and inverted images but it can be diminished or magnified. This fact is due to the variation and change in the position the object is located or placed. The ray diagrams can be used to produce images on concave mirror obviously as stated below:

1. Rays parallel to the principal axis are reflected away from the mirror through the focus (principal focus).
2. Rays passing through the focus are reflected parallel to the principal axis.
3. Rays produced through the curvature are reflected back through the same center.

These three principles determine the position of the image produced or formed.

1. When the object is located beyond C, the image formed is:

(i) inverted (ii) real

(iii) diminished (smaller) (iv) formed between C and F

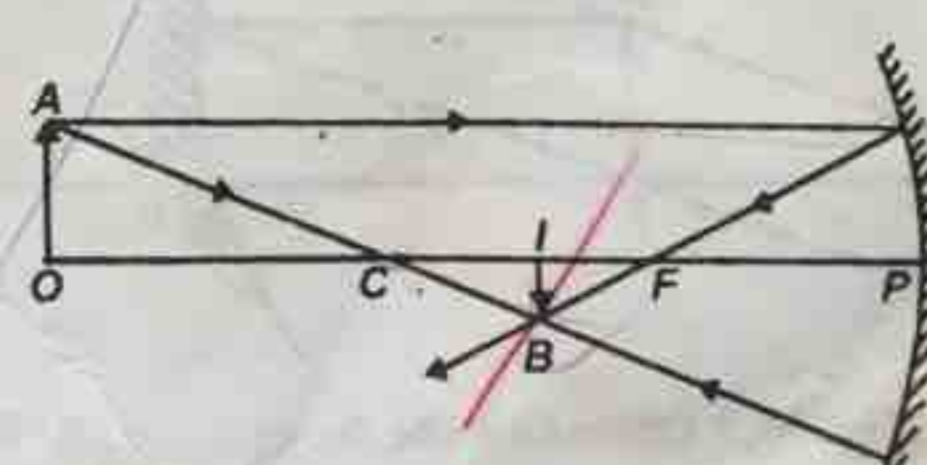

Fig. 30.4 Object before C

2. When the object is positioned (placed) on the centre of curvature, the image formed is:

(i) real

(ii) inverted

(iii) same size as object

(iv) at C

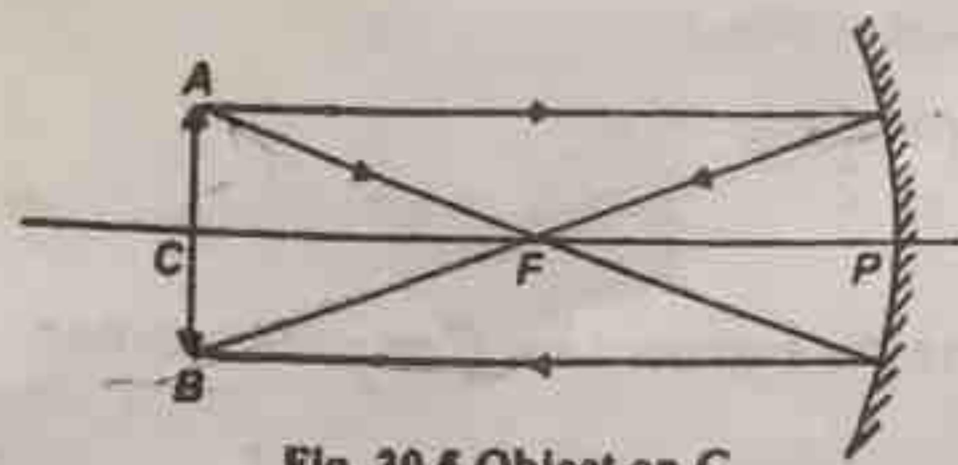

Fig. 30.5 Object on C

3. When an object is positioned in-between the centre of curvature and the focus, object between C and F, the image produced is
(i) real
(ii) inverted
(iii) larger than object (magnified / enlarged)
(iv) beyond C

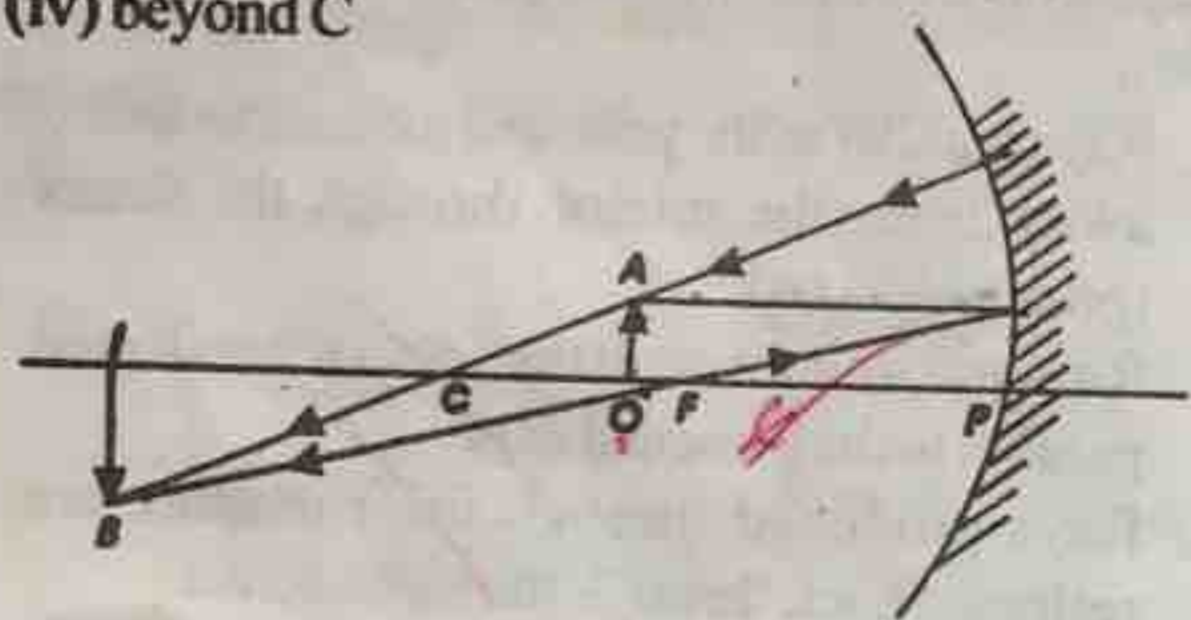

Fig. 30.6 Object between C and F

4. When the object is positioned on the focus, the image is formed at infinity. This implies that there are no points of intersection for the ray produced.

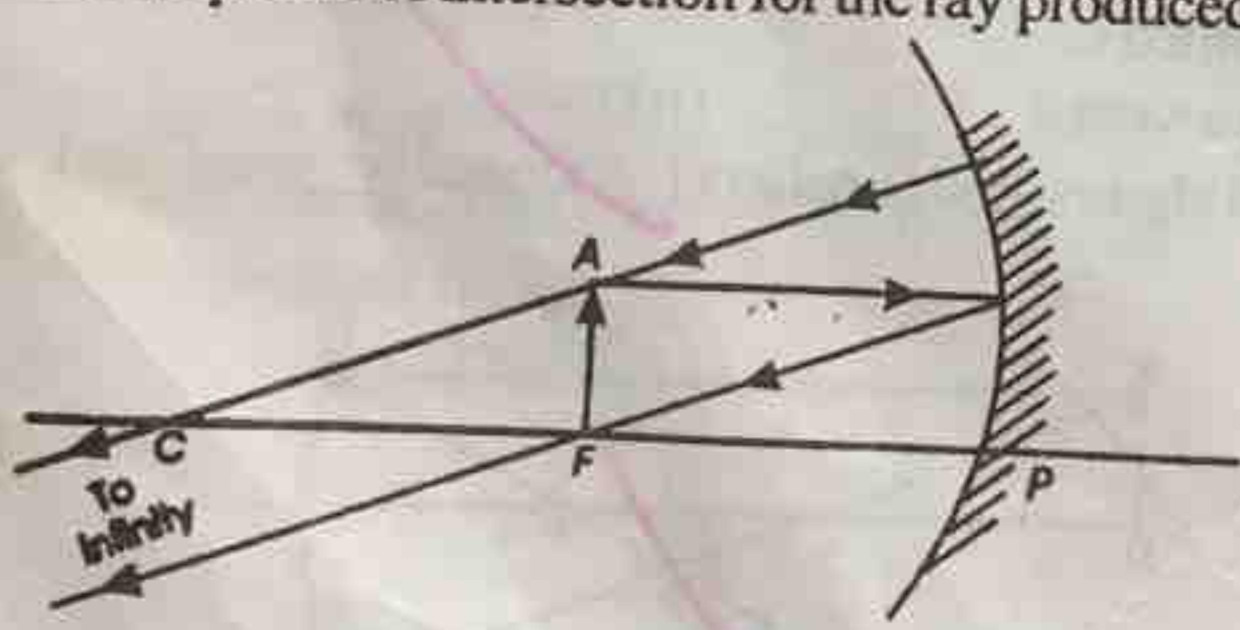

Fig. 30.7 Object on the focus

5. When the object is placed or positioned after the focus, or in-between the pole and the focus, O between F and the pole (P) the image produced becomes:

(i) virtual
(ii) magnified/enlarged
(iii) erect
(iv) behind the mirrors

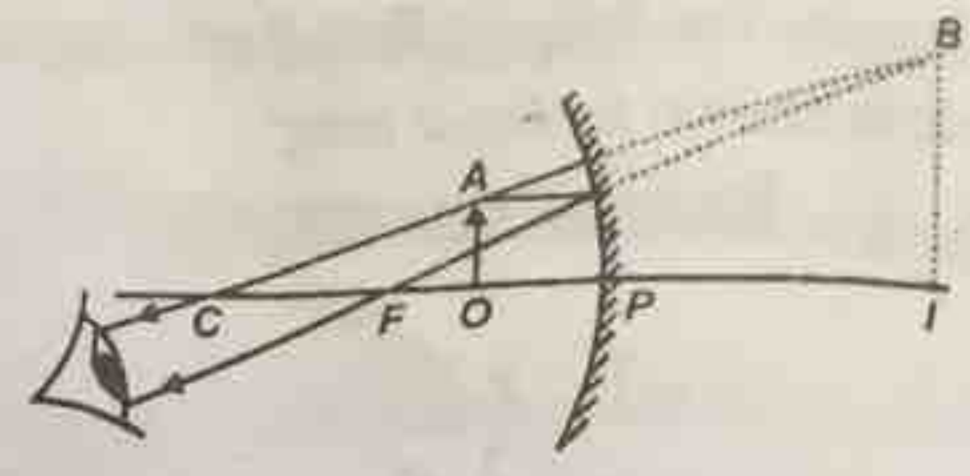

Fig. 30.8 Object between F and the pole P

6. When the object is at infinity, the image formed is:
(i) inverted
(ii) real
(iii) smaller than the object (diminished)
(iv) at F

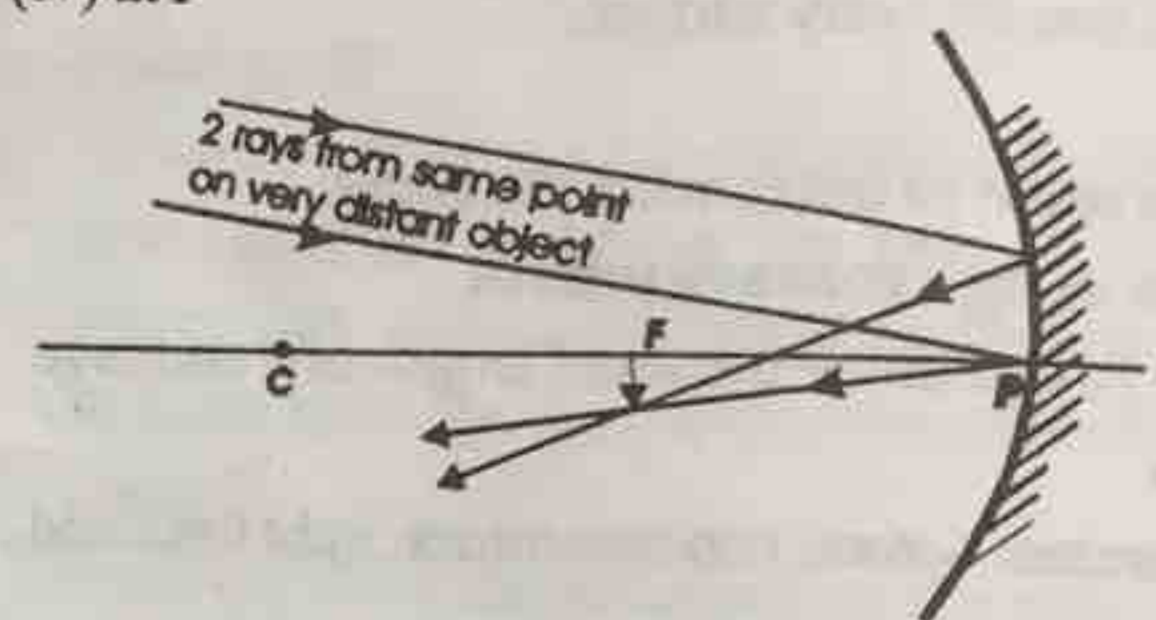

Fig. 30.9 Object at infinity

30.5 Images Formed by a Convex Mirror

The nature of images formed, regardless of the position of the object is always:
(i) virtual
(ii) diminished
(iii) erect or upright

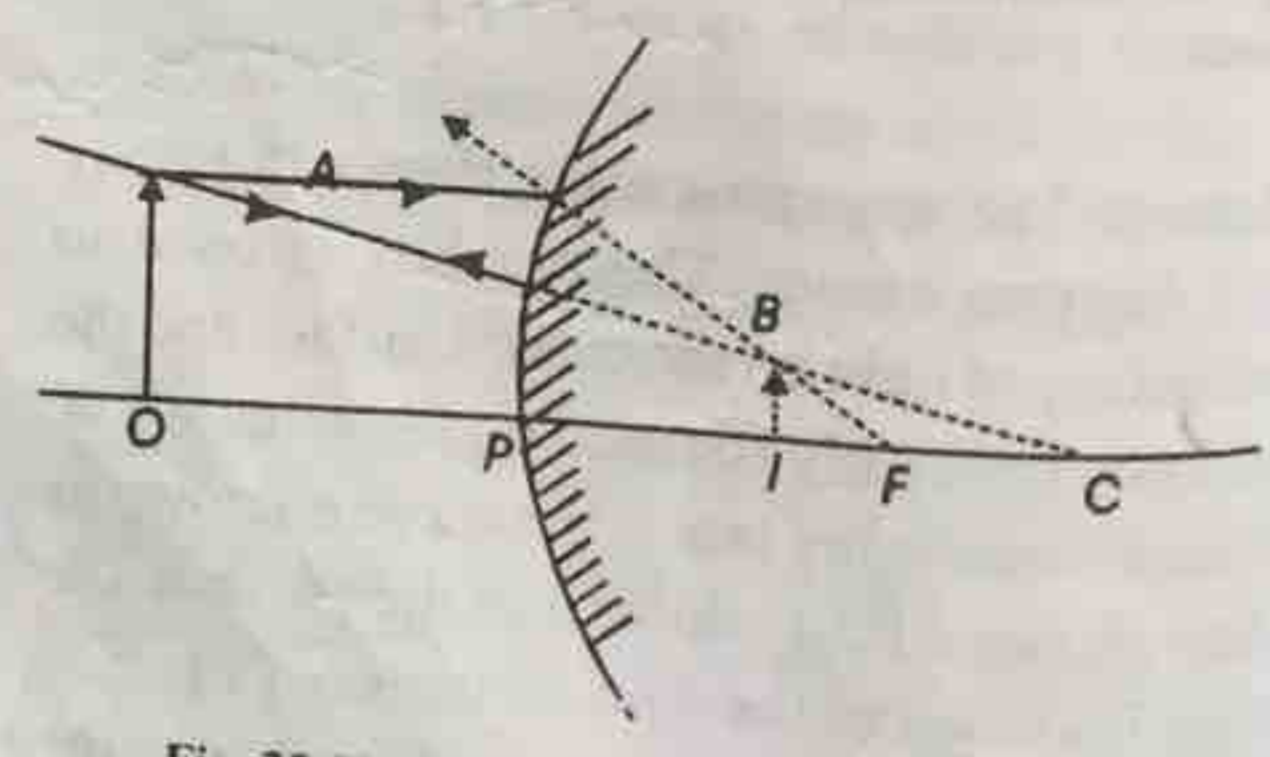

Fig. 30.10 Image formed by a convex mirror

NB: (i) The focal length of a concave (converging) mirror is positive (+ve). (ii) The focal length of a