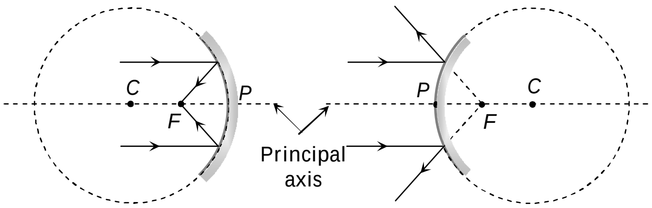
Curved Mirror

It is a part of a transparent hollow sphere whose one surface is polished.



Convex mirror diverges the light rays and used in road lamps, side mirror in vehicles *etc*.

(1) **Terminology**

(i) Pole (P) **:** Mid point of the mirror

(ii) Centre of curvature (C) : Centre of the sphere of which the mirror is a part.

(iii) Radius of curvature (R): Distance between pole and centre of curvature.

($R_{concave} = -ve$, $R_{convex} = +ve$, $R_{plane} = \infty$)

(iv) Principle axis : A line passing through P and C.

(v) Focus (F) : An image point on principle axis for an object at ∞.

(vi) Focal length (f) : Distance between P and F.

(vii) Relation between f and R : $f = \frac{R}{2}$

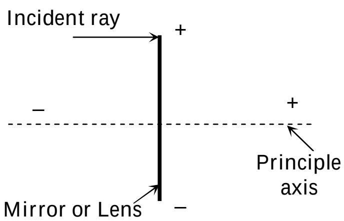
($f_{concave} = -ve$, $f_{convex} = +ve$, $f_{plane} = \infty$)

(viii) Power : The converging or diverging ability of mirror

(ix) Aperture : Effective diameter of light reflecting area. Intensity of image $\propto$ Area $\propto$ (Aperture)^2

(x) Focal plane : A plane passing from focus and perpendicular to principle axis.

(2) **Sign conventions :**



(i) All distances are measured from the pole.

(ii) Distances measured in the direction of incident rays are taken as positive while in the direction opposite of incident rays are taken negative.

(iii) Distances above the principle axis are taken positive and below the principle axis are taken negative.

Useful sign

Concave mirror		Convex mirror
Real image ($u \geq f$)	**Virtual image ($u < f$)**	

Distance of object $u \rightarrow -$	$u \rightarrow -$	$u \rightarrow -$
Distance of image $v \rightarrow -$	$v \rightarrow +$	$v \rightarrow +$
Focal length $f \rightarrow -$	$f \rightarrow -$	$f \rightarrow +$
Height of object $O \rightarrow +$	$O \rightarrow +$	$O \rightarrow +$
Height of image $I \rightarrow -$	$I \rightarrow +$	$I \rightarrow +$
Radius of curvature $R \rightarrow -$	$R \rightarrow -$	$R \rightarrow +$
Magnification $m \rightarrow -$	$m \rightarrow +$	$m \rightarrow +$

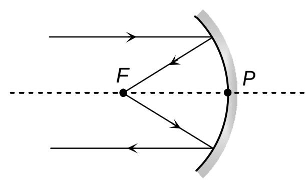
Image Formation by Curved Mirrors

Concave mirror : Image formed by concave mirror may be real or virtual, may be inverted or erect, may be smaller, larger or equal in size of object.

(1) When object is placed at infinite (*i.e.* $u = \infty$)

Image

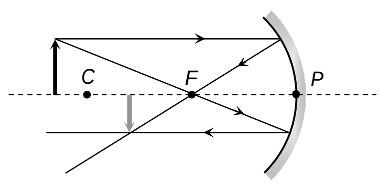
⟶ At F
⟶ Real
⟶ Inverted
⟶ Very small in size
⟶ Magnification $m << -1$



(2) When object is placed between infinite and centre of curvature (*i.e.* $u > 2f$)

Image

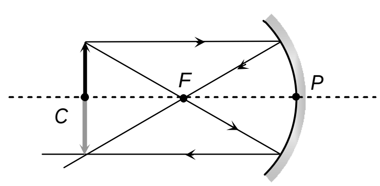
⟶ Between F and C
⟶ Real
⟶ Inverted
⟶ Small in size
⟶ $m < -1$



(3) When object is placed at centre of curvature (*i.e.* $u = 2f$)

Image

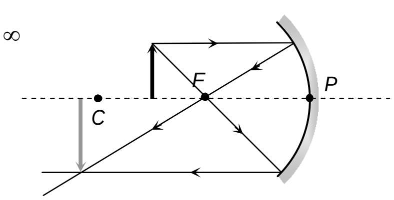
⟶ At C
⟶ Real
⟶ Inverted
⟶ Equal in size
⟶ $m = -1$



(4) When object is placed between centre of curvature and focus (*i.e.* $f < u < 2f$)

Image

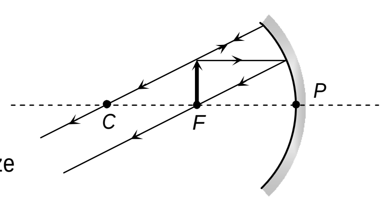
⟶ Between $2f$ and ∞
⟶ Real
⟶ Inverted
⟶ Large in size
⟶ $m > -1$



(5) When object is placed at focus (*i.e.* $u = f$)

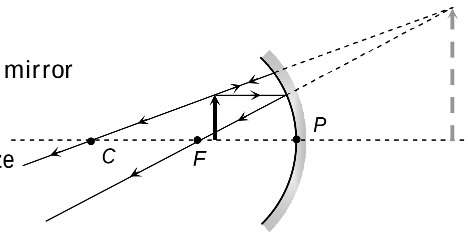
Image

⟶ At ∞
⟶ Real
⟶ Inverted
⟶ Very large in size
⟶ $m >> -1$



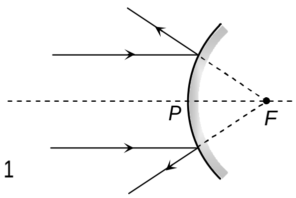
(6) When object is placed between focus and pole (*i.e.* $u < f$)

Image
- Behind the mirror
- Virtual
- Erect
- Large in size
- $m > +1$



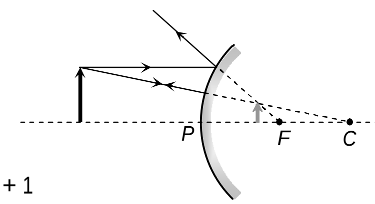
Convex mirror : Image formed by convex mirror is always virtual, erect and smaller in size.
(1) When object is placed at infinite (*i.e.* $u = \infty$)

Image
- At F
- Virtual
- Erect
- Very small in size
- Magnification $m << +1$



(2) When object is placed any where on the principal axis

Image
- Between P and F
- Virtual
- Erect
- Small in size
- Magnification $m < +1$



Mirror Formula and Magnification

For a spherical mirror if u = Distance of object from pole, v = distance of image from pole, f = Focal length, R = Radius of curvature, O = Size of object, I = size of image

(1) **Mirror formula :** $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

(2) **Lateral magnification :** When an object is placed perpendicular to the principle axis, then linear magnification is called lateral or transverse magnification.

$$m = \frac{I}{O} = -\frac{v}{u} = \frac{f}{f-u} = \frac{f-v}{f}$$

(* Always use sign convention while solving the problems)

Axial magnification : When object lies along the principle axis then its axial magnification $m = \frac{I}{O} = \frac{-(v_2 - v_1)}{(u_2 - u_1)}$

If object is small; $m = -\frac{dv}{du} = \left(\frac{v}{u}\right)^2 = \left(\frac{f}{f-u}\right)^2 = \left(\frac{f-v}{f}\right)^2$

Areal magnification : If a 2*D*-object is placed with it's plane perpendicular to principle axis. It's Areal magnification

$$m_s = \frac{\text{Area of image } (A_i)}{\text{Area of object } (A_o)} \Rightarrow m_s = m^2 = \frac{A_i}{A_o}$$