Chapter 10: Light - Reflection & Refraction

Reflection of light: Bouncing back of light when it strikes on a polished surface is known as reflection of light.

Laws of Reflection: There are two laws of reflection. They are:

(i) Angle of incidence is equal to the angle of reflection.

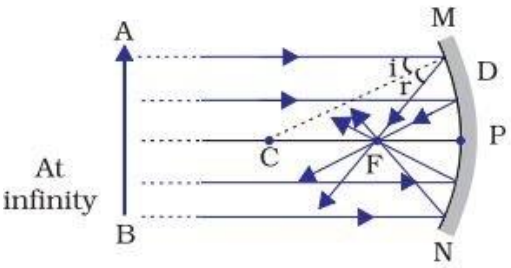
(ii) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

Spherical Mirror: Mirror whose reflecting surface is part of the hollow sphere.
The spherical mirror is of two types:

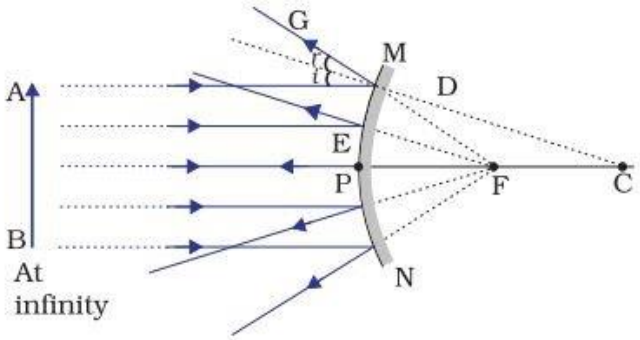
Convex mirror: It is a spherical mirror whose reflecting surface is curved outwards. It diverges the light therefore it is also called the diverging mirror.

Concave mirror: It is a spherical mirror whose reflecting surface is curved inwards. It converges the light therefore it is also called converging mirror.

Reflection of light by curved surfaces



Concave Mirror



Convex Mirror

General terms in context of spherical mirrors:

Centre of curvature: The centre of the sphere of which the mirror was a part is called the centre of curvature.

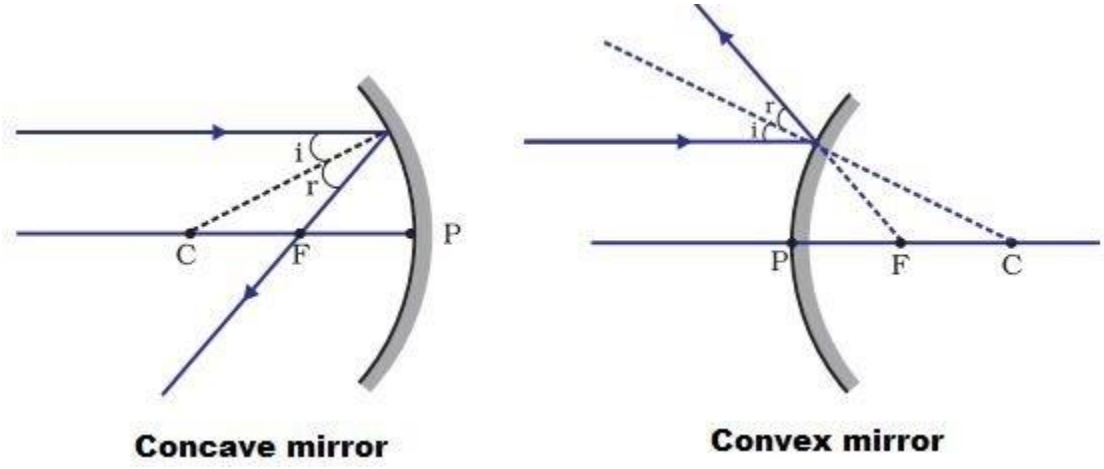
Principal axis: The line joining the pole and center of curvature is called principal axis.

Principal focus: The point on principal axis where all the parallel light rays actually meet or appear to meet after reflection is called principal focus.

Focal length: The distance between the pole and the focus is called focal length.

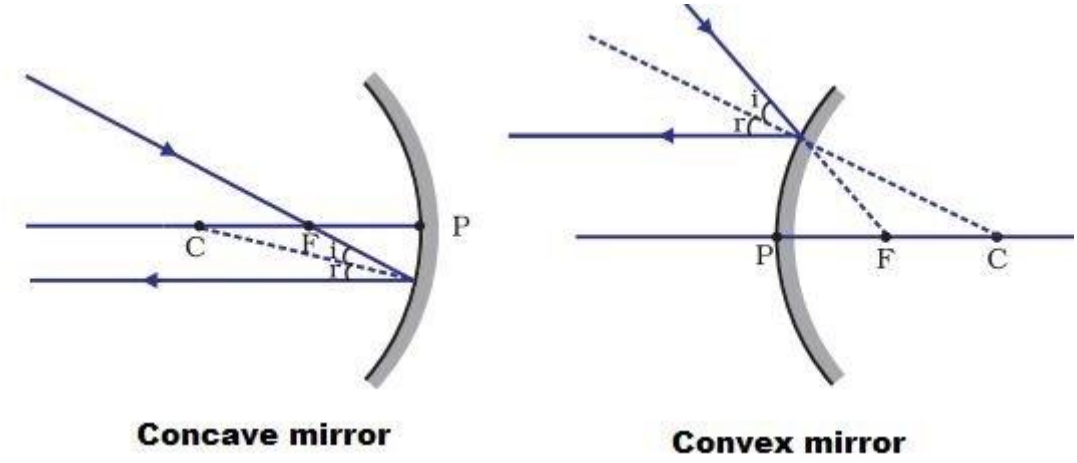
Rules for reflection of rays by spherical mirrors

(i) A ray parallel to the principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.



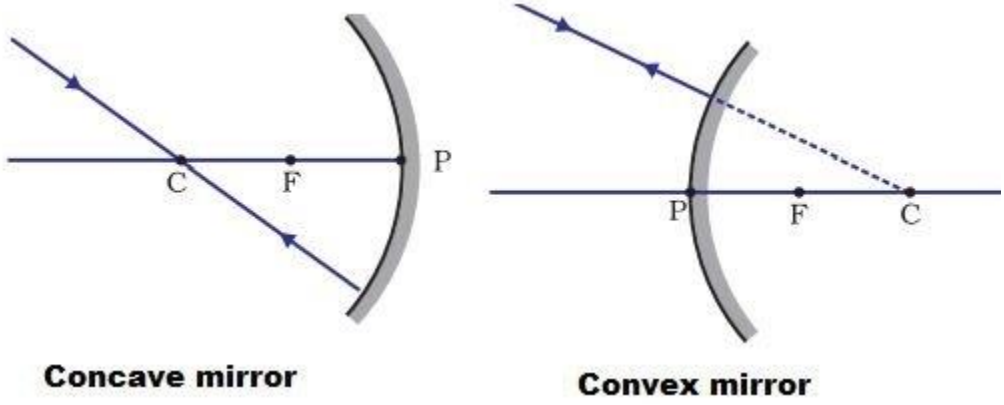
Concave mirror **Convex mirror**

(ii) A ray passing through the principal focus of a spherical mirror, after reflection, will emerge parallel to the principal axis.



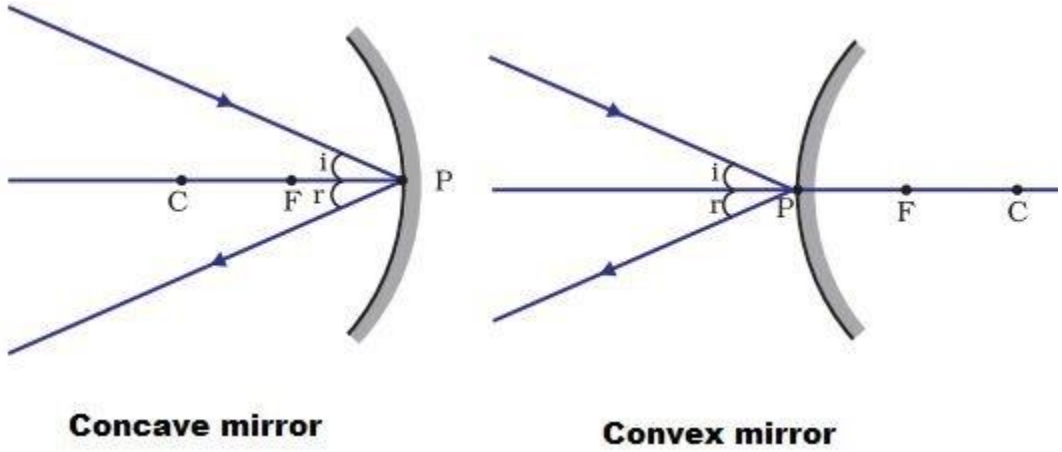
Concave mirror **Convex mirror**

(iii) A ray passing through the centre of curvature of a spherical mirror, after reflection, is reflected back along the same path.



Concave mirror **Convex mirror**

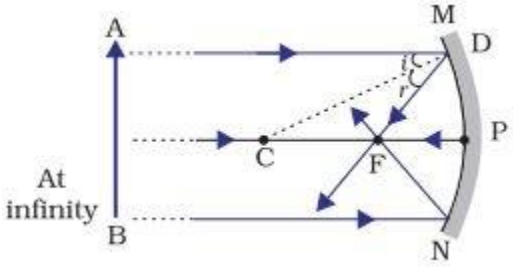
(iv) A ray incident obliquely to the principal axis is reflected obliquely following the laws of reflection, i.e., angle of incidence is equal to angle of reflection.



Concave mirror **Convex mirror**

Image formation by concave mirror

(i) When the object is at infinity

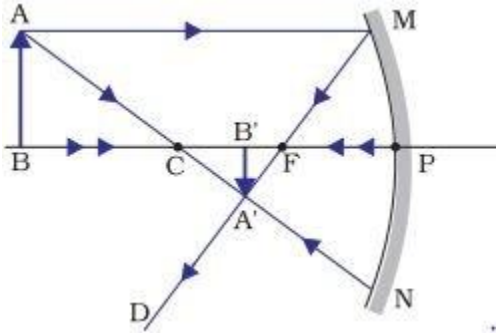


→ Image is formed between F and C

→ Image is diminished

→ Image is real and inverted

(ii) When the object is beyond C

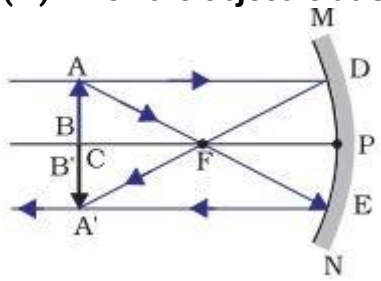


→ Image is formed at focus F

→ Image is highly diminished or point size

→ Image is real and inverted

(iii) When the object is at C

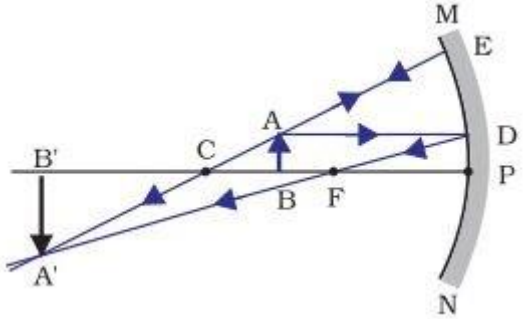


→ Image is formed at C

→ Image is of the same size as that of the object

→ Image is real and inverted

(iv) When the object is between C and F

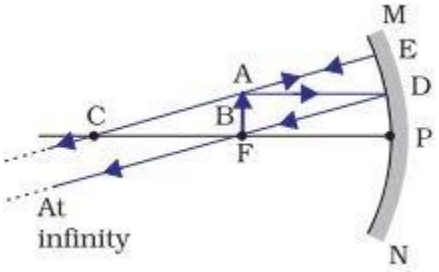


→ Image is formed beyond C

→ Image is enlarged

→ Image is real and inverted

(v) When the object is at F

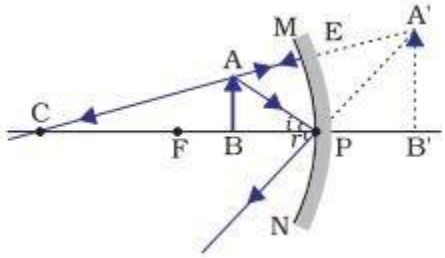


→ Image is formed at infinity

→ Image is highly enlarged

→ Image is real and inverted

(vi) When the object is between P and F



→ Image is formed behind the mirror

→ Image is enlarged

→ Image is virtual and erect

Uses of Concave Mirror

(i) Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.

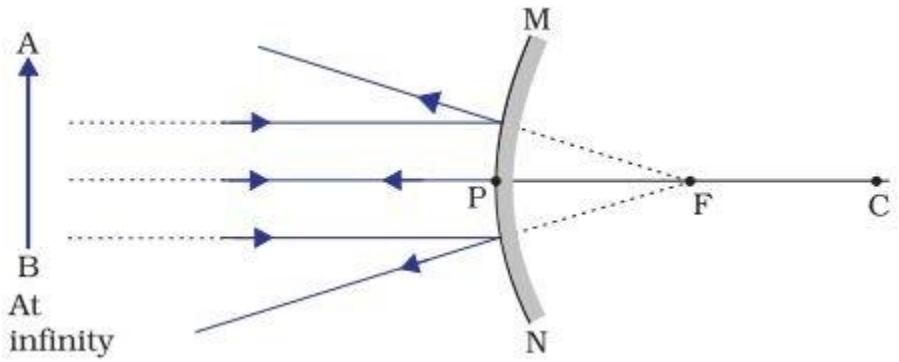
(ii) They are used as shaving mirrors to see a larger image of the face.

(iii) The dentists use concave mirrors to see large images of the teeth of patients.

(iv) Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

Image formation by convex mirror:

(i) When the object is at infinity

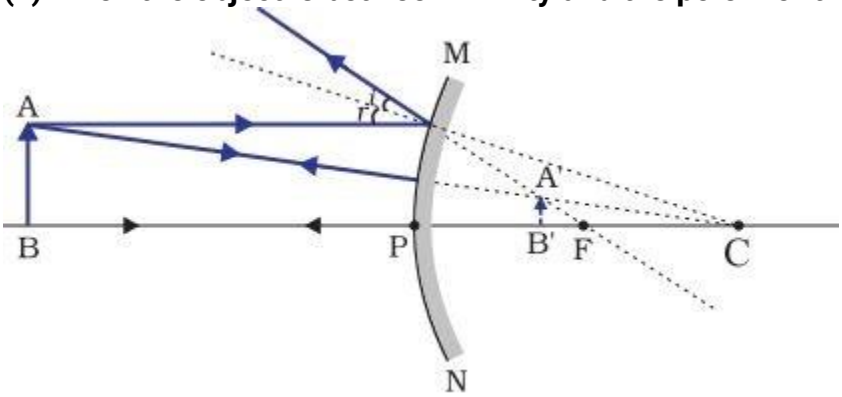


→ Image is formed at focus F behind the mirror

→ Image is highly diminished or point sized

→ Image is virtual and erect

(ii) When the object is between infinity and the pole P of the mirror



→ Image is formed between P and F behind the mirror

→ Image is diminished

→ Image is virtual and erect

Uses of convex mirrors

(i) Convex mirrors are used as rear-view mirrors in vehicles because

→ they always give an erect and diminished image

→ they give a wider field of view as they are curved outwards.

(ii) They are used in shops as security mirrors.

Mirror formula (Derivation not required)

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

where, v = Image distance

u = Object distance

f = Focal length

Magnification of Spherical Mirrors

$$\text{Magnification } (m) = \frac{h'}{h} = -\frac{v}{u}$$

where, h' = Height of the image

and h = Height of the object

Note -The height of the image should be taken as positive for virtual images. However, it is to be taken as negative for real images.

Refraction of light: Bending of the light rays as it passes from one medium to another medium is known as refraction of light.

Laws of refraction
Two laws of reflection are:

(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is constant for the light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction.

$$\frac{\sin i}{\sin r} = constant$$

Refractive index: The extent of the change in direction of light that takes place in a given pair of media is expressed in terms of the refractive index. This can be expressed in an equation form as

$$n_{21}=\frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}}=\frac{v_1}{v_2}$$

Absolute refractive index: Refractive index of medium 2 with respect to vacuum is called the absolute refractive index of the medium. It is represented as n_2.

Optical density: The ability of a medium to refract light is expressed in terms of its optical density.

→ A medium with the larger refractive index is optically denser medium.

→ A medium with the lower refractive index is optically rarer medium.

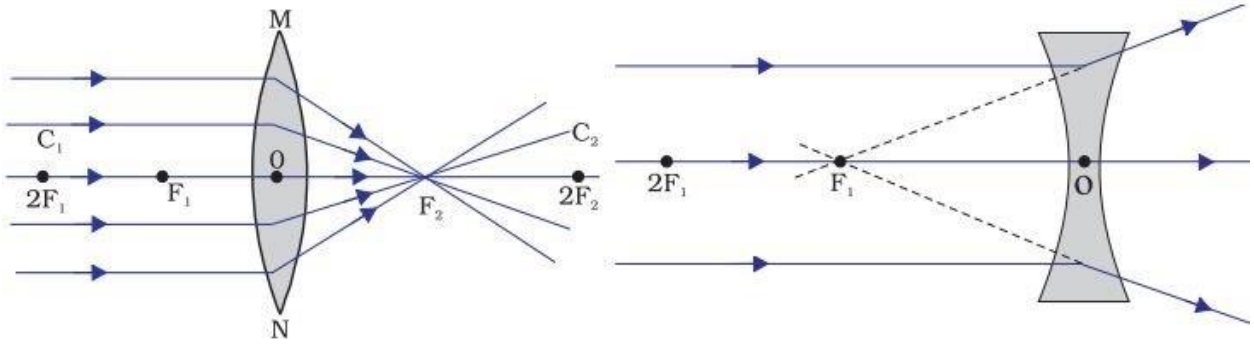
→ The speed of light is higher in a optically rarer medium than a optically denser medium.

Spherical lens: A transparent medium bound by two surfaces, of which one or both surfaces are curved is called a spherical lens.

Concave lens: It is a spherical lens in which two spherical surfaces bulge inwards. It is also called diverging lens.

Convex lens: It is a spherical lens in which two spherical surfaces bulge outwards. It is also called converging lens.

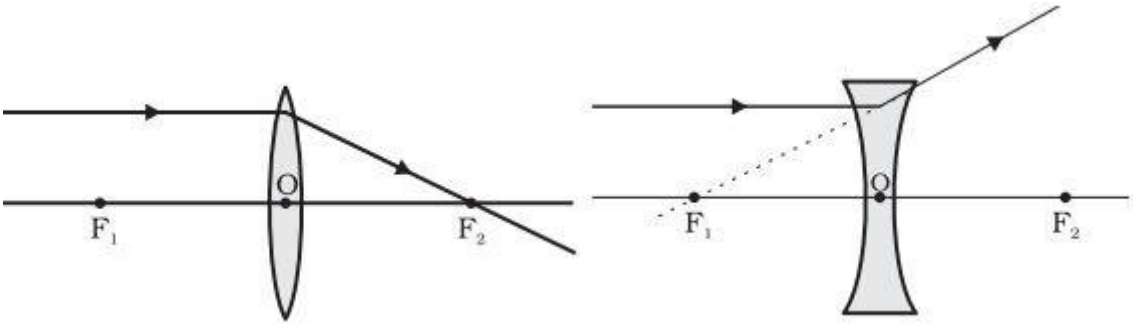
Refraction of light by spherical lens:



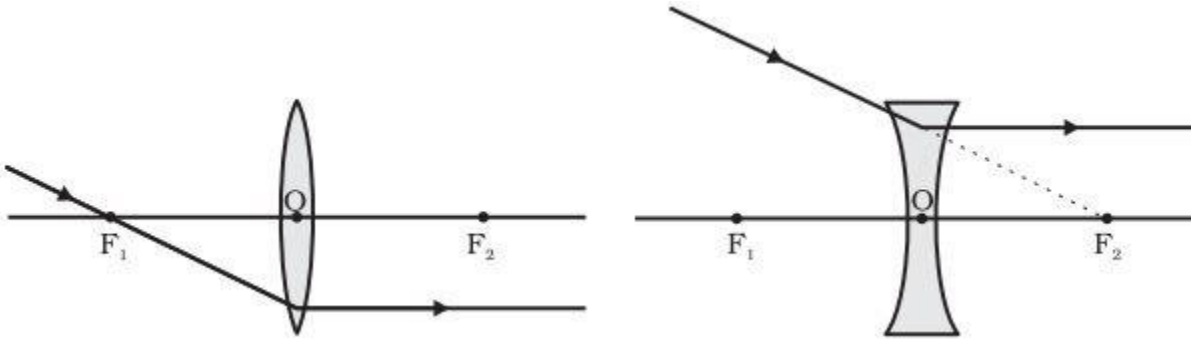
Converging action of a convex lens *diverging action of a concave lens*

Rules for reflection of rays by spherical mirrors

(i) A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens. In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens.



(ii) A ray of light passing through a principal focus, after refraction from a convex lens, will emerge parallel to the principal axis. A ray of light appearing to meet at the principal focus of a concave lens, after refraction, will emerge parallel to the principal axis.



(iii) A ray of light passing through the optical centre of a lens will emerge without any deviation.

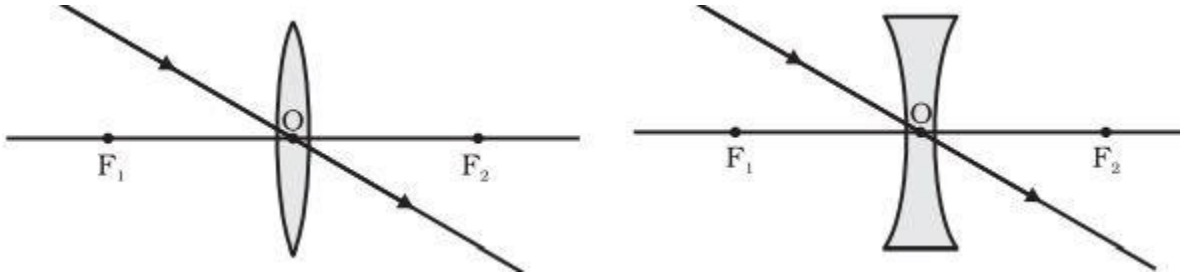
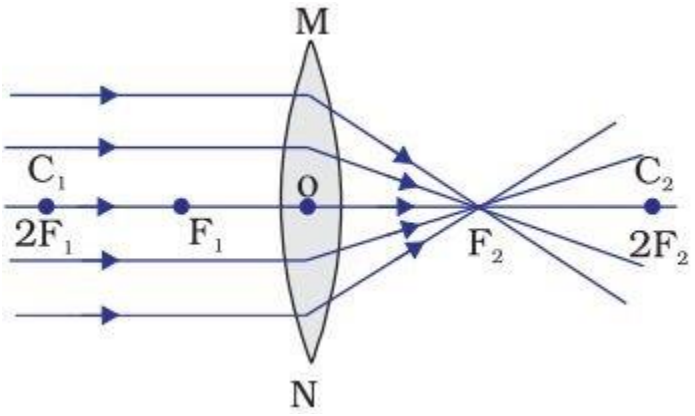


Image formation by Convex Lens

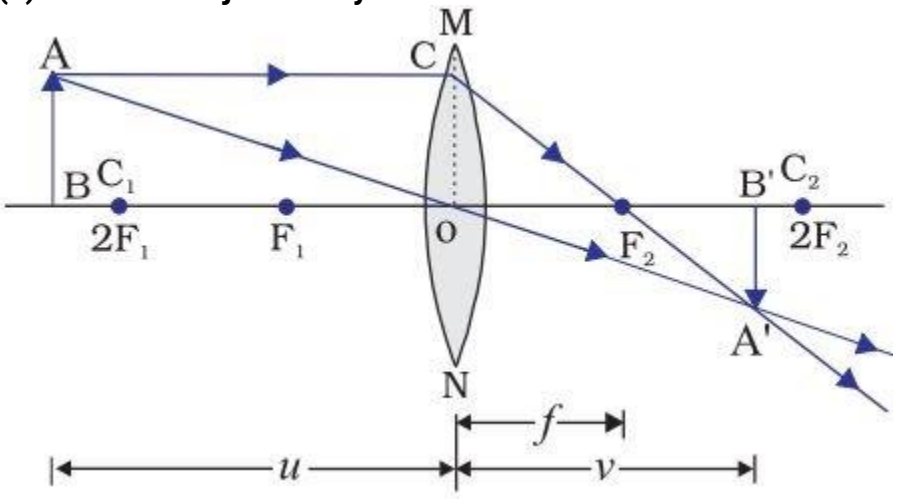
(i) When the object is at infinity



→ Image is formed at focus F_2
→ Image is highly diminished or point-sized

→ Image is real and inverted

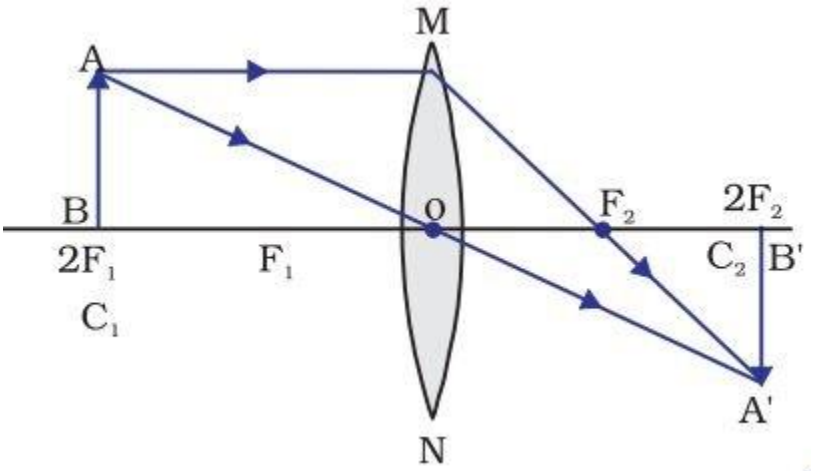
(ii) When the object is beyond $2F_1$



→ Image is formed between F_2 and $2F_2$
→ Image is diminished

→ Image is real and inverted

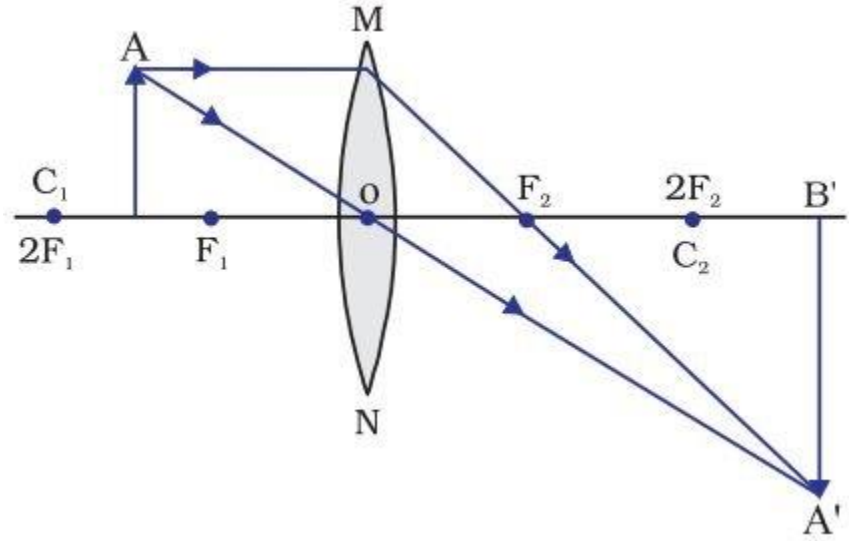
(iii) When the object is at $2F_1$



→ Image is formed at $2F_2$
→ Image is same size as that of object

→ Image is real and inverted

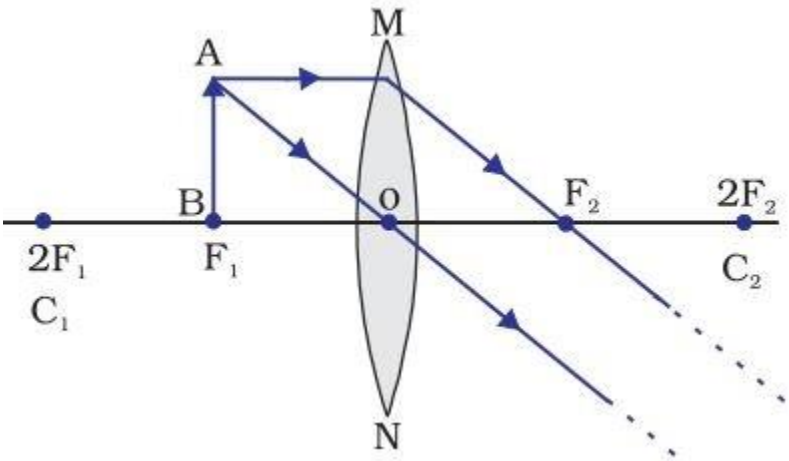
(iv) When the object is between F_1 and $2F_1$



→ Image is formed beyond $2F_2$
→ Image is enlarged

→ Image is real and inverted

(v) When the object is at focus F_1

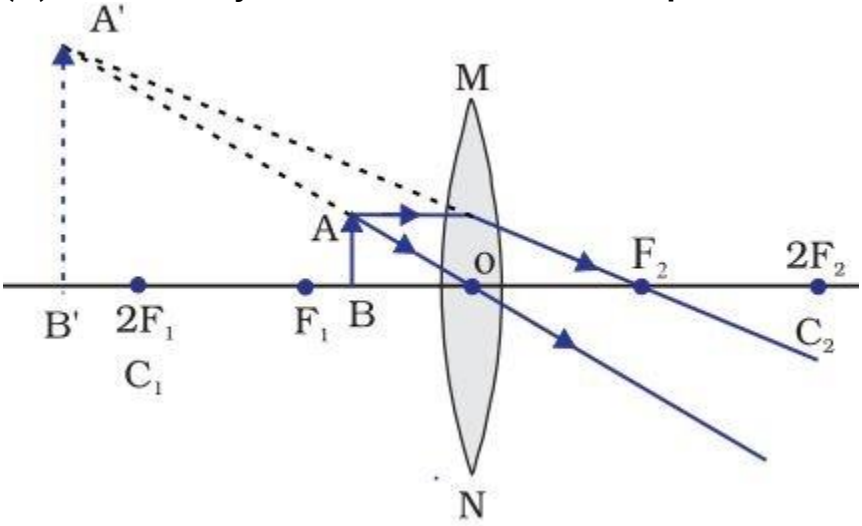


→ Image is formed at infinity

→ Image is infinitely large or highly enlarged

→ Image is real and inverted

(vi) When the object is between focus F_1 and optical centre O



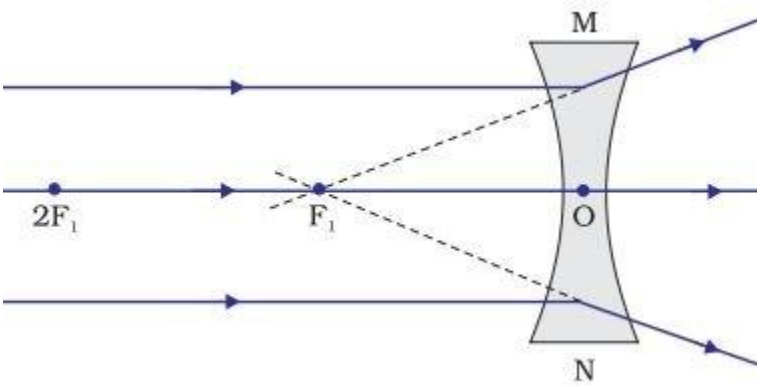
→ Image is formed on the same side of the lens as the object

→ Image is enlarged

→ Image is virtual and erect

Image formation by Concave Lens

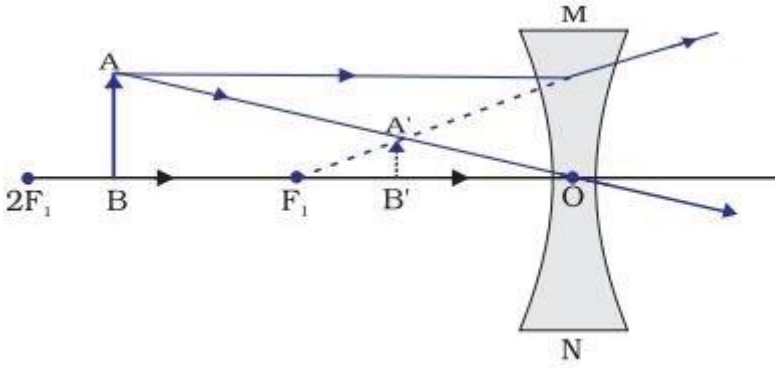
(i) When the object is at infinity



→ Image is formed at focus F_1
→ Image is highly diminished or point sized

→ Image is virtual and erect

(ii) When the object between infinity and optical centre O of lens



→ Image is formed between focus F_1 and optical centre O
→ Image is diminished

→ Image is virtual and erect

Lens formula (Derivation not required)

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

Magnification

$$\text{Magnification } (m) = h'/h = v/u$$

Power of a lens: The degree of convergence or divergence of light rays is expressed in terms of power. It is given as: P = 1/f
→ The SI unit of power is dioptre (D).

→ Power of convex lens is positive.

→ Power of concave lens is negative.