UNIT - 4

LIGHT : REFLECTION AND REFRACTION

- Light is a form of energy which produces in our eye's the sensation of sight.
- Light travels along straight line path.
- light is neither a 'Wave' nor a partcle. light has a dual character. It is emitted or obsorbed as a particle but it propagates as a wave.

SOME IMPORTANT TERMS RELATED WITH LIUHT :-

(i) **Source** :- A source of light is an object, from which light is given out there are of Two types.

(A) Self luminous
(B) non luminous

(ii) **Medium** :- A medium is a substance through which light propagates or tries to do so. There are three types of media of light.

(A) Transparent
(B) Translucent
(C) opaque

(iii) **Ray** :- A Ray of light is the straight line path along which light travels. A number of Rays combined together form a beam of light. A narrow beam of light is called a pencil of light. There are of three types.

(A) Convergent
(B) Divergent
(C) Parallel

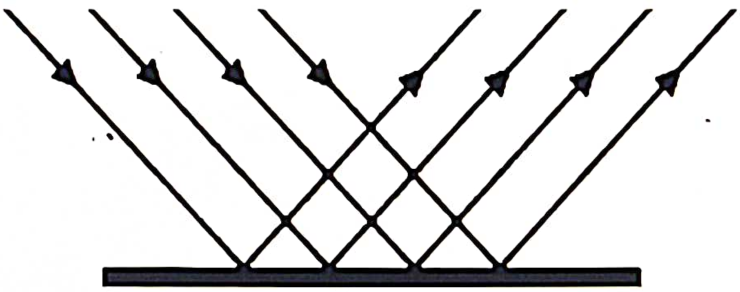
REFLECTION OF LIGHT

Reflection of light is the phenomenon of bouncing back of light in the same medium on striking the surface of any object.

Reflection is of two types.

Regular Reflection | **Irregular Reflection**

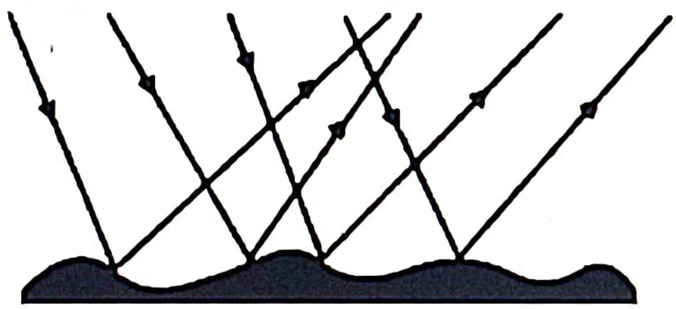
(A) Regular Reflection :-



when the reflecting surface is smooth and well polished, the parallel rays falling on it are reflected is parallel to one another, the Reflected light goes in an particular direction. this is Regular reflection.

(B) Irregular Reflection :-

when the reflecting surface is rough the parallel ray's falling on it are reflected in different directions.

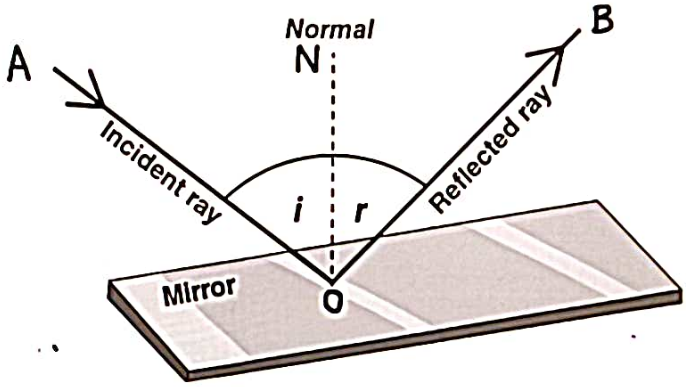


LAWS OF REFLECTION OF LIGHT

Here we see the two laws of reflection of light :-

Ist LAW :- According to first law, the incident ray, the reflected ray and the normal all lie in the same plane.

IInd LAW :- The Angle of reflection is always equal to the angle of incidence.



IInd LAW :- The Angle of reflection is always equal to the angle of incidence.

Here

AO	-	Incident Ray
OB	-	Reflected Ray
$\angle AON$	-	Incident Angle
$\angle NOB$	-	Reflected Angle
NO	-	Normal

For normal incidence $\angle i = \angle r = 0$

When a ray of light is incident normally, retrace its path on reflection.

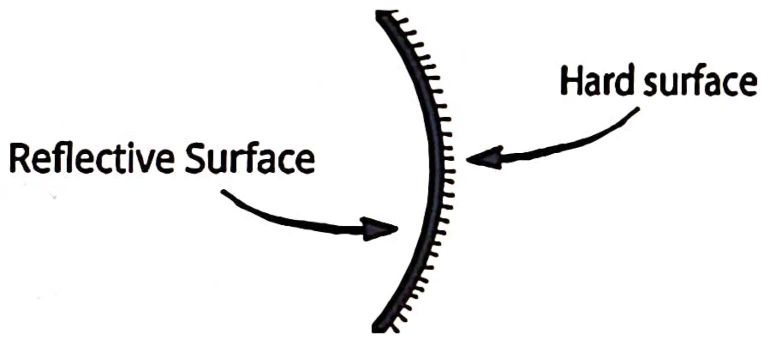
Characteristics of Image Formed By Plane Mirrors

(i) Image of a real object is virtual.
(ii) The Image formed in a plane mirror is always erect.
(iii) The size of image in a plane mirror is always the same as the size of the object.
(iv) In plane mirror, image and object have same distance from the mirror.
(v) The image formed in a plane mirror is laterally inverted.

SPHERICAL MIRRORS

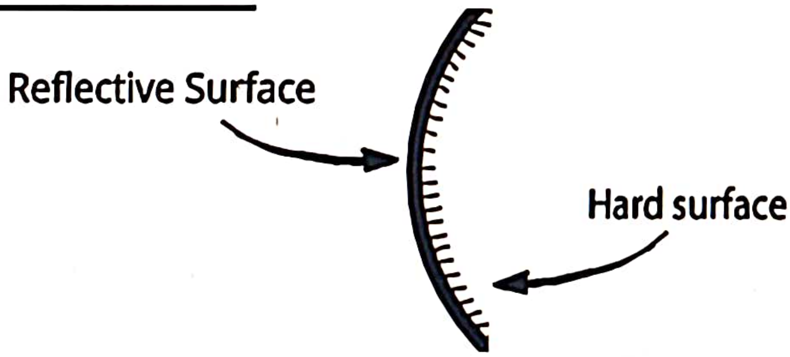
A spherical mirror is that mirror whose reflecting surface is a part of a hollow sphere of glass. Spherical mirrors are of two types.

(A) Concave mirror :-



Concave mirror is that spherical mirror in which reflecting surface is towards the center of the sphere.

(B) Convex mirror :-



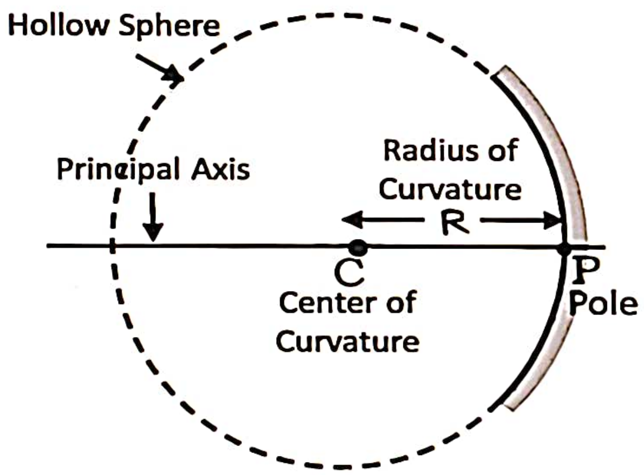
Convex mirror is the spherical mirror in which reflecting surface is away from the center of the sphere.

Some Important Terms

(i) **Center of curvature** :- The center of curvature of a spherical mirror is the center of the hollow sphere of glass of which the spherical mirror is a part. It represented by C.

(ii) **Pole** :- the pole of a spherical mirror is the center of the mirror. It is also called vertex and represented by P.

(iii) **Radius of curvature** :- The radius of curvature of a spherical mirror is the radius of the hollow sphere of glass of which the spherical mirror is a part represented by R.



(iv) **Principle axis** :- The principal axis of a spherical mirror is the straight line passing through the center of curvature C and the pole P of the mirror.

(v) **Apeture** :- The apeture of a spherical mirror is the diameter of the reflecting surface of the mirror.

Principal Focus and Focal Length of a Concave Mirror.

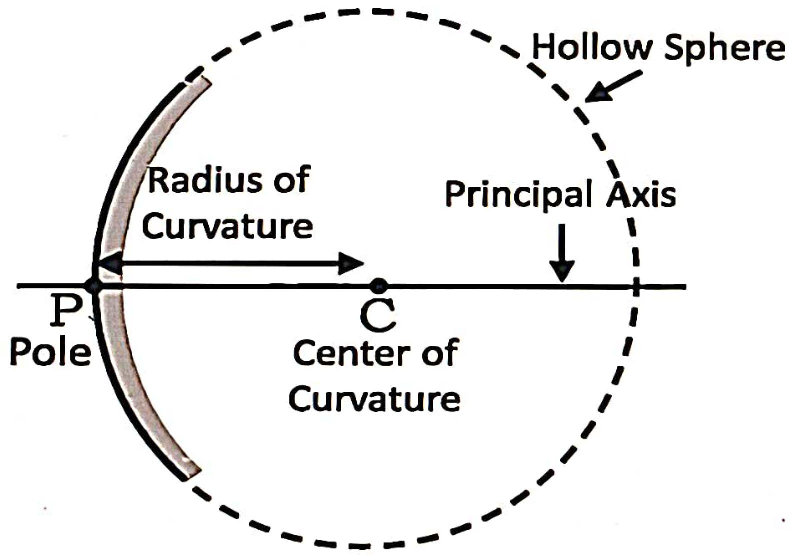
The principal Focus of a concave mirror is a point on the principal axis of the mirror, at which rays of light incident on the mirror in a direction parallel to the principal axis actually meet after reflection from the mirror.
Denoted by F.

Focal length of a concave mirror is the distance of principal focus F of the mirror from the pole P of the mirror.

As a concave mirror converges the parallel beam of light falling on it, there fore it is called a converging mirror.

Principal Focus and Focal Length of a Convex Mirror :-

The principal Focus of a convex mirror is the paint on the principal axis of the mirror, From which ray of light incident on the mirror in a direction parallel to the principal axis, appear to diverge, after reflection from the mirror.



Focal length (F) is the distance from pole to principal focus.

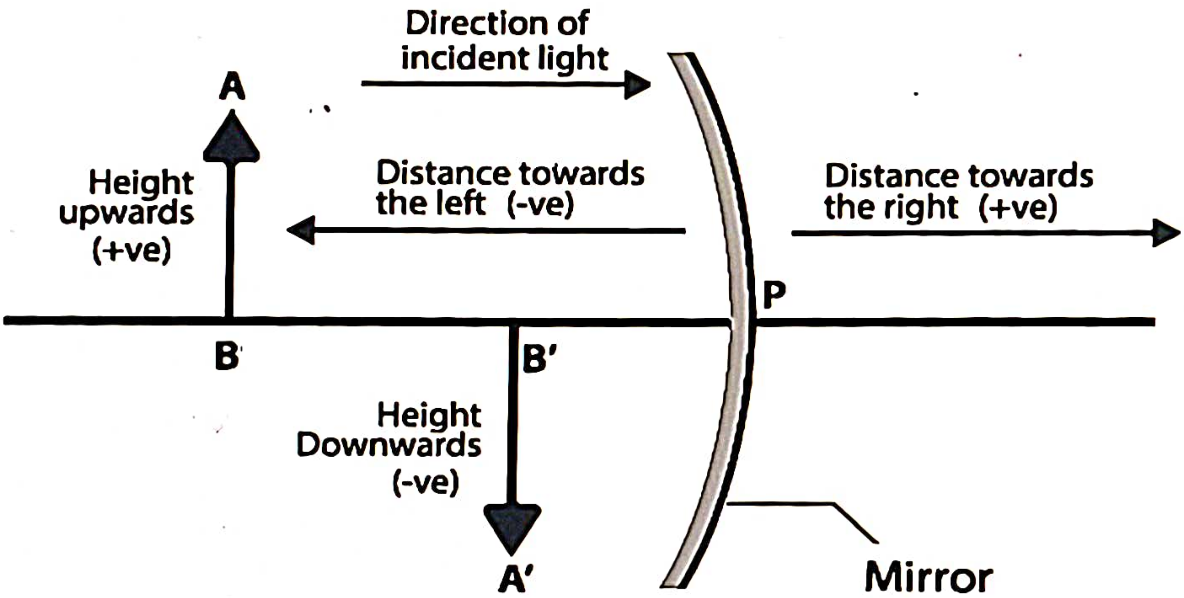
It is also called diverging mirror.

For Both mirrors :-

$$F = \frac{R}{2}$$

F = Focal length
R = Radius of mirror

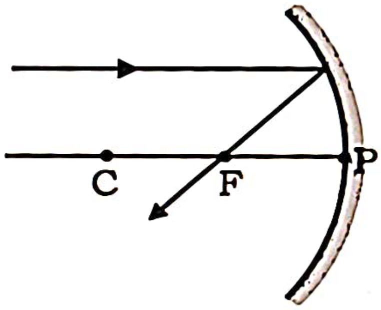
Sign Conventions For Spherical Mirror :-



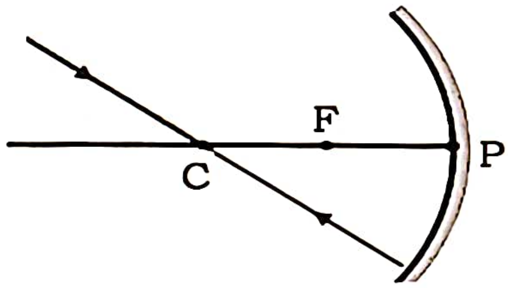
- Principal axis taken along x- axis.
- Pole (P) taken as the origin.
- object is taken on the left side.
- Distance measured in the direction of incident light are taken positive and nagative if direction is opposite.
- Hights upwords side measured positive and measurd downward is nagative.

Rules For Tracing Images By Concave Mirror

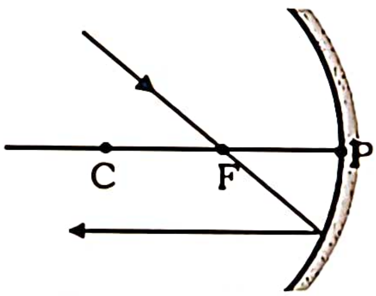
Rule 1 :- A Ray of light falling on a concave Mirror in a direction parallel to the principal axis of the mirror passes actually through the principal focus of the mirror on reflection from the mirror.



Rule 2 :- A ray of light incident on a concave Mirror on passing through center of Curvature of the mirror is reflected back along the same path, such a ray retrace its path in opposite direction.



Rule 3 :- A ray of light incident on a concave mirror on passing through Focus of the Mirror becomes parallel to principal axis of the mirror, on reflection.



Rule 4 :- A ray of light incident obliquely towards the pole P of concave mirror is reflected obliquely as per the low of reflections.

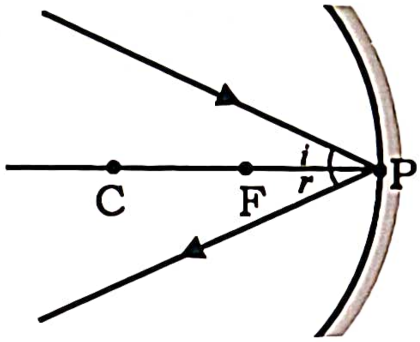
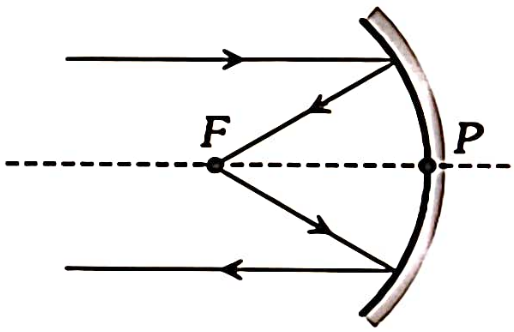


Image Formation By a Concave Mirror Different Position of Objects

Case I :- When the object is at infinity.

Image

- → At F
- → Real
- → Inverted
- → Very small in size



When an object is at a very large distance from a concave mirror it is said to be at infinity. A' B' is the image and this image is

(i) Real and inverted

(ii) Formed at the principal Focus F.

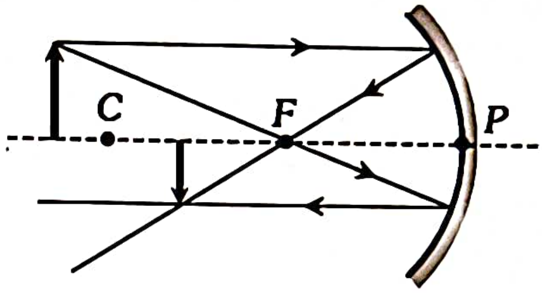
(iii) Much smaller in size than the object.

(iv) used by ENT specialists as a 'head mirror'.

Case II :- When the object is beyond the center of curvature of concave mirror.

Image

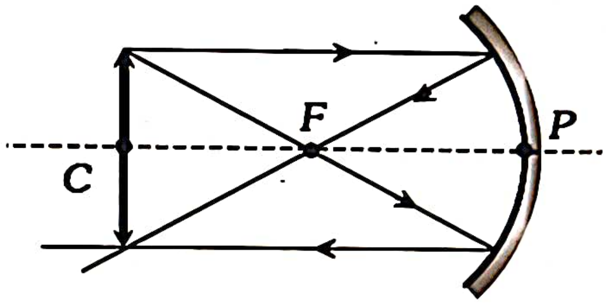
→ Between F and C
→ Real
→ Inverted
→ Small in size



Case III :- When the object is at the center of curvature of concave mirror.

Image

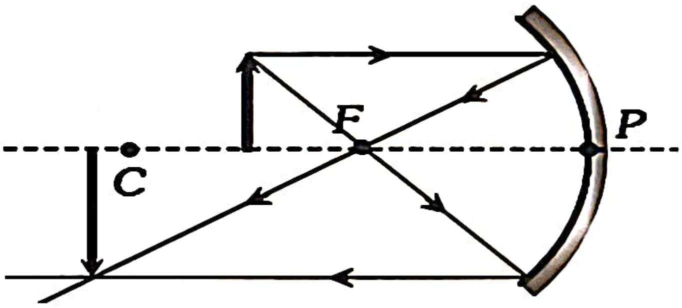
→ At C
→ Real
→ Inverted
→ Equal in size



Case IV :- When the object lie between center of curvature and focus of concave mirror.

Image

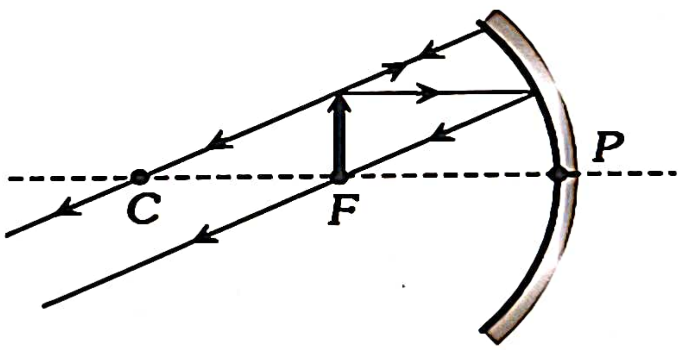
→ Between 2f and ∞
→ Real
→ Inverted
→ Large in size



Case V :- When the object is at the focus of a concave mirror.

Image

→ At ∞
→ Real
→ Inverted
→ Very large in size



* Just Reciprocal case of 1.

Case VI :- When the object is held between focus and pole of the concave mirror.

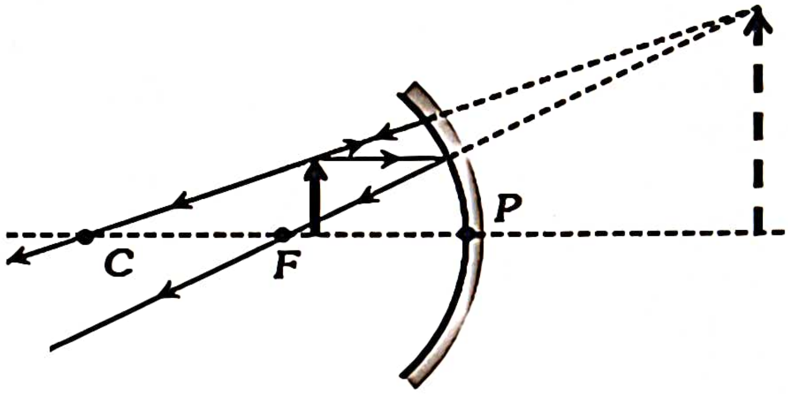
Image

→ Behind the mirror

→ Virtual

→ Erect

→ Large in size



MIRROR FORMULA

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

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

u = Object distance from mirror

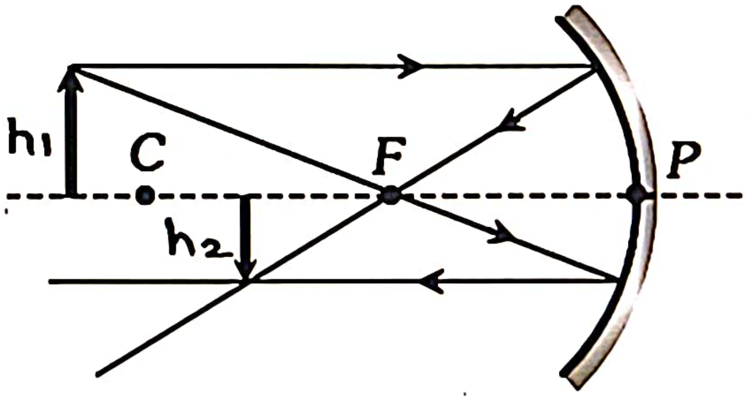
v = Image distance from mirror

f = Focal length

Linear Magnification By A Concave Mirror :-

The linear magnification produced by a concave mirror is defiend as the ratio of hight of the image (h_2) to the height of the object (h_1).

$$m = \frac{h_2}{h_1}$$



- The linear magnification (m) may be m=1, m<1, m>1.
- m may be positive and Negative.

When linear magnification is negative, the image formed by concave mirror must be real and inverted.

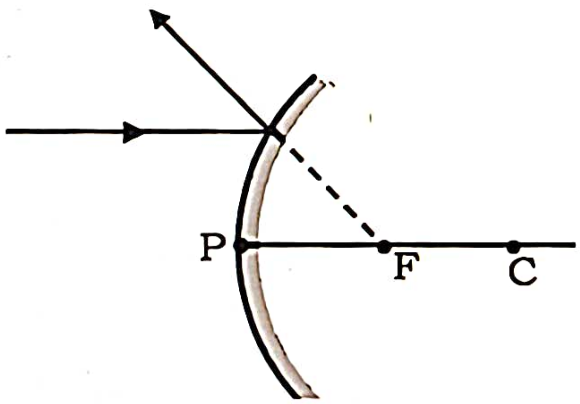
if m is positive, the image formed by concave mirror must be Virtual and erect.

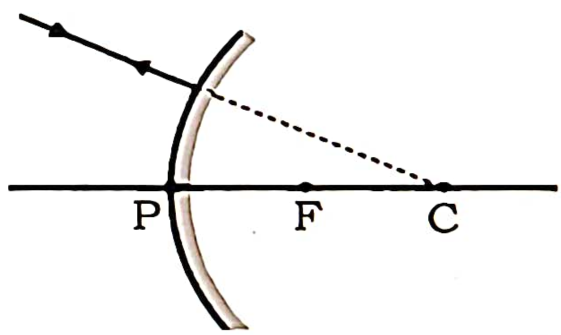
$$m = \frac{h_2}{h_1} = \frac{-v}{u}$$

Rules for tracing images formed by Convex Mirrors:-

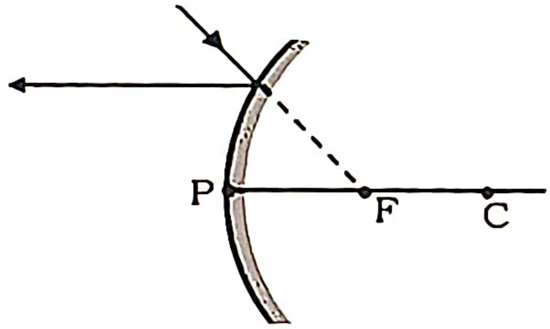
Rule 1:- A Ray of light falling on the mirror in a direction parallel to principal axis of a Convex mirror, appears to be Coming from its focus, on frelecting from the mirror.

Rule 2:- A Ray of light falling on a convex mirror on passing through center of curvature of the mirror is reflected back along the same path, such a Ray retrace its path on reflection.





Rule 3 :- A Ray of light falling on a convex mirror on passing through focus of the mirror, become parallel to the principal axis of the mirror, on reflection.



Rule 4 :- A ray of light incident obliquely towards the pole (P) of a convex mirror is reflected obliquely such that the incident and reflected rays make equal angles with the principal axis.

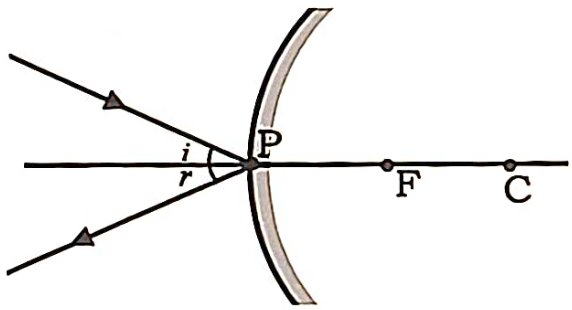
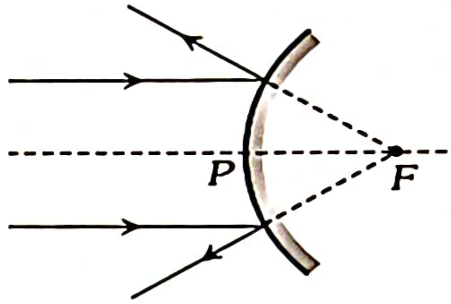


Image Formation By a Convex Mirror :-

Case I :- When the object is at infinity.

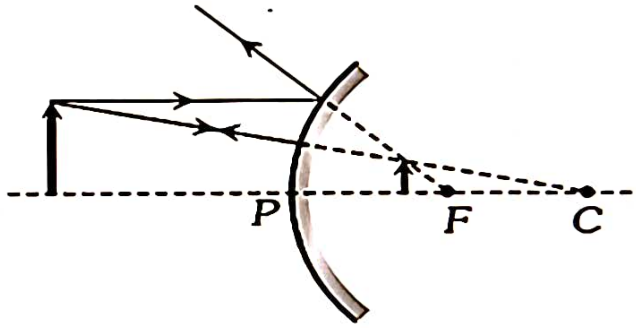
Image
→ At F
→ Virtual
→ Erect
→ Very small in size



- The image is virtual and exect image.
- The image is highly diminished in size.

Case II :- When the object is at finite distance from the mirror.

Image
→ Between P and F
→ Virtual
→ Erect
→ Small in size

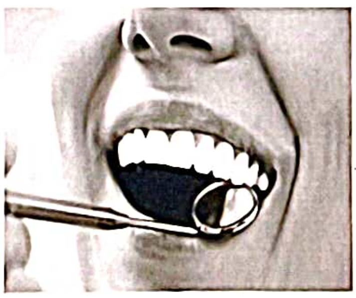


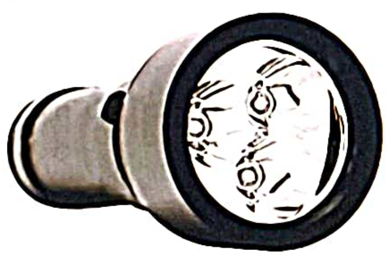
- The image is virtual and erect
- It is diminished (very small)

Uses of Spherical Mirrors

(i) Concav Mirror :-

- It is used as a reflectors in torches, search light, head light of motor vehicles.

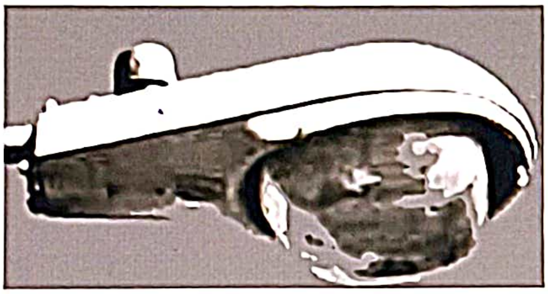




- used as doctor's head mirror.
- used as a shaving mirror.
- used by dentist.
- used in solar cookers.

(ii) <u>Convex Mirror</u> :-

- used as a Reflector in street lamp.
- used by drivers.

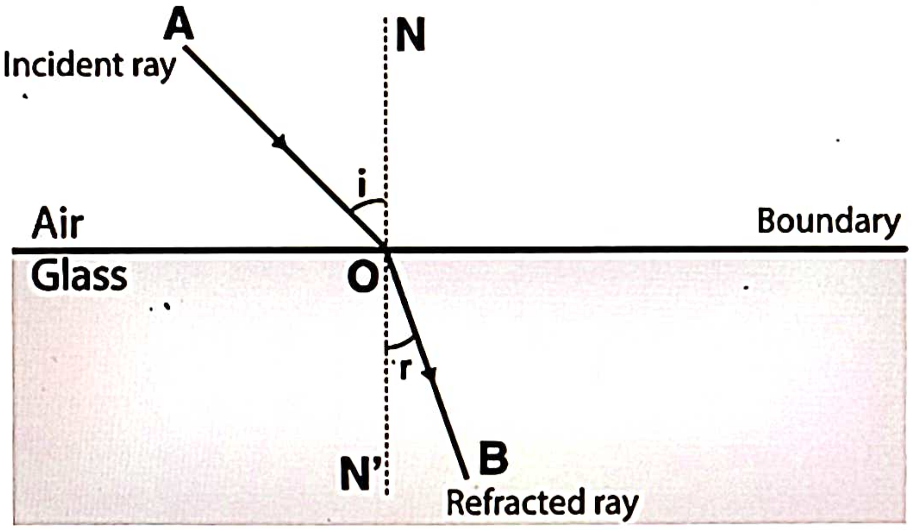


➡ How to distinguished between a plane mirror, Concave & convex mirror without touching them.

- Plane mirror produces virtual, erect image of the same size.
- A concave mirror produce a virtual ereact and magnified image of our face.
- A convex mirror produced a virtual, ereact but diminished image.

Refraction of Light

This phenomenon of change in the path of light in going from one medium to another is called refraction of light. thus refraction of light is the phenomenon of bending of light from its orginal path on entering another medium. the refraction occurrs right at the boundary of the two media.



- AO is called incident Ray.
- OB is called Refracted Ray.
- $\angle AON = i$ angle of incidence.
- $\angle BON' = r$ angle of refraction.

Velocity of light concept of Refractive index of an optical medium:-

- The speed of light in Vaccum is a fundamental. Constant of nature. which is $c = 3 \times 10^8$ m/s
- A transparent substance in which light can travel is called an optical medium.
- Light travels faster in an optically rarer medium and light travels slower in an optically denser medium.

- The refractive index of a medium is defiend as the ratio of speed of light in vaccum to the speed of light in the medium.

$$\text{Refractive index} = \frac{\text{speed of light in vaccum}}{\text{speed of light in medium}}$$

$$\boxed{n = \frac{c}{v}}$$

- A medium with higher value of refractive index is said to be optically denser compared to a medium with lower value of refractive index.
- Note that refractive index is a characteristics property of the medium whose value depends only on nature of material of the medium and the colour or wavelength of light.

Relative Refractive index :-

when light passes from one medium 1 to another medium 2, the refractive index of medium 2 with respect to medium 1 is written as ($^1n_2$) and is called refractive index.

$$^1n_2 = \frac{n_2}{n_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2}$$

$$^1n_2 = \frac{1}{^2n_1}$$

Cause of Refraction :-

The basic cause of refraction is the change in the speed of light in going from one medium to the other.

Laws OF Refraction of Light :-

(i) whenever light goes from one medium to another, The frequency of light does not change. However the Velocity of light and the wavelength of light change.

(ii) The incident Ray, refracted Ray, and normal to the interface of two media at the point of incidence, all lie in the same Plane.

(iii) The product of refractive index and sine of angle of incidence at a point in a medium is constant.

$$n \cdot \sin i = \text{Constant}$$

So $$n_1 \sin i = n_2 \sin r$$

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = {}^1n_2$$

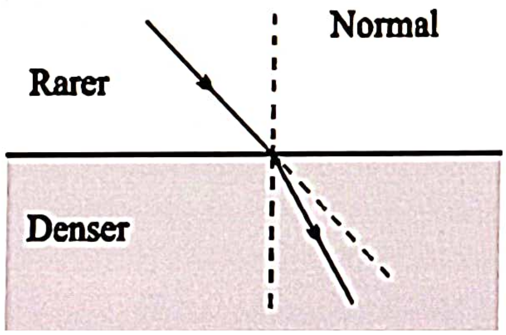
The ratio of sine of angle of incidence to the sine of angle of refraction is constant for the pair of media in contact.

This is called snell's law.

The Direction of Bending of Light

Here we see the two cases :-

Case I :- In going from a rarer to a denser medium.



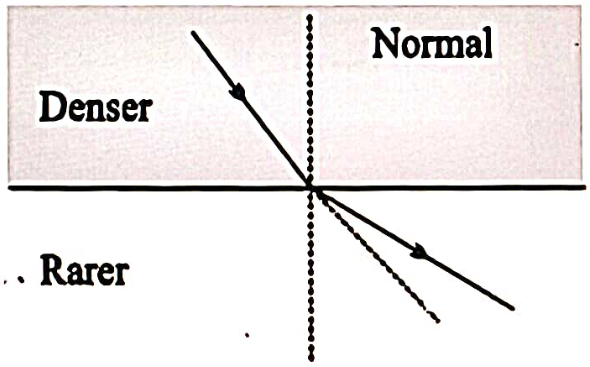
When lights travels from a Rarer to a denser medium. It Bends towards normal at the interface of two media.

According to the snell's law

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} > 1$$

$\sin i > \sin r$ or $i > r$

<u>Case 2 :-</u> In going from a denser to a rarer medium:-



When light travels from a denser to a rarer medium. It bends away from normal to the interface of two media.

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = \frac{n_R}{n_D} < 1$$

$\sin i < \sin r$

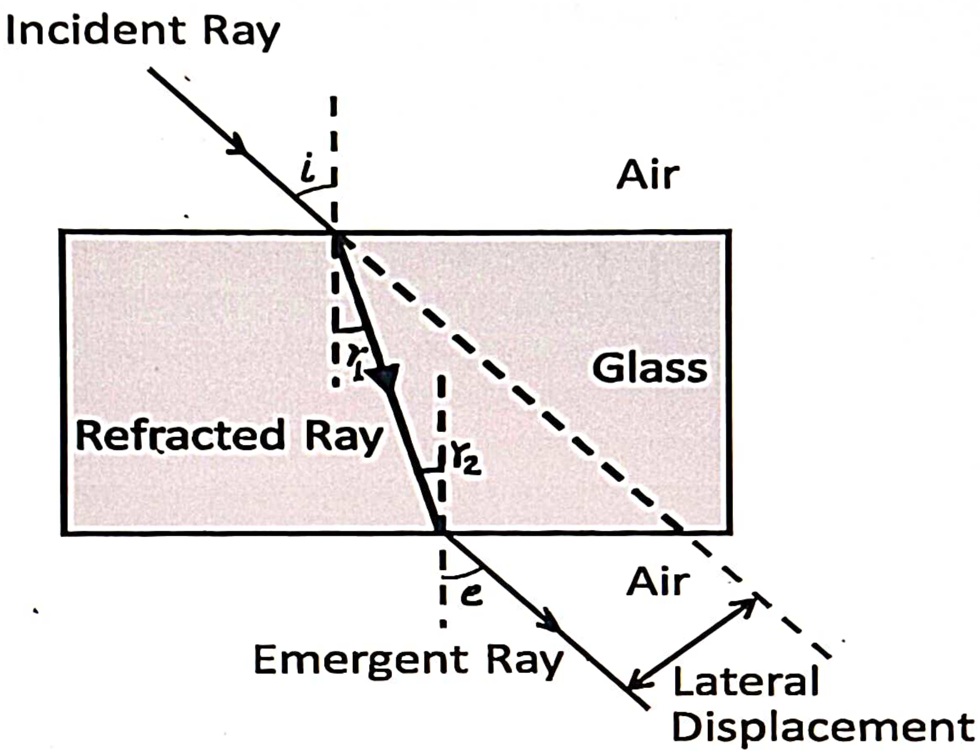
$i < r$

Condition for no Refraction :-

(i) No refraction occurs when light is incident normally on a boundary of two media.

(ii) When both medium have some refractive index. No Refraction occurs at the boundary.

Refraction through A Rectangular Glass Slab :-



By help of this diagram we can see that when a incident Ray enter into glass slab then it turns towards normal becouse of denser medium so according to Snell's low.

$$\frac{\sin i}{\sin r_1} = \frac{n_g}{n_a} \quad \text{— ①}$$

Similarly Ray exit from glass slab

$$\frac{\sin r_2}{\sin e} = \frac{n_a}{n_g} \quad \text{— ②}$$

By eq. ① a ②

$$\boxed{\frac{\sin i}{\sin r_1} = \frac{\sin e}{\sin r_2}}$$

$r_1 = r_2$ So

$$\sin i = \sin e$$
$$i = e$$

SPHERICAL LENSES

A spherical lens is a piece of a transparent refracting Material (usually glass). which is bound by two surfaces often, both the surface of a lens are spherical.

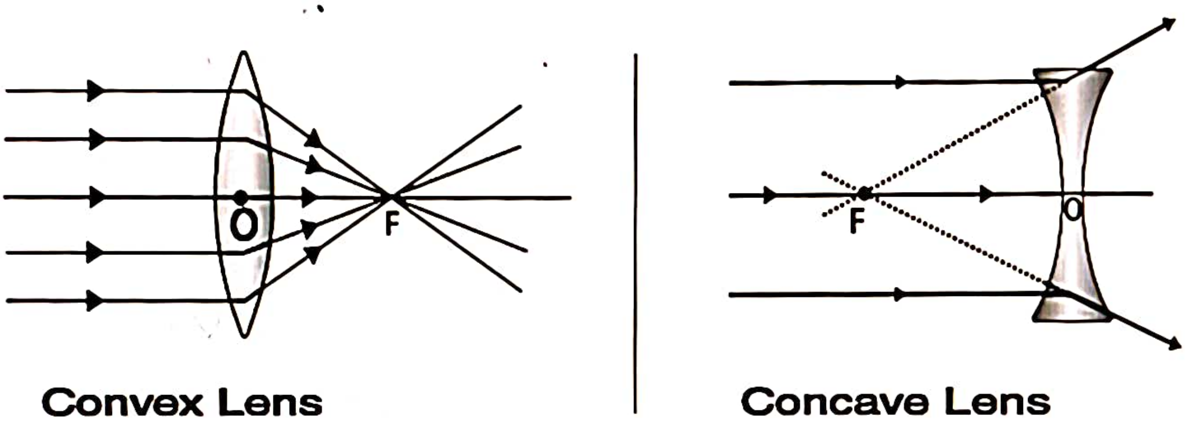
There are of two types

(i) **Convex lens or converging lens :-**

A lens is said to a convex if it is thick at the centre and thin at the edges.

(ii) **Concave or Diverging lens :-**

A lens is thick at the edge and thin at the centre, is Called Concave lens.



Convex Lens　　　　Concave Lens

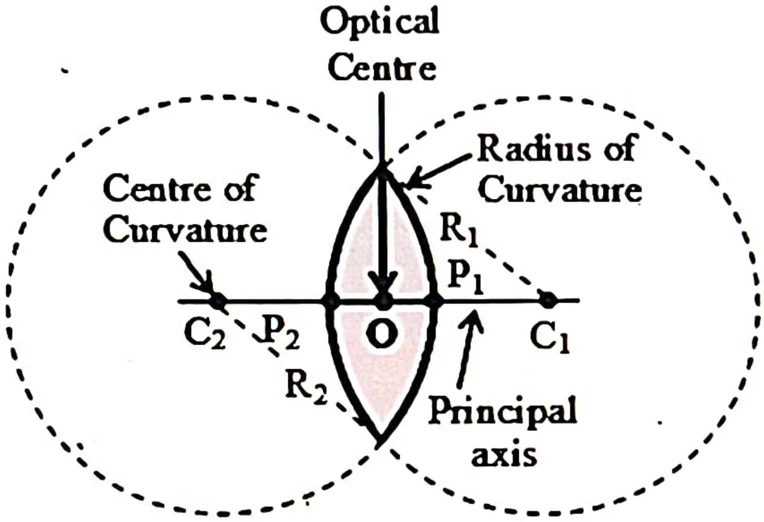
SOME IMPORTANT TERMS :-

(i) **Aperture :-** The aperture of a lens is the diameter of the circular edge of the lens. Represent by AB.

(ii) **Centre of curvatures :-** A lens have two surface a two centres so the centres of sphere are Called Centres of curvatures of the lens.

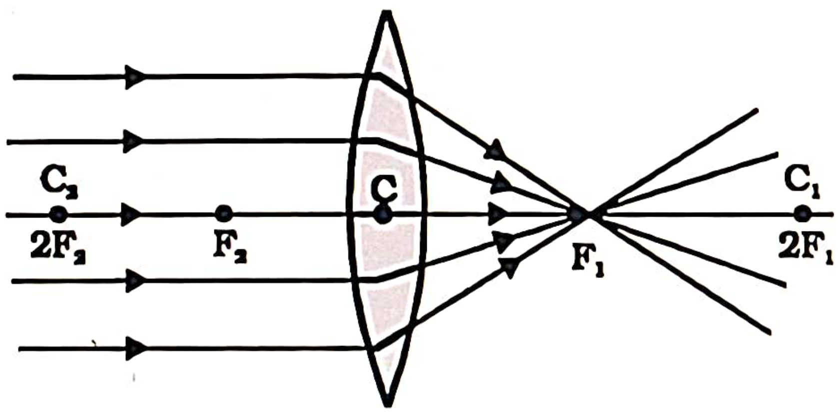
(iii) **Principle axis:-** An imaginary straight line passing through centres of curvature of the two surfaces of the lens is called principal axis of the lens.

(iv) **Optical Centre :-** The optical centre of a lens is a point on the principal axis of the lens, such that a ray of light passing through it goes undeviated.



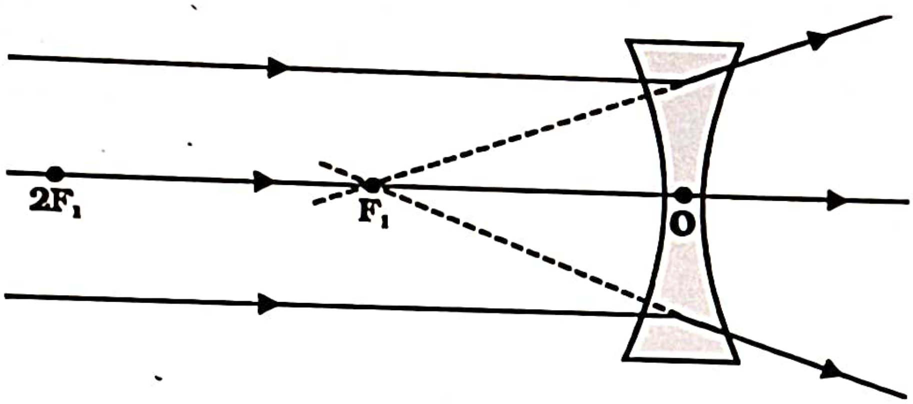
Principal focus and focal length of a Convex lens

- First principal focus of a convex lens is the position of a point object on the principal axis of the lens, for which the image formed by the lens is at infinity.



Distance between F_1 & C is called first focal length (F_1) of convex lens.

Principal focus and focal length of a concave lens



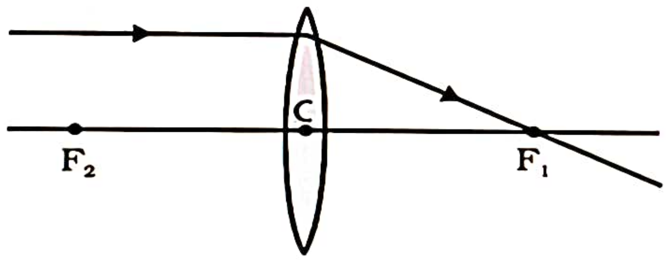
First principal focus is virtual position of a point object on the principal axis, for which the image formed is at infinity.

Distance between C & F_1 called first principal focal length of concave lens F_1.

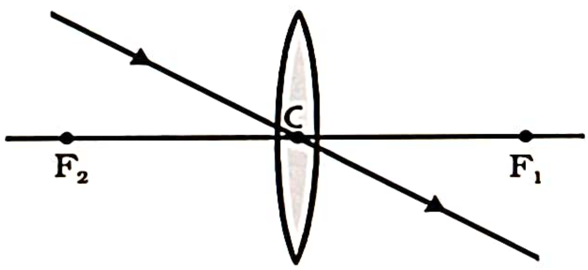
Formation of image by a convex lens :-

To understand this topic you must know about the basic laws of convex lens these are fallowings.

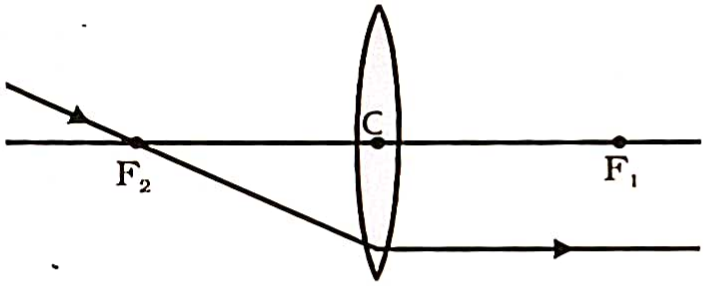
(I) Ray incident on the lens in a direction parallel to the principal axis of convex lens.



(II) Ray passing through C of lens passes straight after refraction through the lens.



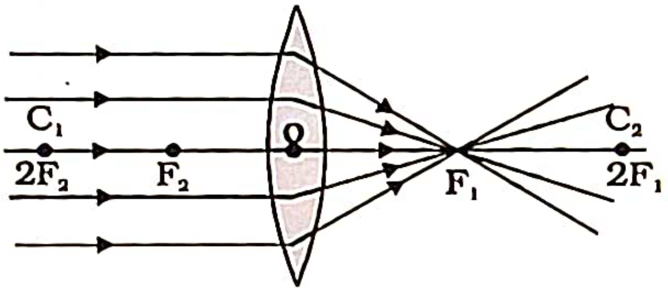
(III) Ray passing through focus, become parallel to the principal axis of the lens, after refraction through the lens.



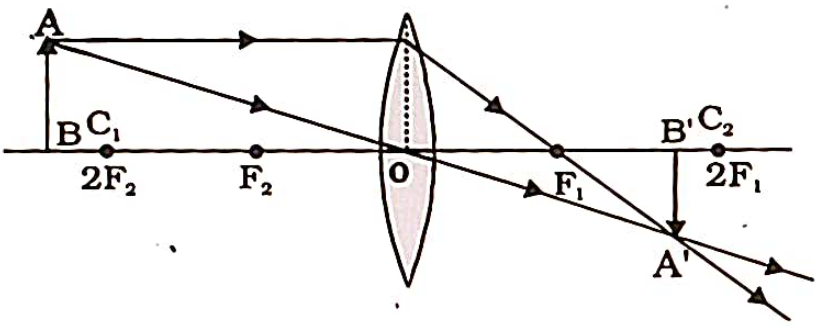
Now by help of the fallowing table we can describe (completely) the charateristics of image-formed by a convex lens.

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished, point-sized	Real and inverted
Beyond $2F_2$	Between F_1 and $2F_1$	Diminished	Real and inverted
At $2F_2$	At $2F_1$	Same size	Real and inverted
Between F_2 and $2F_2$	Beyond $2F_1$	Enlarged	Real and inverted
At focus F_2	At infinity	Infinitely large or highly enlarged	Real and inverted
Between focus F_2 and optical centre O	On the same side of the lens as the object	Enlarged	Virtual and erect

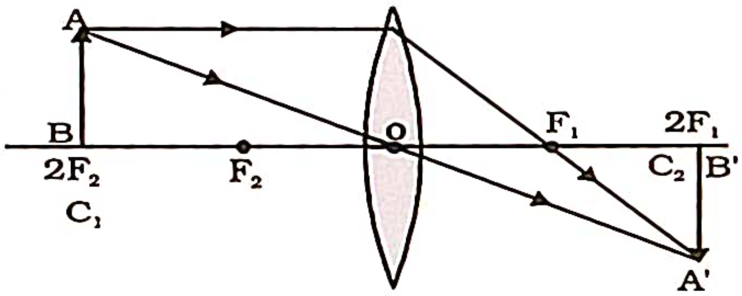
Case I :- When the object is at infinity.



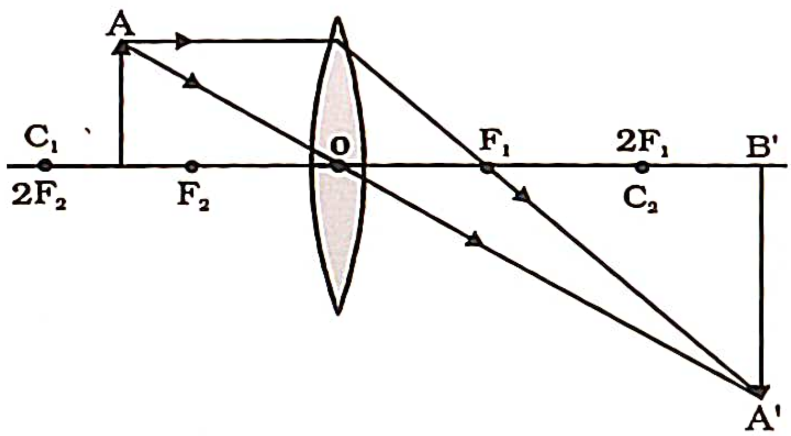
Case II :- When the object is held beyond $2F_2$



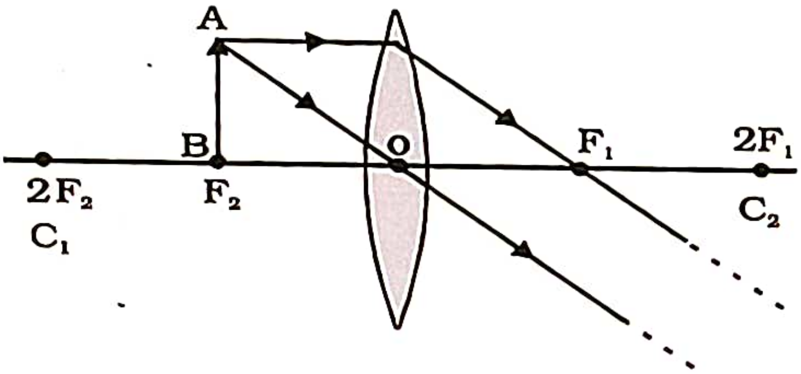
Case III :- When the object is held at $2F_2$



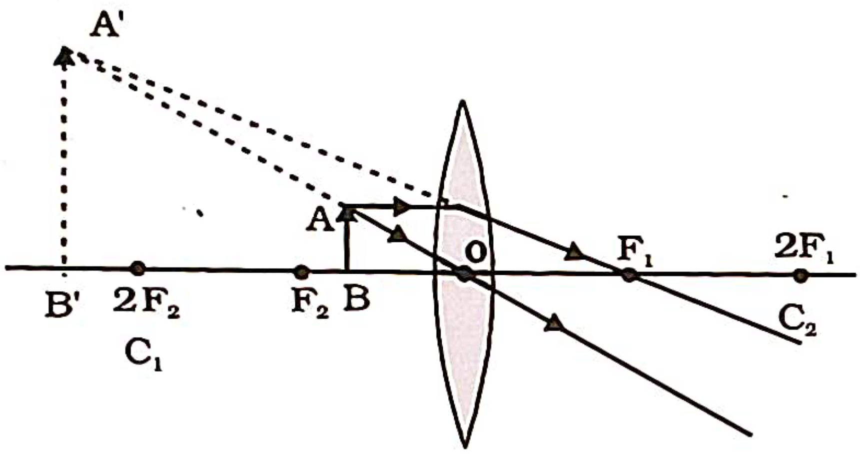
Case IV :- When the object is held between F_2 and $2F_2$



Case V :- When the object is at F_2



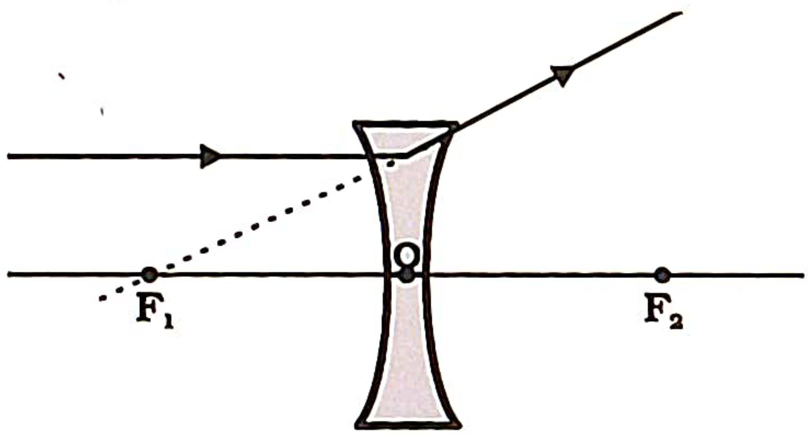
Case VI :- When the object is between O and F_2



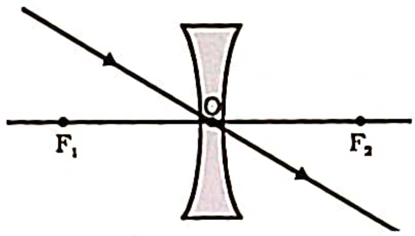
Formation of image By a Concave Lens :-

Here we see the three low for understand the formation of image.

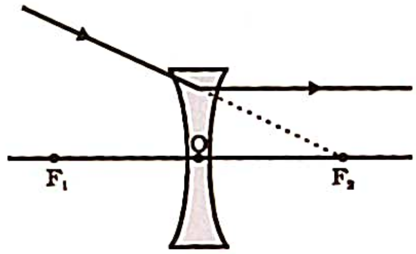
- A Ray incident in a direction parallel to principal axis on refraction this ray appears to come from principal focus of concave.



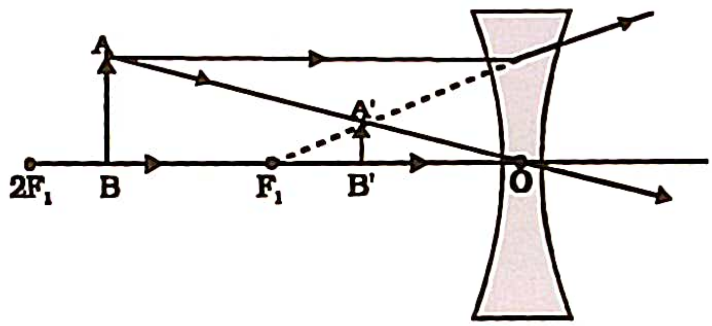
- A Ray passing through optical centre of concave lens, passes straight after refraction through the lens.



- A Ray of light appearing to meat at the principal focus, after refraction emerge parallel to the principal axis of the lens.



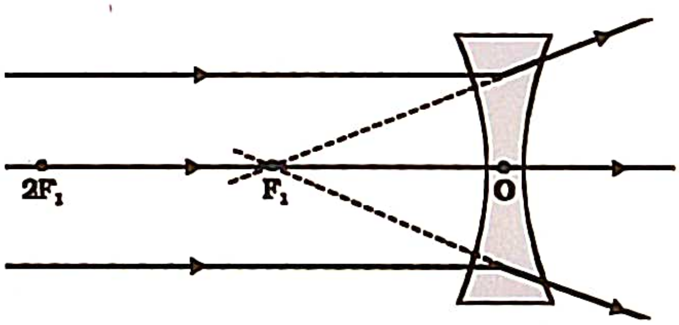
Case I :- When the object lie between optical center and infinity.



Here the image formed is -

- Virtual and erect
- Smaller in size than the object
- between O and F_2

Case II :- When the object is at infinity



The image formed is -

- Virtual and erect
- Smaller than object
- At principal focus F_2

LENS FORMULA

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

v = image distance
u = object distance
f = focal length of a lens

Liner Magnification Produced By Lens :-

The liner magnification produced by a lens is defined as the ratio of size of the image (I) as formed By refraction through the lens to the size of the object (O).

$$m = \frac{I}{O} = \frac{h_2}{h_1}$$

- For convex lens

$$m > = < 1$$

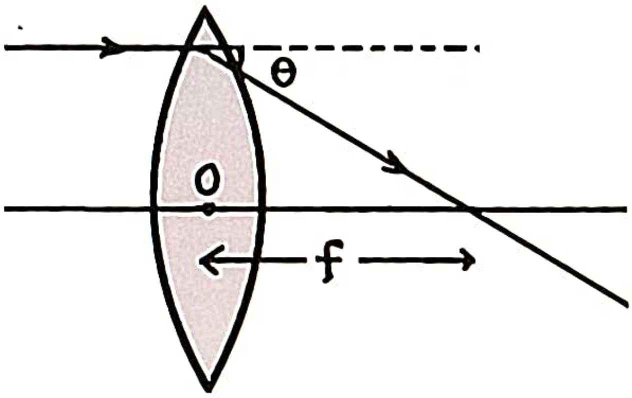
- For concave

$$m < 1$$

POWER OF A LENS :-

- Power of a lens is defiend as the ability of the lens to converge the rays of light falling on it.

- Power of a lens is given by reciprocal of focal length.

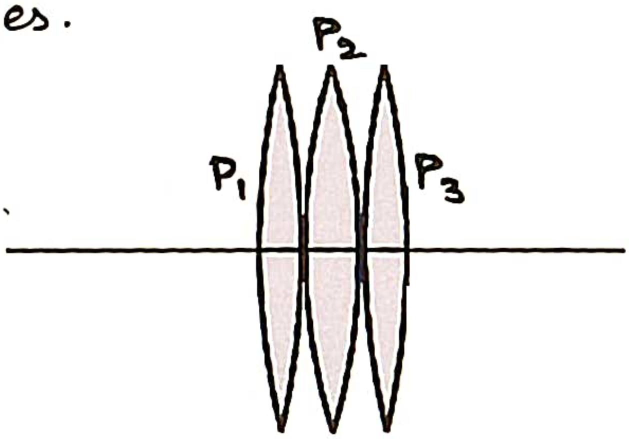


$$P\,(\text{dioptre}) = \frac{1}{f\,(\text{metre})}$$

- A convex lens coverage the ray of light falling on it, power of a convex lens is said to be positive. while a concave lens diverge the ray so power of a concave lens is said to be nagative

- One dioptre is the power of a lens of focal length one metre.

- When a no. of thin lenses are placed in contact with one another, the power of the combination is equal to algebric sum of the powers of individual lenses.



$$P = P_1 + P_2 + P_3 + \ldots\ldots$$

UNIT - Light Reflection & Refraction
Assignment - I

Q.1 A child runs toward a plan mirror with a velocity of 2 m/s. With what speed will her image move towards her?

(A) 2 m/s (B) zero

(C) 4 m/s (D) none of the above

Q.2 The focal length of a concave mirror that produces four time larger real image of an object held at 5 cm from the mirror is

(A) – 20 cm (B) – 4 cm

(C) 20 cm (D) 5 cm

Q.3 What is mirror formula

Q.4 What is source, medium and Ray and their classification.

Q.5 Define reflection of light and also explain law of reflection of light.

Q.6 Explain concave and convex mirror also explain principal focus and focal length for both with suitable diagram?

Q.7 Explain 4 Rules for tracing images formed by concave Mirrors and 2 rules for convex mirror with suitable diagram?

Q.8 Draw the images which is formed by a concave and convex mirror in different positions of the object.

Q.9 An object 4 cm. in size is placed at a distance of 25 cm from a concave mirror of focal length 15 cm. Find the position, Nature and hight of the image.

Q.10 A 4.5 cm. needle is placed 12 cm away from a Convex Mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror.

Q.11 A convex mirror used for near view on an automobile has a redius of curvature of 3.00 m. If a bus is located at 5.00 m from this mirror, find the position, nature and magnification of the image.

Q.12 A Arrow 2.5 cm. high is placed at a distance of 25 cm from a diverging mirror of focal length 20 cm. Find the nature, position and size of the image formed.

UNIT - Light Reflection & Refraction
Assignment - II

Q.1 Define the refraction of light with suitable diagram.

Q.2 Explain absolute refractive Index and Relative Refractive index, also explain their formula.

Q.3 Describe the laws of Refraction of light?

Q.4 With the help of diagram, explain the direction of bending of light.

Q.5 Explain the Refraction through a rectangular glass Slab.

Q.6 Explain principal focus and focal length of a convex lens.

Q.7 Explain the formation of images by a convex lens.

Q.8 Define power of a lens.

Q.9 A concave lens has focal length of 15 cm. at what distance should an object from the lens be placed so that it formed an image at 10 cm. from the lens. also find the magnification of the lens.

Q.10 A convex lens of focal length 20 cm. is placed in contact with a concave lens of focal length 10 cm. What is the focal length and power of the combination.