-REFLECTION OF LIGHT:

BASIC CONCEPT: Light is a form of energy like other forms of energies i.e heat, sound, electricity and mechanical etc. It travels in a medium inform of beams or rays .It exhibits both particles and wave nature while travelling or propagating through a medium. One of the important characteristics of light rays is that it follows a rectilinear path or straight line path while travelling through a medium. The medium may air, water, glass or vacuum etc. The evidence for it is the formation of sharp shadows of an opaque object if the source light is small.

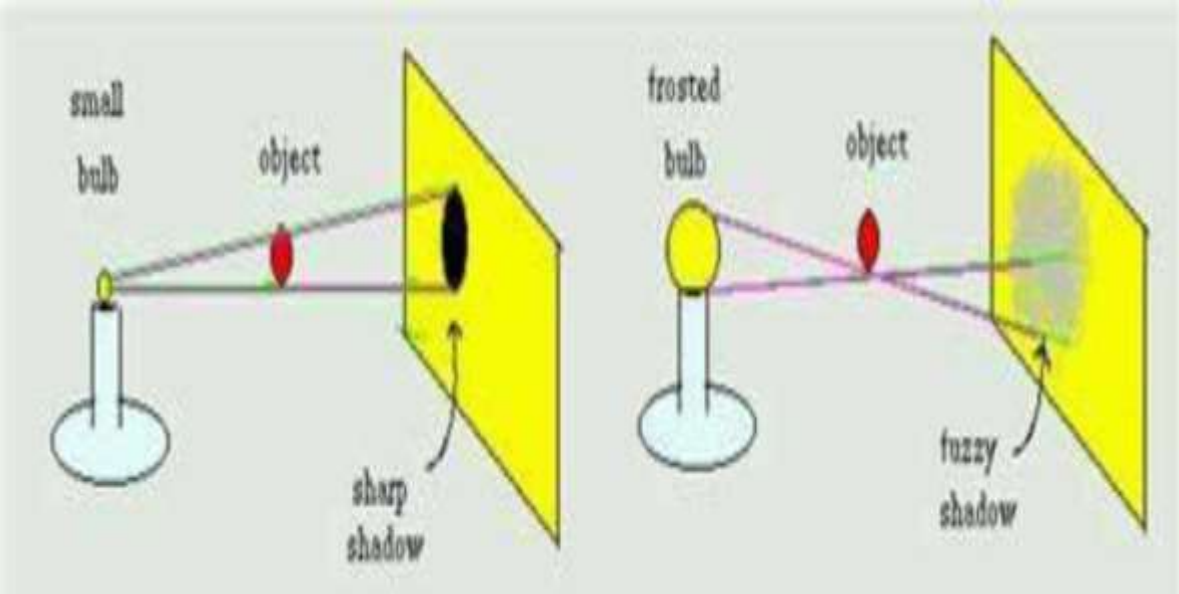


Fig-1

PROPERTIES OF LIGHT: Light exhibits different properties like reflection, refraction, diffraction and polarization etc. Here, we shall mainly study two important properties like REFLECTION and REFRACTION.

Definition: A light ray while travelling in a straight line path in a medium falls on a smooth, polished and opaque surface is bounced back to the same medium. This property of light is known as reflection.

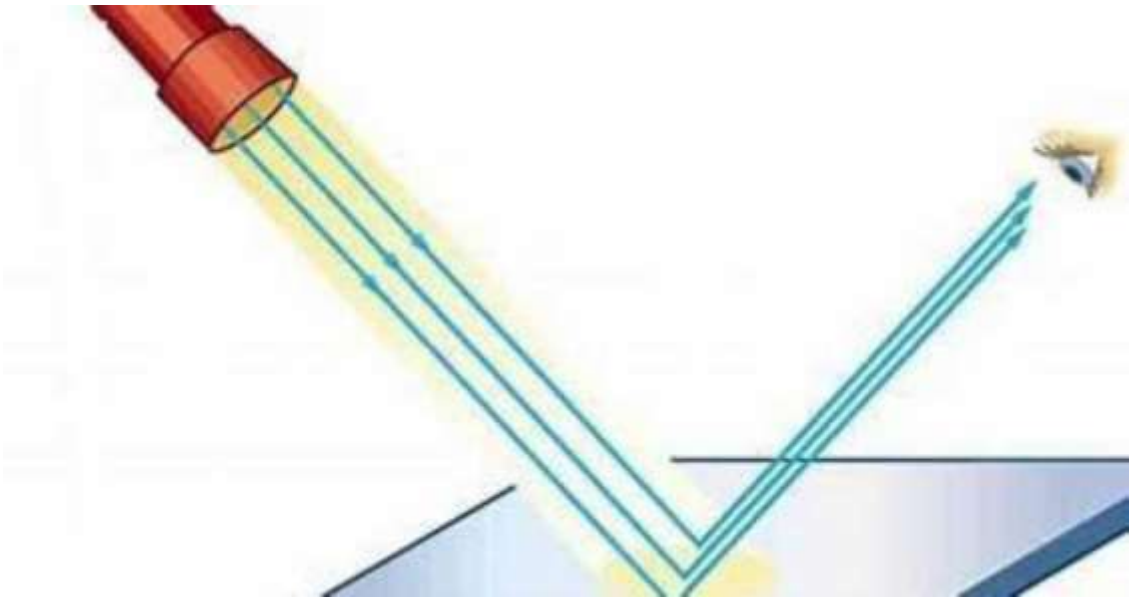


Fig-2

Laws of reflection: There are two laws of reflection.

i) The angle of incidence is equal to angle of reflection.

ii) The incident ray, the normal to the reflecting surface at the point of incidence and reflected ray all lie in the same plane

Plane Reflecting Surface(Plane Mirror):

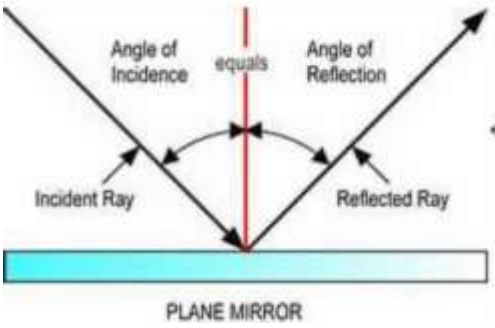


Fig-3

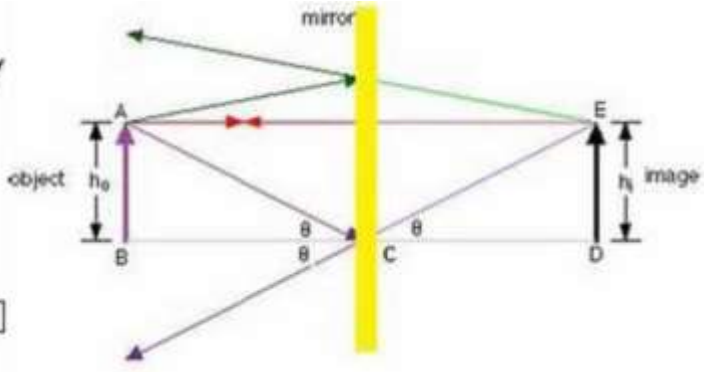


Fig-4

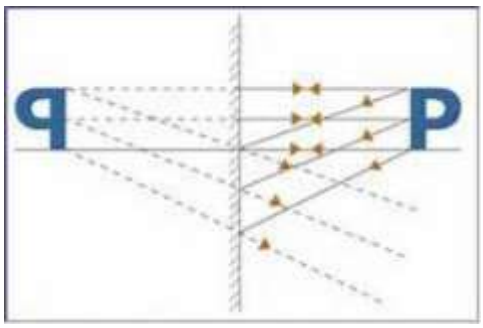


Fig-5

Explanation:

a) Incident ray-The ray of light from the source of light falling on the reflecting surface at the point of incidence is known as incident ray.

b) Reflected ray- The ray of light which bounces back to the same medium after reflection at the point of incidence of the reflecting surface is known as reflected ray.

c) Point of incidence: The point at which incident ray falls on the reflecting surface.

d) Reflecting surface: The smooth, polished and opaque surface on which reflection takes place is known as reflecting surface.

e) Angle of incidence-It is the angle made by the incident ray with the normal drawn at the point of incidence.

f) Angle of reflection-It is the angle made by the reflected ray with the normal drawn at the point incidence.

The image formed by a plane reflecting surface or a plane mirror possess following properties

i) Virtual,
ii) Erect
iii) Object Size=Image Size
iv) Object distance=Image distance

The image is formed in opposite side of the object .Virtual images are unreal images which cannot be captured by a screen. Lateral

inversion of the image also takes place. For better explanation refer fig- and fig-3

The laws of reflection is applicable for all types of reflecting surfaces whether plane or curved reflecting surfaces. The most commonly used curved reflecting surfaces are Spherical Mirrors.

REFLECTION IN SPHERICAL MIRRORS:

Spherical mirrors are of two types-

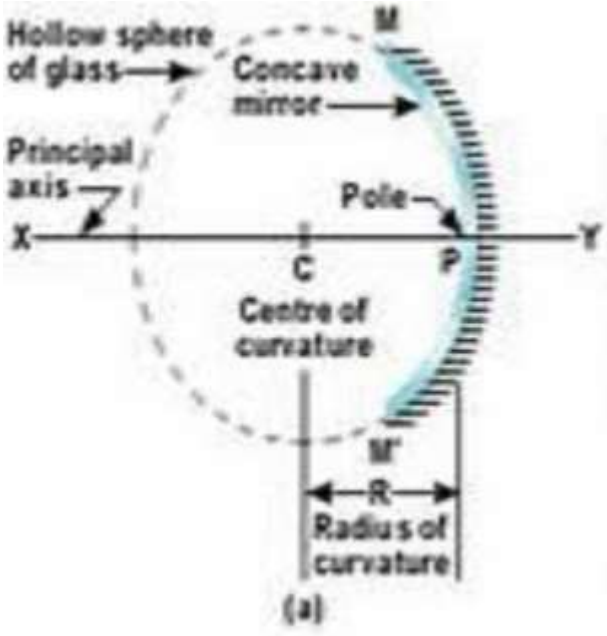


Fig-6

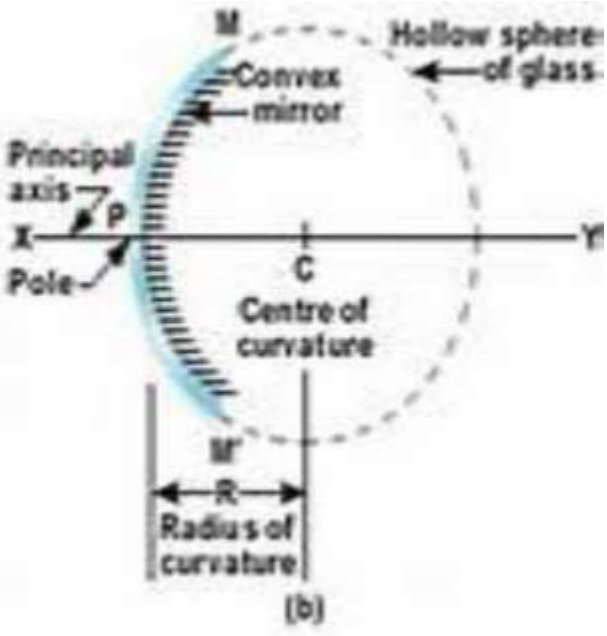
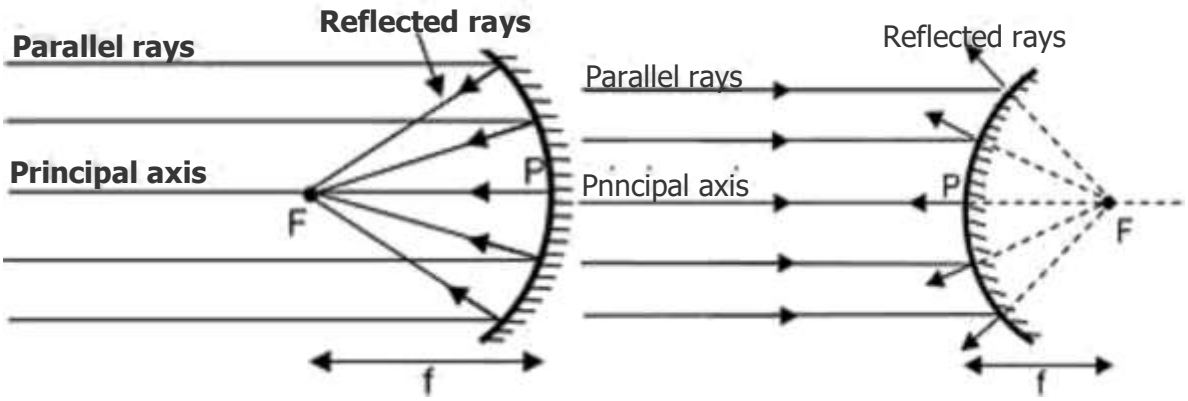


Fig-7



i) Concave mirror: A spherical mirror whose reflecting surface is curved inward is called concave mirror

ii) Convex Mirror: A spherical mirror whose reflecting surface is curved outward is called convex mirror

Important terms connected with spherical mirrors:

Pole(P): Pole of the spherical mirror is the centre of its reflecting surfaces which lies on it. It commonly denoted by letter 'P' .

Centre of Curvature(C):It is the centre of the sphere of which the reflecting surface is the part of the spherical mirror. It is denoted by the letter'C'

It is not the part of the spherical mirror. It lies in front of reflecting surface in case of concave mirror and opposite to the reflecting surface in case of convex mirror .

Radius of Curvature(R): It is the radius of sphere of which the reflecting surface is the part of the spherical mirror. It is denoted by the letter 'R'.

Principal Axis (PC):It is the straight line passing through the pole and the centre of curvature of the spherical mirror.

Principal Focus (F): When light rays parallel principal axis are incident on the reflecting surface of the spherical mirror is concentrated

at a point or appears to be concentrated at a point on the principal axis. This is known as principal focus of the spherical mirror.

Focal Length(f):The distance between the pole and principal focus of the spherical mirror is called focal length(f).

Aperture: The diameter of circular outline of the reflecting surface of the spherical mirror is known as aperture of the spherical mirror (MN)

For better explanations of the above terms refer fig-5&6

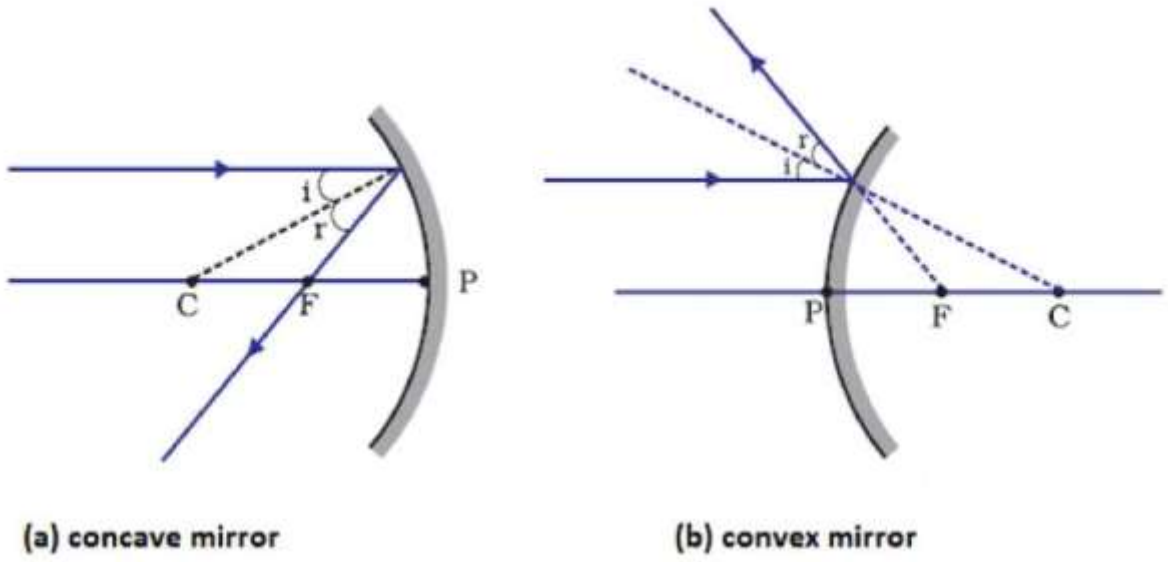
IMAGE FORMATION BY SPHERICAL MIRRORS:

The nature, position and the size of the image formed by the spherical mirror depends on the position of the objects with respect to pole (P).focus (F) and the centre of curvature(C) by strictly obeying the laws of reflection.

Infinite number of rays originates from each point of the object placed before the spherical mirror. For simplicity and clarity of the ray diagram for explanation of image formation, at least two rays are chosen whose reflected rays with intersection forms a point image of a point object. The ray diagram of specific cases of incident rays for spherical mirror is given for further explanation of image diagrams of the objects in their relative positions. Rules for obtaining images formed by spherical mirrors

(1) Rule 1

A ray of light which is parallel to the principle axis of the mirror passes through its focus after reflection from the mirror as shown below in the figure

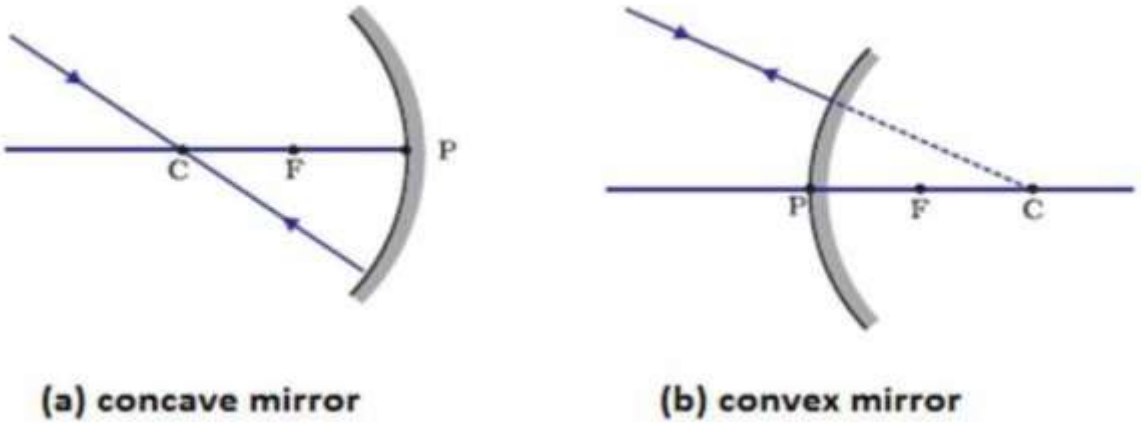


(a) concave mirror (b) convex mirror

From the figure given above it can be clearly seen that the light rays passes through principal focus in case of concave mirrors and appears to diverge from principal focus in case of concave mirror.

(2) Rule 2

A ray of light passing through the center of curvature of the curvature of the concave mirror or directed in the direction of the center of curvature of a convex mirror, is reflected back along the same path as shown below in the figure



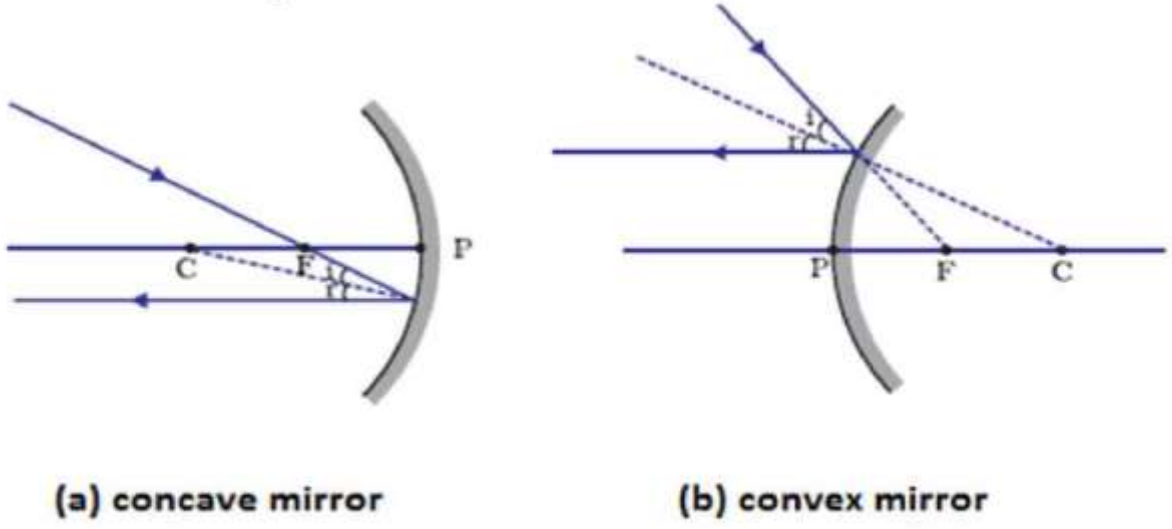
(a) concave mirror (b) convex mirror

This happens because the incident rays fall on the mirror along the normal to the reflecting surface.

(3) Rule 3

A ray passing through principle focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, becomes parallel to the principle axis after

reflection and is shown below in the figure

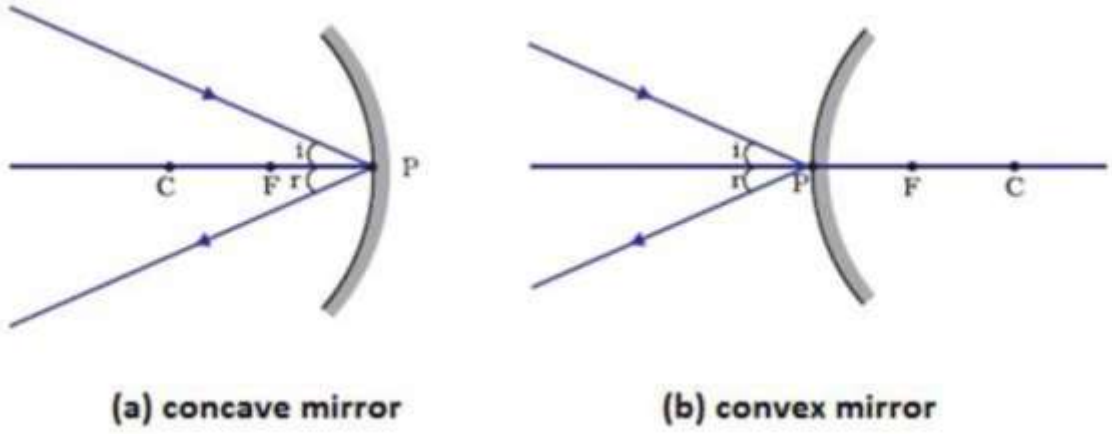


(a) concave mirror (b) convex mirror

(4) Rule 4

A ray incident obliquely to the principal axis, towards a point P (pole of the mirror), on the concave mirror or a convex mirror, is reflected obliquely. The incident and reflected rays follow the laws of reflection at the point of incidence (point P), making equal angles with the principal axis and is shown below in the

figure



(a) concave mirror (b) convex mirror

Image formation in Concave Mirrors-The

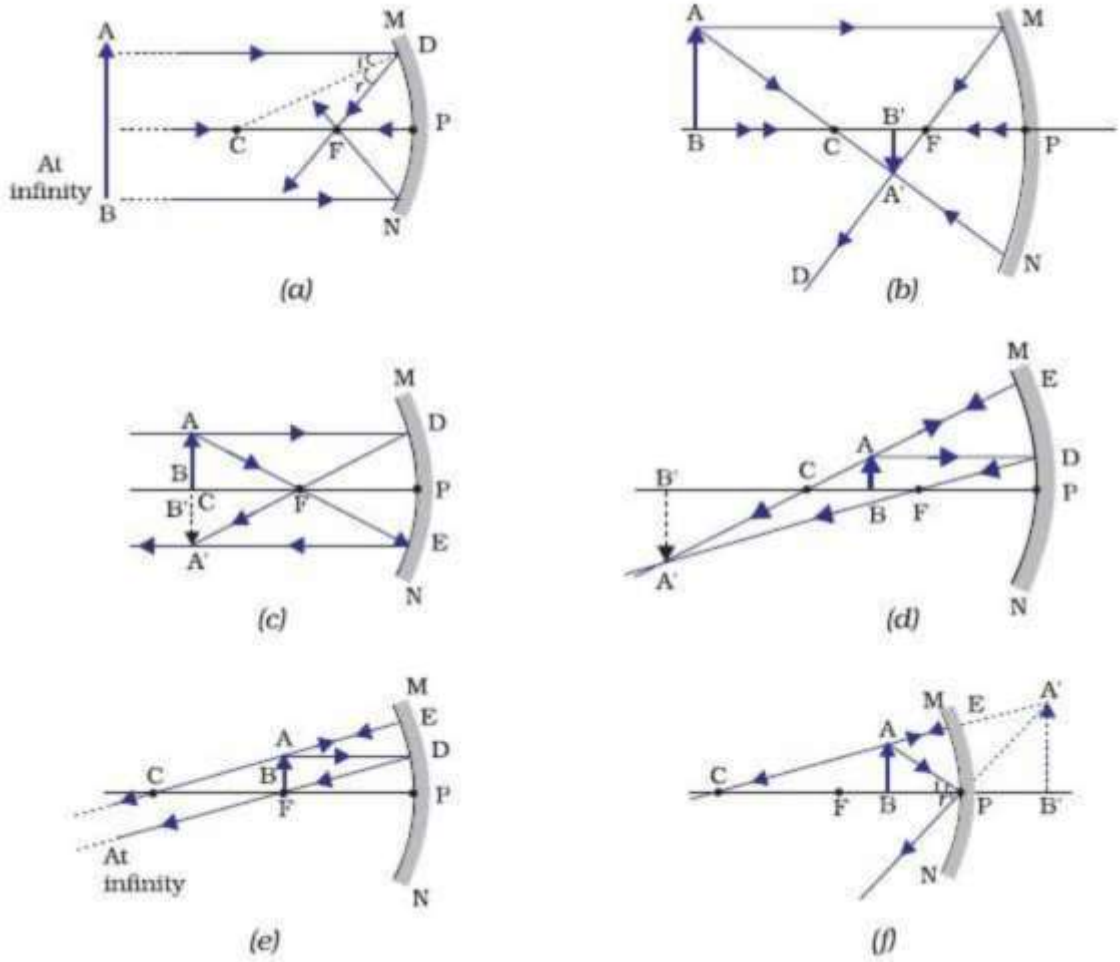
different positions of the object (AB) are as follows

i) Object is at infinity: If the object is at infinity, the rays AM and BN are parallel to the principal axis and after reflection pass through the principal focus of the concave mirror ,so image formed at focus is point size and real.

ii) Object is beyond the centre of curvature(C):A ray (AM)parallel to principal axis from the

object passes through the focus (F)and. Similarly, the image of the bottom B of the of the object is formed at B'. Hence A'B' is the required image of the object. It is formed between focus (F) and centre of curvature(C),real, inverted and diminished.

iii)Object is at centre of curvature(C):A ray(AD) from tip A of the object parallel to the principal axis after reflection passes through the focus of the concave mirror and another ray (AE) passing through focus reflected back parallel to principal axis. The two rays meet at point A' as shown in figure. Similarly,the image of bottom B of the object is formed at B'. Hence, A'B' is the required image of the object.The image is formed exactly at centre of curvature, same size, Inverted and real.



iv)Object is in between centre of curvature(c) and focus(F):A ray(AM) from the tip A of the object falls at the point M of the reflecting surface and reflected back along the same line through centre of curvature(C) and another parallel ray(AD) after reflection at D of the

reflecting surface reflected along the focus. The two rays after reflection meet at point A'. Similarly, the image of the bottom 'B' formed at B' as shown in figure. Hence, A'B' is the required image. it is formed between centre of curvature and infinity distance. The image is inverted, enlarged and real.

v) Object is at focus(F):The two incident rays(AD&AM) from the tip A of the object(AB)becomes parallel, image so formed inverted and highly enlarged and real.

vi) Object is in between focus (F) and pole (P):A ray(AM) from tip A of the object AB falls at M of the reflecting surface and reflected back through centre of curvature (C) and another ray (AP) falls at pole P and reflected back making equal angle with principal axis. The two reflected rays diverge from each other and

appears to converge at a point in the opposite side of the concave mirror

SUMMARY:

Object position	Image position	Size of image	Nature of image
At Infinity	Focus(F)	Point sized	Real
Beyond C	Between F and C	Small	Real and Inverted
At C	AtC	Same as that of the object	Real and Inverted
Between C .md F	Behind C	Enlarged	Real and Inverted
At F	At infinity	Highly enlarged	Real and Inverted
Between F and P	Behind mirror	Enlarged	Virtual and erect

Uses of concave mirrors: Some of the practical applications are as follows,

i) It is used in torches, search lights and vehicle head lights for powerful parallel beams of lights.

ii) It is used as shaving mirror to see large image of the face.

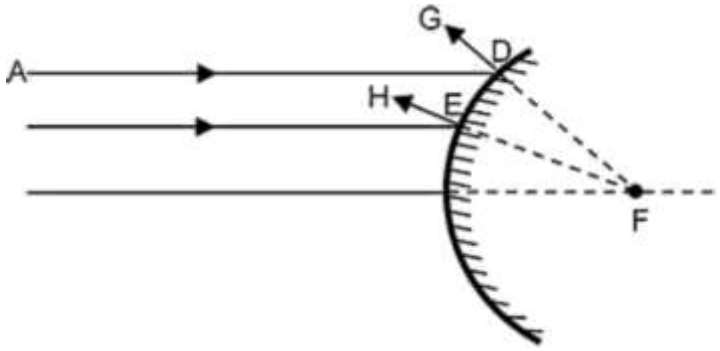
iii) It used by Dentist to see large image of teeth of the patients.

iv)It is used in solar furnaces to produce heat by concentrating sunlight.

Image formation in convex mirror: The image formed in a convex mirror is always virtual and erect, whatever be the position of the object may be.

1. When the object is placed at infinity

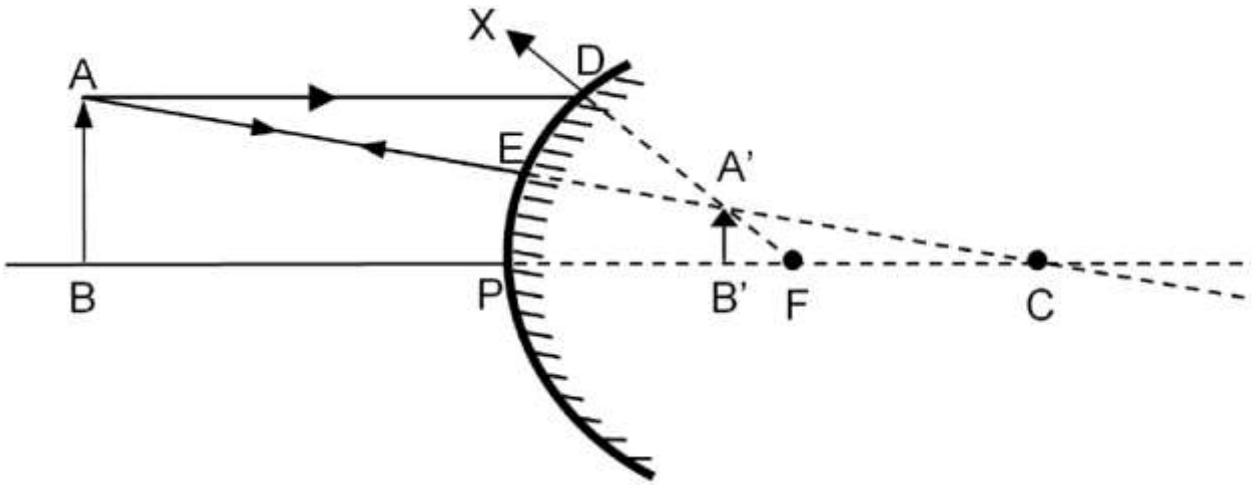
When the object is placed at infinity, the two rays AD and BE which run parallel to the principal axis gets diverged in the directions DG and EH respectively after getting reflected from the convex mirror. When the diverged rays DG and EH are extended backwards, they intersect each other at the principal focus F.



Therefore, in convex mirror if the object is present at infinity then the image is formed behind the mirror at the principal focus, which is highly diminished, virtual and erect.

2. When the object is placed anywhere between pole and infinity:

If the object is placed anywhere between the pole and infinity, a ray of light AD starting from point A of the object which travels parallel to the principal axis gets reflected along DX. On producing back, DX appears to come from F. another ray AE from point A of the object which go towards the centre of curvature is reflected back along EA.



These two reflected rays i.e. DX and EA are diverging rays and appears to intersect each other at point A' when produced back. So in this case the image is formed behind the mirror, between the pole and the principal focus, which is diminished, virtual and erect**. SUMMARY:**

SL No	Position of object	Position of image	Size of Image	Nature of image
1	Infinity	Focus F behind the mirror	Highly Diminished	Virtual and Erect
2	Between infinity and pole P	Between pole P and focus F	Diminished	Virtual and Erect

Uses of convex Mirror: It is used as rear view mirrors in vehicles enabling for safe driving of the vehicle.

Sign Convention for Reflection in Spherical Mirror:

We follow a set of sign convention for reflection in spherical mirrors. This is known as New Cartesian Sign Convention. In this convention, Pole(P) of the spherical mirror is taken as origin and the principal axis is taken as X-axis.

i) The object is always placed to the left of the mirror and light falls on the mirror from left hand side.

ii) All distances parallel to the principal axis are measured from the pole of the mirror.

iii) All distances measured right from the origin are taken as positive and left from the origin is taken as negative

iv) All perpendicular distances(Y-Axis) measured above the principal axis is taken as positive and

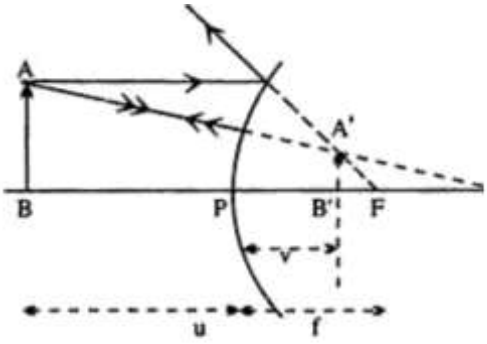
that measured below the principal axis taken as negative.

Mirror Formula for image formation in Spherical Mirror:

Let u- Object distance: It is distance between pole (P) and the object

v- Image distance: It is the distance between pole (P) and the image

f- Focal length: It is the distance from pole of the mirror to focus of mirror.



The relationship between object distance(u),image distance(v) and focal length(f) of the spherical mirror is known as mirror formula.

It is expressed as 1/u+1/v=1/f

While solving numerical problems related to spherical mirrors, we should use New Cartesian Sign Convention.

Magnification: The magnification of image in spherical mirror is the relative extent of magnification of an image size with respect to object size. It is expressed as ratio of height of image to height of the object. The magnification of the image is usually represented by ' m'

Let Height of the object=AB=h Height of the image=A'B'=h'

$$m=h'/h$$

The magnification of the image in spherical mirror may be related to object distance distance(u) and image distance (v)

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

The negative sign of magnification is for real images and positive sign for virtual images.