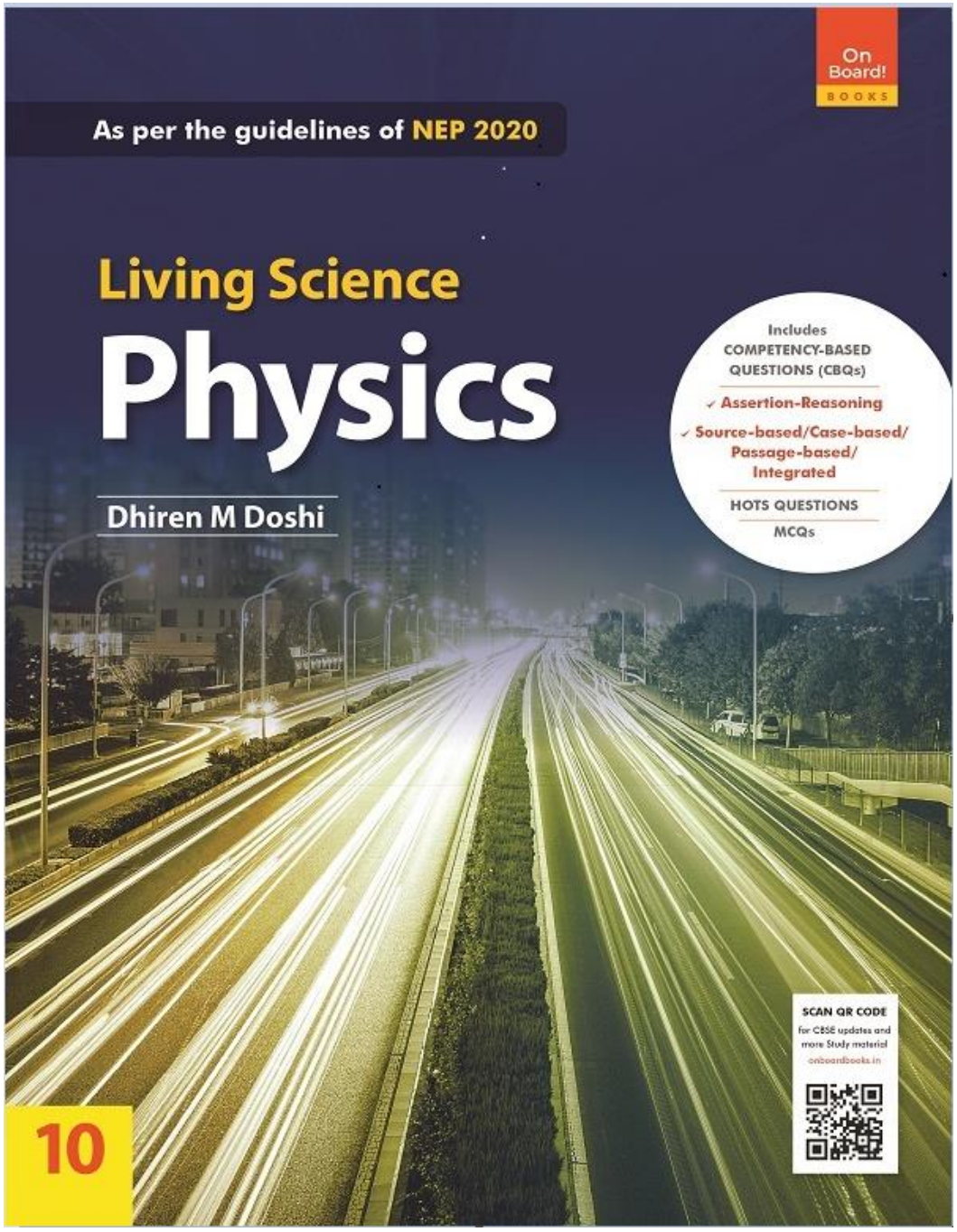


CBSE Living Science Physics

Class 10

Chapter 4: REFLECTION OF LIGHT

Learning Objectives

- ❖ Ray and beam of light

Reflection of light

- ❖ Regular and irregular reflections
- ❖ Laws of reflection
- ❖ Lateral inversion
- ❖ Characteristics of an image formed by a plane mirror

Spherical Mirrors

- ❖Rules for obtaining the images formed by spherical mirrors

Formation of images by a concave mirror

Uses of spherical mirrors

- ❖ Concave mirrors
- ❖ Convex mirrors

Mirror formula

New cartesian sign convention

- ❖ Mirror formula
- ❖ Magnification

What are luminous and non-luminous objects?

The objects which emit light of their own are called luminous objects, for example, the sun and a burning candle.

The objects which do not emit light of their own are called non-luminous objects, for example, a book and a table.

Ray and beam of light

A ray of light is the direction of path followed by light emitted by a source. It is represented by a straight line with an arrowhead showing the direction in which it is travelling.

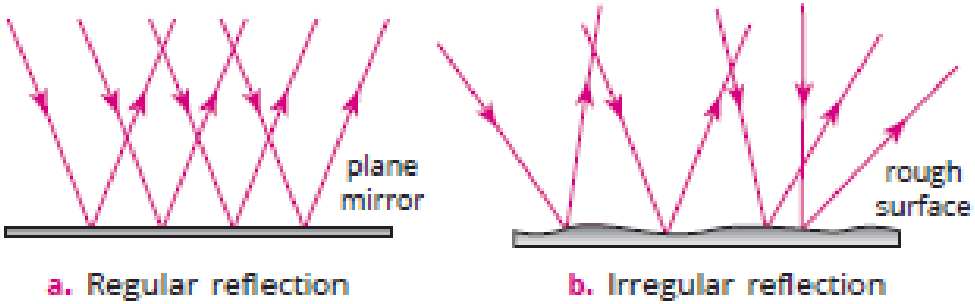
A bundle or group of light rays emitted by a source of light and moving in the same direction is called a beam of light.

Reflection of Light

Reflection is the phenomenon in which light rays on striking a polished smooth surface such as a mirror are sent back into the same medium.

Regular and irregular reflections

The phenomenon due to which a parallel beam of light travelling through a certain medium on striking a smooth, highly polished surface



(such as a mirror) bounces back from it as a parallel beam of light in some other direction is called **regular reflection of light**.

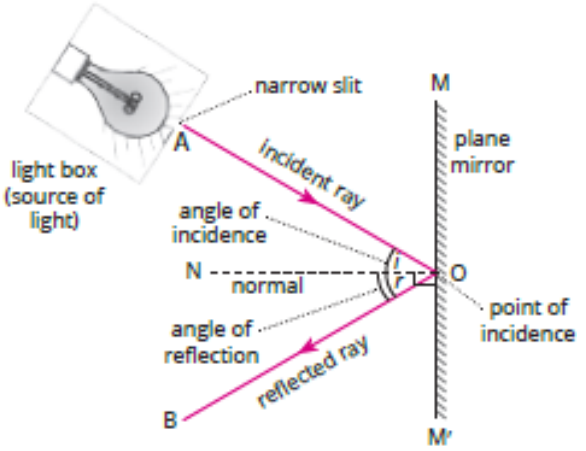
The phenomenon due to which a parallel beam of light travelling through a certain medium on striking a rough surface (such as cardboard), gets reflected in various directions in the same medium is called **irregular reflection of light.**

Reflection of light from a plane mirror

Some important terms related to the reflection of light.

1. Incident ray: The ray of light which falls on the mirror's reflecting surface is called the incident ray.

2. Point of incidence: The point at which the incident ray strikes the reflecting surface of the mirror is called the point of incidence.



3. Reflected ray: The ray of light which is sent back by the mirror is called the reflected ray.

4. Normal: The 'normal' is a line drawn at right angle (perpendicular) to the mirror surface at the point of incidence.

5. Angle of incidence: The angle which the incident ray makes with the normal at the point of incidence is called the angle of incidence.

6. Angle of reflection: The angle which the reflected ray makes with the normal at the point of incidence is called the angle of reflection.

Laws of Reflection

When light falls on a smooth reflecting surface, for example mirror, it obeys the following two laws of reflection:

1. The angle of incidence ($\angle i$) is equal to the angle of reflection ($\angle r$).
2. The incident ray, the normal to the reflecting surface at the point of incidence, and the reflected ray, all lie in the same plane.

Lateral Inversion

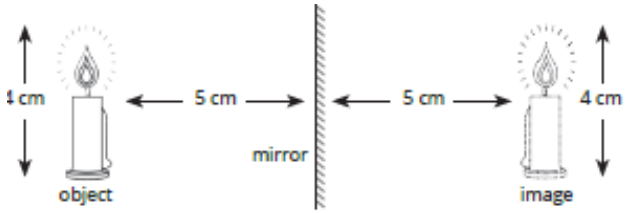
This is the phenomenon due to which when an object and its image in a plane mirror are compared, the left side of the object appears to be on the right of the image and the right of the object appears to be on the left of the image.

The word AMBULANCE on the hospital vans is written in the form of its mirror image as AMBULANCE.

Characteristics of an Image Formed by a Plane Mirror

- The image is formed behind the mirror and has the same size as the object.
- The image is laterally inverted.
- The image is as far behind the mirror as the object is in front of it.
- The image is virtual, i.e. it cannot be received on a screen.
- The image is erect.

Characteristics of an image formed by a plane mirror



1.The image is formed behind the mirror and has the same size as the object.

2.The image is laterally inverted.

3. The image is as far behind the mirror as the object is in front of it.

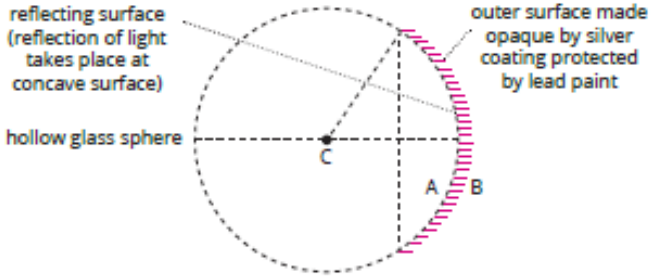
4. The image is virtual. It cannot be received on a screen.

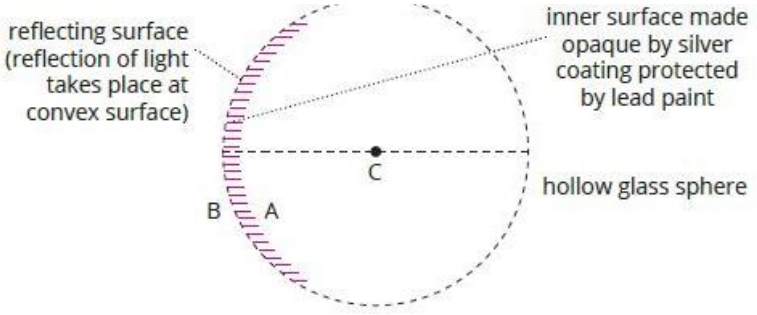
5. The image is erect.

Spherical Mirrors

A spherical mirror is obtained by taking a part of a hollow sphere of glass or any polished metal. The reflecting surface of a spherical mirror may be curved inwards or outwards.

A spherical mirror whose reflecting surface is curved inwards, i.e. faces towards the centre of the sphere is called a **concave mirror**.



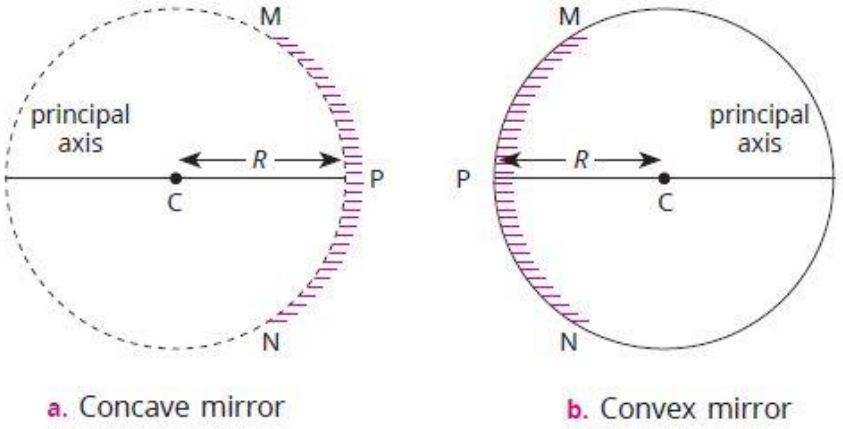


A spherical mirror whose reflecting surface is curved outwards, i.e. faces away from the centre of the sphere is called a **convex mirror.**

Refer to Table 4.1.(Page 151) for the differences between concave mirror and convex mirror

Terms Related to Spherical Mirrors

❖ **Aperture:** The effective width or distance of the spherical mirror from which reflection of light can take place is called its aperture. It represents the size of the mirror. It is denoted by MN in the following figures.



❖ **Pole:** The centre of the reflecting surface of a spherical mirror is called its pole. It is usually denoted by letter P. It is the middle point of a spherical mirror and lies on the surface of a mirror.

❖ **Centre of Curvature:** The geometric centre of the hollow sphere of which the spherical mirror is a part is called the centre of curvature of the spherical mirror. The centre of curvature of a concave mirror lies in front of it but in case of convex mirror it lies behind it. It is denoted by the letter C.

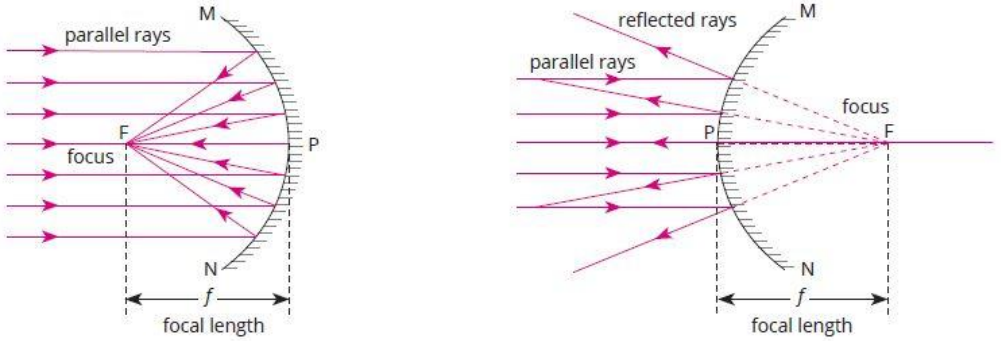
❖ **Radius of Curvature:** The radius of the hollow sphere of which the reflecting surface of the spherical mirror is a part is called the radius of curvature of the spherical mirror. This is the distance between the pole and the centre of curvature of the spherical mirror (PC). It is denoted by the letter *R*.

❖ **Principal Axis:** The straight line passing through the centre of curvature and the pole of a spherical mirror is called its principal axis. It is normal to the mirror at its pole. In Figure the line PC represents the principal axis.

❖ **Principal Focus:** The principal focus of a concave mirror is a point on its principal axis at which all the light rays that are parallel and close to the axis, converge after reflection from the mirror. This is why, a concave mirror is called a converging mirror. The focus of a concave mirror is in front of the mirror with respect to the source of light. A concave mirror has a real focus.

The principal focus of a convex mirror is a point on its principal axis from which a beam of light rays, initially parallel to the axis, appears to diverge after being reflected from the convex mirror. Thus, a convex mirror is also called a diverging mirror. A convex mirror has a virtual focus. The focus of a convex mirror is located behind the mirror with respect to the source of light.

❖ **Focal Length:** The distance between the pole and the principal focus of a spherical mirror is called the focal length. It is denoted by the letter *f*.



Real image: When rays of light from an object after getting reflected from a mirror actually meet at a point, a real image is formed. The image which can be obtained on a screen is called a real image. A concave mirror gives a real image if the object is placed at or beyond the focus. A convex mirror never forms a real image. A real image is always inverted with respect to the object.

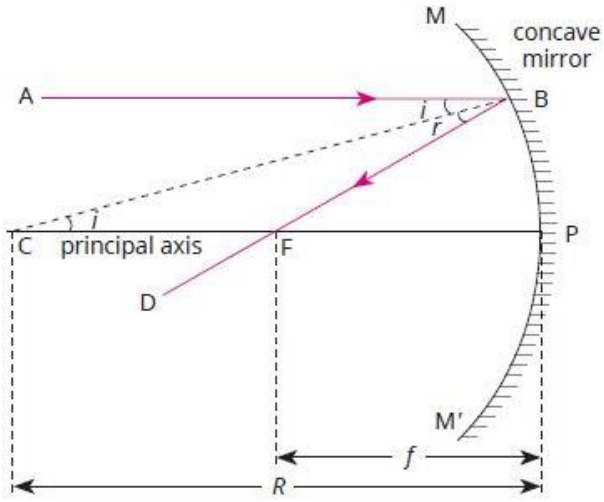
Virtual image: When the rays of light after getting reflected from a mirror appear to meet at a point, a virtual image is formed. Such an image can only be seen in a mirror but cannot be obtained on a screen. So, the image which can only be seen in a mirror but cannot be obtained on a screen is called a virtual image. A virtual image is always erect with respect to the object.

A concave mirror forms a virtual image when the object is placed at distances less than its focal length. A convex mirror always forms a virtual image.

Relationship between the focal length (*f*) and the radius of curvature (*R*) of a spherical mirror

It has been found that for spherical mirrors of small apertures, the radius of curvature (*R*) is equal to twice the focal length (*f*), i.e.

Radius of curvature = 2 × Focal length $R = 2f$



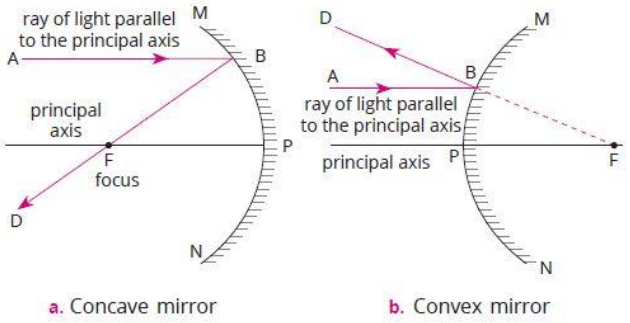
This relationship is true for both concave and convex mirrors. This implies that the principal focus of a spherical mirror lies midway between the pole and centre of curvature.

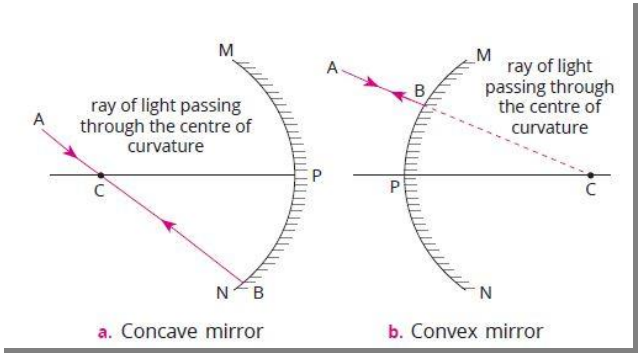
Refer to Table 4.3 (Page 153) for the differences between real image and virtual image

Rules for Obtaining the Images Formed by Spherical Mirrors

Rule I

A ray of light parallel to the principal axis either passes or appears to pass through the focus after reflection.



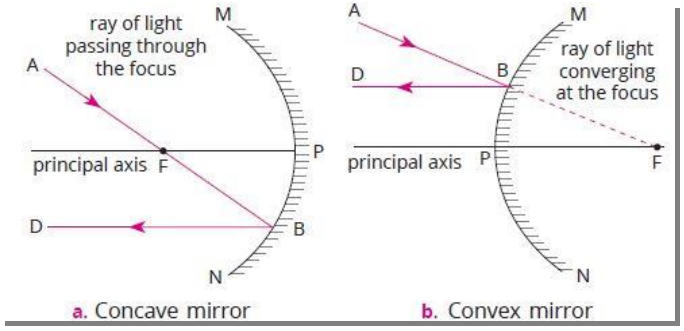


Rule II

A ray of light passing through the centre of curvature is reflected back along its original path.

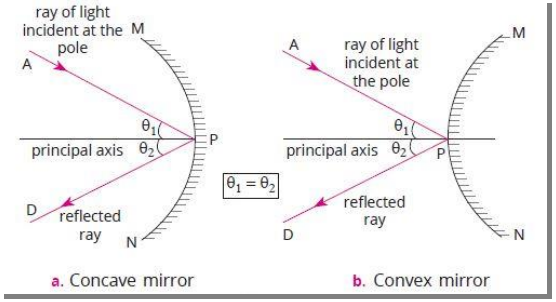
Rule III

A ray of light passing through the focus (in a concave mirror) or converging at the focus (in a convex mirror) becomes parallel to the principal axis after reflection



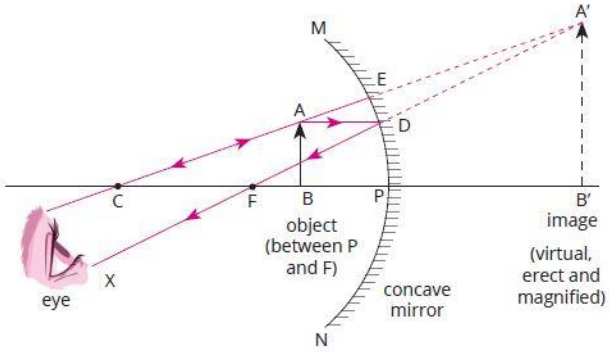
Rule IV

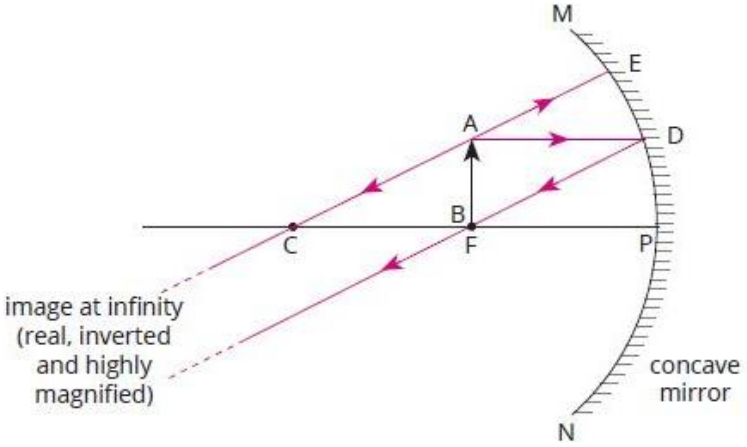
A ray of light incident at the pole of a spherical mirror gets reflected along a path such that the angle of incidence is equal to the angle of reflection.



Formation of Images by a Concave Mirror

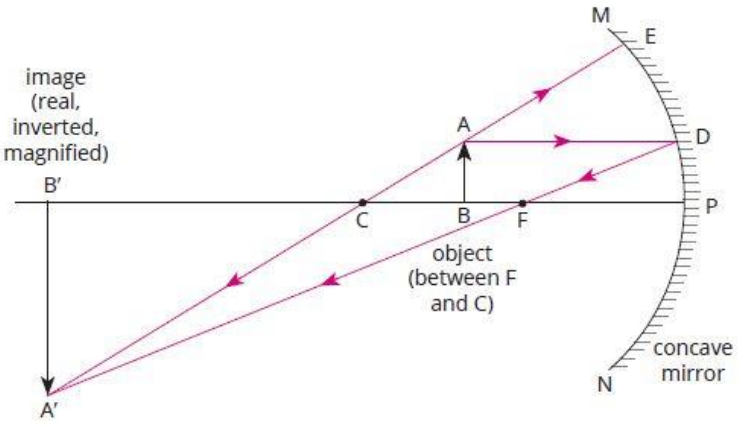
Case I: Image formed when the object is placed between the pole (P) and the focus (F) of the mirror
The image formed has the following characteristics:
Position: Behind the mirror
Nature: Virtual and erect
Size: Larger than the size of the object (magnified)



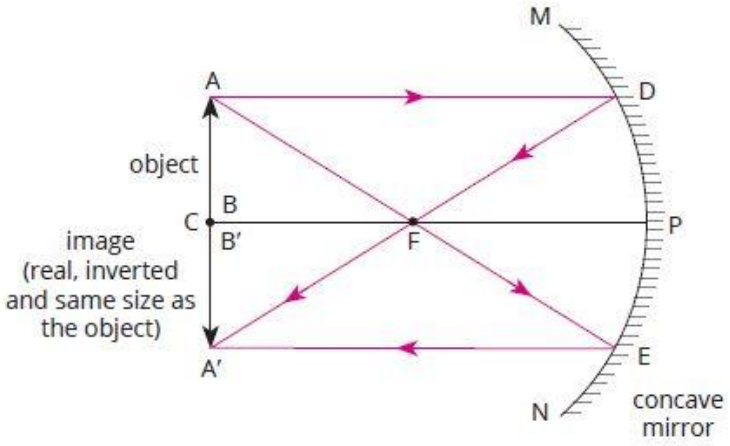


Case II: Image formed when the object is placed at the focus (F) of the mirror
The image formed has the following characteristics:
Position: At infinity **Nature:** Real and inverted
Size: Highly magnified

Case III: Image formed when the object is placed between the focus (F) and the centre of curvature (C) of the mirror
The image formed has the following characteristics:
Position: Beyond the centre of curvature
Nature: Real and inverted
Size: Larger than the object (magnified)



Case IV: Image formed when the object is placed at the centre of curvature (C) of the mirror
The image formed has the following characteristics:
Position: At the centre of curvature
Nature: Real and inverted
Size: Same size as the object



Case V: Image formed when the object is placed beyond the centre of curvature (C) of the mirror

The image formed has the following characteristics:

Position: Between the focus and centre of curvature of the mirror

Nature: Real and inverted

Size: Smaller than the size of the object (diminished)

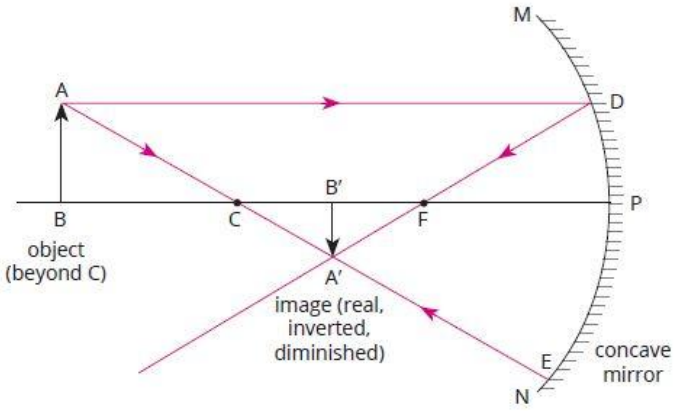


Fig. 4.22 Position of the object: beyond C

Case VI: Image formed when the object is at infinity

The image formed has the following characteristics:

Position: At the focus (F) of the mirror

Nature: Real and inverted

Size: Highly diminished

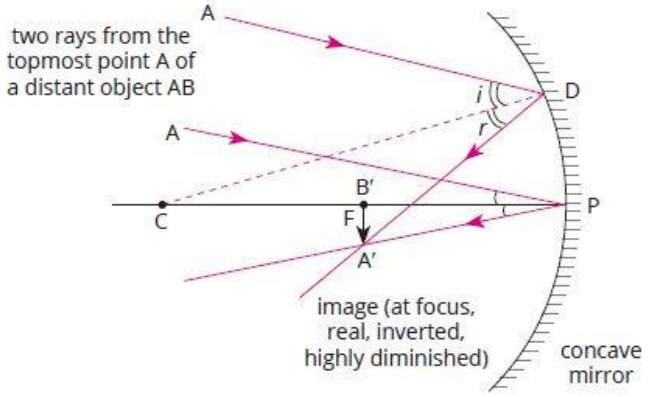


Fig. 4.23 Object at infinity

The images formed by a concave mirror for different positions of the object and their uses are given in Table 4.4 (page 147).

Formation of Images by a Convex Mirror

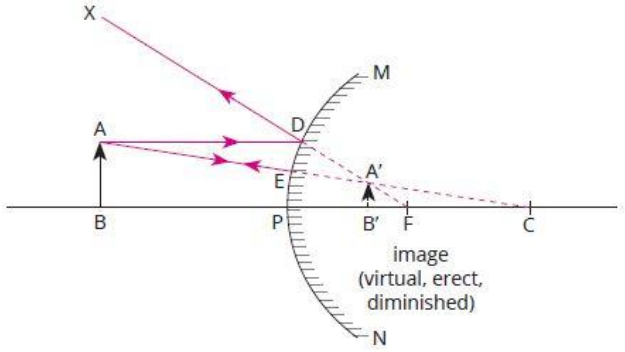
Case I: Image formed when the object is placed anywhere between the pole (P) and infinity

The image formed has the following characteristics:

Position: Behind the mirror between the pole (P) and focus (F)

Nature: Virtual and erect

Size: Diminished



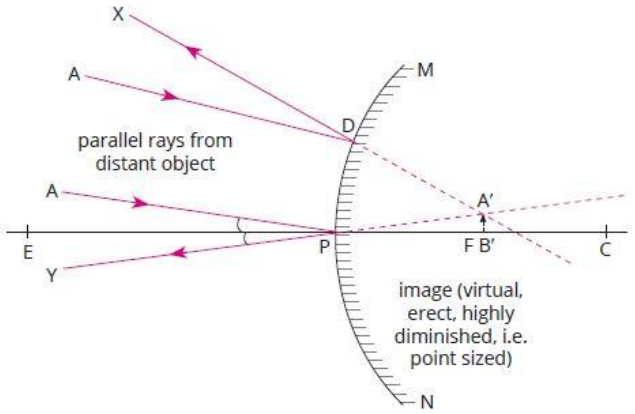
Case II: Image formed when the object is placed at infinity

The image formed has the following characteristics:

Position: Behind the mirror at the focus (F)

Nature: Virtual and erect

Size: Highly diminished



Refer to Table 4.4 (page 159) for the images formed by a concave mirror for different positions of the object

Uses of Spherical Mirrors

Concave Mirrors

Concave mirrors are used in the following ways:

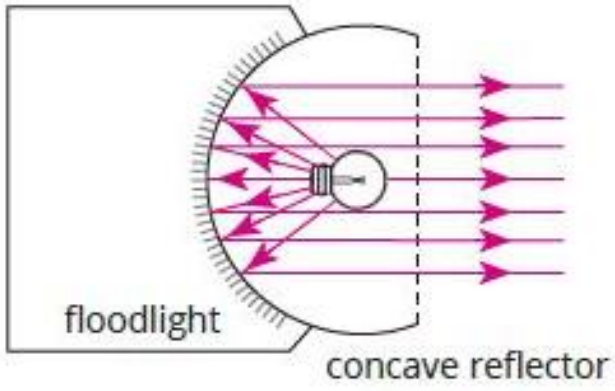
❖ As Reflectors in Projectors, Headlights, Lighthouses, Searchlights and Reflecting Telescopes: The source of light is placed at the focus of the mirror, resulting in a parallel beam of light.

❖ As Shaving Mirrors: The face is placed close to the mirror, i.e. within the focal point of the mirror, resulting in an enlarged and erect image.

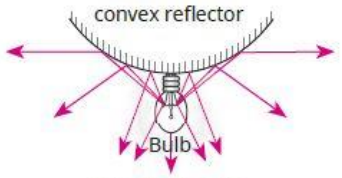
❖ As Doctor's Head Mirror (Object at Infinity): A parallel beam of light incident on the mirror is focused on to a point, which helps the doctor clearly study a body part like a teeth, ear, nose or throat.

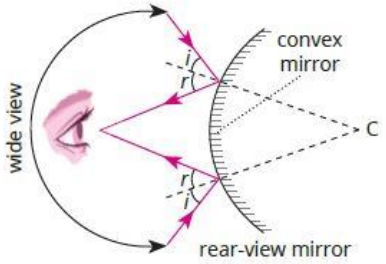
❖ For Heating: Solar radiations are converged over the small area of a solar cooker, generating adequate heat to cook food.

❖ In Floodlights: A bright bulb is positioned between the focus and the pole to obtain a divergent beam.



Convex Mirrors





❖ As Rear-view Mirrors in Vehicles: The image formed in a convex mirror is highly diminished due to which it gives a wide field of view of the traffic at the back of the vehicle and the image produced is also erect.

❖ Safe View at Dangerous Corners: Convex mirrors are placed on staircases or at blind turns on roads to enable looking at a section not visible otherwise.

❖ Vigilance Mirrors: It is used in shops as an anti-shoplifting measure.

❖ Streetlights: Streetlights use convex mirrors to diverge light over an extended area.

Distinguishing Between Plane Mirror, Concave Mirror and Convex Mirror Without Touching Them

Bring each mirror one by one close to your face and observe the image formed in it. The mirror is a

1. plane mirror, if the image is erect, of the same size as the object and does not change size or nature on moving the mirror closer to or away from the face.

2. concave mirror, if the image is erect, magnified and becomes inverted on moving the mirror away from the face.
3. convex mirror, if the image is erect, diminished and remains erect on moving the mirror away from the face.

New Cartesian Sign Convention

A set of sign conventions called the New Cartesian Sign Convention are followed to specify the position of the object and the image. The conventions are as follows:

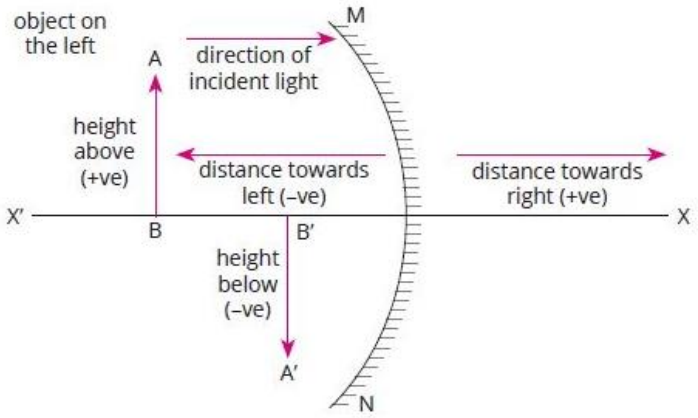
❖ The object is always placed to the left of the mirror. The incident light from the object falls on the mirror from the left-hand side.

❖ All distances parallel to the principal axis are measured from the pole of the mirror, i.e. the pole (P) acts as the origin of the coordinate system.

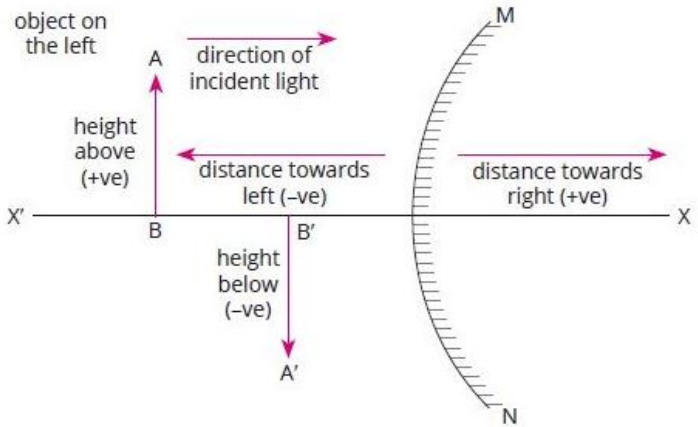
❖ The principal axis is taken as the x-axis of the coordinate system. Distances measured to the right of the origin are taken as positive; those measured to the left of the origin are taken as negative.

❖ Heights or distances measured above and perpendicular to the principal axis are taken as positive; those below and perpendicular to the principal axis are taken as negative.

The distance of the object from the pole of the spherical mirror is called the object distance (u). The distance of the image from the pole of the mirror is called the image distance (v).



a. Concave mirror



b. Convex mirror

Mirror Formula

A formula which gives the relationship between object distance (u), image distance (v) and focal length (f) is known as the mirror formula. It is written as

$$1/v + 1/u = 1/f$$

The mirror formula contains three terms v, u and f. If any two of them are known, the third can be obtained.

Refer to Table 4.6, (page 163) for the sign convention at a glance is given in

Magnification

The ratio of the height of the image (*h*') to the height of the object (*h*). It is denoted by the letter *m*.

Magnification (*m*) = Height of the image (*h*') / Height of the object (*h*)

Magnification is also described as the ratio of the image distance (*v*) to the object distance (*u)*.

Magnification (*m*) = −Image distance (*v*) / Object distance (*u*)

Thus, m = *h'/h* = −*v/u*

Sign of Magnification

❖ *m* is positive: *h*' and *h* have the same sign, i.e. image is formed on the same side of the principal axis as the object. Therefore, the image is virtual and erect with respect to the object.

❖ *m* is negative: The image is real and inverted with respect to the object.

SUMMARY

1. Light: Light is a form of energy that produces the sensation of sight.

2. Reflection of light: It is a phenomenon in which light rays on striking a polished surface (such as a mirror) are sent back into the same direction.

3. Laws of reflection: a. The angle of incidence is equal to the angle of reflection, b. The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

4. Lateral inversion: It is a phenomenon in which when looked in a plane mirror, the left of the object becomes the right of the image and vice versa.

5. Plane mirror: A virtual, erect and laterally inverted image is formed behind the mirror and has the same size as the object.

6. Spherical mirror: A mirror which is a part of a sphere in which inner or outer surface is reflecting.

7. Concave mirror: A spherical mirror whose reflecting surface is curved inwards is called concave mirror. It forms a virtual and erect image when the object is placed between focus (F) and pole (P) of the mirror. In other cases, it always forms a real and inverted image of the object.

SUMMARY...

8. Convex mirror: A spherical mirror whose reflecting surface is curved outwards is called convex mirror. It always forms virtual, erect and diminished image of the object, whatever may be its position in front of the mirror.

9. Real image: The image which can be obtained on the screen is called real image. It is inverted with respect to the object.

10. Virtual image: The image which cannot be obtained on the screen is called a virtual image. It is erect with respect to the object.

11. Uses of concave mirror: a. As reflectors in projectors, lighthouses, headlights, searchlights, etc. b. As shaving mirrors c. As doctor's head mirror d. For heating purposes in solar cookers.

12. Uses of convex mirror: a. As rear-view mirror used in vehicles b. As vigilance mirrors, c. For safe viewing of dangerous corners.

13. Magnification: It is the ratio of the height of the image to the height of the object.