



**AV & AVS Education**

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## Reflection of light

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**Light-** light is a form of energy, which induces the sensation of vision in our eyes and makes us able to see various things present in our surrounding.

Note: we detect light with our eyes.

**Luminous** objects are objects that generate their own light.

Example: sun, bulb, tube light, glow worms, Stars, Torch etc.

**Non-luminous** object is one that does not produce its own light.

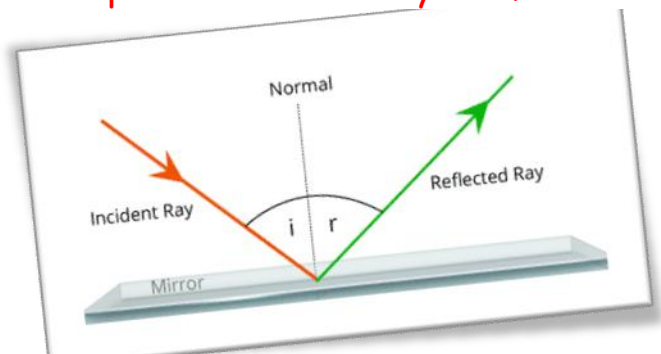
Example: Moon, tree, table, painting etc.

### Property of Light

- It is form of energy
- It travels in straight line
- Light can form shadows
- Speed of light in air/ vacuum is  $3 \times 10^8$  m/s
- Light have dual nature-
  1. As a particle
  2. As a wave

### REFLECTION OF LIGHT

The bouncing back of rays of light from a polished and shiny surface is called reflection or reflection of light.



**Note:** A highly polished surface, such as a mirror, reflects most of the light falling on it. And dull/rough surfaces reflect less light

### General terms related to plane mirrors:

**Incident ray-** An incident ray is a ray of light that strikes on the surface.

**Reflected ray-** A ray that represents the light reflected by the surface.

**Point of incidence-** The point of incidence is the point where the ray of incidence strikes the mirror.

**Normal-** Normal is a line perpendicular to mirror drawn at point of incidence.

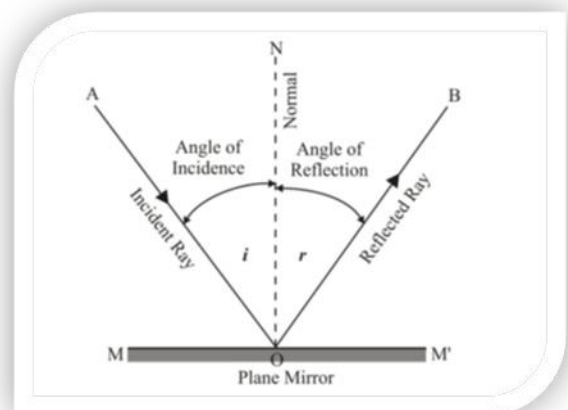
**Angle of incidence-** Angle between incident ray and normal, called angle of incidence. It is denoted by  $i$ .

**Angle of reflection-** Angle between reflected ray and normal, called angle of reflection. It is denoted by  $r$ .

### Laws of Reflection of light:

#### The two laws of reflection are:

- i) The angle of incidence is equal to the angle of reflection,
- ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.



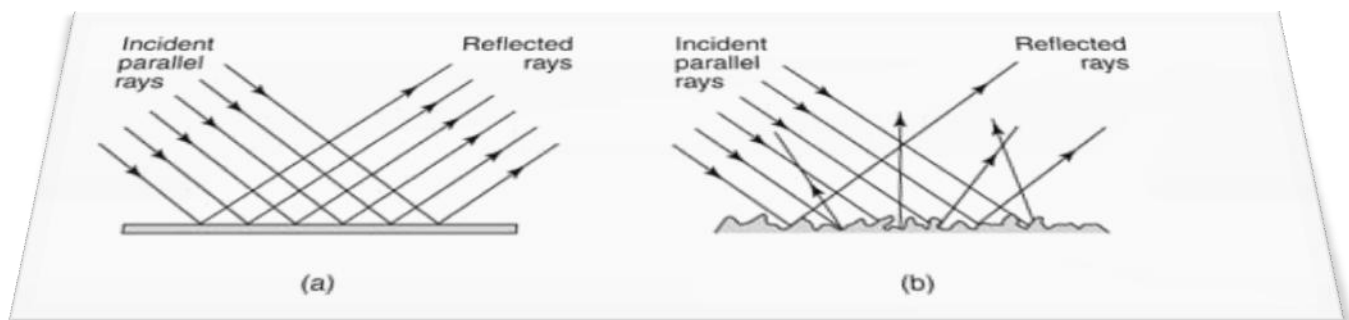
## Types of reflection

**Regular reflection:** When the reflection surface is smooth and well-polished, the parallel rays falling on it are reflected parallel to another one.

Example: plane mirror, reflection from still water etc

**Diffused reflection:** When the reflecting surface is rough, the parallel rays falling on it are reflected in different direction. Such a reflection is known as diffuse reflection or irregular reflection.

Example: reflection of light from the wall of a room or tree etc



## Lateral inversion:

When an object is placed in front of the plane mirror, sides are reversed. Right becomes left and left becomes right. This reversal is only in the direction perpendicular to the surface of the mirror.



**Image:** Image is the point where light rays meet or appear to meet.

Image can be of two types:

**Real image-** A real image occurs where rays converge,

Example: light rays actually meet at image. They can be projected on screen

**Virtual image** - virtual image occurs where rays only appear to converge, Example: light rays appear to meet at image. They cannot be projected on screen

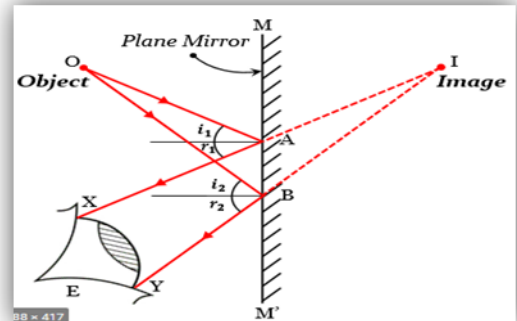
### Property of image formed by plane mirror:

- Image is virtual and cannot be projected on screen
- Image is erect
- Image is of the same size as the object
- Laterally inverted
- Distance of image and object from the plane mirror is same

### Formation of image in plane mirror

#### Uses of plane mirror

- To see ourselves
- To make some instruments like periscope
- In shops for decoration

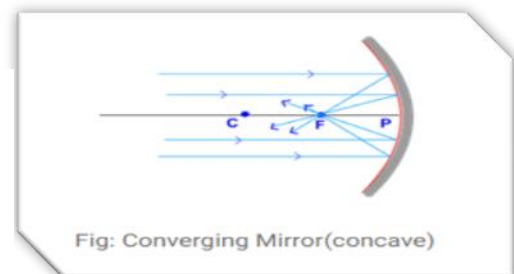
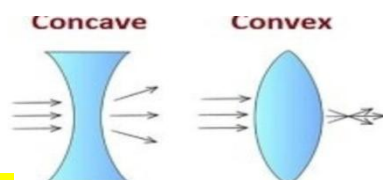


### Spherical mirrors

The curved surface of a **shining spoon** could be considered as a curved mirror. The most commonly used type of curved mirror is the spherical mirror.

### Types of Spherical Mirror

1. A spherical mirror whose outer surface is polished and inner side is the reflecting surface is **called concave mirror**. A concave mirror is also known as **converging mirror**.



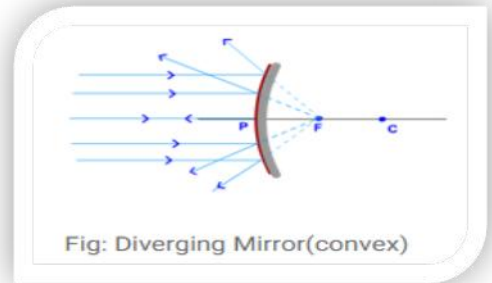
### Use of concave mirror

Makeup mirror, Dental mirror, solar furnace, Headlight, Telescope, Microscope, Shaving mirror etc

## Properties of concave mirror

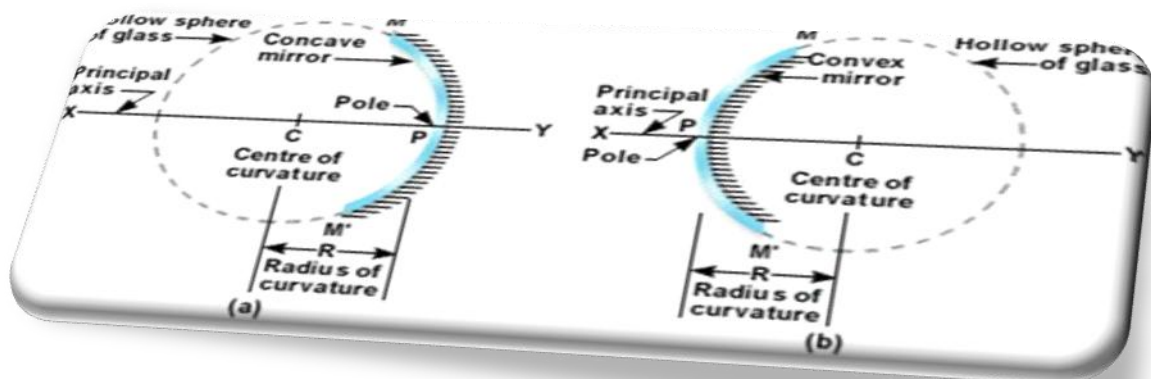
Real, inverted and enlarge images are always formed.

2. A spherical mirror, spherical mirror whose inner is polished and outer side is the reflecting surface is called convex mirror. A convex mirror is also known as diverging mirror.



## Properties of convex mirror

Virtual, erect and diminished images are always formed.



**Pole:** The centre of reflecting surface of a spherical mirror is known as Pole. Pole is generally represented by 'P'.

**Centre of Curvature:** Sphere has a centre. This point is called the centre of curvature of the spherical mirror. It is represented by the letter 'C'.

**Radius of Curvature:** The radius of sphere of which the reflecting surface of a spherical mirror is a part is called the Radius of Curvature of the spherical mirror. It is denoted by letter 'R'.

**Aperture:** The diameter of reflecting surface of a spherical mirror is called aperture. It is denoted by  $M_1, M_2$

**Principal Axis:** Imaginary line passing through the centre of curvature and pole of a spherical mirror is called the Principal Axis. It is denoted by X and Y.

**Focus or Principal Focus:** Point on principal axis at which parallel rays coming from infinity converge after reflection is called the Focus. Focus is represented by letter 'F'.

**Focal length:** The distance from pole to focus is called focal length. Focal length is denoted by letter 'f'. Focal length is equal to half of the radius of curvature.

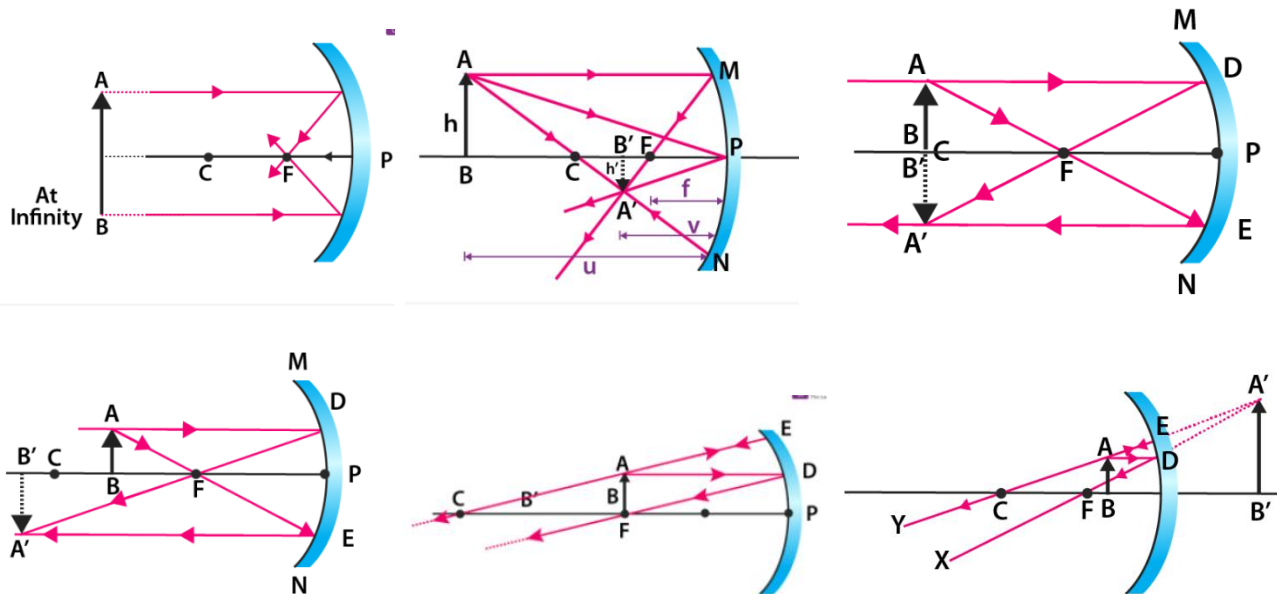
$$\text{Or, } f = \frac{R}{2} \quad \text{Or, } R = 2f$$

### Formation of image in concave mirror

There is some case-

1. Between the P and F
2. At the F
3. Between the F and C
4. At the center
5. Beyond the C
6. Infinite

## Formation of image by a concave mirror -



Position of the object

Position of the image

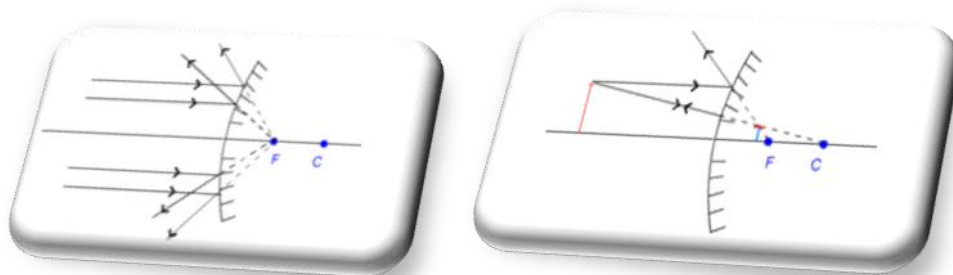
Size of the image

Nature of the image

At infinity	At the focus F	Highly diminished, point sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

## Formation by a convex mirror

There are only two possibilities of position of object in the case of a convex mirror, i.e. object at infinity and object between infinity and pole of a convex mirror.



### Position and Nature of Image in Convex Mirror

Position of object	Position of image	Size of image	Nature of image
At infinity	At F, behind mirror	Highly diminished	Virtual and Erect
Between infinity and pole	Between F and P, behind mirror	Diminished	Virtual and Erect

### Uses of concave mirror:

1. torches, search-lights and vehicles headlights to get powerful parallel beams of light
2. As shaving mirror
3. It is used by dentists to see larger image of teeth of the patient
4. As reflector in solar furnace
5. In doctor's head mirror to see various body parts like nose, ears etc.
6. In dish TV antennas to focus signals

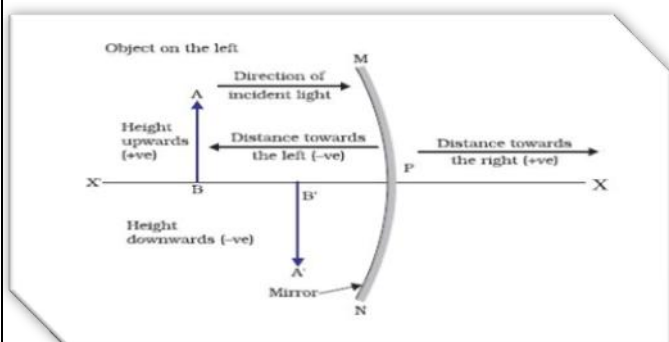


## Uses of convex mirrors

1. It is used in rear view mirror of vehicles.
2. In big shops for security

## Sign Convention for Reflection by Spherical Mirrors

1. All distances parallel to the principal axis are measured from the pole of the mirror.
2. All the distances measured to the right of **the origin (along + x-axis)** are taken as positive while those measured to the left of the origin **(along - x-axis)** are taken as negative.
3. Distances measured perpendicular to and above the principal axis **(along + y-axis)** are taken as positive.
4. Distances measured perpendicular to and below the principal axis **(along -y-axis)** are taken as negative



Concave mirror			Convex mirror
	Real image	Virtual image	
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	$h_o \rightarrow +$	$h_o \rightarrow +$	$h_o \rightarrow +$
Height of image	$h_i \rightarrow -$	$h_i \rightarrow +$	$h_i \rightarrow +$
Radius of curvature	$R \rightarrow -$	$R \rightarrow -$	$R \rightarrow +$
Magnification	$m \rightarrow -$	$m \rightarrow +$	$m \rightarrow +$

## Magnification

Magnification is the ratio of the height of the image to the height of the object. It is usually represented by the letter 'm'.

$$\text{Magnification}(m) = \frac{\text{Height of image } (h')}{\text{Height of object } (h)}$$

$$\text{Or, } m = \frac{h'}{h}$$

$$\text{Magnification } (m) = \frac{\text{Distance of image}}{\text{Distance of object}} = -\frac{v}{u}$$

$$\text{Thus, } m = \frac{h'}{h} = -\frac{v}{u}$$

### Summary:

#### 1. The Mirror Formula

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

$\uparrow$  focal length       $\uparrow$  object distance       $\uparrow$  image distance

#### 2. In the RIP convention:

• v is +ve for real images, and -ve for virtual images

• f is +ve for a real principal focus (E.g. concave mirror)

## Numerical

1. A concave mirror produces 10cm long image of an object of height 2cm. What is the magnification produced?
2. Size of image of an object by a mirror having a focal length of 20cm is observed to be reduced to  $\frac{1}{3}$ rd of its size? At what distance the object has been placed from the mirror? What is the nature of the image and the mirror?
3. If the magnification of a body of size 1m is 2, what is the size of the image?
4. Find the position of an object, which when placed in front of a concave mirror of focal length 20 cm produces a virtual image, which is twice the size of the object.
5. Find the position, nature and size of the image of an object 3cm high placed at a distance of 9cm from a concave mirror of focal length 18cm.
6. An object is placed at a distance of 12cm in front of a concave mirror. It forms a real image four times larger than the object. Calculate the distance of the image from the mirror.
7. A 2.5cm candle is placed 12 cm away from a convex mirror of focal length 30cm. Give the location of the image and the magnification.
8. An object is placed in front of a concave mirror of focal length 20cm. The image formed is 3 times the size of the object. Calculate two possible distances of the object from the mirror.
9. a concave mirror produces a real image 10 mm tall, of an object 2.5mmtall placed at 5cm from the mirror. Calculate focal length of the mirror and the position of the image. An object is placed at a large distance in front of a convex mirror of radius of curvature 40cm. How far is the image behind the mirror?
10. An object is placed 15cm from a convex mirror of radius of curvature 90 cm. Calculate positions of the image and its magnification.
11. The image formed by a convex mirror of focal length 30cm is a quarter of the object. What is the distance of the object from the mirror?
12. When an object is placed at a distance of 60cm from a convex mirror, the magnification produced is  $\frac{1}{2}$ . Where should the object be placed to get a magnification of  $\frac{1}{3}$ ?

13. An object is placed 18cm front of a mirror. If the image is formed at 4cm to the right of the mirror. Calculate its focal length. Is the mirror convex or concave? What is the nature of the image? What is the radius of curvature of the mirror?

14. A convex mirror used for rear view on an automobile has a radius of curvature of 3m. If a bus is located at 5m from this mirror, find the position, nature and magnification of the image.

15. An object 3cm high is held at a distance of 50cm from a diverging mirror of focal length 25cm. Find the nature, position and size of the image formed.

16. An converging mirror of focal length 20cm forms an image which is two times the size of the object. Calculate two possible distances of the object from the mirror.

17. The linear magnification of a convex mirror of focal length 15cm is  $\frac{1}{3}$ . What is the distance of the object from the focus of the mirror?

18. The focal length of a convex mirror is 12.5 cm. How far is its Centre of curvature-?

(i) From the pole

(ii) From the focus.