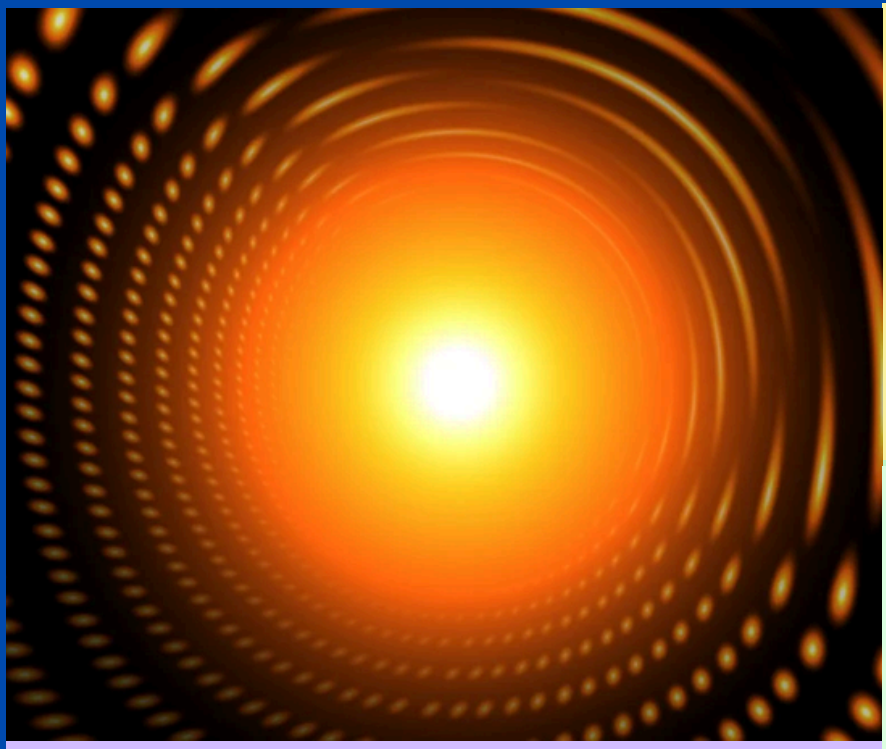
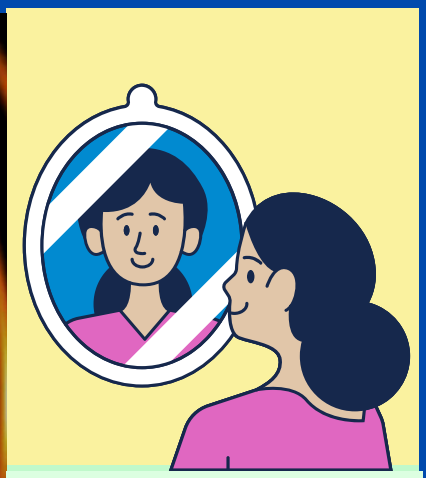
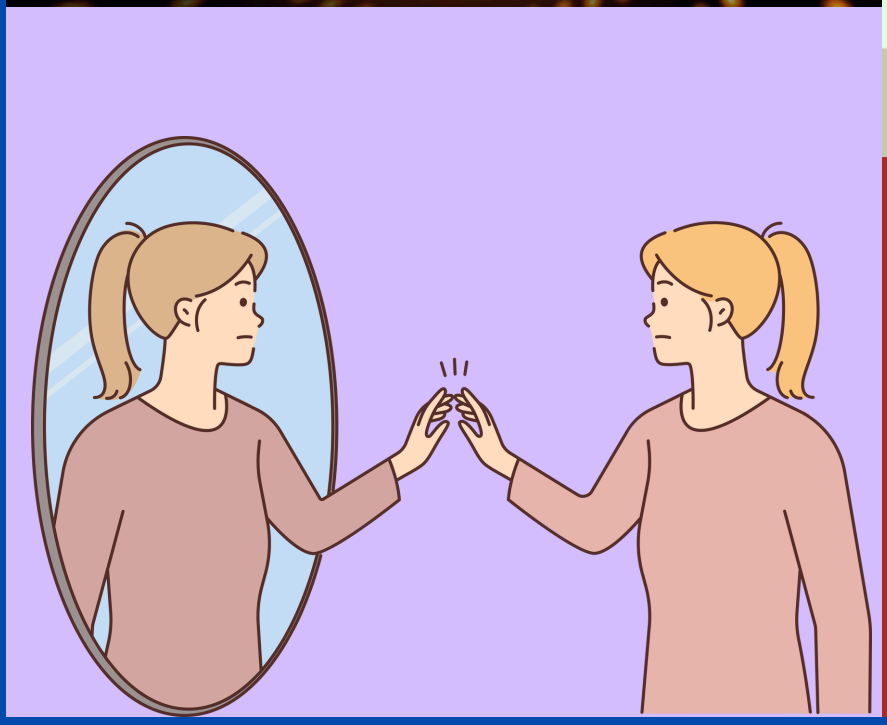






SCIENCE

Light

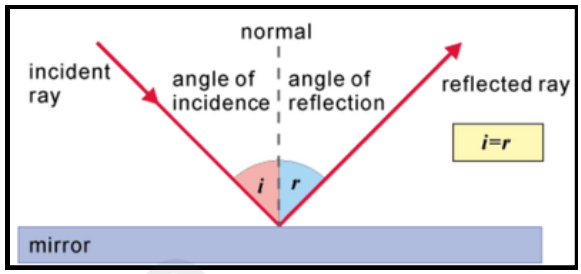
PRASHANT KIRAD

Reflection

- Reflection is the phenomenon where light bounces back into the same material after hitting a surface.

Laws of Reflection: EMA

- **The First Law of Reflection:** The incident ray, the reflected ray, and the normal to the surface at the point of incidence, all lie in the same plane.

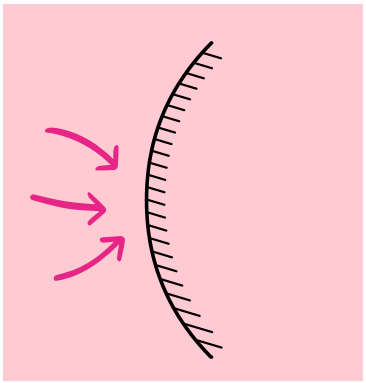


- **The Second Law of Reflection:** The angle of incidence is equal to the angle of reflection. In other words, the angle between the incident ray and the normal is equal to the angle between the reflected ray and the normal.

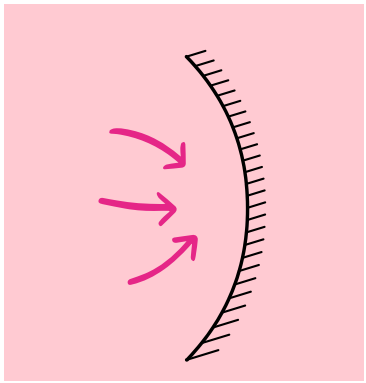
Properties of Image formed by a Plane Mirror:

- An image formed by a plane mirror is virtual and erect.
- The Image is laterally inverted.
- The image formed is as far behind the mirror as the object is in front of it.
- The Size of the image is equal to that of the Object.

Spherical Mirrors: A spherical mirror is a mirror that has the shape of a piece cut out of a spherical surface.



Convex Mirror: A convex mirror is a curved mirror with a reflective surface that bulges outward, similar to the shape of a sphere.



Concave Mirror: A concave mirror is a mirror that curves inward, resembling the inner surface of a hollow sphere.

Important Terms in Spherical Mirror

EMA

- Pole: It's the midpoint of the spherical mirror.
- Centre in curvature: The center of the imaginary sphere of which the mirror is a part is called as center of the curvature.
- Radius in curvature: The radius of curvature of a spherical mirror is the radius of the circle or hollow sphere that the mirror is part of.
- Principal Axis: A straight line passing through the pole and center of curvature.
- Principal Focus: That point on principal axis through which the reflected light ray pass when incident light ray was travelling parallel to the principal axis.
- Aperture: The diameter of the mirror's reflecting surface.

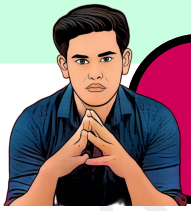
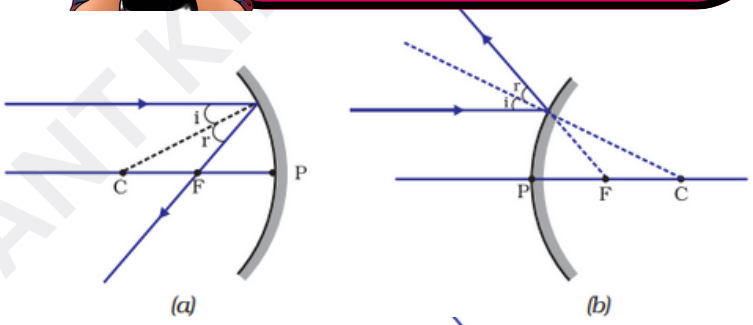


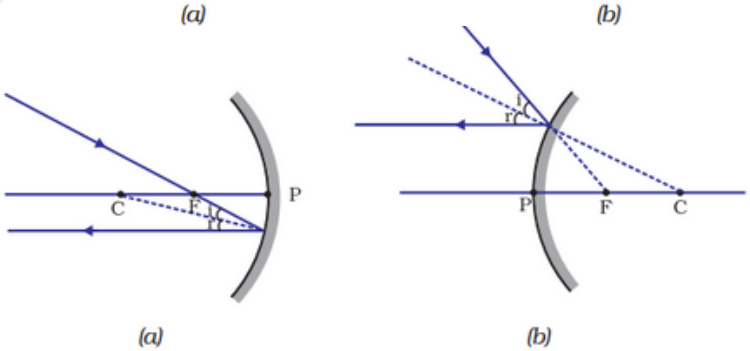
Image formation se question aana pakka hai!
- Prashant Bhaiya

Ray Diagram Rules:

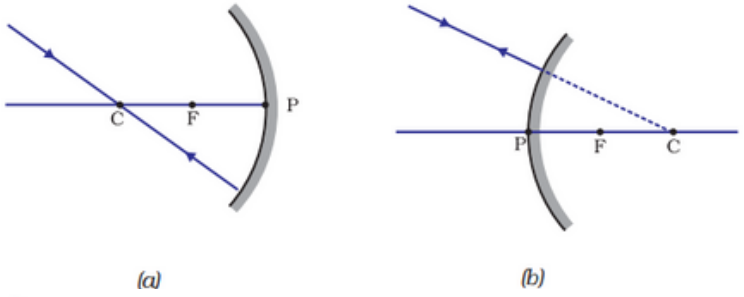
1) A parallel ray will either pass through or appear to converge at the principal focus for a concave mirror and appear to diverge from the principal focus for a convex mirror.



2) A ray directed at the principal focus of a concave mirror or passing through the principal focus of a convex mirror will come out parallel to the principal axis.



3) A ray passing through the center of curvature of a concave mirror or directed toward the center of curvature of a convex mirror will be reflected back along its original path



4) Ray incident obliquely to the principal axis towards the pole of the concave mirror or a convex mirror is Reflected Obliquely.

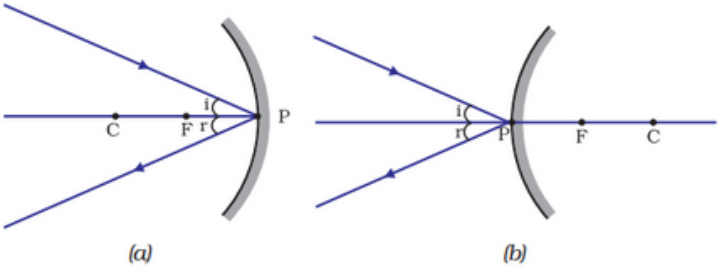
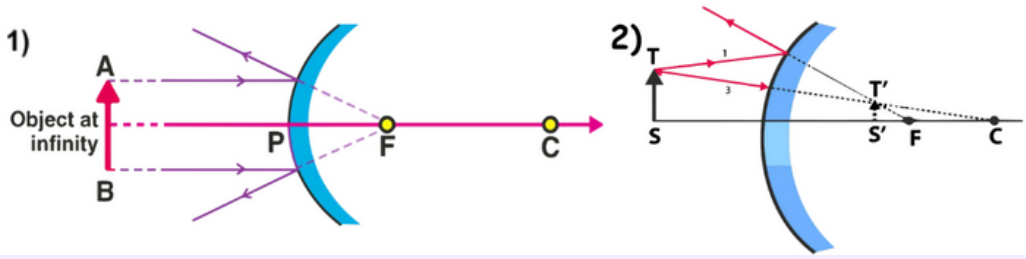
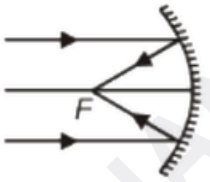
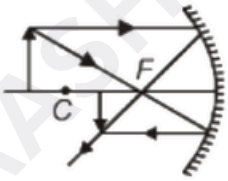
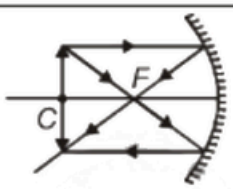
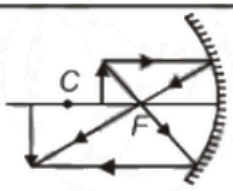
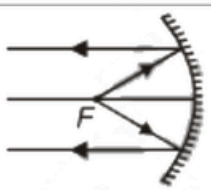
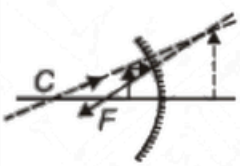


Image Formation by Convex Mirror



Position of the Object	Position of the Image	Size of the Image	Nature of the Image
At infinity	At focus, F, behind the mirror	Highly diminished and pointed in size	Virtual and erect
Between infinity and the pole of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

Image Formation by Concave Mirror

Position of object	Figure	Position of image	Nature of image
1. At infinity		At the principal focus or in the focal plane	Real, inverted, extremely diminished in size
2. Beyond the centre of curvature		Between the principal focus and centre of curvature	Real, inverted and diminished
3. At the centre of curvature		At the centre of curvature	Real, inverted and equal to object
4. Between focus and centre of curvature		Beyond centre of curvature	Real, inverted and bigger than object.
5. At the principal focus		At infinity	Extremely magnified
6. Between the pole and principal focus		Behind the mirror	Virtual, erect and magnified

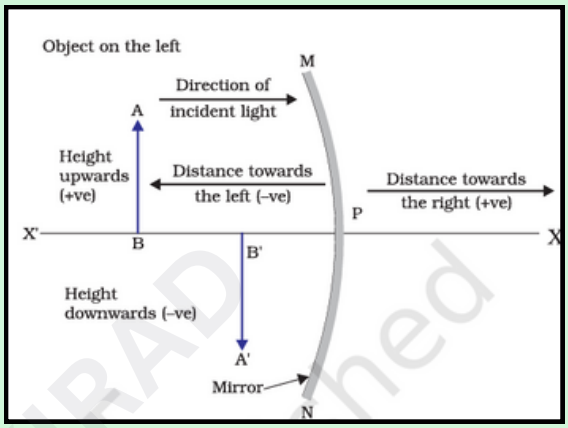
Uses of Spherical Mirror:

Concave mirrors (f = -ve): It excel in focusing and magnification, finding uses in telescopes, headlights, and personal grooming. With their wide field of view.

Convex mirrors (f = +ve): It are crucial for safety in vehicles and security systems.

Sign Convention:

1. Object on the left, light comes from the left.
2. Start measuring from the mirror's pole.
3. Left is negative, right is positive.
4. Above the principal axis is positive.
5. Below the principal axis is negative.

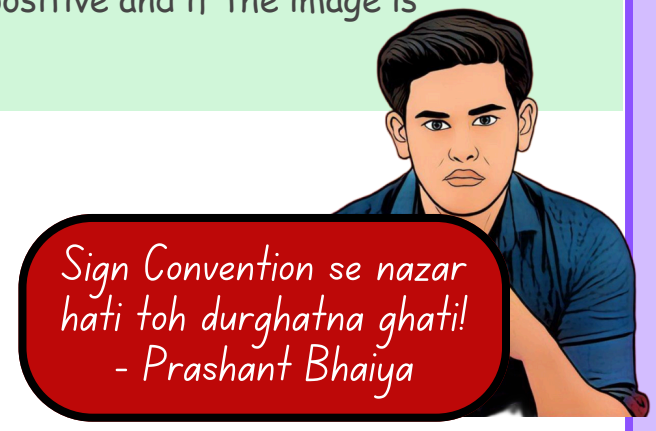


Important:

- The object distance u, is always negative.
- The image distance v, is positive if the image is formed behind a concave mirror and negative if the image is formed in front of the mirror.
- The image distance v, is always positive for a convex mirror.
- The focal length of a concave mirror is always negative and that of a convex mirror is always positive.
- The height of an object is always positive.
- If the image is erect the height is taken as positive and if the image is inverted, the height is taken as negative.

Mirror Formula:

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



Magnification:

Magnification is defined as the enlargement of the image formed by a mirror, whether it is a concave mirror or a convex mirror, relative to the size of the object.

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

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

Refraction

- The phenomenon of change in the direction of light when it passes from one transparent medium to another is called refraction.

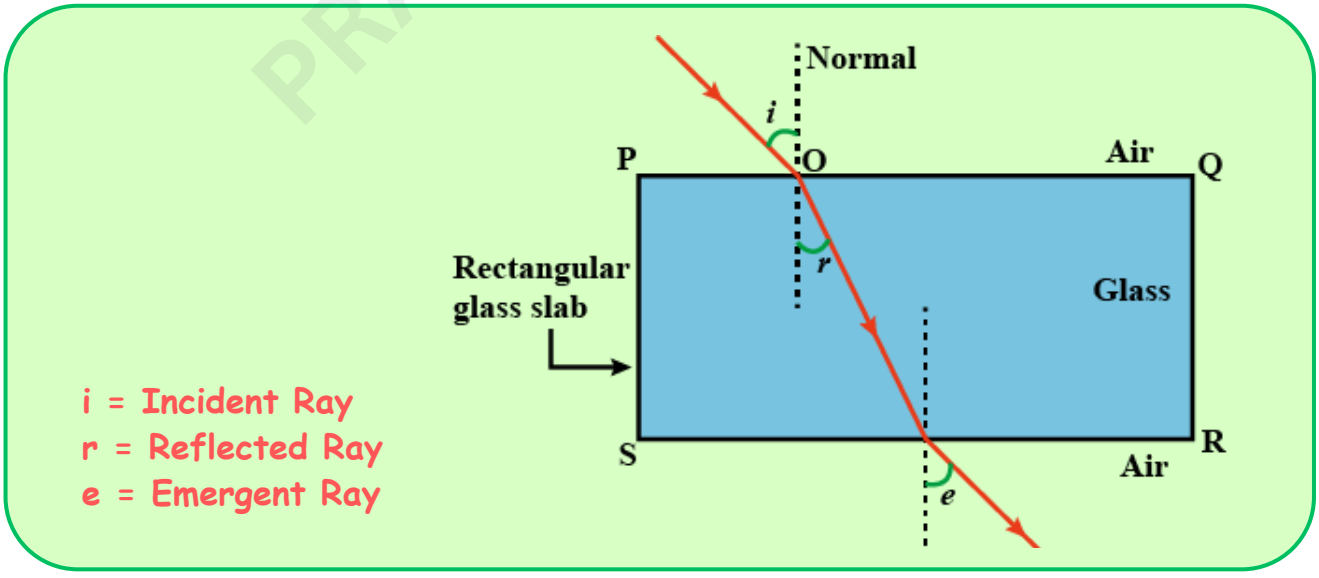
Laws of Refraction: EMA

- **The First Law of Refraction:** 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.
- **The Second Law of Refraction:** The ratio of sine of angle of incidence to the sine of angle of refraction is a 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.
- If i is the angle of incidence and r is the angle of refraction, then,

$$\frac{\text{Sin i}}{\text{Sin r}} = \mu = \text{Constant}$$

- This constant value is called the refractive index of the second medium
- with respect to the first.

Refraction through a Rectangular Glass Slab:



- Angle of incidence = Angle of emergence $(\angle i) = (\angle e)$
- When a ray of light is incident perpendicularly on a plane glass slab, it passes through undeviated. In this case, the angle of incidence ($\angle i$) is 0°, and therefore, the angle of refraction ($\angle r$) is also 0°.

Refractive Index

EMA

The refractive index measures how light changes direction when it moves from air to another material. It shows how fast or slow light travels and bends in different substances (medium), helping us understand its behavior.

$$\text{Refractive index of Medium 2 with respect to Medium 1} = \frac{\text{Speed of Light in Medium 1}}{\text{Speed of Light in Medium 2}}$$

$$n_{21} = \frac{\text{Speed of Light in Medium 1}}{\text{Speed of Light in Medium 2}}$$

Absolute Refractive Index

The absolute refractive index is the refractive index of a substance compared to a vacuum (where the first medium is free space or a vacuum). The refractive index of water is 1.33, which means that light travels about 1.33 times slower in water compared to its speed in air.

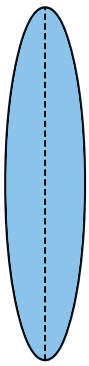
$$n = \frac{c}{v}$$

c → speed of light in vaccum/air

v → speed of light in medium

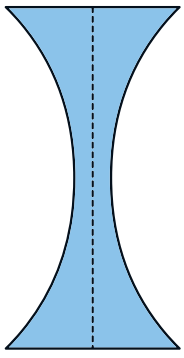
Spherical Lens:

A spherical lens is an optical device that uses two spherical transparent surfaces to converge or diverge light rays.



Convex

1. **Thick at middle**
2. **Converging Lens**



Concave

1. **Thin at middle**
2. **Diverging Lens**

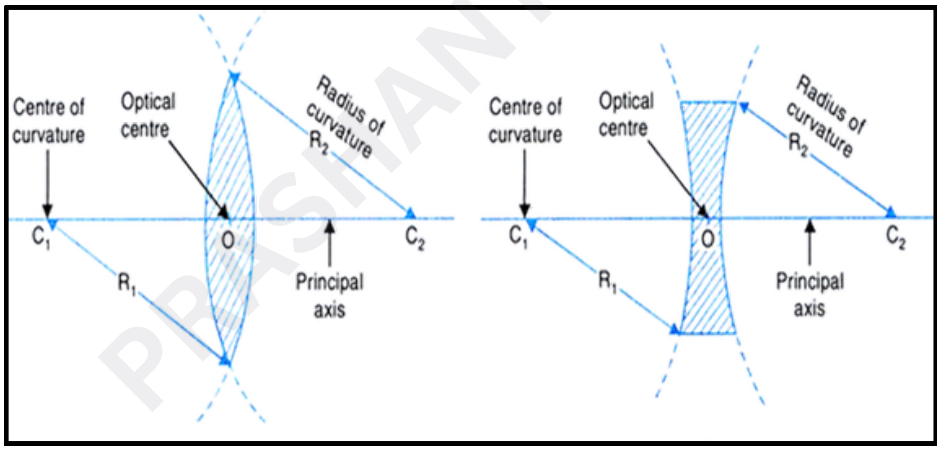
(1) **Concave lens** - A concave lens is thin in the middle and thicker at the edges, and it makes light spread out.

(2) **Convex lens** - A convex lens has a thicker middle and thinner edges, and it makes light converge.

Important Terms in Spherical Lens

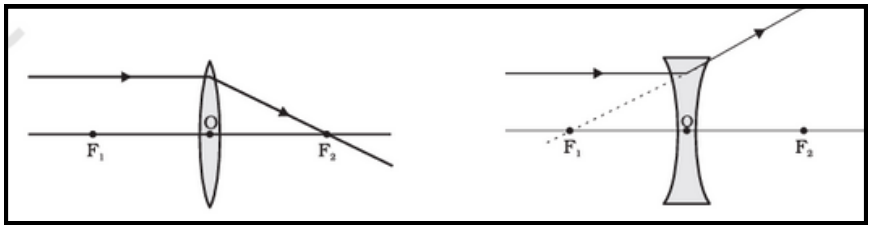
EMA

- Centre in curvature: The center of curvature for a spherical lens is the point on the principal axis that is at the same distance from the lens as the radius of curvature.
- Principal Axis: An imaginary straight line passing through the two centers of curvature of a lens is called its principal Axis.
- Principal focus: The point where parallel rays meet (convex lens) or appear to diverge from (concave lens). Lenses have two such points.
- Aperture: The aperture of a spherical lens is its effective diameter, representing the size of the circular outline.
- Optical center (O): The optical center of a lens is where light passes through without bending.
- Focal length: Focal length is the distance between the principal focus and the optical center.

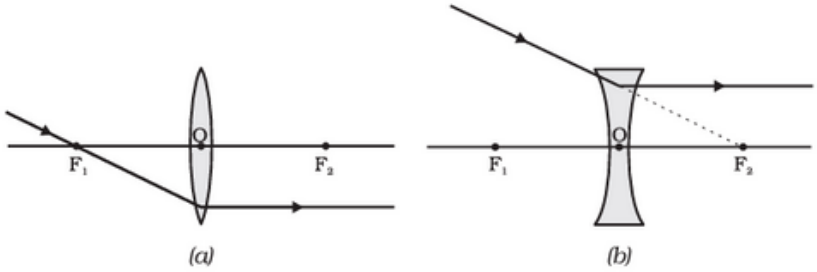


Ray Diagram Rules:

1) Rays parallel to the principal axis converge at the principal focus after refraction in a convex lens, while they appear to diverge from the principal focus in a concave lens.



2) A ray passing through or directed to the focus will emerge parallel to the principal axis.



3) A ray directed towards the optical center will emerge without deviation.

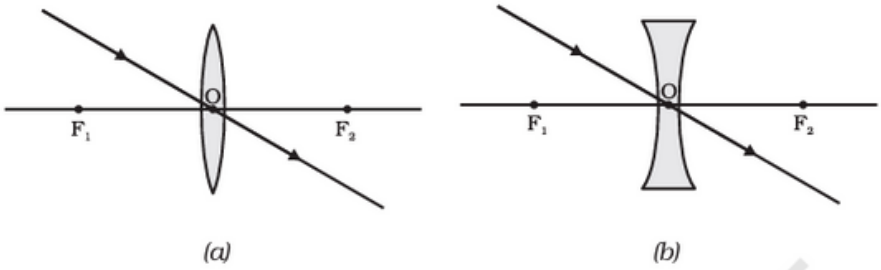
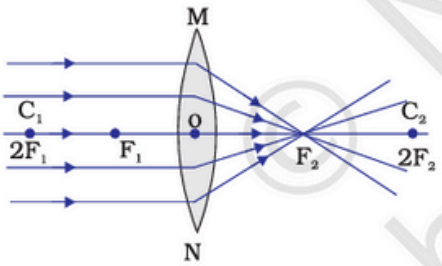
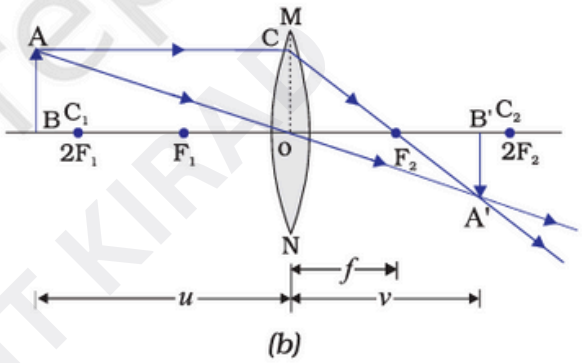
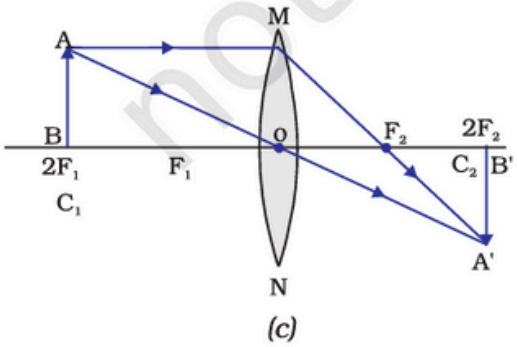
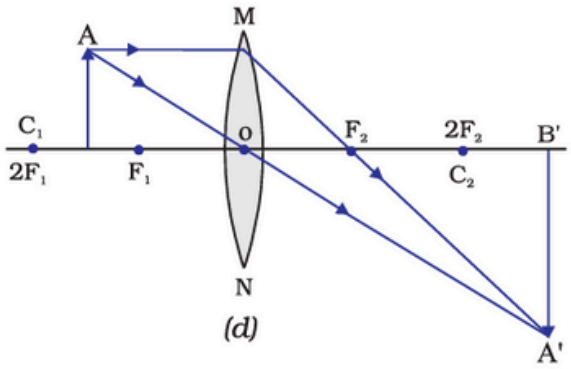


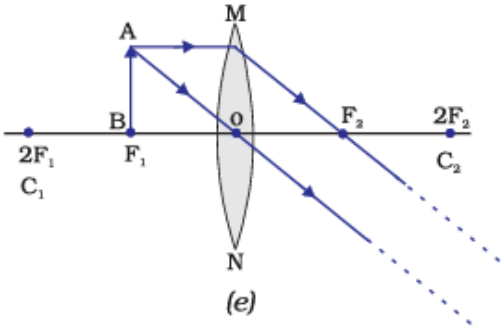
Image formation by Convex Lens











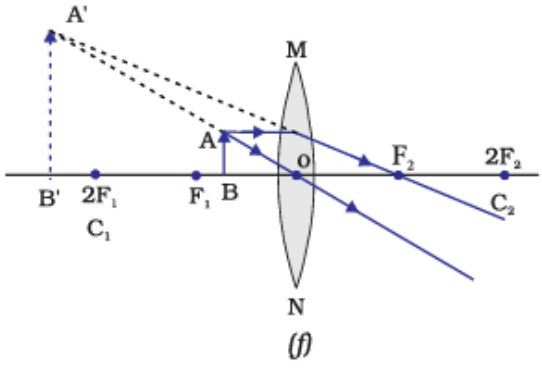
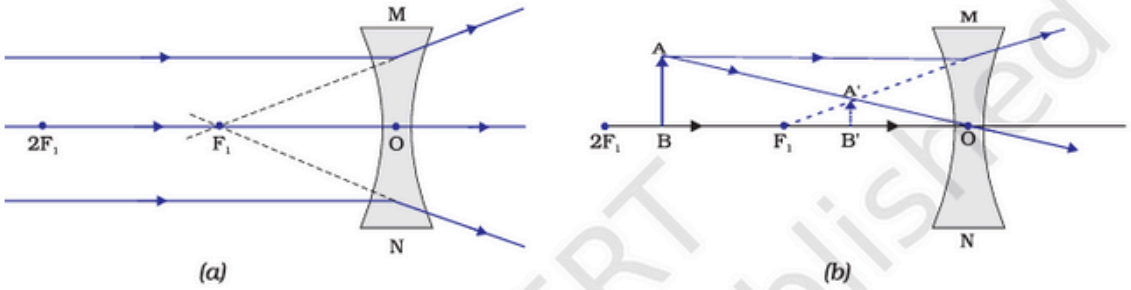


Image formation by Concave Lens



Lens Formula and Magnification:

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

LENS EQUATION

Magnification: The magnification of a lens is the ratio of the height of an image to the height of an object. It can also be expressed as the ratio of the image distance to the object distance.

$$m = \frac{\text{Height of the Image}}{\text{Height of the object}} = \frac{h'}{h}$$

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

Power of Lens:

The power of a lens is a measure of its ability to converge or diverge light and is defined as the reciprocal of its focal length (F) in meters. It is typically measured in diopters (D) and is calculated using the formula:

$$P = \frac{1}{f \text{ (in m)}}$$

f = focal length in metre
SI unit = Dioptre (D)

Power for Convex Lens : +ve
Power for Concave Lens : -ve

TOP 7 IMPORTANT QUESTIONS

1. As the velocity of light increases, the refractive index of the medium decreases. Light enters from air to water having a refractive index of 4/3. Find the speed of light in water. The speed of light in a vacuum is 3X10⁸ m/s. [CBSE 2012] (2 - Marks)

Solution:

Given: $${}_{w}^{a}n = \frac{4}{3},\ c = 3 \times 10^8\ \text{m/s}$$

$${}_{w}^{a}v = ?$$

As $${}_{w}^{a}n = \frac{c}{v_w} \Rightarrow v = \frac{c}{{}_{w}^{a}n}$$

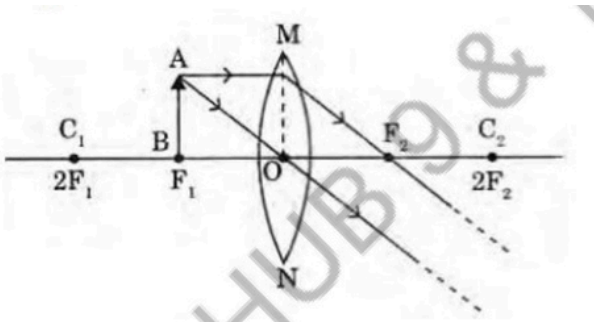
$$v_w = \frac{3 \times 10^8 \times 3}{4}$$

$$= 2.25 \times 10^8\ \text{ms}^{-1}$$

2. An object is placed at the focus of a convex lens. Draw a ray diagram to locate the position of the image formed, if any. State its position and nature.

Solution:

Image is formed at infinity, image will be real, inverted and enlarged.



3. What is meant by the power of a lens? Give its SI unit.

Solution:

Power of a lens is the ability of the lens to converge or diverge a ray of light incident on it. It is the reciprocal of the focal length of the lens, i.e. P = 1/f. The SI unit of power is D (dioptre), f is measured in metre.

4. Differentiate between reflection and refraction of light.

Solution:

Reflection	Refraction
It is the phenomenon of bouncing back of ray of light in the same medium after striking with a surface.	It is the phenomenon of bending a ray of light when it travels from one another medium.
$\angle i = \angle r$	$\angle i \neq \angle r$
Reflection can take place from any surface.	Refraction can take place from a transparent interface.

5. (a) Name the spherical mirror used as: [CBSE 2012] (2-Marks)

1. Shaving mirror,

2. Rearview mirror in vehicles,

3. Reflector in search – fights.

(b) Write any three differences between a real and virtual image

Solution:

(a) 1.Concave Mirror
2.Convex Mirror
3.Concave parabolic

(b)

Real Image	Virtual Image
It can be taken on a screen.	It cannot be taken on a screen.
It is always inverted.	It is always erected.
When reflected or refracted rays actually meet at a point, then real image is formed.	When reflected or refracted rays appear to meet at a point then virtual image is formed.

6.A 2.0 cm tall object is placed perpendicular to the principal axis of a convex lens of 1 focal length 10 cm. The distance of the object from the lens is 15cm. Find the position, nature, and size of the image forms.

Solution:

In convex lens, $h_1 = 2.0$ cm

$f = 10$ cm

$u = -15$ cm

$v = ?$

Lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \frac{1}{(-15)} = \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$$

$$v = 30 \text{ cm}$$

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

$$\frac{h_2}{2.0} = \frac{30}{-15}$$

$$h_2 = -4 \text{ cm}$$

Image is real, inverted and four times enlarged.

7. (a) A concave mirror produces a three-times enlarged image of an object placed 10 cm in front of it Calculate the focal length of the mirror.

(b) Show the formation of the image with the help of a ray diagram when the object is placed 6 cm away from the pole of a convex mirror.

Solution:

(a) $u = -10$ cm

Let a real image is formed in concave mirror i.e.,

$$m = -\frac{v}{u} = -3$$

$$v = 3u$$

$$v = 3 \times 10 \text{ cm} = 30 \text{ cm}$$

Mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$$\frac{1}{f} = \frac{1}{-30} + \frac{1}{-10}$$

$$\frac{1}{f} = -\frac{1}{30} - \frac{1}{10} = \frac{-4}{30}$$

$$f = -\frac{30}{4} = -7.5 \text{ cm}$$

(b) When $u = -6$ cm from pole of a convex mirror. For convex mirror, the image will be virtual, erected and smaller.