CLASS 10 NOTES

SCIENCE

Light

PRASHANT KIRAD

REFLECTION

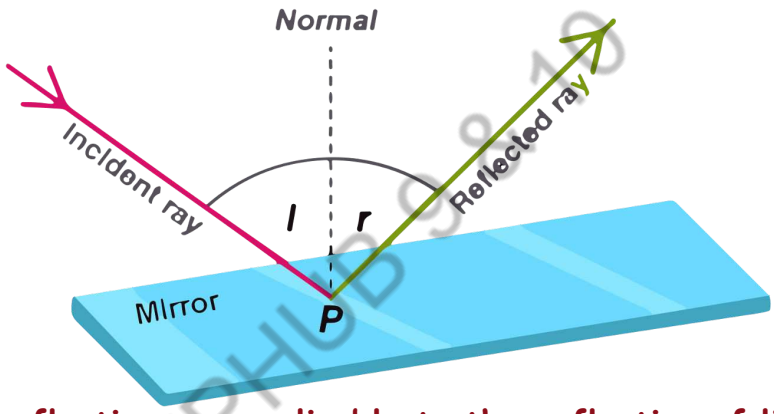
The phenomenon where light rays return to the same medium upon striking a surface is known as "reflection."

Laws of Reflection:

Exam me aayega

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.

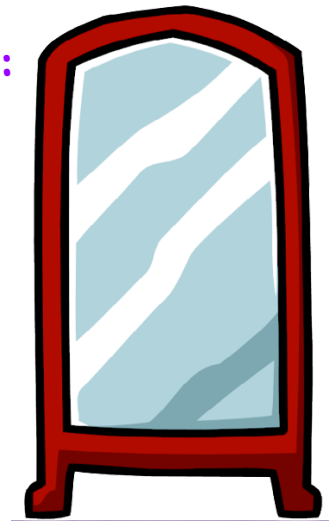
The Second Law of Reflection: The angle of incidence is equal to the angle of reflection. In other words, the angle between the incident ray and the normal is equal to the angle between the reflected ray and the normal.



These laws of reflection are applicable to the reflection of light from any smooth surface, not just mirrors.

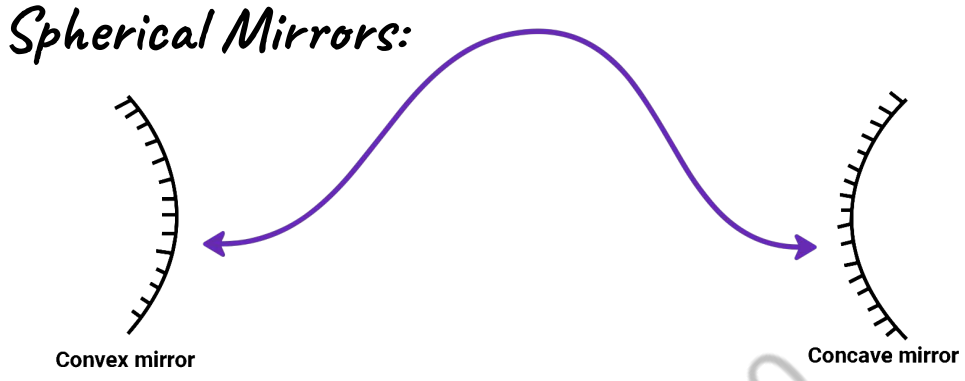
Properties of Image Formed by a Plane Mirror:

1. An image formed by a plane mirror is virtual and erect.
2. The Image is laterally inverted
3. The image formed is as far behind the mirror as the object is in front of it
4. The Size of the image is Equal to that of the Object (m=1)



Spherical Mirrors:

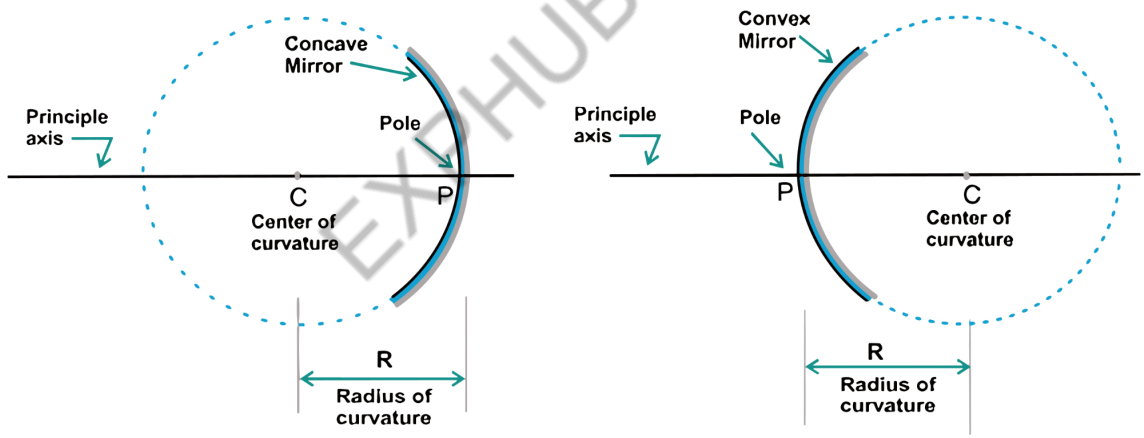
Mirrors, Whose reflecting surfaces are spherical in the part of a hollow sphere of glass. A **Concave mirror** is a curved mirror where the reflecting surface is on the inner side of the curved shape. **Convex Mirror** is a curved mirror where the reflective surface bulges out toward the light source.



(1) **Concave mirror** - Whose Reflecting Surface is curved **inwards** is called a concave mirror.

(2) **Convex mirro**r -Whose Reflecting Surface is curved **outwards** is called a convex mirror.

Terms used in Spherical mirrors:



- **Pole:** The center of a spherical mirror's reflecting surface coincides with the mirror's surface itself. Typically, we denote the mirror's pole with the letter "P."

- **Centre of curvature:** A spherical mirror has a curved surface from a sphere. The center of that sphere is the center of curvature. In concave mirrors, it's in front, in convex mirrors, it's behind.

- **Radius of curvature:** The sphere's radius, from which the reflecting surface of a spherical mirror is derived, is symbolized by the letter "R."

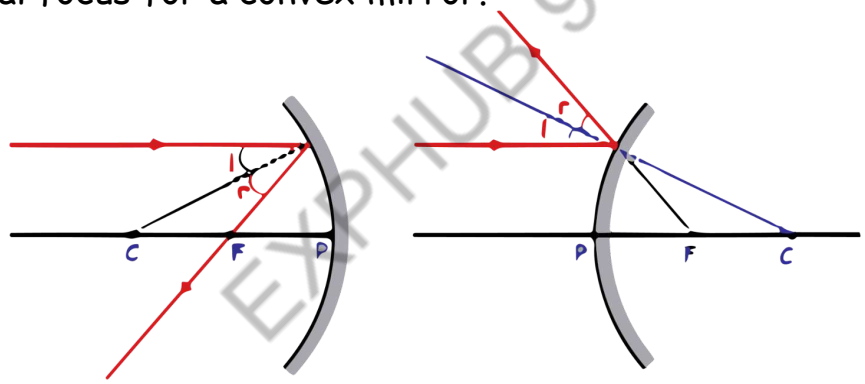
- **Principal axis:** The principal axis of a spherical mirror is a straight line that extends through the mirror's pole and its center of curvature. This axis is perpendicular to the mirror's surface at its pole

- **Principal Focus:** Parallel rays meet at the principal focus (F) for a concave mirror and seem to diverge from the principal focus (F) for a convex mirror. The distance between the mirror's center and the principal focus is the focal length.

- **Aperture:** The reflecting surface's diameter in a spherical mirror is called the aperture. When the aperture is much smaller than the radius of curvature, we can use R = 2f as an approximation.

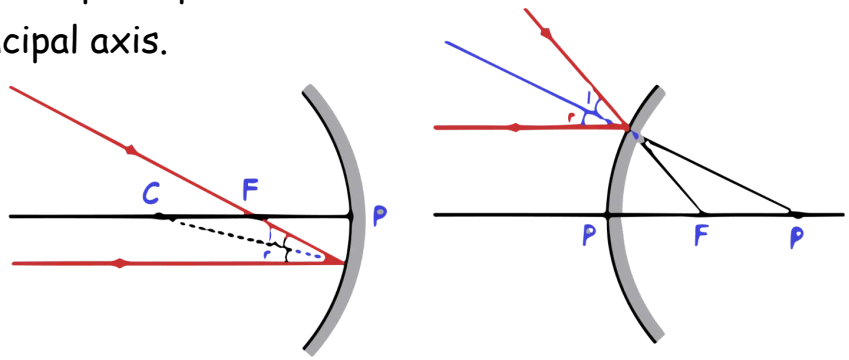
Ray Diagrams Rules:

(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.



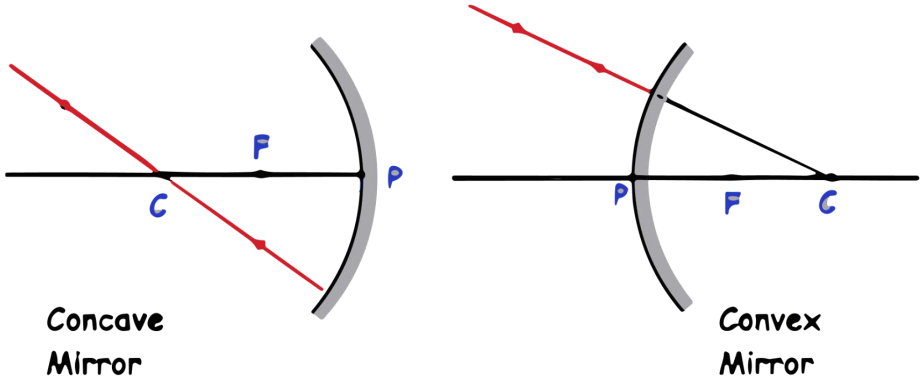
Concave Mirror Convex Mirror

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.

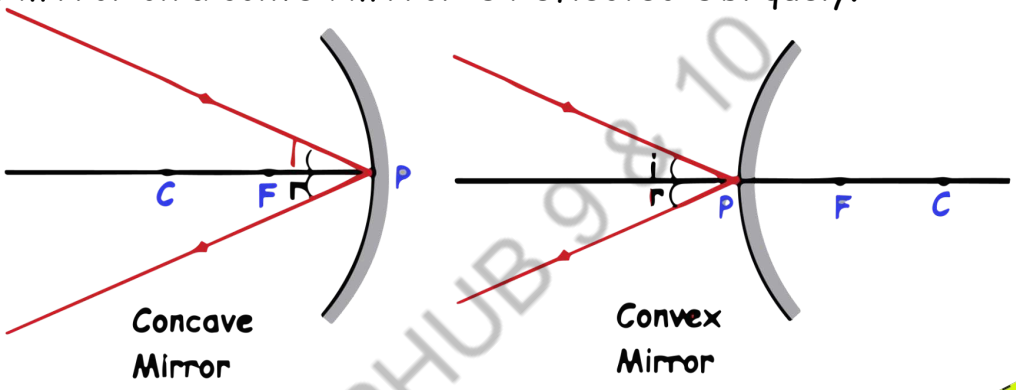


Concave Mirror Convex Mirror

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



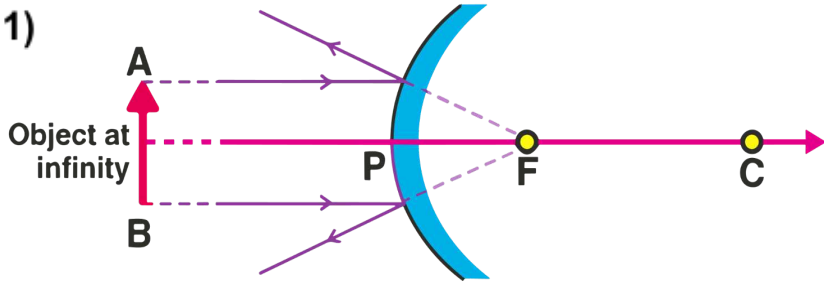
4. Ray incident obliquely to the principal axis towards the pole of the concave mirror on a convex mirror is Reflected Obliquely.



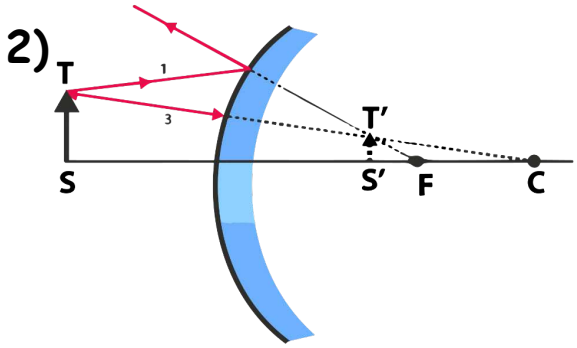
E.M.A

IMAGE FORMATION BY CONVEX MIRROR:

1)



2)

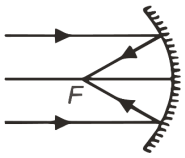
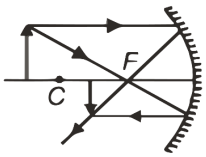
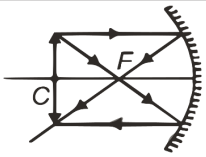
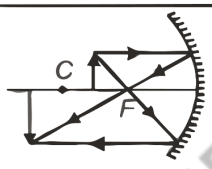
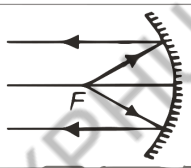
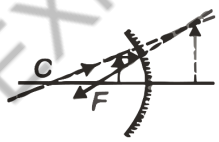


	Position of the Object	Position of the Image	Size of the Image	Nature of the Image
(1)	At infinity	At focus, F, behind the mirror	Highly diminished and pointed in size	Virtual and erect
(2)	Between infinity and the pole of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

IMAGE FORMATION BY CONCAVE MIRROR:

E.M.A

Concave Mirror

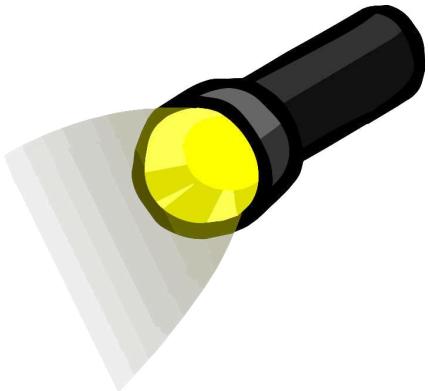
Position of object	Figure	Position of image	Nature of image
1. At infinity		At the principal focus or in the focal plane	Real, inverted, extremely diminished in size
2. Beyond the centre of curvature		Between the principal focus and centre of curvature	Real, inverted and diminished
3. At the centre of 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

v.imp

Uses of Spherical Mirrors:

Concave: Converging $f = (-ve)$

Concave mirrors are used in torches, headlights, shaving mirrors, dental examinations, and solar furnaces for heat.

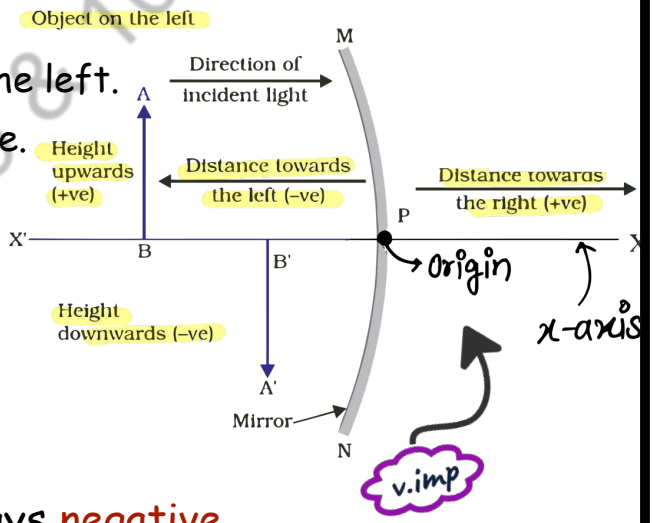


Convex: Diverging f=(+ve)

Convex mirrors are used in vehicles's rear-view mirrors to provide smaller but upright images and a wider field of view, enhancing driver visibility.

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:

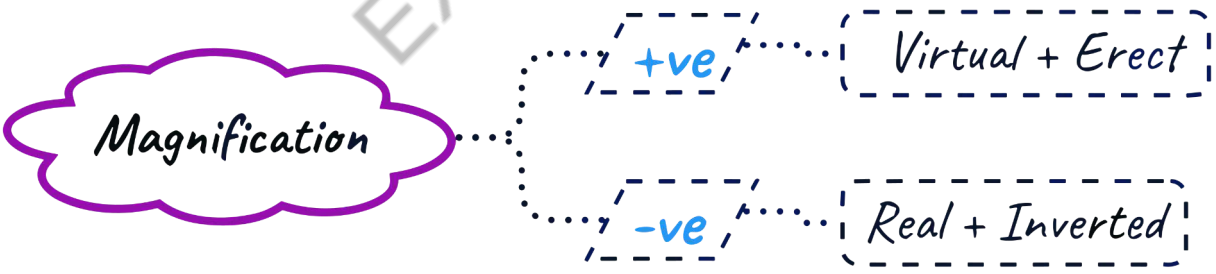
$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

- The distance of the Object from its pole is called the Object distance **(u)**
- The distance of the Image from its pole is called the image distance **(v)**
- The distance of the principal focus from the pole is called the focal length **(f)**

Magnification (m):

Magnification Produced by a spherical mirror gives the relative Extent to which the image of an Object is magnified with respect to the Object's size.

$$m = \frac{h\ image}{h\ object} = \frac{-v}{u}$$



1. 0<m<1: Diminished (Between 0 and 1)
2. m=1: Same Size
3. m>1: Enlarged

#An object is placed at a distance of 8cm from a convex mirror of a focal length of 12cm. Find the position of the image.

Focal length (f) = 12cm;

Object distance (u) = -8cm;

By mirror formula;

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

$\Rightarrow \frac{1}{v} + \frac{1}{-8} = \frac{1}{12}$

$\Rightarrow \frac{1}{v} + \frac{1}{8} = \frac{1}{12}$

$\frac{1}{v} = \frac{3+2}{24}$

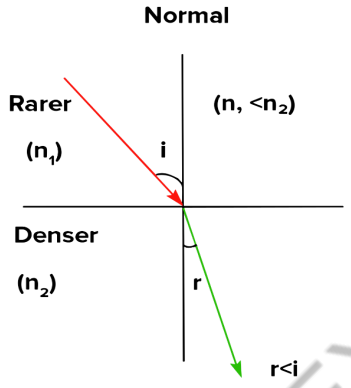
$\Rightarrow \frac{1}{v} = \frac{5}{24}$

$\Rightarrow v = \frac{5}{24} = 4.8$ cm.

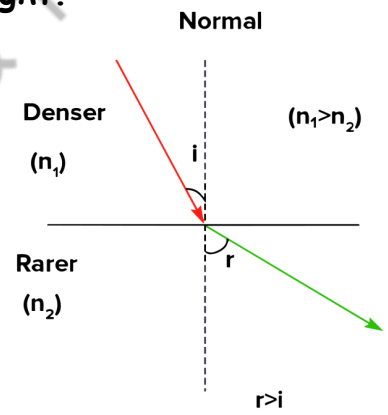
Since v = 4.8cm which is positive hence image is behind the mirror.

REFRACTION

A Change in the path of a light ray as it passes from one medium to another medium is called the Refraction of light.



Light rays undergo refraction by bending toward the normal when they transition from a rarer medium to a denser one.



Light rays refract by bending away from the normal when they transition from a denser medium to a rarer one.

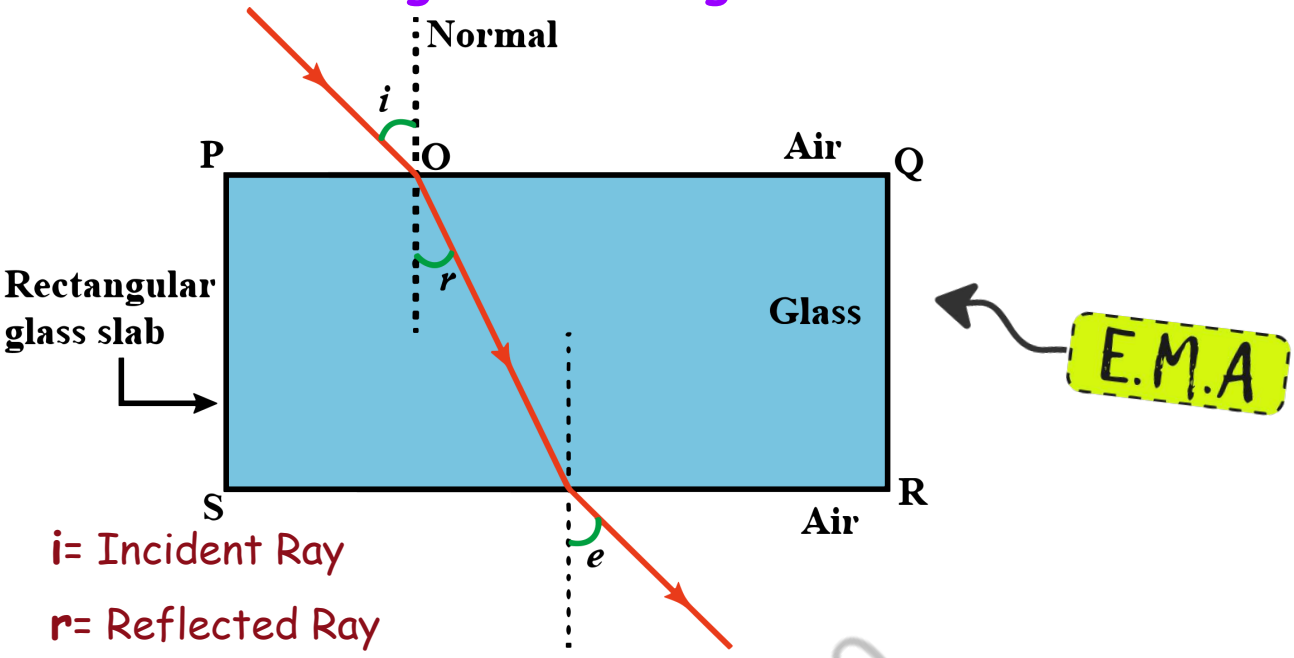
LAWS OF REFRACTION:

- The incident ray, the reflected ray, and the normal to the surface of separation of two media at the same point of incidence, all lie in the same plane.
- **Snell's law:** The ratio of sine of angle of incidence to the sine of angle of refraction for a light of a given color is constant for a given pair of media.

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

μ - refractive index

Refraction through a Rectangular Glass slab:



- Angle of incidence = Angle of emergence **(∠i)=(∠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 (∠i) is 0°, and therefore, the angle of refraction (∠r) is also 0°.

Refractive Index:

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, 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

Special Question:

#Question

Calculate the angle of incidence of the light ray incident on a surface of a plastic slab of refractive index $\sqrt{3}$, if the angle of refraction is 30°.

(Use: $\sin 30^\circ = \frac{1}{2}$ and $\sin 60^\circ = \frac{\sqrt{3}}{2}$)

Solution:

Given: Light is travelling from air medium to the plastic slab

The angle of refraction $r = 30^\circ$

Refractive index of the plastic slab $n_2 = \sqrt{3}$

Refractive index of air $n_1 = 1$

The angle of incidence $i = ?$

Using Snell's law -

$n_1 \sin i = n_2 \sin r$

$$\Rightarrow \sin i = \frac{n_2 \sin r}{n_1} = \frac{\sqrt{3} \times \sin 30^\circ}{1} = \frac{\sqrt{3}}{2} = \sin 60^\circ$$

$$\Rightarrow i = 60^\circ$$

Question

The refractive index of dense flint glass is 1.65 and that of alcohol is 1.36 both with respect to air. What is the refractive index of flint glass with respect to alcohol?

Solution:

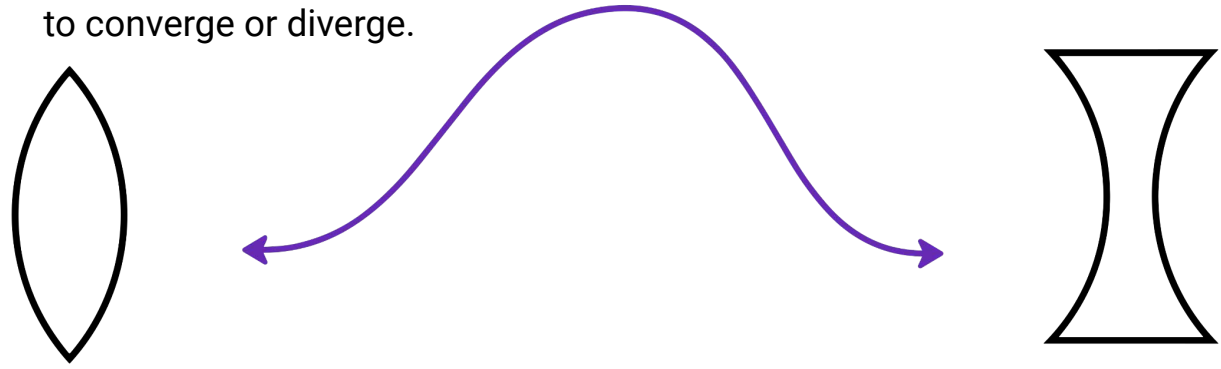
Refractive index of flint glass = $n_1 = 1.65$

Refractive index of alcohol = $n_2 = 1.36$

Therefore, Refractive index of flint glass with respect to alcohol = $n_{12} = \frac{n_1}{n_2} = \frac{1.65}{1.36} = 1.21$.

Spherical Lens:

A spherical lens is an optical lens with a curved surface that causes light rays to converge or diverge.



CONVEX

1 . Thick at middle

2. Converging Lens

CONCAVE

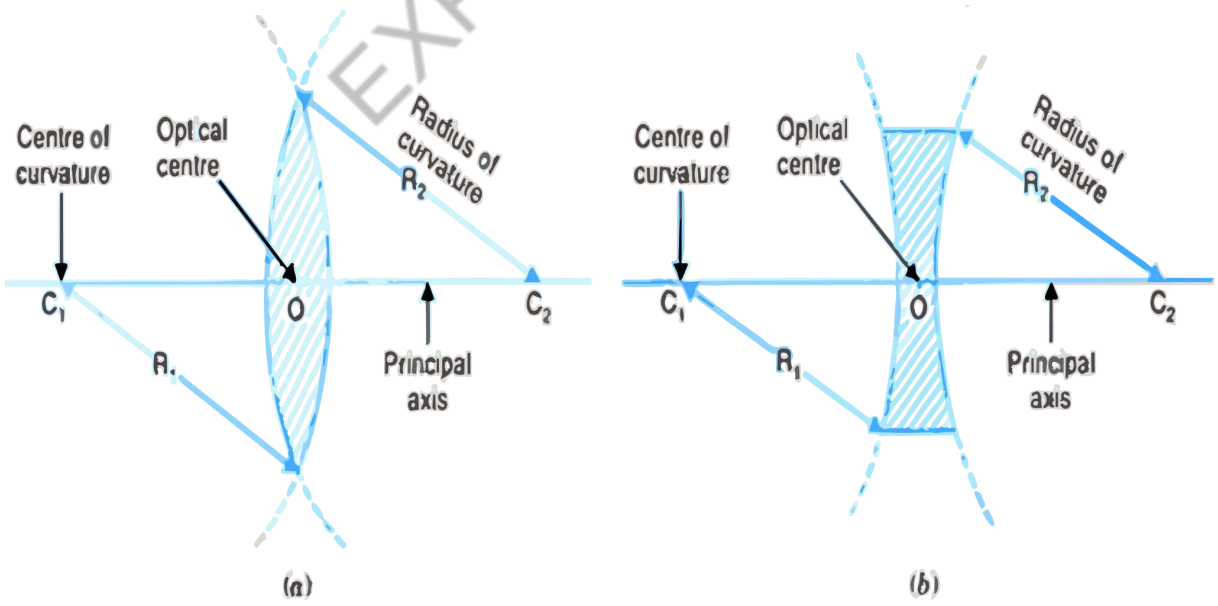
1. Thin at middle

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.

Terms used in Spherical Lens:



- **Center of curvature (c):** 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.

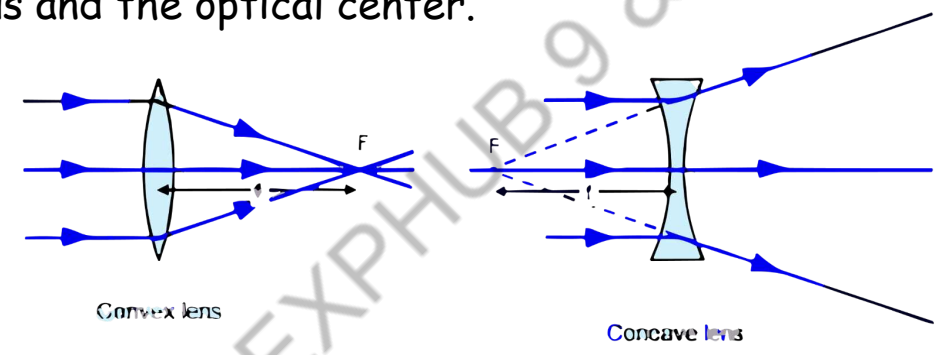
- **Principal Axis:** An imaginary straight line passing through the two centers of curvature of a lens is called its principal Axis.

- **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.

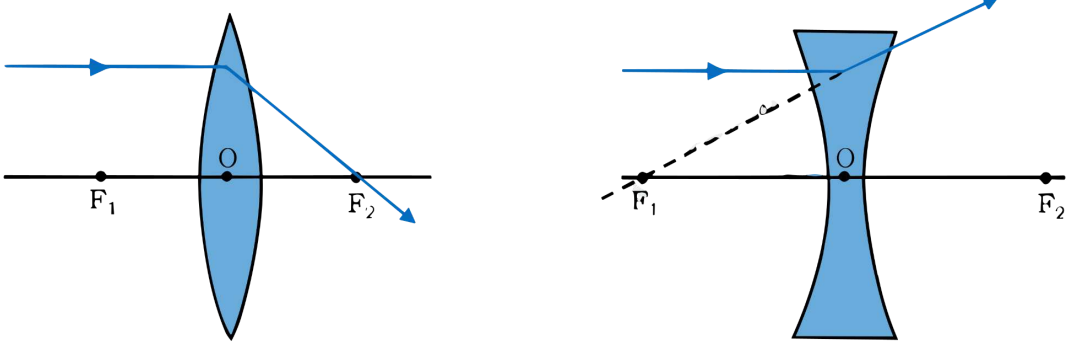
- **Focal length:** Focal length is the distance between the principal focus and the optical center.



RAY DIAGRAMS:

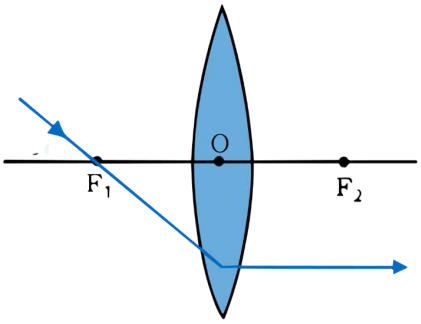
Rules:

- 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.

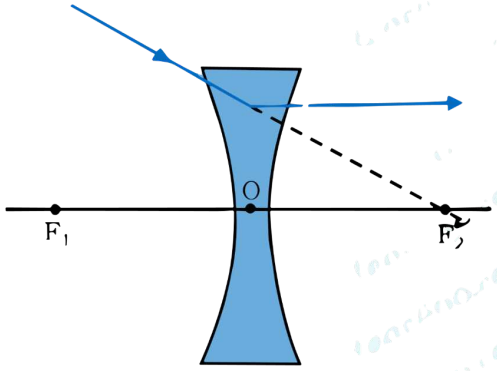


Convex Lens Concave Lens

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

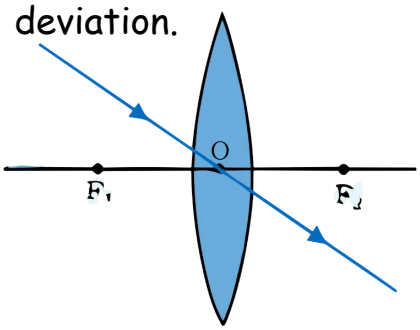


Convex Lens

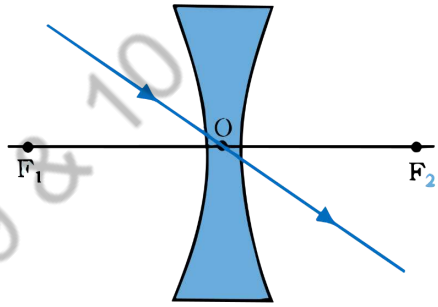


Concave Lens

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

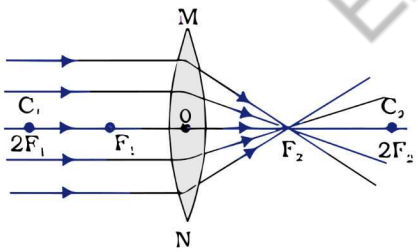


Convex Lens

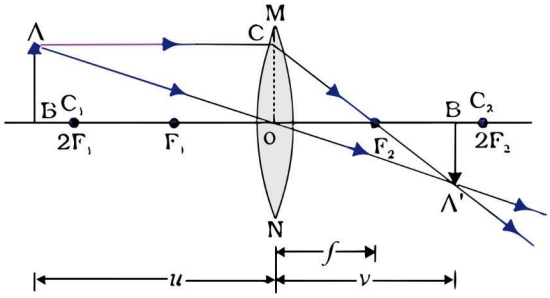


Concave Lens

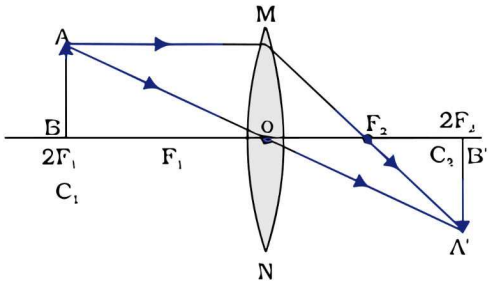
Image formation by Convex Lens:



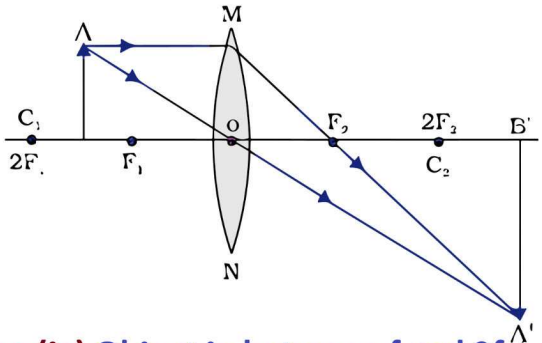
Case (i) Object at infinity



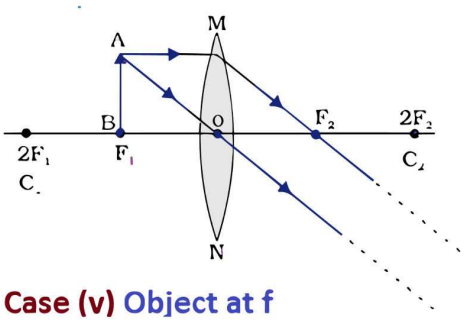
Case (ii) Object at beyond 2f



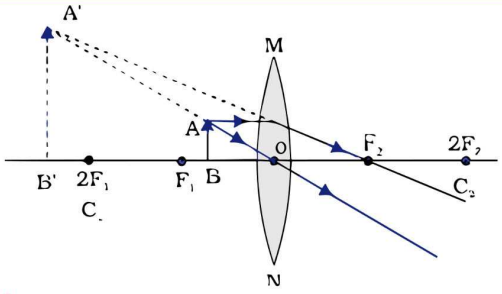
Case (iii) Object at 2f



Case (iv) Object in between f and 2f

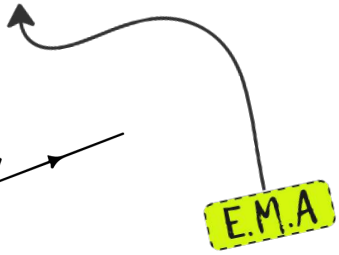


Case (v) Object at f

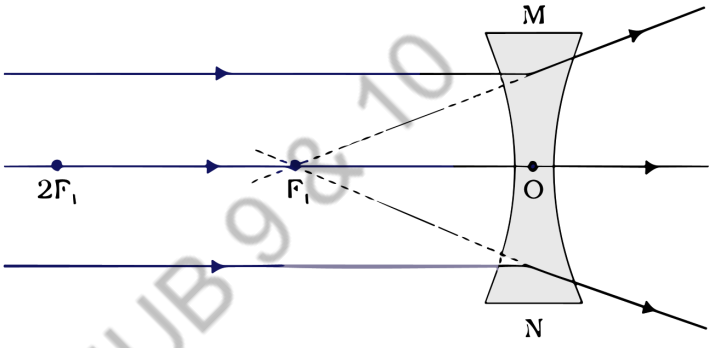


Case (vi) Object distance < f

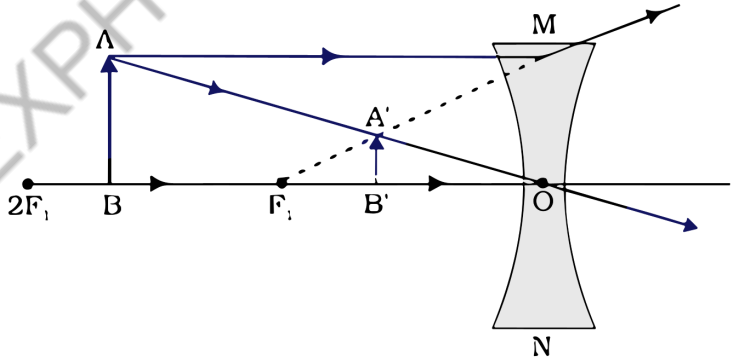
Image formation by Concave Lens:



Infinity



Between infinity and optical center O of the lens



Lens formula & Magnification:

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

- u= image distance
- v = object distance,
- f= focal length

Note: We apply sign conventions similar to those used for spherical mirrors, with the exception that all measurements are taken from the optical center of the lens.

Magnification - Ratio of the height of the Image and the height of the Object Represented by **(m)**

$$m = \frac{hi}{ho} = \frac{v}{u}$$

hi - height of the image
ho- height of the object

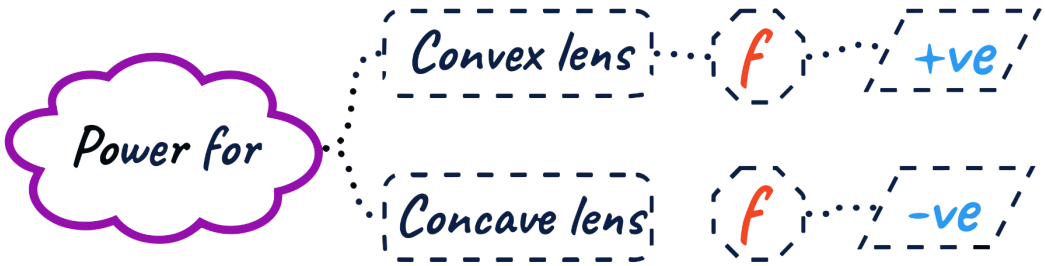
(-Ve) Sign shows that the image is virtual & erect.
(+Ve) Sign shows that the image is real & inverted.

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:

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

f - focal length in meter.
SI unit => (D) Dioptre



#TOP 7 QUESTIONS

Q.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 3*10^{8} m/s. [CBSE 2012] (2 - Marks)

Solution:

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

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

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

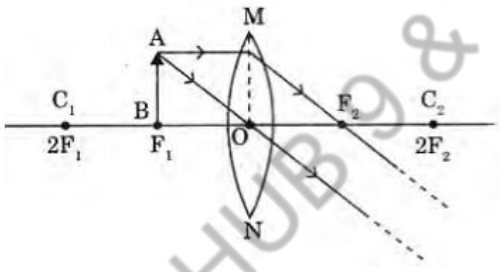
$$v_w = \frac{3 \times 10^{8} \times 3}{4}$$

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

Q.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. [CBSE 2013] (2-Marks)

Solution:

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



Q.3) What is meant by the power of a lens? Give its SI unit. When two or more lenses are placed in conta

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. $P = \frac{1}{f}$. The SI unit of power is D(dioptre) if f is measured in metre.

Q.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 of reflection)	$\angle i \neq \angle r$ (angle of refraction)
Reflection can take place from any surface.	Refraction can take place from a transparent interface..

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

1. **Shavingmirror,**
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 can not 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

Q.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 15 cm. Find the position, nature, and size of the image forms. [All India 2013] (5-Marks)**

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.

Q.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.,

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

$$v = 3u$$

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

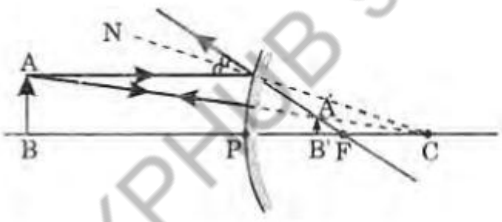
Mirror formula, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

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

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

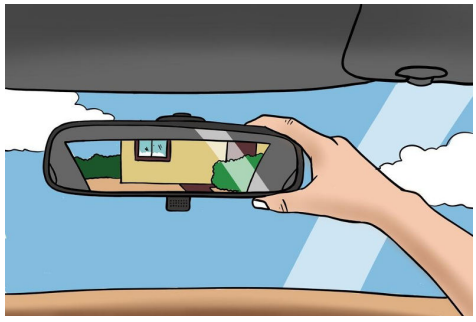
$$f = -\frac{30}{4} = -7.5 \text{ cm}$$

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



Competency-based Question-Answer:

Q.1) **A rear-view mirror is a device that allows the driver to see the traffic on the road behind him. It usually finds its place at the top of the windscreen inside the cabin. This device is one of the most basic but essential safety devices in the vehicle. It provides assistance to the driver during overtaking, parking in reverse gear, etc. Generally, vehicles also have a pair of mirrors attached to the body from the outside. They are known as 'side mirrors or Outer Rear View Mirrors (ORVM) which serve the same purpose. Almost all modern cars mount their side mirrors on the doors-normally at A-pillar rather than the wings (the portion of the body above the wheel well).**

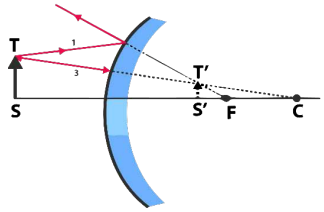


(a) What type of Mirror is required to make ORVM in the vehicles?
(b) What type of image is formed by such a mirror?
(C) Draw a ray diagram to show the formation of an image by this type of mirror.
(d) Why are these types of mirrors used as rear-view mirrors in vehicles?

Solution:

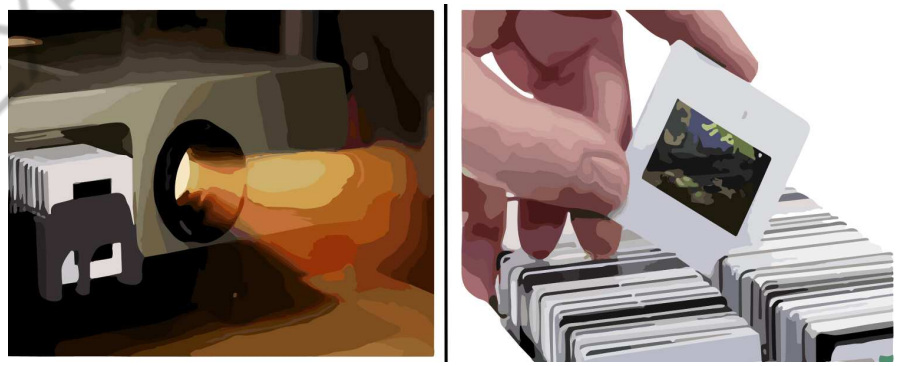
(a) Convex Mirror
(b) Convex mirror always forms an erect, virtual, and diminished image for all positions of the object placed in front of it.

(c)



(d) Convex mirrors are used as rear-view mirrors in vehicles to see the traffic at the rear side (or back side) because- (i) a convex mirror always produces an erect image of the object; (ii) the image formed in a convex mirror is highly diminished due to which a convex mirror gives a wide field of view.

Q.2) **The above images are those of a specialized slide projector. Slides are small transparencies mounted in sturdy frames ideally suited to magnification and projection since they have a very high resolution and a high image quality. There is a tray where the slides are to be put into a particular orientation so that the viewers can see the enlarged erect images of the transparent slides. This means that the slides will have to be inserted upside down in the projector tray. To show her students the images of insects that she investigated in the lab, Mrs. Iyer brought a slide projector. Her slide projector produced a 500-times enlarged and inverted image of a slide on a screen 10 m away. (CBSE 22-23 SQPs)**



(a) *Based on the text and data given in the above paragraph, what kind of lens must the slide projector have?*

(b) If v is the symbol used for image distance and u for object distance then with one reason state what will be the sign for v/u in the given case.

(c) A slide projector has a convex lens with a focal length of 20 cm. The slide is placed upside down 21 cm from the lens. How far away should the screen be placed from the slide projector's lens so that the slide is in focus?

(d) When a slide is placed 15 cm behind the lens in the projector, an image is formed 3 m in front of the lens. If the focal length of the lens is 14 cm, draw a ray diagram to show image formation. (not to scale)

(d) When a slide is placed 15 cm behind the lens in the projector, an image is formed 3 m in front of the lens. If the focal length of the lens is 14 cm, draw a ray diagram to show image formation. (not to scale)

Solution:

(a) The slide projector has a Convex lens.

(b) Sign of v/u i.e. "m" will be negative as the image formed is real and inverted.

c) Given f=20cm, u = -21 cm; v (screen distance) = ?

using lens formula 1/u + 1/f = 1/v

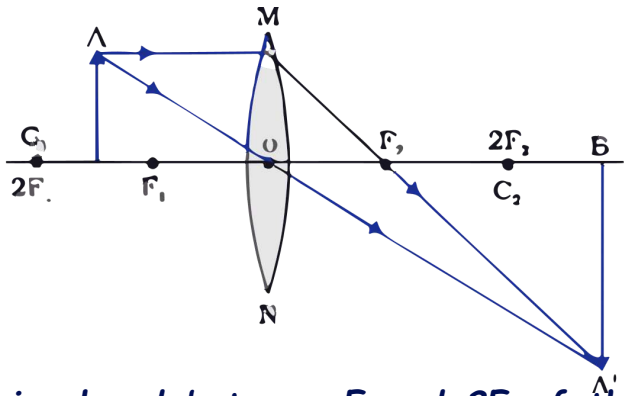
=> 1/v = 1/20 + 1/-21

=> 1/v = 21-20/420 = 1/420

v = 420 cm or 4.2 m

So, the screen be placed 4.2 m away from the lens of the projector.

(d)



Here the slide is placed between F and 2F of the lens and the image is formed beyond 2F' of lens on its other side.