Light- reflection and refraction

1 Optics

It is that branch of physics which deals with the study of light and phenomenon due to light. it may be divided in to two parts: 1. Ray Optics   2. Wave Optics.

- Reflection, refraction, dispersion of light can be explained using ray optics.
- Polarization, interference, Diffraction, etc can be explained using wave optics.

2 Lights

A form of energy which travel in form of radiations with or without medium and due to which vision process is possible is called light.

Form of Light:

Ray:

The path along which light travel from source to receiver called ray

Pencil of Ray:

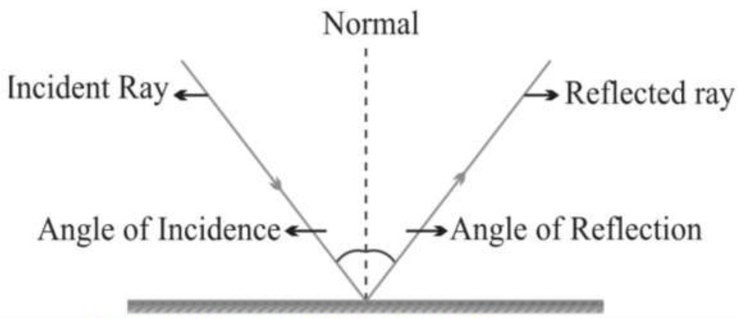
A group of rays starting from a point called pencil of ray.

Beam of Ray:

A collection of ray with well defined boundary called beam.

3 Reflection of Light:

The phenomenon of bending or re-bouncing back of light in the same medium after striking a reflecting surface (mirror) is called reflection of light. The vision process is possible only due to reflection of light.



4 Laws of Reflection:-imp

1st Law:

The incident ray, reflected ray and normal to the surface lie in the same plane.

2nd Law:

The angle of incidence is equal to the angle of reflection.

i.e $\angle i = \angle r$

Q.1 A ray of light incident at an angle 60° .Than what is the angle of reflection

Ans 60°

5 Real and Virtual images

- An image is formed when the light rays coming from an object meet at a point after reflection from a mirror (or refraction from lens).
- The images are of two types

1. **Real Images:-**

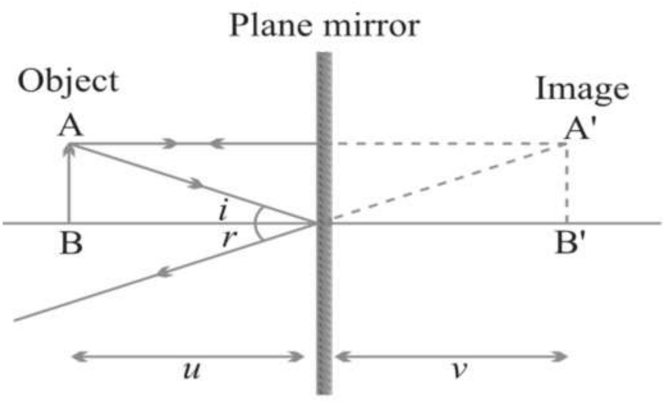
   Real images are formed when rays of light that comes from an object (or source) meets at a point after reflection from a mirror (or refraction from a lens). Real images can be formed on a screen and can be seen with the eyes.

2. **Virtual images:-**

   Virtual image is an image in which the outgoing rays from an object do not meet at a point. It will appear to meet at a point in or behind the optical device (i.e., a mirror) but they do not actually meet after reflection from a mirror (or refraction from a lens). A plane mirror always forms virtual images.

(6) Plane Mirror

A mirror whose reflecting part is plane called plane mirror.

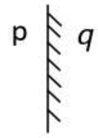


7.Characteristic of Image Formed by Plane Mirror:

(i) The image formed by plane mirror is of same size to that of object.

(ii) The image formed by a plane mirror is at same distance behind the mirror as the object is in front of it.

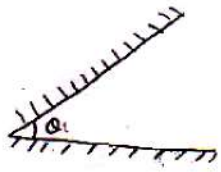
(iii) Image formed by plane mirror is virtual and erect.



(iv) The image formed by plane mirror is latterly inverted. i.e

8. Some important facts about the plane mirror.

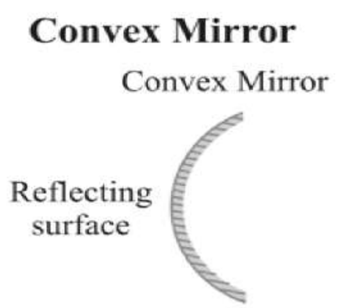
- If the mirror is rotated at an angle θ then image rotates at angle 2 θ.
- The minimum length of a plane mirror should be equal to half of the height of an object to see full size.
- If a object moves toward plane mirror with a speed v then image will move toward or away from mirror with speed 2v.
- The linear magnification of a plane mirror is 1 and focal length=∞ and power of plane mirror is O.
- The number of image formed between two planes inclined at an angle Q will be equal to
  - Lateral inversion:-

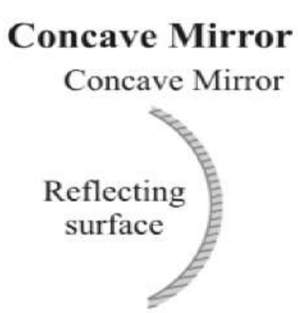


If an object is placed in front of the mirror, then the right side of the object appears to be the left side and left side of the object appears to be the right side of this image. This change of sides of an object and its mirror image is called lateral inversion.

9. Spherical Mirrors:

A part of spherical reflecting surface is called spherical mirror. These are of two types:





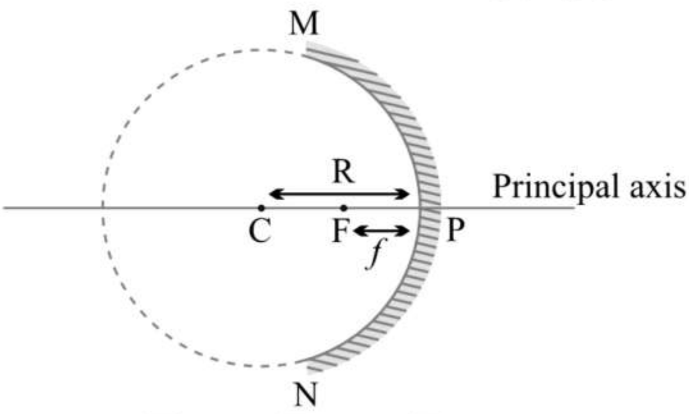
(i)Convex Mirror:

A spherical mirror whose inner part is polished and outer part is reflecting called convex mirror called convex mirror.

(ii)Concave Mirror:

A spherical mirror whose inner part is reflecting and outer part is polished called concave mirror or a mirror whose reflecting part is toward centre called concave mirror.

10. Some Important Terms Related to Spherical Mirrors:



(i) **Centre of Curvature (C):** The centre of sphere of which the spherical mirror is a part called centre of curvature.

(ii) **Radius of Curvature (R):** the radius of sphere of which the spherical mirror is a part called radius of curvature.

(iii) **Pole (Vertex):** The midpoint of the spherical mirror is called pole (P).

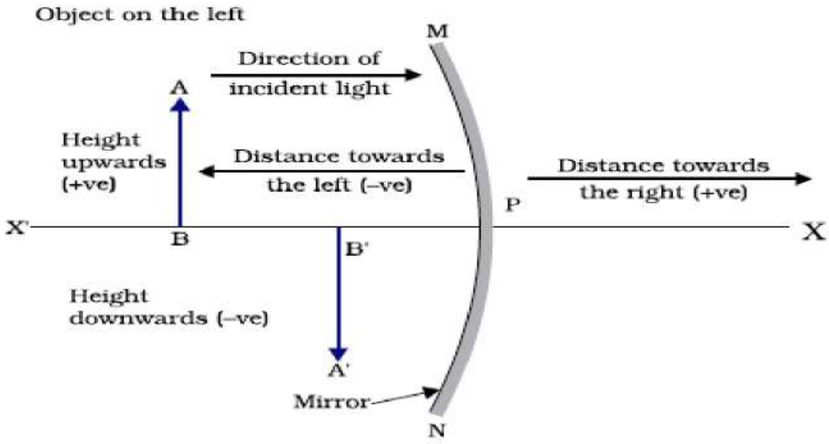
(iv) **Principle Axis:** The line joining the C and P called principle axis.

(v) **Aperture:** The effective diameter of the mirror is called aperture.

(vi) **Focus:** The point on the principle axis at which light after reflection from mirror meets or appears to meat called focus (F).

(vii) **Focal Length:** The distance between pole and focus of a mirror is called focal length (f).

11. New Cartesian Sign Convention for Spherical Mirrors:- imp



(i) All the distances should be measured from the pole of mirror.

(ii) The distances measured in direction of light are taken +ve.

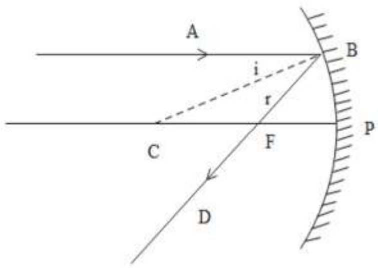
(iii) The distance measured in oppose to direction of light are taken –ve.

(iv) The distance measured above the principle axis should be taken +ve.

(v) The distance below the principle axis should be taken –ve.

12. Relation between Focal Length and Radius of Curvature of a Spherical Mirror:

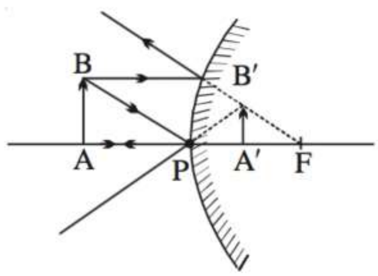
(a) For Concave Mirror: imp



Suppose a concave mirror of focal length f and radius of curvature R. Again suppose that a ray of light parallel to principle axis after reflection passes from the focus. As shown in fig.

$$f = \frac{R}{2}$$

(b) For Convex Mirror: imp

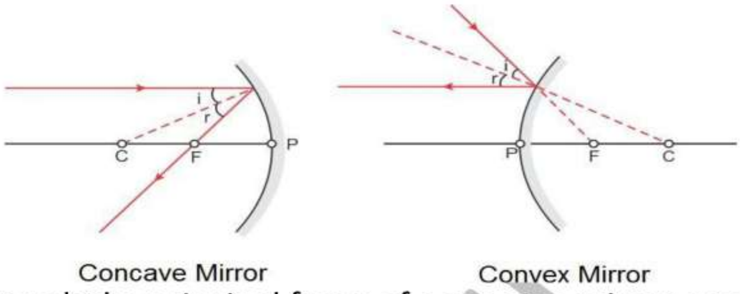


Suppose a convex mirror of focus f and radius of curvature R. again suppose that a rays of light coming from ∞, after reflection seems to be pass from the focus. As shown in fig.

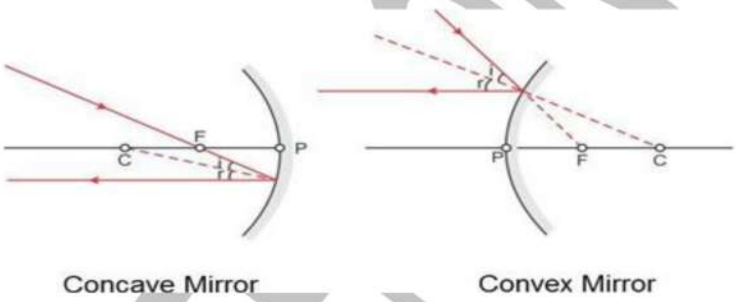
$$\text{Or} \quad f = \frac{R}{2}$$

13. Rules for tracing images formed by Spherical Mirrors

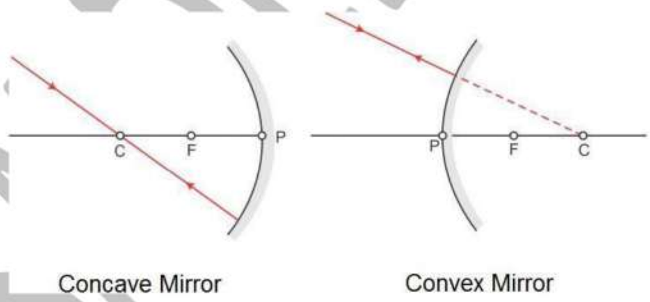
Rule 1: A ray which is parallel to the principal axis after reflection passes through the principal focus in a concave mirror or appears to diverge from the principal focus in a convex mirror.



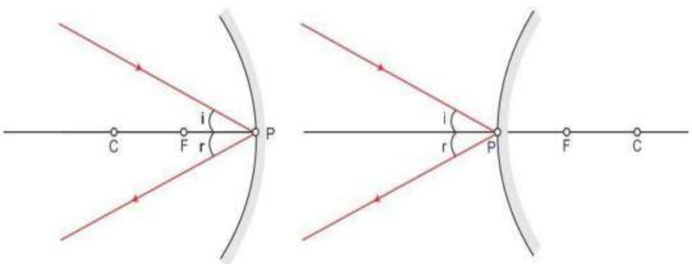
Rule 2: A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror emerges parallel to the principal axis after reflection.



Rule 3: A ray passing through the centre of curvature of a concave mirror or directed towards the centre of curvature of a convex mirror is reflected back along the same path.

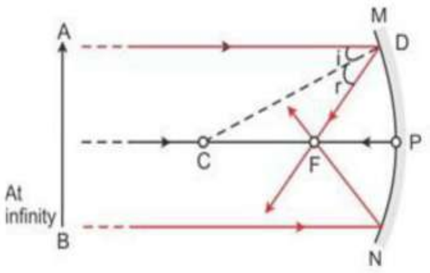


Rule 4: A ray incident obliquely towards the pole of a concave mirror or a convex mirror is reflected obliquely as per the laws of reflection.

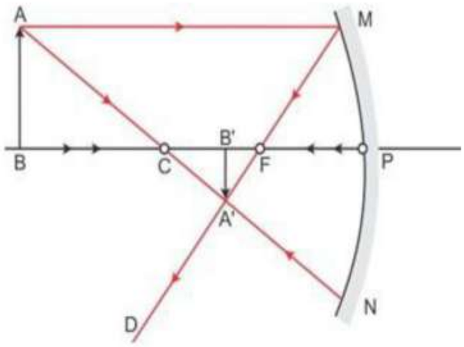


14.Image formation by a concave mirror

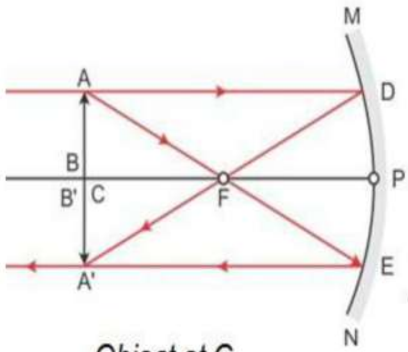
- **Ray Diagrams**



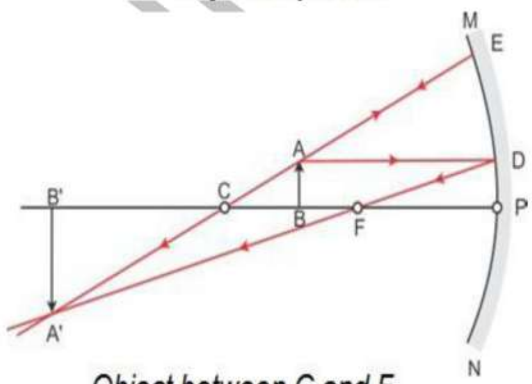
Object at infinity



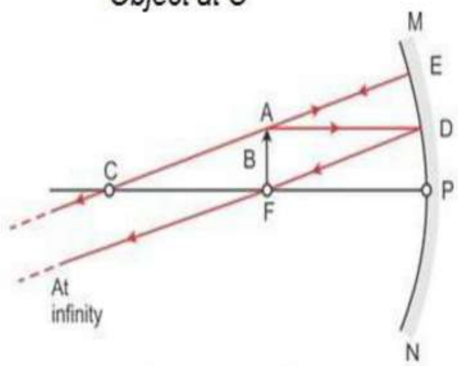
Object beyond C



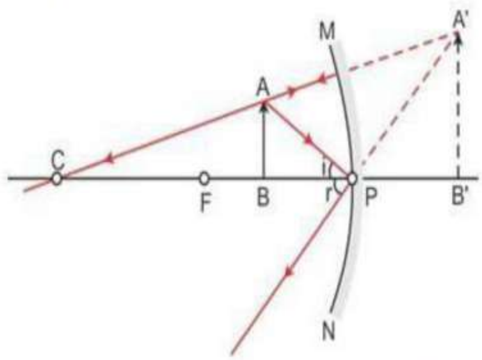
Object at C



Object between C and F



Object at F



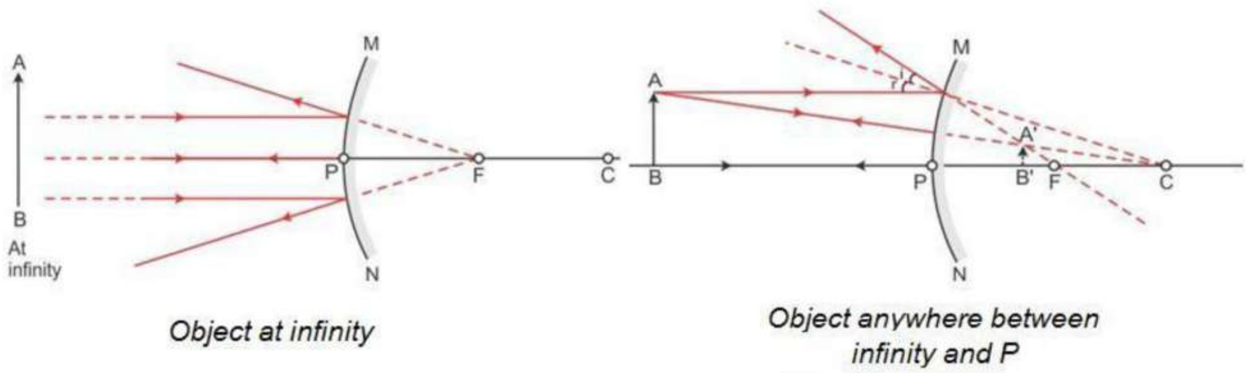
Object between F and P

- **15.Characteristics of images formed**

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F	Highly diminished	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Equal to size of object	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between F and P	Behind the mirror	Enlarged	Virtual and erect

16. Image formation by a convex mirror

- **Ray Diagrams**



- **17.Characteristics of images formed**

Position of object	**Position of image**	**Size of image**	**Nature of image**
At infinity	At focus F behind the mirror	Highly diminished, point sized	Virtual and erect
Anywhere between infinity and the pole of the mirror	Between P and F behind the mirror	Diminished	Virtual and erect

18. Mirror Formula or Mirror Equation: imp

A relation between u, v, f of a mirror is called mirror formula.

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

19. Linear Magnification of Mirror (m): imp

It is defiened as the ratio of height of the image to the height of the object

i.e $$\text{Linear Magnification} = \frac{\text{Height of the Image}}{\text{Height of the Object}} = \frac{I}{O} = -\frac{v}{u}$$

If m>1 then image will be larger then object.

If m<1 then image will be smaller then obect

If m=1 then size of image will be equal to size of obejct (plane mirror)

If m=-ve image will be real and if m = +ve image will be virtual.

20. Application or Uses of Spherical Mirror: imp

Concave Mirror: Dentist, ENT specialist, for saving and make up, in cinema projector, in reflecting type telescope, in solar cooker, in search light, motor head light, in torch, in dish antenna.

Convex Mirror: As rear view mirror, in reflector for street lighting, in big shops to monitor the activities of customers.

Question2: **An object is placed in front of a concave mirror at a distance of 7.5 cm from it. If the real Image is formed at a distance of 30 cm from the mirror, find the focal Length of the mirror. What Would be the focal? Length if the image is virtual?**

Solution: **Case I:** When the image is real. We have u = – 7.5 cm; $v = -30$ cm ; $f = ?$

We know $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or, $f = \frac{uv}{u+v} = \frac{(-7.5)\times(-30)}{-7.5-30}$ = **– 6 cm**

Case II: When the image is virtual: In this case, $u = -7.5$ cm v = + 30 cm

We know $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or, $f = \frac{uv}{u+v}=\frac{(-7.5)(30)}{-7.5+30}$ = **– 10 cm**

Question3: **An object 5 mm high is placed 30 cm from a convex mirror whose focal length is 20 cm. Find the position (in cm), size (in mm) and nature of the image.**

Solution: We have, $u = -30$ cm ; $v = ?$ $f = +20$ cm

We know $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or, $v = \frac{uf}{u-f} = \frac{(-30)(+20)}{-30-20}$ = + 12 cm

The image is formed 12 cm behind the mirror, it is virtual.

Now, $m = \frac{I}{O}=-\frac{v}{u}=-\frac{12}{-30}$ or, $I = \frac{2}{5}\times O=\frac{2}{5}\times 5$ = + 2 mm

Hence the height of the image = **2mm** the positive sign indicates that the image is erect.

Question4: **An object 2 mm high is placed 150 mm from a concave mirror of focal length 5 cm. Find the position (in mm) and size (in mm) of the image.**

Solution: We have u = –15 cm; $v = ?$ $f = -5$ cm we know that

$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ Or, $v = \frac{uf}{u-f}=\frac{(-15)(-5)}{-15+5}$ = – 7.5 cm = **–75 mm**

The image is formed at a distance of 75 mm in front of mirror.

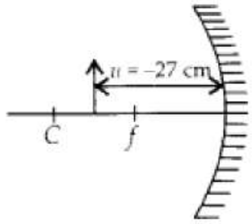
Now, $m = \frac{I}{O}=-\frac{v}{u}$ or, $\frac{I}{O}=-\frac{(-7.5)}{(-15)}$ or, $I =$ **–1 mm** the negative sign indicates that image is inverted.

Question 5. A small candle, 2.5 cm in size is placed at 27 cm in front of a concave mirror of radius of curvature 36 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Describe the nature and size of the image. If the candle is moved closer to the mirror, how would screen have is moved?

Solution: The object is kept between f and C. So the image should be real, inverted and beyond C. To locate the sharp image, screen should be placed at the position of image.

The focal length $f = -\frac{R}{2} = -18cm\,, u = -27cm$ using the formula $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ $we\ get\ v = -54\ cm$ Size of the image can be calculated by $m = -\frac{v}{u} = -\frac{I}{O}$ $so\ I = -5cm$

So, the image is inverted and magnified. Thus in order to locate the sharp image, the screen should be kept 54 cm in front of concave mirror and image on the screen will be observed real, inverted and magnified. If the candle is moved closer to the mirror, the real image will move away from the mirror, hence screen has to be shifted away from the mirror to locate the sharp image.

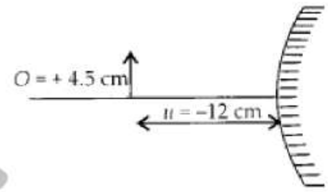


Question 6: **A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror.**

Solution: A convex mirror always form virtual image, which is erect and small in size of an object kept in front of it. Focal length of convex mirror $f = +15$ cm Object distance u = – 12 cm.

Using mirror formula $\frac{1}{v}+\frac{1}{-12}=\frac{1}{15} \Rightarrow v=\frac{60}{9}=6.66cm$

Therefore, image is virtual, formed at 6.67 cm at the back of the mirror.



Magnification $m=-\frac{v}{u}=0.55$ so size of the image I= (m×O) =2.5 cm

It shows the image is erect, small in size and virtual. When the needle is moved farther from mirror the image also move towards focus and decreasing in size. As u approaches v approaches focus but never beyond f.

Example:7 6 A convex mirrors used for rear-view on an automobile has a radius of curvature of 3 m. If a bus is located at 5 m from this mirror, find the position, nature and size of the image.

Solution Radius of curvature, R = + 3 m;

Object-distance, u = – 5 m; Image-distance, v = ? Height of the image, h′= ?

Focal length, $f=\frac{R}{2}=\frac{3}{2}=+1.5\,m$ (as the principal focus of a convex mirror is behind the mirror)

Since $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or, $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{1.5}-\frac{1}{-5}=\frac{1}{1.5}+\frac{1}{5}=\frac{5+1.5}{7.5}=+1.15$ m

The image is 1.15 m at the back of the mirror.

Magnification, $m=\frac{h'}{h}=-\frac{v}{u}=-\frac{1.15}{-5}=0.23$ The image is virtual, erect and smaller in size by a factor of 0.23.

Example 8: an object, 4.0 cm in size, is placed at 25.0 cm in front of a concave mirror of focal length 15.0 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Find the nature and the size of the image.

Solution Object-size, h = + 4.0 cm; u = – 25.0 cm; f = –15.0 cm; Image-distance, v =? Image-size, h′ =?

From Eq. (10.1): $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or, $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-15}-\frac{1}{-25}=\frac{1}{-15}+\frac{1}{25}=\frac{-5+3}{75}=-37.5$ cm

The screen should be placed at 37.5 cm in front of the mirror. The image is real.

Also, magnification, $m=\frac{h'}{h}=-\frac{v}{u} \Rightarrow h'=-\frac{v}{u}h=-\frac{-37.5\times 4}{-25}=-6cm.$

Height of the image, h′ = – 6.0 cm the image is inverted and enlarged.

Question9: Find the focal length of a convex mirror whose radius of curvature is 32 cm.

Question10: A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?

21. Reflecting of Light:

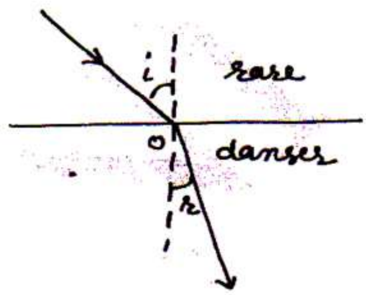
The phenomenon of the change in the path of light when it move from one medium to another medium is called refraction of light. Refraction of light occurs because light changes its velocity when it moves from one medium to another medium. On refraction both velocity and wavelength of light changes but frequency remains unchanged.

22. Laws of Refraction of Light: imp

(i)The incident ray, refracted ray and normal to the surface meet at a point.

(ii)Snell's Law:

The ratio of sine of angle of incidence to the sine of angle of refraction is constant for a pair of media.



i.e $\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = {}^1n_2 = \text{constant}$

Here ${}^1n_2$ is called refractive index of second media w.r.t first medium.

23. Refractive Index: or Absolute Refraction Index: imp

The ratio of velocity of light in vacuum to the velocity of light in a medium is called absolute refractive index or simply refractive index i.e $n = \frac{C}{v}$ where $C = 3 \times 10^8 \text{m/sec}$

Absolute refractive index may not be less than one because $C > v$.

Relative Refraction Index:

Suppose there are two medium of refractive index n_1 and n_2 then $\frac{n_2}{n_1} = {}^1n_2$ called relative refractive of two w.r.t one. Or ${}^1n_2 = \frac{n_2}{n_1} = \frac{C}{v_2} \times \frac{v_1}{C} = \frac{v_1}{v_2}$

Or $\frac{n_2}{n_1} = \frac{v_1}{v_2}$

- Clearly smaller, the refractive index of a medium larger the velocity of light in that medium.
- Refractive indexes are a scalar quantity and have no units.
- A medium having higher refraction index called optical denser medium and a medium having lower refraction index called rare medium.

Question11: **If wavelength of light in glass is 7200 Å, then find the wavelength of same light (in Å) in water. ($\mu_w = 4/3$, $\mu_g = 3/2$)**

Solution: $\frac{\lambda_{water}}{\lambda_{glass}} = \frac{\mu_{glass}}{\mu_{water}}$ ***so*** $\lambda = \frac{3/2}{4/3} \times 720\text{Å}$ = **8100 Å**

Question 12: the refractive index of glass is 1.5. What is the speed of light in glass?

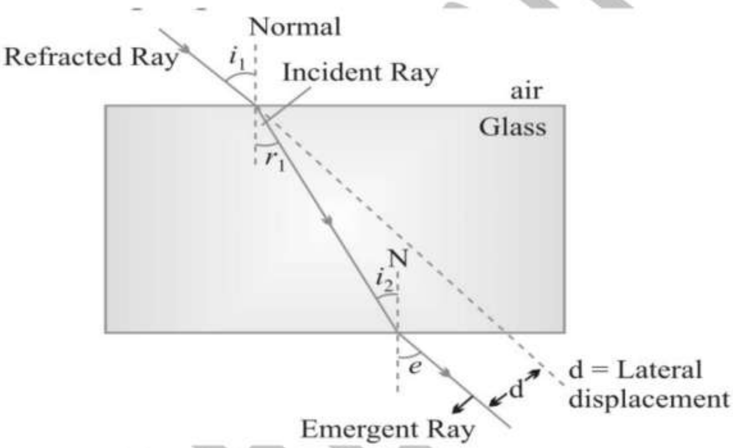
Answer: Given, Refractive index of the glass $\mu_{glass} = 1.5$ Speed of light in vacuum $c = 3 \times 10^8 ms^{-1}$

As we know, Refractive index of a medium $\mu_{medium} = \frac{c}{v_{medium}}$.

Where v_{medium} is the speed of light in that medium

So from here, $v_g == \frac{c}{\mu_g} = 2 \times 10^8\ m/s$ hence the speed of light in water is $2 \times 10^8\ m/s$

24. Principle of Reversibility of Light (Refraction through a Glass Slab): imp

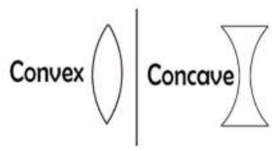


Suppose a ray of light PQ incident at Q point on a glass slab as shown in fig.

- We can see that when a mirror is placed ⊥ to the path of light, then light regain its original path. This phenomenon is called **principle of reversibility of light.**
- The perpendicular distance between incident ray and emergent ray is called lateral shift. In above fig. d is the lateral shift.

25. Lens

A lens is piece of transparent material bounded by two refracting surfaces out of which at least one is curved.



Uses:

Lenses are commonly used to correct vision deflects in human eyes. They are also used in microscopes, telescopes and cameras, cinemas, photography.

26. Terms Used in Lenses:

Optical Centre: The point in the lens through which the light passes un-deviated

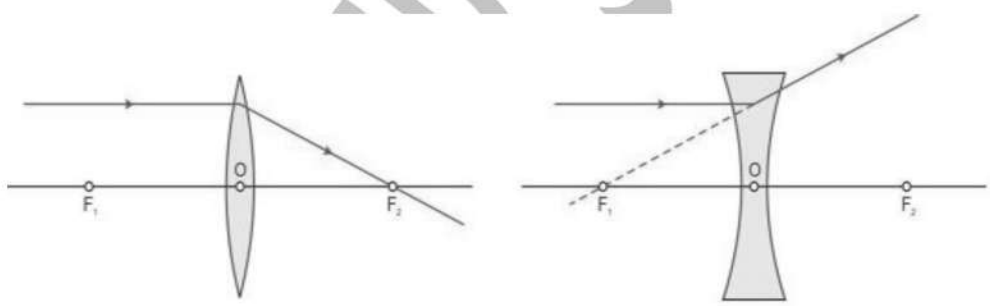
Principle Focus (F): The point on the principle axis on which the rays parallel to principle axis after refraction meats or appear to meet.

New Cartesian Sign Convention:

1. All the distance should be measured from the centre of the lens.
2. The distance measured in direction of light are taken +ve and in opposite to direction of light are taken – ve.

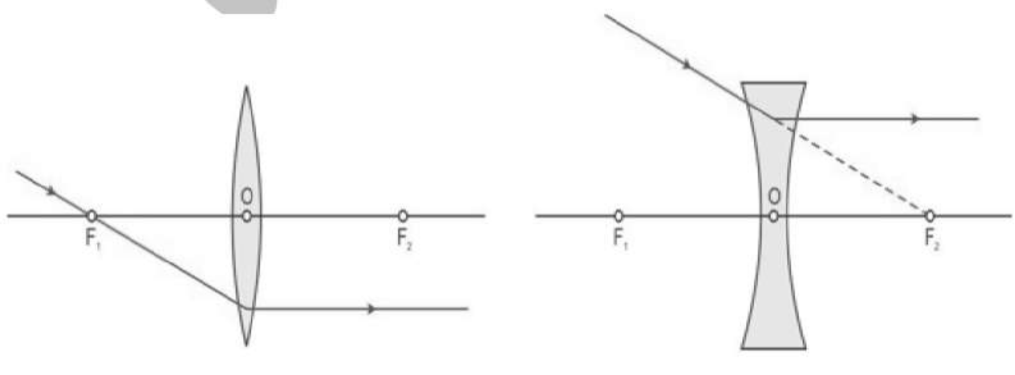
- **27. Rules for tracing images formed by spherical lens**

Rule 1: A ray which is parallel to the principal axis, after refraction passes through the principal focus in case of a convex lens or appears to diverge from the principal focus on the same side of the lens in a concave lens.



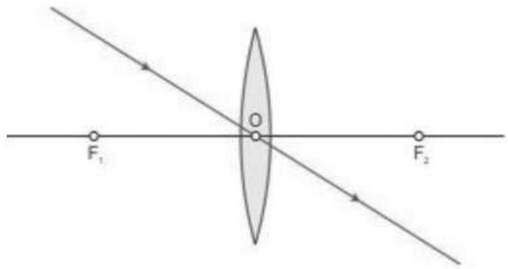
Convex Lens   Concave Lens

Rule 2: A ray passing through the principal focus of a convex lens or appearing to meet at the principal focus of a concave lens after refraction emerges parallel to the principal axis.

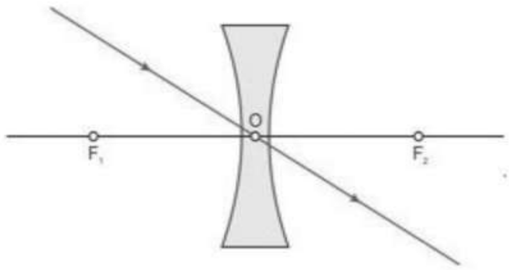


Convex Lens   Concave Lens

Rule 3: A ray passing through the optical centre of a convex lens or a concave lens emerges without any deviation.



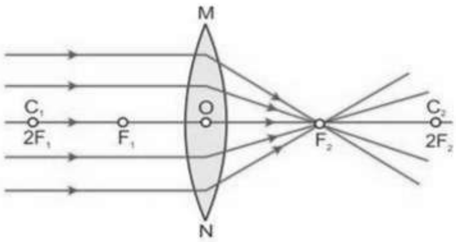
Convex Lens



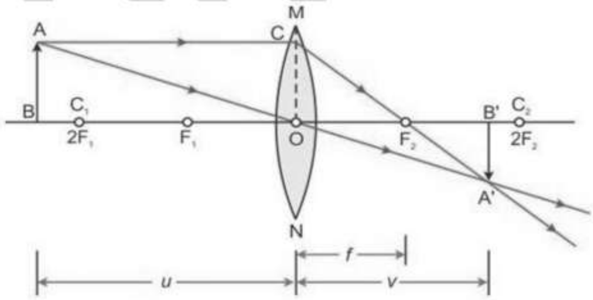
Concave Lens

28. Image formation by a convex lens

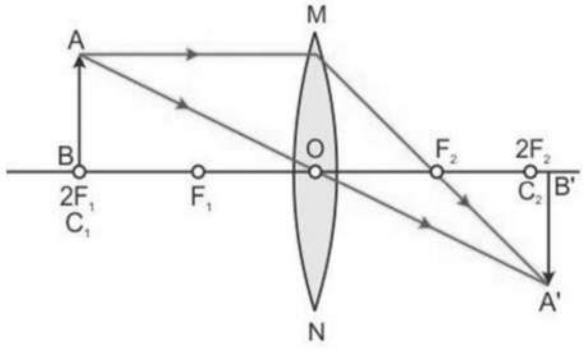
- **Ray Diagrams**



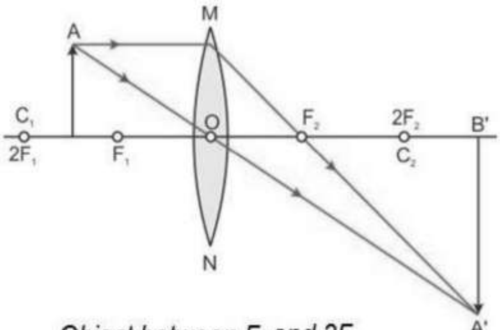
Object at infinity



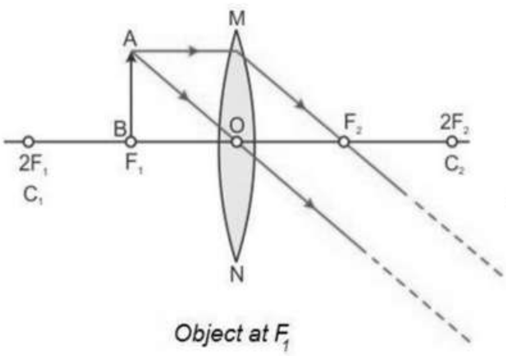
Object beyond 2F1



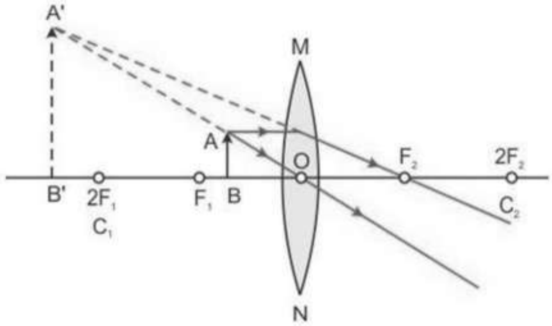
Object at 2F1



Object between F1 and 2F1



Object at F1



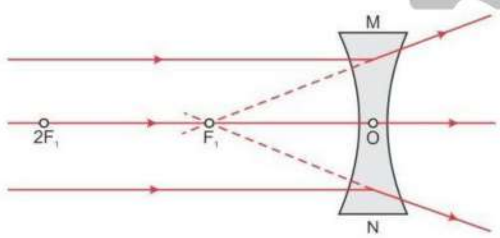
Object between F1 and C

- **29.Characteristics of images formed**

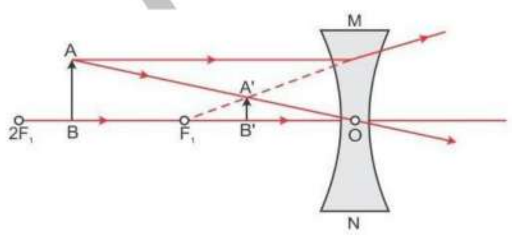
Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_2	Highly diminished	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Equal to size of object	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Highly enlarged	Real and inverted
Between F_1 and O	Beyond F_1 on the same side as the object	Enlarged	Virtual and erect

- **30.Image formation by a concave lens**

  - **Ray Diagrams**



Object at infinity



Object between infinity and optical centre

  - **Characteristics of images formed**

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_1	Highly diminished	Virtual and erect
Between infinity and O	Between focus F_1 and O	Diminished	Virtual and erect

31. Thin Lens Formula: imp

The relation between the distance of object, image v and focal length f of a lens is called thin lens formula or lens formula.

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

This is the lens formula.

32. Linear Magnifications:

Linear magnification of a lens is defined as the ratio of size of image to the size of an object. It is denoted by m.

i.e $$m = \frac{\text{Size of Image}}{\text{Size of Object}} = \frac{I}{O}$$

33. Power of a Lens: imp

The ability of a lens to converse or diverse a beam of light falling on it is called power of lens. It is defined as the reciprocal of the focal length in meter

i.e $$P = \frac{1}{f(\text{in m})} = \frac{100}{f(\text{in cm})}$$

Power of convex lens is $+ve$ and power of concave lens is $-ve$.

Si unit of power is dioptre (D) i.e 1 dioptre (D) $= \frac{1}{f = 1m}$

Hence, the power of a lens is one dioptre whose focal length is one meter.

Example 13 a concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also, find the magnification produced by the lens.

Solution: A concave lens always forms a virtual, erect image on the same side of the object.

Image-distance v = –10 cm; Focal length f = –15 cm; Object-distance u =?

Since $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ Or, $\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{-15} + \frac{1}{10} = \frac{-2+3}{30} = \frac{1}{30}$

Or, u = – 30 cm Thus, the object-distance is 30 cm. Also $m = \frac{v}{u} = \frac{-10}{-30} = \frac{1}{3} = 0.33$

The positive sign shows that the image is erect and virtual. The image is one-third of the size of the object.

Example 14 a 2.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 10 cm. The distance of the object from the lens is 15 cm. Find the nature, position and size of the image. Also find its magnification.

Solution Height h = + 2.0 cm; f = + 10 cm; u = –15 cm; v =? h′ =?

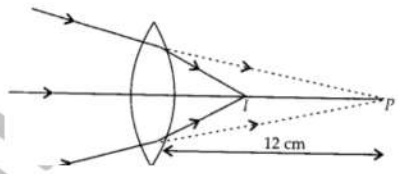
Since $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ Or, $\frac{1}{v} = \frac{1}{u} + \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{-15} + \frac{1}{10} = \frac{-2+3}{30} = \frac{1}{30}$ or, v = + 30 cm

The positive sign of v shows that the image is formed at a distance of 30 cm on the other side of the optical centre. The image is real and inverted.

Magnification $m = \frac{h'}{h} = \frac{v}{u} \Rightarrow h' = \frac{v}{u}h = \frac{2\times30}{-15} = -4cm$. Also $m = \frac{v}{u} = -2$

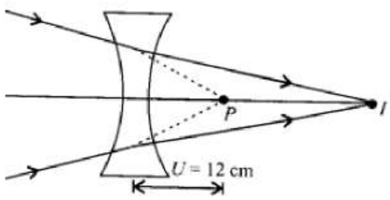
The negative signs of m and h′ show that the image is inverted and real. It is formed below the principal axis. Thus, a real, inverted image, 4 cm tall, is formed at a distance of 30 cm on the other side of the lens. The image is two times enlarged.

Question 15. A beam of light converges at a point P. Now a lens is placed in the path of the convergent beam 12 cm from P. At what point does the beam converge if the lens is
(a) a convex lens of focal length 20 cm, and (b) a concave lens of focal length 16 cm?



Solution:
(a) The convex lens is placed in the path of convergent beam. Using lens formula
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{20} + \frac{1}{12} = \frac{8}{60} \Rightarrow v = 7.5\ cm$

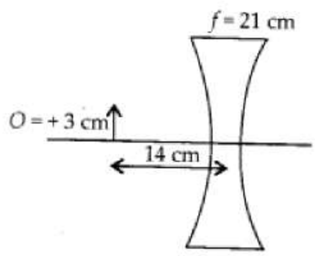
The image 1 is formed by further converging beams at a distance of 7.5 cm from lens.



(b) A concave lens is placed in the path of convergent' beam, the concave lens further diverge the light.

Using lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = -\frac{1}{16} + \frac{1}{12} = \frac{1}{48} \Rightarrow v = 48\ cm$ The image I is formed by diverged rays at 48 cm away from concave lens.

Question 16. An object of size 3.0 cm is placed 14 cm in front of a concave lens of focal length 21 cm. Describe the image produced by the lens.



Solution: Object of size 3 cm is placed 14 cm in front of concave lens.

Using lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{-21} - \frac{1}{14} = -\frac{42}{5} \Rightarrow v = -8.4\ cm$

Formula for magnification $m = \frac{Size\ of\ Image}{Size\ of\ Object} = \frac{I}{O} = \frac{-v}{-u} = \frac{v}{u} \Rightarrow \frac{I}{O} = \frac{v}{u} \Rightarrow \mathrm{I} = 1.8\mathrm{cm}$

➢ Assertion Reason Questions:

1. For two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:
   a. Both A and R are true, and R is correct explanation of the assertion.
   b. Both A and R are true, but R is not the correct explanation of the assertion.
   c. A is true, but R is false. D. A is false, but R is true.
1. **Assertion:** Keeping a point object fixed, if a plane mirror is moved, the image will also move.

   Reason: In case of a plane mirror, distance of object and its image is equal from any point on the mirror.

   Explanation (a)

   The image formed in a plane mirror is at the same distance behind the mirror as the object is in the front of the mirror. Image and the object are at equal distances from a plane mirror.

2. **Assertion:** The size of the mirror affects the nature of the image.

   Reason: Small mirrors always form virtual images.

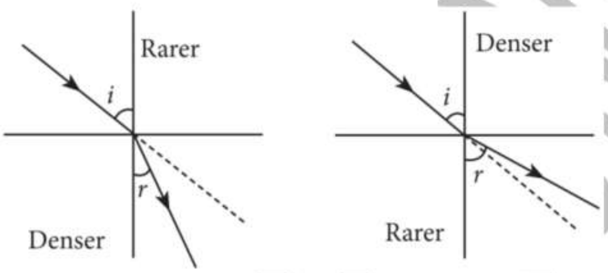
Explanation: (d)

The size of the image does not affect the nature of the image, except that a bigger image as it gathers more tight rays due to wider aperture.

➢ Case Study Questions:

1. Read the following and answer any four questions from (i) to (v).

When the rays of light travels from one transparent medium to another, the path of light deviate, This phenomenon is called refraction of light. The bending of light depends on the optical density of medium through which the light passes.



This speed of light varies from medium to medium. A medium in which the speed of light is more is optically rarer medium whereas in which the speed of light is less is optically denser medium. Whenever light goes from one medium to another, the frequency of light does not change however, speed and wavelength change. It concluded that change in speed of light is the basic cause of refraction.

i. When light travels from air to glass, the ray of light bends:

   (a)Towards the normal (B) Away from normal

   (c) Anywhere. (d) None of these.

ii. A ray of light passes from a medium A to another medium B. No bending of light occurs if the ray of light hits the boundary of medium B at an angle of:

   (a) 0º (B) 45º (c) 90º (d) 120º

iii. When light passes from one medium to another, the frequency of light:

   (a) Increases (B) Decreases (c) Remains same (d) None of these

iv. When light passes from glass to water, the speed of light:

   a. Increases. (B) Decreases. (c) Remains same. (d) First increases then decrease.

v. The bottom of pool filled with water appears to be due to refraction of light:

   a. Shallower (B) Deeper (c) At same depth (d) Empty

2. The lenses form different types of images when object placed at different locations. When a ray is incident parallel to the principal axis, then after refraction, it passes through the focus or appears to come from the focus. When a ray goes through the optical centre of the lens, it passes without any deviation. If the object is placed between focus and optical canter of the convex lens, erect and magnified image is fanned. As the object is brought closer to the convex lens from infinity to focus, the image moves away from the convex lens from focus to infinity. Also, the size of image goes on increasing and the image is always real and inverted. A concave lens always gives a virtual, erect, and diminished image irrespective to the position of the object.

i. The location of image fanned by a convex lens when the object is placed at infinity is

(a)At focus (b) At 2F (c) At optical centre (d) Between F and 2F

ii. When the object is placed at the focus of concave lens, the image formed is:

(a)Real and smaller (b) Virtual and inverted (c) Virtual and smaller (d) Real and erect

iii. The size of image formed by a convex lens when the object is placed at the focus of convex lens is:

(a)Small (b) Point in size (c) Highly magnified (d) same as that of object

iv. When the object is placed at 2F in front of convex lens, the location of image is:

(a)At F (b) At 2 F on the other side (c)At infinity (d)Between F and optical centre

v. At which location of object in front of concave lens, the image between focus and optical centre is formed:

(a)Anywhere between centre and infinity (b)At F (c)At 2F (d)Infinity

➢ **Case Study Answer:**

1. i (a) Towards the normal. ii. (c) 90º iii. (c) Remains same IV. (a) Increases. V. (a) Shallower
2. i (a) At focus ii. (b)Virtual and inverted iii. (c) Highly magnified iv (b) At 2 F on the other side
   v. (a) Anywhere between centre and infinity

17. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the convex lens if the image is equal to the size of the object? Also, find the power of the lens.

18. Find the power of a concave lens of focal length 2 m.

EXERCISES

1. Which one of the following materials cannot be used to make a lens?

(a) Water (b) Glass (c) Plastic (d) Clay

2. The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

(a) Between the principal focus and the centre of curvature (b) At the centre of curvature

(c) Beyond the centre of curvature (d) between the pole of the mirror and its principal focus.

3. Where should an object be placed in front of a convex lens to get a real image of the size of the object?

(a) At the principal focus of the lens (b) At twice the focal length

(c) At infinity (d) between the optical centre of the lens and its principal focus.

4. A spherical mirror and a thin spherical lens have each a focal length of –15 cm. The mirror and the lens are likely to be

(a) Both concave. (b) Both convex.

(c) The mirror is concave and the lens is convex. (d) The mirror is convex, but the lens is concave.

5. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

(a) Only plane. (b) Only concave. (c) Only convex. (d) Either plane or convex.

6. Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

(a) A convex lens of focal length 50 cm. (b) A concave lens of focal length 50 cm

(c) A convex lens of focal length 5 cm. (d) A concave lens of focal length 5 cm.

7. We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

8. Name the type of mirror used in the following situations.

(a) Headlights of a car. (b) Side/rear-view mirror of a vehicle. (c) Solar furnace.

Support your answer with reason.

9. **One-half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations**.

10. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and the nature of the image formed.

11. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

12. An object is placed at a distance of 10 cm from a convex mirror of focal length

15 cm. Find the position and nature of the image.

13. The magnification produced by a plane mirror is +1. What does this mean?

14. An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

15. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focused image can be obtained? Find the size and the nature of the image.

16. Find the focal length of a lens of power – 2.0 D. What type of lens is this?

17. A doctor has prescribed a corrective lens of power +1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging?