Light : Reflection and Refraction

Quick Revision

Light is a form of energy which enables us to see a variety of objects in the world around us. An object reflects the light rays that fall on it. These reflected light rays, when received by our eyes, make the object visible to us.

1. Reflection of Light

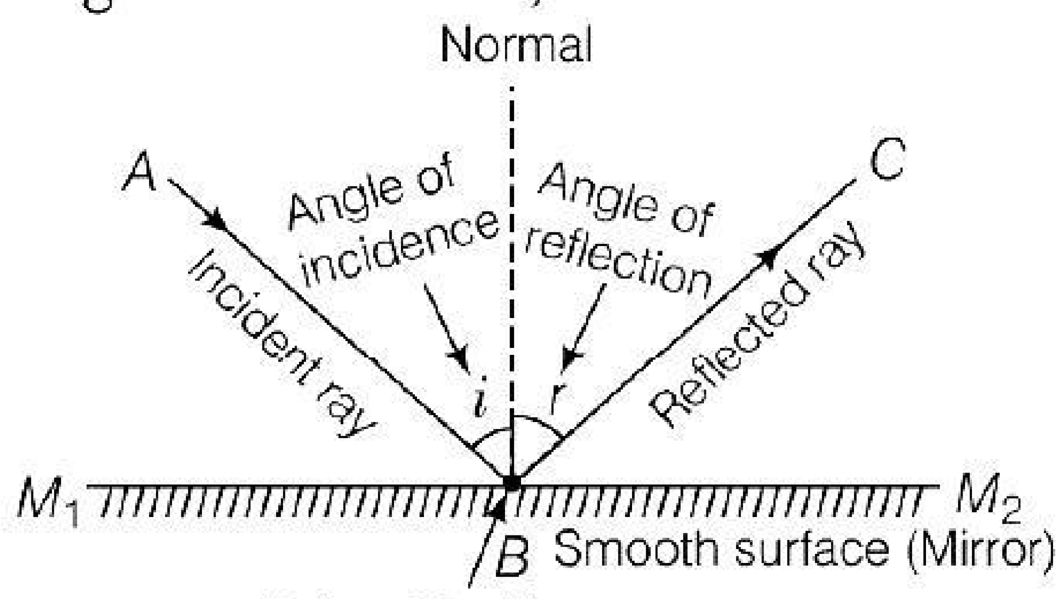
The phenomenon of bouncing back of light rays in the same medium on striking a smooth surface, is called reflection of light.

2. Laws of Reflection

There are two laws of reflection

(i) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

(ii) Angle of incidence is always equal to the angle of reflection, i.e. $\angle i = \angle r$.



Reflection of light

A ray of light which is incident normally on a mirror is reflected back along its own path.

3. Image

If light rays coming from a point after reflection meet at another point or appear to meet at another point, then second point is called the image of first point.

There are two types of image, i.e.

(i) **Real image** If the light rays coming from a point actually, meet after reflection, then the image formed is called a real image.

(ii) **Virtual image** If the light rays coming from a point, after reflection does not actually meet, but appear to meet at a point when produced backwards then the image formed is called a virtual image.

4. Mirror

Mirror is a polished surface like glass, having a silvery shining coating on one side which reflects almost all the light incident on it.

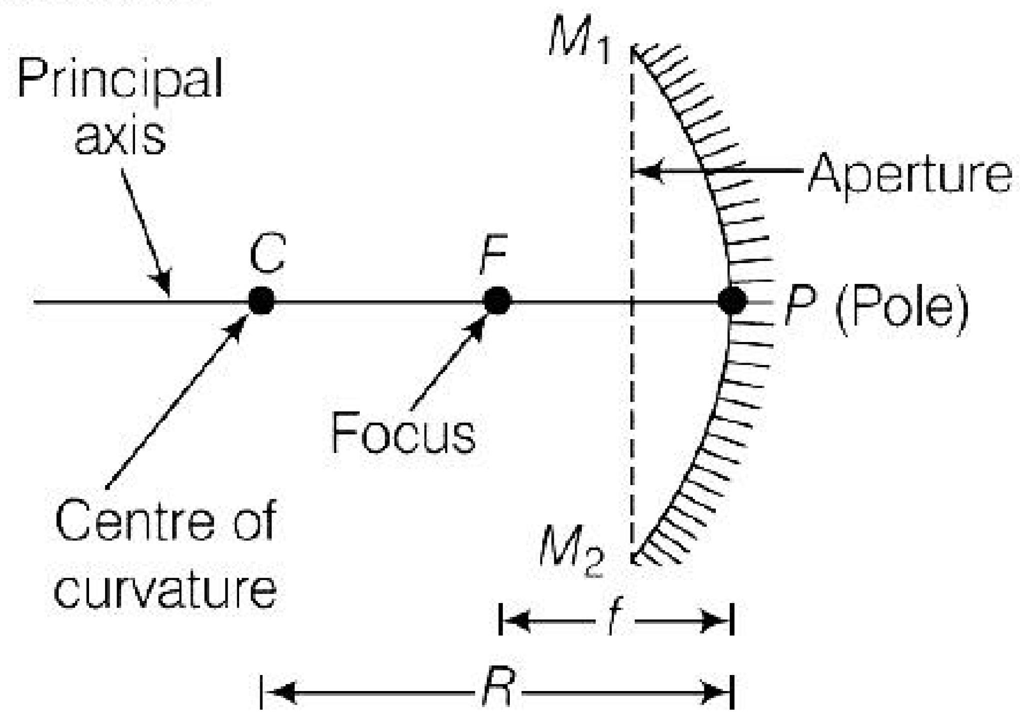
Mainly, there are two types of mirror

(i) **Plane mirror** If the reflecting surface of mirror is a plane, then the mirror is called a plane mirror.

(ii) **Spherical mirror** If the reflecting surface of the mirror is curved inwards or outwards, then the mirror is called a spherical mirror.

There are two types of spherical mirror

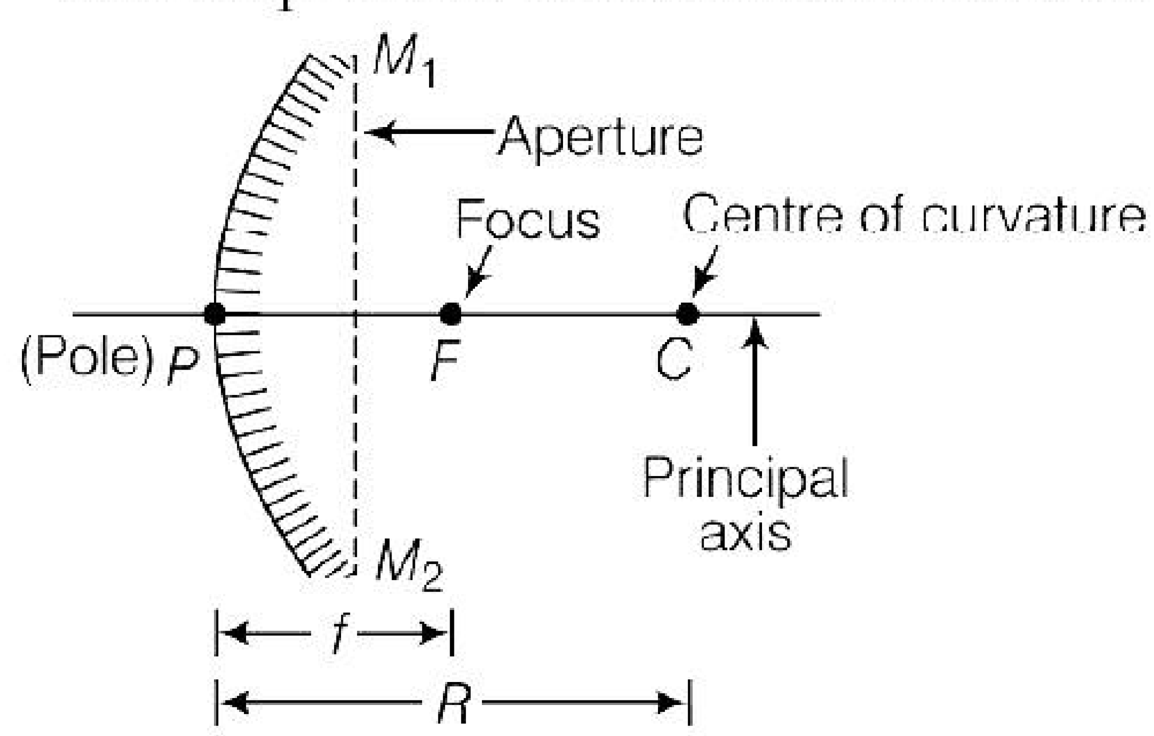
(i) **Concave mirror** A spherical mirror whose reflecting surface is towards the centre of the sphere is called concave mirror.



Concave or converging mirror

where, f = focal length, R = radius of curvature.

(ii) **Convex mirror** A spherical mirror whose reflecting surface is away from the centre of the sphere is called convex mirror.



Convex or diverging mirror

5. Some Definitions Related to Spherical Mirror

(i) **Pole** The mid-point of reflecting surface of the spherical mirror is called pole.

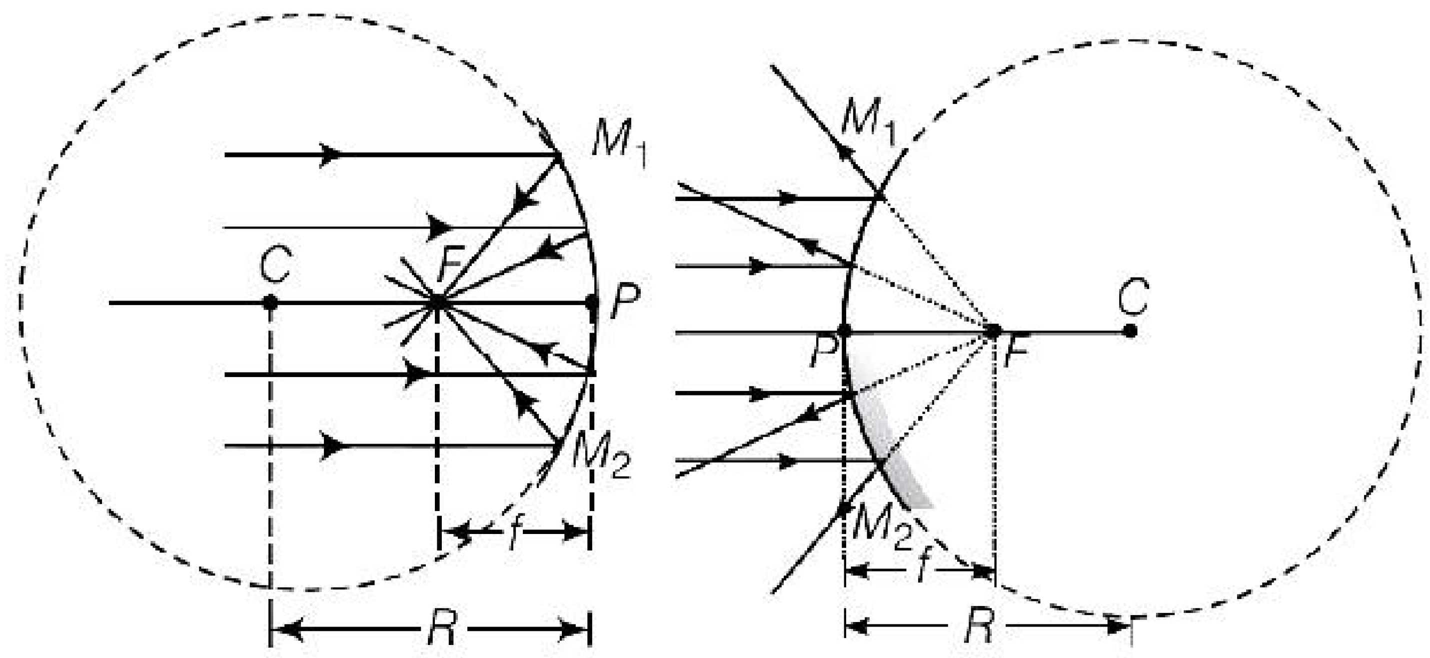
(ii) **Centre of curvature** It is the centre of the imaginary sphere of which, mirror is a part. In case of concave mirror, the centre of curvature lies in front of it, while in case of convex mirror, the centre of curvature lies behind it. It is marked by C.

(iii) **Radius of curvature** The distance between pole and centre of curvature is called radius of curvature. It is denoted by R in the above figures.

(iv) **Principal axis** The principal axis of a spherical mirror is the line joining the pole and centre of curvature. In the figure, PC is the principal axis.

(v) **Aperture** The diameter of the reflecting surface of a spherical mirror is called its aperture. M_1M_2 is the aperture of the mirror.

(vi) **Principal focus of a spherical mirror** It is a point on the principal axis of the mirror at which the light rays coming parallel to principal axis, after reflection actually meet (or appear to be coming from). It is represented by F. For a concave mirror, the focus is in front of the mirror, while for a convex mirror, the focus is behind the mirror.



Principal focus of a concave mirror

Principal focus of a convex mirror

The focus of a concave mirror is real, while the focus of a convex mirror is virtual.

(vii) **Focal length** The distance between pole and principal focus of a spherical mirror is called its focal length. It is represented by f.

If the aperture of the mirror is small, then

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

The focal length of a plane mirror is infinite.

(viii) **Focal plane** The plane passing through focus and perpendicular to the principal axis is called focal plane.

6. Reflection by Spherical Mirrors

- The rays coming parallel to the principal axis pass through the focus after reflection or appear to come from focus.
- The rays coming through the focus of mirror or coming towards focus, becomes parallel to principal axis after reflection.
- The light ray coming through centre of curvature or towards centre of curvature, reflects on the same path.
- A ray incident obliquely to principal axis, towards a point P on the concave or convex mirror is reflected obliquely, following the laws of reflection.

Image Formation by Concave Mirror

Position of Object	Position of Image	Nature and Size of Image
At infinity	At focus or in the focal plane	Real, inverted, extremely diminished in size
Beyond the centre of curvature but at finite distance from mirror	Between focus and the centre of curvature	Real, inverted and diminished
At the centre of curvature	At the centre of curvature	Real, inverted and same size as that of object
Between focus and centre of curvature	Beyond the centre of curvature	Real, inverted and magnified
At the focus	At infinity	Real, inverted and extremely magnified
Between the pole and focus	Behind the mirror	Virtual, erect and magnified

Image Formation by Convex Mirror

Position of Object	Position of Image	Nature and Size of Image
At infinity	At the principal focus, behind the mirror	Virtual, erect and extremely diminished
Between infinity and the pole (i.e. at finite distance)	Between the principal focus and the pole, behind the mirror	Virtual, erect and diminished

7. **Sign Conventions for Reflection by Spherical Mirrors**
   - For concave mirror f, u and v are always negative $(-)$.
   - If image is formed behind concave mirror, then v is taken positive $(+)$ and if image is formed in front of the mirror, then v is taken negative $(-)$.
   - For convex mirror f and R are positive $(+)$ and u is negative $(-)$. In convex mirror, images formed behind the mirror, then v is taken as positive $(+)$.
   - Distances measured perpendicularly above the principal axis (along Y-axis) are taken as positive and distances below the principal axis (along Y-axis) are taken as negative.

8. **Mirror Formula**
   - In a spherical mirror, the distance of object (u), distance of image (v) and focal length (f) are related as by the formula
   - The mirror formula is expressed as

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

where, u = object distance from mirror,
v = image distance from mirror
and f = focal length of the mirror.

9. **Magnification by Spherical Mirror**

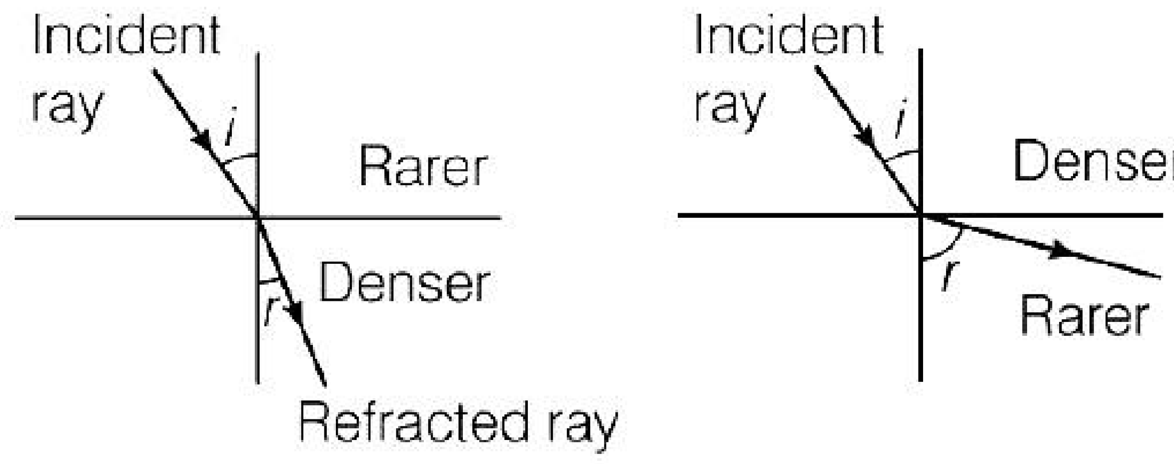
It is expressed as the ratio of height of image to the height of object.

Magnification, $m=\frac{h_i}{h_o}$

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

10. **Refraction of Light**
    - Change in path of a light ray as it passes from one transparent medium to another medium is called refraction of light.
    - When light travels from a rarer medium to a denser one, it bends towards the normal $(i > r)$ and when travels from a denser medium to a rarer one, it bends away from the normal $(i < r)$.

    where, i = angle of incidence, r = angle of refraction.



Refraction of light

(i) **Cause of refraction** Speed of light is different in different media, i.e. more in rarer medium and comparatively less in denser medium. So, when light enters a denser medium, its speed reduces and it bends towards the normal and when it enters a rarer medium, its speed increases and it bends away from the normal.

(ii) **Laws of refraction** Refraction of light occurs according to the following laws

- 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 ratio of sine of angle of incidence to the sine of angle of refraction is a constant, i.e. $\frac{\sin i}{\sin r} = (\mu \text{ or } n)$ constant

  It is also known as **Snell's law** and that constant is called refractive index (μ).
- Refractive index of any medium 2 with respect to other medium 1 is written as

$$_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r}$$

where, i = incident angle in medium 1

and r = refracted angle in medium 2.

(iii) **Refractive index** If c is the speed of light in air and v is the speed of light in medium, then the refractive index of the medium is

$$\mu = \frac{\text{Speed of light in vacuum/air}}{\text{Speed of light in medium}} = \frac{c}{v}$$

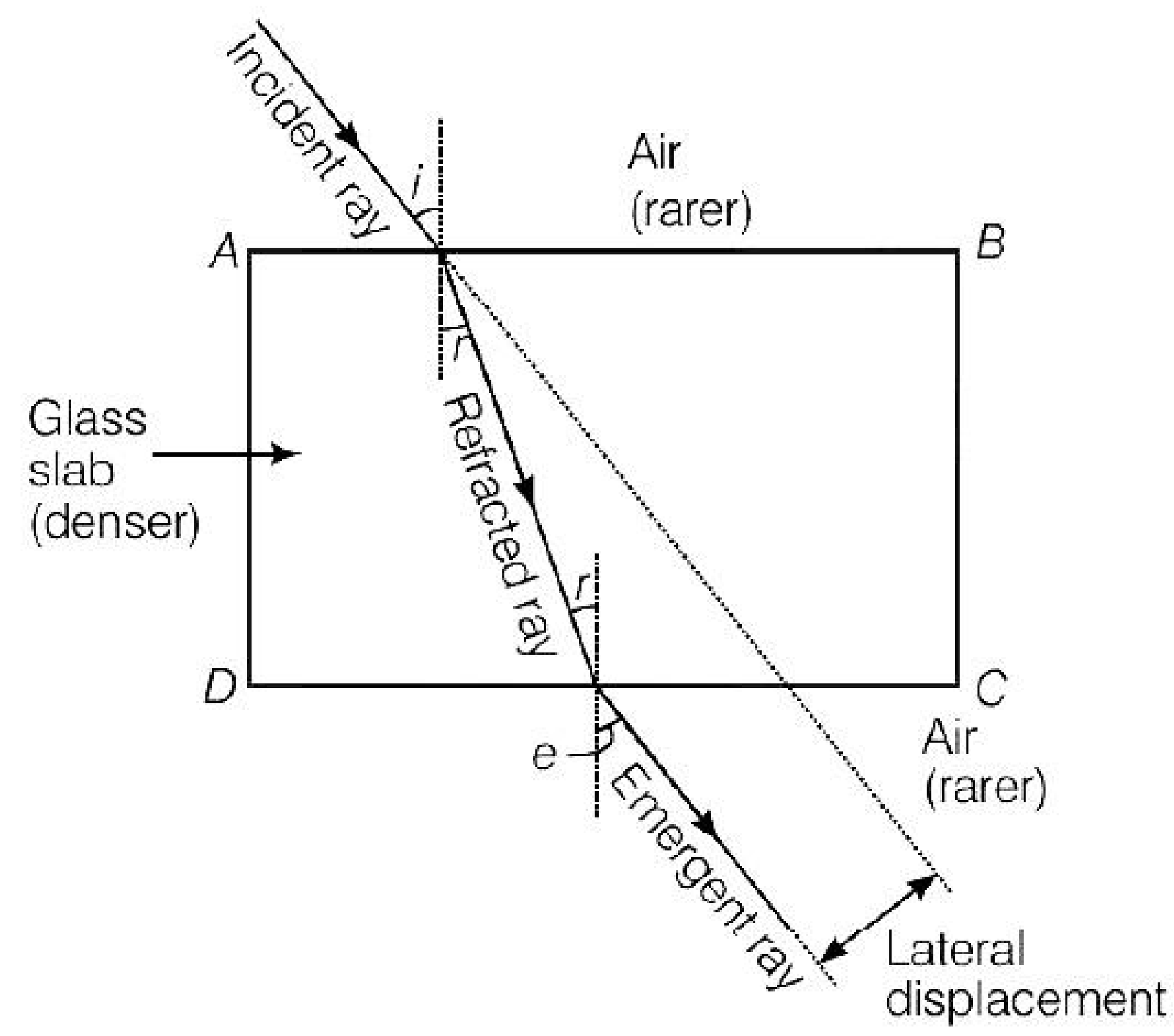
(iv) **Absolute refractive index** The refractive index of a medium with respect to vacuum is called absolute refractive index of the medium. The absolute refractive index of a medium is simply called its refractive index.

For glass-water pair,

$$_w\mu_g = \frac{_a\mu_g}{_a\mu_w}$$

11. **Refraction through a Rectangular Glass Slab**

- When a light ray enters into a glass slab, then the emergent ray is parallel to the incident ray but it is shifted sideward slightly.
- This perpendicular distance between the emergent ray and incident ray when the light passes out of a glass slab is called **lateral displacement**.
- In this case, refraction takes place twice, first when ray enters glass slab from air and second when exists from glass slab to air.



Refraction through a glass slab

where, i = angle of incidence,

r = angle of refraction

and e = angle of emergence.

Angle of incidence = Angle of emergence, i.e. $\angle i = \angle e$.

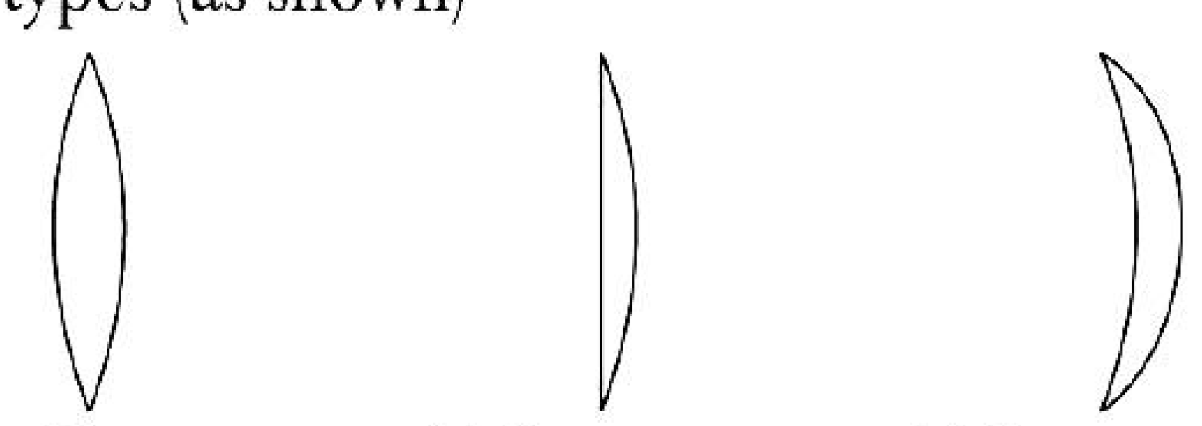
If the incident ray falls normally to the surface of glass slab, then there is no bending of the ray of light, it goes straight without any deviation.

12. **Lens**

It is a transparent medium bounded by two surfaces, atleast one of which is curved.

Lens are of two types

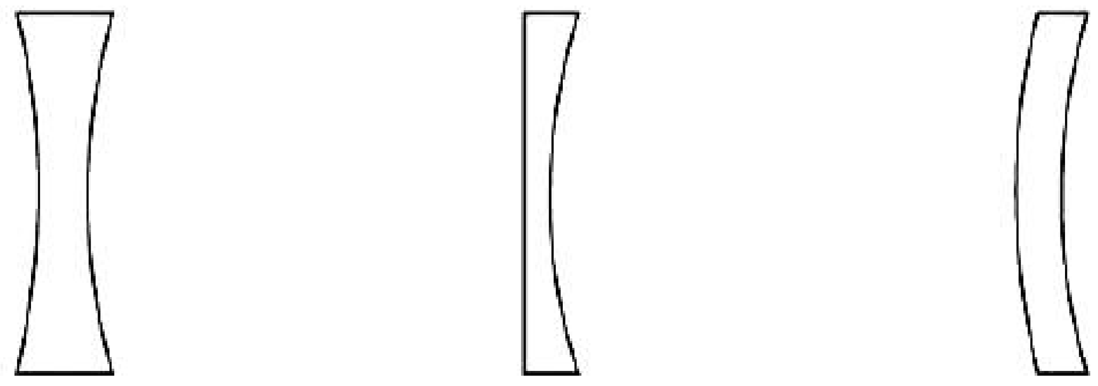
(i) **Convex or convergent lens** A lens which is thicker at the centre and thinner at its end is called convex lens. Convex lenses are of three types (as shown)



(a) Double convex lens (b) Plano-convex lens (c) Concavo-convex lens

A convex lens is also known as **converging lens** because it converges a parallel beam of light rays passing through it.

(ii) **Concave or diverging lens** A lens which is thinner at the centre and thicker at its ends is called concave lens. Concave lenses are of three types (as shown)



(a) Double concave lens (b) Plano-concave lens (c) Convexo-concave lens

A concave lens is also known as **diverging lens** because it diverges a parallel beam of light rays passing through it.

13. **Some Definitions Related to Lens**

(i) **Optical centre** The centre point of a lens is known as its optical centre. It is represented by O.

(ii) **Centre of curvature** The centres of the two imaginary spheres of which the lens is a part are called centres of curvature of the lens. It is represented by C.

(iii) **Radii of curvature** The radii of the two imaginary spheres of which the lens is a part are called radii of the curvature of lens.

(iv) **Focal plane** The plane passing through the focus and perpendicular to the principal axis is called focal plane.

(v) **Principal focus** Lens has two principal foci

- **First principal focus** It is a point on the principal axis of lens, from where the directed rays become parallel to principal axis after refraction.
- **Second principal focus** It is the point on the principal axis at which the rays coming parallel to the principal axis, converge on the other side of lens (convex) or appear to meet on the same side of lens (concave), after refraction from the lens.

(vi) **Focal length** The distance between focus and optical centre of lens is called focal length of lens.

(vii) **Aperture** The effective diameter of the circular outline of a spherical lens is called its aperture.

14. **Refraction through a Lens**

Rays which are parallel to the principal axis, after refraction will pass through principal focus in case of convex lens and will appear to be coming from principal focus in case of concave lens.

Ray passing through or directed to the focus will emerge parallel to the principal axis.

Ray directed to optical centre will emerge out undeviated.

Image Formation by a Convex Lens

Position of Object	Position of Image	Nature and Size of Image
At infinity	At F_2	Real, inverted and extremely diminished
Beyond $2F_1$ (at finite distance)	Between F_2 and $2F_2$	Real, inverted and diminished
At $2F_1$	At $2F_2$	Real, inverted and of same size as that of object
Between F_1 and $2F_1$	Beyond $2F_2$	Real, inverted and magnified
At F_1	At infinity	Real, inverted and highly magnified
Between lens and F_1	On same side of the lens as the object	Virtual, erect and magnified

Image Formation by a Concave Lens

Position of Object	Position of Image	Nature and Size of Image
At infinity	At focus on same side of lens as object	Virtual, erect and highly diminished
Any where between optic centre and infinity	Between focus and optical centre, on the same side of lens as object	Virtual, erect and diminished

15. **Sign Convention for Spherical Lenses**

- Sign convention for lenses is same as that for mirrors.
- Focal length of convex lens is positive, whereas focal length of concave lens is negative.

16. **Lens Formula**
- The relation between object distance (u), image distance (v) and focal length (f) is known as lens formula.
- The lens formula is expressed as $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$
- All distances in lens are measured from optical centre.

17. **Linear Magnification**
- The ratio of height of image to height of object is called linear magnification.
- Linear magnification, $m=\frac{i}{o}$ or $m=\frac{v}{u}$
- Linear magnification is positive, when image formed is **virtual** and linear magnification is negative, when image formed is **real**.

18. **Power of a Lens**

The ability of a lens to converge or diverge light rays is called power (P) of the lens. It is defined as the reciprocal of focal length,

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

For combination of lenses,

$$P = P_1 + P_2 + P_3 + \dots$$

Objective Questions

Multiple Choice Questions

01. Which of the following is not correct?
(a) Light is an electromagnetic wave.
(b) Light travels in a straight line.
(c) Light is a transverse wave.
(d) Light is a longitudinal wave.

02. In which of the following media, velocity of the light will be maximum?
(a) Air (b) Water
(c) Glass (d) Vacuum

03. The laws of reflection hold good for *(NCERT Exemplar)*
(a) plane mirror only
(b) concave mirror only
(c) convex mirror only
(d) all mirrors irrespective of their shape

04. Image formed by a mirror is always straight whatever will be the distance, then mirror is
(a) only plane
(b) only concave
(c) only convex
(d) either plane or convex

05. Focal length of a plane mirror is
(a) zero (b) infinite
(c) 25 cm (d) –25 cm

06. An object is placed at a distance of 10 cm in front of a plane mirror, then the distance of image from mirror will be
(a) 5 cm (b) 10 cm (c) 20 cm (d) 0

07. The relation between focal length f and radius of curvature R for a spherical mirror is
(a) $f=2R$ (b) $f=\frac{R}{2}$ (c) $f=\frac{R}{4}$ (d) $f=\frac{2}{R}$

08. For a convex mirror, parallel rays of light appear to diverge from a point called the ....
(a) radius of curvature (b) pole
(c) aperture (d) principal focus

09. The radius of curvature of concave mirror is 12 cm. Then, the focal length will be
(a) 12 cm (b) 6 cm
(c) - 24 cm (d) - 6 cm

10. The focal length of a spherical mirror is 10 cm. Hence, its radius of curvature will be 5 cm.
(a) True
(b) False
(c) Can't say
(d) Partially true/false

11. Whose sight area is the highest?

(a) Plane mirror (b) Convex mirror
(c) Concave mirror (d) Concave lens

12. The image of an object is real, inverted and smaller in size, if it is placed before a mirror which is

(a) convex (b) concave
(c) plane (d) None of the above

13. What will be the position and nature of the image of an object formed by a convex mirror placed between infinity and pole (P) of the mirror ?

(a) In between pole (P) and focus (f) behind mirror, virtual and erect
(b) In between pole (P) and focus (f) behind mirror, virtual and inverted
(c) In front of mirror, real and erect
(d) In front of mirror, virtual and erect

14. A full length image of a distant tall building can definitely be seen by using

(a) a concave mirror
(b) a convex mirror
(c) a plane mirror
(d) both concave as well as plane mirror

15. Nature of a mirror having a focal length +10 cm is converging in nature.

(a) True (b) False
(c) Can't say (d) Partially true/false

16. Where an object should be placed in front of the concave mirror, so that its image be erect and larger in size ?

(a) At the centre of curvature (C) of the mirror
(b) At the focus point (f) of the mirror
(c) In between the centre of curvature (C) and the focus point (f) of the mirror
(d) In between the pole (P) and the focus point (f) of the mirror

17. When an object is kept within the focus of a concave mirror, an enlarged image is formed behind the mirror. This image is *(CBSE 2020)*

(a) real (b) inverted
(c) virtual and inverted (d) virtual and erect

18. A real image is formed by the light rays after reflection or refraction when they

I. actually meet or intersect with each-other.
II. actually converge at a point.
III. appear to meet when they are produced in the backward direction.
IV. appear to diverge from a point.

Which of the above statements are correct ?

(a) (I) and (IV) (b) (II) and (IV)
(c) (I) and (II) (d) (II) and (III)

19. What will be the position and nature of the image of an object formed by a concave mirror placed between focus (f) and pole (P) of the mirror ?

(a) In between pole (P) and focus (f) in front of mirror, virtual and erect
(b) In between pole (P) and focus (f) in front of mirror, virtual and inverted
(c) Behind the mirror, real and erect
(d) Behind the mirror, virtual and erect

20. Rays from sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed so that size of its image is equal to the size of the object? *(NCERT Exemplar)*

(a) 15 cm in front of the mirror
(b) 30 cm in front of the mirror
(c) between 15 cm and 30 cm in front of the mirror
(d) more than 30 cm in front of the mirror

21. To determine the focal length of a concave mirror by forming image of a distant object, the screen should be placed

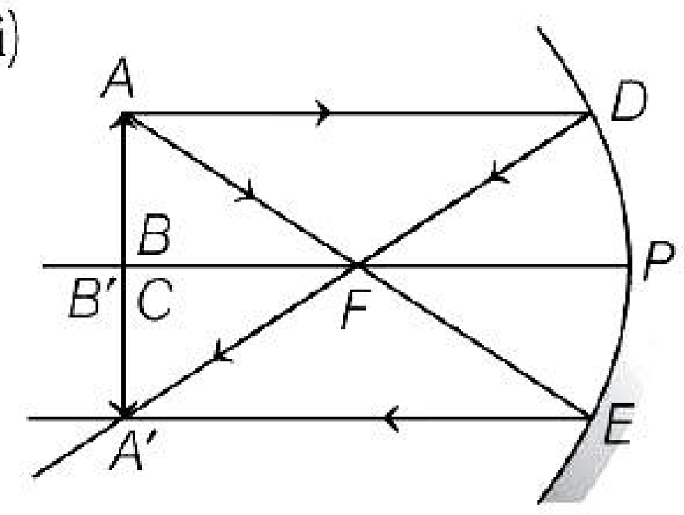
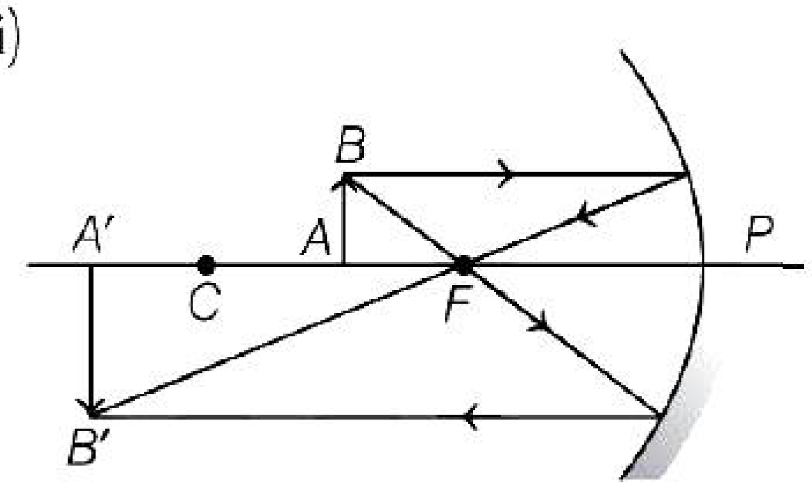
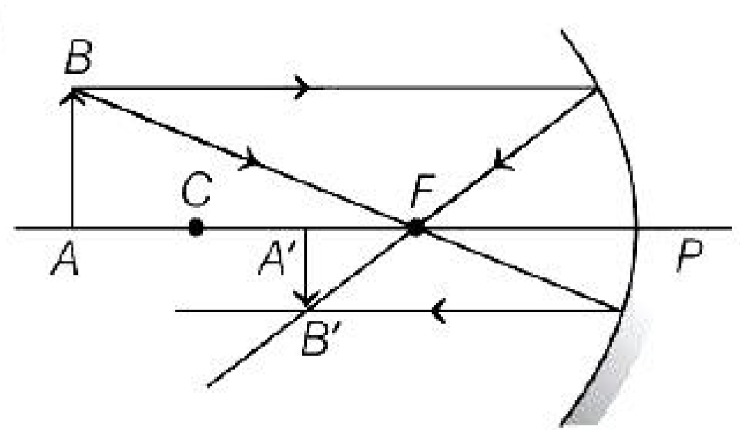
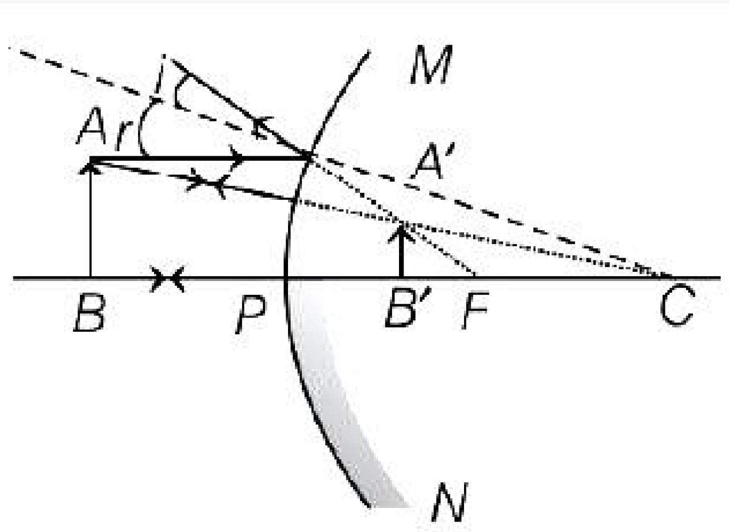
(a) in any direction
(b) inclined at angle of 45°
(c) at right angle to the plane of mirror
(d) parallel to the plane of mirror

22. A girl is standing in front of a magic mirror. She finds the image of her head bigger, the middle portion of her body of the same size and that of the legs smaller.

The following is the order of combinations for the magic mirror from the top. *(NCERT Exemplar)*

(a) Plane, convex and concave
(b) Convex, concave and plane
(c) Concave, plane and convex
(d) Convex, plane and concave

23. Match Column I with Column II and choose the most appropriate option from the codes given below.

Column I (Nature and size of image)	Column II (Ray diagram)
(A) Virtual, erect and diminished	(i) 
(B) Real, inverted and same size as that of object	(ii) 
(C) Real, inverted and enlarged	(iii) 
(D) Real, inverted and diminished	(iv) 

Codes

	A	B	C	D
(a)	(i)	(ii)	(iii)	(iv)
(b)	(iv)	(i)	(ii)	(iii)
(c)	(iv)	(iii)	(ii)	(i)
(d)	(i)	(iii)	(iv)	(ii)

24. An object is placed 20 cm from the concave mirror of focal length 10 cm, then image is formed ......

(a) behind the mirror
(b) between the mirror and focus
(c) at focus
(d) centre of curvature of mirror

25. A concave mirror produces three times magnified real image of an object placed at 10 cm in front of it. The image is located at ......

(a) 30 cm
(b) 40 cm
(c) 10 cm
(d) 90 cm

26. A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. The focal length of this mirror is *(NCERT Exemplar)*

(a) −30 cm
(b) −20 cm
(c) −40 cm
(d) −60 cm

27. A convex mirror of focal length f produces an image $\frac{1}{n^{th}}$ of the size of the object.

The distance of the object from the mirror is ......

(a) $\frac{n+1}{n}f$
(b) $(n+1)f$
(c) $(n-1)f$
(d) $\frac{n-1}{n}f$

28. Magnification produced by a rear view mirror fitted in vehicles

(a) is less than one
(b) is more than one
(c) is equal to one
(d) (a) or (b) depending upon the position of the object

29. Match Column I with Column II and choose the most appropriate option from the codes given below.

Column I (Magnification, m)	Column II (Nature of image)
(A) $m = 1$	(i) Inverted image
(B) $m < 1$	(ii) Diminished image
(C) $m > 0$	(iii) Erect image
(D) $m < 0$	(iv) Size of image = Size of object

Codes

	A	B	C	D		A	B	C	D
(a)	(iv)	(ii)	(iii)	(i)	(b)	(i)	(iv)	(ii)	(iii)
(c)	(iv)	(iii)	(ii)	(i)	(d)	(i)	(ii)	(iii)	(iv)

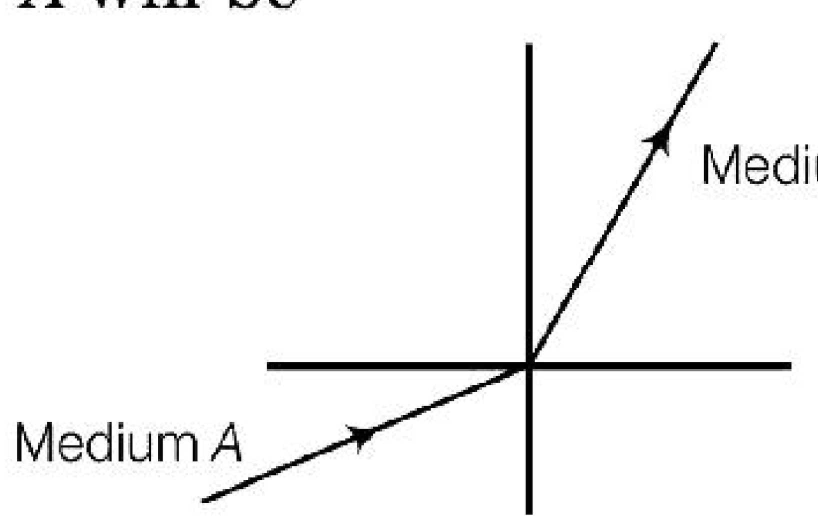
30. A ray of light travelling from air enters a liquid at an angle of 45° with the normal. If the corresponding angle of refraction is 30°, then the refractive index of the liquid with respect to air is

(a) 1.44 (b) 1.41
(c) 1.21 (d) 1.45

31. Velocity of light in air is 3×10^8 m/s. While its velocity in a medium is 1.5×10^8 m/s. Then, refractive index of this medium is

(a) 3 (b) 5
(c) 0.5 (d) 2

32. A light ray enters from medium A to medium B as shown in the figure. The refractive index of medium B relative to A will be



(NCERT Exemplar)

(a) greater than unity (b) less than unity
(c) equal to unity (d) zero

33. No refraction of light occurs if the ray of light hits the boundary of interface of medium at an angle of 90°.

(a) True
(b) False
(c) Can't say
(d) Partially true/false

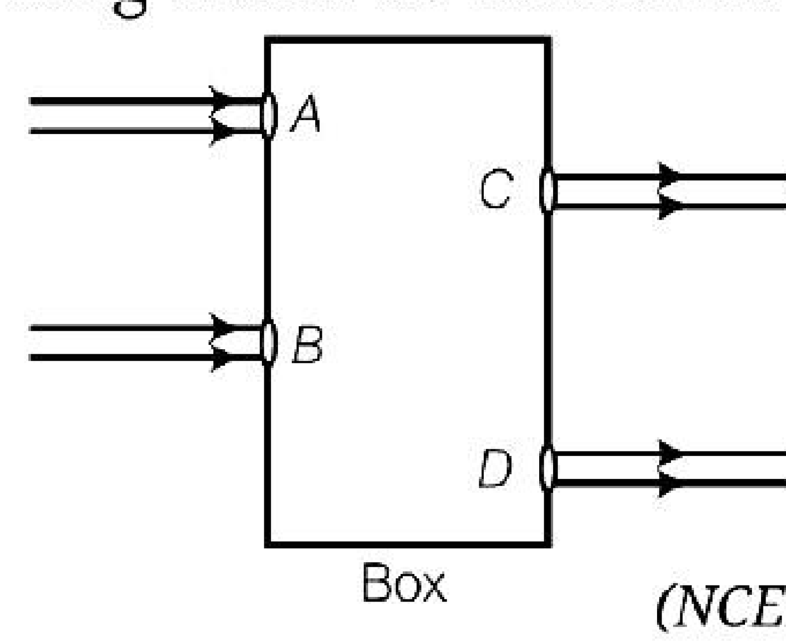
34. Speed of light in vacuum is 3×10^8 m/s. Then, speed of light in glass (refractive index 1.5) will be

(a) 4.5×10^8 m/s (b) 2.0×10^6 m/s
(c) 3.0×10^6 m/s (d) 2.0×10^8 m/s

35. Refractive index of glass with respect to air is $\frac{3}{2}$, then refractive index of air with respect to glass will be

(a) $\frac{1}{3}$ (b) $\frac{1}{2}$
(c) $\frac{2}{3}$ (d) $\frac{3}{4}$

36. Beams of light are incident through the holes A and B and emerge out of box through the holes C and D respectively as shown in the figure. Which of the following could be inside the box?



(NCERT Exemplar)

(a) A rectangular glass slab
(b) A convex lens
(c) A concave lens
(d) A prism

37. If a ray of light passes from denser to rarer medium, the angle of refraction will be lesser than the angle of incidence.

(a) True (b) False
(c) Can't say (d) Partially true/false

38. Light ray is incident normally on the boundary surface of two media, then angle of refraction will be

(a) Zero (b) 45°
(c) 60° (d) 80°

39. You are given water, mustard oil, glycerine and kerosene. In which of these media, a ray of light incident obliquely at same angle would bend the most? *(NCERT Exemplar)*

(a) Kerosene (b) Water
(c) Mustard oil (d) Glycerine

40. As the refractive indices of water, glass and sulphuric acid are 1.33, 1.53 and 1.43 respectively, hence light travels slowest in sulphuric acid.

(a) True (b) False
(c) Can't say (d) Partially true/false

41. A light ray is incident on a rectangular glass slab at an angle of $60°$. The angle between the ray coming out of the slab and the normal to the face of rectangular slab from which it comes out is

(a) 30° (b) 60°
(c) 90° (d) 0°

42. The radius of curvature of a concave lens is 20 cm. Its focal length will be

(a) –20 cm (b) –10 cm
(c) 40 cm (d) 10 cm

43. Which of the following can make a parallel beam of light when light from a point source is incident on it? *(NCERT Exemplar)*

(a) Concave mirror as well as convex lens
(b) Convex mirror as well as concave lens
(c) Two plane mirrors placed at 90° to each other
(d) Concave mirror as well as concave lens

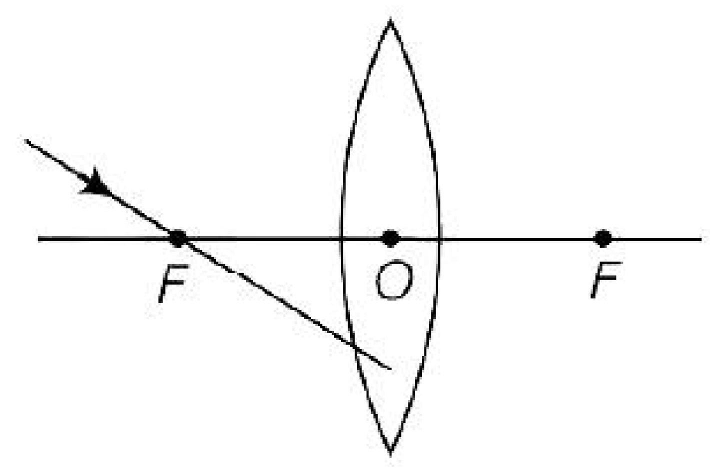
44. For which of the following image of an object placed at infinity will be highly diminished and point sized?

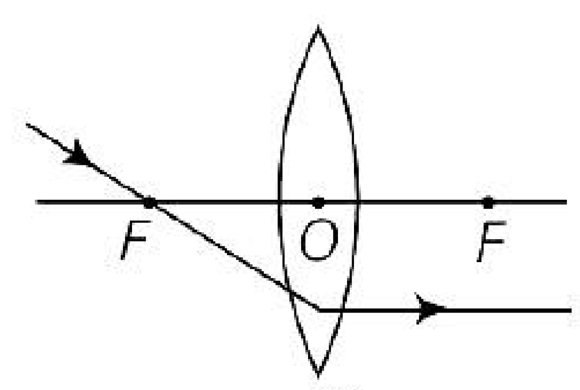
(a) Convex mirror only
(b) Concave mirror only
(c) Convex lens only
(d) Concave mirror, convex mirror, concave lens and convex lens

45. To make an image real, inverted and larger than the object with a convex lens of focal length f, the object should be placed

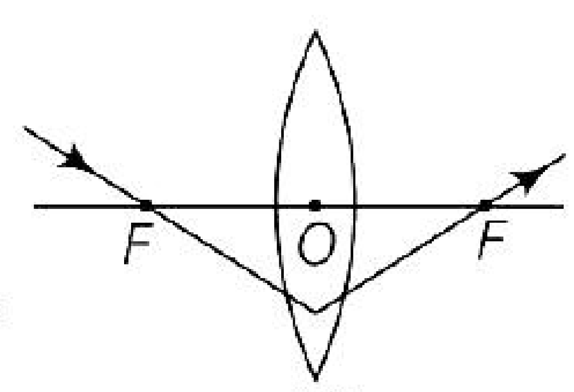
(a) on the focus of lens
(b) on the distance $2f$ of lens
(c) between f and $2f$ of lens
(d) between $2f$ and infinity

46. Which of the following ray diagrams is correct for the ray of light incident on a lens shown in figure?

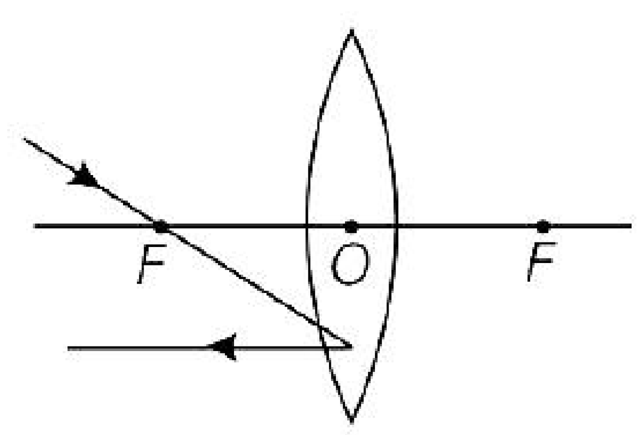




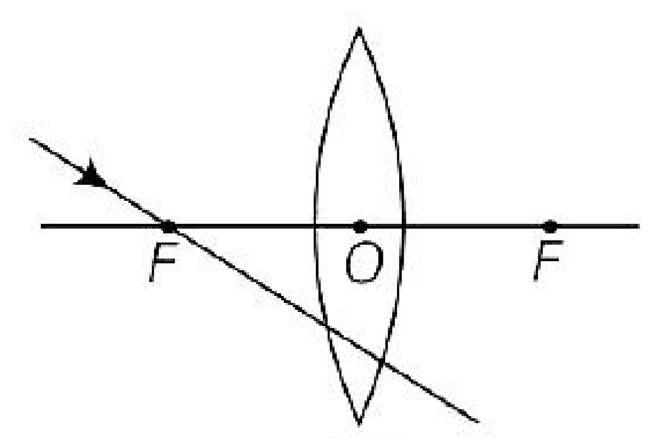
(A)



(B)



(C)



(D)

(NCERT Exemplar)

(a) *A* (b) *B*
(c) *C* (d) *D*

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

(a) both concave
(b) both convex
(c) mirror is concave and lens is convex
(d) mirror is convex and lens is concave

48. Nature of image formed by a concave lens is always real and erect.

(a) True (b) False
(c) Can't say (d) Partially true/false

49. A concave lens of focal length forms an image which is n times the size of object. The distance of object from the lens is

(a) $(1-n)f$ (b) $(1+n)f$

(c) $\left(\frac{1+n}{n}\right)f$ (d) $\left(\frac{1-n}{n}\right)f$

50. Consider the following propoerties of virtual images

A. cannot be projected on the screen

B. are formed by both concave and convex lens

C. are always erect

D. are always inverted

The correct properties are

(a) (A) and (D)

(b) (A) and (B)

(c) (A), (B) and (C)

(d) (A), (B) and (D)

51. Magnification produced by .... lens is always less than 1.

(a) concave (b) convex

(c) any (d) cylindrical

52. The image of an object placed in front of a lens is formed at a distance three times to that of the object, the magnification of the image is

(a) 1 (b) 2

(c) 3 (d) 4

53. A doctor has prescribed a corrective lens of power + 1.5 D. The nature of lens is

(a) diverging (b) converging

(c) half diverging (d) None of these

54. Two thin lenses of power 3D and –2D are placed in contact, then power and focal length of the lens combination is

(a) +2 D, +100 cm

(b) +1 D, +100 cm

(c) + 5 D, +20 cm

(d) +1 D, –100 cm

55. Match Column I with Column II and choose the most appropriate option from the codes given below.

Column I (Terms or laws)	Column II (Formula or relation)
A. Lens formula	(i) $\angle i \propto \angle r$
B. Snell's law	(ii) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$
C. Refractive index	(iii) $\frac{c}{v}$
D. Power of lens	(iv) $\frac{1}{f\text{(in metre)}}$

Codes

	A	B	C	D
(a)	(i)	(iii)	(iv)	(ii)
(b)	(ii)	(iv)	(i)	(iii)
(c)	(ii)	(i)	(iii)	(iv)
(d)	(iii)	(i)	(iv)	(ii)

Assertion-Reasoning MCQs

Direction (Q.Nos. 56-62) For given questions, two statements are given—one labeled Assertion (A) and the other labeled 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 A.

(b) Both A and R are true but R is not the correct explanation of the A.

(c) A is true but R is false.

(d) A is false but R is true.

56. 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.

57. Assertion A ray incident along normal to the mirror retraces its path.

Reason In reflection, angle of incidence is always equal to angle of reflection.

58. **Assertion** When a concave mirror is held under water, its focal length will increase.

Reason The focal length of a concave mirror is independent of the medium in which it is placed.

59. **Assertion** Higher is the refractive index of a medium or denser the medium, lesser is the velocity of light in that medium.

Reason Refractive index is inversely proportional to velocity.

60. **Assertion** Property of converging lens does not remain same in all media.

Reason Property of lens whether the ray is diverging or converging is independent of the surrounding medium.

61. **Assertion** A convex lens is made of two different materials. A point object is placed on the principal axis. The number of images formed by the lens will be two.

Reason The image formed by convex lens is always virtual.

62. **Assertion** Although the surfaces of a goggles, lenses are curved, it does not have any power.

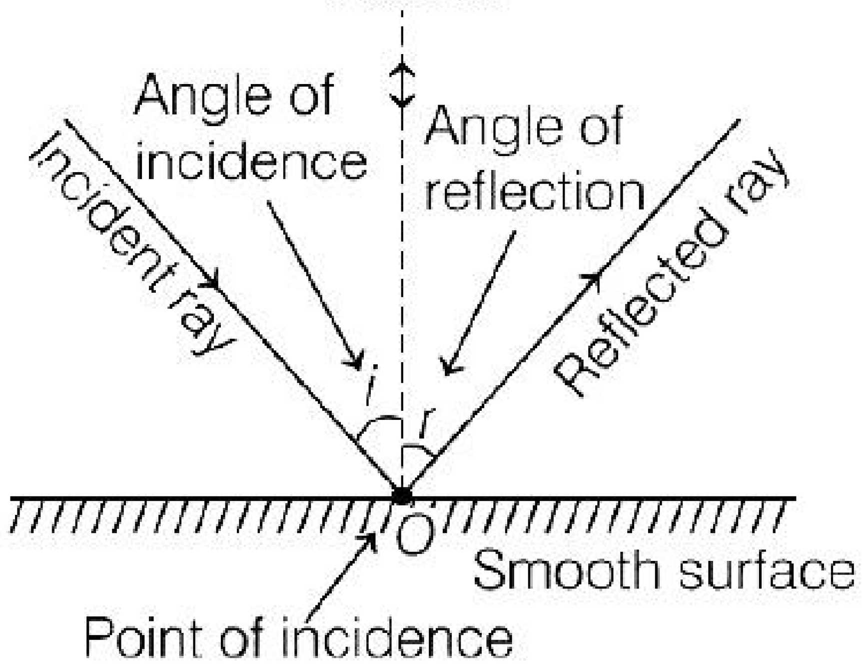
Reason In case of goggles, both the curved surfaces have equal radii of curvature.

Case Based MCQs

63. Read the following and answer questions from (i) to (v).

Light is a form of energy which induces sensation of vision to our eyes.
It becomes visible when it bounces off on surfaces and hits our eyes.

The phenomenon of bouncing back of light rays in the same medium on striking a smooth surface is called reflection of light.



Reflection from plane surface

If parallel beam of incident rays remains parallel even after reflection and goes only in one direction is known as regular reflection. It takes place mostly in plane mirrors or highly polished metal surfaces.

The mirror outside the driver side of a vehicle is usually a spherical mirror and printed on such a mirror is usually the warning "vehicles in this mirror are closer than they appear."

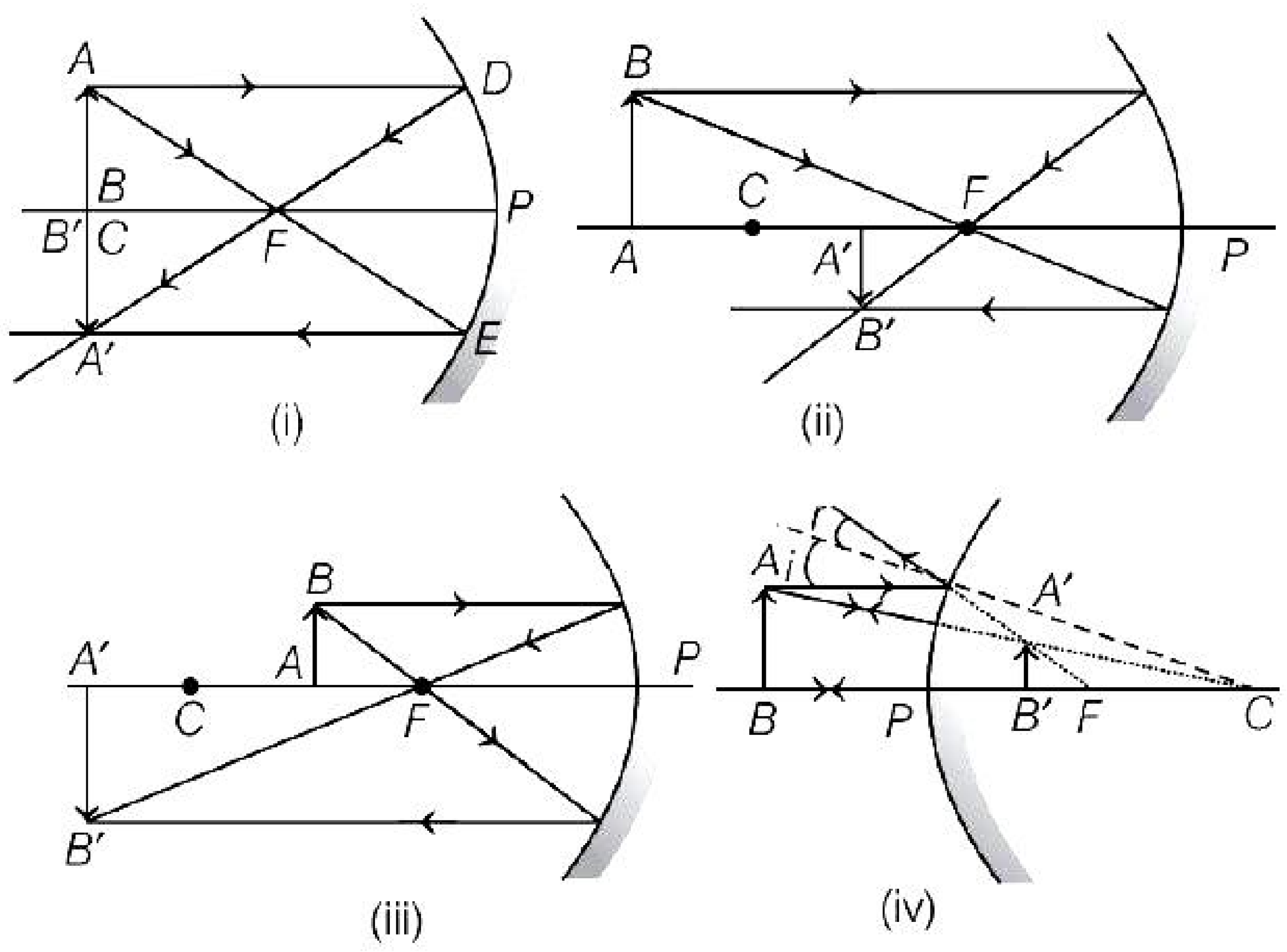
(i) Which type of mirror is used outside the driver's side of a vehicle?

(a) Plane mirror
(b) Concave mirror
(c) Convex mirror
(d) Magic mirror

(ii) No matter how far you stand from a mirror, your image appears erect. The mirror can be

(a) Plane
(b) Concave
(c) convex
(d) Either plane or convex

(iii) Which of the following diagrams represents the image formation in above case?



(a) (i) (b) (ii) (c) (iii) (d) (iv)

(iv) If an object is placed at 10 cm from a convex mirror of radius of curvature 60 cm, then find the position of image.

(a) 4 cm
(b) 7.5 cm
(c) 10 cm
(d) 12.5 cm

(v) The focal length of mirror is 12 cm. The radius of curvature is

(a) 12 cm (b) 24 cm
(c) 20 cm (d) 36 cm

64. Read the following and answer questions from (i) to (v).

If the reflecting surface of the mirror is curved inwards or outwards, then the mirror is called a spherical mirror.

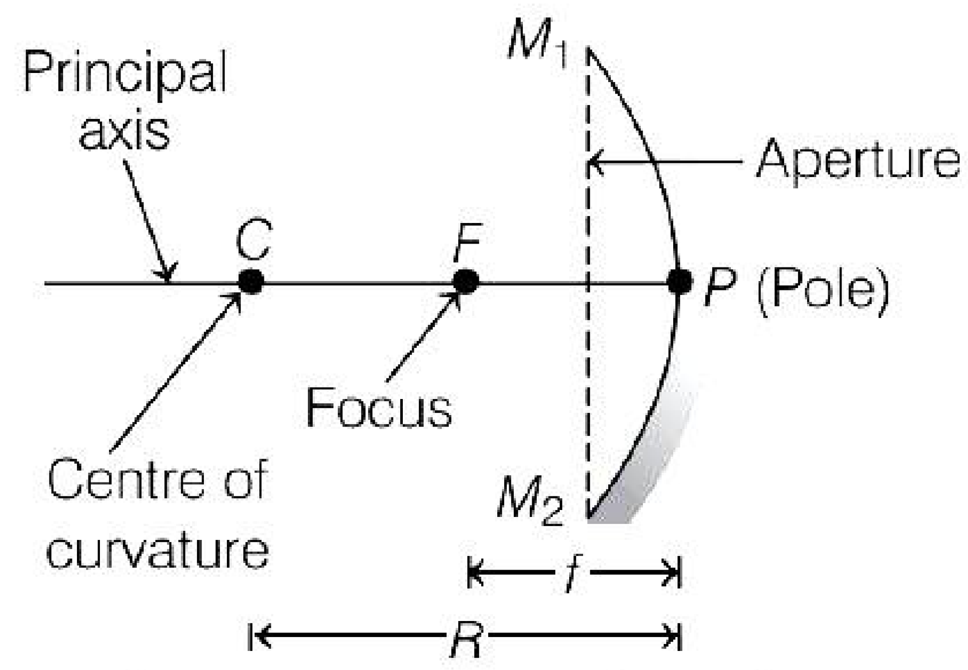
Spherical mirrors are of two types:

(i) Concave (ii) Convex

The spherical mirror with inward curved reflecting surface is called concave mirror.

A beam of light generally converges after reflection from such surfaces, hence it is also called convergent mirror.

e.g. The inner curved surface of a shining spoon can be considered as a concave mirror.



Concave or converging mirror

Here, f = focal length and R = radius of curvature.

Two students A and B performed an experiment on finding the image formation by a concave mirror.

They performed the experiment for different positions of object and obtained different positions of image.

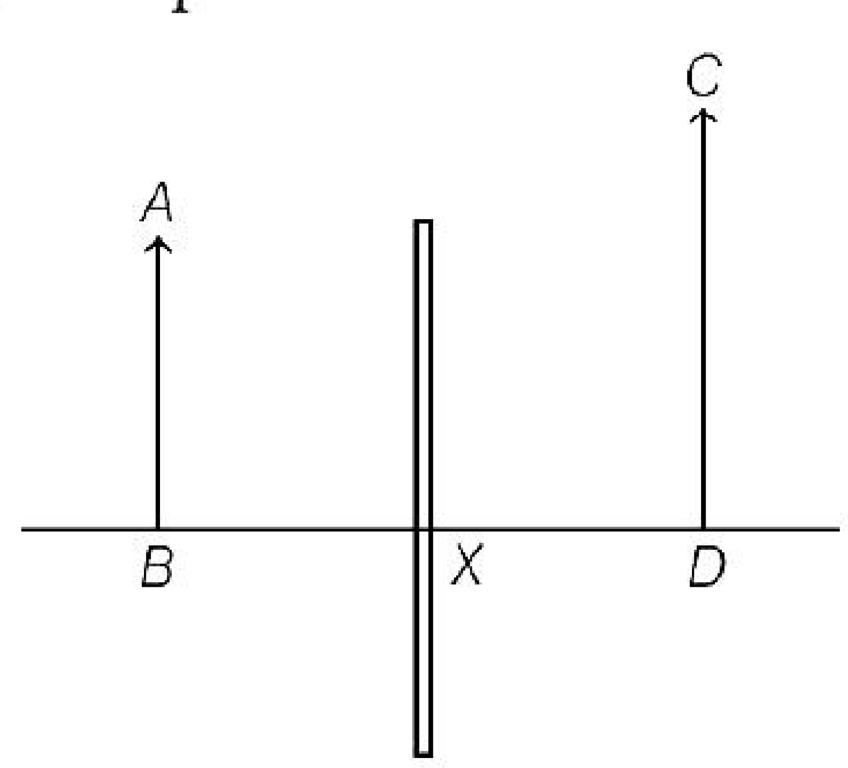
(i) If the object is placed between focus and centre of curvature, the position of image will be

(a) at focus
(b) between focus and pole
(c) beyond centre of curvature
(d) None of the above

(ii) The image of a bright object is brought on a screen with the help of a concave mirror. If the upper half of the concave mirror is covered, then

(a) the size of the image will become half
(b) the image will be disappeared
(c) the brightness of the image will be reduced
(d) the image will change its position

(iii) CD is an image of an object AB formed by an optical device X. Identify X.



(a) Concave lens (b) Convex lens
(c) Concave mirror (d) Convex mirror

(iv) If the object is placed at a distance of 10 cm in front of the mirror, the image will be formed at a distance of [Take, magnification to be (– 3)]

(a) 20 cm (b) –20 cm
(c) 30 cm (d) – 30 cm

(v) For the given data showing the focal lengths of three concave mirrors *A*, *B* and *C*; and the respective distances of different objects from these mirrors.

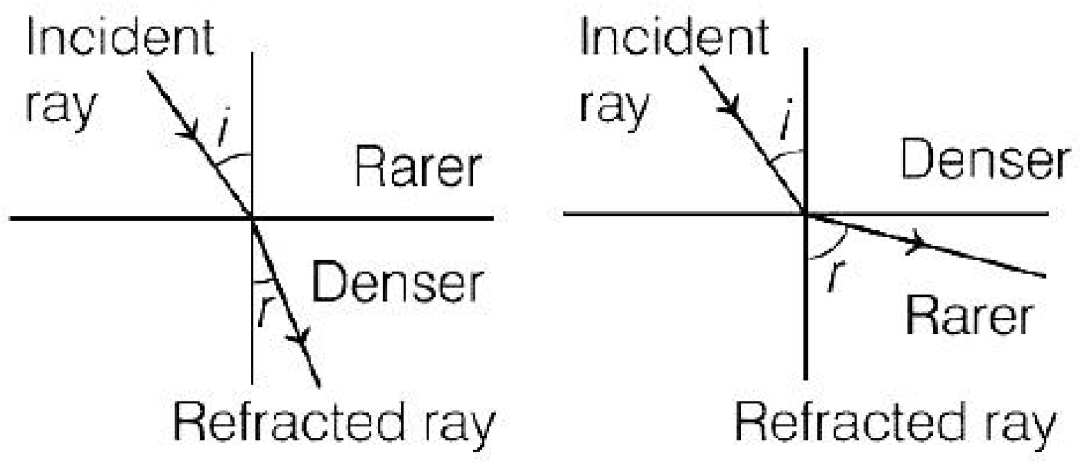
Concave mirrors	Object distance (in cm)	Focal length (in cm)
A	45	20
B	30	15
C	20	30

In the given positions of objects from the mirrors, the mirror(s) which will form diminished image(s) of the object(s) is/are

(a) Only *A*
(b) Only *B*
(c) Only *C*
(d) Both *A* and *B*

65. Read the following and answer questions from (i) to (v).

The refractive index of a medium with respect to vacuum is called absolute refractive index of the medium. It is given by, $\mu = \frac{\sin i}{\sin r}$



Refraction of light

Absolute refractive indices of some of the materials *A*, *B*, *C* and *D* are given in the following table :

Medium	Refractive index
A	1.54
B	1.33
C	2.42
D	1.65

(i) How is absolute refractive index related to speed of light?

(a) $\mu = \frac{c}{v_m}$ (b) $\mu = cv_m$
(c) $\mu_c = v_m$ (d) $v\mu = c$

(ii) In which of the materials given in the above table, light travels fastest?

(a) *A* (b) *B*
(c) *C* (d) *D*

(iii) The speed of light in air is $3 \times 10^8 \text{ ms}^{-1}$ and that in medium *A* is $2.5 \times 10^8 \text{ ms}^{-1}$. The refractive index of *A* will be

(a) 1.2 (b) 0.5
(c) 4.5 (d) 1.5

(iv) When light travels from air to glass,

(a) angle of incidence > angle of refraction
(b) angle of incidence < angle of refraction
(c) angle of incidence = angle of refraction
(d) Can't say

(v) The refractive index of *P* with respect to *Q* is 2. Find the refractive index of *Q* with respect to *P*.

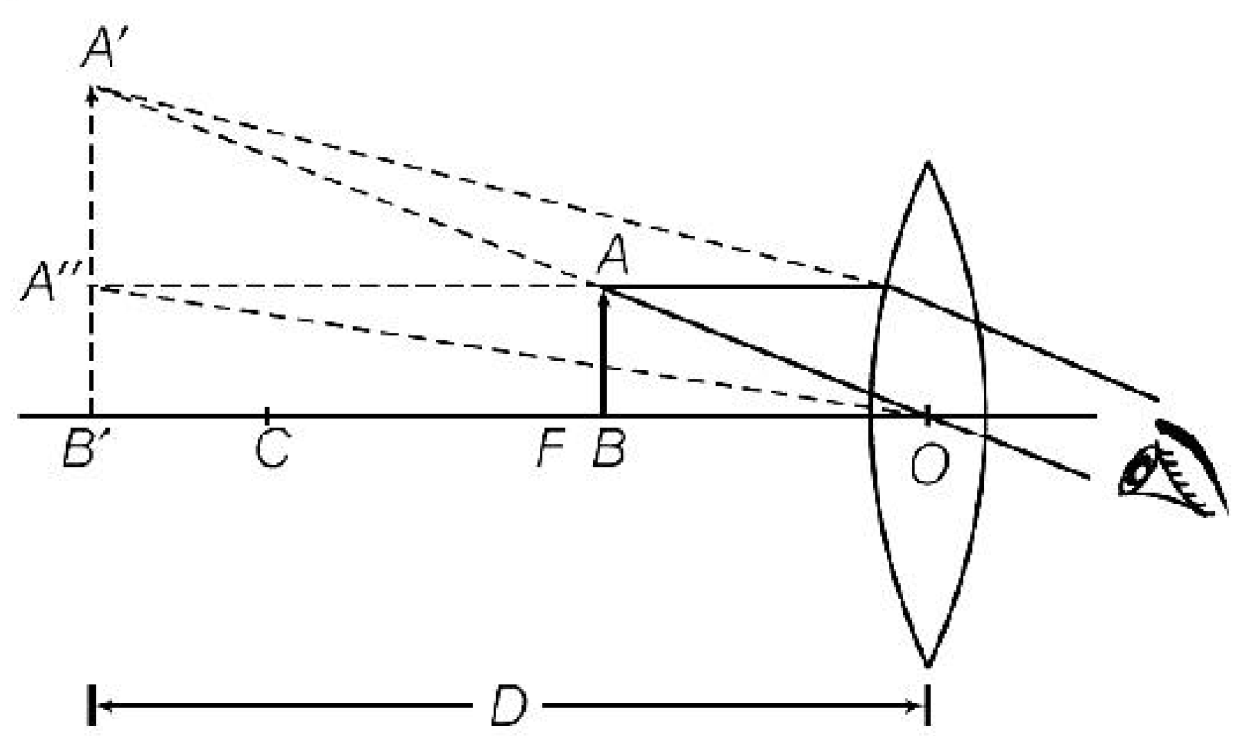
(a) 0.5 (b) 0.2
(c) 2 (d) 2.5

66. Read the following and answer questions from (i) to (v).

Magnification products like magnifying glass, compound microscope, telescope, etc., are important instruments for the daily activities of many individuals today.

Whether the application is for commercial, professional or personal use, a magnifier enhances one's ability to perform or enjoy a task or hobby. A magnifying glass is a convex lens that is used to produce a magnified image of an object. The magnification of a magnifying glass depends upon whether it is placed between the user's eye and the object being viewed and the total distance between them.

The highest magnifying power is obtained by putting the lens very close to the eye and moving the eye and the lens together to obtain the best focus.

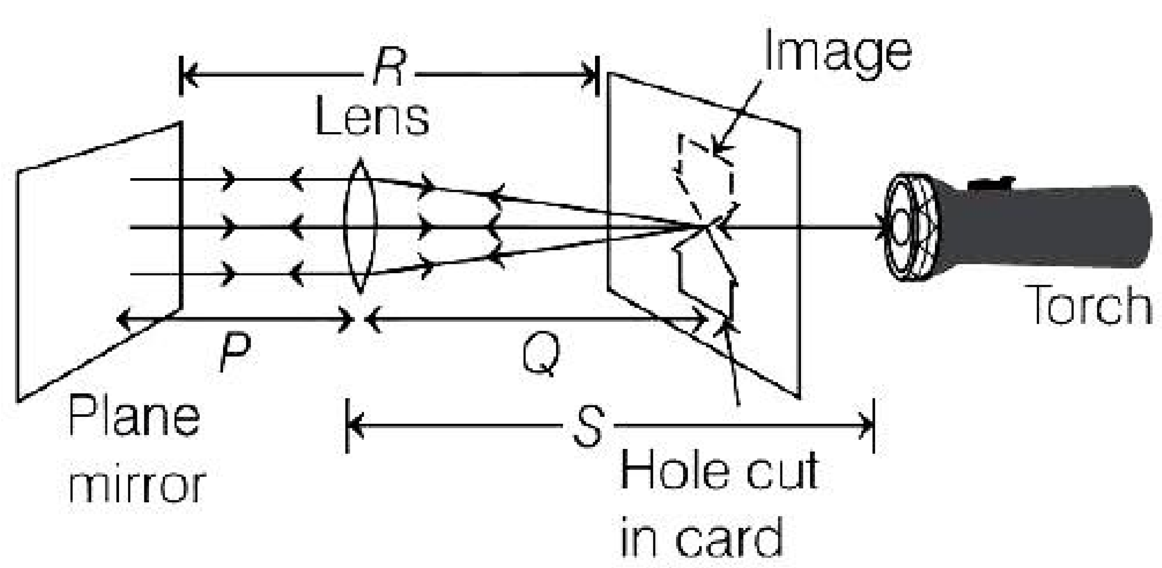


Convex lens as magnifier

(i) Which one of the following materials cannot be used to make a lens?

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

(ii) The following diagram shows an experiment to measure the focal length of a lens. What is the focal length of the following lens?



(a) P (b) Q
(c) R (d) S

(iii) On what factors, magnification of a magnifying glass depends?

(a) Position between the user's eye and the object
(b) Distance between user's eye and object
(c) Both (a) and (b)
(d) None of the above

(iv) Which of the following lenses would you prefer to use while reading small letters found in dictionary?

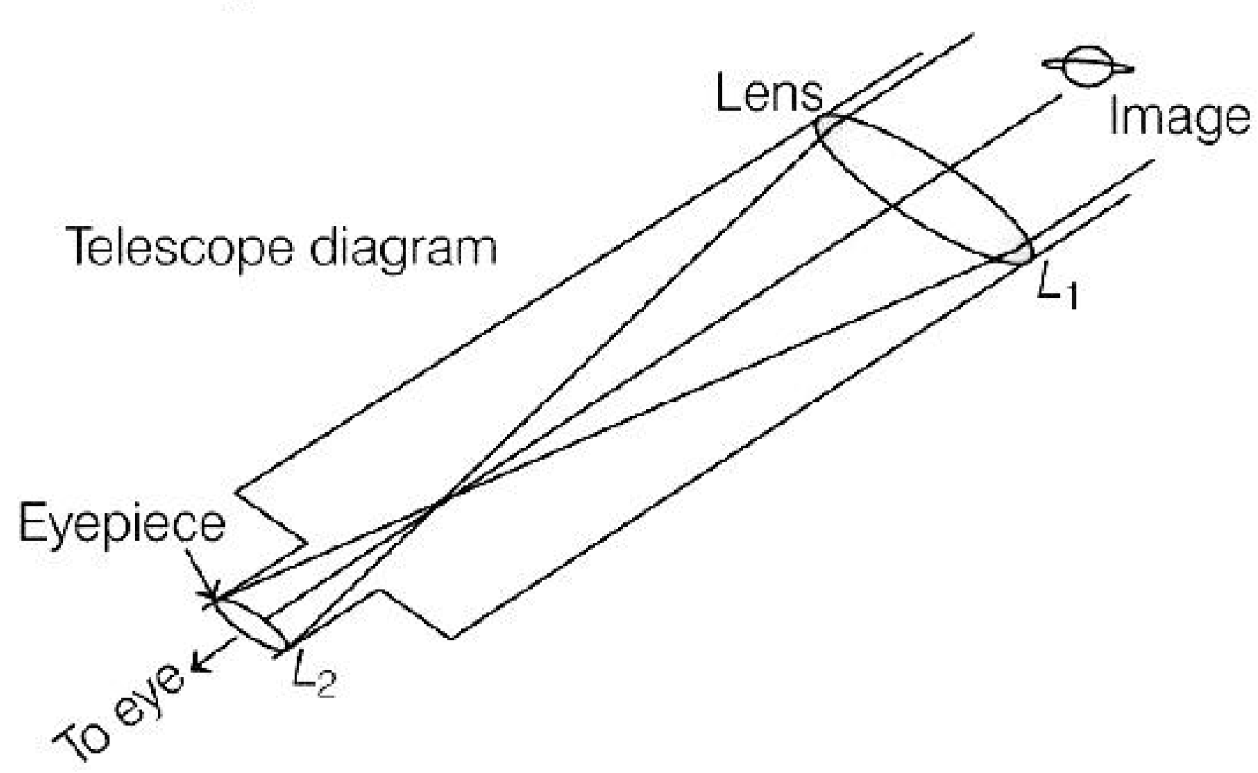
(a) A convex lens of focal length 50 cm
(b) A concave lens of focal length 50 cm
(c) A convex lens of focal length 5 cm
(d) A concave lens of focal length 5 cm

(v) A convex lens forms an image of magnification–2 of height 6 cm. The height of object is

(a) 6 cm (b) 4 cm
(c) 3 cm (d) 2 cm

67. Read the following and answer questions from (i) to (v).

Sumati wanted to see the stars of the night sky. She knows that she needs a telescope to see those distant stars. She finds out that the telescopes, which are made of lenses, are called refracting telescopes and the ones which are made of mirrors are called reflecting telescopes.



So, she decided to make a refracting telescope. She bought two lenses, L_1 and L_2 out of which L_1 was bigger and L_2 was smaller.

The larger lens gathers and bends the light, while the smaller lens magnifies the image. Big, thick lenses are more powerful. So to see far away, she needed a big powerful lens. Unfortunately, she realised that a big lens is very heavy.

Heavy lenses are hard to make and difficult to hold in the right place. Also, since the light is passing through the lens, the surface of the lens has to be extremely smooth. Any flaws in the lens will change the image. It would be like looking through a dirty window.

(CBSE Sample Paper 2021)

(i) Based on the diagram shown, what kind of lenses would Sumati need to make the telescope?

(a) Concave lenses (b) Convex lenses
(c) Bi-focal lenses (d) Flat lenses

(ii) If the powers of the lenses L_1 and L_2 are in the ratio of 4 : 1, what would be the ratio of the focal length of L_1 and L_2?

(a) 4 : 1 (b) 1 : 4 (c) 2 : 1 (d) 1 : 1

(iii) What is the formula for magnification obtained with a lens?

(a) Ratio of height of image to height of object
(b) Double the focal length
(c) Inverse of the radius of curvature
(d) Inverse of the object distance

(iv) Sumati did some preliminary experiment with the lenses and found out that the magnification of the eyepiece (L_2) is 3. If in her experiment with L_2 she found an image at 24 cm from the lens, at what distance did she put the object?

(a) 72 cm
(b) 12 cm
(c) 8 cm
(d) 6 cm

(v) Sumati bought not-so-thick lenses for the telescope and polished them. What advantages, if any, would she have with her choice of lenses?

(a) She will not have any advantage as even thicker lenses would give clearer images.
(b) Thicker lenses would have made the telescope easier to handle.
(c) Not-so-thick lenses would not make the telescope very heavy and also allow considerable amount of light to pass.
(d) Not-so-thick lenses will give her more magnification.

ANSWERS

Multiple Choice Questions

1. (d)	2. (d)	3. (d)	4. (d)	5. (b)	6. (b)	7. (b)	8. (d)	9. (d)	10. (b)
11. (b)	12. (b)	13. (a)	14. (b)	15. (b)	16. (d)	17. (d)	18. (c)	19. (d)	20. (b)
21. (d)	22. (c)	23. (b)	24. (d)	25. (a)	26. (b)	27. (b)	28. (a)	29. (a)	30. (b)
31. (d)	32. (a)	33. (a)	34. (d)	35. (c)	36. (a)	37. (b)	38. (a)	39. (d)	40. (b)
41. (b)	42. (b)	43. (a)	44. (d)	45. (c)	46. (a)	47. (a)	48. (d)	49. (d)	50. (c)
51. (a)	52. (c)	53. (b)	54. (b)	55. (c)					

Assertion-Reasoning MCQs

56. (a) 57. (a) 58. (d) 59. (a) 60. (c) 61. (c) 62. (a)

Case Based MCQs

63. (i) (c), (ii) (d), (iii) (d), (iv) (b), (v) (b)
64. (i) (c), (ii) (c), (iii) (c), (iv) (d), (v) (a)
65. (i) (a), (ii) (b), (iii) (a), (iv) (a), (v) (a)
66. (i) (d), (ii) (b) (iii) (c) (iv) (c) (v) (c)
67. (i) (b), (ii) (b), (iii) (a), (iv) (c), (v) (c)

EXPLANATIONS

1. Light is an electromagnetic wave because it can travel even in vacuum and it has all other characteristics of EM wave. So, it is a transverse wave. It travels in a straight line and particles vibrate perpendicular to the direction of propagation of wave. Hence, statement (d) is incorrect.

2. Velocity of light is maximum in vacuum, i.e. 3×10^8 m/s.

3. The laws of reflection holds good for light reflected from any smooth surface i.e., all mirrors regardless of their shape.

4. The plane and convex mirrors always form the erect (straight) image.

5. Focal length of a plane mirror is infinite.

6. The distance of image is equal to the distance of object from plane mirror. Therefore, the distance of image from mirror will be 10 cm.

7. The focal length of spherical mirror is half of the radius of curvature, i.e. $f = \frac{R}{2}$.

8. Principal focus of a convex mirror is a point on its principal axis from which a beam of light rays parallel to axis, diverge after being reflected from the mirror.

9. Given, radius of curvature, $R = 12$ cm

We know that, the focal length of concave mirror has negative value.

Hence, focal length, $f = \frac{-R}{2} = \frac{-12}{2} = -6$ cm

10. False;

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

Hence, $R = 2f = 2 \times 10 = 20$ cm

11. The sight area of convex mirror is the highest, because it produces diminished images of objects at different positions.

12. If the object is placed between centre of curvature and focus of a concave mirror, real, inverted and diminished image is formed.

13. The image will be formed between pole (P) and focus (f) behind mirror, virtual and erect.

14. The convex mirror forms virtual, erect and diminished image of the objects. So, it can form full length image of a distant tall building.

15. False, the focal length of a convex mirror (diverging) is positive while that of a concave mirror (converging) is negative.

16. The object should be placed between the pole (P) and the focus point (f) of the mirror.

17. When object is placed on the focus or between the focus and pole of a concave mirror, the image will be formed behind the mirror, which is virtual, erect and enlarged.

18. If the light rays coming from a point actually meet or converge at a point after reflection or refraction, then the image formed is called a real image.

19. The image will be formed behind mirror, virtual and erect.

20. The rays from sun *i.e.,* from infinity, are parallel to the principal axis after reflection converge at a point, known as focus. Therefore, focal length (f) of concave mirror is 15 cm. And we know that, same size, real and inverted image is formed by concave mirror when object is placed at $2f$ or centre of curvature. So, object should be placed at $15 \times 2 = 30$ cm.

21. The image formed by a concave mirror is always perpendicular to the principal axis. So, the screen should be placed parallel to the plane of mirror.

22. Concave mirror (of large focal length) can be used to see a larger image of the head, the plane mirror for middle portion to see her body of the same size and convex mirror to see the diminished image of leg. Hence, the combinations for magic mirror from the top is concave mirror, plane mirror and convex mirror.

23. A $\rightarrow$ (iv); When object is placed between infinity and the pole of convex mirror, image formed is virtual, erect and diminished.

B $\rightarrow$ (i); When object is at the centre of curvature of concave mirror, image formed is real, inverted and same size as that of object.

C → (ii); When object is between focus and centre of curvature of concave mirror, image formed is real, inverted and enlarged.

D → (iii); When object is at some distance from concave mirror beyond centre of curvature, image formed is real, inverted and diminished.

24. Given, focal length of concave mirror, $f = -10$ cm

Distance of object from concave mirror, $u = -20$ cm

From the mirror formula,

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \Rightarrow \frac{1}{-20}+\frac{1}{v}=\frac{1}{-10}$$

$$\Rightarrow \frac{1}{v}=\frac{1}{20}-\frac{1}{10}$$

$$\Rightarrow \frac{1}{v}=\frac{1-2}{20} \Rightarrow \frac{1}{v}=\frac{-1}{20}$$

$$\Rightarrow v=-20 \text{ cm}$$

Hence, the image is formed at the centre of curvature of mirror.

25. Given, $u=-10$ cm

We know that, magnification,

$$M=\frac{-v}{u}$$

$$\Rightarrow \quad -3=\frac{-v}{-10} \Rightarrow v=-30 \text{ cm}$$

So, the image is formed at a distance of 30 cm in front of the mirror.

26. Given, object size, $h=+10.0$ mm $=+1.0$ cm ($\because 1\,\text{cm}=10\,\text{mm}$)

Image size, $h'=-5.0$ mm $=-0.5$ cm (for real image)

Image distance, $v=-30$ cm (For real image)

Focal length, $f=?$

As, magnification, $m=-\dfrac{h'(\text{image size})}{h\,(\text{object size})}$

Also, magnification, $m=\dfrac{-v}{u} \Rightarrow -\dfrac{h'}{h}=\dfrac{-v}{u}$

$$\frac{0.5}{1}=\frac{-30}{u} \Rightarrow u=-60 \text{ cm}$$

Using mirror formula, $\dfrac{1}{f}=\dfrac{1}{v}+\dfrac{1}{u}$

$$\Rightarrow \frac{1}{f}=\frac{1}{-30}-\frac{1}{60}=\frac{-2-1}{60}=\frac{-3}{60}$$

$$\Rightarrow f=-20 \text{ cm}$$

27. Given, $m=\dfrac{1}{n}=-\dfrac{v}{(-u)}$

$$\Rightarrow \quad v=\frac{u}{n}$$

From mirror formula, $\dfrac{1}{v}+\dfrac{1}{u}=\dfrac{1}{f}$

$$\Rightarrow \quad \frac{n}{u}+\frac{1}{u}=\frac{1}{f}$$

or $\quad u=(n+1)f$

28. The convex mirror forms virtual, erect and diminished image of the object. The rear view mirror also forms same type of image. Therefore, magnification (m) produced by a rear view mirror fitted in vehicles is less than one, i.e. $m<1$.

29. A → (iv); $m=1$ means $h_i=h_o$.

B → (ii); $m<1$ means image is reduced or diminished in size.

C → (iii); $m>0$ means image formed is upright or erect.

D → (i); $m<0$ means image formed is inverted.

30. Given, angle of incidence, $i=45°$

Angle of refraction, $r=30°$

Refractive index of liquid with respect to air,

$$_{a}n_{l}=\frac{\sin i}{\sin r}$$

$$=\frac{\sin 45°}{\sin 30°}=1.41$$

31. Refractive index of medium with respect to air,

$$_{a}n_{m}=\frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

$$_{a}n_{m}=\frac{3\times10^{8}}{1.5\times10^{8}}=2$$

32. Since light ray in the medium B bends towards normal. So it has greater refractive index and lesser velocity of light w.r.t. medium A.

So refractive index of medium B w.r.t. medium A is greater than unity.

33. True;

As $\angle i=0°$, $\angle r=0°$.

Hence, no refraction will take place.

34. $v_g=\dfrac{c}{\mu}=\dfrac{3\times10^{8}}{1.5}=2.0\times10^{8}$ m/s

35. We know that refractive index of air with respect to glass,

$$_a n_g = \frac{1}{_g n_a} \Rightarrow \frac{3}{2} = \frac{1}{_g n_a} \Rightarrow {_g n_a} = \frac{2}{3}$$

36. Here, the emergent rays are parallel to the direction of the incident ray. Therefore, a rectangular glass slab could be inside the box as the extent of bending of light ray at the opposite parallel faces *AB* (air-glass interface) and *CD* (glass-air interface) of the rectangular glass slab are equal and opposite. This is why the ray emerges parallel to the incident ray.

37. False;

If a ray of light passes from denser to rarer medium, the refracted ray will bend away from the normal.

Hence, angle of refraction will be more than the angle of incidence.

38. If a ray of light is incident normally on the boundary of separation of two media, then angle of incidence and angle of refraction both are zero.

39. The given material having their refractive index as kerosene is 1.44, water is 1.33, musterd oil is 1.46 and glycerine is 1.74.

Thus, glycerine is most optically denser, having the largest refractive index. Therefore, ray of light with bend most in glycerine.

40. False;

As, refractive index, $\mu = \frac{c}{v}$

$\Rightarrow v \propto \frac{1}{\mu}$

So, light will travel with slowest speed in glass, being of greatest refractive index.

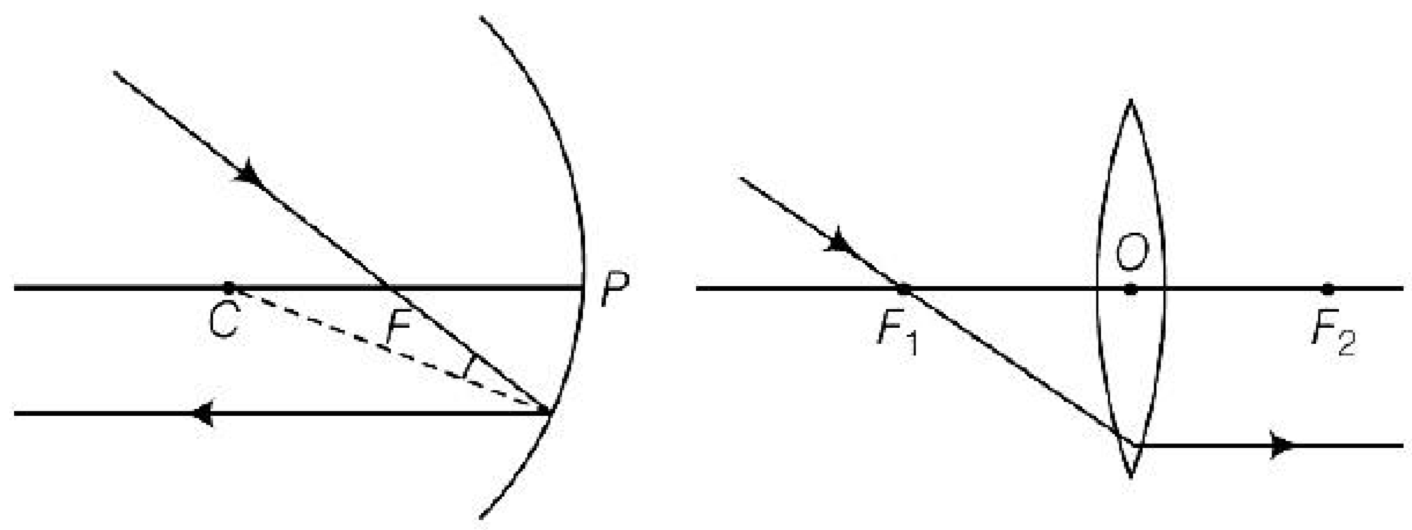
41. $\because$ Angle of incidence, $\angle i = 60°$, hence $\angle e = 60°$, where $\angle e =$ angle of emergence.

42. As we know, $f = \frac{R}{2}$

Hence, $f = \frac{20}{2} = 10$ cm

As it is concave lens, so $f = -10$ cm

43. A ray passing through the principal focus of a concave mirror or convex lens, after reflection/refraction, will emerge parallel to the principal axis.



44. The incident rays which comes from an object placed at infinity will be parallel and the rays parallel to the principal axis, after reflection/refraction by concave mirror, convex mirror, concave lens and convex lens, will pass or appear to pass through the principal focus. Hence, image will be highly diminished and point sized.

45. The object should be placed between f and $2f$ of the lens.

46. A ray of light passing through the principal focus of a convex lens after refraction will emerge parallel to the principal axis.

47. The focal length is taken negative for both concave mirror and concave lens.

48. Partially true;

The image formed by a concave lens is always virtual, and erect.

49. For concave lens,

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

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

$$\Rightarrow \quad \left(\frac{1}{n} - 1\right) = \frac{u}{f} \qquad (\because v = nu)$$

$$\Rightarrow \quad u = \left(\frac{1-n}{n}\right) f$$

50. Virtual images are always erect and can not be projected on the screen. These are formed by both concave and convex lens.

51. Concave; As concave lens always produces diminished image whenever an object is placed anywhere between optical centre (C) and infinity in front of it, hence magnification produced will less than 1.

52. Magnification,

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

53. Given, power of lens, $P = +1.5$ D

Focal length of lens, $f = \frac{1 \times 100}{1.5} = 66.7$ cm

Focal length of the lens is positive, hence the given lens is a converging lens.

54. Given, power of lenses, $P_1 = 3$D and $P_2 = -2$D

Power of combination of lenses,

$$P = P_1 + P_2 = 3\text{D} - 2\text{D} = +1\text{D}$$

Combined focal length $= \frac{1}{P} \times 100$ cm

$$= \frac{1}{1} \times 100 = 100 \text{ cm}$$

55. A → (ii); The formula of lens is the relation between object distance (u), image distance (v) and focal length (f), and represented as

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

B → (i); According to Snell's law, angle of incidence (i) ∝ angle of refraction (r)

C → (iii); Refractive index,

$$(\mu) = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in that medium}} = \frac{c}{v}$$

D → (iv); Power of lens (P) $= \frac{1}{f(\text{in metre})}$

56. The image formed in a plane mirror is at the same distance behind the mirror as the object is in front of mirror. So, if the object or mirror is moved, then image will also move.

57. When light ray incident along normal to the mirror, angle of incidence $\angle i = 0°$. According to law of reflection $\angle i = \angle r$, therefore angle of reflection $\angle r = 0°$, i.e. the incident ray retraces its path.

58. Focal length is the property of mirror and is independent of the medium in which it is placed. So, when a concave mirror is placed under water, its focal length remains same.

59. According to Snell's law,

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2}$$

$\Rightarrow n_1 v_1 = n_2 v_2$

This shows that higher is the refractive index of a medium or denser the medium, lesser is the velocity of light in that medium.

60. Property of a lens depends on the refractive index of surrounding medium.

61. As, the lens is made up of two materials, so it has two refractive indices and two focal lengths. Hence, two images will be formed. The image formed by convex lens is always real except in case when the object is placed between focus and optical centre.

62. In case of goggles, both the curved surfaces have equal radii of curvature. So, the focal length have of lens becomes infinite.

∴ Power, $P = \frac{1}{f} = 0$

63. (i) Convex mirrors are used as rear view mirrors in vehicles as they give an erect image and have a wider field of view.

(ii) The images formed by a plane mirror and also for convex mirror are always erect, for all positions of object.

(iii) When an object is placed in front of a convex mirror at any distance, the image is formed between the focus and the pole, behind the mirror.

(iv) Given, object distance, $u = -10$ cm

Radius of curvature, $R = 60$ cm

∴ Focal length, $f = R/2 = \frac{60}{2} = 30$ cm

∵ By mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{30} - \left(-\frac{1}{10}\right) = \frac{4}{30}$$

$$\Rightarrow v = 7.5 \text{ cm}$$

(v) Given, $f = 12$ cm

As, radius of curvature, $R = 2f$

$$\Rightarrow R = 2 \times 12 = 24 \text{ cm}$$

64. (i) When object is placed between focus and centre of curvature, the image will be formed beyond centre of curvature.

(ii) If the upper half of the concave mirror is covered, then the total reflecting surface gets reduced. So, the brightness of the image will be reduced.

(iii) As the image formed is erect and magnified, so it would be concave mirror.

(iv) Given, $u = -10$ cm, $m = -3$

As, we know that, $m = \frac{-v}{u}$

∴ Image distance, $v = -mu$

$$= -(-3)(-10) = -30 \text{ cm}$$

(v) Using mirror formula, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$, we get

$v_A = -36$ cm, $v_B = -30$ cm and $v_C = 60$ cm

$\therefore$ Magnification $\left(m = -\frac{v}{u}\right)$ be less than 1 only in case of A. So, image formed by A is diminished in size.

65. (i) Absolute refractive index (μ)

$$= \frac{\text{Speed of light in vacuum } (c)}{\text{Speed of light in that medium } (v_m)}$$

(ii) Since, B has the least refractive index, it indicates that B is much optically rarer than all other medium, hence light travels fastest in medium B.

(iii) Refractive index of A

$$= \frac{\text{Speed of light in air}}{\text{Speed of light in that medium}}$$

$$= \frac{3\times10^8}{2.5\times10^8} = 1.2$$

(iv) Since, for glass refractive index > 1, i.e.

$$\frac{\sin i}{\sin r} > 1$$

$\Rightarrow \sin i > \sin r$ or $i > r$

(v) Given, $_Q\mu_P = 2$

$\therefore$ Refractive index of Q w.r.t. P is,

$$_P\mu_Q = \frac{1}{_Q\mu_P} = \frac{1}{2} = 0.5$$

66. (i) Clay can never be transparent, so it can not be used to make lens.

(ii) According to the diagram, Q is the focal length as it is the distance between focus and optical centre.

(iii) The magnification of a magnifying glass depends upon whether it is placed between the user's eye and the object being viewed and total distance between them.

(iv) A convex lens with smaller focal length would act as a better magnifier. So, a convex lens of focal length 5 cm is used in given case.

(v) Given, $m = -2$, $h_2 = -6$ cm

$\therefore$ Magnification, $m = \frac{h_2}{h_1}$

$$\Rightarrow \quad -2 = \frac{-6}{h_1} \Rightarrow h_1 = 3 \text{ cm}$$

67. (i) As shown in the given diagram, Sumati would need convex lenses in order to make the telescope.

(ii) Let f_1 and f_2 be the focal lengths of lenses L_1 and L_2, respectively.

As, power $= \frac{1}{\text{focal length}}$

Ratio of powers of lenses L_1 and L_2,

$$\frac{P_1}{P_2} = \frac{4}{1} \quad \text{(given)}$$

$$\Rightarrow \frac{1/f_1}{1/f_2} = \frac{4}{1} \Rightarrow \frac{f_2}{f_1} = \frac{4}{1}$$

$$\Rightarrow \frac{f_1}{f_2} = \frac{1}{4}$$

Hence, ratio of focal lengths of lenses L_1 and $L_2 = 1:4$

(iii) Magnification obtained by a lens is the ratio of height of image (h_i) to the height of object (h_o), i.e.,

Magnification, $m = \frac{h_i}{h_o}$

(iv) Given, magnification, $m = 3$

Image distance, $v = 24$ cm

Object distance, $u = ?$

As, $m = \frac{v}{u} \Rightarrow u = \frac{v}{m} = \frac{24 \text{ cm}}{3} = 8$ cm

Hence, she should put the object at 8 cm from the lens L_2.

(v) The telescope made by using not-so-thick lenses (i.e., thin lenses) will not be very heavy. Also, it will allow considerable amount of light to pass through it.