SOLVED EXAMPLES

Ex.1 An image is formed on the screen by a convex lens. When upper half part of lens is covered with black paper, then :

(A) half image is formed

(B) full image is formed

(C) intensity of image will be enhanced

(D) intensity of image will be reduced

Sol On covering the lens half by a black paper will reduce the intensity of image and not the part of image. So full image is formed.

Hence correct answer is (B, D).

Ex.2 A convex lens is made out of a substance of 1.2 refractive index. The two surfaces of lens are convex. If this lens is placed in water whose refractive index is 1.33, it will behave as :

(A) convergent lens (B) divergent lens

(C) plane glass plate (D) like a prism

Sol. The focal length of lens in water is given by

$$f_l = \frac{{}_a\mu_g - 1}{\frac{{}_a\mu_g}{{}_a\mu_\ell} - 1} f_a = \frac{1.2-1}{\frac{1.2}{1.33}-1} f_a$$

$$f_l = -\frac{0.2 \times 1.33}{0.13} f_a$$

Hence f_l is negative and as such it behaves as a divergent lens.

Hence correct answer is (B).

Ex.3 An equiconvex lens has a power of 5 diopter. If it is made of glass of refractive index 1.5 then the radius of the curvature of each surface will be

(A) 20 cm (B) 10 cm

(C) 5 cm (D) zero

Sol. The focal length of an equiconvex lens is given by

$$\frac{1}{f} = \frac{2(\mu-1)}{R}$$

It is given that $\frac{1}{f}$ = + 5 and μ = 1.5

Therefore, $5 = \frac{2(1.5-1)}{R}$

or $R = \frac{1}{5}$ metre = 20 cm

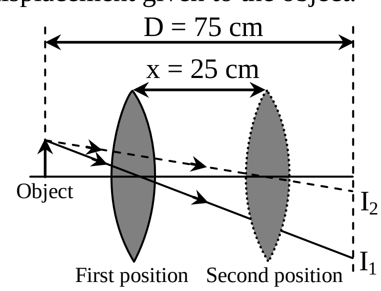
Thus the answer is (A).

Ex.4 A convex lens when placed in the first position forms a real image of an object on a fixed screen. The distance between the object and the screen is 75 cm. On displacing the lens from first position by 25 cm to the second position, again a real image is formed on the screen. Then the focal length of the lens is

(A) 25.0 cm (B) 16.7 cm

(C) 50.3 cm (D) 33.3 cm

Sol. The question is based on the conventional method of measurement of focal length by displacement method. According to this method where D is the distance between object and the image, and x is the displacement given to the object.



From the data x = 25 cm and D = 75 cm .

Thus

$$f = \frac{(75)^2-(25)^2}{4\times 75} = \frac{(75-25)-(75+25)}{4\times 75}$$

$$= \frac{50\times 100}{4\times 75} = \frac{50}{3} = 16.7 \text{ cm}$$

Ex.5 A bi-convex lens is made from glass of refractive index 1.5 and radius of curvature of both surfaces of the lens is 20 cm. The incident ray parallel to principal axis will be focussed at a distance L cm from lens on principal axis where :

(A) L = 10 (B) L = 20

(C) L = 40 (D) L = 20/3

Sol. From lens formula

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$= 0.5\left[\frac{1}{R} - \left(\frac{1}{-R}\right)\right] = \frac{0.5 \times 2}{20}$

f $= 20$ cm

Therefore rays coming parallel to axis will form image at 20 cm.

Hence correct answer is (B).

Ex.6 A convex lens of power 4D is kept in contact with a concave lens of power 3D, the effective power of combination will be :

(A) 7D (B) 4D/3 (C) 1D (D) 3D/4

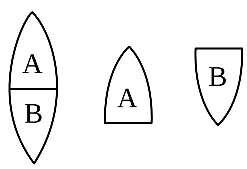
Sol. Effective power P is

$= P_1 + P_2$

$= 4 - 3 = 1D$

Hence correct answer is (C).

Ex.7 The power of a plano-convex lens is P. If this lens is cut longitudinally along its principal axis into tow equal parts and then they are joined as given in the figure. The power of combination will be :



(A) P (B) 2P (C) P/2 (D) zero

Sol. One part of combination will behave as converging lens and the other as diverging lens of same focal length. As such total power will be zero.

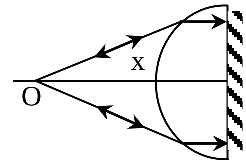
Hence correct answer is (D).

Ex.8 The plane surface of a planoconvex lens is silvered. If radius of curved surface is R and refractive index is μ, then the system behaves like a concave mirror whose radius will be :

(A) $\frac{R}{\mu}$ (B) $R\mu$

(C) $\frac{R}{\mu - 1}$ (D) $R(\mu - 1)$

Sol. Let the image of an object at O is formed at the same point as shown in figure. The distance of O from the plane surface is x. The rays suffer refraction at first surface (curved) as they reach lens. After wards become parallel and gets reflected form plane surface and so retrace the path and image is formed at O itself.



$\frac{\mu}{v} - \frac{1}{u} = \frac{\mu - 1}{R}$

$u = -x, v = \infty$

$\frac{\mu}{\infty} + \frac{1}{x} = \frac{\mu - 1}{R}$

$x = \frac{R}{\mu - 1}$

As such O behaves as equivalent to centre of curvature of equivalent concave mirror.

$\therefore$ radius $= x = \frac{R}{\mu - 1}$

Hence correct answer is (C).

Ex.9 A 35 mm film is to be projected on a 20 m wide screen situated at a distance of 40 m from the film- projector. Calculate the distance of the film from the projection lens and focal length of projection lens.

Sol. As in case of projector,

$m = \frac{I}{O} = \frac{v}{u}$

So $-\frac{(20 \times 100\text{cm})}{(3.5\text{cm})} = \frac{40 \times 100}{u}$

i.e., $u = -7$ cm

i.e., film is at a distance of 7 cm in front of projection lens.

And from lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, here we have

$\frac{1}{4000} - \frac{1}{-7} = \frac{1}{f}$

or $f \cong 7$ cm $= 70$ mm

[as (1/4000) << (1/7)]

i.e., focal length of projection lens is 70 mm.

Ex.10 A compound microscope has an objective of focal length 2 cm and an eye- piece of focal length 5 cm. If an object is placed at a distance of 2.4 cm in front of the field lens, find the magnifying power of the instrument and length of the tube if (a) final image is at infinity (b) final image is at least distance of distinct vision (= 25 cm).

Sol. As object is at a distance of 2.4 cm. in front of field lens of focal length 2 cm. field lens will form its image at distance v such that

$$\frac{1}{v} - \frac{1}{-2.4} = \frac{1}{2} \text{ i.e., } v = 12 \text{ cm.}$$

so that $m = \frac{v}{u} = \frac{12}{-2.4} = -5$

(a) If final image is at infinite (far point)

For eye- piece, $\frac{1}{\infty} - \frac{1}{u_e} = \frac{1}{5}$

i.e. , $u_e = -5$ cm.

and $m_\theta = (D/F_e) = (25/5) = 5$

So, $MP = m \times m_\theta = -5 \times 5 = -25$

and $L = v + u_e = 12 + 5 = 17$ cm.

In this situation eye is said to be relaxed and for a given microscope MP is minimum while length of tube maximum.

(b) If final image is at D (Near point)

For eye- piece, $\frac{1}{-25} - \frac{1}{u_e} = \frac{1}{5}$

i.e., $u_e = \frac{-25}{6} = -4.17$ cm.

and, $m_\theta = [\,1 + (D/f_e)\,] = [1 + (25/5)] = 6$

So, $MP = m \times m_\theta = -5 \times 6 = -30$

and, $L = v + u_e = 12 + 4.17 = 16.17$ cm.

In this situation eye is said to be strained and for a given microscope MP is maximum while length of tube is minimum.

Note : In case (b) $m_e = \frac{D}{u_e} = \frac{-25}{(-25/6)} = 6 = m_\theta$

So here $MP = m \times m_\theta = m \times m_e$ = linear magnification

Ex.11 In a compound microscope the objective and the eye- piece have focal lengths of 0.95 cm and 5 cm respectively, and are kept at a distance of 20 cm. The last image is formed at a distance of 25 cm from the eye- piece. Calculate the position of object and the total magnification.

Sol. As final image is at 25 cm in front of eye piece

$$\frac{1}{-25} - \frac{1}{u_e} = \frac{1}{5} \text{ i.e., } u_e = -\frac{25}{6}$$

And so, $m_e = \frac{v_e}{u_e} = \frac{-25}{(-25/6)} = 6$ ...(1)

Now for objective,

$v = L - u_e = 20 - (25/6) = (95/6)$

So if object is at a distance u from the objective,

$$\frac{6}{95} - \frac{1}{u} = \frac{1}{95.0}$$

i.e., $u = -\frac{95}{94}$ cm

i.e. object is at a distance (95/94) cm in front of field lens.

Also, $m = \frac{v}{u} = \frac{(95/6)}{(-95/94)} = -\left[\frac{94}{6}\right]$ ...(2)

So total magnification,

$$M = m \times m_e = -\left[\frac{94}{6}\right] \times (6) = -94$$

i.e., final image is inverted, virtual and 94 times that of object.

LEVEL # 1

Questions based on Refraction at curved surface

Q.1 A point object is placed in air at a distance of 40 cm from a concave refracting surface of refractive index 1.5. If the radius of curvature of the surface is 20 cm, then the position of the image is –
(A) in air and at 30 cm from pole
(B) in refracting medium and at 30 cm from pole
(C) in air and at infinity
(D) in refracting medium and at infinity

Q.2 An object is placed at a distance of 10 cm (in a medium of $\mu = 1$) from the pole of a spherical refracting surface bounding a medium of $\mu = 1.5$. If the image formed is virtual and at a distance of 40 cm, then the spherical surface is –
(A) concave with radius of curvature = 8 cm
(B) convex with radius of curvature = 8 cm
(C)concave with radius of curvature = 3.6 cm
(D) convex with radius of curvature = 3.6 cm

Q.3 An object is placed at a distance of 20 cm, in rarer medium, from the pole of a convex spherical refracting surface of radius of curvature 10 cm. If the refracting index of the rarer medium is 1 and of the refracting medium is 2, then the position of the image is at –
(A) (40/3) cm from the pole and inside the denser medium
(B) 40 cm from the pole and inside the denser medium
(C) (40/3) cm from the pole and outside the denser medium
(D) 40 cm from the pole and outside the denser medium

Questions based on Lens-maker's formula

Q.4 A convex lens of glass ($\mu = 1.5$) is immersed in water. Compared to its power in air, its power in water-
(A) increases
(B) decreases
(C) remain same
(D) nothing can be predicted

Q.5 The radii of curvatures of a double convex lens are 15 cm and 30 cm, and its refractive index is 1.5. Then its focal length is -
(A) + 10 cm (B) – 10 cm
(C) + 20 cm (D) – 20 cm

Q.6 The two spherical surfaces of a double concave lens have the same radius of curvature R, and the refractive index of the medium enclosed by the refracting surfaces is μ then the focal length of the lens is
(A) $f = \frac{R}{2}$ (B) $f = \frac{R}{2(\mu-1)}$
(C) $f = \frac{R}{2(1-\mu)}$ (D) $f = \frac{-(\mu-1)R}{2}$

Q.7 A thin lens is made with a material having refractive index $\mu = 1.5$. Both the sides are convex. It is dipped in water ($\mu = 1.33$). It will behave like
(A) a convergent lens (B) a divergent lens
(C) a rectangular slab (D) a prism

Q.8 The radius of curvature of convex surface of thin plane convex lens is 15cm and refractive index of the material is 1.6. The power of the lens will be
(A) + 1 D (B) – 2D
(C) + 3D (D) + 4 D

Q.9 The focal length of a convex lens of glass ($\mu = 1.5$) is 2 cm. The focal length of the lens when immersed in a liquid of refractive index 1.25 will be
(A) 5 cm (B) 2.4 cm
(C) 1 cm (D) 4 cm

Q.10 The focal length of a plano-convex lens is equal to its radius of curvature. The value of the refractive index of its material is

(A) 1.33 (B) 1.6 (C) 1.5 (D) 2

Questions based on Image formation by thin lenses

Q.11 An object is placed at a distance of 5 cm from a convex lens of focal length 10 cm, then the image is -

(A) real, diminished and at a distance of 10 cm from the lens

(B) real, enlarged and at a distance of 10 cm from the lens

(C) virtual, enlarged and at a distance of 10 cm from the lens

(D) virtual, diminished and at a distance of 10/3 cm from the lens.

Q.12 A convex lens of focal length f will form a magnified real image of an object if the object is placed

(A) anywhere beyond 2f

(B) anywhere beyond f

(C) between f and 2f

(D) between lens and f

Q.13 The image produced by a concave lens is

(A) always virtual (B) always real

(C) always inverted (D) always enlarged

Q.14 To obtain magnified virtual image of an object by a convex lens of focal length f, the distance between the object and the lens should be

(A) > 4f

(B) < f

(C) between 2f and 4f

(D) 6f

Q.15 An object is placed at a distance (f/2) from a convex lens. The image will be

(A) at (3/2) f, real inverted

(B) at one of the foci, virtual and double in size

(C) at 2f, virtual and erect

(D) none of these

Q.16 A biconvex lens can form a virtual image if the object is placed

(A) between the lens and its focus

(B) at the focus of the lens

(C) between *f* and 2 *f*

(D) at infinity

Questions based on Power lens & combination of lens

Q.17 Two convex lenses of equal focal length f are placed in contact. The focal length of the combination is

(A) f/2 (B) f (C) 2f (D) 3f/2

Q.18 Two thin lenses of focal lengths + 60cm and – 20cm are placed in contact. The focal length of combination is

(A) + 15 cm (B) –15 cm

(C) + 30 cm (D) – 30 cm

Q.19 A convex lens of power + 6D is placed in contact with a concave lens of power -4D. Then the nature of the combination and focal length is

(A) concave 25 cm (B) convex 50 cm

(C) concave 20 cm (D) convex 100 cm

Q.20 What is the power of a diverging lens of focal length 40 cm ?

(A) 2.5 dioptre (B) 4.0 dioptre

(C) – 3.5 dioptre (D) – 2.5 dioptre

Q.21 Two convex lenses of powers 4 D and 6 D are separated by a distance of $\frac{1}{6}$ m. The power of the optical system so formed is

(A) –6 D (B) +6 D

(C) 10 D (D) 2 D

Q.22 A lens of power + 2 dioptres is placed in contact with a lens of power – 1 dioptre. The combination will behave like

(A) a convergent lens of focal length 50 cm

(B) a divergent lens of focal length 100 cm

(C) a convergent lens of focal length 100 cm

(D) a convergent lens of focal length 200 cm

Q.23 When the two thin lenses of same nature are put in contact, the focal length of the combination is -

(A) the geometric mean of the two focal lengths

(B) the same as the larger focal length

(C) greater than either focal length

(D) smaller than either focal length

Q.24 Two thin lenses of focal lengths 20 cm and 25 cm are placed in contact. The effective power of the combination is

(A) 1/9 dioptre (B) 45 dioptre

(C) 6 dioptre (D) 9 dioptre

Q.25 A thin convex lens of focal length 10 cm and a thin concave lens of focal length 26.2 cm are in contact. The combination acts as

(A) concave lens of focal length 16.4 cm

(B) convex lens of focal length 6.2 cm

(C) concave or convex lens depends upon μ of material of lenses

(D) none of the above.

Q.26 A convex lens of focal length A and a concave lens of focal length B are placed in contact. The focal length of the combination is

(A) (A+ B) (B) (A – B)

(C) $\frac{AB}{(A+B)}$ (D) $\frac{AB}{(B-A)}$

Q.27 When a thin convex lens is put in contact with a thin concave lens of the same focal length, the resultant combination has a focal length equal to

(A) $f/2$ (B) 2 f (C) 0 (D) ∞

Q.28 Two lenses whose powers are + 2D and – 4D respectively. The power of combination :

(A) – 2D (B) + 2D

(C) – 4D (D) + 4D

Questions based on Displacement method

Q.29 If I_1 and I_2 be the sizes of the images respectively for the two positions of the lens in the displacement method, then the size of the object is given by

(A) $I_1 I_2$ (B) $\sqrt{(I_1 I_2)}$

(C) $\sqrt{(I_1 / I_2)}$ (D) $\sqrt{(I_2 / I_1)}$

Q.30 A convex lens forms a real image on a screen placed at a distance 60 cm from the object. When the lens is shifted towards the screen by 20 cm , another image of the object is formed on the screen. The focal length of the lens is :

(A) 45 cm (B) 40 /3 cm

(C) 30 cm (D) 12 cm

Questions based on Silvered lens

Q.31 A plano-convex lens when silvered on the plane side behaves like a concave mirror of focal length 60 cm. However, when silvered on the convex side it behaves like a concave mirror of focal length 20 cm. Then the refractive index of the lens is

(A) 3.0 (B) 1.5 (C) 1.0 (D) 2.0

Q.32 The plane surface of a planoconvex lens of focal length f is silvered. It will behave as :

(A) plane mirror

(B) convex mirror of focal lengths 2f

(C) concave mirror of focal length f/2

(D) none of the above

Questions based on Microscope

Q.33 The focal length of the objective of a microscope is -

(A) Greater than the focal length of eye piece

(B) Lesser than the focal length of the eye piece

(C) Equal to the focal length of the eye piece

(D) Any of (A) (B) and (C)

Q.34 When length of a microscope tube increases its magnifying power -

(A) Decreases

(B) Increase

(C) Does not change

(D) May increase or decrease

Q.35 In a simple microscope, if the final image is located at infinity then its magnifying power-

(A) 25/F (B) 25/D

(C) F/25 (D) (1+ 25/F)

Q.36 In a simple two lens refracting microscope, the intermediate image, in normal use is-

(A) Virtual, erect and magnified

(B) Real, erect and magnified

(C) Real, inverted and magnified

(D) Virtual, inverted and magnified

Q.37 The magnifying power of compound microscope in terms of the magnification m_0 due to objective, and the magnification power m_E by the eye-piece is given by -

(A) $\frac{m_0}{m_E}$ (B) $m_0 \times m_E$

(C) $m_0 + m_E$ (D) $m_0 - m_E$

Q.38 The final image produced by a compound microscope is -

(A) real and erect

(B) virtual and erect

(C) virtual and inverted

(D) real and inverted

Q.39 In a simple microscope, if the final image is located at 25 cm from the eye placed close to the lens, then the magnifying power is -

(A) 25/F (B) 1 + 25/F

(C) F/25 (D) F/25 + 1

Questions based on Telescope

Q.40 In astronomical telescope, the final image is formed at -

(A) The least distant of distinct vision

(B) The focus of objective ions

(C) The focus of the eye lens

(D) Infinity

Q.41 If f_0 and f_e are the focal lengths of the objective and eye- piece respectively for a telescope, the magnifying power of the telescope will be -

(A) f_e / f_0 (B) $f_0 \times f_e$

(C) f_0 / f_e (D) $f_0 + f_e$

Q.42 In which of the following the length of the tube is equal to the sum of the focal lengths of the field and eye lenses -

(A) Astronomical telescope

(B) Galilean telescope

(C) Terrestrial telescope

(D) Microscope

Q.43 Two convex lenses of focal length 0.3 m and 0.05 m are used to make a telescope. The distance kept between them is equal to -

(A) 0.35 m (B) 0.25 m

(C) 0.175 m (D) 0.15 m

Q.44 An astronomical telescope has a magnifying power 10. The focal length of the eye piece is 20 cm. the focal length of the objective is -

(A) 2 cm (B) 200 cm

(C) (1/2) cm (D) (1/200) cm

Q.45 The magnifying power of an astronomical telescope can be increased, if we-

(A) Increase the focal length of the objective

(B) Increase of the focal length of the eye piece

(C) Decreases the focal length of the objective

(D) Decrease the focal length of the objective and at the same time increase the focal length of the eye piece.

Q.46 When the length of an astronomical telescope tube increases its magnifying power -

(A) Decreases

(B) Increases

(C) Does not change

(D) May increase or decrease

Q.47 The resolving power of a telescope depends upon-

(A) length of telescope

(B) focal length of objective

(C) diameter of objective

(D) focal length of the eye piece

Q.48 If an astronomical telescope has objective and eye-pieces of focal lengths 200 cm and 4cm respectively, then the magnifying power of the telescope for the normal vision is -

(A) 42 (B) 50

(C) 58 (D) 204

Q.49 In question no. 48, the length of the telescope for normal vision, is -

(A) 204 cm (B) 200 cm
(C) 196 cm (D) 203.45 cm

Q.50 In question no.48, the magnifying power of the telescope for least distance of distinct vision is-
(A) 42 (B) 50 (C) 58 (D) 204

Q.51 In question no.48, the length of the telescope for least distance of distinct vision is
(A) 204 cm (B) 200 cm
(C) 196 cm (D) 203.45 cm

Q.52 If F_0 and F_e are the focal lengths of the objective and eye-piece respectively for a Galilean telescope, its magnifying power is about
(A) $F_0 + F_e$ (B) $F_0 \times F_e$
(C) F_0/F_e (D) $\frac{1}{2}$ $F_0 + F_e$

Q.53 The numerical value of the length of Galilean telescope for normal vision is (assuming f_0 and f_e as positive length)
(A) $f_0 \times f_e$ (B) f_0/f_e
(C) $f_0 + f_e$ (D) $f_0 - f_e$