2 PUC: CHAPTER- 09
RAY OPTICS AND OPTICAL INSTRUMENTS

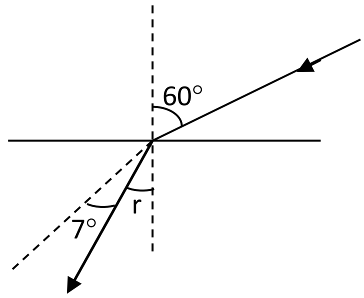
1. A ray of light passes from air into a liquid and the angle of incidence is 60°. If the deviation produced is 7°, then the refractive index of the liquid is

a) $\frac{2\sqrt{3}}{5}$ b) $\frac{\sqrt{3}}{2}$ c) $\frac{5}{4}$ d) $\frac{5\sqrt{3}}{8}$

(d)

Here, r = 60° - 7° = 53°

$\therefore \quad \mu = \frac{\sin 60^\circ}{\sin 53^\circ} = \frac{\sqrt{3}/2}{4/5} = \frac{5\sqrt{3}}{8}$



2. If the refractive index of water is 4/3 and that of glass is 5/3, then the critical angle of incidence for light tending to go from glass to water is

a) $\sin^{-1}\left(\frac{3}{4}\right)$ b) $\sin^{-1}\left(\frac{3}{5}\right)$ c) $\sin^{-1}\left(\frac{4}{5}\right)$ d) $\sin^{-1}\left(\frac{2}{3}\right)$

(c)

$\sin\theta_c = \frac{\mu_{water}}{\mu_{glass}} = \frac{4/3}{5/3} = \frac{4}{3}$

$\therefore \ \theta_c = \sin^{-1}\left(\frac{4}{5}\right)$

3. A ray of light is incident at an angle of 70° into a medium having refractive index μ. The reflected and the refracted rays are found to suffer equal deviations in opposite directions. Then, μ equals

a) tan70° b) 2 sin70° c) cosec70° d) none of these

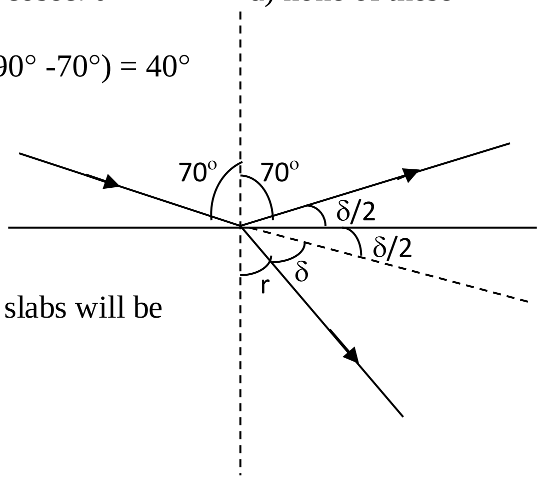
(b)

The deviation in the reflected ray is 2 × (δ/2) = 2 (90° -70°) = 40°

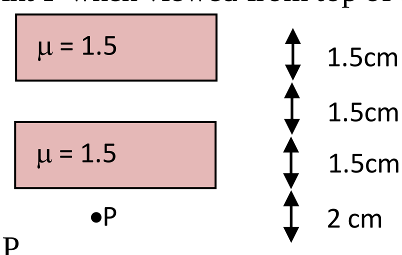
So, the deviation in refracted ray is also 40°

$\Rightarrow$ r = 90° - (δ + δ/2) = 30°

$\therefore \ \mu = \frac{\sin 70^\circ}{\sin 30^\circ}$ = 2 sin70°



4. The image of point P when viewed from top of the slabs will be



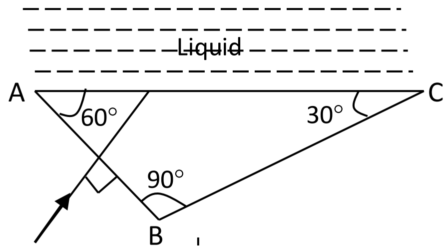
a) 2.0 cm above P b) 1.5 cm above P
c) 2.0 cm below P d) 1 cm above P

(d)

$N_s = t\,[1 - (1/n)]$

The image gets shifted upwards by $1.5\left(1-\frac{1}{1.5}\right)+1.5\left(1-\frac{1}{1.5}\right)=1\text{cm}$

5. Light is incident normally on face AB of a prism as shown in fig. A liquid of refractive index μ is placed on face AC of the prism. The prism is made of glass of refractive index 3/2. The limits of μ for which total internal reflection takes place on face AC is



a) $\mu > \frac{\sqrt{3}}{2}$ b) $\mu < \frac{3\sqrt{3}}{4}$

c) $\mu > \sqrt{3}$ d) $\mu < \frac{\sqrt{3}}{2}$

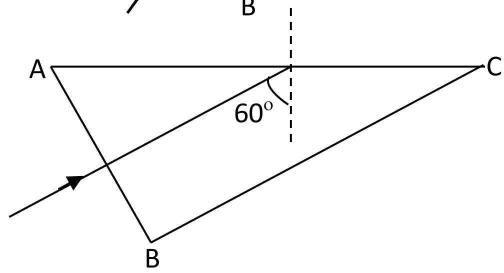
(b)

The angle of incidence (from geometry) on face AC is 60°. For total internal reflection to take place,

$\theta_c < 60^\circ$ or $\sin\theta_c < \sqrt{3}/2$

where , $\sin\theta_c = \frac{\mu}{3/2} = \frac{2\mu}{3}$

$\Rightarrow \frac{2\mu}{3} < \frac{\sqrt{3}}{2}$ $\therefore\ \mu < \frac{3\sqrt{3}}{4}$



6. An object is placed 50 cm in front of a convex surface of radius 20 cm. If the surface separates air from glass of refractive index 1.5, the distance of the image from the lens and its nature are

a) 3 cm, real b) 30 cm, virtual

c) 300 cm, real d) 300 cm, virtual

(c)

Here, u = -50cm, $\mu_1 = 1$, $\mu_2 = 1.5$, R = 20 cm

Now, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1.5}{v} - \frac{1}{-50} = \frac{1.5-1}{20}$ $\Rightarrow v = 300\,cm$

Also, as v is +ve, the emergent rays are converging and hence, the image is real.

7. A thin converging lens of refractive index 1.5 has a power of + 0.5 D. When this lens is immersed in a liquid, it acts as a diverging lens of focal length 200 cm. The refractive index of the liquid is

a) 4/3 b) 3/2 c) 3 d) 2

(c)

In air, $\frac{1}{f} = (1.5-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow 0.5 = 0.5\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow \frac{1}{R_1} - \frac{1}{R_2} = 1$

In liquid, $\frac{1}{f'} = \left(\frac{1.5}{\mu} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow \frac{1}{-2} = \left(\frac{1.5}{\mu} - 1\right) \times 1$

$\therefore\ \mu = 3$

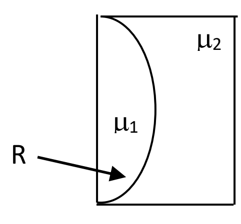
8. A planoconvex lens fits exactly into a planoconcave lens. Their plane surface is parallel to each other. If the lenses are made of different materials of refractive indices μ_1 and μ_2 and R is the radius of curvature of the curved surface of the lenses, then focal length of the combination is

a) $\frac{R}{\mu_1 - \mu_2}$ b) $\frac{2R}{\mu_2 - \mu_1}$ c) $\frac{R}{2(\mu_1 - \mu_2)}$ d) $\frac{R}{2 - (\mu_1 + \mu_2)}$

(a)

Here, $\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right) = \frac{\mu_1 - 1}{R}$

$\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{\infty}\right) = \frac{\mu_2 - 1}{-R}$



The focal length (f) of the combination is given by

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{R}(\mu_1 - \mu_2)$

$\therefore\ f = \frac{R}{\mu_1 - \mu_2}$

9. The distance between an object and the screen is 100 cm. A lens produces an image on the screen when placed at either of two position 40 cm apart. The power of the lens is approximately

a) 3 D b) 5 D c) 7 D d) 9 D

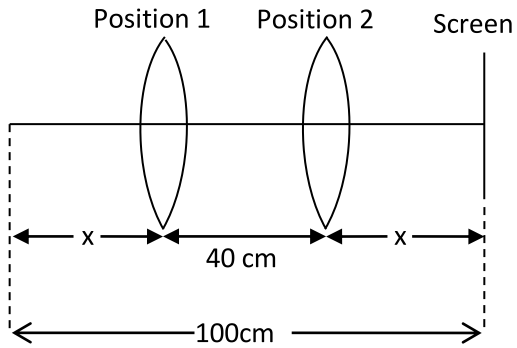
(b)

From the figure ,x + 40 + x = 100

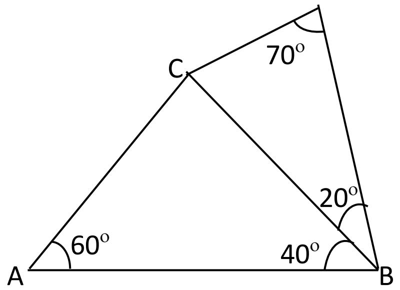
$\Rightarrow$ x = 30 cm

For position 1, u = 30 cm, v = 40 + x = 70 cm

$\therefore P = \frac{1}{v} - \frac{1}{u} = \frac{1}{0.7} - \frac{1}{-0.3} = \frac{1}{0.21} \approx 5D$

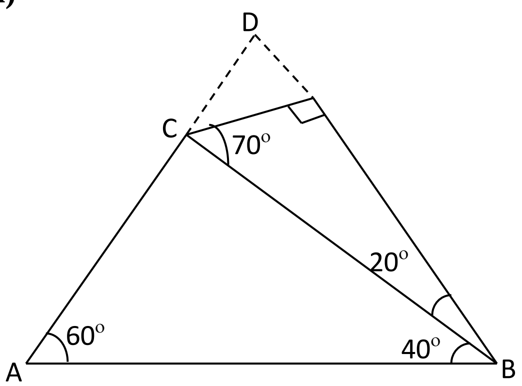


10. Two prisms of same glass ($\mu = \sqrt{3}$) are stuck together without gap as shown. Find the angle of incidence i on the face AC such that the deviation produced by the combination is minimum



a) 60° b) 15° c) 30° d) 45°

(a)



On projecting lines upwards, we find that an equilateral prism is formed. For minimum devitation, r = A/2 = 30°. $\Rightarrow$ sin i=n sin r = $\sqrt{3}$ sin 30° = $\sqrt{3/2}$

$\therefore$ i= 60°

11. A compound microscope has a magnification of 30. The focal length of the eyepiece is 5 cm. If the final image is formed at the least distance of vision (25 cm), the magnification produced by the objective is

a) 5 b) 7.5 c) 10 d) 6

(a)

For the image at D = 25 cm,

$m = m_0 m_e = m_0\left(1 + \frac{D}{f_e}\right) \Rightarrow 30 = m_0\left(1 + \frac{25}{5}\right)$

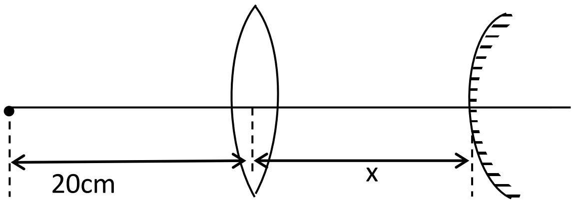
$\therefore m_0 = 5$

12. A point object O is placed at a distance of 20 cm from a convex lens of focal length 10 cm as shown in fig. At what distance x from the lens should a convex mirror of focal length 60 cm, be placed so that final image coincides with the object?

a) 10 cm

b) 40 cm

c) 20 cm



d) final image can never coincide with the object in the given conditions.

(c)

If the image of the object placed at 2 f = 20 cm is formed at the pole of convex mirror, i.e., at x = 20 cm, the final image shall coincide with the object.

13. A girl stands between two plane mirrors facing each other and inclined to each other at 50°. The number of images that she can see is

a) 5 b) 8 c) 6 d) 7

(c)

Let $m = \frac{360}{\theta}$

$\theta = 50^o$, then $m = \frac{360}{50} = 7.2$

If m is fraction, then n is integer next to higher to m – 1

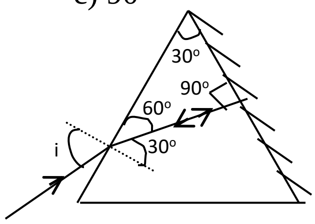
$\therefore n = m - 1 = 7.2 - 1 = 6.2$

$\therefore n \cong 6$

14. One face of prism of refracting angle 30° and refractive index 1.414 is silvered. At what angle must a ray of light fall on the unsilvered face so that after refraction into the prism and reflection at the silvered surface it retraces its path?

a) 45° b) 30° c) 90° d) 0°

(a)



$n = \frac{\sin i}{\sin r} = \frac{\sin i}{\sin 30}$

$\text{Sin}i = n \times \sin 30^o = \sqrt{2} \times \frac{1}{2} = \frac{1}{\sqrt{2}}$

$\Rightarrow i = 45^o$

15. A point source of light is placed at a distance 2f form a converging lens of focal length f. The intensity on the other side of the lens is maximum at a distance

a) f b) between f and 2f

c) 2f d) beyond 2f.

(c)

Intensity of light is maximum at the point of convergence, i.e. at the position of image.

Object distance u = -2f.

From lens formula, $\frac{1}{f} = -\frac{1}{u} + \frac{1}{v} \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{f} - \frac{1}{2f} \Rightarrow v = 2f.$

$\therefore$ Intensity is maximum at a distance of 2f from the lens.

16. A lens placed between a lamp and screen, which are 60cm apart. The image formed on the screen is four times as large as the lamp. The distance between the lens and lamp is

a) 10cm b) 12cm c) 16cm d) 20cm

(b)

Magnification m = 4 $\Rightarrow$ Image distance v = 4u ($\because$ m = v/u)

Distance between the screen and lamp = u + v = 60cm.

i. e, 4u + u = 60 $\Rightarrow$ u = 12cm.

17. A film of area $25cm^2$ is projected on a screen using a projector. If linear magnification is 4 times then area of the image on the screen is

a) $100cm^2$ b) $200cm^2$

c) $1600cm^2$ d) $400cm^2$

(d)

Linear magnification m = 4.

Areal magnification $A = m^2 = 16$.

But areal magnification $A = \frac{\text{Area of the image}}{\text{Area of the object}} = \frac{A_I}{25}$.

$\therefore$ Area of the image $A_I = A(25) = 16 \times 25 = 400cm^2$

18. The length of an astronomical telescope in normal adjustment is 100cm. If the focal length of the eyepiece is 10cm, the magnifying power is

a) 100 b) 1.5 c) 1000 d) 9.0

(d)

Length of the telescope in normal adjustment $f_e + f_o = 100cm$.

Focal length of the eyepiece f_e = 10cm.

Focal length of the objective $f_o = 100 - f_e = 100 - 10 = 90cm$

Magnifying power $m = \frac{f_o}{f_e} = \frac{90}{10} = 9$

19. In a compound microscope, the magnification produced by the objective is 3. If focal length of the eyepiece is 10cm, the magnifying power of the microscope is

a) 3.5 b) 6.5 c) 10.5 d) 30

(c)

Magnification produced by a compound microscope is

$$m = \frac{v}{u}\left(1 + \frac{D}{f_e}\right) = m_o\left(1 + \frac{D}{f_e}\right) = 3\left(1 + \frac{25}{10}\right) = 10.5$$

20. A convex mirror of focal length f produces an image (1/n)th of the size of the object. The distance of the object from the mirror is

a) (n-1)f b) f/n c) (n+1)f d) nf

(a)

$m = \frac{1}{n} = \frac{-v}{(-u)} \Rightarrow v = \frac{u}{n}$

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

$\therefore \frac{n}{u} - \frac{1}{u} = \frac{1}{f}$

u = (n-1) f

21. Light takes time t_1 second to travel a distance x in vacuum and the same light takes t_2 second to travel 10 cm in a medium. Critical angle for corresponding medium will be

a) $\sin^{-1}\left(\frac{10t_2}{t_1 x}\right)$ b) $\sin^{-1}\left(\frac{t_2 x}{10t_1}\right)$

c) $\sin^{-1}\left(\frac{10t_1}{t_2 x}\right)$ d) $\sin^{-1}\left(\frac{t_1 x}{10t_2}\right)$

(c)

$c = \frac{x}{t_1}, v = \frac{10}{t_2}$

$\sin i_c = \frac{1}{\mu} = \frac{v}{c} = \frac{10}{t_2} x \frac{t_1}{x}; i_c = \sin^{-1}\left(\frac{10t_1}{t_2 x}\right)$

22. The focal lengths of objective and eye lens of an astronomical telescope are respectively 2 metre and 5 cm. Final image is formed at (i) least distance of district vision (ii) infinity. Magnifying power in two cases will be

a) -48, -40 b) -40, -48 c) -40, +48 d) -48, +40

(a)

(i) $M = -\frac{f_0}{f_e}\left(1+\frac{f_e}{d}\right) = -\frac{200}{5}\left(1+\frac{5}{25}\right) = -48$ (since least distance d = 25 cm)

(ii) $M = -\frac{f_0}{f_e} = -\frac{200}{5} = -40$

23. An object is placed at a distance 2f from the pole of a convex mirror of focal length f. The linear magnification is

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

(a)

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

$\therefore\ m = \frac{v}{u} = \frac{2}{3}\frac{f}{2f} = \frac{1}{3}$

24. A man's near point is 0.5 m and far point is 3 m. Power of spectacle lenses required for (i) reading purposes, (ii) seeing distant objects, respectively, are

a) -2 D and + 3D b) +2 D and –3 D
c) +2 D and - 0.33 D d) -2 D and +0.33 D

(c)

For reading purpose : u = -25 cm, v = -50 cm, f=?

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = -\frac{1}{50} + \frac{1}{25} = \frac{1}{50}$; $P = \frac{100}{f} = +2D$

For distant vision, f'= distance of far point = -3 m

$P = \frac{1}{f'} = -\frac{1}{3}D = -0.33D$

25. A vessel is half filled with a liquid of refractive index μ. The other half of the vessel is filled with an immiscible liquid of refractive index 1.5 μ. The apparent depth of the vessel image is 50% of the actual depth. Then μ is

a) 1.4 b) 1.5 c) 1.55 d) 1.67

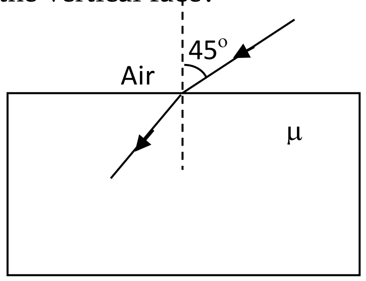
(d)

Let d be the depth of two liquids. The apparent depth $\frac{t_1}{n_1} + \frac{t_2}{n_2} = \frac{d}{2}$

$\frac{(d/2)}{\mu} + \frac{(d/2)}{1.5\mu} = \frac{d}{2}$ or $\frac{1}{\mu} + \frac{2}{3\mu} = 1$

Solving we get μ = 1.671

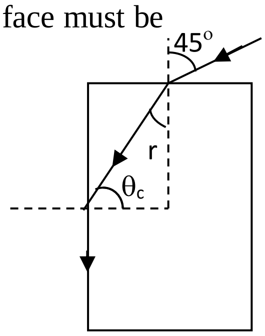
26. In fig. for an angle of incidence of 45° at the top surface, what is the minimum refractive index for total internal reflection at the vertical face?



a) $\frac{\sqrt{2}+1}{2}$ b) $\sqrt{3/2}$ c) $\sqrt{1/2}$ d) $\sqrt{2}+1$

(b)

For the minimum refractive index, the incident angle at the vertical face must be critical angle θ_c



Now, $\dfrac{\sin 45^\circ}{\sin r} = \mu$ and $r + \theta_c = 90^\circ$

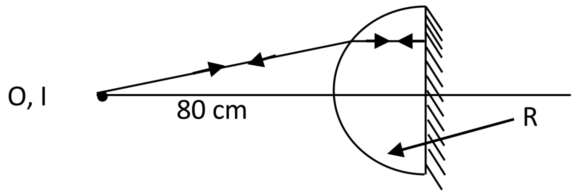
$\Rightarrow \sin r = \dfrac{1}{\sqrt{2}\,\mu}$ and $\cos r = \sin \theta_c = \dfrac{1}{\mu}$

$\Rightarrow \left(\dfrac{1}{\sqrt{2}\,\mu}\right)^2 + \left(\dfrac{1}{\mu}\right)^2 = 1 \quad \therefore \ \mu = \sqrt{3/2}$

27. When a thin planoconvex lens (μ=1.5) polished from its plane surface behave like a concave mirror of focal length 40 cm. The radius of curvature of the lens is

a) 10 cm b) 20 cm c) 30 cm d) 40 cm

(d)



When plane surface of the plano convex lens is silvered, new focal length f' = f/2

Focal length of the lens f = 2f' = 80 cm

Focal length of planoconvex lens $f = \dfrac{R}{n-1}$

R = f (n -1) = 80 (0.5) = 40 cm

28. A point object O is placed on the principal axis of a convex lens of f = 20cm at a distance of 40cm to the left of it. The diameter of the lens is 10cm. An eye is placed 60cm to the right of the lens and a distance h below the principal axis. The maximum value of h to see the image is

a) 0 b) 2.5cm c) 5cm d) 10cm

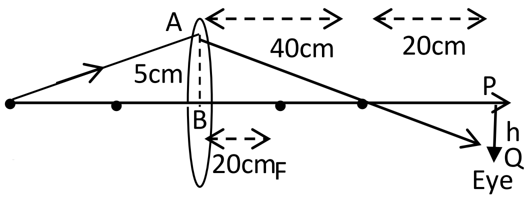
(b)

u = -40cm, f = +20cm

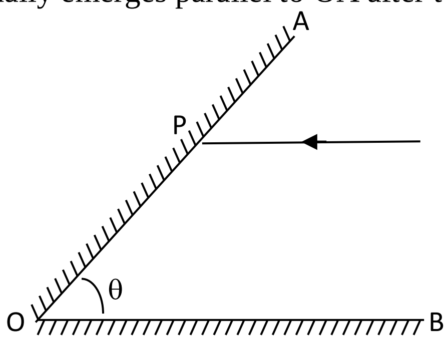
Object distance is twice the focal length. There fore image distance v = 2f = 40cm.

From the similar triangles ABI and PQI,

$\dfrac{PQ}{AB} = \dfrac{PI}{BI}$ i. e, $\dfrac{h}{5} = \dfrac{20}{40} \Rightarrow h = 2.5\text{cm}$

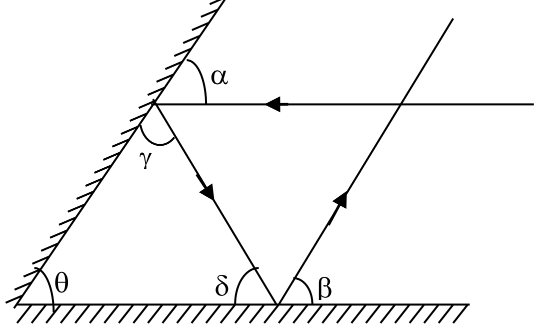


29. Two plane mirrors are inclined at angle θ as shown in fig. If a ray parallel to OB strikes the other mirror at P and finally emerges parallel to OA after two reflection, then θ is equal to



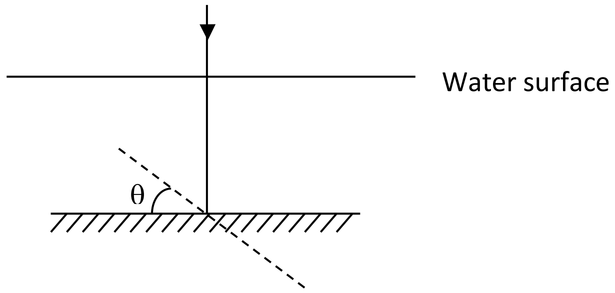
a) 90°
b) 60°
c) 45°
d) 30°

(a)



Since, the incident and emerget rays are parallel to the mirrors, we have $\alpha = \beta = \theta$.
By law of reflection, $r = \alpha = \theta$ and $\delta = \beta = \theta$. As $\theta + r + \delta = 180^o$, we have $3\theta = 180^o$
$\therefore\ \theta = 60^o$

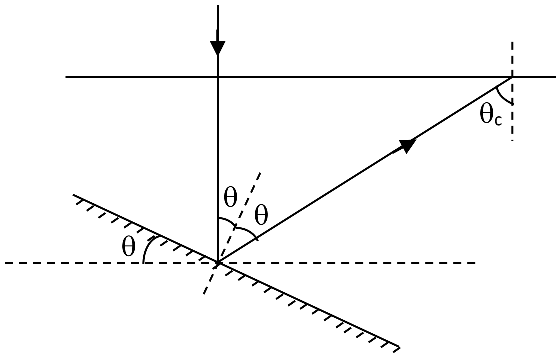
30. A plane mirror is placed horizontally inside water ($\mu = 4/3$). A ray falls normally on it. The mirror is rotated by angle θ such that after reflection, the ray does not come out of water. The minimum value of θ is



a) $\frac{\pi}{4}$ b) $\sin^{-1}\left(\frac{3}{4}\right)$

c) $\frac{1}{2}\sin^{-1}\left(\frac{3}{4}\right)$ d) $2\sin^{-1}\left(\frac{3}{4}\right)$

(c)



For the ray not to come out of water, the minimum value of θ should be such that

$2\theta = \theta_c = \sin^{-}\left(\frac{1}{\mu}\right)$ $\therefore\ \theta = \frac{1}{2}\sin^{-1}\left(\frac{3}{4}\right)$

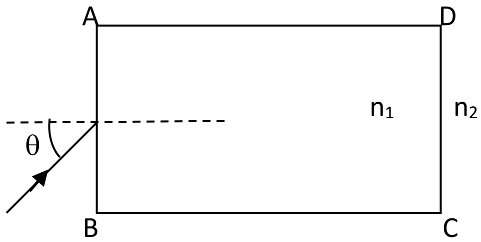
31. A rectangular glass slab ABCD of refractive index n_1 is immersed in water of refractive index n_2 ($n_1 > n_2$). A ray of light is incident at the surface AB of the slab as shown. The maximum value of the angle of incidence θ, such that the ray comes out only from the outer surface CD is given by

a) $\sin^{-1}\left(\sqrt{\frac{n_1^2 - n_2^2}{n_2}}\right)$

b) $\sin^{-1}\left(\frac{n_1}{n_2}\right)$

c) $\sin^{-1}\left(\sqrt{\frac{n_1^2 - n_2^2}{n_1}}\right)$

d) $\sin^{-1}\left(\frac{n_2}{n_1}\right)$



(a)

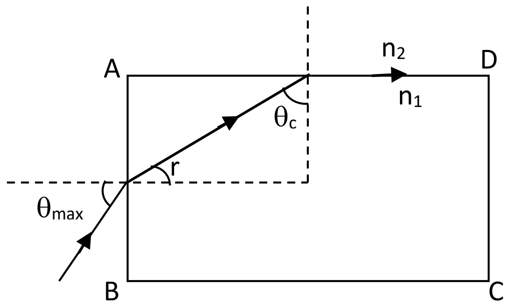
For the maximum value of θ, the angle of incidence on face AD is the critical angle θ_c.
For refraction through AB,

$\frac{\sin\theta_{max}}{\sin r} = \frac{n_1}{n_2}$ and $r = \theta_c = 90^o$

$\Rightarrow \sin r = \frac{n_2}{n_1}\sin\theta_{max}$

For refraction through AD,

$\cos r = \sin\theta_c = \frac{n_2}{n_1}$ $|\ \theta_c = 90 - r$

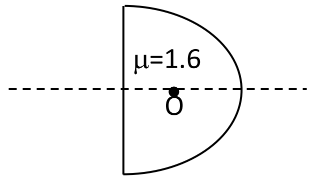


$\sin^2 r + \cos^2 r = 1 \quad \Rightarrow \left(\frac{n_2}{n_1}\sin\theta_{max}\right)^2 + \left(\frac{n_2}{n_1}\right)^2 = 1 \Rightarrow \sin^2\theta_{max} = \left(\frac{n_1}{n_2}\right)^2 - 1$

$\therefore\ \theta_{max} = \sin^{-1}\left(\frac{\sqrt{n_1^2 - n_2^2}}{n_2}\right)$

32. A plastic hemisphere has a radius of curvature of 8 cm and refractive index of 1.6. On the axis halfway between the plane surface and the spherical one (4 cm from each) is a small object O. The distance between the two images when viewed along the axis from the two sides of the hemisphere is approximately

a) 1.0 cm b) 1.5 cm
c) 3.75 cm d) 2.5 cm



(d)

The image of O when viewed from left is at a distance $\frac{4\,cm}{\mu} = \frac{4\,cm}{1.6} = 2.5\,cm$ from the flat surface.

When viewed from right, the distance |v| from curved surface is given by $\frac{1}{v} - \frac{1.6}{-4} = \frac{1-1.6}{-8}$.

$\Rightarrow v = -40/13$ cm $\quad \Rightarrow |v| \approx 3$ cm

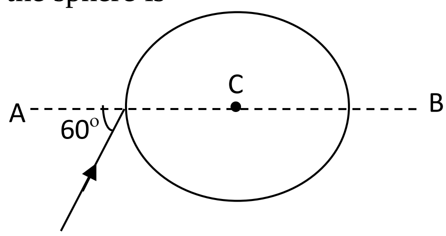
The distance of this image from flat surface is 8 – 3= 5 cm.

The distance between the two images is approximately = 5 - 2.5 = 2.5 cm.

33. A ray of light falls on a transparent sphere with centre at C as shown in fig. The ray emerges from the sphere parallel to line AB. The refractive index of the sphere is

a) $\sqrt{2}$ b) $\sqrt{3}$

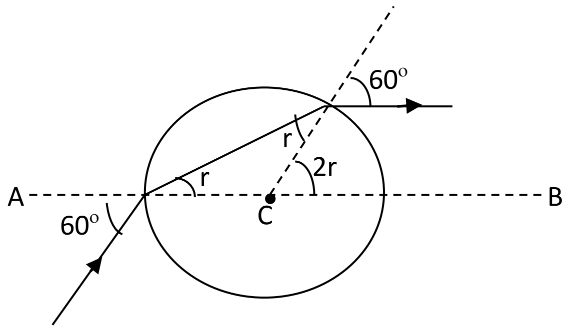
c) 3/2 d) 2



(b)

We can see from fig. that if the emergent ray is parallel to AB, then 2 r = 60°

$\Rightarrow r = 30^o \therefore\ \mu = \frac{\sin 60^o}{\sin 30^o} = \sqrt{3}$



34. A short linear object of length b lies along the axis of a concave mirror of focal length f at a distance u from the pole of the mirror. The size of the image is approximately equal to

a) $b\left(\frac{u-f}{f}\right)^{1/2}$ b) $b\left(\frac{f}{u-f}\right)^{1/2}$ c) $b\left(\frac{u-f}{f}\right)$ d) $b\left(\frac{f}{u-f}\right)^2$

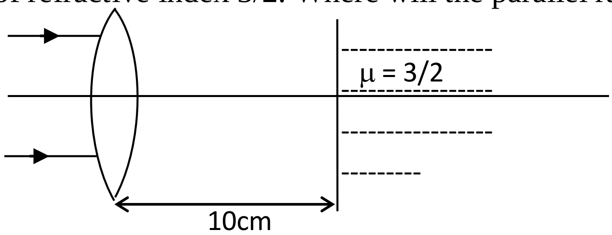
(d)

Differentaining the mirror equation $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$, we get $-\frac{du}{u^2} - \frac{dv}{v^2} = 0$

$\Rightarrow \frac{dv}{du} = -\left(\frac{v}{u}\right)^2$ when, $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{u-f}{uf} \Rightarrow \frac{dv}{du} = -\left(\frac{f}{u-f}\right)^2$

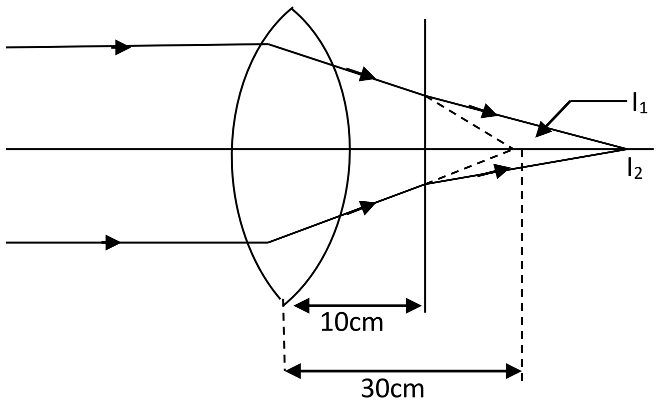
The size of image is therefore, $|dv| = \left| \left(\frac{f}{u-f}\right)^2 du \right| = b\left(\frac{f}{u-f}\right)^2$

35. Focal length of a thin convex lens is 30 cm. At a distance of 10 cm from the lens, there us a plane refracting surface of refractive index 3/2. Where will the parallel rays incident on lens converge?



a) At a distance of 27.5 cm from the lens
b) At a distance of 25 cm from the lens
c) At a distance of 45 cm from the lens
d) At a distance of 40 cm from the lens

(d)

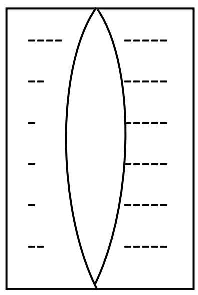


The image I_1 of parallel rays by lens is at a distance f = 30 cm from the plane refracting surface. The distance v from the refracting surface of image I_2 is given by $-\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$

$\frac{3/2}{v} - \frac{1}{20} = \frac{3/2 - 1}{\infty}$ $\Rightarrow$ v = 30 cm

36. As shown in fig. a convergent lens is placed inside a cell filled with liquid. The lens has focal length +20 cm when in air and its material has refractive index 1.50. If the liquid has refractive index 1.60, the focal length of the system is

a) + 80 cm
b) – 80 cm
c) – 24 cm
d) – 100 cm



(d)

Let the radius of left and right side of the lens be R_1 and R_2 respectively. Then, for the lens in air, we have $\frac{1}{20} = (1.5-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10}\text{cm}^{-1}$

The focal lengths of the two lenses formed by liquid on the left and right side are respectively given by

$\frac{1}{f_1} = (1.6-1)\left(\frac{1}{\infty} - \frac{1}{R_1}\right) = \frac{0.6}{R_1}$

And $\frac{1}{f_2} = (1.6-1)\left(\frac{1}{-R_2} - \frac{1}{\infty}\right) = \frac{-0.6}{R_2}$

The combined focal length f of the system is given by

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{20} + \frac{1}{f_2} + \frac{1}{20} - 0.6\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{1}{20} - 0.6 \times \frac{1}{10} = -\frac{1}{100}$

$\therefore$ f = - 100 cm

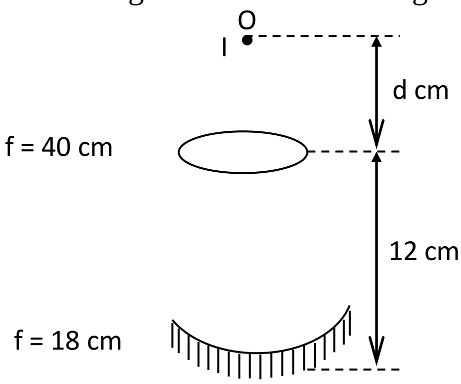
37. A convex lens of focal length 40 cm is held coaxially above a concave mirror of focal length 18 cm. A luminous point object placed d cm above the lens on its axis gives rise to final image coincident with itself. Then d is equal to

a) 15

b) 18

c) 24

d) 30

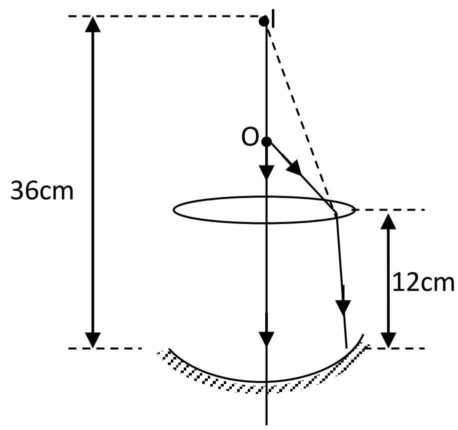


(a)

For the final image to be coincident with the object itself, the rays must retrace their path. So, the image due to convex lens must be formed at distance 2 f = 2 × 18 =36 cm from the concave mirror, i.e., at a distance 36 - 12=24 cm from the lens and above the lens.

For refraction by lens, we have u= -d, v= -24 cm, f = 40 cm

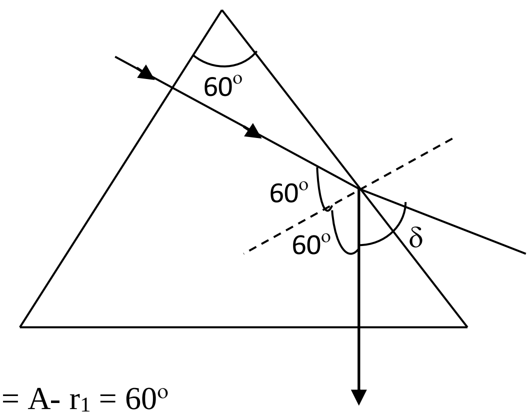
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-24} - \frac{1}{-d} = \frac{1}{40}$ $\therefore$ d = 15 cm



38. An equilateral triangular prism is made of glass (μ = 1.5). A ray of light is incident normally on one of the faces. The angle between the incident and emergent ray is

a) 60° b) 90° c) 120° d) 180°

(a)

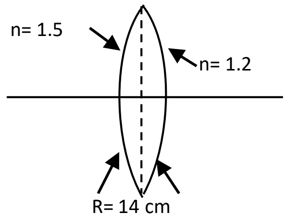


Here, A = 60°, r_1 = 0°, r_2 = A- r_1 = 60°

$\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right) = \sin^{-1}\left(\frac{2}{3}\right)$

As $r_2 > \theta_c$, there is a total internal reflection on the second face. The emergent ray comes out normally from the base. The angle between the incident and emergent rays is δ = 180° - (60°+ 60°)= 60°

39. A bi-convex lens is formed with two thin plano-convex lenses as shown in fig. Refractive index n of the first lens is 1.5 and that of the second lens is 1.2. Both the curved surfaces are of the same radius of curvature R=14 cm. For this bi-convex lens, for an object distance of 40 cm, the image distance will be



a) – 280.0 cm

b) 40.0 cm

c) 21.5 cm

d) 13.3 cm

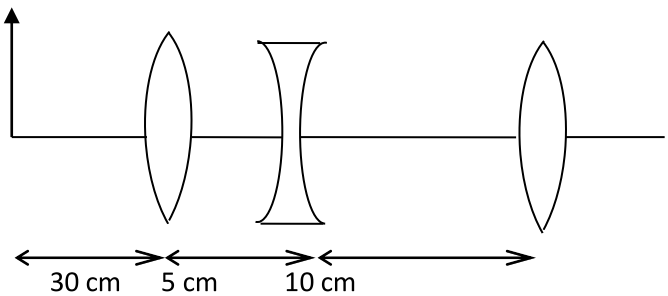
(b)

The focal length of the combined lens is given by $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}=(1.5-1)\left(\frac{1}{14}-\frac{1}{\infty}\right)+(1.2-1)\left(\frac{1}{\infty}-\frac{1}{-14}\right)$

$=\frac{1}{20} \Rightarrow f = 20\text{ cm} \Rightarrow \frac{1}{v}=\frac{1}{u}+\frac{1}{f}=\frac{1}{-40}+\frac{1}{20}=\frac{1}{40}$

$\therefore$ v = 40.0 cm

40. The position of final image formed by the given lens combination from the third lens will be at a distance of (f_1=+ 10 cm, f_2 = - 10 cm and f_3 = + 30 cm).



a) 15 cm b) infinity c) 45 cm d) 30 cm

(d)

For 1st lens, u_1 = -30, f_1= + 10cm,

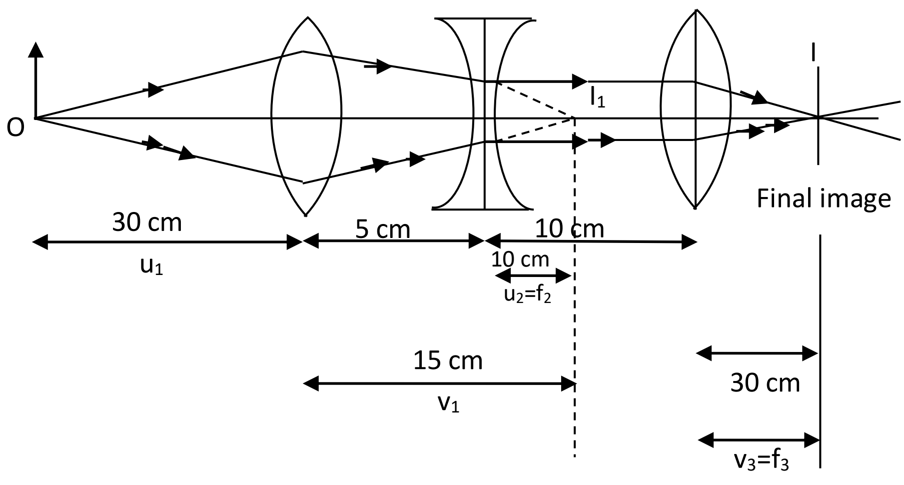
Formula of lens, $\frac{1}{v_1}+\frac{1}{30}=\frac{1}{10}$

Or v_1 = 15 cm at I_1 behind the lens.

The image I_1 serves as virtual object for concave lens. For second lens, which is concave, u_2 = (15-5) =10 cm. I_1 acts as object. f_2 = -10 cm.

The rays will emerge parallel to axis as the virtual object is at focus of concave lens, as shown in the figure. Image of I_1 will be at infinity. These parallel rays are incident on the third lens viz the convex lens, f_3 = + 30 cm. These parallel rays will be brought to convergence at the focus of the third lens.

$\therefore$ image distance from third lens v_3= f_3 = 30 cm



41. One face of rectangular glass plate 6 cm thick is silvered. An object held 8 cm in front of the first face, forms an image 12 cm behind the silvered face. The refractive index of the glass is

a) 0.4 b) 0.8 c) 1.2 d) 1.6

(c)

Thickness of glass plate (t) = 6 cm;

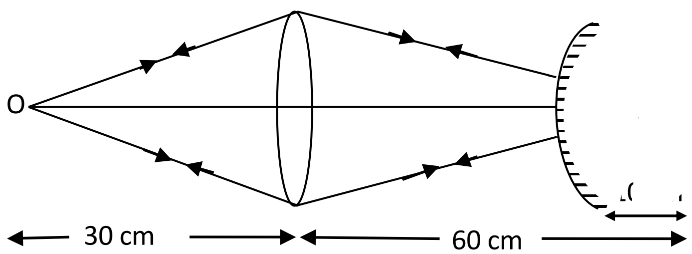
Distance of the object (u) = 8 cm and distance of the image (v) = 12 cm. Let x = Apparent position of the silvered surface in cm. Since the image is formed due to reflection at the silvered face and by the property of mirror image distance of object from the mirror = Distance of image from the mirror or x+8=12+6-x or x= 5 cm.

Therefore refractive index of glass = $\frac{\text{Real depth}}{\text{Apparent depth}} = \frac{6}{5} = 1.2$

42. A luminous object is placed at a distance of 30 cm from the convex lens of focal length 20 cm. On the other side of the lens, at what distance from the lens a convex mirror of radius of curvature 10 cm be placed in order to have an upright image of the object coincident with it?

a) 12 cm b) 30 cm c) 50 cm d) 60 cm

(c)



$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$; $\frac{1}{v} - \frac{1}{-30} = \frac{1}{20} \Rightarrow v = 60\,\text{cm}$

Coincidence is possible when the image is formed at the centre of curvature of the mirror. Only then the rays refracting through the lens will fall normally on the convex mirror and retrace their path to form the image at O. So the distance between lens and mirror = 60-10 = 50 cm.

43. The radius of curvature of a thin plano-convex lens is 10 cm (of curved surface) and the refractive index is 1.5. If the plane surface is silvered, then it behaves like a concave mirror of focal length

a) 10 cm b) 15 cm c) 20 cm d) 5 cm

(a)

f = R/(n - 1) = 10/0.5 = 20 cm.

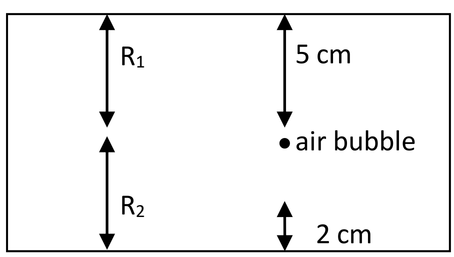
When plane surface is silvered f' = f/2 = 20/2 = 10 cm

44. An air bubble in a glass slab (μ = 1.5) is 5 cm deep when viewed from one face and 2 cm deep when viewed from the opposite face. The thickness of the slab is

a) 7.5 cm b) 10.5 cm c) 7 cm d) 10 cm

(b)

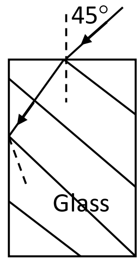
$1.5 = \frac{\text{Real depth }(R_1)}{\text{Apparent depth (5cm)}}$ $\therefore$ R_1 = 1.5x5=7.5 cm



For opposite face, $1.5 = \frac{R_2}{2} \Rightarrow R_2 = 3.0\,\text{cm}$

$\therefore$ Thickness of the slab = $R_1 + R_2$ = 7.5+3
= 10.5 cm

45. A light ray falls on a rectangular glass slab as shown. The index of refraction of the glass, if total internal reflection is to occur at the vertical face, is

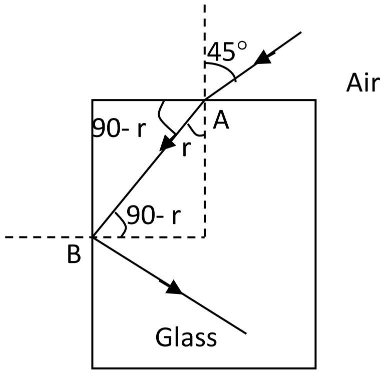


a) $\sqrt{3/2}$ b) $\frac{(\sqrt{3}+1)}{2}$

c) $\frac{(\sqrt{2}+1)}{2}$ d) $\sqrt{5}/2$

(a)

For point A, ${}_a\mu_g = \frac{\sin 45}{\sin r} \Rightarrow \sin r = \frac{1}{\sqrt{2}\ {}_a\mu_g}$



For point B, sin (90-r) = ${}_a\mu_g$

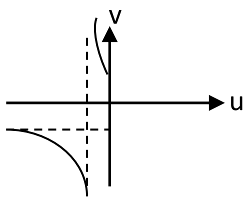
(90-r) is critical angle.

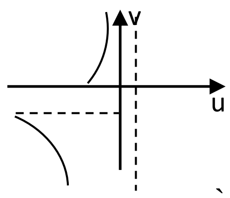
$\therefore$ cos r = ${}_g\mu_a = \frac{1}{{}_a\mu_g}$

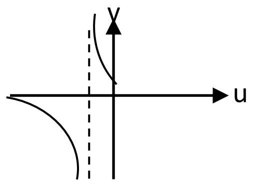
$\Rightarrow {}_a\mu_g = \frac{1}{\cos r} = \frac{1}{\sqrt{1-\sin^2 r}} = \frac{1}{\sqrt{1-\frac{1}{2\ {}_a\mu_g^{\ 2}}}}$

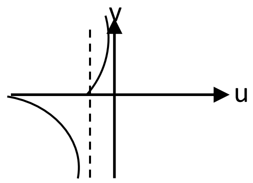
${}_a\mu_g^{\ 2} = \frac{1}{1-\frac{1}{2\ {}_a\mu_g^2}} = \frac{2\ {}_a\mu_g^2}{2\ {}_a\mu_g^2 - 1} \Rightarrow 2\ {}_a\mu_g^{\ 2}$ -1=2 $\Rightarrow {}_a\mu_g = \sqrt{\frac{3}{2}}$

46. As the position of an object (u) reflected from a concave mirror is varied, the position of the image (v) also varies. By letting u change from - ∞ to 0, the graph between v versus u will be

a)


b)


c)


d)


(a)

As u $\to$ -∞, v $\to$ - f

As $u^-\to$ -f, v $\to$ -∞

As $u^+\to$ -f, v $\to$ + ∞

As u $\to$ 0, v $\to$ 0

47. A biconvex lens has a radius of curvature of magnitude 20 cm. Which one of the following options best describe the image formed of an object of height 2 cm placed 30 cm from the lens?

a) Virtual, upright, height = 1 cm

b) Virtual, upright, height = 0.5 cm

c) Real, inverted, height = 4 cm

d) Real, inverted, height = 1 cm

(c)

R = 20 cm, h_0 =2, u=-30 cm

We have, $\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \left(\frac{3}{2}-1\right)\left[\frac{1}{20} - \left(-\frac{1}{20}\right)\right] \Rightarrow \frac{1}{f} = \left(\frac{3}{2}-1\right) x \frac{2}{20}$

$\therefore$ f = 20 cm

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}\Rightarrow\frac{1}{20}=\frac{1}{v}+\frac{1}{30}$$

$$\frac{1}{v}=\frac{1}{20}-\frac{1}{30}=\frac{10}{600}$$

v = 60 cm

$$m=\frac{h_i}{h_0}=\frac{v}{u}\Rightarrow h_i=\frac{v}{u}x\,h_0=\frac{60}{30}x\,2=-4\,cm$$

So, image is inverted.

48. For a given lens, the magnification was found to be twice as large as when the object was shift to next line 0.15 m distant from it as when the distance was 0.2 m. The focal length of the lens is

a) 1.5 m b) 0.20 m c) 0.10 m d) 0.05 m

(c)

When u = 0.2 cm, magnification M = $\frac{v}{u}$ $\therefore$ v = 0.2 M

When u = - 0.15 cm, magnification = 2M = $\frac{V}{0.15}$ $\therefore$ V= 0.3 M

As $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\therefore\ \frac{1}{0.2M}-\frac{1}{-0.2}=\frac{1}{0.3M}-\frac{1}{(-0.15)}=\frac{1}{f}$

Solving we get, magnification M = 1

$\therefore\ \frac{1}{0.2x1}-\frac{1}{-2}=\frac{1}{f}\Rightarrow\quad \frac{1}{f}=\frac{1}{0.2}+\frac{1}{0.2}\Rightarrow$ f = 0.1m

49. An object is placed 1.5 m in front of the curved surface of a plano convex lens whose flat surface is silvered. A real image is formed 300 cm in front of the lens. The focal length of the lens is

a) 100 cm b) 200 cm c) 150 cm d) 300 cm

(b)

If f is the effective focal length of concave mirror formed, then

$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}=\frac{1}{-150}+\frac{1}{-300}=-\frac{1}{100}\Rightarrow$ f = -100 cm

If f_1 is the focal length of lens, then $\frac{1}{f}=-\frac{2}{f_l}+\frac{1}{f_m}\Rightarrow\frac{1}{f_l}=\frac{1}{2}\left(\frac{1}{f_m}-\frac{1}{f}\right)=\frac{1}{2}\left(\frac{1}{\infty}-\frac{1}{-100}\right)$

$\therefore$ f_l = 200 cm

50. An object is placed at a distance of 40 cm in front of a concave mirror of focal length 20 cm. The image produced is

a) real, inverted and smaller in size b) real, inverted and of same size

c) real and erect d) virtual and inverted

(b)

Object distance u = - 40 cm

Focal length f = - 20 cm

According to mirror formula $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ or $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}$ Or $\frac{1}{v}+\frac{1}{-20}-\frac{1}{(-40)}=\frac{1}{-20}+\frac{1}{40}$

$\frac{1}{v}=\frac{-2+1}{40}=-\frac{1}{40}$ or v = - 40 cm.

Negative sign shows that image is in front of concave mirror. The image is real.

Magnification, $m=\frac{-v}{u}=-\frac{(-40)}{(-40)}=-1$

The image is of the same size and inverted.