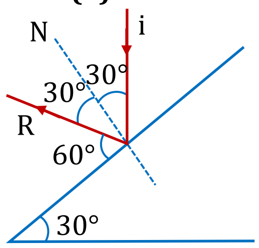
Geometrical Optics

SOLUTIONS

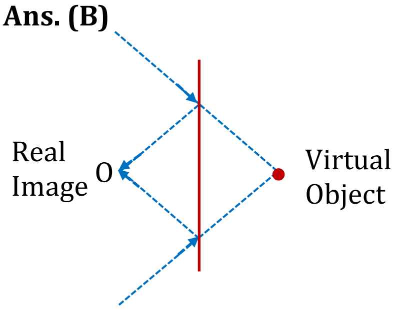
EXERCISE – O

1. **Ans. (C)**



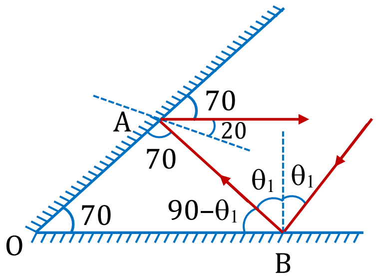
Angle between i and N = 30°
Angle between R and N = 30°
Therefore, the required angle between mirror and reflected ray will be θ = 90 – 30 = 60°.

2. **Ans. (B)**



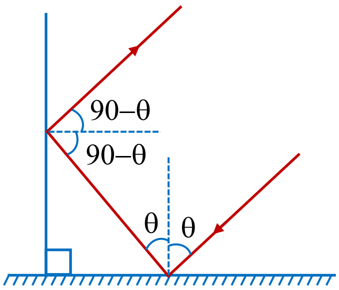
The real image is formed when the beam of rays are convergent.

3. **Ans. (A)**



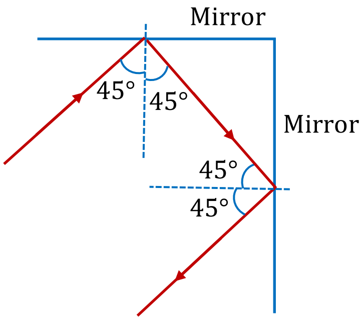
ΔOAB
$70 + 70 + 90 - \theta = 180$
$\theta = 50$

4. **Ans. (D)**



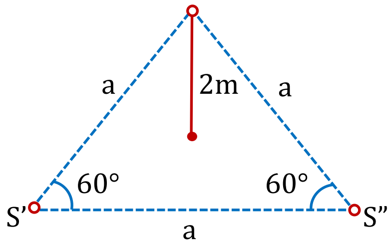
From the ray diagram angle between the mirrors is 90°.

5. **Ans. (B)**



6. **Ans. (A)**

Here $\frac{a}{\sqrt{3}} = 2\ a = 2\sqrt{3}$



Area = $\frac{\sqrt{3}}{4}a^2 = \left(\frac{\sqrt{3}}{4}\right)\left(2\sqrt{3}\right)^2 = \left(\frac{\sqrt{3}}{4}\right)(4\times3) = 3\sqrt{3}m^2$

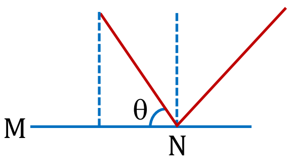
7. **Ans. (A)**

Angle of incidence is 70°, $\delta = \pi - 2i = 180° - 2 \times 70° = 40°$

8. **Ans. (D)**

There are only 2 reflection if $\alpha > 60°$.

9. **Ans. (C)**



$\tan\theta = \frac{10}{10/\sqrt{3}}$; $\theta = 60°$. If $\theta < 60°$, the ray will not strike the PQ.

10. **Ans. (A)**

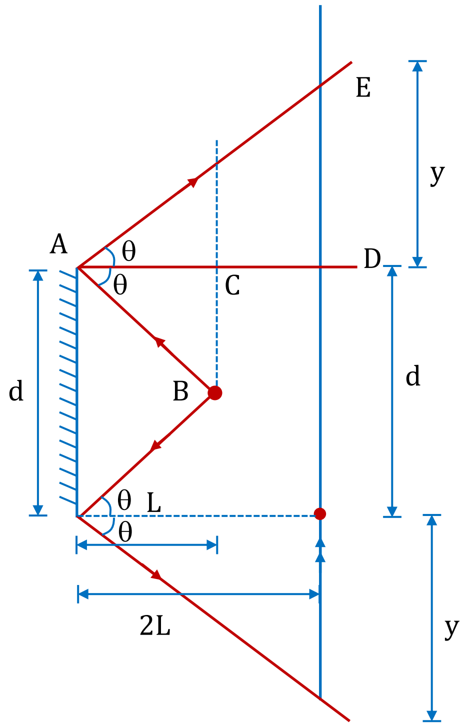
$\cos(\pi - 2i) = \left(\frac{\hat{i}}{2} + \frac{\sqrt{3}}{2}\hat{j}\right) \cdot \left(\frac{\hat{i}}{2} - \frac{\sqrt{3}}{2}\hat{j}\right)$

$\therefore \quad i = 30°$

11. **Ans. (A)**

Both the rays should have common normal which is only in case *I*.

12. Ans. (D)



In ΔABC $\tan\theta = \frac{BC}{AC} = \frac{d}{2L}$ ... (1)

In ΔADE $\tan\theta = \frac{DE}{AD} = \frac{y}{2L}$ ... (2)

eq^n (1) & eq^n (2)

$$\frac{d}{2L} = \frac{y}{2L}$$

$$y = d$$

Hence, greatest distance over which he can see the image of the light source in the mirror is

$$d + 2y = 3d.$$

13. Ans. (C)

The wall will act as two mirrors inclined to each other at 90° and so will form $\frac{360}{90°} - 1 = 3$ images of the person.

Three images by walls now these images with object will act as objects for the ceiling mirror and so ceiling will form 4 images. Hence total no of images formed 3 + 4 = 7.

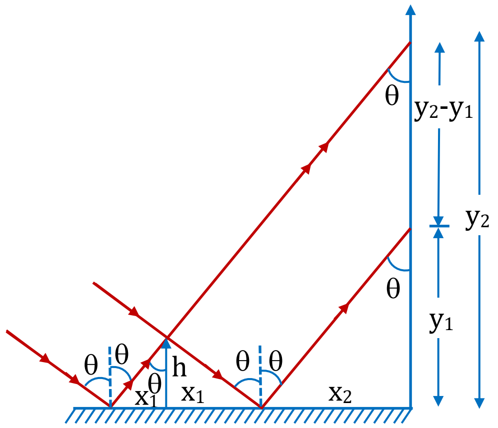
14. Ans. (D)

When an object is placed in between two parallel mirror, the number of images formed is infinite.

15. Ans. (B)

No ray undergoes more than one reflection

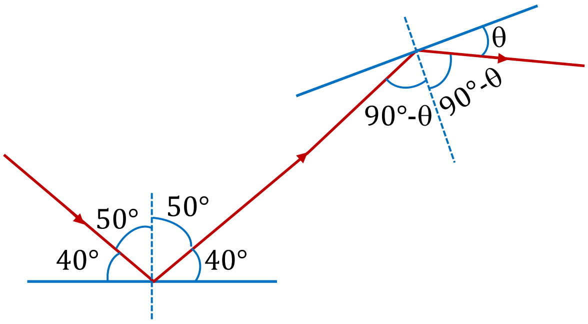
16. Ans. (B)



$$\tan\theta = \frac{x_1}{h} = \frac{x_2}{y_1} = \frac{2x_1 + x_2}{y_2}$$

$$\Rightarrow x_2 = \frac{y_1}{h}x_1 \quad \Rightarrow \quad \frac{2x_1 + \frac{y_1}{h}x_1}{y_2} = \frac{x_1}{h} \quad \Rightarrow \quad 2 + \frac{y_1}{h} = \frac{y_2}{h} \Rightarrow y_2 - y_1 = 2h$$

17. Ans. (A)



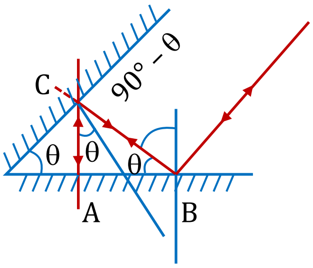
$180-2(90-\theta)=40^{\circ}$

$2\theta=40^{\circ} \Rightarrow \theta=20^{\circ}$

5 clockwise rotation.

18. Ans. (B)

After second reflection reflected ray should fall normal on other mirror.

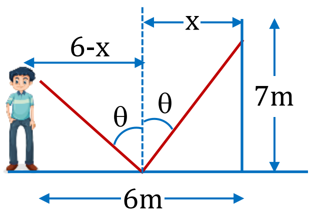


In ΔABC

$\theta + \theta + \theta + 90° = 180°$

$\theta = 30°$

19. Ans. (B)



$\dfrac{6-x}{x}=\dfrac{1.75}{7} \Rightarrow x=4.8m$

20. Ans. (A)

No, if Images $=\dfrac{360}{\theta}-1$

$=\dfrac{360}{60}-1$

$= 6 - 1$

$= 5$

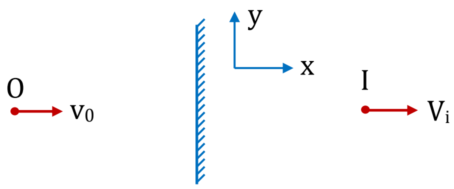
21. Ans. (C)

$\vec{v}_o = 10\hat{\imath}, \vec{v}_i = 6\hat{\imath}$

Here $\vec{v}_{im} = -\vec{v}_{om}$

$\Rightarrow \vec{v}_i - \vec{v}_m = -(\vec{v}_o - \vec{v}_m)$

$\Rightarrow \vec{v}_m = \dfrac{\vec{v}_i+\vec{v}_o}{2} = \dfrac{10\hat{\imath}+6\hat{\imath}}{2} = 8\hat{\imath}$



22. **Ans. (B)**

In direction perpendicular to mirror $V_I - V_M = -[V_0 - V_M]$ $V_I = 2V_M - V_0 = 2 \times 1 - 2 = 0$

In direction parallel to mirror $V_I = V_0$

23. **Ans. (A)**

$\hat{v}_B = -\hat{v}_{IA}$

$(v_{IA})_B = v_{IA} - v_B$

$= |v_A|\hat{v}_{IA} - |v_B|\hat{v}_B$

$= |v_A|\hat{v}_{IA} + |v_B|\hat{v}_{IA}$

$= [|v_A| + |v_B|]\hat{v}_{IA}$

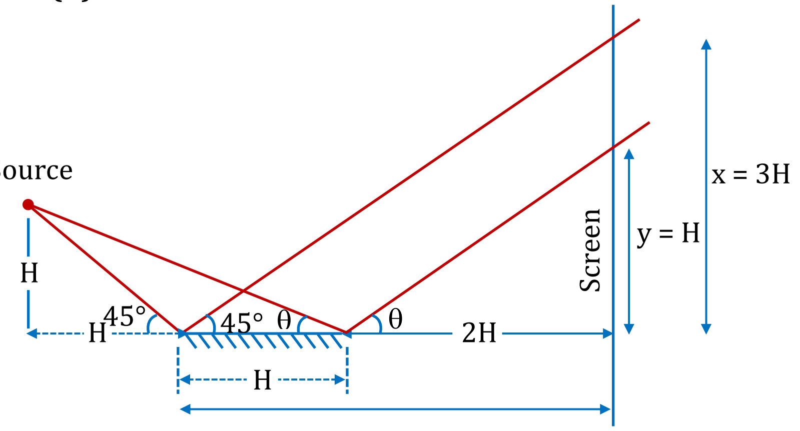
$(v_{IA})_B = |v_A| + |v_B|$

$= v_A + v_B$

24. **Ans. (A)**

Minimum length of mirror $= \frac{H}{2} = \frac{1.8}{2} = 0.9m$

25. **Ans. (A)**

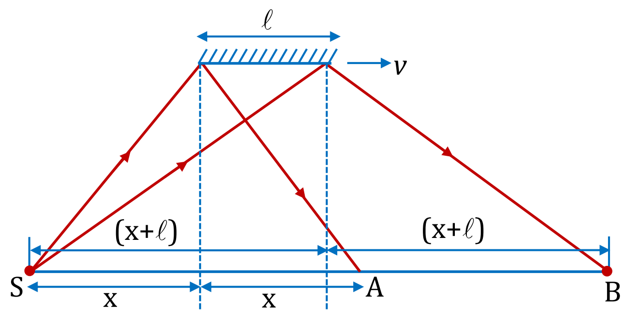


$\tan\theta = \frac{H}{2H} = \frac{y}{2H} \Rightarrow y = H$

$\tan 45° = \frac{H}{H} = \frac{x}{3H} \Rightarrow x = 3H$

the length of the screen that will receive reflected light from the mirror is $= 3H - H = 2H$

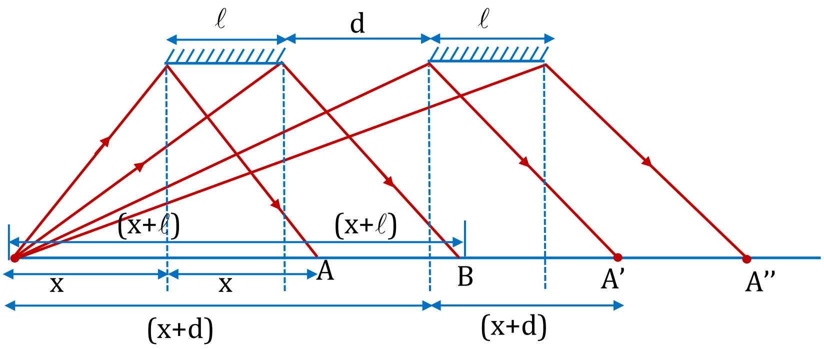
26. **Ans. (C)**



$SA = 2x$, $SB = 2(x + \ell)$

$AB = SB - SA = 2\ell$

Length of the patch will be $= 2\ell$



$SA = 2x$

$SA' = 2(x + d)$

$SA' - SA = 2(x + d) - 2x = 2d$

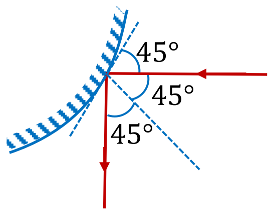
So if plane mirror is moved then patch will move $2d$ in same time so velocity of patch will be 2v if velocity of mirror is v.

27. Ans. (D)

Since the incident ray is between focus and pole, reflected ray will be '4'.

28. Ans. (C)

$$\frac{dy}{dx} = 2x = (2)\left(\frac{1}{2}\right) = 1$$



$\Rightarrow$ Tangent at given point makes angle 45° with x-axis.

$\Rightarrow$ Angle of reflection = 45°.

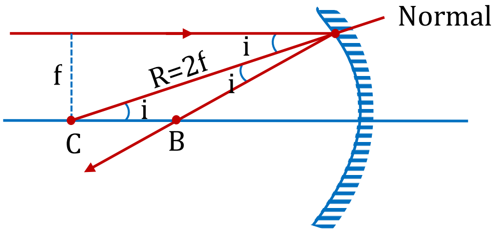
29. Ans. (A)

$\sin i = \frac{f}{R} = \frac{1}{2}; i = 30°$

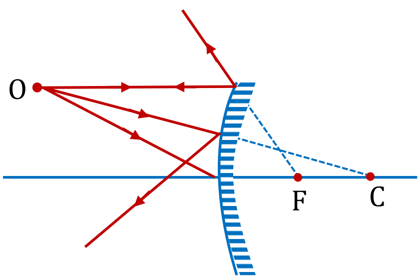
Not a paraxial ray

$$CB = \frac{R}{2\cos i} = \frac{f}{(\sqrt{3}/2)} = f\left(\frac{2}{\sqrt{3}}\right)$$

$$\frac{CB}{f} = \frac{2}{\sqrt{3}}$$



30. Ans. (A)



31. Ans. (B)

$\because$ As image is formed on screen so it is Real Image.

Real Image formed by concave mirror which is inverted

$m = -2$

32. **Ans. (D)**

$v =\ v=\frac{u-f}{uf}\ = -60\ cm$

$\Rightarrow\ \frac{h_I}{5}=\frac{-v}{u}$

$h_I = -25\ cm$

33. **Ans. (C)**

$\frac{1}{-0.5}+\frac{1}{0.2}=\frac{2}{r}\ \Rightarrow\ \frac{2}{r}=3$; $r = 0.667\ m = 66.67\ cm$

34. **Ans. (B)**

$M=-\frac{v}{u}=-2$

35. **Ans. (C)**

$f=\frac{+R}{2}=10\,cm$

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

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

$\frac{1}{\frac{-u}{2}}+\frac{1}{u}=\frac{1}{10}$

$\frac{-1}{u}=\frac{1}{10}$

$u=-10\,cm$

The object distance must be 10 cm.

36. **Ans. (C)**

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

So, $u = 2f = v$

37. **Ans. (D)**

Image of A is at A' :

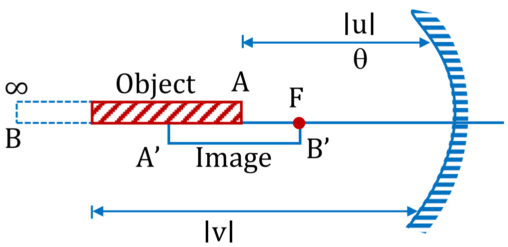
$u_A = -u$

$\frac{1}{v_A}+\frac{1}{u_A}=\frac{1}{f}$

$\frac{1}{v_A}+\frac{1}{-u_A}=\frac{1}{-f}$

$\frac{1}{v_A}=\frac{1}{u}-\frac{1}{f}=\frac{f-u}{fu}$

$v_A=v=\frac{uf}{f-u}$



Size of image = $|v| - |u| = \frac{f^2}{u-f}$

38. **Ans. (C)**

$f = \oplus$ (Convex mirror)

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

at point A

$u > 0$ & $v > 0$

& $\frac{1}{v}>\frac{1}{u} \Rightarrow u > v$

Magnification $m=-\frac{v}{u}$ is Negative & Less than one

So, Image is virtual, inverted, diminished.

39. **Ans. (C)**

Position of object	**Position of image**
$-\infty - C$	$C - F$
$C - F$	$-\infty - C$
$F - P$	$P - +\infty$

So, for any position of object image can't be between f and P.

40. **Ans. (C)**

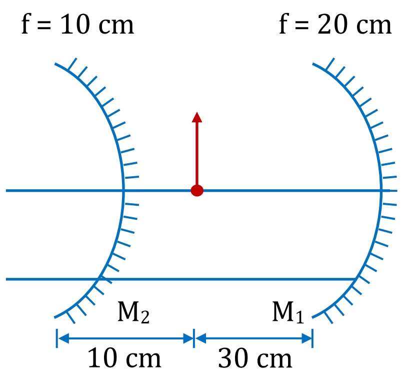
For M_1

$U = -30; f = -20$

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

$\frac{1}{v}=\frac{1}{30}-\frac{1}{20}=\frac{2-3}{60}=-\frac{1}{60}$

$v = -60\ cm$



Magnification for Mirror $M_1 = m_1 = \frac{-v}{u} = -2$

For M_2

$u = +20; f = +10$

$\frac{1}{20}+\frac{1}{v}=\frac{1}{10}$

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

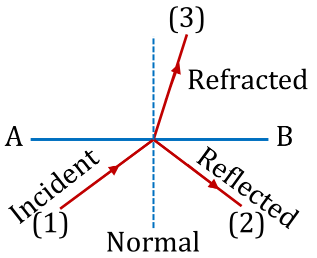
$v = +20$

Magnification for mirror $M_2 = m_2 = \frac{-v}{u}$

$M_2 = -1$

Net Magnification $= m_1 . m_2 = 2$

41. **Ans. (C)**



42. **Ans. (D)**

Principal of reversibility of light rays. You should aim the laser light directly to the satellite.

43. **Ans. (A)**

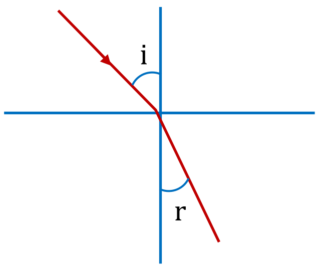
The dots shifted towards slab but due to incline view as slab spots appear to shift upward.

44. **Ans. (B)**

$\mu_1 \sin 45° = \mu_2 \sin 30° = \mu_3 \sin 60°$

$$\Rightarrow \frac{\mu_3}{\mu_1} = \frac{\sin 45°}{\sin 60°} = \sqrt{\frac{2}{3}}$$

45. **Ans. (C)**



$1 \sin i = \mu \sin r$

$i \times \sin 60 = \sqrt{3} \sin r$

$\sin r = \frac{1}{2}$

$r = 30$

$\sin i = \mu \sin r$

$$\cos i \frac{di}{dt} = \mu \cos r \frac{dr}{dt}$$

$$\frac{dr}{dt} = \frac{1}{\mu}\left(\frac{\cos i}{\cos r}\right)\frac{di}{dt}$$

$$= \frac{1}{\sqrt{3}}\frac{\cos 60}{\cos 30} \times 3 = 1 \text{ rad/sec}$$

46. **Ans. (C)**

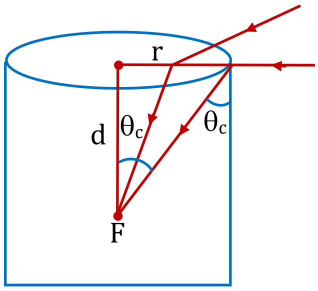
$$\sqrt{2} \sin \phi = \frac{1}{\sqrt{2}}$$

$\phi = 30°$

$$t = \frac{AB}{V}$$

$$V = \frac{C}{\sqrt{2}}$$

47. **Ans. (B)**



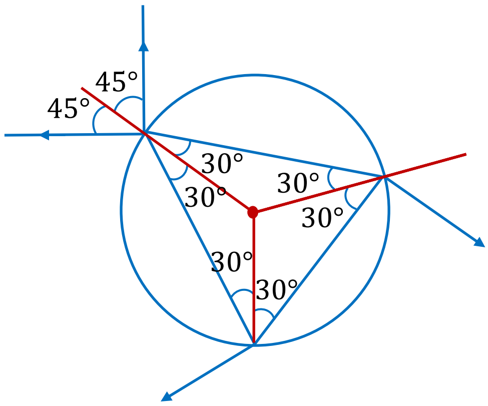
$r = \frac{30}{2} = 15cm$

$\frac{r}{d} = \tan\theta_C$

$\frac{r}{d} = \frac{3}{4}$

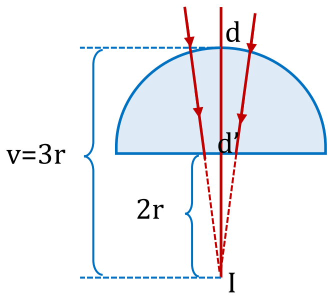
$d = \frac{4r}{3} = 20\ cm$

48. **Ans. (A)**



Final deviation = 90° or 270°.

49. **Ans. (D)**



$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\frac{3/2}{v} - \frac{1}{\infty} = \frac{3/2 - 1}{r}$

$v = 3r$

Using similar triangles,

$\frac{d'}{d} = \frac{2r}{3r}$

$d' = \frac{2}{3}d$

50. **Ans. (A)**

No change in distance will be observed because O is kept at the centre of each refracting surface.

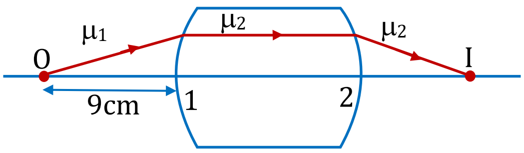
51. **Ans. (D)**

$v = \left(\frac{Ru}{R-u}\right)$

$v = \frac{-2.5uR}{1.5u + R}$

v is negative.

52. **Ans. (A)**



At surface 1 : $u_1 = -9$, $\mu_1=1$, $\mu_2 = 2$, $R = +9$; $\frac{2}{v_1}-\frac{1}{-9}=\frac{2-1}{+9} \Rightarrow \boxed{v_1=\infty}$

At surface 2 : $u_2 = \infty$; $\mu_1=2$, $\mu_2 = 1$, $R = -9$; $\frac{1}{v}-\frac{2}{\infty}=\frac{1-2}{-9} \Rightarrow \boxed{v=9\ cm}$ from 2

53. **Ans. (C)**

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

$$\frac{1}{f_{air}} = \left(\frac{\mu_{glass}}{\mu_{air}}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

and $\frac{1}{f_{liquid}} = \left(\frac{\mu_{glass}}{\mu_{liquid}}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$$\Rightarrow \frac{f_{liquid}}{f_{air}} = \frac{\left(\frac{\mu_{glass}}{\mu_{air}}-1\right)}{\left(\frac{\mu_{glass}}{\mu_{liquid}}-1\right)}$$

$$\Rightarrow \frac{f_{liquid}}{20} = \frac{(1.5-1)}{\left(\frac{1.5}{1.6}-1\right)}$$

$\Rightarrow f_{liquid} = -160\ cm$

54. **Ans. (B)**

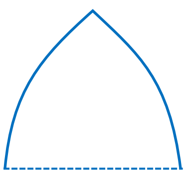
Case(P)

$$\frac{1}{f}=(\mu-1)\left(\frac{1}{R}-\frac{1}{\infty}\right)=\frac{\mu-1}{R}$$

Lens is converging and focal length will change.

Here $\mu=\frac{\mu_2}{\mu_1}=\mu_2$ (if $\mu_1=1$)

Case (Q)



There will be No change in focal length.

If $\mu_1=1$ the lens will be converging

Case (R) $\mu_1=\mu_2$ Hence no deviation.

Case (S) $\frac{1}{f}=\left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)=-ve$

55. **Ans. (B)**

For plano convex lens

$u = -20\ cm$, $v = +40\ cm$, $f = 2R$

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \text{ (lens formula)}$$

$$\frac{1}{40}+\frac{1}{20}=\frac{1}{2R}$$

$$R=\frac{20}{3}$$

For the convex lens

$$u = -20\ cm, f = R = \frac{20}{3}$$

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

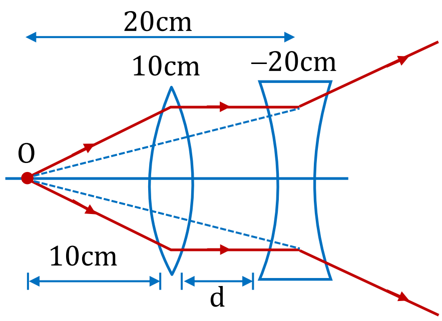
$$\frac{1}{v}+\frac{1}{20}=\frac{3}{20}$$

$$L=|f_o|+\left|\frac{f_e D}{f_e+D}\right|$$

$v = 10\ cm$

56. **Ans. (A)**

Since the object is placed at the focal length of the convex lens, the emerging rays are parallel to the principal axis. The concave lens will further diverge the parallel rays so that a virtual image is formed at its focus (i.e. 20 cm to the left of the concave lens)

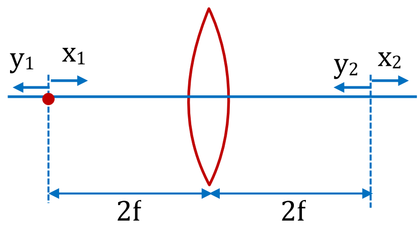


Thus, the final image formed by the concave lens will be at the object's position if the object is at a distance of 20 cm to the left if the concave lens.

57. **Ans. (C)**

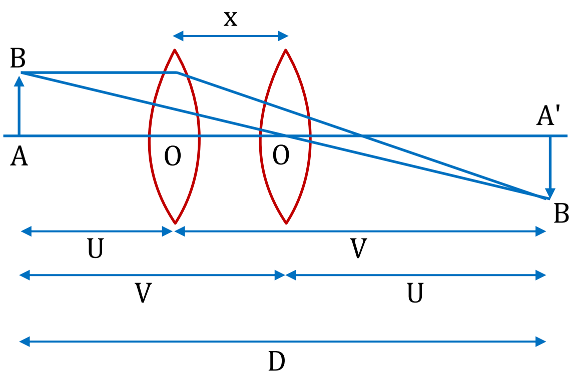
$$\frac{\text{Displacement of image}}{\text{Displacement of object}}=\left(\frac{\text{Position of image}}{\text{Position of object}}\right)^2$$

When distance between real object and its real image is $4f$ for a converging lens, both object and its image are at a distance of $2f$ from the lens and $4f$ is minimum distance between real image and real object.



58. **Ans. (B)**

$m_1 = \frac{V}{U}, m_2 = \frac{U}{V}$ (V & U interchange value between the object & screen)



$m_1 - m_2 = \frac{V}{U} - \frac{U}{V}$

$m_1 - m_2 = \frac{V^2 - U^2}{UV} = \frac{(V-U)(V+U)}{UV}$

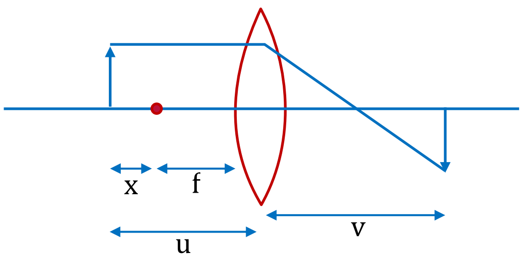
Now $V - U = X$, $\frac{1}{f} = \frac{1}{V} - \frac{1}{(-U)}$

$\frac{1}{f} = \frac{U+V}{UV}$

$\therefore m_1 - m_2 = \frac{x}{f} \Rightarrow f = \frac{X}{m_1 - m_2}$

59. **Ans. (A)**

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} - \frac{1}{-(f+x)} = \frac{1}{f}$



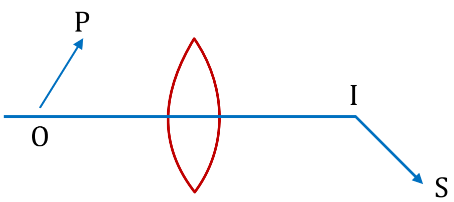
$\frac{1}{v} = \frac{1}{f} - \frac{1}{f+x} \Rightarrow \frac{1}{v} = \frac{(f+x)-f}{f(f+x)} \Rightarrow \frac{1}{v} = \frac{x}{f(f+x)}$

$v = \frac{f(f+x)}{x} \Rightarrow m = \frac{v}{u} = \frac{\frac{f(f+x)}{x}}{(f+x)}$

$m = \frac{f}{x}$

60. **Ans. (C)**

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



in x direction

$\frac{dv}{dt} = \frac{v^2}{u^2}\frac{du}{dt}$

in y direction

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

+ve

$\frac{dv}{dt} = m\frac{du}{dt}$

61. **Ans. (B)**

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

first case :

$$u_1\times\left(\frac{1}{+v_1}-\frac{1}{(-u_1)}=\frac{1}{f}\right)$$

real image

$$\frac{u_1}{v_1}+1=\frac{u_1}{f} \qquad \text{... (1)}$$

Second case :

$$u_2\times\left(\frac{1}{(-v_2)}-\frac{1}{(-u_2)}=\frac{1}{f}\right)$$

virtual image

$$-\frac{u_2}{v_2}+1=\frac{u_2}{f} \qquad \text{... (2)}$$

Same size, $\frac{u_1}{v_1}=\frac{u_2}{v_2}$

adding (1) & (2)

$$2=\frac{u_1+u_2}{f}$$

$$f=\frac{u_1+u_2}{2}$$

62. **Ans. (C)**

i = 60°; A = 30°

$i + e - (A) = \delta = 30°$

60° + e – (30°) = 30°

$e = 0 \Rightarrow r_2 = 0$

$r_1 + r_2 = 30° \Rightarrow r_1 = 30°$

$1 \times \sin i = \mu \sin r_1$

$1 \times \sin 60° = \mu \sin 30°$

$\mu=\sqrt{3}$

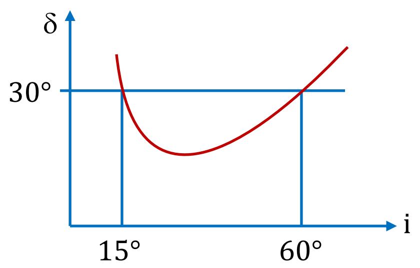
63. **Ans. (B)**

$\delta = i + e - A$

30° = 15° + 60° – A

A = 45°

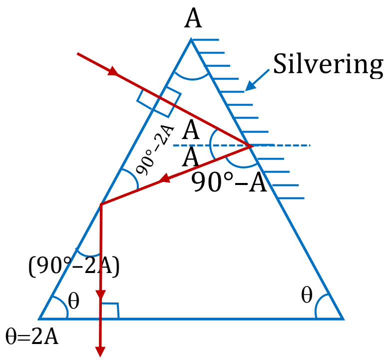
For same deviation, i and e can be interchanged.



64. **Ans. (B)**

For minimum deviation position of refracted ray inside the prism is parallel to base of the prism.

65. Ans. (C)



and $A + \theta + \theta = 180°$

$5A = 180°$

$A = 36°$

$\theta = 72°$

66. Ans. (D)

$1 \sin i = \mu \sin (r_1)$

and $\mu \sin (r_2) = 1 \sin e$

and $r_2 + r_1 = A$

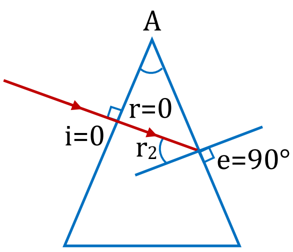
So, by decreasing i, e increases but $|\Delta i| \neq |\Delta e|$

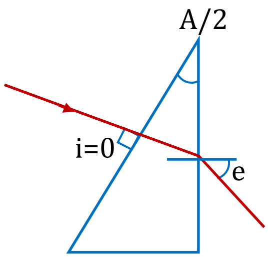
If $i > e$, then $|\Delta i| > |\Delta e|$

Hence, new value of e will be

$37° < e < 40°$

67. Ans. (A)





$r_2 = A$ $\qquad$ $r_2 = \frac{A}{2}$

$\mu \sin A = 1 \sin 90°$ $\qquad$ $\mu \sin \frac{A}{2} = 1 \sin e$

Dividing the two equations.

$$2 \cos \frac{A}{2} = \frac{1}{\sin e}$$

$$e = \sin^{-1}\left(\frac{1}{2}\sec\frac{A}{2}\right)$$

68. Ans. (C)

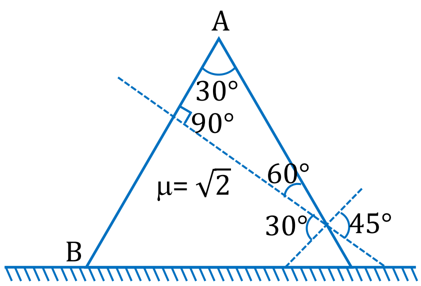
From the shown diagram $\mu \sin 30° = 1 \sin\alpha$

$$\sqrt{2}\left(\frac{1}{2}\right) = \sin\ r$$

$r = 45°$

Deviation angle $\delta = (i + e) - (r_1 + r_2)$

$$\delta = (0 + 45°) - 30° \Rightarrow 15°$$



69. **Ans. (A)**

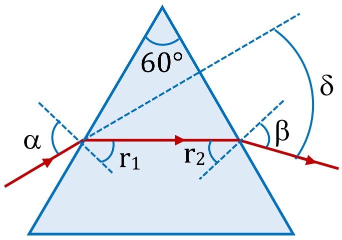
From geometry, we can find that

$r_1 + r_2 = 60°$ and $\delta = \alpha + \beta - (r_1 + r_2)$

i.e., $\delta = \alpha + \beta - 60°$

So to compute δ, we have to find β.

Using Snell's law at 1st and 2nd refracting surface, we have



$$\frac{\sin\alpha}{\sin r_1} = \frac{3}{2}$$

$$\Rightarrow \frac{\sin 37°}{\sin r_1} = \frac{3}{2}$$

$\Rightarrow$ $\sin r_1 = 0.4$

$\Rightarrow$ $r_1 = 23.6°$

So, $r_2 = A - r_1 = 36.4°$

$$\frac{\sin r_2}{\sin\beta} = \frac{1}{3/2}$$

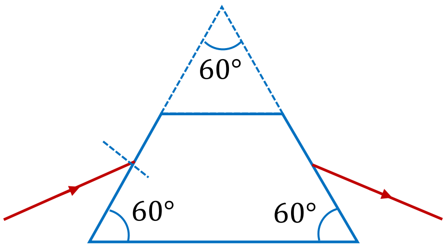
$\sin\beta = 1.5 \times \sin(36.4°) = 0.885$

$\Rightarrow$ $\beta = 62.3°$

So, $\delta = 37° + 62.3° - 60° = 39.3°$

70. **Ans. (B)**

For minimum deviation,



$\angle r_1 = \angle r_2 = 30°$

$\therefore$ $\angle i = \angle e = 45°$

$\therefore$ $\delta_{min} = i + e - A = 30°$

71. **Ans. (C)**

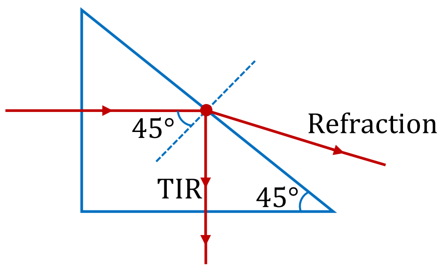
Light of larger wavelength bends less.

Hence red ray deviates least.

72. **Ans. (B)**

Refractive index is smaller for light with larger wavelength. Hence violet bends more compared to red option (B) is correct.

73. **Ans. (A)**



$45° > \theta_C$	$45° \le \theta_C$
$\sin 45° > \sin\theta_C$	$\sin 45° \le \sin\theta_C$
$\frac{1}{\sqrt{2}} > \frac{1}{\mu}$	$\frac{1}{\sqrt{2}} \le \frac{1}{\mu}$
$\sqrt{2} < \mu$	$\sqrt{2} \ge \mu$

Red Green and blue

74. Ans. (A)

Dispersive power $\omega = \frac{\Delta n}{n-1}$ where n is the refractive index.

$$\frac{1}{F} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \frac{-\Delta F}{F^2} = \Delta n\left(\frac{1}{\frac{1}{R_1} - \frac{1}{R_2}}\right) = \frac{\Delta n}{n-1} \times \frac{1}{f} \qquad ...(1)$$

Also for thin lens combination

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\Rightarrow \frac{-\Delta F}{F^2} = \frac{-\Delta f_1}{f_1^2} - \frac{\Delta f_2}{f_2^2}$$

$$\Rightarrow \frac{\Delta F}{F^2} = \frac{\Delta n_1}{(n_1 - 1) f_1} + \frac{\Delta n_2}{(n_2 - 1) f_2} \qquad \{\text{Using eq.(1)}\}$$

$$\Rightarrow \frac{\Delta F}{F^2} = \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2}$$

For no dispersion $\boxed{\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0}$

75. Ans. (D)

$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ For achromatic combination

$$\Rightarrow \frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = \frac{4}{3}$$

$$\Rightarrow -f_1 = \frac{4}{3} f_2$$

and $\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{60}$

$$\Rightarrow \frac{-3}{4f_2} + \frac{1}{f_2} = \frac{1}{60} \qquad \Rightarrow \boxed{f_2 = 15\ cm}$$

and thus $\boxed{f_1 = -20\ cm}$

76. Ans. (B)

$$\frac{1}{f_1} + \frac{1}{f_2} = 2 \qquad ...(1)$$

$$\Rightarrow 5 + \frac{1}{f_2} = 2 \Rightarrow \frac{1}{f_2} = -3$$

$$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = -(-3) \times \frac{1}{5} = \frac{3}{5}$$

77. Ans. (B)

Achromatic combination :

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$$

Given,

$$\omega_2 < \omega_1 \Rightarrow |f_1| > |f_2|$$

and $\frac{1}{F} = \left(\frac{1}{f_1} + \frac{1}{f_2}\right) > 0$ converging

so, f_1 is –ve diverging

and f_2 is +ve converging

78. Ans. (C)

$$(\mu_{rel} - 1)A = \left[\frac{\left(\frac{5}{4}\right)}{\left(\frac{3}{2}\right)} - 1\right]4° = -\frac{2°}{3}$$

79. Ans. (C)

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

$$\frac{-1}{50} + \frac{1}{25} = \frac{1}{f}$$

$\Rightarrow$ $\boxed{f = 50\ cm}$ convex.

80. Ans. (D)

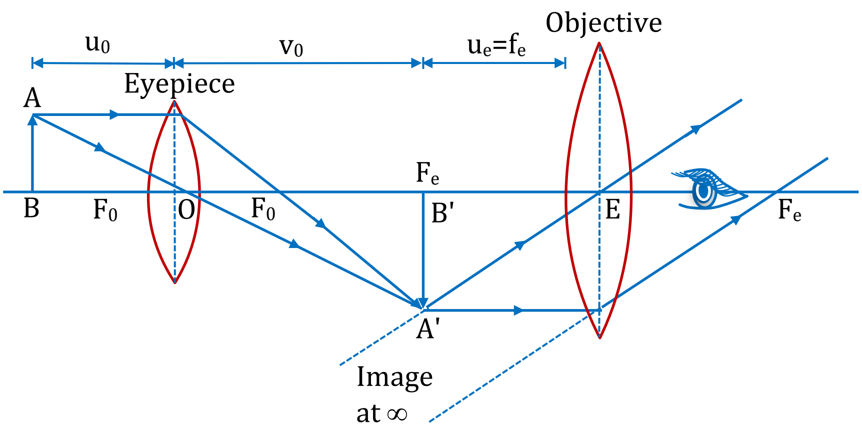
When eye sees a far object than its muscles are relaxed and focal length of lens is maximum to see near object it decrease it's focal length. But focal length of eye can not be decreased beyond a limit.

81. Ans. (B)

The angular magnification of simple microscope is ,

hence it can be increased by decreasing the focal length or increasing the power of lens.

82. Ans. (D)



For proper working of instruments the magnification by objective lens should be greater than 1. Hence image formed by objective will formed beyond $2f_0$.

$$v_0 > 2f_0$$

$$L = v_0 + u_e$$

Hence $L > 2f_0$

83. Ans. (A)

Net magnification of compound microscope

$m = m_0 \cdot m_e$

$m_e \rightarrow$ magnification due to eye piece

$m_0 \rightarrow$ magnification due to objective

When final image is at least vision

$$m_e = \left(1 + \frac{D}{f_e}\right) = \left(1 + \frac{25}{5}\right) = 6$$

$m = m_0 \cdot m_e$

$$m_0 = \frac{30}{6} = 5$$

$m_0 = 5$

84. Ans. (B)

Given $\rightarrow$ least vision for man = 40 *cm*

Man can not see object placed at a distance less than 40 *cm*

To see a object at 25 *cm*, let he used a lens of focal length 'f'.

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

$$\frac{1}{(-40)} - \frac{1}{(-25)} = \frac{1}{f}$$

$$\frac{-5+8}{200} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{3}{200}$$

Power of lens = $\dfrac{100}{f} = +1.5D$

85. Ans. (B)

To see object at less than 100 *cm*, let man used a lens of focal length of f.

Lens will form an image at 100 *cm* of an object at 25*cm* to see the object clear.

$v = -100$ *cm* and $u = -25$ *cm*

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

$$\frac{1}{-100} - \frac{1}{(-25)} = \frac{1}{f}$$

$$\frac{-1+4}{100} = \frac{1}{f}$$

$$\frac{1}{f} = \frac{3}{100}$$

Power of lens $= \dfrac{100}{f} = 3D$

86. **Ans. (C)**

Astigmation can be removed by using cylindrical lens.

87. **Ans. (A)**

When incoming light is not focused on retina by eye lens, and its focused behind the retina for a near object. This condition is known as hypermetropia.

88. **Ans. (A)**

Length of an astronomical telescope.

$$L = f_0 + \frac{f_e D}{f_e + D} \qquad \Rightarrow L - f_0 = \frac{f_e D}{f_e + D}$$

so, as L increase $\frac{f_e D}{f_e + D}$ increases.

and $m = -\frac{f_0 (f_e + D)}{f_e D}$ (In astronomical telescope)

So, as $\frac{f_e D}{f_e + D}$ increase m decreases.

89. **Ans. (A)**

$f_0 + f_e = 42$

$\frac{f_0}{f_e} = 6$

90. **Ans. (D)**

$f_e \rightarrow$ focal length of eye piece

$f_0 \rightarrow$ focal length of objective

$m_\infty = \frac{f_0}{f_e} = 5$

$f_0 = 5 \cdot f_e$ ...(i)

$f_0 + f_e = 36$ ...(ii)

$f_e = 6\ cm$

$f_0 = 30\ cm$

91. **Ans. (C)**

$m_\infty = \frac{f_0}{f_e}$ $f_e = 5\ cm$

Given angular magnification is normal adjustment is = 10

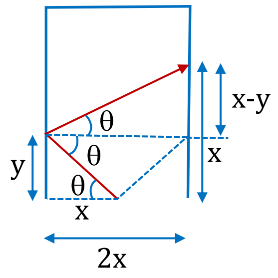
$\frac{f_0}{f_e} = 10$

$f_o = 50\ cm, f_e = 5\ cm$

Distance between eye piece and objective = $f_0 + f_e$ = 55 cm

92. Ans. (ABCD)

$\tan\theta = \frac{y}{x} = \frac{x-y}{2x}$; $x \neq 0, y = x/3$



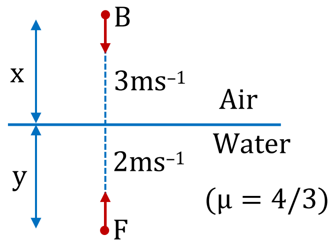
93. Ans. (BD)

If observer is in air then $d_1 = \left(x + \frac{y}{\mu}\right)$

and $v_1 = \frac{dx}{dt} + \frac{1}{\mu}\frac{dy}{dt}$

If observer is in water $d_2 = \mu x + y$

and $v_2 = \frac{\mu dx}{dt} + \frac{dy}{dt}$



94. Ans. (ABD)

Shift = $4\left(1 - \frac{1}{2}\right) = 2cm$

Shift will always takes place in direction of incident ray.

So, for mirror

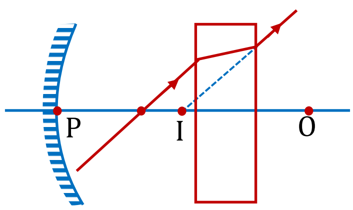
$u = -150\ cm$

$v = \frac{uf}{u-f} = -75cm$

Final images = 75 + 2 = 77cm

Image will be virtual

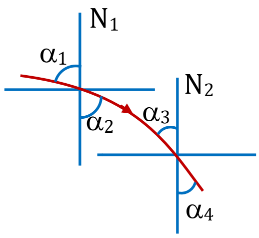
$PI = 77\ cm$



95. Ans. (AB)

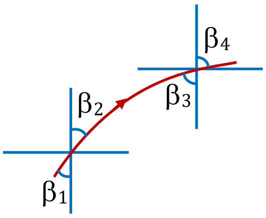
Critical angle : $\theta_c = \sin^{-1}\left(\frac{\mu_{rarer}}{\mu_{denser}}\right)$

96. Ans. (AD)



$\alpha_1 > \alpha_2 > \alpha_3 > \alpha_4$

When ray goes down refractive index increases that means angle from normal decreases.

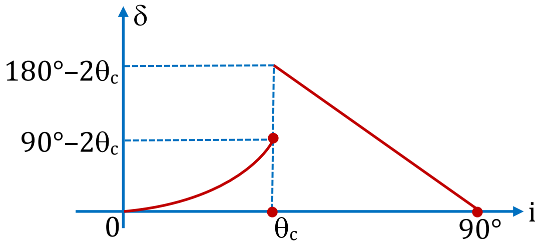


$\beta_1 < \beta_2 < \beta_3 < \beta_4$

When ray goes up refractive index decreases that means angle from normal increases.

97. **Ans. (BCD)**

Here, $\theta_C = 30°$



and $\sin\theta_C = \frac{\mu_r}{\mu_d}$

or $\sin 30° = \frac{\mu_1}{\mu_2}$

so, $\frac{\mu_1}{\mu_2} = \frac{1}{2}$

and δ_{max} $(180° - 2\theta_C) = 120°$ during *TIR*

98. **Ans. (AC)**

$n_1 < n_2$ Given

(A) If $n_3 < n_1$ $\theta_c \downarrow$

$\Rightarrow n_3 < n_1 < n_2$

So T.I.R. take place at *AB*

(B) $n_3 > n_1$

No T.I.R. as critical angle increase

(C) $n_3 > n_2$ than T.I.R. at CD surface.

If $n_3 > n_1$ than T.I.R. at AB

(D) If $n_3 < n_1$ No T.I.R. at CD

99. **Ans. (AC)**

For a thin strip at distance x and thickness dx, $1 = \frac{a}{a-x}\sin r$

$\Rightarrow \sin r = \frac{a-x}{a}$

$\Rightarrow \tan r = \frac{(a-x)}{\sqrt{a^2-(a-x)^2}} = \frac{dy}{dx}$ ...(i)

Equation of path of light = $(x-a)^2 + y^2 = a^2$

For $x = \frac{a}{2}$, $\mu = \frac{a}{a-\frac{a}{2}} = 2$

$\therefore$ $1 = 2\sin r$

$\Rightarrow \sin r = \frac{1}{2} = 30°$

$\therefore$ $\delta = \frac{\pi}{2} - \frac{\pi}{6} = \frac{\pi}{3}$

100. **Ans. (BC)**

Image is virtual and inverted, only when object is also, virtual.

101. **Ans. (BD)**

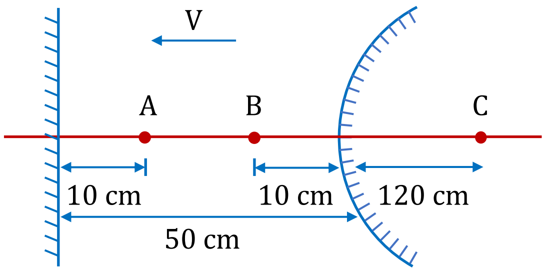
From the given diagram, image is real (if object is real) or virtual (if object is virtual) and diminished.

102. Ans. (BC)

Image by Plane Mirror act as object as spherical Mirror

For Point A

With Spherical Mirror



$u = -60\ cm$

$f = +60\ cm$

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

$$\frac{1}{v}-\frac{1}{60}=\frac{1}{60}$$

$\Rightarrow\ v = 30\ cm$

For B

$u = -90; f = 60$

$$\frac{1}{v}-\frac{1}{90}=\frac{1}{60}$$

$$\frac{1}{v}=\frac{1}{60}+\frac{1}{90}$$

$$\frac{1}{v}=\frac{5}{180}$$

$v = 36\ cm$

Length of $AB = 36 - 30 = 6\ cm$

Magnification $=\frac{6}{30}=\frac{1}{5}$

Virtual, Erect & Move toward convex mirror.

103. Ans. (AB)

If $d_1 = 120\ cm$

Refraction through curved surface

$$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

$$\frac{1.5}{v}-\frac{1}{(-120)}=\frac{1.5-1}{60}=\frac{0.5}{60}$$

$\Rightarrow\ v = \infty$

This means Ray will be Parallel to Principal axis & after Reflection with Plane Mirror Ray Retrace its Path.

(A)

If $d_1 = 240\ cm$

Refraction through curved surface

$$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

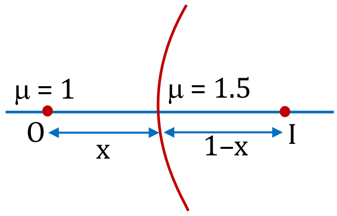
$$\frac{1.5}{v}-\frac{1}{(-240)}=\frac{1.5-1}{60}$$

$$\frac{1.5}{v}=\frac{1}{120}-\frac{1}{240}=\frac{1}{240}$$

$v = 240 \times 1.5 = 360\ cm$

Now to form image again at 'O' d_2 should be 360 cm so that ray can Retrace its Path.

104. **Ans. (AB)**



$$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

$$=\frac{1.5}{(1-x)}-\frac{1}{(-x)}=\frac{-5}{-10} = \frac{1.5}{(1-x)}-\frac{1}{(-x)}=\frac{-5}{-10}$$

$x = 4, 5\ m$

$x = 40, 50\ cm$

105. **Ans. (AD)**

For Concavo-Convex

$R_1 = -20\ cm$

$R_2 = -10\ cm$

$\mu = 1.5$

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

$$=0.5\left[\frac{-1}{20}+\frac{1}{10}\right]=\frac{1}{40}$$

$F = +40\ cm\ (A)$

For Convexo-Concave

$R_1 = +20\ cm$

$R_2 = +10\ cm$

$\mu = 1.5$

$$\frac{1}{f}=0.5\left[\frac{1}{20}-\frac{1}{10}\right]=\frac{-1}{40}$$

$F = -40\ cm$ (D)

A, D

106. **Ans. (AC)**

A concave mirror (focal length $-ve$) can form real image of a real object power of mirror.

$$P=-\frac{1}{f}=+ve$$

So if total power of combination is $+ve$ then we get the desired result

$$P=2P_L+P_M$$

$$P=2(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)+\frac{1}{f_M}$$

For option (C)

$$\Rightarrow\quad P=2(\mu-1)\left(\frac{1}{R}-\frac{1}{\infty}\right)-\frac{2}{\infty}=+ve$$

For option (A)

$$P=2(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)-\frac{2}{R_2}$$

$$P=\frac{2(\mu-1)}{R_1}-\frac{1}{R_2}(2\mu-2+2)$$

$$P=\frac{2(\mu-1)}{R_1}-\frac{2\mu}{R_2}\ \text{= may be +ve}$$

Option (B)

$$P = 2(\mu - 1)\left(\frac{1}{\infty} - \frac{1}{R}\right) - \frac{2}{R} = -ve$$

Option (D)

$$P = 2(\mu - 1)\left(\frac{-1}{R} - \frac{1}{\infty}\right) - \frac{2}{\infty} = -ve$$

107. Ans. (BD)

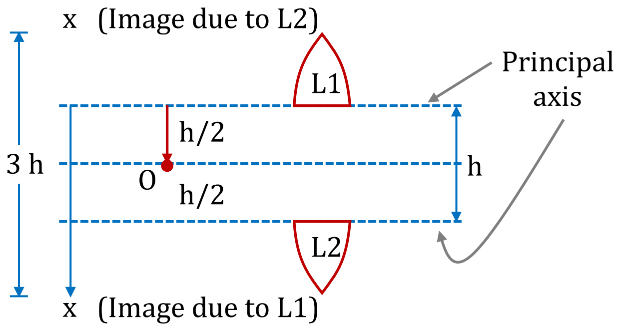
Here we use the concept of magnification to locate the position (height) of images.

Case (1) Erect image (+ve magnification)

Object height = $\frac{h}{2}$, image height = $2h$

$$m = \frac{f}{u+f}$$

$$\Rightarrow \quad +4 = \frac{f}{-30+f} \Rightarrow \boxed{f = 40cm}$$

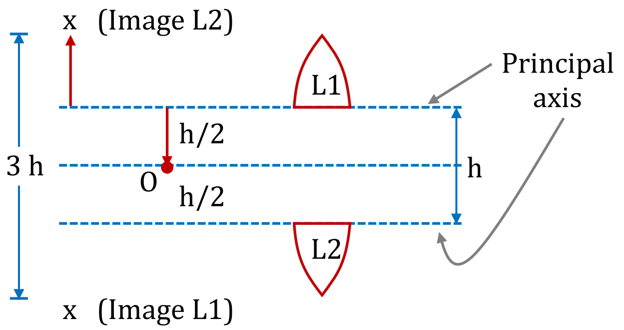


Case (2) Inverted image (–*ve* magnification)

Object height = $\frac{h}{2}$, image height = h

$$m = \frac{f}{u+f} = -2$$

$$\Rightarrow \quad \frac{f}{-30+f} = -2 \Rightarrow \boxed{f = 20cm}$$



108. Ans. (AC)

Detector will detect maximum light when the image of source is formed at the detector.

Let this happens after a time t. At this time $u = -(90 - 10t)$; $v = 10\,t$

From lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$; $\frac{1}{10\ t} - \frac{1}{-(90-10\ t)} = \frac{1}{20}$

This gives $t = 3$ sec and $t = 6$ sec.

109. Ans. (ABCD)

$$\frac{I_1}{I_2} = \left(\frac{D+x}{D-x}\right)^2 = 4.84 = \frac{22 \times 22}{100}$$

$$\Rightarrow \quad \frac{D+x}{D-x} = \frac{22}{10} = \frac{11}{5}$$

$\Rightarrow \quad 5D + 5x = 11D - 11x$

$\Rightarrow \quad 16x = 6D$

$$\Rightarrow \quad x = \frac{6 \times 96}{16} = 36\,\text{cm}.$$

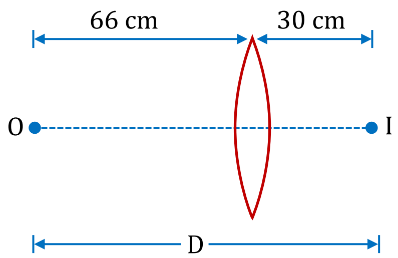
and $I_1 I_2 = O^2$

$\Rightarrow \dfrac{I_1}{I_2} = \left(\dfrac{O}{I_2}\right)^2 = 4.84 = \dfrac{484}{100} \qquad (I_1 > I_2)$

$\Rightarrow \dfrac{O}{I_2} = \dfrac{11}{5}$

and $f = \dfrac{D^2 - x^2}{4D} = \dfrac{(D+x)(D-x)}{4D}$

$f = \dfrac{(96+36)(96-36)}{4 \times 96} = 20.625$ cm.



and shorter image will be closer to the lens.
using $u = -66\ cm$, $v = 30\ cm$, $f = 20.625\ cm$.
Hence option (D) is also correct.

110. Ans. (BD)

In far sightedness image is formed beyond retina for unaided eye. This is corrected using a converging lens as eye lens is not able to bend sufficiently.
In short sightedness image is formed before the retina. Eye lens bend light ray more than required. This is corrected using diverging lenses before eyes.

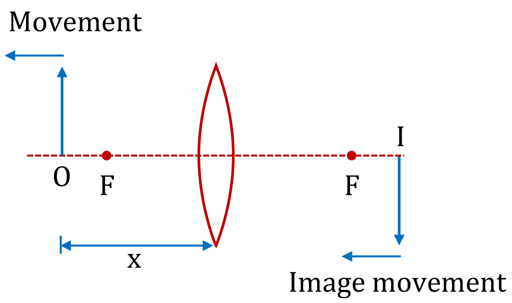
111. Ans. (A)

Due to squeezing focal length gets reduced.
Effecting the object is moving away from focus towards infinity hence image will move towards the lens.

112. Ans. (B)

As the object moves away from the focus towards infinity its size decreases.

113. Ans. (A)



Hence to stop image movement focal length should be in increased.

$v = \dfrac{1}{f} - \dfrac{1}{x}$

114. Ans. (B)

$|m| = -\dfrac{f_o}{f_e}$

115. Ans. (A)

$L = |f_o| + |f_e|$

116. Ans. (C)

$|M| = \dfrac{-f_o}{f_e}\left(1 + \dfrac{f_e}{D}\right)$

117. Ans. (D)

$L = |f_o| + |u_e| \Rightarrow L = |f_o| + \left|\dfrac{f_e D}{f_e + D}\right|$

118. **Ans. (A-Q), (B-P), (C-S), (D-R)**

For A $\frac{360°}{30°} = 12 \Rightarrow$ Number of images = 11

For B $\frac{360°}{36°} = 10 \Rightarrow$ Number of images = 9

For C $\frac{360°}{22.5°} = 16 \Rightarrow$ Number of images = 15

For D $\frac{360°}{50°} = 7.2$, as it is not exactly divisible therefore we have to draw and check number of images = 8

119. **Ans. (A-P), (B-Q), (C-RT), (D-PT)**

(A) $1 \times \sin 45° = \sqrt{2} \sin r_1$

$\Rightarrow \quad r_1 = 30°$

$\therefore \quad r_1 + r_2 = A = 100°$

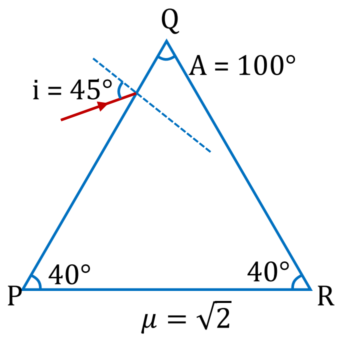
$r_2 = 70°$

$\therefore$ critical angle $\theta_c = \sin^{-1}\left(\frac{1}{n}\right)$

$= 45°$

$r_2 > 45°$

so, T.I.R. at surface QR



(B) $1 \times \sin 45° = \mu \sin r_1$

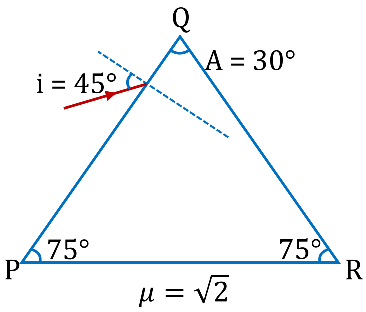
$r_1 = 30°$

$\because \quad r_1 + r_2 = A$

$r_2 = 0°$

$\Rightarrow \quad e = 0$

Hence light emerges normal to QR



(C) $1 \times \sin 90° = \mu \sin r_1$

$r_1 = 45°$

$\because \quad r_1 + r_2 = A = 90°$

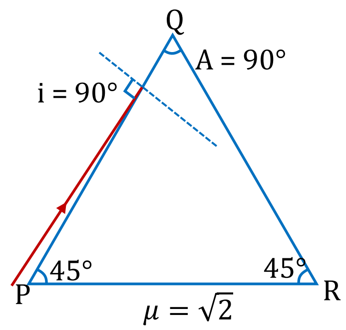
$r_2 = 45°$

$\mu \times \sin r_2 = 1 \times \sin e$

$e = 90°$

$\because \quad r_1 = r_2$

Hence light emerges parallel to surface QR when light ray passes through the prism it is parallel to the base PR.



Grazing incidence

(D) $i = 0$

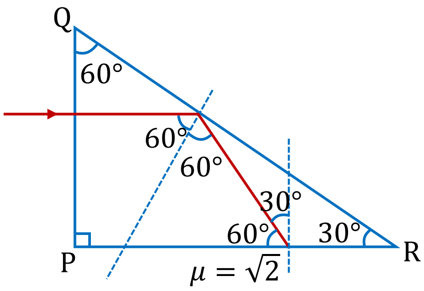
$\Rightarrow \quad r_1 = 0$

$r_2 = A = 60°$

Critical angle $\theta_c = 45°$

$\because \quad r_2 > 45°$ hence reflection at QR

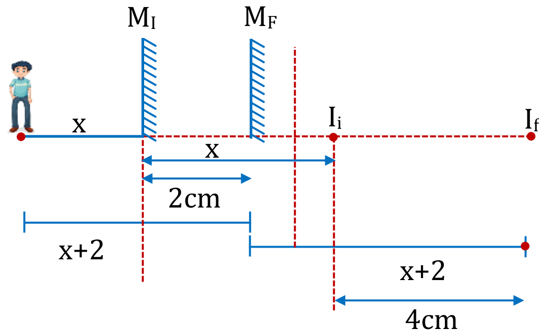
So, P,T



Normal incidence

EXERCISE – S

1. **Ans.** 4

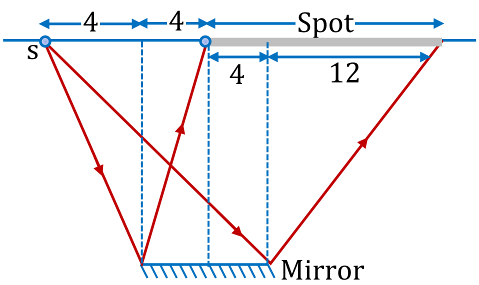


Initially distance of image = x

Final distance of image = $x + 4$

Distance moved by image = 4 cm

2. **Ans.** 2

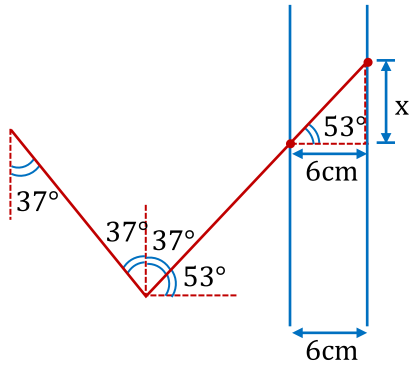


Size of spot = 4 + 12 = 16 cm

$$\frac{32}{x} = 16$$

$\therefore x = 2$

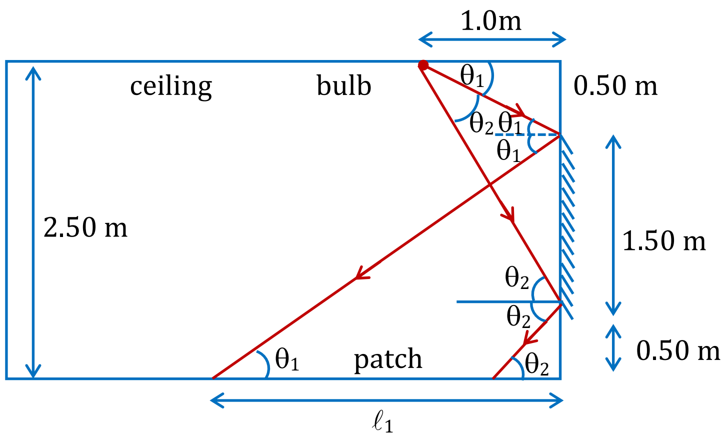
3. **Ans.** 0.50



tan 53° = $\frac{4}{3} = \frac{x}{6}$

$\Rightarrow \quad x = 8\ cm$

4. **Ans.** 3.75



$\tan\theta_1 = \frac{0.5}{1.0} = \frac{1.50+0.50}{\ell_1} \Rightarrow \ell_1 = 4.0\ m$

$\tan\theta_2 = \frac{0.50+1.50}{1.0} = \frac{0.50}{\ell_2} \Rightarrow \ell_2 = 0$

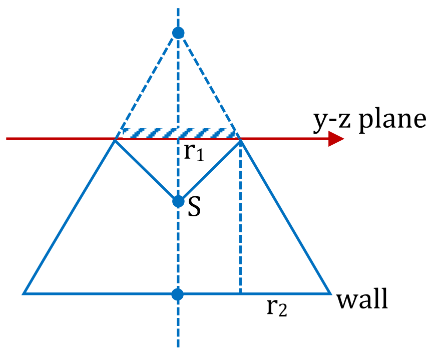
length of patch on floor = $\ell_1 - \ell_2 = 3.75\ m$

5. **Ans.** 9

Top view of the situation

Area of spot is proportional to square of radius so

$$\frac{A_{spot}}{A_{mirror}} = \frac{r_2^2}{r_1^2} = 9$$



6. **Ans.** 7.00

$$\vec{v}_1 = \left(6\hat{i} - \hat{j} + 2\hat{k}\right) + (-2\hat{j})$$

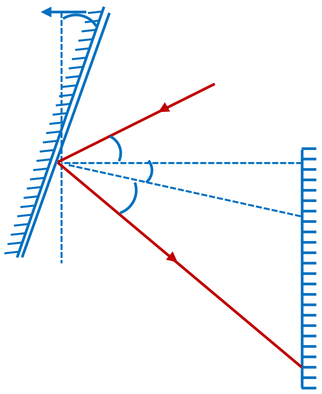
$$\underset{\text{due to object}}{\downarrow} \qquad \underset{\text{due to mirror}}{\downarrow}$$

$$= 6\hat{i} + 3\hat{j} + 2\hat{k}$$

$$v_I = \sqrt{36 + 9 + 4}$$

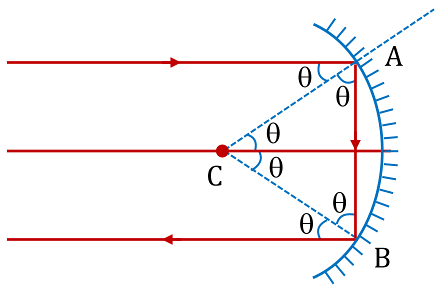
$$= \sqrt{49} = 7$$

7. **Ans.** 1



tan (11.5 + 41.5)° = tan 53° = $\frac{PQ}{0.75}$ $\Rightarrow PQ = \frac{4}{3} \times 0.75 = 1m$.

8. **Ans.** 4



In ΔABC

θ + θ + 2θ = 180°

$$\theta = \frac{180°}{4} = \frac{\pi}{4} \text{ Radian}$$

$\Rightarrow$ $N = 4$

9. **Ans.** 25

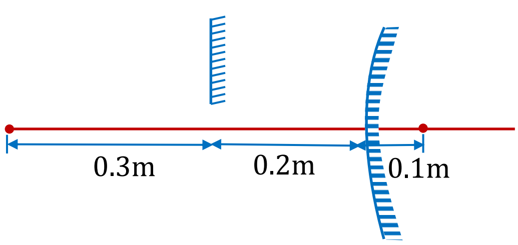


Image formed by plane mirror is at 0.3 *m* from plane mirror.

For convex mirror,

$u = -0.5\ m$, $v = 0.1\ m$, $f = ?$

From mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{f} = 8 \Rightarrow f = \frac{1}{8} m$$

Thus, radius of curvature = $2f$ = 25 *cm*.

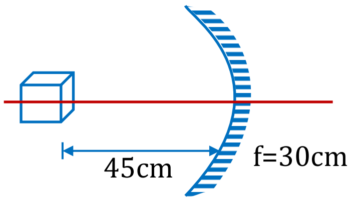
10. **Ans.** 16 mm^3

$u = -45\ cm, f = -30\ cm$

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

$v = -90\ cm$

Along principal axis,



Small size of image is $|dv_x| = \left(\frac{v}{u}\right)^2 du_x$

$dx = 4\ mm.$

Perpendicular to principal axis,

Size of image $|dy| = |dz| = \left(\frac{v}{u}\right) 1\ mm = 2\ mm$

Approx. volume of image = $(dx)\ (dy)\ (dz) = 16\ mm^3$

11. **Ans.** 5

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-15} = \frac{1}{+15}$$

$\Rightarrow\ v = 7.5\ cm$

$\Rightarrow\ m = -\frac{v}{u} = -\left(\frac{7.5}{-15}\right) = \frac{1}{2}$

Axial velocity of image = $m^2\ V_{\text{Object}} = \sqrt{5}\ cm/s$

Transverse velocity of image = $m\ V_{\text{Object}} = 2\sqrt{5}\ cm/s$

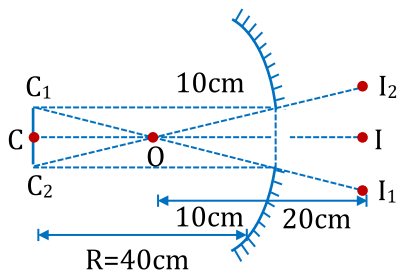
Speed of image = 5 cm/s

12. **Ans.** 2 mm

$u = -10\ cm, f = -20\ cm$

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

$v = +20\ cm$



line joining object & image, passes through centre of curvature.

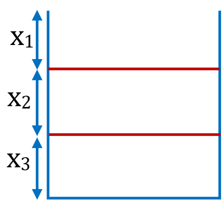
Using similar triangle's property

$$\frac{C_1C_2}{CO} = \frac{I_1I_2}{QI}$$

$$\frac{2mm}{30cm} = \frac{I_1I_2}{30cm}$$

$I_1I_2 = 2mm$

13. **Ans.** 8

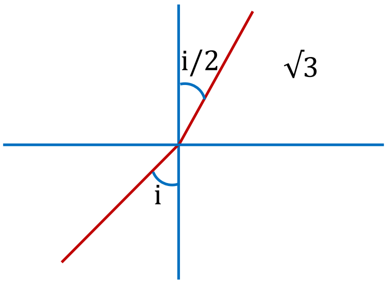


$x_1 + x_2 + x_3 = 60cm$ ...(i)

$x_1 = \frac{x_2}{2} = \frac{x_3}{1.5}$ ...(ii)

14. **Ans.** 60

$1 \sin i = \sqrt{3} \sin \frac{i}{2}$



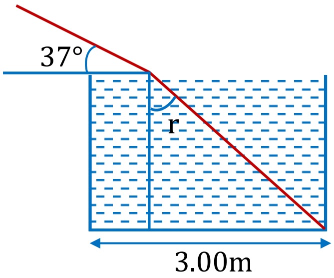
$2\cos\frac{i}{2} = \sqrt{3}$

$\cos\frac{i}{2} = \frac{\sqrt{3}}{2}$

$\frac{i}{2} = 30°$

$i = 60°$

15. **Ans.** 4



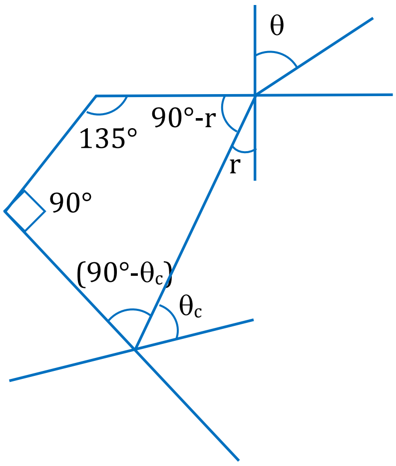
By Snell's law

$1 \sin 53° = \mu \sin r$

$\frac{4}{5} = \frac{4}{3}\sin r\,;\ \sin r = \frac{3}{5}$

$\therefore$ Depth = $4m$

16. **Ans.** $\theta < \sin^{-1}(2\sin 15°)$



Solving for limiting case

$\sin\theta = \mu \sin r = 2\sin r$

and $\sin\theta_C = \frac{1}{\mu} = \frac{1}{2}$

$\theta_C = 30°$

and $90° + 135° + 90° - r + 90° - q_C = 360°$

$r = 15°$

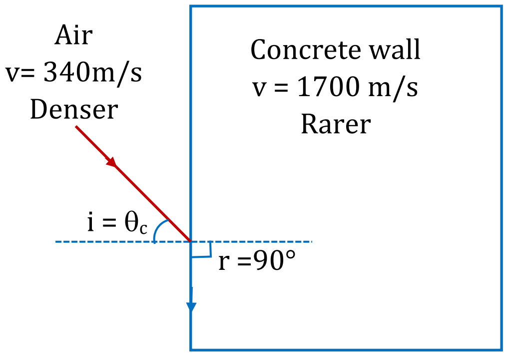
$\sin\theta < 2\sin 15°$

17. **Ans.** (a) $\sin^{-1}\left(\frac{1}{5}\right)$ (b) air

$\mu = \frac{C}{V}$

As V increases, μ decreases

(a) *TIR* occurs when ray moved from denser to rarer medium



$\mu_{air} \sin\theta_C = \mu_{wall} \sin 90$

$\frac{C}{V_{ari}}\sin\theta_C = \frac{C}{V_{wall}}\sin 90°$

$\theta_C = \sin^{-1}\left(\frac{1}{5}\right)$

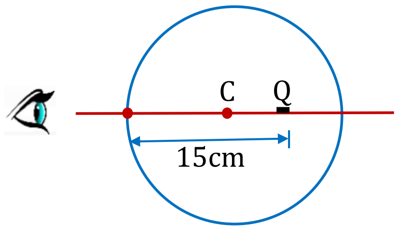
(b) Ray should move from denser to rarer (from air)

18. **Ans.** $\frac{8}{3}mm$

u = – 15 cm

$\mu_1 = 3/2$

$\mu_2 = 1$



$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1}{v} - \frac{3/2}{-15} = \frac{1-3/2}{-10}$$

$v = -20\ cm$

Small size of image is

$$(dv) = \frac{\mu_1}{\mu_2}\left(\frac{v}{u}\right)^2 \cdot (1mm)$$

$$= \frac{3/2}{1}\left(\frac{20}{15}\right)^2 (1mm) = \left(\frac{3}{2}\right)\left(\frac{16}{9}\right) mm = \frac{8}{3} mm \text{ (Real)}$$

19. **Ans.** 4

The given ray cuts y – axis at (0, 1) and x-axis at (3,0).

Taking u = + 3cm, f = + 15cm

we get v = + 2.5 cm

So, the refracted ray passes through (0,1) and (2.5, 0).

Its equation then becomes

$y = -0.4x + 1$.

20. **Ans.** 14.00

$$u = -\left(4 + \frac{4}{2}\right) \times 2 = -12\ cm$$

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

$\Rightarrow\ v = -24\ cm$

for final image (refraction through plane surface) we can write.

$$24 = 2\left(\frac{x}{1} + \frac{4}{2}\right)$$

$\Rightarrow\ 24 = 2x + 4$

x = 10 cm

so distance from P is 14 cm.

21. **Ans.** 7.50

Event-1 : $$\frac{\frac{3}{2}}{v_1} - \frac{\frac{4}{3}}{-4R} = \frac{\frac{3}{2} - \frac{4}{3}}{R}$$

$\Rightarrow v_1 = -9R$

Event-2 : $$\frac{1}{v_2} - \frac{\frac{3}{2}}{-11R} = \frac{1 - \frac{3}{2}}{-R}$$

$$\therefore\ v_2 = \frac{11R}{4} = 5.5m$$

22. **Ans.** (i) 0.2 *m*, (ii) 0.4 *m*

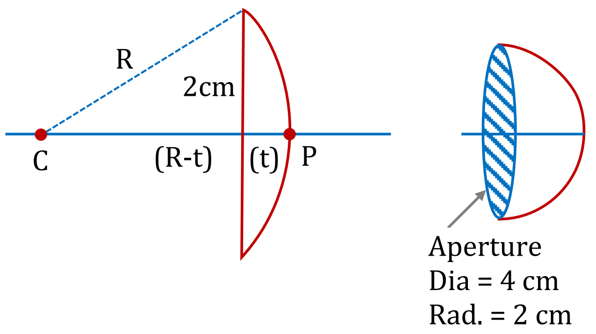
Using Pythagoras theorem,

$R^2 = (R - t)^2 + (2cm)^2$

$t = 1\ mm$

We get, $R = 20\ cm = 0.2\ m$

Now, thickness $t = 1\ mm$ is very small as compared to aperture and R. Hence, we can assume it as thin lens.



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

$= (1.5 - 1)\left(\frac{1}{20} - \frac{1}{\infty}\right)$

$f = 40\ cm = 0.4\ m$

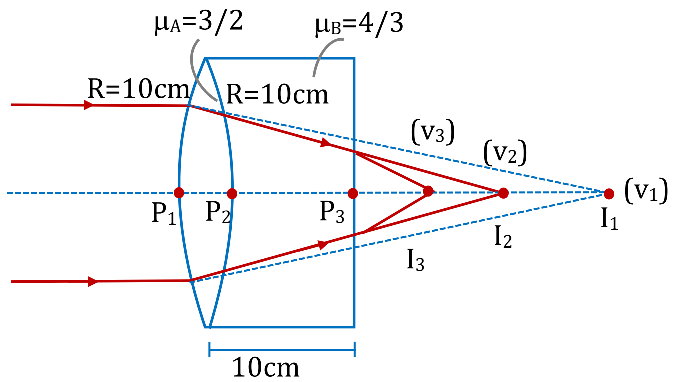
23. **Ans.** 17.5 *cm*

For P_1, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\frac{3/2}{v_1} - \frac{1}{-\infty} = \frac{3/2 - 1}{+10}$

$v_1 = +30\ cm$ from P_1

For thin lens, I_1 will act as object O_2 for P_2, $v_1 = u_2$



For P_2, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\frac{4/3}{v_2} - \frac{3/2}{v_1} = \frac{4/3 - 3/2}{-10cm}$

$v_1 = +30\ cm$

$\Rightarrow\ v_2 = +20\ cm$ from P_2

Now, I_2 will act as object O_3 for P_3

$u_3 = +10\ cm$ from P_3

For P_3, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$\frac{1}{v_3} - \frac{4/3}{+10} = \frac{1 - 4/3}{(\infty)}$

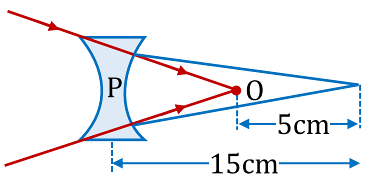
$v_3 = +7.5\ cm$ from P_3

So, final image is at 17.5 *cm* from P_1.

24. **Ans.** 30

$P_0 = 10\ cm;\ P_I = 15\ cm$

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



$\Rightarrow\ \frac{1}{15} - \frac{1}{10} = \frac{1}{f}$

$\Rightarrow\ \frac{10 - 15}{150} = \frac{1}{f}$

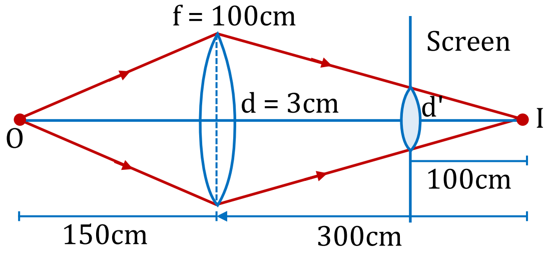
$\Rightarrow\ f = -30\ cm$

25. **Ans.** $\pi/4\ cm^2$

$u = -150, f = +100$

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

$$v = \frac{uf}{u+f} = 300\ cm$$



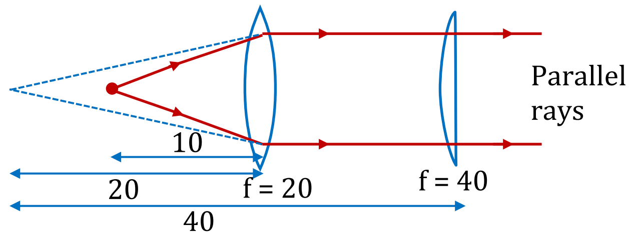
Using similar triangles.

$$\frac{3cm}{300cm} = \frac{d'}{100cm}$$

$d' = 1\ cm$

Illuminated area on screen $= \pi\left(\frac{d'}{2}\right)^2 = \frac{\pi}{4}cm^2$

26. **Ans.** 1



$d = 20\ cm$; $5d = 100\ cm = 1$ meter.

27. **Ans.** 4

$$\frac{1}{F_{\text{lens}}} = (1.5 - 1)\left[\frac{1}{-40} - \frac{1}{-20}\right] = \frac{1}{80}; F_\ell = 80\ cm$$

$$F_m = -\frac{20}{2} = -10\ cm; \frac{1}{F_{eq}} = \frac{1}{f_m} - \frac{2}{f_\ell} = \frac{1}{-10} - \frac{2}{80}; f_{eq} = -8\ cm$$

Hence, object should be placed at $x = 16\ cm$, i.e. at the centre of curvature.

28. **Ans.** (a) $f = -20\ cm$,

(b) $+80\ cm$, convergent achromatic lens

For achromatic combination of lens,

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$$

$$\omega = \frac{\mu_v - \mu_r}{\left(\frac{\mu_v + \mu_r}{2}\right) - 1}$$

Crown glass $\omega_1 = \dfrac{1.525 - 1.515}{\left(\frac{1.525+1.515}{2}\right)-1} = \dfrac{0.010}{0.520} = \dfrac{1}{52}$

Flint glass $\omega_2 = \dfrac{1.655 - 1.645}{\left(\frac{1.655+1.645}{2}\right)-1} = \dfrac{0.010}{0.650} = \dfrac{1}{65}$

$f = -20\ cm$

Focal length of combination.

$$\frac{1}{F_{eq}} = \frac{1}{f_1} + \frac{1}{f_2}$$

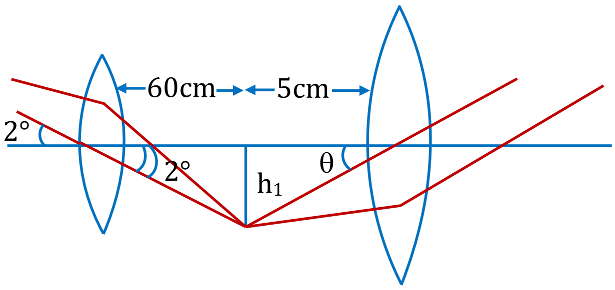
$$= \frac{1}{16} - \frac{1}{20}$$

$F_{eq} = +80\ cm$ converging.

29. **Ans.** 24.00

$2^{\circ} = \frac{h_1}{60}$ ... (1)

$\theta = \frac{h_1}{5}$ ...(2)



eq (2) ÷ eq (1) ...

$\Rightarrow \frac{\theta}{2} = \frac{60}{5}$

$\theta = 24°$

30. **Ans.** 14.60

For better resolution, smaller focal length should be objective.

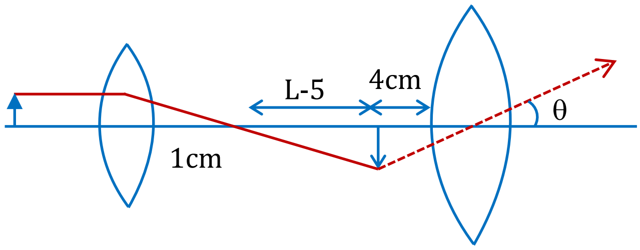
$h_0 = 1\ cm\ f_e = 4cm.$

$Q_0 = \frac{h_0}{25}$

$Q = \frac{60h_0}{25} = \frac{h_I}{4}$

$\frac{L-5}{1} = \frac{h_I}{h_0} = \frac{240}{25}$

$L = 14.6\ cm$

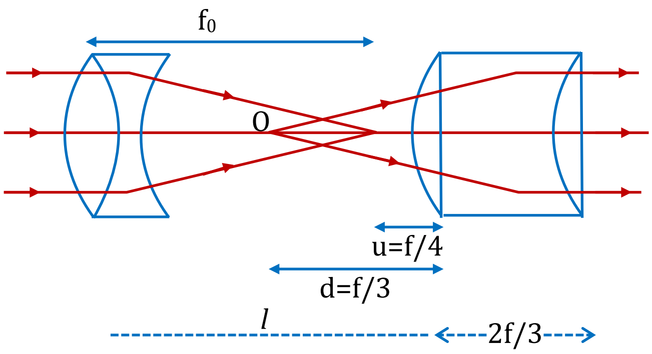


31. **Ans.** 101

$d = f - \frac{2f}{3} = \frac{f}{3}$

for f_{object} ; $\frac{1}{f_0} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{20} - \frac{1}{25}$

$\Rightarrow f_0 = 100cm$



for final image to be formed at infinity.

Point 'O' acts as focus of eyepiece

$\frac{1}{f_e} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

$\Rightarrow f_e = \frac{3f}{4}$

$\ell = \frac{f}{4} + 100$

for left lens of eyepiece

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

$\Rightarrow \frac{1}{(-f/3)} - \frac{1}{u} = \frac{1}{f}$

$\Rightarrow u = -\frac{f}{4} = -1$

$\Rightarrow f = 4$

$\ell = 100 + \frac{f}{4} = 101cm$

32. **Ans.** 25

In case of simple microscope,

Magnification, $m = 1 + \dfrac{D}{f_0}$ or $6 = 1 + \dfrac{D}{f_0}$

$\Rightarrow\ 5 = \dfrac{25}{f_0} \Rightarrow f_0 = 5\ cm$

As total magnification double using an eyepiece along with the given lens i.e., case of compound microscope.

Magnification, $m = \dfrac{\ell.D}{f_0 \cdot f_e}$ or $12 = \dfrac{60 \times 25}{5 f_e}$

$\therefore\quad f_e = 25\ cm.$

EXERCISE - JEE (Main) PYQ

1. **Ans. (4)**

$$\frac{1}{f} = \left(\frac{3/2}{1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{...(1)}$$

$$\frac{1}{f_1} = \left(\frac{3/2}{4/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{...(2)}$$

$$\frac{1}{f_2} = \left(\frac{3/2}{5/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{...(3)}$$

2. **Ans. (4)**

Frequency of light (ν) > frequency of green light (ν_G).

μ is also greater than μ_G and critical angle of light is less than green light therefore light will suffer total internal reflection and not come out to the air.

For frequency of light (ν) < ν_G ; light will not suffer T.I.R. Therefore, light will come out to the air.

3. **Ans. (3)**

For all light to come out from face AC angle of emergence $e = 90$

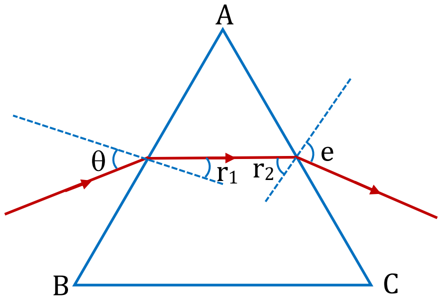
Apply Snell's Law at face AC

$\mu \sin r_2 = 1 \sin e$

$r_2 = \sin^{-1}\left(\dfrac{1}{\mu}\right)$ (if $e = 90$)

$r_1 = A - \sin^{-1}\left(\dfrac{1}{\mu}\right)$ ($\therefore\ r_1 + r_2 = A$)

(Prism)



Apply Snell's law at face AB

$1 \sin\theta = \mu \sin(r_1)$

$\theta = \sin^{-1}\left(\mu \sin\left(A - \sin^{-1}\left(\dfrac{1}{\mu}\right)\right)\right)$

For all light transmitted through AC, $e < 90°$

$\Rightarrow\quad \theta > \sin^{-1}\left(\mu \sin\left(A - \sin^{-1}\left(\dfrac{1}{\mu}\right)\right)\right)$

4. **Ans. (1)**

Angular magnification is 20.

5. **Ans. (2)**

$i = 35°, \delta = 40°, e = 79°$

$\delta = i + e - A$

$40° = 35° + 79° - A$

$A = 74°$

and $r_1 + r_2 = A = 74°$

Solving these, we get $\mu = 1.5$

Since, $\delta_{min} < 40°$

$$\mu < \frac{\sin\left(\frac{74+40}{2}\right)}{\sin 37}$$

$\mu_{max} = 1.44$

6. **Ans. (3)**

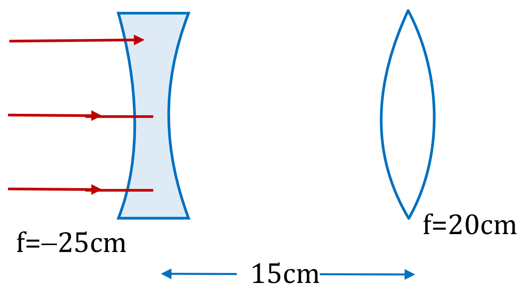
As parallel beam incident on diverging lens if forms virtual image at $v_1 = -25$ *cm* from the diverging lens which works as a object for the converging lens ($f = 20$ *cm*)

So, for converging lens $u = -40$ *cm*, $f = 20$ *cm*

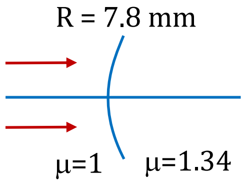
$\therefore$ Final image

$$\frac{1}{V} - \frac{1}{-40} = \frac{1}{20}$$

$V = 40$ *cm* from converging lenses.



7. **Ans. (3)**



$$\frac{1.34}{V} - \frac{1}{\infty} = \frac{1.34-1}{7.8}$$

$\therefore$ $V = 30.7$ *mm*

8. **Ans. (2)**

$$\frac{1}{2f_2} = \frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right)$$

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

$$\frac{(\mu_1 - 1)}{R} = \frac{(\mu_2 - 1)}{2R}$$

$2\mu_1 - \mu_2 = 1$

9. **Ans. (2)**

Since $D_m = (\mu - 1)A$

and on increasing the wavelength, μ decreases and hence D_m decreases. Therefore, correct answer is (2).

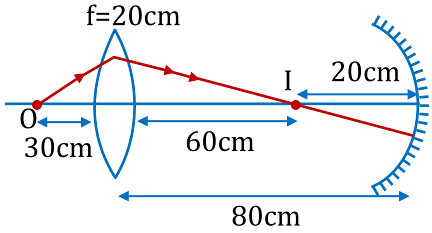
10. **Ans. (1)**

From $\frac{1}{f} = (\mu_{rel} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Focal length of lens will change hence image disappears from the screen.

11. **Ans. (2)**

Image formed by lens



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

$$\frac{1}{v}+\frac{1}{30}=\frac{1}{20}$$

v = +60 *cm*

If image position does not change even when mirror is removed it means image formed by lens is formed at centre of curvature of spherical mirror.

Radius of curvature of mirror = 80 – 60 = 20 *cm*

⇒ Focal length of mirror f = 10 *cm*

For virtual image, object is to be kept between focus and pole.

⇒ Maximum distance of object from spherical mirror for which virtual image is formed, is 10*cm*.

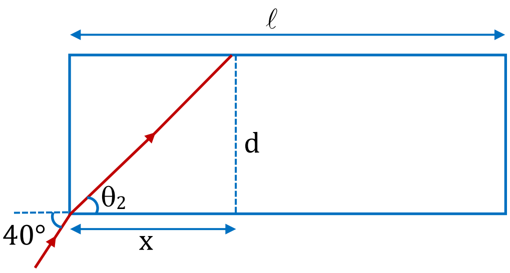
12. **Ans. (2)**

Note:

If we approximate the angle θ_2 as 30° initially then answer will be closer to 57000. But if we solve thoroughly, answer will be close to 55000.

So, both the answers must be awarded.

Detailed solution is as following:



Exact solution:

By Snells' law 1 sin 40° = (1.31)sin θ_2

$$\sin\theta_2=\frac{.64}{1.31}=\frac{64}{131}\approx .49$$

Now $$\tan\theta_2=\frac{64}{\sqrt{(131)^2-(64)^2}}=\frac{64}{\sqrt{13065}}\approx\frac{64}{114.3}=\frac{d}{x}$$

Now no. of reflections

$$=\frac{2\times 64}{114.3\times 20\times 10^{-6}}=\frac{64\times 10^5}{114.3}$$

$\approx 55991 \approx 55000$

Approximate solution:

By Snells' law 1 sin 40° = (1.31)sin θ_2

$$\sin\theta_2=\frac{.64}{1.31}=\frac{64}{131}\approx .49$$

If assume $\Rightarrow \theta_2\approx 30°$

$$\tan 30°=\frac{d}{x}\Rightarrow x=\sqrt{3}d$$

Now number of reflections

$$=\frac{\ell}{\sqrt{3}d}=\frac{2}{\sqrt{3}\times 20\times 10^{-6}}=\frac{10^5}{\sqrt{3}}$$

$\approx 57735 \approx 57000$

13. Ans. (2)

$$F_m = -\frac{18}{2} = -9cm$$

$$-\frac{1}{9} = \frac{1}{\infty} - \frac{2}{f_\ell} \qquad \Rightarrow \quad f_\ell = 18cm$$

$$\frac{1}{18} = \frac{1}{2}\left(\frac{2}{R}\right) \qquad \Rightarrow \quad R = 18cm$$

$$\frac{1}{f_2} = (\mu_1 - 1)\left(\frac{-1}{18}\right)$$

$$\frac{1}{F_m^{'}} = \frac{1}{\infty} - \frac{2}{18} + \frac{2(\mu_1 - 1)}{18}$$

$$\frac{1}{F_m^{'}} = -\frac{1}{9} + \frac{(\mu_1 - 1)}{9}$$

$$\frac{1}{F_m^{'}} = \frac{-2}{27}$$

$$\Rightarrow \quad \frac{-2}{27} = \frac{-1}{9} + \frac{(\mu_1 - 1)}{9}$$

$$\Rightarrow \quad \mu_1 - 1 = \frac{1}{3}$$

$$\Rightarrow \quad \mu_1 = \frac{4}{3}$$

14. Ans. (4)

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

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

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

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

At $v = a$, $m_1 = 1 - \dfrac{a}{f}$

At $v = a + b$, $m_2 = 1 - \dfrac{a+b}{f}$

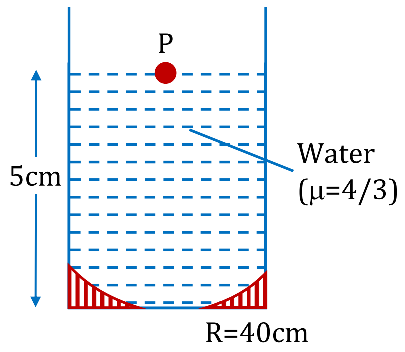
$$m_2 - m_1 = c = \left[1 - \frac{a+b}{f}\right] - \left[1 - \frac{a}{f}\right]$$

$$c = \frac{b}{f}$$

$$f = \frac{b}{c}$$

15. **Ans. (1)**

Light incident from particle P will be reflected at mirror



$$u=-5cm,\ f=-\frac{R}{2}=-20cm$$

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

$$v_1=+\frac{20}{3}cm$$

This image will act as object for light getting refracted at water surface

So, object distance $d=5+\frac{20}{3}=\frac{35}{3}cm$

Below water surface.

After refraction, final image is at

$$d'=d\left(\frac{\mu_2}{\mu_1}\right)$$

$$=\left(\frac{35}{3}\right)\left(\frac{1}{4/3}\right)$$

$$=\frac{35}{4}=8.75cm$$

$$\approx 8.8\,cm$$

16. **Ans. (3)**

From lens equation

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

$$\frac{1}{v}-\frac{1}{(-20)}=\frac{1}{(.3)}=\frac{10}{3}$$

$$\frac{1}{v}=\frac{10}{3}-\frac{1}{20}$$

$$\frac{1}{v}=\frac{197}{60};v=\frac{60}{197}$$

$$m=\left(\frac{v}{u}\right)=\frac{\left(\frac{60}{197}\right)}{20}$$

Velocity of image wrt. to lens is given by

$$v_{I/L} = m^2 v_{O/L}$$

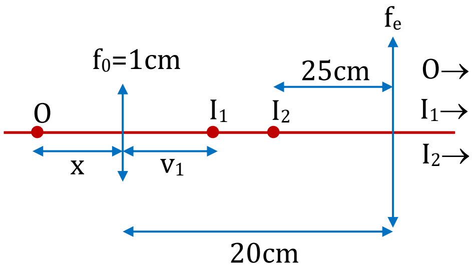
Direction of velocity of image is same as that of object

$$v_{O/L} = 5\text{ m/s}$$

$$v_{I/L} = \left(\frac{60\times 1}{197\times 20}\right)^2(5)$$

$$= 1.16\times 10^{-3}\ m/s \text{ towards the lens}$$

17. **Ans. (4.48)**



O⟶ object
I_1⟶ image formed by 1st lens
I_2⟶ image formed by 2nd lens

$$\frac{1}{v_1}-\frac{1}{-x}=\frac{1}{1}\Rightarrow v_1=\frac{x}{x-1}$$

For first lens = $\left|\frac{v_1}{u_1}\right|=\frac{1}{x-1}$

Also, magnification $|m_1|$ = $\left|\frac{v_1}{u_1}\right|=\frac{1}{x-1}$

For 2nd lens this is acting as object

So $\quad u_2 = -(20 - v_1) = -\left(20-\frac{x}{x-1}\right)$

And $\quad v_2 = -25cm$

Angular magnification $|m_A|$ = $\left|\frac{D}{u_2}\right|=\frac{25}{|u_2|}$

Total magnification $m = m_1 m_A = 100$

$$\left(\frac{1}{x-1}\right)\left(\frac{25}{20-\frac{x}{x-1}}\right)=100$$

$$\frac{25}{20(x-1)-x}=100\Rightarrow 1=80(x-1)-4x$$

$\Rightarrow \quad 76x = 81$

$\Rightarrow \quad u_2 = \left(20-\frac{81/76}{81/76-1}\right)=\frac{-19}{5}$

Now by lens formula

$$\frac{1}{-25}-\frac{1}{-19/5}=\frac{1}{f_e}$$

$\Rightarrow \quad f_e=\frac{25\times 19}{106}\approx 4.48cm$

18. **Ans. (476)**

Using displacement method

$$f = \frac{D^2 - d^2}{4D}$$

Here, $D = 100\ cm$

$d = 40\ cm$

$$f = \frac{100^2 - 40^2}{4(100)} = 21\ cm$$

$$P = \frac{1}{f} = \frac{100}{21}\ D$$

$$\frac{N}{100} = \frac{100}{21}$$

$N = 476$

19. **Ans. (1)**

$$M = \frac{v_0}{-u_0}\left(1 + \frac{d}{f_e}\right)$$

As focal length of eye lens and lens is very small.

$\therefore \quad u_0 \approx f_e$

$v_0 \approx L$

$$M = \frac{-L}{f}\left(1 + \frac{d}{f_e}\right)$$

$$-375 = \frac{15}{-0.5}\left(1 + \frac{2f}{f_e}\right)$$

$f_e = 22\ mm$

20. **Ans. (2)**

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

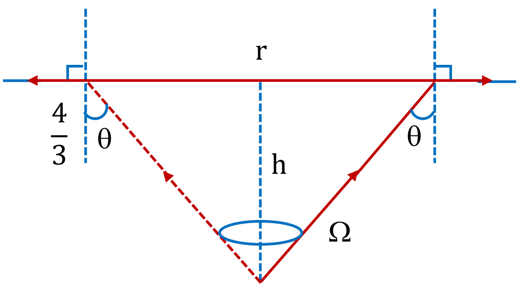
At focus $m = \infty$ $\quad$ $x = f$

At centre $m = -1$ $\quad$ $x = 2f$

21. **Ans. (1)**

$$\frac{4}{3}\sin\theta = 1 \sin 90°$$

$$\sin\theta = \frac{3}{4}$$



Area of sphere in which light spread = $4\pi R^2$

$\Omega = 2\pi\,(1 - \cos\theta)$

$$\Omega = 2\pi\left(1 - \frac{\sqrt{7}}{4}\right)$$

4π steradians $\rightarrow P$

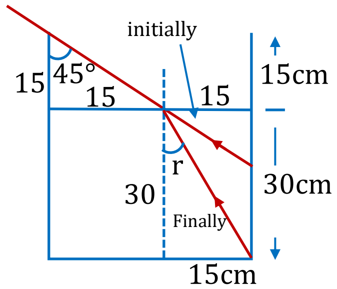
$$2\pi(1-\cos\theta) \rightarrow \frac{P}{4\pi} 2\pi(1-\cos\theta) = P'$$

$$\text{Ratio} = \frac{P'}{P} = \frac{2\pi(1-\cos\theta)}{4\pi} = \frac{(1-\cos\theta)}{2} = \frac{1 - \frac{\sqrt{7}}{4}}{2} = \frac{0.33}{2} = 0.17$$

$\therefore \quad$ Correct answer (1).

22. **Ans. (158)**

$$\tan r = \frac{15}{30} = \frac{1}{2}$$



$$\sin r = \frac{1}{\sqrt{5}}$$

$1 \sin 45° = \mu \sin r$

$$\frac{1}{\sqrt{2}} = \mu\left(\frac{1}{\sqrt{5}}\right)$$

$$\boxed{\mu = \sqrt{\frac{5}{2}} = 1.581}$$

$$\frac{N}{100} = \mu$$

$N = 100\ \mu$

$N = 158.11$

So, integer value of $N = 158.00$.

23. **Ans. (3)**

Using $\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\frac{1}{f} = \left(\frac{1.5}{1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(1)$$

and $\frac{1}{f_1} = \left(\frac{1.5}{1.42} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(2)$

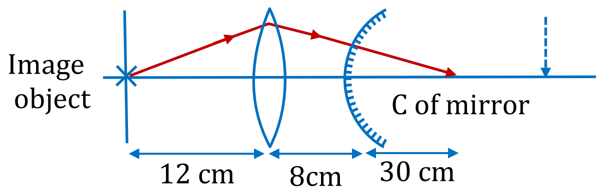
Equation (1)/(2), we get

$$\frac{f_1}{f} = \frac{0.5}{0.056}$$

$$= 8.93 \approx 9$$

24. **Ans. (50)**

For the object to coincide with image, the light must fall perpendicularly to mirror. Which means that the light will have to converge at C of mirror.



Without the mirror also, the light would coverage at C.

So the distance is : 12 + 8 + 30 = 50 *cm*

25. Ans. (4)

Mirror used is convex mirror (rear-view mirror)

$\therefore \quad V_{I/m} = -m^2 V_{O/m}$

Given,

$$V_{O/m} = 40 m/s$$

$$m = \frac{f}{f-u} = \frac{10}{10+190} = \frac{10}{200}$$

$$\therefore \quad V_{I/m} = -\frac{1}{400} \times 40 = -0.1 m/s$$

$\therefore$ Car will appear to move with speed 0.1 m/s.

26. Ans. (12)

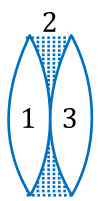
$$\ell = t \sin i \left[1 - \frac{\cos i}{\sqrt{\mu^2 - \sin^2 i}}\right]$$

$$\Rightarrow \quad 4\sqrt{3} = t \sin 60° \left[1 - \frac{\cos 60°}{\sqrt{3 - \frac{3}{4}}}\right] = t\frac{\sqrt{3}}{2}\left[1 - \frac{1}{3}\right] = \frac{t}{\sqrt{3}}$$

$$\Rightarrow \quad t = 12\, cm$$

27. Ans. (10)

$$\frac{1}{f_1} = \frac{1}{15} = \left(\frac{3}{2} - 1\right)\left[\frac{2}{R}\right]$$



$$\frac{1}{R} = \frac{1}{15}$$

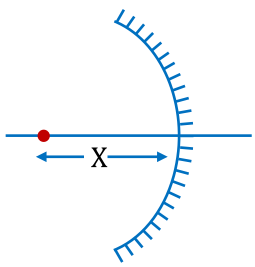
$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

$$= \frac{1}{15} + \left(\frac{5}{4} - 1\right)\left[\frac{-2}{R}\right] + \frac{1}{15} = \frac{1}{15} - \frac{1}{30} + \frac{1}{15} = \frac{2-1+2}{30} = \frac{3}{30} = \frac{1}{10} = 10$$

28. Ans. (3)

by mirror formula

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



$$\frac{1}{v_1} + \frac{1}{-15} = \frac{1}{(-20)}$$

$$\frac{1}{v_1} = -\frac{1}{20} + \frac{1}{15}$$

$$= \frac{-3+4}{60}$$

v_1 = 60 cm

$$\frac{1}{v_2}+\frac{1}{(-25)}=\frac{1}{(-20)}$$

$$\frac{1}{v_2}=\frac{-1}{20}+\frac{1}{25}$$

$$=\frac{-5+4}{100}=\frac{-1}{100}$$

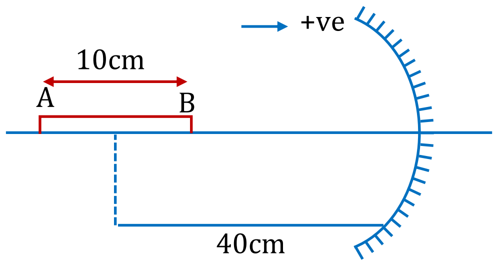
$v_2 = -100\ cm$

$d = 60 + 100 = 160\ cm$

29. Ans. (32)

$U_A = -45\ cm, f = -20\ cm$

$$V_A = \frac{-45\times(-20)}{-45-(-20)}=\frac{-900}{25} = -36\ cm$$



And $U_B = -35cm$

$$\therefore\ V_B = \frac{-35\times(-20)}{-35-(-20)}=\frac{700}{-15}$$

$\therefore\ V_A - V_B$ = length of image

$$= \left(-36+\frac{140}{3}\right)cm$$

$$= \frac{-108+140}{3}cm$$

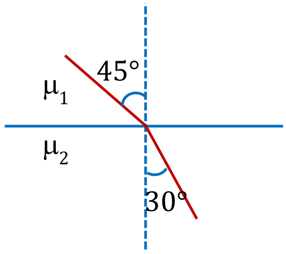
$$= \frac{32}{3}\ cm$$

$\therefore\ x = 32$

30. Ans. (2)

Snell's law $\mu_1 \sin 45° = \mu_2 \sin 30°$

$$\frac{\mu_1}{\mu_2}=\frac{1}{\sqrt{2}}$$

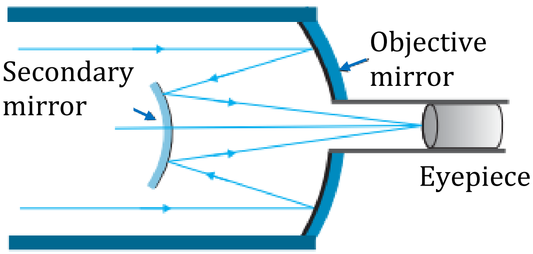


$$\Rightarrow\ \frac{\mu_1}{\mu_2}=\frac{\lambda_2}{\lambda_1}=\frac{1}{\sqrt{2}}$$

$$\Rightarrow\ \lambda_2=\frac{\lambda_1}{\sqrt{2}}$$

Frequency doesn't change on change in medium.

31. Ans. (4)

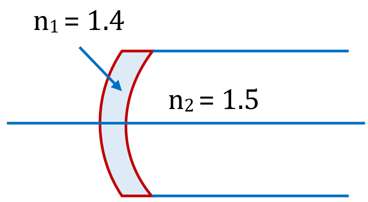


It has advantage of a large focal length in a short telescope

EXERCISE - JEE (Advanced) PYQ

1. **Ans. (AC)**

When rays are moving from air to glass,



$$\frac{1.5}{f_1}=\frac{(1.4-1)}{+R}+\frac{(1.5-1.4)}{+R}$$

$$\frac{1.5}{f_1}=\frac{0.4}{R}+\frac{0.1}{R}=\frac{0.5}{R}$$

$|f_1| = 3R$

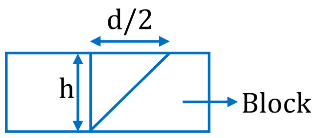
When rays are moving from glass to air,

$$\frac{1}{F_2}=\frac{(1-1.4)}{-R}+\frac{(1.4-1.5)}{-R}=\frac{0.5}{R}$$

$|f_2| = 2R$

2. **Ans. (C)**

From the given situation, at critical angle,



$$\tan\theta=\frac{(d/2)}{h}=\frac{5.77}{10}$$

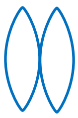
$\therefore \quad \sin\theta_C \approx \frac{1}{2}$

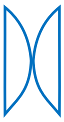
$\mu_{denser} \sin\theta_C = \mu_{rarer} \sin(\pi/2)$

$\Rightarrow \quad 2.72\times\frac{1}{2}=\mu_r$

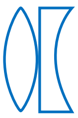
$\Rightarrow \quad \mu_r = 1.36$

3. **Ans. (B)**

$P \to 2$  $\frac{1}{F_{eq}}=\frac{1}{f_1}+\frac{1}{f_2}=(1.5-1)\left(\frac{2}{r}\right)\times 2=\frac{2}{r}$ $\quad F_{eq} = r/2$

$Q \to 4$  $\frac{1}{F_{eq}}=(1.5-1)\left(\frac{2}{r}\right)=\frac{1}{r}$ $\quad F_{eq} = r$

$R \to 3$  $\frac{1}{F_{eq}}=(1.5-1)\left(-\frac{2}{r}\right)=-\frac{1}{r}$ $\quad F_{eq} = -r$

$S \to 3$  $\frac{1}{F_{eq}}=\frac{1}{r}+\frac{1}{(-2r)}$ $\quad F_{eq} = 2r$

4. **Ans. (7)**

For reflection from concave mirror,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{v}-\frac{1}{15}=\frac{-1}{10}$$

$$\frac{1}{v}=\frac{1}{15}-\frac{1}{10}=\frac{-1}{30}$$

$\therefore$ $v = -30$

Magnification $(m_1) = -\frac{v}{u}=-2$

Now for refraction from lens,

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

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

$\therefore$ Magnification $(m_2) = \frac{v}{u}=-1$

$\therefore$ $M_1 = m_1m_2 = 2$

Now when the set-up is immersed in liquid, no effect for the image formed by mirror.

We have $(\mu_L - 1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=\frac{1}{10}$

$$\Rightarrow \left(\frac{1}{R_1}-\frac{1}{R_2}\right)=\frac{1}{5}$$

When lens is immersed in liquid,

$$\frac{1}{f_{\text{liquid}}}=\left(\frac{\mu_L}{\mu_S}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) = \frac{2}{7}\times\frac{1}{5}=\frac{2}{35}$$

$$\therefore \frac{1}{v}-\frac{1}{u}=\frac{1}{f_{\text{liquid}}}$$

$$\Rightarrow \frac{1}{v}=\frac{2}{35}-\frac{1}{20}=\frac{8-7}{140}=\frac{1}{140}$$

$\therefore$ Magnification $= -\frac{140}{20}=-7$

$\therefore$ $M_2 = 2 \times 7 = 14$

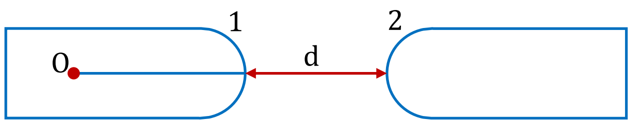
$$\therefore \left|\frac{M_2}{M_1}\right|=7$$

5. **Ans. (B)**

For first surface

$$\frac{1}{V}-\frac{1.5}{-50}=\frac{1-1.5}{-10}$$

$V = 50\ cm$



For second surface

$$\frac{1.5}{\infty}-\frac{1}{-(d-50)}=\frac{1.5-1}{10}$$

$d = 70\ cm$

6. **Ans. (2)**

By Snell's law

$1 \sin 60 = n \sin r_1$

$\Rightarrow \quad \sin r_1 = \frac{1}{2} \Rightarrow r_1 = 30°$ ...(1)

By differentiating 'w.r.t' n

$0 = \sin r_1 + n \cos r_1 \left(\frac{dr_1}{dn}\right)$

$= \frac{1}{2} + \sqrt{3}\left(\frac{\sqrt{3}}{2}\right)\frac{dr_1}{dn}$

$\frac{dr_1}{dn} = -\frac{1}{3}$ ...(2)

By applying Snell's law

$n \sin r_2 = 1 \sin \theta$

$n \sin (60 - r_1) = 1 \sin \theta \quad [\because \; A = r_1 + r_2]$

By differentiating 'w.r.t' n

$\sin (60 - r_1) - n \cos (60 - r_1)\, \frac{dr_1}{dn} = \cos\theta \frac{d\theta}{dn}$

By substituting value of 'r_1' and $\frac{dr_1}{dn}$ from (1) and (2)

$\frac{d\theta}{dn} = 2$

7. **Ans. (AC)**

Let the whole structure is placed in a medium of refractive index n', then

$n' \sin i = n_1 \sin (90 - \theta)$

$n' \sin i = n_1 \cos \theta$ ...(i)

Here for i_m ; $\theta = C$ and $\sin C = \frac{n_2}{n_1}$

From eq. (i), $n' \sin i_m = n_1 \sqrt{1 - \frac{n_2^2}{n_1^2}} = \sqrt{n_1^2 - n_2^2}$

$\Rightarrow \quad \sin i_m = \frac{\sqrt{n_1^2 - n_2^2}}{n'}$

Now, for (A) $(NA)_{S_1} = \frac{3}{4}\sqrt{\frac{45}{16} - \frac{9}{4}} = \frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$ $\quad (NA)_{S_2} = \frac{3\sqrt{15}}{16}\sqrt{\frac{64}{25} - \frac{49}{25}} = \frac{3\sqrt{15}}{16}\frac{1}{5}\sqrt{15} = \frac{9}{16}$

For (B) $(NA)_{S_1} = \frac{\sqrt{15}}{6} \times \frac{3}{4} = \frac{\sqrt{15}}{8}$ $\quad (NA)_{S_2} = \frac{3}{4} \times \frac{\sqrt{15}}{5}$ Not equal

For (C) $(NA)_{S_1} = 1 \times \frac{3}{4} = \frac{3}{4}$ $\quad (NA)_{S_2} = \frac{\sqrt{15}}{4} \times \frac{\sqrt{15}}{5} = \frac{15}{4 \times 5} = \frac{3}{4}$

For (D) $(NA)_{S_1} = \frac{3}{4}$ $\quad (NA)_{S_2} = \frac{3}{4}\,\frac{\sqrt{15}}{5}$ Not equal

8. **Ans. (D)**

It is given that $NA_2 < NA_1$

$\Rightarrow \quad i_{m2} < i_{m1}$

Condition for TIR of lower i_m must be satisfied.

Hence NA_2 will be the numerical aperture of the combined structure.

9. **Ans. (A)**

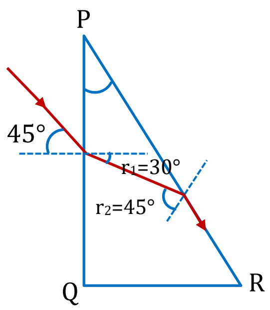
$1 \sin 45° = \sqrt{2} \sin r_1 \Rightarrow r_1 = 30°$

$1 \sin 90° = \sqrt{2} \sin r_2 \Rightarrow r_2 = 45°$

$r_2 - r_1 = \theta$

$\theta = 45° - 30°$

$\Rightarrow \quad \theta = 15°$



10. **Ans. (ABD)**

For parallel slab

$n_1 \sin \theta_i = n_2 \sin \theta_f$

And ℓ depends on refraction angle in slab.

$\therefore \quad \ell$ depends on refractive index of slab and independent of n_2.

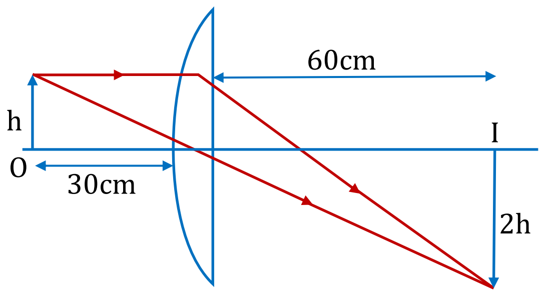
11. **Ans. (AD)**

For lens

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

$$\frac{1}{60} - \frac{1}{(-30)} = \frac{1}{f} \Rightarrow f = 20cm \qquad \text{...(i)}$$

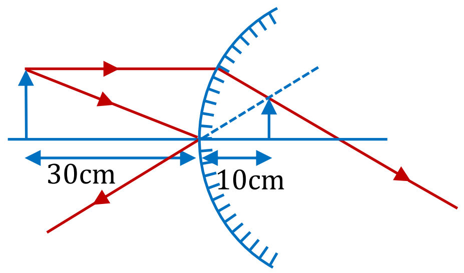
Also, $\frac{1}{f} = (n-1)\left(\frac{1}{R} - \frac{1}{\infty}\right) = \frac{(n-1)}{R}$ ...(ii)



For reflection from convex mirror (curved surface)

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} = \frac{2}{R}$$

$$\frac{1}{+10} + \frac{1}{-30} = \frac{1}{f} = \frac{2}{R} \qquad \text{...(iii)}$$



$R = 30\ cm$

From (i), (ii) and (iii)

$n = 2.5,$

Faint image is erect and virtual.

12. Ans. (A)

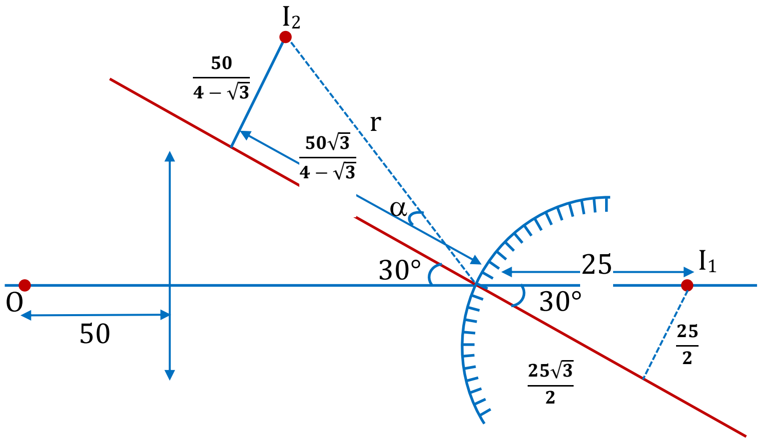
For lens $V = \dfrac{(-50)(30)}{-50+30} = 75$

For mirror

$$V = \frac{\left(\frac{25\sqrt{3}}{2}\right)(50)}{\frac{25\sqrt{3}}{2} - 50} = \frac{-50\sqrt{3}}{4-\sqrt{3}}$$

$$m = -\frac{v}{u} = \frac{h_2}{h_1} \Rightarrow h_2 = -\left(\frac{\frac{-50\sqrt{3}}{4-\sqrt{3}}}{\frac{25\sqrt{3}}{2}}\right) \cdot \frac{25}{2}$$

$$h_2 = \frac{+50}{4-\sqrt{3}}$$



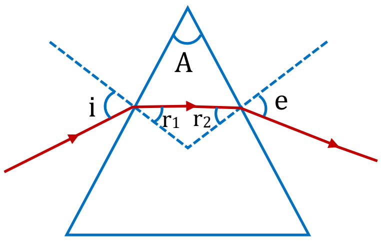
The x coordinate of the images = 50 – v cos 30 + h_2 cos 60 25.

The y coordinate of the images = v sin 30 + h_2 sin 60 25.

13. Ans. (ACD)

$i = e$ (for minimum deviation)

$r_1 + r_2 = A$, $r_1 = r_2$



(A) $\delta_m = 2i - A = A$ (given)

$\Rightarrow \quad i = A$

$\Rightarrow \quad r_1 = \dfrac{A}{2} = \dfrac{i}{2}$

(B) $\mu = \dfrac{\sin(A)}{\sin(A/2)} = 2\cos\dfrac{A}{2}$

$\Rightarrow \quad A = 2\cos^{-1}\left(\dfrac{\mu}{2}\right)$

(C) $\mu \sin(r_2) = 1$

$\Rightarrow \quad \cos r_2 = \sqrt{1 - \dfrac{1}{\mu^2}} \quad \Rightarrow \quad \mu\cos r_2 = \sqrt{\mu^2 - 1}$

$r_1 + r_2 = A$

$r_1 = A - r_2$

$\sin r_1 = \sin(A - r_2)$

$\sin i = \mu \sin r_1 = \mu \sin(A - r_2)$

$i = \sin^{-1}\left[\mu \sin(A - r_2)\right]$

$i = \sin^{-1}\left(\mu \sin A \cos r_2 - \mu \cos A \sin r_2\right)$

$i = \sin^{-1}\left[\sin A\sqrt{\mu^2 - 1} - \cos A\right]$

$i = \sin^{-1}\left[\sin A\sqrt{4\cos^2\left(\dfrac{A}{2}\right) - 1} - \cos A\right] \quad \left[\because\ \mu = 2\cos\left(\dfrac{A}{2}\right)\right]$

(D) Condition of min. deviation $i = e$ and $r_1 = r_2 = \dfrac{A}{2}$

Ray will be parallel to base.

14. **Ans. (8)**

Applying Snell's law between entry and exit surfaces,

$$n \sin \theta = \mu \sin\left(\frac{\pi}{2}\right)$$

$\Rightarrow$ $$1.6 \sin 30° = \mu \sin\left(\frac{\pi}{2}\right)$$

$\therefore$ $\mu = 0.8$

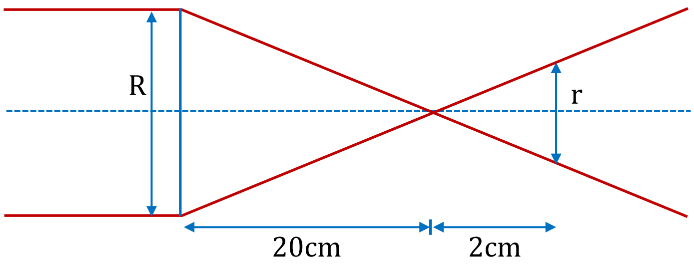
$\therefore$ $0.8 = n - m\Delta n$

$= 1.6 - m \times 0.1$

$\therefore$ $m = 8$

15. **Ans. (130 [129.95, 130.05])**

$$\frac{r}{R} = \frac{2}{20} = \frac{1}{10}$$



$\therefore$ Ratio of area = $\frac{1}{100}$

Let energy incident on lens be E.

$\therefore$ Given $\frac{E}{A} = 1.3$

So final, $\frac{E}{a} = ??$

$E = A \times 1.30$

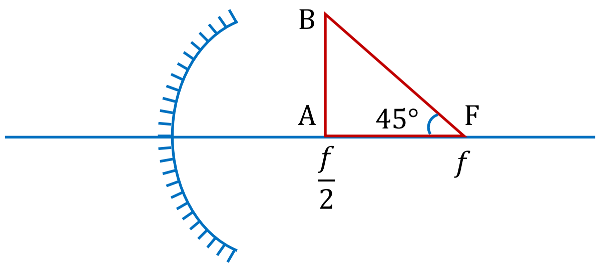
Also, $\frac{a}{A} = \frac{1}{100}$

$\therefore$ Average intensity of light at 22 cm = $\frac{E}{a} = \frac{A \times 1.3}{a} = 100 \times 1.3 = 130 kW/m^2$.

16. **Ans. (D)**

Distance of point A is $f/2$

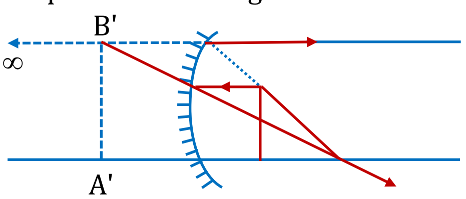
Let A' is the image of A from mirror, for this image



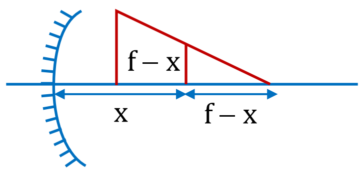
$$\frac{1}{v} + \frac{1}{-f/2} = \frac{1}{-f}$$

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

Image of line AB should be perpendicular to the principle axis and image of F will form at infinity, therefor correct image diagram is



OR



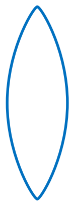
$$\frac{f}{f-u} = \frac{h_2}{h_1}$$

$$h_2 = \frac{-f(f-x)}{(-f+x)}$$

$h_2 = f$

17. **Ans. (ACD)**

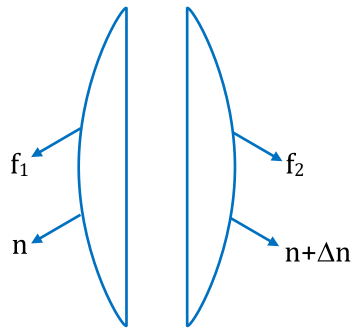
When $n_1 = n_2 = n$



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

So, $f = \dfrac{R}{2(n-1)}$ ...(1)

2nd case :



$$\frac{1}{f_1} = \frac{n-1}{R}$$

$$\frac{1}{f_2} = \frac{(n+\Delta n)-1}{R}$$

$$\frac{1}{f_{eq}} = \frac{1}{f+\Delta f} = \left(\frac{n-1}{R}\right) + \frac{(n+\Delta n)-1}{R} = \frac{2(n-1)+\Delta n}{R}$$

$$\Delta f = \left(\frac{R}{2(n-1)+\Delta n}\right) - \left(\frac{R}{2(n-1)}\right) = \frac{-R\Delta n}{4(n-1)^2}$$

$$\frac{\Delta f}{f} = -\frac{\Delta n}{2(n-1)} \quad ...(2)$$

(A) Relation between $\dfrac{\Delta f}{f}$ and $\dfrac{\Delta n}{n}$ is independent of R so (A) is correct.

(B) $2n - 2 < n$ because $n < 2$

$$\Rightarrow \quad \frac{\Delta f}{f} = \frac{1}{2}\left|\frac{\Delta n}{n-1}\right| > \frac{\Delta n}{n}$$

So, $\dfrac{\Delta f}{f} > \left|\dfrac{\Delta n}{n}\right|$, so (B) is wrong

(C) $|\Delta f| = \dfrac{f\Delta n}{2(n-1)} = \dfrac{(20\times 10^{-3})}{2(1.5-1)} = 20\times 10^{-3} = 0.02$

So, (C) is correct.

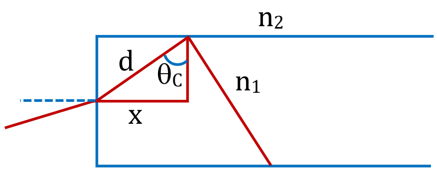
(D) If $\dfrac{\Delta n}{n} < 0$ then $\dfrac{\Delta f}{f} > 0$ from equation (2).

18. **Ans. (50)**

For maximum time the ray of light must undergo *TIR* at all surfaces at minimum angle i.e. θ_C

For *TIR* $n_1 \sin\theta_C = n_2$

$$\sin\theta_C = \frac{1.44}{1.5}$$



In above Δ, $\sin\theta_C = \dfrac{x}{d}$

$$d = \frac{x}{\sin\theta_C}$$

Similarly, $D = \dfrac{L}{\sin\theta_C}$

where L = length of tube, D = length of path of light

Time taken by light

$$t = \frac{D}{C} = \frac{L/\sin\theta_C}{2\times 10^8}$$

$t = 50 \times 10^{-9} s$

19. Ans. (CD)

$H_1 = \dfrac{2H}{3} = \dfrac{2}{3}\times\dfrac{3}{10} = \dfrac{1}{5}m = 20cm$

For 2[nd]

$$\frac{1}{v}+\frac{3}{2H}=\frac{-1}{2(-3)}$$

$$\frac{1}{v}=\frac{1}{6}-\frac{10}{2}=\frac{1}{6}-\frac{30}{6}=\frac{-29}{6}$$

$$H_2 = \frac{6}{29} > H_1 = 20.69 \text{ cm}$$

For 3[rd]

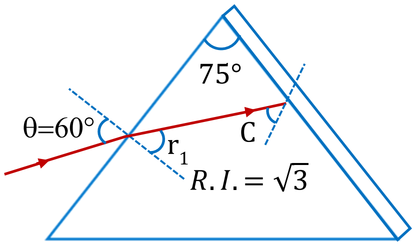
$$\frac{1}{v}+\frac{3}{2H}=\frac{-1}{2(3)}$$

$$\frac{1}{v}=\frac{-1}{6}-5=\frac{-31}{6}$$

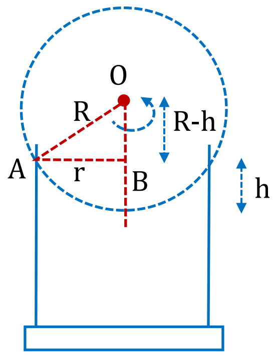
$$H_3 = \frac{6}{31}$$

So, $\boxed{H_3 < H_1 < H_2}$ and $(H_2 - H_1) = \dfrac{6}{29}-\dfrac{1}{5}=0.69cm$.

20. Ans. (1.50)



At θ = 60° ray incidents at critical angle at second surface



So, $\sin\theta = \sqrt{3}\sin r_1$

$$\frac{\sqrt{3}}{2}=\sqrt{3}\sin r_1$$

$$r_1 = 30°$$

$$r_2 = 45° = C$$

$$\sqrt{3}\sin 45° = n\sin 90°$$

$$n = \sqrt{\frac{3}{2}} \Rightarrow n^2 = \frac{3}{2}$$

21. **Ans. (AD)**

In ΔOAB

$R^2 = (R - h)^2 + r^2$

$R^2 = R^2 - 2hR + h^2 + r^2$

$\Rightarrow \quad 2hR = h^2 + r^2$

$$\Rightarrow \quad R = \frac{h^2 + r^2}{2h}$$

Now considering equation of surface

$$y = y_0 + \frac{\omega^2 r^2}{2g}$$

$$h = \frac{\omega^2 r^2}{2g}$$

Now using, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

$$\Rightarrow \quad \frac{1}{v} + \frac{4}{3(H-h)} = \frac{1-4/3}{R}$$

$$\Rightarrow \quad \frac{1}{v} = \frac{-1}{3R} - \frac{4}{3H} \qquad (H - h \simeq H)$$

$$\Rightarrow \quad \frac{1}{v} = \frac{-2h}{3r^2} - \frac{4}{3H} \qquad \left(R \simeq \frac{r^2}{2h}\right)$$

$$\Rightarrow \quad \frac{1}{v} = -\frac{4}{3H}\left[1 + \frac{\omega^2 H}{4g}\right]$$

$$\Rightarrow \quad v = \frac{-3H}{4}\left[1 + \frac{\omega^2 H}{4g}\right]^{-1}$$

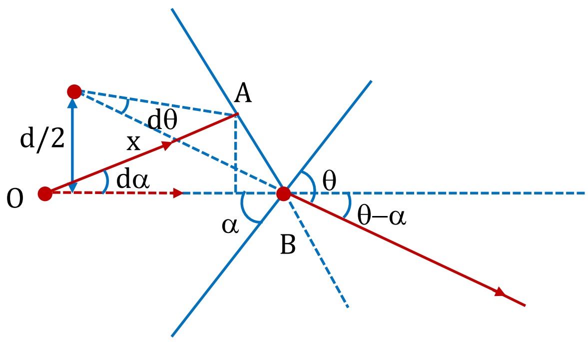
$\therefore \quad$ Apparent depth = $\frac{3H}{4}\left[1 + \frac{\omega^2 H}{4g}\right]^{-1}$

22. **Ans. (2)**

We will assume that observer sees the image of object through edge $\Rightarrow \alpha = 45°$

$$AB = \frac{12d\alpha}{\cos\alpha} = \frac{xd\theta}{\cos\theta}$$

By applying Snell's Law



$$\frac{4}{3}\sin\alpha = 1\sin\theta$$

$$\frac{4}{3}\cos\alpha d\alpha = \cos\theta d\theta$$

$$\Rightarrow \quad \frac{9}{\cos^2\alpha} = \frac{x}{\cos^2\theta}$$

$$1\sin\theta = \frac{4}{3}\sin\alpha$$

$\Rightarrow \quad \sin\theta = \dfrac{2\sqrt{2}}{3}$

$\Rightarrow \quad x = 18 \times \dfrac{1}{9} = 2$

$d = 2x \sin(\theta - \alpha)$

$= 4 \times \dfrac{1}{\sqrt{2}}\left(\dfrac{2\sqrt{2}}{3} - \dfrac{1}{3}\right) = \dfrac{8 - 2\sqrt{2}}{3} \approx 1.73 \approx 2$

23. Ans. (B)

Focal length of convex lens (f_1)

$$\frac{1}{f_1} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad = (1.5 - 1)\left[\frac{1}{20} - \left(\frac{1}{-20}\right)\right]$$

$$\frac{1}{f_1} = \frac{1}{20}$$

$\Rightarrow \quad \boxed{f_1 = +20\,cm}$

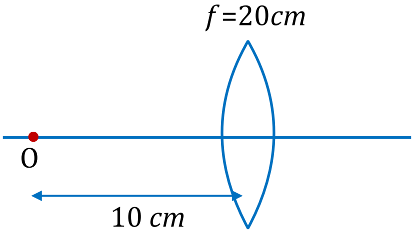
Focal length of concave lens (f_2)

$$\frac{1}{f_2} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{f_2} = (1.5 - 1)\left[-\frac{1}{20} - \frac{1}{20}\right] = \frac{1}{-20}$$

$\Rightarrow \quad \boxed{f_2 = -20\,cm}$

For lens 1

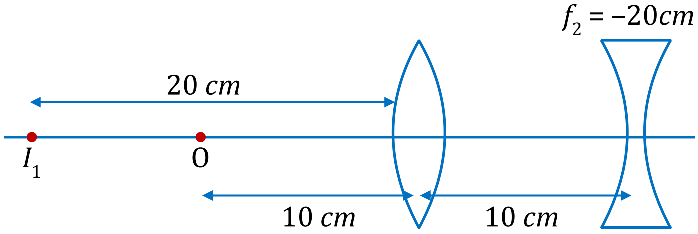


$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$\Rightarrow \quad \boxed{v = -20\,cm}$

$$m_1 = \frac{v}{u} = \frac{-20}{-10} = 2$$

For lens 2



$u = -30, f = -20, \dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

$\boxed{v = -12\,cm}$

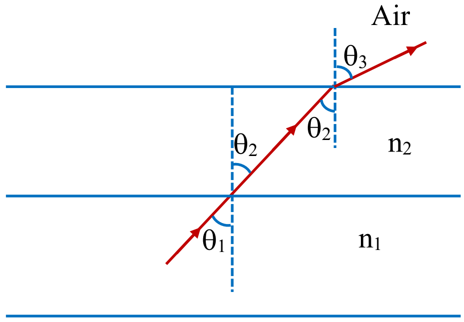
$$m_2 = \frac{v}{u} = \frac{-12}{-30} = \frac{2}{5}$$

Net magnification

$$m = m_1 m_2 = 2 \times \frac{2}{5} = \frac{4}{5} = 0.8$$

24. Ans. (BCD)

$\sin\theta > \frac{1}{n_1}(\text{Given})$



i.e. $\sin\theta_1 > \frac{1}{n_1}$

$n_1\sin\theta_1 = n_2\sin\theta_2$

$\sin\theta_2 = \frac{n_1\sin\theta_1}{n_2}$

If $n_1 = n_2$ then $\theta_2 = \theta_1$

$n_2\sin\theta_2 = (1)\sin\theta_3$

$\sin\theta_3 = n_2\sin\theta_2$

$\sin\theta_3 = n_1\sin\theta_1$

$\sin\theta_1 = \frac{\sin\theta_3}{n_1} > \frac{1}{n_1}$

$\sin\theta_3 > 1$

Which is not possible so our assumption for entering the ray in air is wrong.

This means ray cannot enter air

For $n_1 > n_2$; $\sin\theta_1 = \frac{n_2}{n_1}\sin\theta_2 > \frac{1}{n_1}$

$\sin\theta_2 > \frac{1}{n_2}$

For surface 2 – air interface

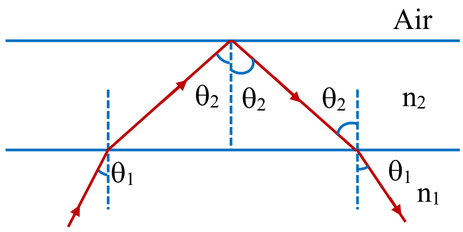
$n_2\sin\theta_2 = \sin\theta_3$

$\sin\theta_2 = \frac{\sin\theta_3}{n_2} > \frac{1}{n_2}$

$\Rightarrow$ $\sin\theta_3 > 1$; which is not true

It means ray is reflected back in medium-2

For surface 1 – surface 2 interface



$n_2\sin\theta_2 = n_1\sin\theta_1$

$\sin\theta_{2C} = \frac{n_1}{n_2}$

θ_{2C} : critical angle

For ray to enter medium-1

$\theta_2 < \theta_{2C}$

$\sin\theta_2 < \sin\theta_{2C}$

$$\frac{n_1}{n_2}\sin\theta_1 < \frac{n_1}{n_2}$$

$$\sin\theta_1 < 1$$

$\theta_1 < 90°$, which is true

Hence ray enters medium-1

For $n_2 > n_1$

$$\frac{n_2}{n_1}\sin\theta_2 > \frac{n_2}{n_1}$$

$$\sin\theta_2 > \frac{1}{n_2}$$

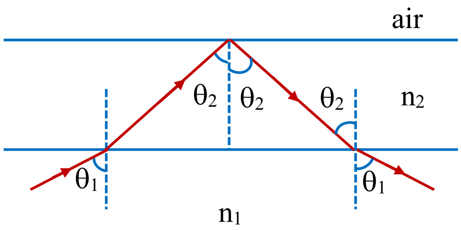
For surface 2 – air interface

$n_2 \sin\theta_2 = \sin\theta_3$

$$\sin\theta_2 = \frac{\sin\theta_3}{n_2} > \frac{1}{n_2}$$

$\Rightarrow$ $\sin\theta_3 > 1$; which is not true

It means ray is reflected back in medium - 2



$n_2 \sin\theta_2 = n_1 \sin\theta_1$

$$\sin\theta_1 = \frac{n_2}{n_1}\sin\theta_2$$

$$\sin\theta_{2c} = \frac{n_1}{n_2}\ ;\ \theta_{2c} \rightarrow \text{critical angle}$$

For ray to enter medium - 1

$\theta_2 < \theta_{2c}$

$\sin\theta_2 < \sin\theta_{2c}$

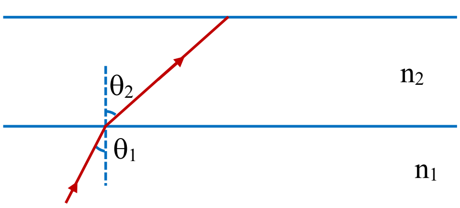
$$\frac{n_1}{n_2}\sin\theta_1 < \frac{n_1}{n_2}$$

$\sin\theta_1 < 1$

$\theta_1 < 90°$, which is true

Hence ray enters medium – 1

Let $n_2 = 1$



$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_2 = 1$

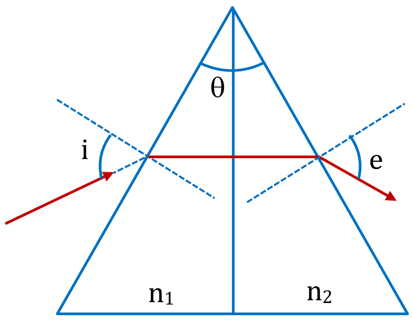
$n_1 \sin\theta_1 = \sin\theta_2$

$$\sin\theta_1 = \frac{\sin\theta_2}{n_1} > \frac{1}{n_1}$$

$\sin\theta_2 > 1$ which is not true

Ray is reflected back in medium.

25. Ans. (BC)



$$1 \times \sin i = n_1 \sin\left(\frac{\theta}{2}\right)$$

$$\sin i = \frac{3}{4}$$

$n_1 \sin 30° = 1 \sin(e)$

$$\Rightarrow \quad \frac{3}{2} \times \frac{1}{2} = \sin e$$

$$\Rightarrow \quad \sin e = \frac{3}{4} \text{ and } \cos e = \frac{\sqrt{7}}{4}$$

On differentiating both sides

$dn \sin 30° = de \cos(e)$

$$de = \frac{dn}{2\cos(e)}$$

$$= \frac{dn}{2 \times \frac{\sqrt{7}}{4}}$$

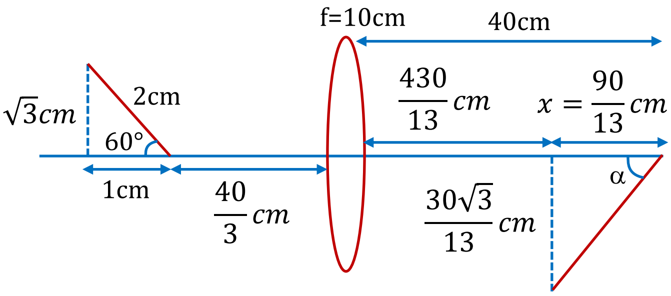
$$de = \frac{2}{\sqrt{7}} dn$$

$\Rightarrow \quad de < dn$

$$de = \frac{2.8 \times 10^{-3} \times 2}{\sqrt{7}} = 2.11\, mrad$$

26. Ans. (6)

$$\frac{h_i}{h_0} = \frac{v}{u} \Rightarrow \frac{-\frac{30\sqrt{3}}{13}}{\sqrt{3}} = \frac{v}{-\frac{43}{3}} \Rightarrow v_1 = \frac{430}{13} cm$$



$$* \ \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} = \frac{1}{10} - \frac{3}{40} \Rightarrow v = 40cm$$

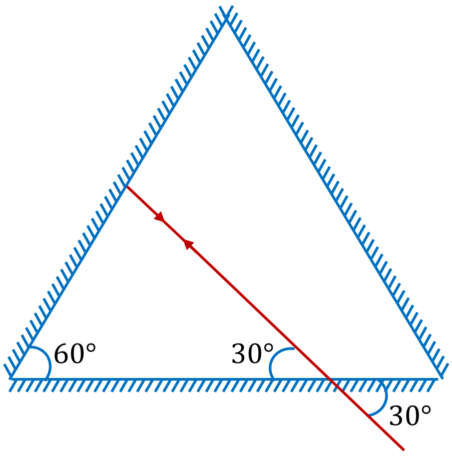
$$* \ x = 40 - \frac{430}{13} = \frac{90}{13} cm$$

$$\tan\alpha = \frac{\frac{30\sqrt{3}}{13}}{\frac{90}{13}} = \frac{1}{\sqrt{3}} \Rightarrow \alpha = 30° = \frac{\pi}{6}$$

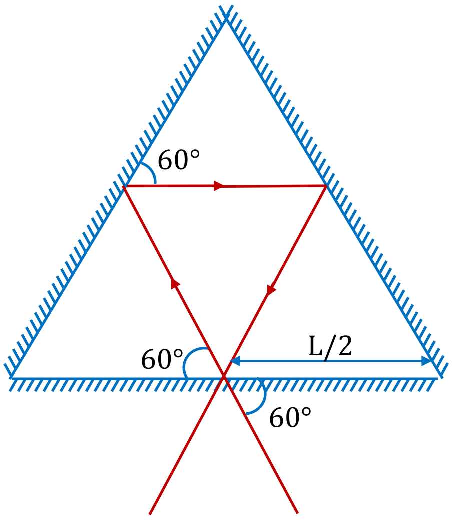
$N = 6$ Ans.

27. Ans. (AB)

(A) Ray will come out after one reflection for $\theta = 30°$ and $0 < \ell < L$

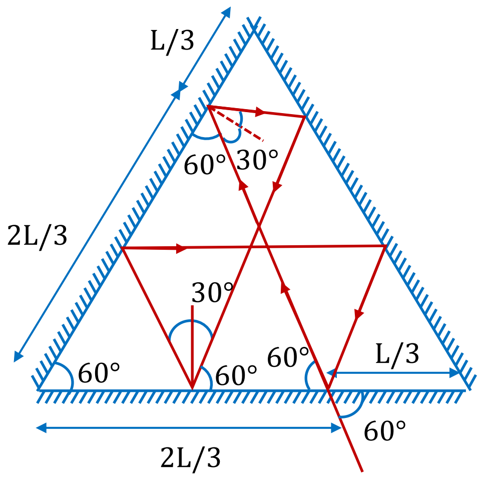


(B)

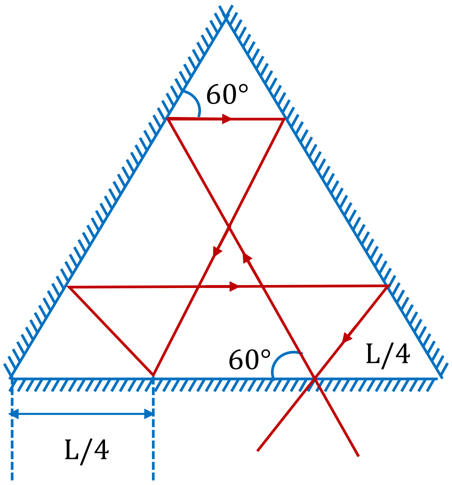


For $\theta = 60°$ and $\ell = \dfrac{L}{2}$, ray will come out after two reflections.

(C) For $\ell = \dfrac{L}{3}$ and $\theta = 60°$ ray will come out after five reflections.



(D) For $\theta = 60°$ and $0 < \ell < \frac{L}{2}$, ray will come out after five reflections



28. Ans. (A)

(I) $v_1 = \frac{uf}{u+f} = \frac{(-20)(10)}{(-20)+(10)} = +20$

$u_2 = +15$

$v_2 = \frac{(15)(15)}{(15)+(15)} = +7.5$

(II) $v_1 = +20$

$u_2 = +15$

$v_2 = \frac{(15)(-10)}{(15)+(-10)} = -30$

(III) $v_1 = +20$

$u_2 = +15$

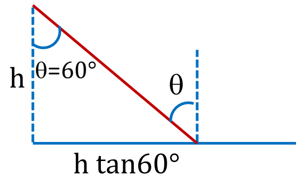
$v_2 = \frac{(15)(-20)}{(15)+(-20)} = 60$

(IV) $v_1 = \frac{(-20)(-20)}{(-20)+(-20)} = -10$

$u_2 = -15$

$v_2 = \frac{(-15)(10)}{(-15)+(10)} = 30$

29. **Ans. (4)**



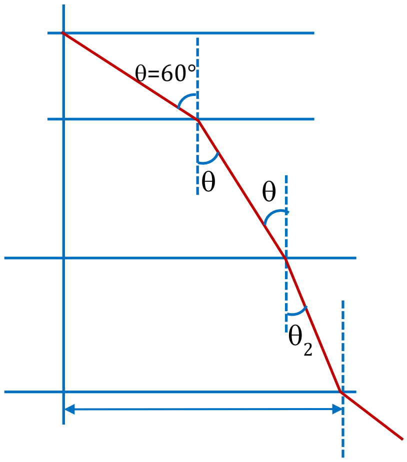
$$1\sin 60° = \sqrt{\frac{3}{2}}\sin\theta$$

$\Rightarrow$ $\theta_1 = 45°$

$$\sqrt{\frac{3}{2}}\sin 45° = \sqrt{3}\sin\theta_2$$

$$= \sqrt{\frac{3}{2}}\frac{1}{\sqrt{2}} = \sqrt{3}\sin\theta_2$$

$= \theta_2 = 30°$



h tan60° + d tan45° + d tan 30°

$$= \frac{1}{3}\sqrt{3} + \left(\frac{\sqrt{3}-1}{2}\right) + \left(\frac{\sqrt{3}-1}{2}\right)\frac{1}{\sqrt{3}}$$

$$= \frac{2\sqrt{3}+3\sqrt{3}-3+3-\sqrt{3}}{6}$$

$$= \frac{4\sqrt{3}}{6}$$

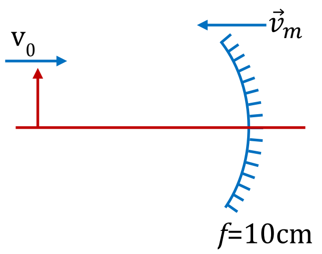
$$\therefore \quad n\frac{4\sqrt{3}}{6} = \frac{8}{\sqrt{3}}$$

$n = 4$

30. **Ans. (3)**

Let

y, x



$u = -30\ cm$

$f = -10\ cm$

$$v = \frac{f_0}{u-f} = -15cm$$

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

$$\frac{dv}{dt} = -\frac{v^2}{u^2}\frac{du}{dt}$$

$$\vec{v}_{\text{Im}} = -\left(\frac{v}{u}\right)^2 \vec{v}_{om}$$

Given $\vec{v}_{\text{I}} = \vec{0}$

$$\vec{v}_{\text{I}} - \vec{v}_m = -\left(\frac{-15}{-30}\right)^2 \left(\vec{v}_{0/m}\right)$$

$$\vec{v}_{\text{I}} - \vec{v}_m = -\frac{1}{4}\vec{v}_0 + \frac{1}{4}\vec{v}_m$$

$\vec{v}_0 = 15cm/s\,\hat{i}$

$\vec{v}_I = \vec{0}cm/s$

$\frac{5}{4}\vec{v}_m = \frac{\vec{v}_0}{4}$

$\vec{v}_m = \frac{\vec{v}_0}{4} = \frac{15cm/s\hat{i}}{5} = 3cm/s\,\hat{i}$

31. **Ans. (ACD)**

$\tan\theta_B = \mu_B = \sqrt{3}$

$i = \theta_B = 60°$

$1\sin 60° = \sqrt{3}\sin r_1$

$r_1 = 30°$

$r_1 + r_2 = A$

$\delta = (i + e) - A$

$60° = 60° + e - A$

$e = A$

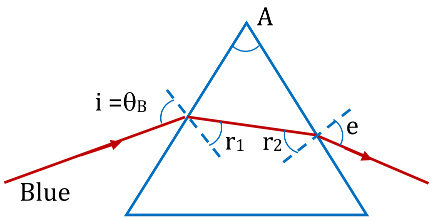
$\sqrt{3}\sin r_2 = 1\sin e$

$\sqrt{3}\sin(A - 30) = \sin A$

Solving

$A = 60°$

$\therefore\quad e = 60°$



For red light

$$\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\frac{A}{2}} = \sqrt{2}$$

32. **Ans. (80 or 150 or 220)**

Two cases are possible if Ist refraction on lens :

Since object is at focus $\Rightarrow$ light will become parallel.

Ist reflection at M_1 :-

Light is parallel $\Rightarrow$ Image will be at focus.

IInd refraction from L :-

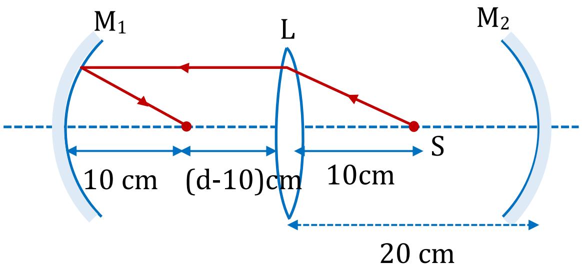
$u = -(d-10)$

$f = 10\ cm$

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

$\frac{1}{v} + \frac{1}{d-10} = \frac{1}{10}$

$\frac{1}{v} = \frac{1}{10} - \frac{1}{(d-10)}$ ...(i)



This v will be object for M_2, and image should be at 10 cm

$\frac{1}{\mu} + \frac{1}{v_1} = \frac{1}{f}$

$$-\frac{1}{(20-v)}-\frac{1}{10}=-\frac{1}{12}$$

$$\frac{1}{12}-\frac{1}{10}=\frac{1}{20-v}$$

$$-\frac{2}{120}=\frac{1}{20-v}$$

$20 - v = -60$

$v = 80\ cm$

From equation (i)

$$\frac{1}{80}=\frac{1}{10}-\frac{1}{d-10}$$

$$\frac{1}{d-10}=\frac{1}{10}-\frac{1}{80}$$

$$\frac{1}{d-10}=\frac{80-10}{800}=\frac{70}{800}$$

$$d-10=\frac{80}{7}\Rightarrow d=10+\frac{80}{7}=\frac{150}{7}$$

$$\boxed{n=150}$$

Case-2: If 1st reflection on mirror m_2

For m_2

$$\frac{1}{V_1}+\frac{1}{-10}=\frac{1}{-12}$$

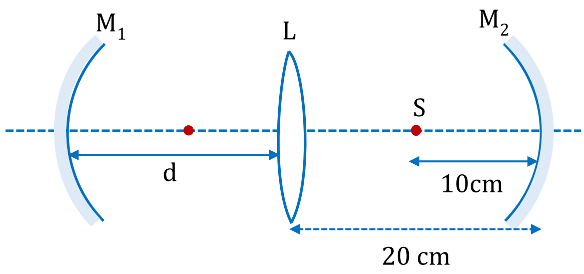
$V_1 = 60$ cm

Then refraction on lens L

$u_2 = -80\ cm$

$$\frac{1}{V_2}-\frac{1}{-60}=\frac{1}{10}$$

$$V_2=\frac{80}{7}$$



Then reflection on m_2

Either V_2 is at centre (normal incidence)

$$d-\frac{80}{7}=20$$

$$d=\frac{220}{7}$$

$$\frac{n}{7}=\frac{220}{7}$$

$$\boxed{n=220}$$

V_2 is at pole of m_2

$$d-\frac{80}{7}=0$$

$$d=\frac{80}{7}$$

$$\frac{n}{7}=\frac{80}{7}$$

$$\boxed{n=80}$$

33. Ans. (1)

$u = 10 \pm 0.1\ cm, v = 20 \pm 0.2\ cm$

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{v^2}dv+\frac{1}{u^2}du=-\frac{1}{f^2}df$$

$$\frac{1}{20}+\frac{1}{10}=\frac{1}{f} \Rightarrow \frac{1}{f}=\frac{3}{20} \Rightarrow f=\frac{20}{3}cm$$

$$\Rightarrow \frac{1}{(20)^2}(0.2)+\frac{1}{(10)^2}(0.1)=\frac{9}{400}df$$

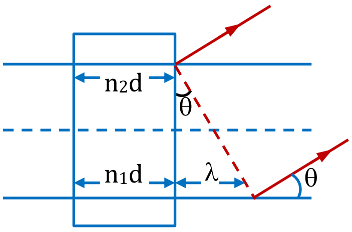
$$df=\frac{1}{9}\left(\frac{400}{400}\times 0.2+\frac{400}{100}\times 0.1\right)$$

$$df=\frac{1}{9}(0.2+0.4) \Rightarrow df=\frac{0.6}{9}$$

$$\frac{df}{f}=\frac{0.6}{9}\times\frac{3}{20}=\frac{1}{100}$$

% error = 1 %

34. Ans. (BD)



$n_1 d + \lambda = n_2 d$

$$\tan\theta=\frac{\ell}{h}=\frac{(n_2-n_1)d}{h}$$

JEE (Main) Practice Paper

SECTION–A

1. Ans. (1)

$L = V_0 + u_e$

when v_0 increases u_e also increase.

$$MP=\frac{V_0}{u_0}\frac{D}{u_e}=\text{Decrease}$$

2. Ans. (1)

$\sin i_c = \frac{1}{\mu}$ and $\lambda \propto \frac{1}{u}$

So colors having wavelength greater than green will emerge.

3. Ans. (3)

$$\omega=\left(\frac{\mu_v-\mu_r}{\mu_y-1}\right) \text{same for both prism}$$

$$\frac{\omega_1}{\omega_2}=1$$

4. **Ans. (3)**

$\theta = (\mu_v - \mu_r)A$

5. **Ans. (1)**

At minimum deviation, $i = e$.

$\delta_{min} = 2i - A$

$60° = 2(60°) - A$

So, $A = 60°$

Now, $\mu = \dfrac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \dfrac{\sin(60°)}{\sin(30°)} = \sqrt{3}$

6. **Ans. (2)**

$\delta_m = 2i - A$ ...(i)

and $r_2 + r_1 = A$ ...(ii)

put in (i)

i = 45°

7. **Ans. (2)**

For rays moving from rarer to denser medium, refracted light move towards normal and vice-versa.

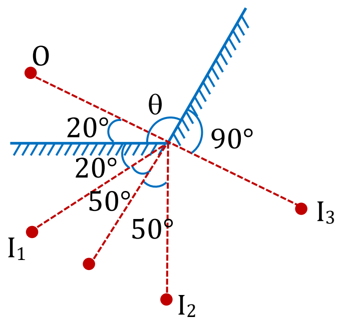
8. **Ans. (2)**

$v_1 = \dfrac{c}{4/3} \Rightarrow \dfrac{3c}{4}, v_2 = \dfrac{c}{8/5} \Rightarrow \dfrac{5c}{8}$

$v_2 = \dfrac{5}{6}v_1$

9. **Ans. (2)**

By ray diagram



10. **Ans. (2)**

Distance of object is equal to focal length

So, $u = \pm f$

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

$\dfrac{1}{v} + \dfrac{1}{\pm f} = \dfrac{1}{f}$

$v = 2f, \infty$

11. **Ans. (1)**

The speed of image observed by observer is independent of the glass slab.

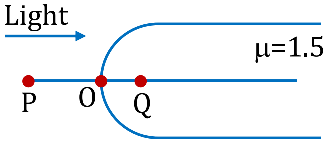
12. **Ans. (1)**

$v = OQ$, $u = OP = -2OQ$

Equation of refraction at curved surface with $OP = 2OQ$

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\Rightarrow \frac{1.5}{OQ} - \frac{1}{-2OQ} = \frac{1.5-1}{R}$$



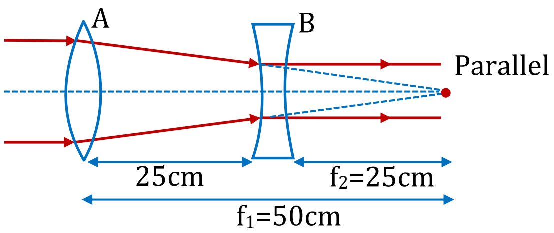
$$\Rightarrow \frac{2}{OQ} = \frac{1}{2R}$$

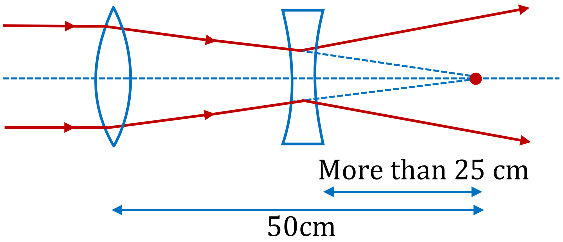
$$\Rightarrow OQ = 4R$$

Therefore, $OP = 2OQ = 2 \times 4R = 8R$

13. **Ans. (1)**

Initially





14. **Ans. (3)**

for I lens u = +5 cm , v = ∞ so, f = -5 cm

for II lens f = + 5 cm

15. **Ans. (1)**

f_A = 24 cm

$$\frac{4/3}{60} - \frac{3/2}{V_1} = \frac{4/3 - 3/2}{-10}$$

$$\frac{1}{48} = (1.5-1)\left(\frac{1}{R}\right) \Rightarrow R = 24cm$$

For B

$$\frac{1}{f} = -(1.6-1)\left(\frac{2}{24}\right) \Rightarrow f = -20cm$$

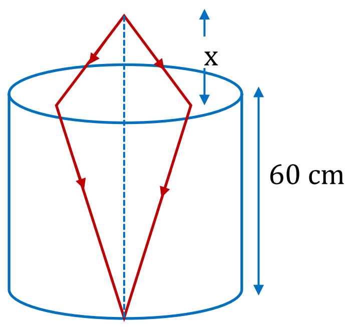
$$\frac{1}{f} = \frac{1}{48} + \frac{1}{48} - \frac{1}{20} \Rightarrow f_B = -120cm$$

16. **Ans. (2)**

$$\frac{\mu_2}{V}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

$$\frac{3/2}{V_1}+\frac{1}{x}=\frac{3/2-1}{10} \qquad \text{...(i)}$$

$$\frac{4/3}{60}-\frac{3/2}{V_1}=\frac{4/3-3/2}{-10} \qquad \text{...(ii)}$$



By eq, (i) & (ii)

$x = 22.5\ cm$

17. **Ans. (1)**

$$\frac{1}{f_{eq}}=\frac{1}{f_m}=\frac{2}{f_\ell} \qquad \text{...(i)}$$

$$\frac{1}{f_\ell}(1.5-1)\left[\frac{1}{\infty}-\frac{1}{(-30)}\right]= \ f_\ell=+60\ cm \text{ and } f_m = -15\ cm$$

from (i)

$f_{eq} = -10\ cm$

So, radius of curvature of mirror = 20 cm

For this distance the image will be real and of same size.

18. **Ans. (3)**

For refraction at curved surface, (near normal incidence)

$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$ [R is $-ve$. For real object u is $-ve$ and for virtual object u is $+ve$.]

19. **Ans. (2)**

$$\frac{\delta_w}{\delta_a}=\frac{\left(\frac{7}{6}-1\right)}{\left(\frac{3}{2}-1\right)}=\frac{1}{3}$$

$$\Rightarrow \quad \frac{\delta_a}{\delta_w}=3$$

20. **Ans. (3)**

$$\frac{1}{v}-\frac{1}{\infty}=\frac{1-n}{-R}$$

$$10=v=\frac{R}{n-1}=\frac{10}{n-1}$$

$\Rightarrow \quad n = 2$

$$\frac{2}{v_1}-\frac{1}{\infty}=\frac{2-1}{10}$$

$v_1 = 20\ cm$

$d_0 = 10\ cm$

$$\frac{10}{2}=\frac{dI}{1}$$

$\Rightarrow \quad d_I = 5\ cm$

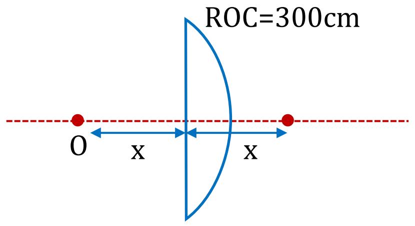
SECTION–B

1. **Ans. (3)**

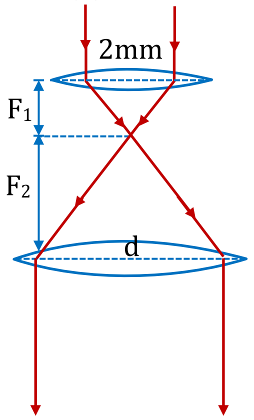
$$\frac{1}{f} = \left(\frac{\mu_L}{\mu_S} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

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

$v = -u = x$



2. **Ans. (5)**



Similar triangles $\frac{2mm}{F_1} = \frac{d}{F_2}$

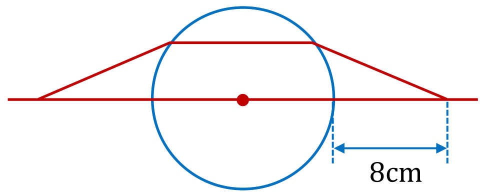
$d = (2mm)\left(\frac{100cm}{40cm}\right) = 5mm$

3. **Ans. (8)**

For first refraction $\frac{2}{v} + \frac{1}{8} = \frac{2-1}{8} = \frac{1}{8}$

$\Rightarrow \quad \frac{2}{v} = 0$

$v = \infty$



It means after first refraction ray become parallel to axis and since power of surface in same from both side, therefore, image will form at a distance 8 *cm* from the nearest surface.

4. **Ans. (5)**

Distance of meeting point of refracted rays will be $\frac{h}{\mu_{rel}} = \frac{2}{1/(5/2)} = 5cm$

5. **Ans. (42)**

For convex mirror, object is at θ_1.

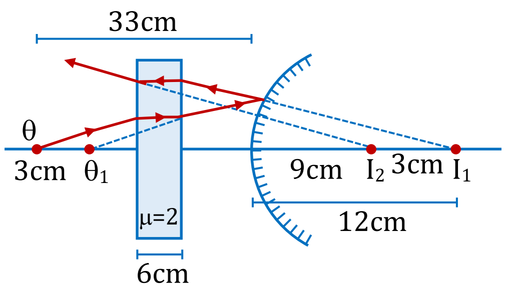
and shift $\theta_1 = t\left(1 - \frac{1}{\mu}\right)$

$= 6\left(1 - \frac{1}{2}\right) = 3cm$

$u_1 = -(30\ cm)$ from mirror

$f_x = +\frac{R}{2} = +20\ cm$

$$\frac{1}{v_1} + \frac{1}{u_1} = \frac{1}{f_1}$$



Position of I_1, $v_1 = \frac{u_1 f_1}{u_1 - f_1} = +12cm$ behind miror.

Shift $I_1 I_2 = t\left(1 - \frac{1}{\mu}\right) = 3cm$

After reflection final image is at $I_2 = 9\ cm$ behind mirror.

So, separation between object θ and final image $I_2 = 33 + 9 = 42\ cm$.

6. Ans. (15)

One end of image is touching rod, this point will be at centre of curvature. (C), image is elongated, so, it will be away from centre C and object will be between C and F.

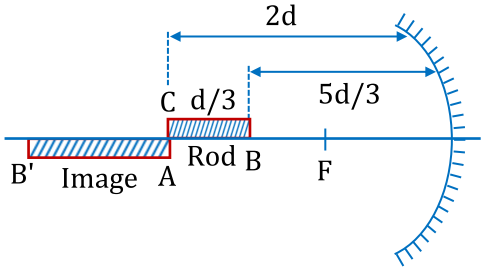
For point B of rod,

$f = -d$, $u = \frac{-5d}{3}$ $\quad (d = 30\ cm)$

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

$v = -\frac{5d}{2}$ is position of B'

So, length of image is $= \frac{5}{2} - 2d \;=\; \frac{d}{2} = 15\ cm$



7. Ans. (2)

$\vec{v}_0 = 5\hat{\imath} + 5\sqrt{3}\hat{\jmath}$

$\vec{v}_I = -15\hat{\imath} + 5\sqrt{3}\hat{\jmath}$

Taking dot product cos θ is zero.

8. Ans. (50)

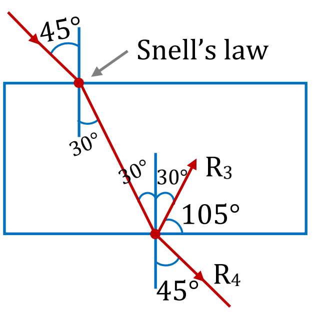
$m = -\frac{f}{u - f} = -\frac{f}{-f - f} = \frac{1}{2}$

$\therefore \quad h_I = mh_0 = \frac{1}{2} = 0.5\ m$

9. Ans. (105)

$\sin \theta_C = \frac{1}{\mu} = \frac{1}{\sqrt{2}}$

$\theta_C = 45°$



10. Ans. (3)

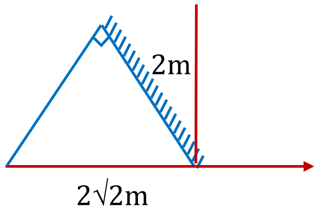
$(\mu_1 - 1)A_1 - (\mu_2 - 1)A_2 = 0$

$\delta_1 + \delta_2 = 0$

JEE (Advanced) Practice Paper

1. Ans. (D)

$$t = \frac{x}{v} = \frac{2\sqrt{2}\times 100}{4} = 50\sqrt{2}\text{ sec}$$



2. Ans. (B)

Length of the image of rod = $L+\frac{L}{\mu}$

3. Ans. (B)

$\theta > \theta_c$

n sin θ > 1 , because n sin θ_c = 1×1= 1

$\frac{n}{\sqrt{2}} > 1 \Rightarrow n > \sqrt{2}$

4. Ans. (C)

$$\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\Rightarrow \quad \frac{1}{V} - \frac{1.5}{(-6)} = \frac{1-1.5}{(-6)}$$

$\Rightarrow \quad V = -6\ cm \quad \Rightarrow \quad |v| = 6\ cm$

5. Ans. (C)

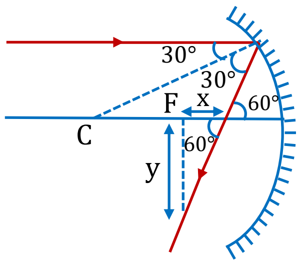
$P = P_L + P_m + P_L$

$P_{\text{net}} = \left(\frac{4\mu-2}{R}\right)$

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

$u = 2f$

6. Ans. (B)



$$\frac{y}{x} = \tan 60^0 = \sqrt{3} \Rightarrow \frac{x}{y} = \frac{1}{\sqrt{3}}$$

7. Ans. (B)

$d = i + e - A$

$30 = 90 - A$

$A = 60°$

$$\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\frac{A}{2}}$$

$$\mu = \frac{\sin 45}{\sin 30} = \sqrt{2}$$

8. Ans. (D)

If first image is at focal point of both lenses then beam emerging from the second lens will be parallel.

9. Ans. (A)

$$\frac{4}{3}\times\frac{1}{2} = \mu \sin r$$

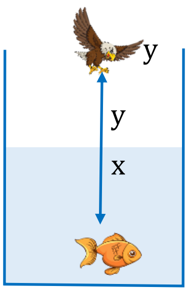
$$\sin r = \frac{2}{3\times 2}\left(1+y^2\right) = \frac{\left(1+y^2\right)}{3}$$

$$\cot r = \frac{dy}{dx} = \frac{\sqrt{9-\left(1+y^2\right)^2}}{\left(1+y^2\right)} = 0$$

$9 - (1 + y^2) = 0$

$y = \sqrt{2}$

10. Ans. (A)



$$\frac{x_{Bf}}{\mu_f} = \frac{y}{1} + \frac{x}{\mu} \Rightarrow x_{Bf} = \mu y + x$$

$$\frac{dx_{Bf}}{dt} = \mu\frac{dy}{dt} + \frac{dx}{dt} = \frac{4}{3}(-12) + 24$$

v= 8 m/s upward

11. **Ans. (B)**

For minimum deviation.

$i = e$

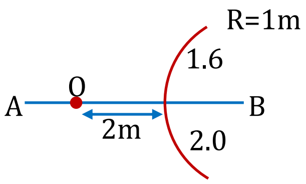
But here, $i \neq e$,

So, $\delta_{min} < \delta = (i + e - A)$

$= 30°$

So, $\delta_{min} < 30°$

12. **Ans. (A)**



$I_1 \Rightarrow \dfrac{1.6}{v} - \dfrac{1}{-2} = \dfrac{1.6-1}{+1} \Rightarrow v_1 = 16$

$I_2 \Rightarrow \dfrac{2.0}{v} - \dfrac{1}{-2} = \dfrac{2-1}{1} \Rightarrow v_2 = 4$

$|v_1 - v_2| = 12\ m$

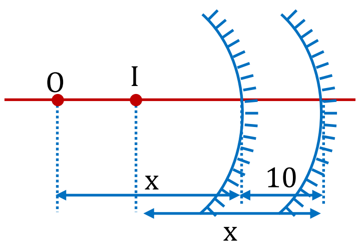
13. **Ans. (ABC)**

For yellow : $(\mu_g)_y = (\mu_{liq})_y$ = No deviation

For red : $\lambda_R > \lambda_{yellow}\ (\mu_g)_R > (\mu_{liq})_R \Rightarrow$ Towards base

For blue : $\lambda_b < \lambda_{yellow}\ (\mu_g)_B < (\mu_{liq})_B \Rightarrow$ Towards vertex

14. **Ans. (C)**



$m = -\dfrac{x}{10+x} = -\dfrac{2}{3}$ ...(i)

On solving (i), we get $x = 20 \Rightarrow x + d = 30\ cm$

15. **Ans. (D)**

$\dfrac{1}{30} + \dfrac{1}{20} = \dfrac{1}{f} \Rightarrow f = 12\ cm$

16. Ans. (A)

$u - 20\ cm$

$f = -12\ cm$

$v = -30\ cm$

$m = -v/u = -3/2$

17. Ans. (1)

$x = \frac{y^2}{2}$

$\frac{dy}{dx} = \frac{1}{y}$, at $y = 1$, slope = 1

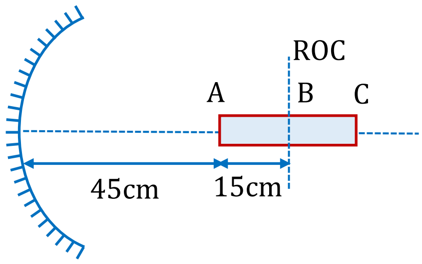
$\angle i = 45°$

$\therefore \quad \angle r = 45°$ *so* deviation in first reflection = 90°.

Similarly, for second reflection, Net deviation = 180°.

18. Ans. (4)

For A : $\frac{1}{V} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{V} = \frac{1}{f} - \frac{1}{u} = -\frac{1}{30} - \left(-\frac{1}{45}\right)$



For C : $u = -75cm; f - 30cm$

So, V = –50 cm

Now, length of image = 40 cm