Exercise-1

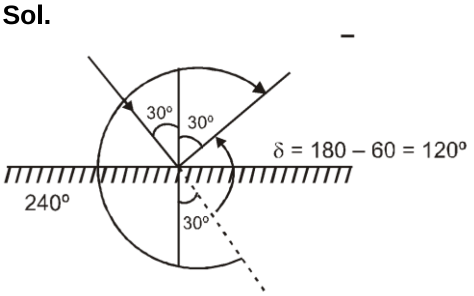
Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

Section (A) : Plane Mirror

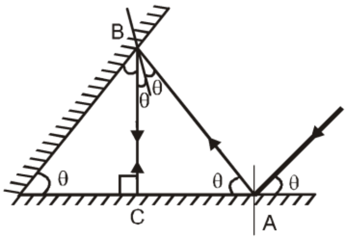
A-1. Sol. 11: 60 – 08 : 20 = 3 : 40

A-2. Sol.



δ = 120° Anticlockwise = (360° – 120°) clockwise

A-4.# Sol.



in ΔABC $\qquad 90 + 3\theta = 180° \Rightarrow \qquad \theta = 30°$

A-5. Sol. $\vec{V}_0 = 3\hat{i} + 4\hat{j} + 5\hat{k} \quad \vec{V}_m = 4\hat{i} + 5\hat{j} + 8\hat{k}$

$V_{IZ} = 2\,V_{mz} - V_{oz} = 2 \times 8 - 5 = 11$

$V_{Ix} = V_{ox} = 3$

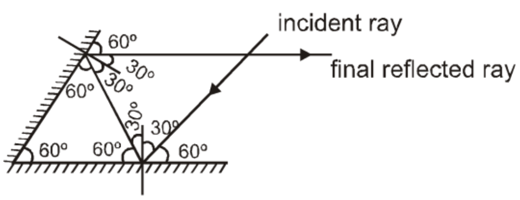
$V_{Iy} = V_{oy} = 4 \quad \Rightarrow \quad \vec{V}_I = 3\hat{i} + 4\hat{j} + 11\hat{k}$

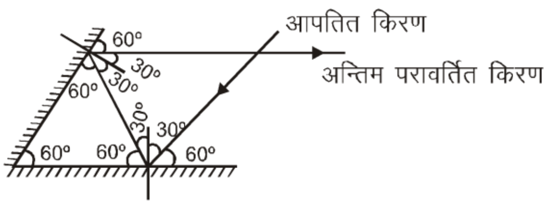
A-6. Sol. $n = \left(\frac{360}{72} - 1\right) = 4$

A-7. Sol. $L_{min} = \frac{H}{2} = \frac{180}{2} = 90$ cm

A-8. Sol. A thick mirror forms a number of images. Image is formed by front surface which is unpolished and hence, reflects only a small part of light, while second image is formed by polished surface which reflects most of intensity. Hence second image is brightest.

A-9. Sol.





final ray is II to first mirror.

Section (B) : Spherical Mirror

B-1. **Sol.** $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

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

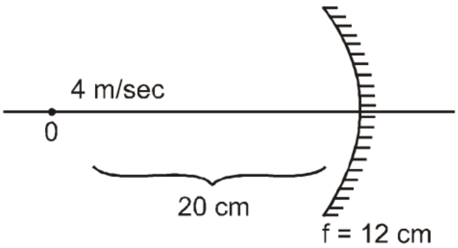
$v=\frac{f}{2}$

B-2. **Sol.** $v=\frac{u}{4}$ $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

u = 90 cm

B-4. **Sol.** When objects is at the centre of curvature C then its image is also at C

B-5. **Sol.**



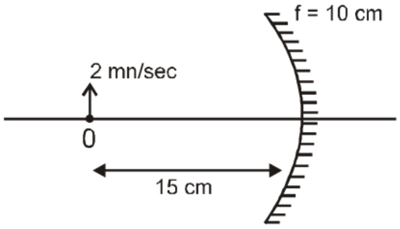
$\frac{1}{f}=\frac{1}{V}+\frac{1}{4}$ $\frac{1}{-12}=\frac{1}{V}+\frac{1}{-20}$ $\Rightarrow$ $\frac{1}{V}=\frac{1}{20}-\frac{1}{12}$

$\Rightarrow$ V = – 30 cm

velocity of image $\frac{dV}{dt}=-\left(\frac{V^2}{u^2}\right)\frac{du}{dt}=-\left(\frac{-30}{-20}\right)^2 4.$ = – 9 cm/sec.

$\Rightarrow$ 9 cm/sec away from mirror

B-6. **Sol.**

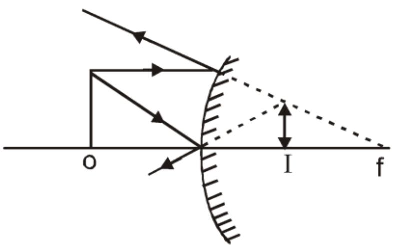


$\frac{1}{f}=\frac{1}{V}+\frac{1}{u}$ $\Rightarrow$ $\frac{1}{-10}=\frac{1}{V}+\frac{1}{-15}$ $\Rightarrow$ $\frac{1}{V}=\frac{2-3}{30}$ V = – 30 cm.

$m=\frac{I}{0}=-\frac{V}{u}=-\frac{-30}{-15}$ I = 20

$\frac{dI}{dt}=2\frac{dO}{dt}$ = 4 mm/sec.

B-7. **Sol.**



B-8.# **Sol.** for real inverted image by concave mirror.
V = – ve , u = – ve f = – ve

$\Rightarrow \frac{u}{f}$ & $\frac{V}{f}$ are positive $\Rightarrow$ 1 is right answer

B-9. **Sol.** v = 2u

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

u = – 30 cm

B-10.# **Sol.** $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$

$\left(\frac{1}{v}-\frac{-1}{4}+\frac{1}{f}\right)$ Straight line with n slope

Section (C) : Refraction in general , Refraction at plane surface and T.I.R.

C-1. **Sol.** For TIR medium at refraction must be rarer.

C-2. **Sol.** $x = \frac{24}{\frac{1}{1}/\frac{4}{3}} = \frac{24}{\left(\frac{3}{4}\right)} = \frac{24 \times 4}{3}$ = 32 cm

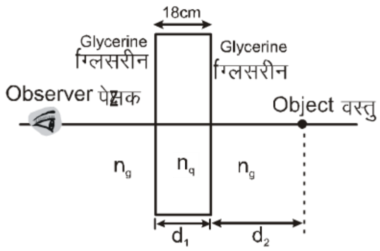
C-3. **Sol.** $t = \frac{x}{v} = \frac{x\mu}{c}$

C-5. **Sol.** $5 + 2 = \frac{t_1}{1.5} + \frac{t_2}{1.5} \Rightarrow 7 \times 1.5 = t_1 + t_2$
$10.5 = t_1 + t_2$

C-6. **Sol.** $\frac{3}{2}\sin C = \frac{4}{3}\sin 90° \Rightarrow C = \sin^{-1}\left(\frac{8}{9}\right)$

C-7. **Sol.** $\mu = \frac{\lambda_V}{\lambda_m} = \frac{6000}{4000} = 1.5$

C-9.# **Sol.** $n_{quartz} = 2$; $n_{glyarine} = \frac{4}{3}$ $\frac{n_{quartz\ DokVZ}}{n_{glyarine\ fXyljhu}} = \frac{2}{4/3} = \frac{3}{2} = \mu_{rel}$



shift $= t\left(1-\frac{1}{\mu_{rel}}\right) = 18\left(1-\frac{1}{3/2}\right) = 6$ cm

C-10. **Sol.** $\mu_d \sin i = \mu_r \sin 2i$

$\mu_d = 2\,\mu_r \cos i$

$i = \cos^{-1}\left(\frac{\mu_d}{2\mu_r}\right) = \cos^{-1}\left(\frac{\mu}{2}\right)$

Section (D) : Refraction by Prism

D-1. **Sol.** $\sqrt{2}\sin 30° = \sin e$

$e = 45°$

Deviation $= 45° - 30° = 15°$

D-2. **Sol.** $i = e$ $\quad r_1 = r_2 = \frac{A}{2} = 30°$

$\sin i = \sqrt{2}\sin 30°$

$i = 45°$

D-3. **Sol.** $r_1 + r_2 = 30°$ $\quad \frac{\sqrt{3}}{2} = \mu \sin r_1$

$\mu \sin r_2 = \frac{1}{2}$

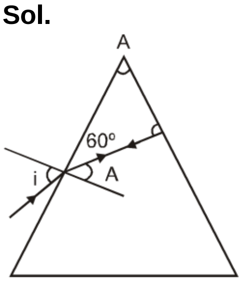
$\mu = \sqrt{3}$

D-5. **Sol.** $r_2 = \sin^{-1}\left(\frac{1}{\mu}\right) = 45^o$

$r_1 = A - r_2 = 75^o - 45^o = 30^o$

$\frac{\sin i}{\sin r_1} = \sqrt{2}$ $\quad\Rightarrow\quad \sin i = \sqrt{2}\sin 30 = \sqrt{2}\times\frac{1}{2}$ $\quad\Rightarrow\quad i = 45^o$.

D-6. **Sol.**



$\frac{\sin i}{\sin A} = \mu$

since i and A are small angle. $\frac{i}{A} = \mu$

D-7. Sol. Deviation by prism.

$\delta_1 = A(\mu - 1) = 4^o (1.5 - 1)$ $\Rightarrow$ $\delta_1 = 2^o$

for plane mirror

$i = 2^o$

$\delta_2 = 180 - 21 = 176^o$ $\Rightarrow$ $\delta = \delta_1 + \sqrt{2} = 178^o$

Section (E) : Refraction by spherical Surface

E-1. Sol. $\frac{n_R - n_i}{R} = \frac{n_R}{v} - \frac{n_i}{u}$

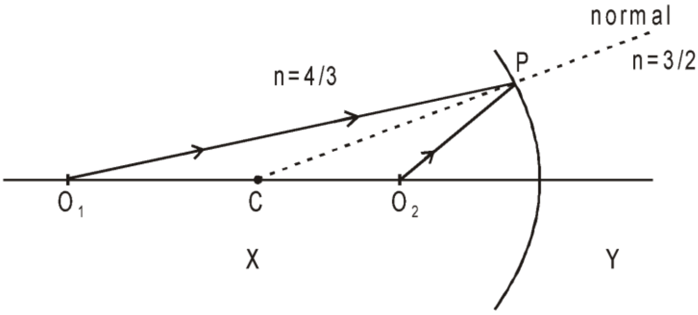
$\frac{2-1}{10} = \frac{2}{v} - \frac{1}{-20}$ $\Rightarrow$ $v = 40$ cm

E-2. Sol. $\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ $\frac{\mu_2}{V} - \frac{\mu_1}{-R} = \frac{\mu_2 - \mu_1}{-R}$

$V = -R$ for all values of μ .

E-3.# Sol. $\frac{1}{V} - \frac{3}{2\times 30} = \frac{1-\frac{3}{2}}{+20}$ $\frac{1}{V} = -\frac{1}{40} + \frac{1}{20} = +\frac{1}{40}$ $V = 40$ cm.

E-4 Sol. **(Moderate)** Let there be two point objects O_1 and O_2, Incident rays from O_1 and O_2 at point P shall both bend towards normal and hence the corresponding refracted rays shall intersect the principal axis in the left medium. Therefore image formed under given condition shall always be virtual.



Section (F) : Lens

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

$\frac{1}{f} = 0$ $\Rightarrow$ $f = \infty$

F-2. Sol. $\frac{1}{f} = (\mu_{rel} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $(R_1 = R, R_2 = -R)$

F-3. Sol. From displacement method

$O = \sqrt{I_1 I_2}$

O = $\sqrt{9 \times 4}$ = 6 cm

F-4. **Sol.** $\because$ u < f

so image is virtual, enlarged and at a distance of 10 cm from the lens.

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

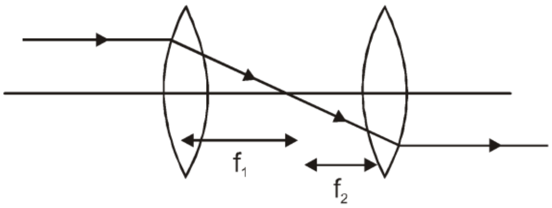
F-5. **Sol.** $n_{rel} < 1$

So, f is negative

F-6. **Sol.** Lens changes its behaviour if R.I. of surrounding becomes greater than R.I. of lens.

$\mu_{lens} < 1.33$

F-7. **Sol.**



Distance between lens is = $f_1 + f_2$,

F-8.# **Sol.** for vertical erect image by diverging lens.

$u = -V_i$, $V = -V_i$ $f = -V_i$

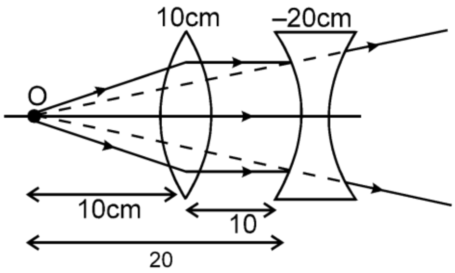
$\frac{4}{f} = -Vi$ and $\frac{V}{f} = +Vi$

$\frac{1}{f} = \frac{1}{V} - \frac{1}{4}$ $1 = \frac{f}{V} - \frac{f}{4}$ $\frac{1}{f} = \frac{1}{x} + 1$

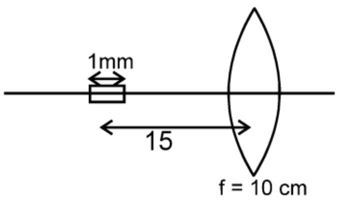
$y = \frac{x}{x+1}$ since x & y are +ve graph lens in first co-ordinate.

F-9.#

Sol.



F-10. **Sol.**



$\frac{1}{10} = \frac{1}{v} = -\frac{1}{(-15)}$ $\Rightarrow$ v = + 30 cm for small object $dv = \frac{v^2}{u^2} du = \left(\frac{30}{15}\right)^2 \times 1 = 4$ mm

F-11. **Sol.** $f_A = f_B = f_C = f_{net} \Rightarrow P_A = P_B = P_C = P_{net} = P$

F-12.# **Sol.** $\mu_1 = \mu_3$ since there is no bending at first surface. $\mu_3 < \mu_2$ since the ray bends towards normal as it passes from μ_3 to μ_2 medium.

F-14_ **Sol.** $\frac{dv}{dt} = \frac{v^2}{u^2} \cdot \frac{du}{dt}$ (where $\frac{dv}{dt}$ denotes image speed w.r.t. lens and $\frac{du}{dt}$ denotes object speed w.r.t. lens)

$= m^2 \cdot \frac{du}{dt} = \frac{1}{4} .8 = 2$

Therefore image speed w.r.t. lens is 2 m/s towards left.

Therefore image speed w.r.t. ground is 3 m/s towards right.

Section (G) : Combination of thin Lens/Lens and Mirrors.

G-1. **Sol.** $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2} = 0$

$= \frac{1}{25} + \frac{1}{-20} - \frac{d}{-500} = 0$

$= \frac{20-25}{500} = -\frac{d}{500}$

d = 5 cm.

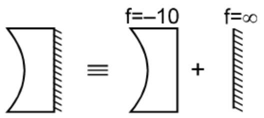
G-2. **Sol.** $P = P_1 + P_2$

$= + 4 + (-3) = + 1$

G-3. **Sol.** $P_L = P_1 + P_2$

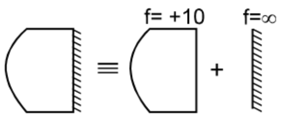
$P_L = \frac{1}{f_L}$

G-4. **Sol.**



$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_L} = 0 - \frac{2}{-10} \Rightarrow F = 5$

G-5_ **Sol.**



$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_L} = 0 - \frac{2}{10} \Rightarrow F = 5$

Section (H) : Dispersion of Light

H-1. **Sol.** $\omega = \left(\frac{\mu_v - \mu_r}{\mu_y - 1}\right)$

H-2. **Sol.** μ_{red} = minimum

H-3. Sol. $\omega = \left(\frac{1.62 - 1.42}{1.5 - 1}\right) = \frac{0.2}{0.5} = \frac{4}{10} = 0.4$

H-4. Sol. $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ for achromatic lens

$\frac{\omega_1}{\omega_2} = -\frac{30}{(-10)} = 3$

H-7. Sol. $C = \sin^{-1}\left(\frac{1}{\mu}\right)$

μ is greatest for voilet

$\Rightarrow$ C is minimum for voilet.

H-8. Sol. Apparent shift $t\left(1 - \frac{1}{\mu}\right)$

μ is least for red $\Rightarrow$ shift in least for red.

H-9. Sol. $\omega = \frac{n_v - n_r}{\left(\frac{n_v + n_r}{2}\right) - 1} = \frac{6}{25}$.

H-10. Sol. ω depends only on material property.

H-11. Sol. Dispersion will not occur for a light of λ = 4000 Å.

Section (I) : Defects of vision

I-1. Sol. $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{-60} - \frac{1}{-10} = \frac{-1+6}{60} = \frac{5}{60} = \frac{1}{12} \Rightarrow f = 12$

I-2. Sol. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{(-40)} - 0 = \frac{1}{f}$

f = – 40 cm

$P_L = \frac{1}{f_L} = -2.5$ D

I-3. Sol. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

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

f = –50 cm

$P_L = \frac{1}{f_L} = -2$D

Section (J) : Optical instruments

J-1. **Sol.** MP = $\left(1+\frac{D}{f}\right) = \left(1+\frac{25}{5}\right)$ = 6

J-3. **Sol.** In normal adjustment

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

so $50 = \frac{100}{f_e}$ $\Rightarrow$ $f_e = 2$ cm

($\because$ eyepiece is concave lens)

and $L = f_0 - f_e = 100 - 2 = 98$ cm

J-8. **Sol.** For normal adjustment

$m = -\frac{f_0}{f_e}$

When final image is at least distance of distinct vision from eyepiece,

$m' = -\frac{f_0}{f_e}\left(1+\frac{f_e}{d}\right) = 10\left(1+\frac{5}{25}\right) = 12$

J-9. **Sol.** $f = \frac{1}{p} = \frac{1}{2}$ metre

f = 0.5 m this is positive so lense is convex lense.

Exercise-2

Marked Questions can be used as Revision Questions.

PART - I : OBJECTIVE QUESTIONS

1.# **Sol.** Deviation by prism = $A(\mu - 1)$

For 90º total deviation, deviation by mirror

= 90 – 2 = 88º

180º – 2i = 88º

2i = 92º

i = 46º

Mirror should be rotated 1º anticlockwise.

2.# **Sol.** For refraction by upper surface

$\frac{1.6}{V_1} - \frac{1}{-2} = \frac{1.6-1}{1}$

$\Rightarrow$ $\frac{1.6}{V_1} = 0.6 - 0.5 = 0.1$

$V_1 = 16$ m

For refraction by lower surface

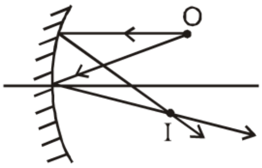
$$\frac{2}{V_2} - \frac{1}{-2} = \frac{2-1}{1}$$

$$\frac{2}{V_2} = 1 - 0.5 = 0.5$$

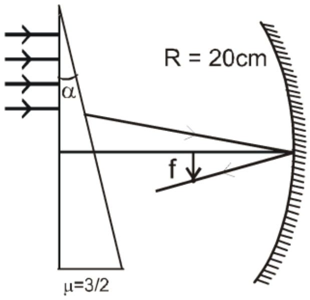
$$V_2 = \frac{2}{0.5} = 4\text{m}$$

Distance between images = (16 – 4) = 12m.

3.# **Sol.**



4.# **Sol.** Division by prism $= 1.8\left(\frac{3}{2}-1\right) = 0.9$



R = 20 cm

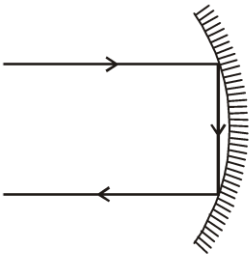
Since, incident ray is almost perpendicular to P-axis

Image will form of focus

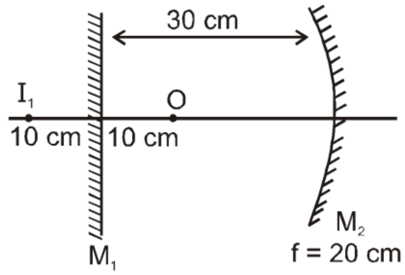
Distance of image from P–axis

$= 100 \times \frac{0.9\pi}{180}$ mm = 1.57 mm

5.# **Sol.** **(Tough)** The only possibility is by reflection from concave mirror as shown.



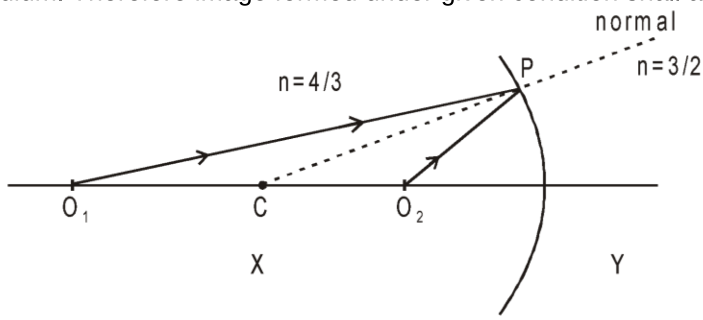
6. **Sol.**



Reflection from M_1
I_1 : image fromed by plane mirror
Reflection from M_2 :
I_1 acts as a object for concave mirror and its image is formed at itself as position of I_1 is centre of curvature of concave mirror.
Reflection from M_1
Plane mirror finally forms image at object O.

7. **Sol.** Image velocity (w.r.t. mirror) = $-m^2$ × object velocity (w.r.t. mirror) = –u
Here m = 1.
Image velocity w.r.t. ground = –2u

8. **Sol.** **(Moderate)** Let there be two point objects O_1 and O_2, Incident rays from O_1 and O_2 at point P shall both bend towards normal and hence the corresponding refracted rays shall intersect the principal axis in the left medium. Therefore image formed under given condition shall always be virtual.



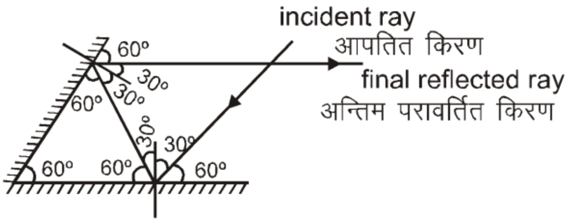
9.# **Hint:** $\frac{1}{10} = \left(\frac{3}{2}-1\right)\left(\frac{1}{R}-\frac{1}{\infty}\right) \Rightarrow \frac{1}{2R} = \frac{1}{10} \Rightarrow R = 5$ cm
Rays should extance the path ⇒ incident rays on mirror should be normal

$\Rightarrow \quad \frac{3/2}{\infty} - \frac{1}{-d} = \left(\frac{1}{-d}-\frac{1/2}{5}\right)$ [u = – d, as lens is their

$\Rightarrow \quad \frac{1}{d} = \frac{1}{10} \quad \Rightarrow \quad d = 10$ cm

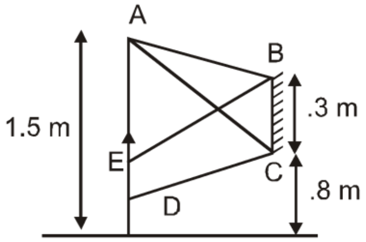
10.# **Sol.** The effective focal length is 5 cm.
The height of final images is = $\frac{v}{u} \times O = \frac{f}{u+f} = \frac{5}{-7.5+5} \times 1 = 2$ cm

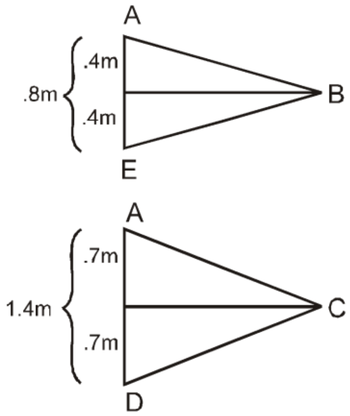
11. **Sol.**



final ray is II to first mirror.

12. **Sol.**





ED = AD – AE = 1.4 – .8 = .6 m

13.# **Hint :** $v = -30$, $m = -\frac{v}{u} = -2$ $\therefore$ A′B′ = C′D′ = 2 × 1 = 2 mm

Now $\frac{B'C'}{BC} = \frac{A'D'}{AD} = \frac{v^2}{u^2} = 4 \Rightarrow B'C' = A'D' = 4$ mm

$\therefore$ length = 2 + 2 + 4 + 4 = **12 mm Ans.**

14.# **Hint :** for M_1 : $V = -60$, $M_1 = -2$

for M_2 : $u = +20$. $f = 10$ $\therefore$ $\frac{1}{V} + \frac{1}{20} = \frac{1}{10}$ $\Rightarrow$ V = 2 0

$\therefore$ $M_2 = -\frac{20}{20} = -1$ $\therefore$ $M = M_1 \times M_2 = +2$

15. **Sol.** Displacement = $\frac{t\sin(i-r)}{\cos r}$ and $1\sin i = n \times \sin r$

Since i and r are small angles. and $i = nr$

Displacement = $t(i-r)$

$\therefore$ Displacement = $t\, i\left(1-\frac{r}{i}\right) = t\theta\left(1-\frac{1}{n}\right) = \frac{t\theta(n-1)}{n}$

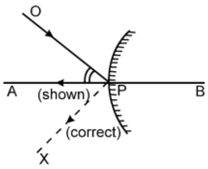
16. **Sol.** For transmission,

$r_2 \le \sin^{-1}(1/\mu)$ & $r_1 \le \sin^{-1}(1/\mu)$

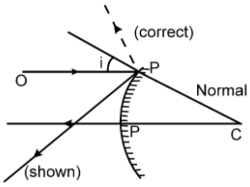
$r_1 + r_2 \le 2\sin^{-1}(1/\mu)$ $A \le 2\sin^{-1}(1/\mu)$

$\sin^{-1}(1/\mu) \ge 45^\circ$ $\Rightarrow$ $\frac{1}{\mu} \ge \frac{1}{\sqrt{2}}$ $\Rightarrow$ $\mu \le \sqrt{2}$.

18.# **Sol.** Error – I

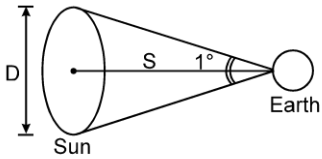


Error – II



19. **Sol.** $\frac{D'}{D} = \frac{v}{u} = \frac{f}{s}$

(image created at focus)



$D' = f \times \frac{D}{s} = 9 \text{ cm } 5 \frac{\pi}{180} \times 1^0 = 1.57 \text{ mm}$

21.# **Sol.** As the object moves from infinity to centre of curvature, the distance between object and image reduces from infinity to zero.

As the object moves from centre of curvature to focus, the distance between object and image increases from zero to infinity.

As the object moves from focus to pole, the distance between object and its image reduces from infinity to zero. Hence the distance between object and its image shall be 40 cm three times.

22.# **Sol.** by shell's law $2\sin 30° = \sqrt{13}\sin r$ [Sol. Made by SSI Sir]

$1 = \sqrt{13}\sin r$

$\sin\gamma = \frac{1}{\sqrt{13}}$, $\tan r = \frac{1}{\sqrt{12}}$

So, lateral displacement = $\frac{t\sin(i-r)}{\cos r}$

$= \frac{t[\sin(i)\cos r - \cos(i)\sin r]}{\cos r}$

$= t[\sin i - \cos i \tan r]$

$= 10[\sin 30 - \cos 30 \times \frac{1}{\sqrt{12}}] = 10\left[\frac{1}{2} = \frac{\sqrt{3}}{2} \times \frac{1}{2\sqrt{3}}\right] = 2.5 \text{ cm}$

23. **Sol.** $\frac{x}{1} = \frac{x_{rel}}{\mu}$

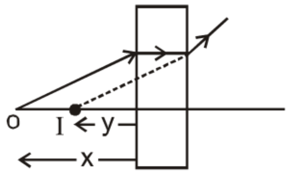
$x_{rel} = \mu x$

$\frac{d^2x_{rel}}{dt^2} = \mu\frac{d^2x}{dt^2}$

$a_{rel} = \mu g$

24.# **Sol.** If $\frac{dx}{dt} = 2$

$\frac{dy}{dt} = 2$



25.# **Sol.** $\frac{\mu}{2R} - \frac{1}{\infty} = \frac{\mu - 1}{R} \Rightarrow \mu = 2.$

26._ **Sol.** $r_2 < \theta_C$; $A - r_1 < \theta_C$

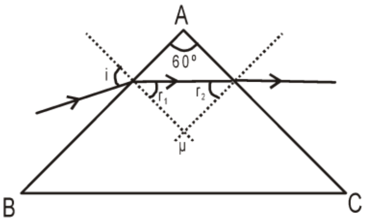
$r_1 > A - \theta_C$

$\Rightarrow \sin r_1 > \sin(A - \theta_C)$

$\Rightarrow \frac{\sin i}{\mu} > \sin(A - \theta_C)$

$\Rightarrow \sin i > \mu(\sin A \cos\theta_C - \sin\theta_C \cos A)$

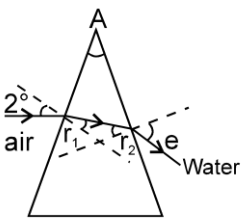
$= \sqrt{\frac{7}{3}}\left(\frac{\sqrt{3}}{2}\sqrt{1-\frac{3}{7}} - \sqrt{\frac{3}{7}}.\frac{1}{2}\right) = 1 - \frac{1}{2} = \frac{1}{2}$



$\Rightarrow \sin i > \frac{1}{2}$

or $i > 30^0$.

27._ **Sol.**



we can use sin x = x (where x is in radians)

$\sin 2° = \frac{3}{2} \sin r_1°$

$\Rightarrow \quad r_1 = \frac{4}{3}^{\circ}$; $\Rightarrow r_2 = A - r_1 = \frac{8}{3}^{\circ}$

$\therefore \quad \frac{3}{2} \sin r_2 = \frac{4}{3} \sin e \Rightarrow e = \frac{9}{8} r_2 = 3°$

$\therefore \quad \delta = i + e - A = 2° + 3° - 4° = 1°$

28._ **Sol.** From Nerwton's equation of lens **[Soln. by SSI Sir]**

size of object = $O^2 = I_1 I_2$

where I_1 is size of Image of object and I_2 is size of image when pisitions of object & image are interchanged

So $A^2 = A_1A_2$ $\Rightarrow$ **A =** $\sqrt{A_1A_2}$

29.# **Sol.** $\frac{1}{f} = (\mu_{rel} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \Rightarrow$ $\frac{1}{f_{Up}} = (\mu_{rel} - 1)\frac{1}{R}$ $\frac{1}{f_{low}} = (\mu_{rel} - 1)\frac{2}{R}$

$\Rightarrow \frac{f_{lower}}{f_{upper}} = \frac{1}{2}$ $\Rightarrow$ $f_{upp.} = 2\, f_{lower}$

Image by upper part will be at larger distance.

30._ **Sol.** $i + e = A + \delta$

$A = (i + e) - \delta = (37^o + 42^o) - 40^o = 39^o$.

32._

PART - II : MISCELLANEOUS QUESTIONS

A-1. **Sol.** From symmetry the ray shall not suffer TIR at second interface, because the angle of incidence at first interface equals to angle of emergence at second interface. Hence statement 1 is false

A-2. **Sol.** If the angle of incidence is greater than critical angle for all colours, the beam will be totally internally reflected. The beam may not always suffer refraction and hence dispersion . Hence both statements are true. Since statement-2 has no connection with TIR, it is not an explanation of statement-1

A-3. **Sol.** In the situation of statement-1, the magnitude of image (v) and object (u) distance is same.

The size of image = $\frac{n_1}{n_2} \times \frac{v}{u}$ × size of object

$\because v = u$ and $n_1 \neq n_2$

$\therefore$ size of image $\neq$ size of object.

Hence statement-1 is false and statement-2 is true.

A-4. **Sol.** **(4)** We know that the refractive index increases with decreases of wavelenght i.e., refractive index is maximum for violet and minimum for red. Therefore index is maximum for violet and minimum for red.

Therefore, the apparent shift $\Delta y = t\left[1 - \left(\frac{1}{\mu}\right)\right]$ is maximum for red and minimum for violet. This is the reason the red coloured letters apper more raised up.

A-5. **Sol.** **(1)** Accodring to Snell's law,

$\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2}$ or $\mu_1 v_1 = \mu_2 v_2$.

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

A-6. **Sol.** **(2)**

The light gathering power (or brightness) of a telescope is directly proportional to area of the objective lens i.e., light gathering power $\propto \pi r^2 \propto \frac{\pi D^2}{4}$, where D is the diameter of the objective.
Thus telescope will have large light gathering power if aperture diameter of the objective lens is large. So by increasing the objective diameter even far off stars may produce images of optimum brightness.

A-7. **Sol.** We cannot interchange the objective and eye lens of a microscope to make a telescope. The reason is that the focal length of lenses in microscope are very small, of the order of mm or a few cm and the difference ($f_0 - f_e$) is very small, while the telescope objective have a very large focal length as compared to eye lens of microscope.

A-8. **Sol.** The resolving power of a microscope is determined by the smallest distance between two point objects which can be distinguished by it. The distance d is given by

$$d = \frac{1.22\lambda}{2n\sin\theta}$$

The resolving power of the microscope is reciprocal of the distance d. An increase in n (refractive index of the transparent medium between the objects and the objective of the microscope) will produce a greater resolving power. It also increases with decrease in wavelength. While the resolving power of telescope is defined as the reciprocal of the smallest angular sepration between two distant objects whose images are distinctly separated by the telescope.

$$\delta\theta = \frac{1.22\lambda}{D}$$

So for higher resolving power telescope should have the objective lens of large diameter (D) and object is illuminated by light of small wavelength. Thus in both the case resolving power is increased by taking illumination light of small wavelength.

Section (B) : Match the column

B-1. **Ans.** **(A) p, s; (B) q ; (C) r, s; (D) r**

Sol. $V_{Im} = -m^2 V_{om}$ (for all types of mirrors)
for A ; m = 1
for B ; |m| > 1
for C & D ; |m| < 1
In case of A & C image is virtual (behind the mirror) and in case of B & D image is real (in front of mirror). Since image and object moves opposite to each other with respect to mirror so when a real object moves closer, virtual image also moves closer while real image moves away from mirror.

Section (C) : One or more than one options correct

C-1. **Sol.** f = – 20 m & $m = -\frac{v}{u} = \pm 2$
using v = 2u.

$$\frac{1}{-20} = \frac{1}{2u} + \frac{1}{u} \Rightarrow \frac{3}{2u} = \frac{1}{-20} \quad u = -30 \text{ cm}$$

using v = – 2u

$$\frac{1}{-20} = \frac{1}{-2u} + \frac{1}{u} \Rightarrow \frac{1}{2u} = \frac{1}{-20} \quad u = -10 \text{ cm}$$

C-2.* **Sol.** (1) No, when object is between infinite and focus ,image is real.
(3) when object is between pole and focus, image is magnified.
(4) when object is between pole and focus image formed by convex mirror is real.

C-3.#* **Sol.** $\frac{C_y}{C_x} = \frac{\sin r}{\sin i}$ = tan 30º = $\frac{1}{\sqrt{3}}$

$C_y = \frac{1}{\sqrt{3}} C_x$.

since y is denser, total internal reflection can take place when ray is incident from y.

C-4.* **Sol.** (1) is not true for minimum deviation.
(2) is true only if refracting side are equal.
(3) Two angles for maximum deviation are 90º and $i_{min.}$
(4) $\delta_{min.} = (\mu - 1)$ A.

C-5.* **Sol.** A = 60º, δ = 40º , i + e = A + δ ⇒ i + e = 100º
and i – e = 20º ⇒ i = 60º or 40º

Exercise-3

Marked Questions can be used as Revision Questions.

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. **Sol.** Larger aperture increases the amount of light gathered by the telescope increasing the resolution.

2. **Sol.** $n = \left(\frac{360^\circ}{\theta}\right) - 1 = \left(\frac{360}{60} - 1\right) = 5$

3. **Sol.** Optics fibres are based on total internal reflection.

4. **Sol.** The objective of compound microscope is a lemax lens and it forms real and enlarged image when an object is placed between its focus and lens.

5. **Sol.** $\frac{360^\circ}{\theta} - 1 = 3. = \theta = 90^\circ$

6. **Sol.** i > c for ITR

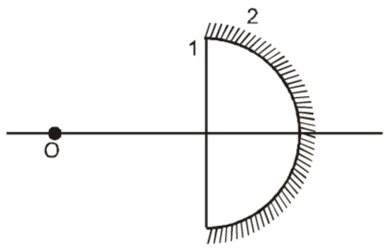
$\therefore 45^\circ > \sin^{-1}\left(\frac{1}{n}\right)$

$\Rightarrow n > \sqrt{2}$

7. **Sol.** To get real image of the size of the object, object should be placed at the centre of curvature of equivalent mirror.

$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_\ell}$

$f_m = -15$cm



and $\frac{1}{f_2} = \frac{1}{-15} - \frac{2}{60}$

$F_2 = -10$ cm

Hence, object should be placed at 20cm from the combination

8. **Sol.** Angle of minimum deviation $D = (\mu - 1) A$

$\because$ $\mu_{blue} > \mu_{red}$

$\therefore$ $D_2 > D_1$

9. **Sol.** A travelling microscope moves horizontally on a main scale provided with a vernier scale, provided with the microscope

10.# **Sol.** For a convex lens

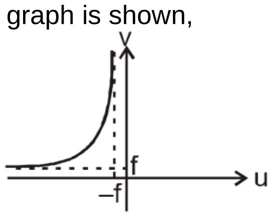
u = –ve f = +ve

If $v = \infty$, u = f and if $u = -\infty$, v = f.

$v = \infty$, u = f $u = -\infty$, v = f.

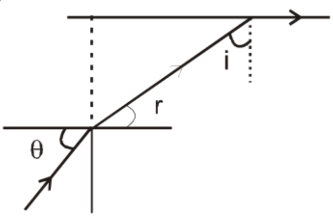
We have v = +ve and u = –ve

and u and v are symmetrical. Hence graph is shown,



11.# **Ans. (3)**

Sol.



$\sin\theta = \frac{2}{\sqrt{3}} \sin r = \frac{2}{\sqrt{3}} \cos i$ ....(i)

and $\frac{2}{\sqrt{3}} \sin i = \sin 90^\circ \Rightarrow$ $i = 60^\circ$ ....(ii)

From (i) and (ii)

$\sin\theta = \frac{1}{\sqrt{3}}$

12. **Sol.** **Ans. (4)**

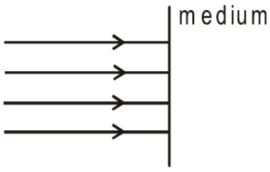
v = u and $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

$\Rightarrow$ v = 2 f, u = 2f

13. **Ans** **(4)**

Sol.

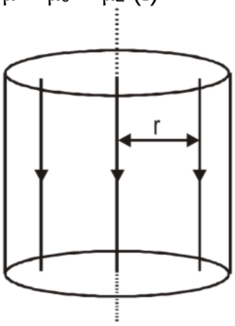


Beam is incident normally therefore does not diverge or converge so it travels as a cylindrical beam.

14. **Ans.** **(4)**
Sol. Beam does not converge or diverge so shape of wave front remain planar.

15. **Ans.** **(1)**

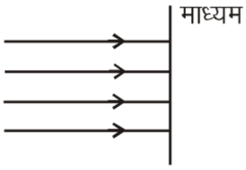
Sol. $\mu = \mu_0 + \mu_2 (I)$



as it is given that intensity of beam is decreasing with increasing radius, and as I decreases μ also decreases.

Now by $V = \frac{C}{\mu}$
speed of light is minimum at axis of cylinder.

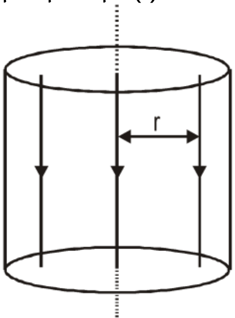
13. **Ans** **(4)**
Sol.



14. **Ans.** **(4)**

15. **Ans.** **(1)**

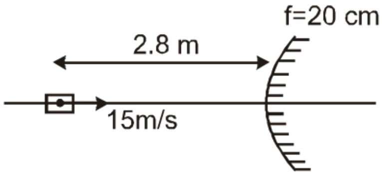
Sol. $\mu = \mu_0 + \mu_2 (I)$



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

16. **Ans.** **(2)**

Sol. Mirror formula : :



$\frac{1}{v}+\frac{1}{-280}=\frac{1}{20}$

$\frac{1}{v}+\frac{1}{20}+\frac{1}{280}$

$\frac{1}{v}+\frac{14+1}{280}$

$v = \frac{280}{15}$

$v_I = -\left(\frac{v}{u}\right)^2 .v_{om}$

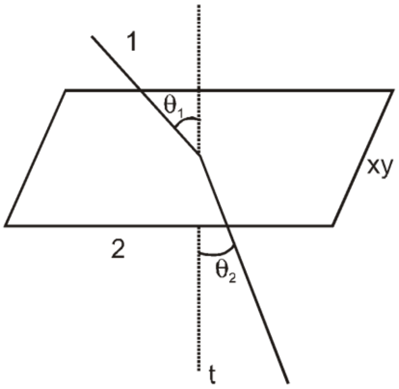
$\therefore v_I = -\left(\frac{280}{15\times 280}\right)^2 .15$

$\therefore v_I = \frac{-15}{15\times 15}$

$v_I = -\frac{1}{15}$ m/s **Ans.**

17. **Ans.** **(2)**

Sol. X–Y



$\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2$

$\cos\theta_1 = \frac{10}{\sqrt{(6\sqrt{3})^2+(8\sqrt{3})^2+100}}=\frac{10}{\sqrt{400}}=\frac{10}{20}$

$\cos\theta_1 = \frac{1}{2}$

$\theta_1 = 60°$

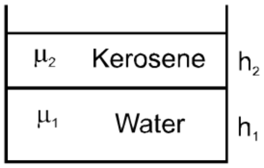
$\sqrt{2}\sin 60° = \sqrt{3}\sin\theta_2$

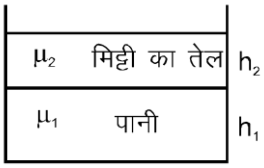
$\sqrt{2}\times\frac{\sqrt{3}}{2} = \sqrt{3}\sin\theta_2$

$\sin\theta_2 = \frac{1}{\sqrt{2}}$

$\theta_2 = 45°$

18. **Sol.**





Apparent shift :

$$= h_1\left(1-\frac{1}{\mu_1}\right)+h_2\left(1-\frac{1}{\mu_2}\right).$$

19. **Sol.** $\mu_R < \mu_B$

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

$$\frac{1}{f_B} > \frac{1}{f_R}$$

$f_R > f_B$.

20. **Ans.** (4)

Sol.

$$\frac{1}{f}=\frac{1}{12}+\frac{1}{240}=\frac{20+1}{240}$$

$$f = \frac{240}{21}\text{m}$$

$$\text{shift} = 1\left(1-\frac{2}{3}\right) = \frac{1}{3}$$

$$\text{Now} = 12-\frac{1}{3} = \frac{35}{3}\text{ cm}$$

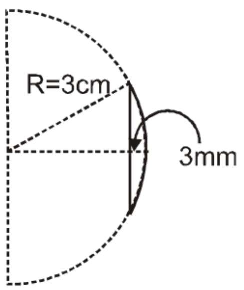
$$\therefore \frac{21}{240} = \frac{3}{35}-\frac{1}{u}$$

$$\frac{1}{u} = \frac{3}{35}-\frac{21}{240}=\frac{1}{5}\left(\frac{3}{7}-\frac{21}{48}\right)$$

$$\frac{5}{u} = \left|\frac{144-147}{48\times 7}\right|$$

u = 560 cm = 5.6 m

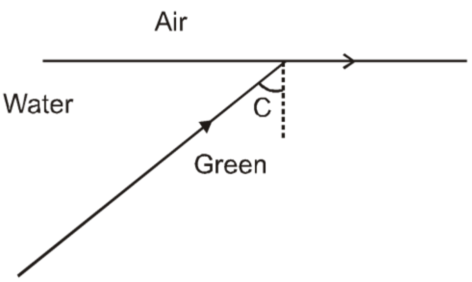
21. **Sol.** $n=\frac{3}{2}$



$3^2 + (R - 3mm)^2 = R^2$
$\Rightarrow 3^2 + R^2 - 2R(3mm) + (3mm)^2 = R^2$
$\Rightarrow R \approx 15$ cm
$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{15}\right)$$
$\Rightarrow f = 30$cm
Ans (3)

23. **Ans. (2)**
Sol.
$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$
$\frac{1}{f} = \frac{1}{2x} \Rightarrow f = 2x$ here $\left(\frac{1}{x} = \frac{1}{R_1} - \frac{1}{R_2}\right)$
$$\frac{1}{f_1} = \left(\frac{3/2}{4/3} - 1\right)\frac{1}{x}$$
$\frac{1}{f_2} = \left(\frac{3/2}{5/3} - 1\right)\left(\frac{1}{x}\right)$: $\Rightarrow$ f_2 is negative
$$\frac{1}{f_1} = \frac{1}{8x} = \frac{1}{4(2x)} = \frac{1}{4f}$$
$\Rightarrow f_1 = 4f$
Analytically, If a lense is inserted in a denser sourrounding the sign of focal length changes and if lens is inserted in a rarer sourrounding , the sign of focal length remain same.
If lense is inserted in rarer medium the focal length increases.

24. **Ans. (2) IN HINDI (3)**
Sol.



here $\sin C = \frac{1}{n_{water}}$
and $n_{water} = a + \frac{b}{\lambda^2}$
If frequency is less $\Rightarrow \lambda$ is greater and hence R.I. (n_{water}) is less and therefore, critical angle increases.

25. **Ans. (3)**
Sol. $\theta = \frac{10}{x}$
$\theta_1 = \frac{10}{x}(20)$
Now 20 times nearer

26. **Ans. (4)**
Sol. When = 35° and e = 79° then $\delta = 40°$
$\delta = i + e - A$

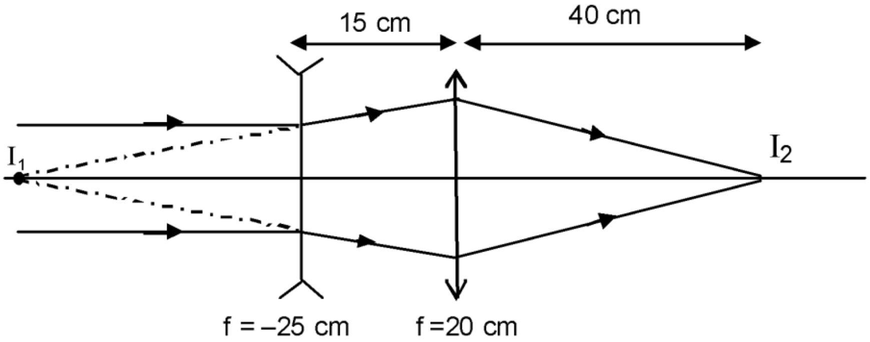
$40° = 35 + 79 – A$
$A = 74°$
Since $i \neq e$ so δ_{min} will less than 40°

$$n = \frac{\sin\left(\frac{\delta_{min} + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$n = \frac{\sin\left(\frac{40° + 74}{2}\right)}{\sin\left(\frac{74}{2}\right)} = \frac{\sin(57°)}{\sin(37°)} = \frac{0.84}{0.60} = 1.4$$

Since δ_{min} will be less than 40° so
n will be less than 1.4
so the closest answer will be 1.5

27. Ans. (2)
Sol. Image formed by first lens is I_1 which is 25 cm left of diverging lens.
For second lens u = 40 cm (i.e. at 2F) so final image will be 40 cm right of converging lens.
Image will be real.

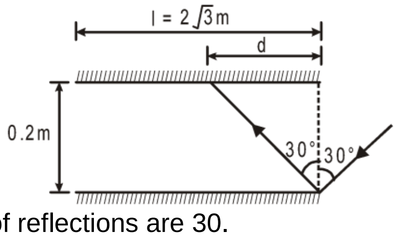


PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. Sol. $d = 0.2 \tan 30° = \frac{0.2}{\sqrt{3}}$

$$\frac{l}{d} = \frac{2\sqrt{3}}{0.2/\sqrt{3}} = 30$$



Therefore, maximum number of reflections are 30.

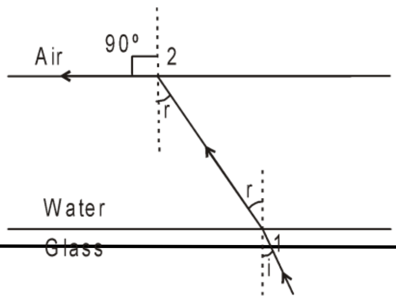
2.(i) Sol. Applying Snell's law ($\mu \sin i$ = constant) at 1 and 2 we have

$$\mu_1 \sin i_1 = \mu_2 \sin i_2$$

Here $\mu_1 = \mu_g$; and $\mu_2 = 1$ and $i_2 = 90°$

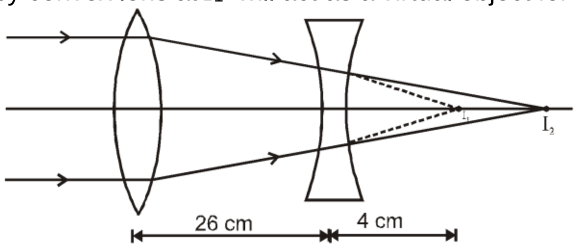
$$i_1 = i$$

$$\mu_g \sin i = (1)(\sin 90°)$$



or $\mu_g = \frac{1}{\sin i}$

(ii) **Sol.** Image formed by convex lens at I_1 will act as a virtual object for concave lens. For concave lens



$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ or $\frac{1}{v} - \frac{1}{4} = \frac{1}{-20}$ or $v = 5$ cm

magnification for concave lens $m = \frac{v}{u} = \frac{5}{4} = 1.25$

As size of the image at I_1 is 2 cm. Therefore, size image at I_2 will be $2 \times 1.25 = 2.5$ cm.

3. **Sol.** When the object is placed at the centre of the glass sphere, the rays from the object fall normally on the surface of the sphere and emerge undeviated.
Hence, the correct option is (B).

4. **Sol.** During minimum deviation the ray inside the prism is parallel to the base of the prism in case of an equilateral prism.
Hence, the correct option is (C)

5. **Sol.** Critical angle $\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$
Wavelength increases in the sequence of VIBGYOR. According to Cauchy's formula refractive index (μ) decreases as the wavelength increases. Hence the refractive index will increase in the sequence of ROYGBIV. The critical angle θ_C will thus increase in the same order VIBGYOR. For green light the incidence angle is just equal to the critical angle. For yellow, orange and red the critical angle will be greater than the incidence angle. So these colours will emerge from the glass air interface.
Hence, the correct option is (A).

6.# **Sol.** By mirror - lens combination formula

$$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_L}$$

$$\frac{1}{F} = \frac{1}{\infty} - \frac{2}{15}$$

By mirror formula

$$\frac{1}{F} = \frac{1}{u} + \frac{1}{v} \Rightarrow -\frac{2}{15} = \frac{1}{-20} + \frac{1}{v}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{2}{15} = \frac{3-8}{60}$$

$v = -12$ cm negative means towards left

7.# **Sol.** $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ ...... (1)

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

$f = +5$

By differentiate eq. (1)

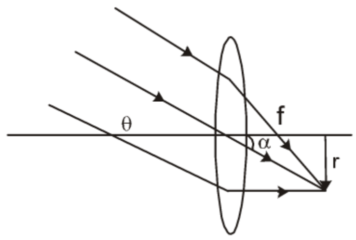
$\Rightarrow \quad \frac{-\Delta f}{f^2} = \frac{-\Delta v}{v^2} + \frac{\Delta u}{u^2} = \frac{1}{+v^2}\Delta v + \frac{1}{u^2}\Delta u$

$\Rightarrow \quad + \frac{\Delta f}{5^2} = \frac{1\times(0.1)}{+10^2} + \frac{1\times(0.1)}{10^2}$

$\Delta f = \frac{0.2}{100}\times 25 = \frac{0.2}{4} = 0.05$

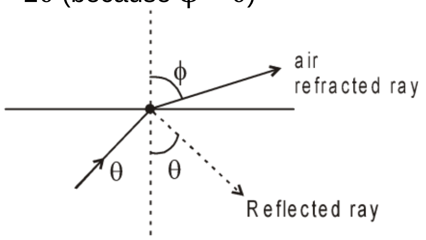
so,, $f = 5 \pm 0.05$ **Ans.**

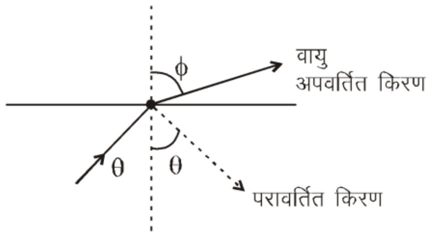
8. **Sol.** $r = f \tan\alpha$



Hence, $\pi r^2 \propto f^2$.

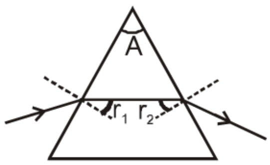
9. **Sol.** There will be partial reflection and refraction as shown in figure.
Angle between the reflected ray and the refracted ray = $180^o - (\theta + \varphi)$ which is less than $180^o - 2\theta$ (because $\varphi > \theta$)

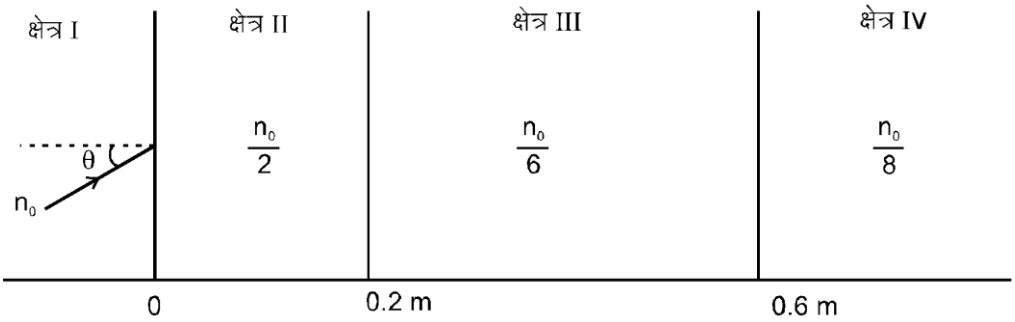




10. **Sol.** Laws of reflection are valid for all surfaces.
So statement (2) is incorrect.

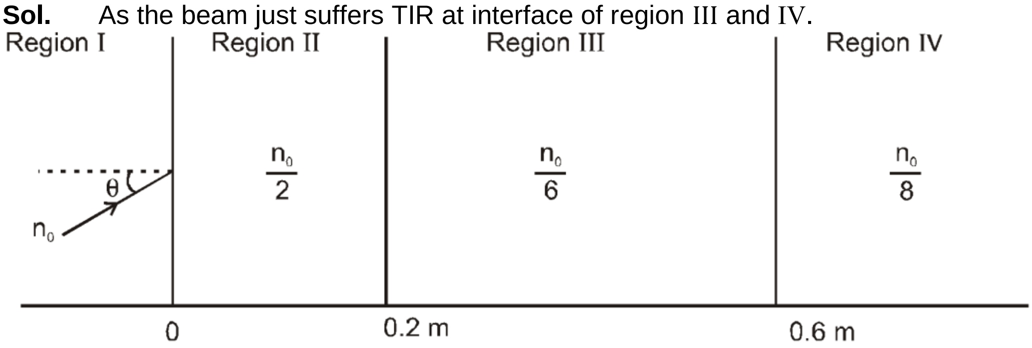
11. **Sol.** For minimum deviation
$i = e$ and $r_1 = r_2 = A/2 = 30^o$
which is independent of nature of light.
Both the lights are set for minimum deviation so angle of refraction will be 30° for both colours.
Ans. (A)





12.

Sol. As the beam just suffers TIR at interface of region III and IV.



$n_0 \sin\theta = \frac{n_0}{2}\sin\theta_1 = \frac{n_0}{6}\sin\theta_2 = \frac{n_0}{8}\sin 90^\circ$

$\sin\theta = \frac{1}{8}$

$\theta = \sin^{-1}\frac{1}{8}$ **Ans. (B)**

13. **Sol.** $x' = \frac{x}{n_{rel}}$, $v' = \frac{v}{n_{rel}} = \frac{\sqrt{2\times 10\times(20-12.8)}}{1}\times\frac{4}{3}$ = 16 m/s.

14*. **Sol.** $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ or $\frac{1}{-|v|}+\frac{1}{-|u|}=\frac{1}{-|f|}$ $\Rightarrow$ $|v| = \frac{|u|\ |f|}{|u|-|f|}$

For $|u| = 42$, $|f| = 24$; $|v| = \frac{(42)\ (24)}{42-24}$ = 56 cm so (42, 56) is correct observation

For $|u| = 48$ or $|u| = 2f$ or $|v| = 2f$ so (48, 48) is correct observation

For $|u| = 66$ cm ; $|f| = 24$ cm

$|v| = \frac{(66)\ (24)}{66-24} \approx 36$ cm which is not in the permissible limit

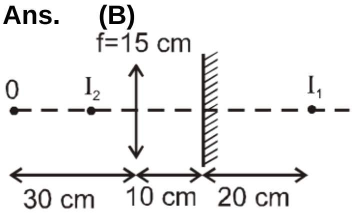
so (66, 33), is incorrect recorded

For $|u| = 78$, $|f| = 24$ cm

$|v| = \frac{(78)\ (24)}{78-24} \approx 32$ cm which is also not in the permissible limit.

so (78, 39), is incorrect recorded.

15. **Ans.** **(B)**



Sol.

First image,

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

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

v = 30, image in formed 20 cm behind the mirror.
Second image, by plane mirror will be at 20 cm infront of plane mirror.

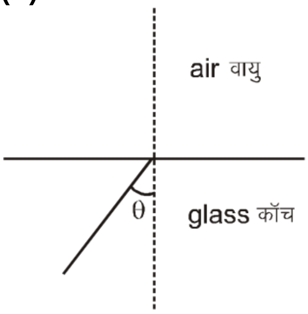
For third image, $\frac{1}{v}-\frac{1}{10}=\frac{1}{15}$

$$\frac{1}{v}=\frac{1}{10}+\frac{1}{15}=\frac{3+2}{30}=\frac{5}{30}$$

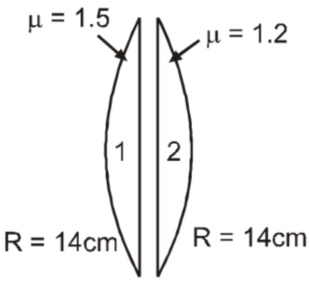
v = 6 cm

Ans. Final image is real & formed at a distance of 16 cm from mirror.

16.# Ans. (C)
Sol. (C)



Initially most of part will be transmitted. When $\theta > i_C$, all the light rays will be total internal reflected. So transmitted intensity = 0
So correct answer is (C)



17. Sol.

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

$$\frac{1}{f_1}=(1.5-1)\left[\frac{1}{14}-\frac{1}{\infty}\right]$$

$$\frac{1}{f_1}=\frac{0.5}{14}$$

$$\frac{1}{f_2}=(1.2-1)\left[\frac{1}{\infty}-\frac{1}{-14}\right]$$

$$\frac{1}{f_2}=\frac{0.2}{14}$$

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}=\frac{0.5}{14}+\frac{0.2}{14}$$

$\frac{1}{f} = \frac{0.7}{14}$

$\frac{1}{v} = \frac{7}{140} - \frac{1}{40} = \frac{1}{20} - \frac{1}{40}$

$\frac{1}{v} = \frac{2-1}{40}$

v = 40 cm

18. **Sol.** $n = \frac{c}{v}$

for metamaterials

$v = \frac{c}{|n|}$

19. **Sol.** **(C)** Meta material has a negative refractive index

$\therefore$ $\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$ $\Rightarrow$ n_2 is negative _

$\therefore$ θ_2 negative _

20. **Sol.** v = 8 m (magnification = $-\frac{1}{3} = \frac{v}{u}$)

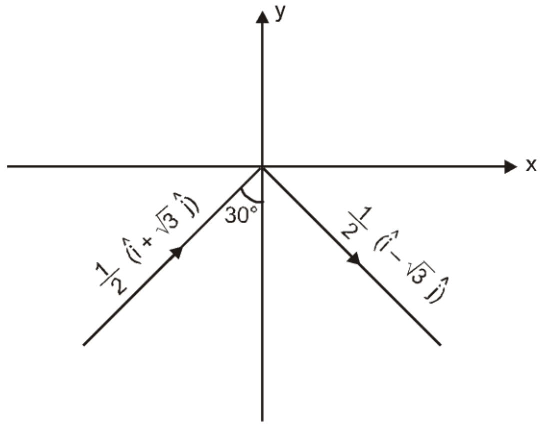
u = –24m

$\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{\infty}+\frac{1}{R}\right)$

R = 3m

21. **Sol.#** Angle between given rays is 120°

so angle of incidence is 30°



22*. _ **Ans.** **(A), (C)**

Sol. $\frac{1}{f_{film}} = (n_1-1)\left(\frac{1}{R}-\frac{1}{R}\right) \Rightarrow f_{film} = \infty$ (infinite)

No effect of presence of film.

From Air to Glass:

Using single spherical Refraction :-

$\frac{n_2}{v} - \frac{1}{u} = \frac{n_2-1}{R}$

$$\frac{1.5}{v} - \frac{1}{\infty} = \frac{1.5-1}{R} \Rightarrow v = 3R$$

$f_1 = 3R$

From Glass to Air :-

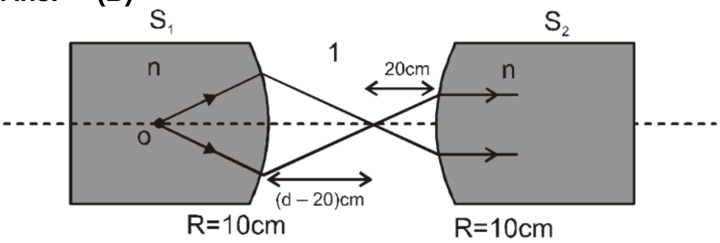
$$\frac{1}{v} - \frac{n_2}{u} = \frac{1-n_2}{-R}$$

$$\Rightarrow \frac{1}{v} - \frac{1.5}{\infty} = \frac{1-1.5}{-R}$$

$\Rightarrow$ $v = 2R$

$\therefore$ $f_2 = 2R$

23. Ans. (B)



at glass rod S_2

$1 \rightarrow n$ refraction

$$\frac{n}{\infty} - \frac{1}{u_2} = \frac{n-1}{+10}$$

$\Rightarrow$ $u_2 = -20$

at glass rod S_1

for $n \rightarrow 1$ refraction

$V_1 = d - 20$

$$\frac{1}{d-20} - \frac{n}{(-50)} = \frac{1-n}{-10}$$

$$\frac{1}{d-20} + \frac{n}{50} = +\frac{1}{20}$$

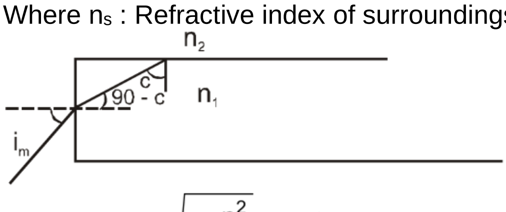
$d = 70$ cm

24*. Ans. (A,C)

Sol. $n_s \sin i_m = n_1 \sin(90 - c)$

$\sin c = \frac{n_2}{n_1}$

Where n_s : Refractive index of surroundings



$$NA = \sin i_m = \sqrt{1 - \frac{n_2^2}{n_1^2}} = \frac{1}{n_s}\sqrt{n_1^2 - n_2^2}$$

For S_1 in Air

$$NA = \frac{1}{1}\sqrt{\frac{45}{16} - \frac{9}{4}} = \frac{3}{4}$$

For S_1 in $n_s = \frac{6}{\sqrt{15}}$

$n_s = \frac{6}{\sqrt{15}}$ S_1

$NA = \frac{\sqrt{15}}{6}\sqrt{\frac{45}{16}-\frac{9}{4}} = \frac{3\sqrt{15}}{24}$

For S_1 in water

$NA = \frac{1}{(4/3)}\sqrt{\frac{45}{16}-\frac{9}{4}} = \frac{3}{4}\left(\frac{3}{4}\right) = \frac{9}{16}$

For S_2 in Air

$NA = \frac{1}{1}\sqrt{\frac{64}{25}-\frac{49}{25}} = \frac{\sqrt{15}}{5}$

For S_2 in water

$NA = \frac{1}{(4/3)}\sqrt{\frac{64}{25}-\frac{49}{25}} = \frac{3}{4}\frac{\sqrt{15}}{5}$

For S_2 in $n_s = \frac{16}{3\sqrt{15}}$

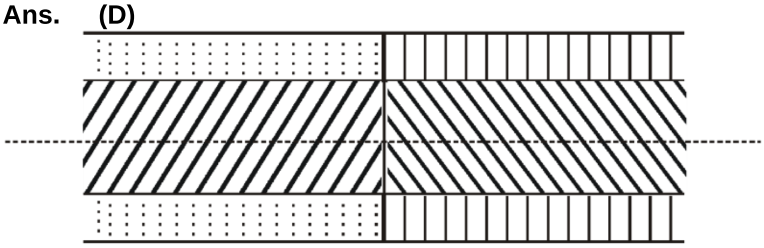
$NA = \frac{3\sqrt{15}}{16}\frac{\sqrt{15}}{5} = \frac{9}{16}$

For S_2 sin $n_s = \frac{4}{\sqrt{15}}$

$NA = \frac{\sqrt{15}}{4}\sqrt{\frac{64}{25}-\frac{49}{25}} = \frac{\sqrt{15}}{4}\frac{\sqrt{15}}{5} = \frac{3}{4}$

25. **Ans.** **(D)**

Sol.



$NA = \frac{1}{n_s}\sqrt{n_1^2 - n_2^2}$

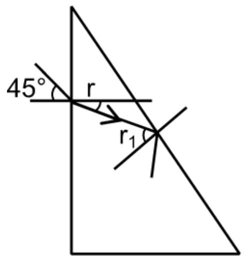
$NA_2 < NA_1$

Therefore the numerical aperture of combined structure is equal to the lesser of the two numerical aperture, which is NA_2

26. **Ans.** **(A)**

Sol. $\frac{\sin 45°}{\sin r} = \sqrt{2}$ $\Rightarrow$ $r = 30°$

Also $r_1 \geq 45°$ for internal reflection.



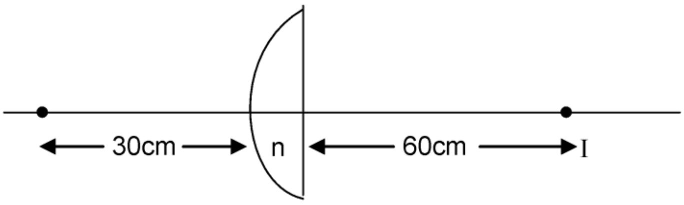
$90 - \theta = r + 90 - r_1$

$r_1 > 30 + \theta \geq 45°$

$\theta \geq 15°$ **Ans. (A)**

27. Ans. (AD)

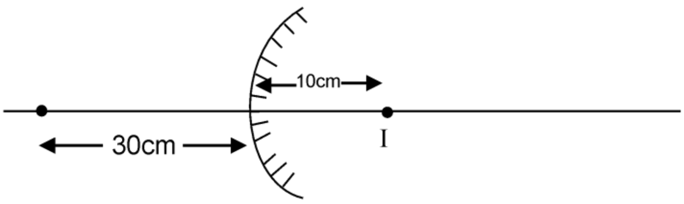
Sol. Case–I



$\frac{1}{60} + \frac{1}{30} = \frac{1}{f_1} \Rightarrow \frac{1}{f_1} = \frac{1}{60} + \frac{2}{60}$

$f_1 = \frac{R}{n-1} = +20cm$

Case –2



$\frac{1}{10} - \frac{1}{30} = \frac{1}{f_2}$

$\frac{3}{30} - \frac{1}{30} = \frac{1}{f_2} = \frac{2}{30}$

$f_2 = 15 = \frac{R}{2} \Rightarrow R = 30$

R = 30 cm

$\frac{R}{n-1} = +20cm = \frac{30}{n-1}$

$\Rightarrow$ = 2n – 2 = 3

$\Rightarrow$ f_1 = +20 cm

RI of lens is 2.5.

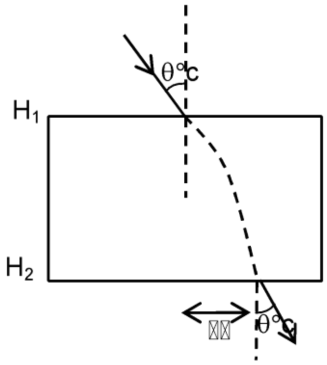
ROC of convex surface is 30 cm

Faint image is erect and virtual

focal length of lens is 20 cm

28. Ans. (ACD)

Sol.



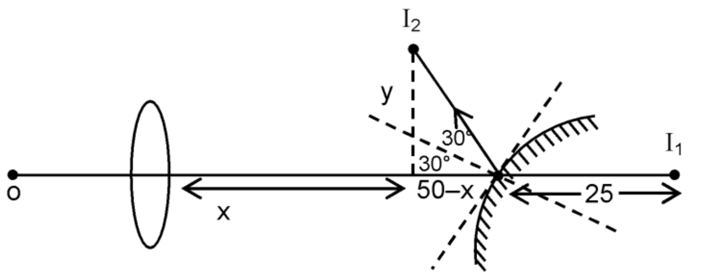
(A*) $n_1\sin\theta_1 = n_2\sin\theta_2$

(C*) ℓ is independent of n_2

(D) ℓ is dependent on n(z)

29. Ans. (B)

Sol.



For I_1 ⇒ $u = -50$ $f = +30$ $v = +75cm$

final image is I_2

$\frac{y}{50-x} = \tan 60 = \sqrt{3}$ $y = 50\sqrt{3} - \sqrt{3}x$

$y + \sqrt{3}x = 50\sqrt{3}$

A and B both option satisfy this,

size of image > size of object

$\sqrt{y^2+(50-x)^2}\sin 30° > 25\sin 30°$

$y^2 + (50-x)^2 > 625$

for option (A) $\frac{625}{3}+\frac{625}{9} < 625$

$\frac{625}{3}+\frac{625}{9} < 625$

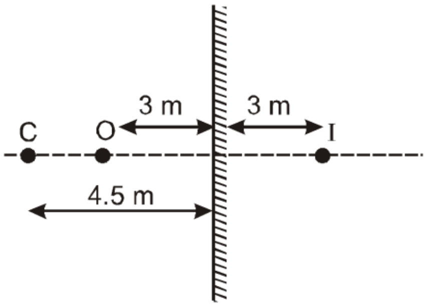
for option (B) 625(3) + 625 > 625

so B is correct.

Additional Problems For Self Practice (APSP)

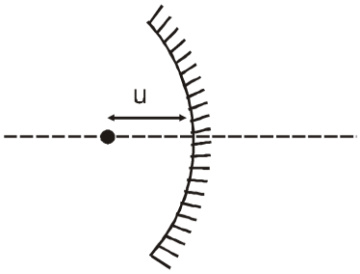
PART-I : PRACTICE TEST PAPER

1. **Sol.**



From diagram distance of camera from image = 4.5 + 3 = 7.5 m.

2.
Sol.



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

$m=-\frac{v}{u}=\frac{uf}{(u-f)u}=\frac{f}{f-u}=\frac{f}{x}$

3. **Sol.** $\frac{1}{f}=(n_{rel}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

For air

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

$\frac{1}{f}=\frac{1}{2}\times\frac{2}{R}$ $\Rightarrow$ $R=f$

For liquid

$\frac{1}{50}=\left(\frac{3}{2n}-1\right)\frac{2}{10}$

$\frac{1}{10}=\left(\frac{3}{2n}-1\right)$

$\frac{3}{2n}=\frac{11}{10}$

$n=1.36$ **Ans.**

4. **Sol.** $m=\frac{v}{u}=\frac{f}{f+u}$

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

$u=\frac{f(1-n)}{n}$

Distance = $\dfrac{-f(1-n)}{n} = \dfrac{f(n-1)}{n}$ **Ans.**

5. **Sol.** For air

$\dfrac{1}{f} = (n_{rel} - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$\dfrac{1}{10} = (1.52 - 1)\dfrac{2}{R}$

R = 10 × 2 × .52

For liquid æo

$\dfrac{1}{f} = \left(\dfrac{1.52}{1.68} - 1\right)\dfrac{2}{R}$

$\dfrac{1}{f} = -\dfrac{.16}{1.68} \times \dfrac{2}{10 \times 2 \times .52}$

f = – 54.60 cm **Ans.**

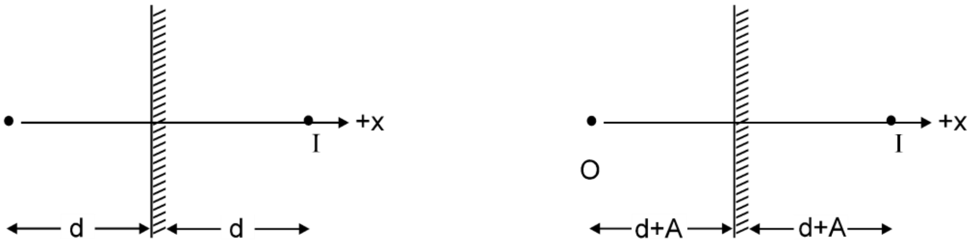
6. **Sol.** If time in object clock is T_1 & time in image clock is T_2 then,

$T_1 + T_2$ = 12 : 00 : 00

4 : 25 : 37 + T_2 = 12 : 00 : 00

T_2 = 07 : 34 : 23

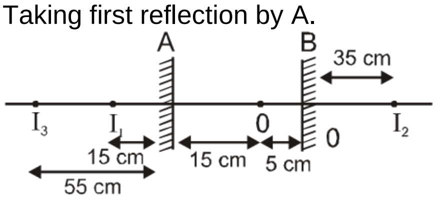
8. **Hint :**



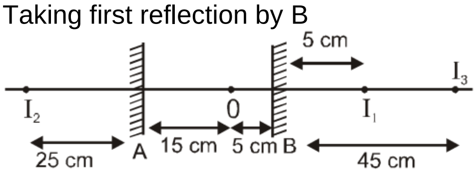
(i) **(ii)**

From figure (i) and (ii) it is clear that if the mirror moves distance 'A' then the image moves a distance '2A'.

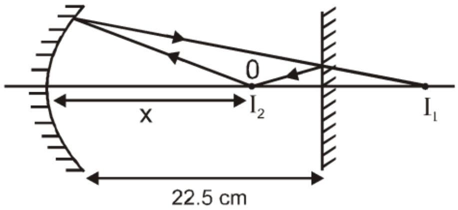
9.
Sol. Taking first reflection by A.



Taking first reflection by B



10.
Sol.



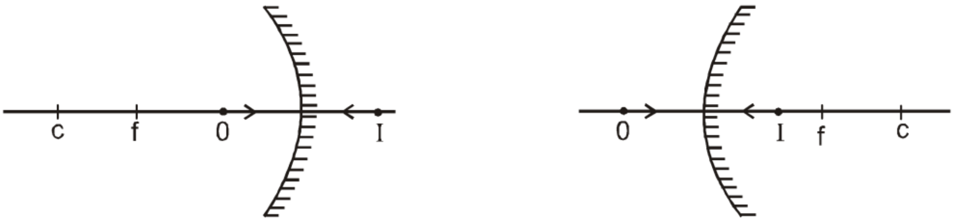
I_1 is the image formed by concave mirror.
For reflection by concave mirror
$u = -x$, $v = -(45 - x)$, $f = -10$ cm,

$$\frac{1}{-10} = \frac{1}{-(45-x)} + \frac{1}{-x}$$

$$\frac{1}{10} = \frac{x + 45 - x}{x(45-x)} \Rightarrow x^2 - 45x + 450 = 0 \Rightarrow x = 15 \text{ cm}, 30 \text{ cm}$$

but x = 30 cm is not acceptable because x < 22.5 cm.

11. Sol.



only in above two cases image moves towards mirror.

12.
Sol. Using mirror formula,

$$\frac{1}{-10} = \frac{1}{v} + \frac{1}{-15} \Rightarrow v = -30 \text{ cm.}$$

$$|\text{Axial magnification}| = \frac{V^2}{u^2} = \left(\frac{30}{15}\right)^2 = 4$$

amplitude of image = 4 × 2 = 8 mm.

13. Sol. Using Newtons formula. x → distance of object from focus

$xy = f^2$ y → distance of object from focus

f → focal length.

$\Rightarrow by = (a/2)^2$, $y = \frac{a^2}{4b}$.

14. Sol. $\frac{I}{O} = -\frac{v}{u}$

If O and I are on same sides of PA . $\frac{I}{O}$ will be positive which implies v and u will be of opposite signs.

Similarly if O and I are on opp. sides, $\frac{I}{O}$ will be -ve which implies v and u will have same sign.

If O is on PA, $I = \left(-\frac{v}{u}\right)(O) = 0 \Rightarrow$ I will also be on. P.A.

15.#

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

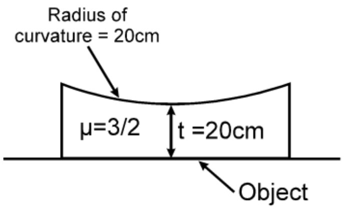
Slope = – 1 intercept M = $\frac{1}{f}$ (positive)

16. **Sol.** i = 2r
1 sin i = n sin r
$\Rightarrow$ 2 sin i/2 cos i/2 = n sin i/2
$\Rightarrow$ cos i/2 = (n/2)
$\Rightarrow$ $i = 2\cos^{-1}(n/2)$

17. **Sol.** $\sin\theta = \frac{1}{\mu} = \frac{C_A}{C_B}$ $\Rightarrow$ $C_B = \frac{V}{\sin\theta}$

18. **Sol.** For transmission
$r_2 \le \sin^{-1}(1/\mu)$ & $r_1 \le \sin^{-1}(1/\mu)$
$r_1 + r_2 \le 2\sin^{-1}(1/\mu)$ $A \le 2\sin^{-1}(1/\mu)$
$\sin^{-1}(1/\mu) \ge 45^o$ $\Rightarrow$ $\frac{1}{\mu} \ge \frac{1}{\sqrt{2}}$ $\Rightarrow$ $\mu \le \sqrt{2}$.

19.# **Sol.**



Considering refraction at the curved surface,
u = – 20 ; $\mu_2 = 1$
$\mu_1 = 3/2$; R = + 20
applying $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ $\Rightarrow$ $\frac{1}{v} - \frac{3/2}{-20} = \frac{1-3/2}{20}$ $\Rightarrow$ v = – 10
i.e. 10 cm below the curved surface or 10 cm above the actual position of flower.

20. **Sol.** $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ $\frac{1}{f} = (1.63 - 1)\left(\frac{2}{R_A}\right) = (n_B - 1)\left(\frac{2}{R_B}\right)$

$n_B - 1 = 0.63 \times \frac{R_B}{R_1} = \frac{0.63}{0.9} = 0.7$ $n_B = 1.7$

21. **Sol.** $P = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ ....(i)

$P_0 = \left(\frac{\mu}{\mu_o} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ .....(ii)

$\frac{P}{P_0} = \frac{(\mu - 1)\mu_0}{(\mu - \mu_0)}$ $P_0 = \frac{P(\mu - \mu_0)}{\mu_0(\mu - 1)}$

22. **Sol.** Lens changes its behaviour if R.I. of surrounding becomes greater than R.I. of lens.

$\mu_{lens} < 1.33$

23.# **Sol.** $f_A = f_B = f_C = f_{net}$ $\Rightarrow$ $P_A = P_B = P_C = P_{net} = P$

24. **Sol.** For m = 2

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

$V = -2u$ ....(i)

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

$\Rightarrow$ $\frac{1}{f} = \frac{1}{2u}$ $\Rightarrow$ $u = \frac{f}{2}$

& $v = -f$

Distance between object & image = f + f/2 = 3f/2

For $m = -2$

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

$v = 2u$

$\Rightarrow$ $\frac{1}{f} = \frac{1}{2u} + \frac{1}{u}$ $\Rightarrow$ $u = \frac{3f}{2}$

& $v = 3f$

Distance between object & image = $3f - \frac{3f}{2}$.

25. **Sol.** $P = P_1 + P_2$

$2 = 5 + P_2$

$P_2 = -3$ D

$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = -\frac{P_2}{P_1} = \frac{3}{5}$

26. **Sol.** $m = \frac{LD}{f_0 f_e}$ Here L = 18 cm D = 25 cm

or $m = \frac{v_0}{-u_0}\left(\frac{D}{f_e}\right)$ Here $\frac{v_0}{-u_0} = \frac{L}{f_0}$

$m = \frac{18 \times 25}{0.2 \times 4} = \frac{2250}{4} = 562.5$

27. **Sol.** displacement $= \frac{t\sin(i-r)}{\cos r}$

Since i and r are small angles.

Displacement = t (i – r)

$= t\,i\left(1 - \frac{r}{i}\right) = t\,\theta\left(1 - \frac{1}{n}\right) = \frac{t\theta(n-1)}{n}$

28. **Sol.** $\delta = A = 2r = (2i - 2r)$

$\Rightarrow$ i = A

$\sqrt{3} = \frac{\sin A}{\sin A/2}$

$\Rightarrow \cos\frac{A}{2} = \frac{\sqrt{3}}{2}$

$\Rightarrow \frac{A}{2} = 30^o$

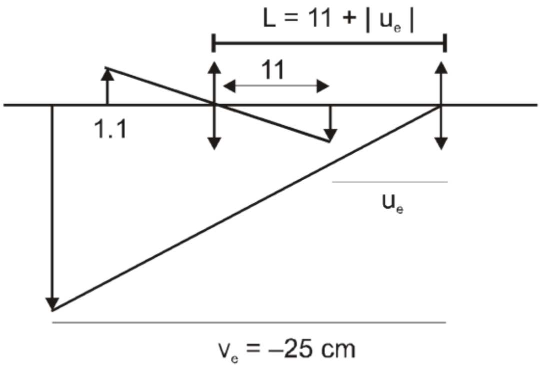
$\Rightarrow A = 2 \times 30 = 60^o$

29. **Sol.** $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{-5} - \frac{1}{-1} = \frac{1}{f}$

f = 1.25 inch

30. **Sol.**



For objective

$\frac{1}{v_0} - \frac{1}{-1.1} = \frac{1}{1}$

$\frac{1}{v_0} = \frac{1}{11}$, $v_0 = 11$ cm

For eyepiece.

$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

$\frac{1}{-25} - \frac{1}{u_e} = \frac{1}{5}$

$-\frac{1}{u_e} = \frac{6}{25}$

$-u_e = \frac{25}{6}$

$\therefore \quad L = 11 + \frac{25}{6} = \frac{91}{6}$ cm

PART - II : PRACTICE QUESTIONS

1.#

Sol. **Key Idea :** For total internal reflection angle of incidence should be greater than critical angle. For total internal reflection to take place, angle of incidence > critical angle

i.e. $i > C$

or $\theta > C$

or $\sin\theta > \sin C$

but $\sin C = \frac{1}{\mu}$

and from figure, $\theta = 90° - r$

So, $\sin(90° - r) > \frac{1}{\mu}$

i.e., $\mu = \frac{1}{\cos r}$ ... (i)

From Snell's law,

$$\frac{\sin 45°}{\sin r} = \mu$$

$\Rightarrow$ $\sin r = \frac{1}{\sqrt{2}\mu}$

$\therefore$ $\cos r = \sqrt{1-\sin^2 r} = \sqrt{1-\frac{1}{2\mu^2}}$

Thus, equation (i) becomes

$$\mu > \frac{1}{\sqrt{1-\frac{1}{2\mu^2}}}$$

$\therefore$ $\mu^2 = \frac{1}{1-\frac{1}{2\mu^2}}$

or $\mu^2 - \frac{1}{2} = 1$

or $\mu = \sqrt{\frac{3}{2}}$

2.# **Sol.** Initially, the focal length of equiconvex lens is

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

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

Case I : When lens is cut along XOX' then each half is again equiconvex with

$R_1 = +R$, $R_2 = -R$

Thus, $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R} - \frac{1}{(-R)}\right]$

$= (\mu - 1)\left[\frac{1}{R} + \frac{1}{R}\right]$

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

$\Rightarrow$ $f' = f$

Case II : When lens is cut along YOY', then each half becomes plano-convex with

$R_1 = R$, $R_2 = \infty$

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

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

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

Hence, f ' = f, f '' = 2f

3. **Sol.** From lens maker's formula

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

When convex lens is dipped in a liquid of refractive index (μ_ℓ) then its focal length

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

or $$\frac{1}{f_\ell} = \frac{(\mu_g - \mu_\ell)}{\mu_\ell}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ....(ii)$$

Dividing equation (i) by equation (ii), we get

$$\frac{f_\ell}{f} = \frac{(\mu_g - 1)\mu_\ell}{(\mu_g - \mu_\ell)} \quad ....(iii)$$

But it is given that refractive index of lens is equal to refractive index of liquid i.e., $\mu_g = \mu_\ell$.

Hence, equation (iii) gives,

$$\frac{f_\ell}{f} = \frac{(\mu_g - 1)\mu_\ell}{0} = \infty \quad \text{(infinity)}$$

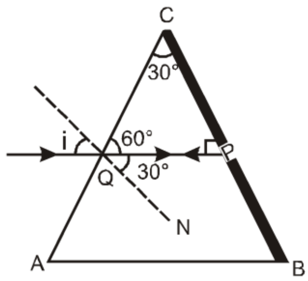
4. **Sol.** According to the given condition, the beam of light will retrace its path after reflection from BC. So

$\angle CPQ = 90°$

Thus, angle of refraction at surface AC

$\angle PQN = \angle r = 90° - 60° = 30°$

By Snell's law



$\mu = \frac{\sin i}{\sin r}$

$\Rightarrow \quad \sqrt{2} = \frac{\sin i}{\sin 30°}$

$\therefore \quad \sqrt{2} \times \sin 30° = \sin i$

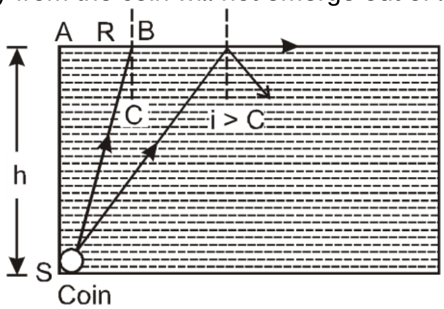
$\Rightarrow \quad \sqrt{2} \times \frac{1}{2} = \sin i$

$\Rightarrow \quad \sin i = \frac{1}{\sqrt{2}} = \sin 45°$

$\therefore \quad i = 45°$

5.# **Sol.** **Key Idea :** Critical angle is the angle of incidence in denser medium for which the angle of refraction in rarer medium is 90°

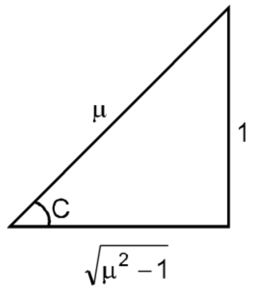
As shown in figure, a light ray from the coin will not emerge out of liquid, if i > C.



Therefore, minimum radius R corresponds to

i = C.

In Δ SAB,



$\frac{R}{h} = \tan C$

or $R = h \tan C$

or $R = \frac{h}{\sqrt{\mu^2-1}}$

Given, R = 3 cm, h = 4 cm

Hence, $\frac{3}{4} = \frac{1}{\sqrt{\mu^2-1}}$

or $\mu^2 = \frac{25}{9}$ or $\mu = \frac{5}{3}$

But $\mu = \frac{c}{v}$ or $v = \frac{c}{\mu}$

$= \frac{3\times10^8}{5/3}$

$= 1.8 \times 10^8$ m/s

6. **Sol.** Focal length of conave mirror f = – 15 cm

magnification = 2 (for virtual image)

Linear magnification $m = \frac{\text{size of image}}{\text{size of object}} = -\frac{\upsilon}{u}$

$2 = -\frac{\upsilon}{u}$ or $\upsilon = -2u$

Now, from the relation

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

or $-\frac{1}{15} = \frac{1}{u} - \frac{1}{2u}$

$= \frac{1}{2u}$

or 2u = – 15 or u = – 7.5 cm

7. **Sol.** Appplying the lens maker's formula

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

we know that the greater positive power is for that material for which $\frac{1}{R_1} - \frac{1}{R_2}$ is maximum and positive. For this condition R_1 and R_2 should be as small as possible but still it must be positive, therefore we must select the combination which has less radius of curvature for convex lens. Hence, option (1) is correct.

8. **Sol.** The focal length of the convex lens

$f = \frac{1}{p}$ m

or $f = \frac{1}{5} \times 100$ cm

or f = 20 cm

From the relation, we get

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

— here, f = 20 cm, u = – 10 cm

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

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

$= \frac{-2+1}{20} = -\frac{1}{20}$

Hence, v = – 20 cm

Therefore, the image will be formed at a distance of 20 cm on the same side of the object.

9.

Sol. For prism

$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

Here, A = 60°

$\Rightarrow \sqrt{3} \times \sin 30° = \sin\left(\frac{60° + \delta_m}{2}\right)$

$\Rightarrow \sin\left(\frac{60° + \delta_m}{2}\right) = \sin 60°$

$\Rightarrow 60° + \delta_\mu = 120° \Rightarrow \delta_m = 60°$

10.# **Sol.** Using the formula

$\mu_{prism} = \frac{\mu_{liquid}}{\mu_{prism}} = \frac{1.32}{1.56} = \frac{11}{13}$ … (i)

Now, the condition for the total internal reflection, occurs when

$\sin\theta \geq \mu$

So, $\sin\theta \geq \frac{11}{13}$

11. **Sol.** Length of tube = 10 cm

$f_0 + f_e = 10$ cm

Magnification $m = \frac{f_0}{f_e} = 4$

$f_0 = 4 f_E$

putting in Eq. (i),

$5f_e = 10$ cm,

or $f_e = 2$ cm,

and $f_o = 8$ cm,

$f_0 = 8$ cm, $f_e = 2$ cm

Hence, L_4 and L_1 will be used.

12. **Sol.** Biconvex lens is cut perpendicularly to the principal it will become a plano-convex lens.

Focal length of biconvex lens

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

$\frac{1}{f} = (n-1)\frac{2}{R}$ $(\because\ R_1 = R,\ R_2 = -R)$

$\Rightarrow$ $f = \frac{R}{2(n-1)}$ … (i)

For plano-convex lens

$\frac{1}{f_1} = (n-1)\left(\frac{1}{R} - \frac{1}{\infty}\right)$

$f_1 = \frac{R}{(n-1)}$ … (ii)

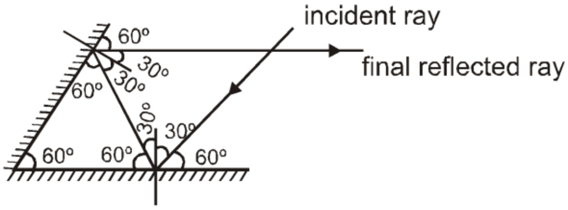
Comparing Eqs. (i) and (ii), we see that focal length becomes double.

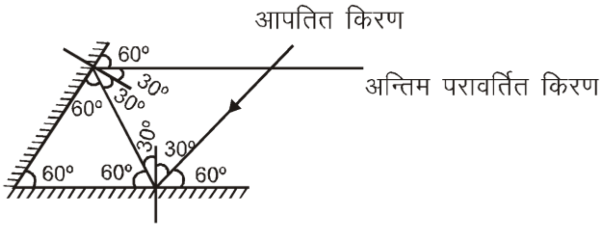
As power of lens $p \propto \frac{1}{\text{focal length}}$

Hence, power will become half.

New power = $\frac{4}{2}$ = 2D

13. **Sol.**





$\delta = (\pi - 60^\circ) + (\pi - 60^\circ) = 240^\circ$

14.

Sol. $\frac{1}{v} - \frac{1}{\infty} = \frac{1}{f}$ $P = \frac{1}{f}$

v = 50 cm f = 50 cm

Specticle lens forms image at 50 cm, which acts as an object for eye.

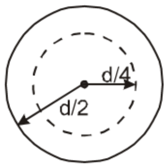
He can see objects clearly input 50 cm

15. Sol. Larger aperture increases the amount of light gathered by the telescope increasing the resolution.

16. Sol. $n = \left(\frac{360^\circ}{\theta}\right) - 1 = \left(\frac{360}{60} - 1\right) = 5$

17. Sol. Optics fibres are based on total internal reflection.

18. Sol.



Initial area $= \frac{\pi d^2}{4}$

after blockening, area that allows light $= \frac{\pi d^2}{4} - \frac{\pi d^2}{16} = \frac{3}{4} \cdot \frac{\pi d^2}{4}$

It is $\frac{3}{4}$ th of the total area of the lens that would allow the light, hence

Intensity is now $\frac{3I}{4}$. There will be no change in focal length

19. Sol. The objective of compound microscope is a lemax lens and it forms real and enlarged image when an object is placed between its focus and lens.

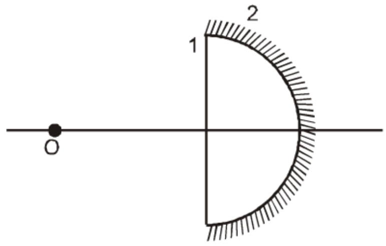
20. Sol. $\frac{360^\circ}{\theta} - 1 = 3. = \theta = 90^\circ$

21.# Sol. i > c for ITR

$\therefore 45^\circ > \sin^{-1}\left(\frac{1}{n}\right)$

$\Rightarrow n > \sqrt{2}$

22. Sol. To get real image of the size of the object, object should be placed at the centre of curvature of equivalent mirror.



$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_\ell}$

$f_m = -15cm$

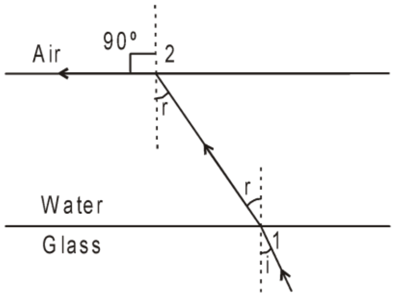
and $\frac{1}{f_2} = \frac{1}{-15} - \frac{2}{60}$

$F_2 = -10$ cm

Hence, object should be placed at 20cm from the combination

23.(i)# Sol. Applying Snell's law (μ sin i = constant)
at 1 and 2 we have

$\mu_1 \sin i_1 = \mu_2 \sin i_2$



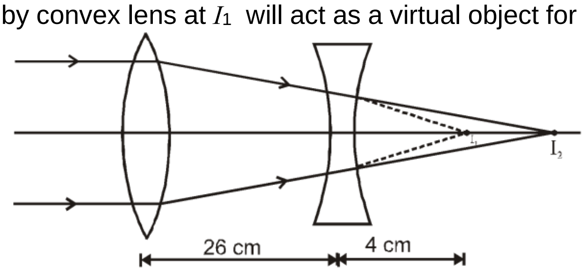
Here $\mu_1 = \mu_g$; and $\mu_2 = 1$ and $i_2 = 90°$

$i_1 = i$

$\mu_g \sin i = (1) (\sin 90°)$

or $\mu_g = \frac{1}{\sin i}$

(ii) Sol. Image formed by convex lens at I_1 will act as a virtual object for concave lens. For concave lens



$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ or $\frac{1}{v} - \frac{1}{4} = \frac{1}{-20}$ or $v = 5$ cm

magnification for concave lens $m = \frac{v}{u} = \frac{5}{4} = 1.25$

As size of the image at I_1 is 2 cm. Therefore, size image at I_2 will be 2 × 1.25 = 2.5 cm.

24.

Sol. When the object is placed at the centre of the glass sphere, the rays from the object fall normally on the surface of the sphere and emerge undeviated.
Hence, the correct option is (B).

25.# **Sol.** During minimum deviation the ray inside the prism is parallel to the base of the prism in case of an equilateral prism.
Hence, the correct option is (C)

26. **Sol.** Critical angle $\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$
Wavelength increases in the sequence of VIBGYOR. According to Cauchy's formula refractive index (μ) decreases as the wavelength increases. Hence the refractive index will increase in the sequence of ROYGBIV. The critical angle θ_C will thus increase in the same order VIBGYOR. For green light the incidence angle is just equal to the critical angle. For yellow, orange and red the critical angle will be greater than the incidence angle. So these colours will emerge from the glass air interface.
Hence, the correct option is (A).