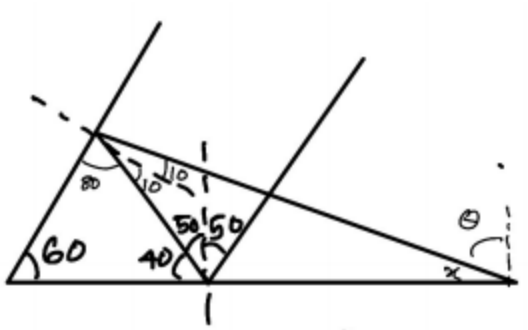
CHAPTER - 16

RAY OPTICS

1. 3



$x = 180 - 160 = 20^\circ$

$\theta = 70^\circ$

2. 1

$90 + x = 110$

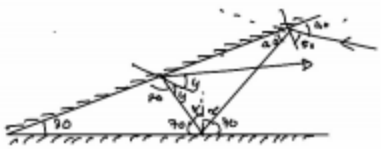
$x = 20$

$y = 10^\circ$

$\delta_1 = 180 - 2\times50 = 80$ (a.c.w)

$\delta_2 = 180 - 2\times20 = 140$ c.w

$\delta_3 = 180 - 2\times10 = 160$ (c.w)



$\delta_{net} = (160 + 140 - 80)$ cw

$= 300 - 80$

$= 220^\circ$

3. 3

$$V_I = -\left(\frac{f}{f-u}\right)^2 V_0$$

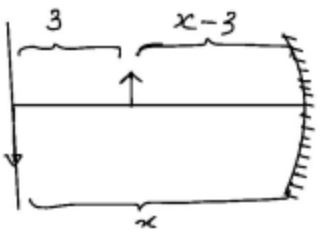
4. 3

$\frac{x}{x-3} = 3$

$x = 3x - 9$

$9 = 2x$

$x = 4.5m$



5. 4

$$\frac{dy}{dx} = 1$$

$$y^2 = 2x$$

$$2y\frac{dy}{dx} = 2$$

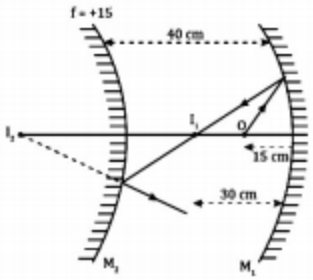
$$\frac{dy}{dx} = \frac{1}{y}$$

$$y = 1$$

$$x = 1/2.$$

6. 2

The correct option is **B** 6 cm behind the convex mirror



For mirror M_1, O act as an object.

Let its image be I_1.

Then u = −15 cm, f = −10 cm

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

Image I_1 will act as an object for mirror M_2 its distance from mirror M_2

$u_1 = -(40 - 30)$ cm = −10 cm

So $\frac{1}{v_1} + \frac{1}{u_1} = \frac{1}{f} \Rightarrow \frac{1}{v_1} + \frac{1}{-10} = \frac{1}{15} \Rightarrow v_1 = +6$ cm

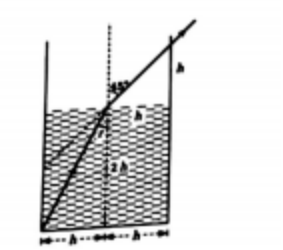
Therefore, image I_2 is formed at a distance 6 cm behind the convex mirror and is virtual.

7. 2

$$\eta = \frac{32}{15+5}$$

$$\eta = \frac{32}{20} = 1.6$$

8. 2



$\mu = \frac{\sin 45}{\sin r}$

From figure, $\sin r = \frac{h}{h\sqrt{5}}$

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

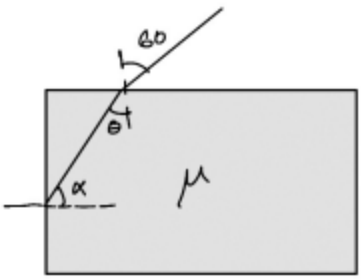
9. 3

Effective object distance from mirror

$= 5 + 7.5$

$= 12.5\text{cm}$

10. 3



$1 \sin 60 = \mu \sin\theta$

$\sin\theta = \frac{\sqrt{3}}{2\mu}$

$\cos\theta = \sqrt{1 - \frac{3}{4\mu^2}}$

$\sin\alpha > \frac{1}{\mu}$

$\sqrt{1 - \frac{3}{4\mu^2}} > \frac{1}{\mu}$

$1 - \frac{3}{4\mu^2} > \frac{1}{\mu^2}$

$1 > \frac{7}{4\mu^2}$

$\mu > \frac{\sqrt{7}}{2}$

11. 1

$V_{B'F} = 9$

$V_{B'} = 9 - 3 = 6$

$V_{B'} = n V_B$

$V_B = \frac{6}{n} = 4.5$

12. 3 $2 = t\left(1-\frac{1}{\mu}\right)$

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

$t = 6\ cm$

13. 1 for T.I.R

$\sin 45 > \frac{1}{n}$

$n > 1.414$

14. 3 $1\sin i = \sqrt{2}\sin 30$

$i = 45^0$

15. 4 $A' = -A\frac{(n-1)}{n'-1}$

16. 3 $u = -100$

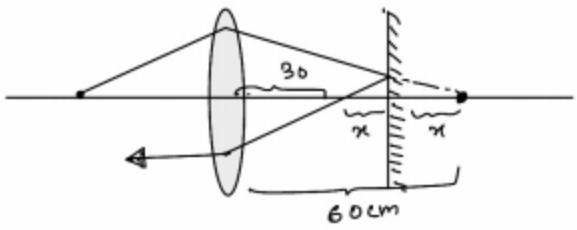
$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

$\frac{1.5}{V} - \frac{1}{-100} = \frac{0.5}{20}$

$\frac{1.5}{V} = -\frac{1}{100} + \frac{2.5}{100} = \frac{1.5}{100}$

$V = 100\ cm$

17. 3



$30 + 2x = 60$

$x = 15$

$30 + x = 45$

18. 2

$f_L = \frac{R}{2(n-1)} = 20cm$

$f_m = -\frac{25}{2}$

$\frac{1}{F} = \frac{1}{f_m} - \frac{2}{f_L} = -\frac{2}{25} - \frac{2}{25} = -\frac{1}{25}$

$F = -25$

$2F = -12.5$

19. 1

$f_0 = 2$

$f_e = 3$

$V_0 + f_e = 15$

$V_0 = 12$

$u_0 = \frac{V_0 f_0}{f_0 - u_0} = \frac{12 \times 2}{2-12} = \frac{12 \times 2}{-10}$

$u_0 = -2.4cm$

20. 2

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

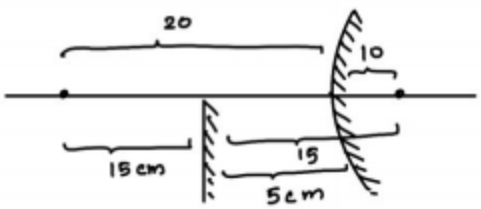
$f_0 + f_e = 36$

$f_0 = 30$

$f_e = 6$

SECTION II (NUMERICAL)

21. 20.



for mirror

$u = -20$, $v = 10$

$f = \frac{uv}{u+v} = \frac{-20 \times 10}{-20+10} = \frac{-20 \times 10}{-10} = 20cm$

22. 6

$f = 20$

$m_{25} = \frac{f}{f+u} = \frac{20}{20-25} = -4$

$m_{50} = \frac{f}{f+u} = \frac{20}{20-50} = \frac{20}{-30} = -\frac{2}{3}$

$\frac{m_{25}}{m_{50}} = \frac{-4 \times 3}{-2} = 6$ //

23. 6. $R = \frac{d}{\sqrt{\mu^2-1}} = \frac{8\,cm}{\sqrt{\frac{25}{9}-1}} = \frac{8\,cm}{\sqrt{\frac{16}{9}}} = \frac{8cm \times 3}{4} = 6\,cm$

24. 48 $i = 20, \; e = 38$

$\delta = 10$

$\delta = i + e - A$

$10 = 20 + 38 - A$

$A = 48^0$

25. 9 $t\left(1 - \frac{1}{n}\right) = 3$

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

$t \times \frac{1}{3} = 3$

$t = 9\,cm$

JEE ADVANCED LEVEL

SECTION III

26. A $t = \frac{s}{(\sin 30)v} = \frac{6m}{0.02\,cm\,s^{-1}} = 900\,s$

27. B

$u_1 = -\frac{3}{2}x$

$V_1 = \frac{u_1 f}{u_1 - f} = \frac{-\frac{3}{2}x(-x)}{-\frac{3}{2}x + x} = \frac{\frac{3x}{2} \times x}{-x/2} = -3x$

$V_2 = -2x$

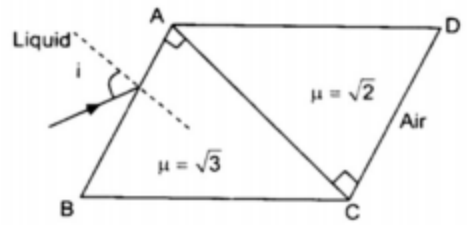
$V_2 - V_1 = -2x - (-3x) = x$

28. A

$\sqrt{3}\sin(90 - i) = \sqrt{2}\sin r$

$1 \sin i = \sqrt{2} \sin(90° - r)$

On solving we get, $i = 45°$



29. C

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

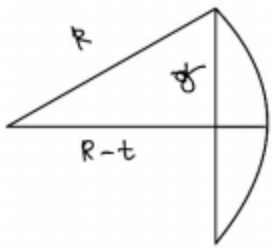
$R^2 = R^2 + t^2 - 2Rt + r^2$

$2Rt = r^2$

$R = \frac{r^2}{2t} = \frac{9}{2 \times 0.3}$

$R = 15\text{cm}$

$f = \frac{R}{n-1} = \frac{15}{0.5} = 30$



30. B

Step 1 (lens)

$u = -15 \quad f = 30$

$v = \frac{-15 \times 30}{-15+30} = \frac{-15\times30}{15} = -30\text{cm}$

for mirror

obj distance = 45

image distance = 45

In third step.

$u = -60$

$v = +60\text{cm}$.

Option. B

31. D

$u = -20$

$v = \frac{-20\times15}{-20+15} = \frac{-20\times15}{-5} = +60\text{cm}$.

For second lens.

$u = -60\text{cm}$

$h_o = -8\text{mm}$.

$v = \frac{-60\times15}{-60+15} = \frac{-60\times15}{-45} = 20$

$\frac{h_i}{h_o} = \frac{20}{-60} = -\frac{1}{3}$

$h_i = \frac{-h_o}{3} = \frac{8}{3}$ //

32. A

$\theta + 90 + r_1 + 90 - r_2 = 180$

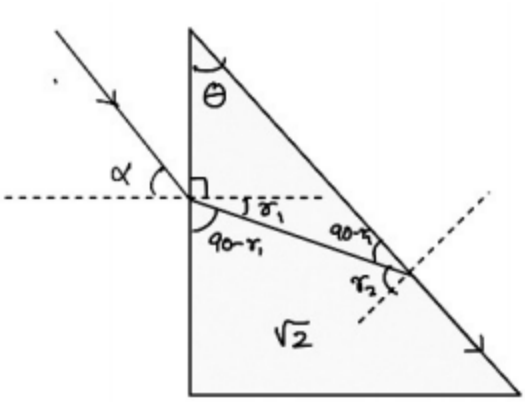
$\theta = r_2 - r_1$

$r_1 = r_2 - \theta$

When $r_2 = \theta_c$

$r_1 = \theta_c - \theta$

$1 \sin i = \sqrt{2} \sin r_1$



$\frac{1}{\sqrt{2}} = \sqrt{2} \sin r_1$

$r_1 = 30^\circ$

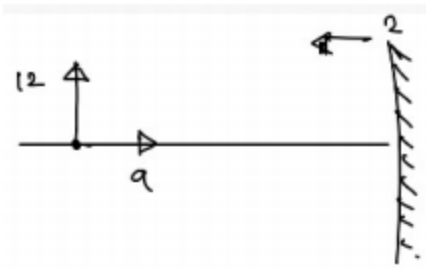
$30 = \theta_c - \theta$

$\theta = \theta_c - 30$

$= \sin^{-1}\frac{1}{\sqrt{2}} - \theta_c = 15^\circ$

SECTION IV (More than one correct)

33. B,C



$V_{I_y} = m \times 12$

$= \frac{f}{f-u} \times 12$

$V_{I_y} = \frac{-20}{-20-(-30)} \times 12$

$V_{I_y} = \frac{-20 \times 12}{10}$

$= -24$

$m = \frac{-20}{-20-(-30)}$

$m = -2$

along x

$V_{IM_x} = -m^2 V_{OM_x}$

$V_{IM_x} = -4 \times (9-(-2))$

$= -4 \times 11$

$V_{I_x} - V_M = -44$

$V_{I_x} = -44 + (-2)$

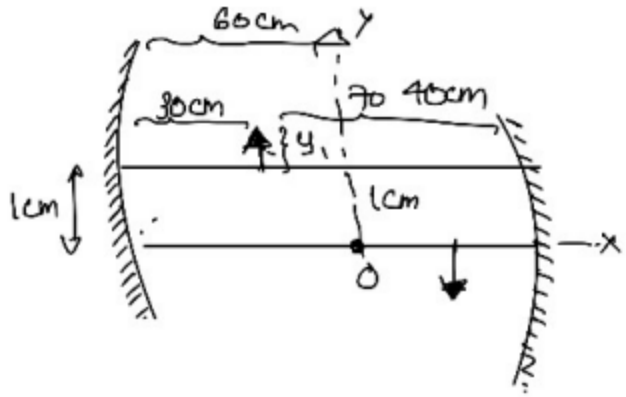
$= -46$

$\vec{V_I} = -46\hat{i} - 24\hat{j}$

$\vec{V_M} = -2\hat{i}$

$\vec{V_{IM}} = -44\hat{i} - 24\hat{j}$

34. A,B,C,D



$u = 60cm$

$f = +20cm$.

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

$v = \frac{60 \times 20}{60-20}$

$v = \frac{60 \times 20}{40} = 30cm$

$m_1 = -\frac{v}{u} = -\frac{30}{60} = -\frac{1}{2}$

$y_1 = m_1 \times 1cm = \frac{1}{2} \times 1 = \frac{1}{2}cm$ //

$1 + y_1 = 1.5cm$

for second reflection

$u = -70, f = -20$

$v = \frac{uf}{u-f} = \frac{-70(-20)}{-70+20} = \frac{70 \times 20}{-50} = -28cm$

$m = -\frac{v}{u} = -\left(\frac{-28}{-70}\right) = -\frac{4}{10} = -0.4$

height of image $= 0.4 \times 1.5 = 0.6cm$

x coordinate of second image $= 12cm$

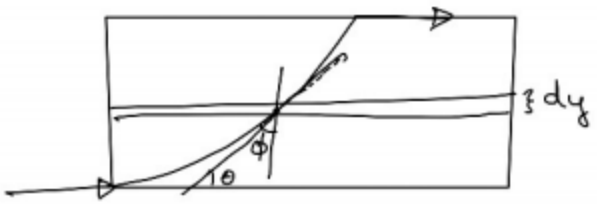
35. A,C,D

$1 \sin 90 = \mu \sin \phi$

$1 = \sqrt{1+y} \sin \phi$

$\sin \phi = \frac{1}{\sqrt{1+y}}$

$\cos \phi = \sqrt{\frac{1+y-1}{1+y}} = \sqrt{\frac{y}{1+y}}$



$\sin\theta = \frac{\sqrt{y}}{\sqrt{1+y}}$, $\cos\theta = \frac{1}{\sqrt{1+y}}$

$\tan\theta = \sqrt{y}$

$\frac{dy}{dx} = \sqrt{y}$

$y^{-1/2}\,dy = dx$

$\frac{y^{1/2}}{1/2} = x$

$\sqrt{y} = \frac{x}{2}$

$y = \frac{x^2}{4}$

when $y = 2$

$x^2 = 4y = 8$

$x = 2\sqrt{2}$,

36. A,B,C

for T.I.R at second surface

$r_2 > \theta_c$ $\quad \theta_c = 45^\circ$

$r_2 > 45$

$r_1 = A - 45$.

$r_1 = 40 - 45 \longrightarrow$ not possible

for T.I.R to be possible

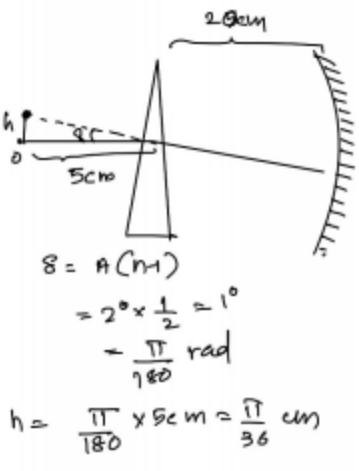
$A > 45^\circ$

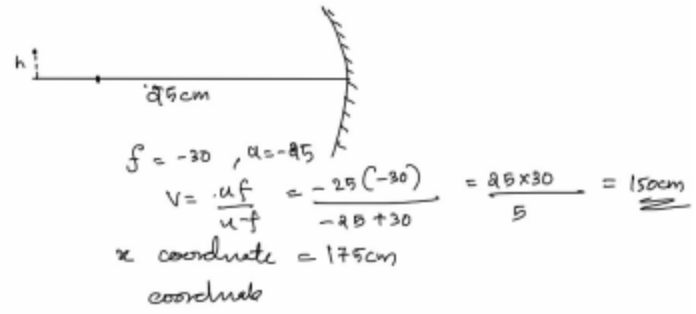
for T.I.R always

$A < 2\theta_c$

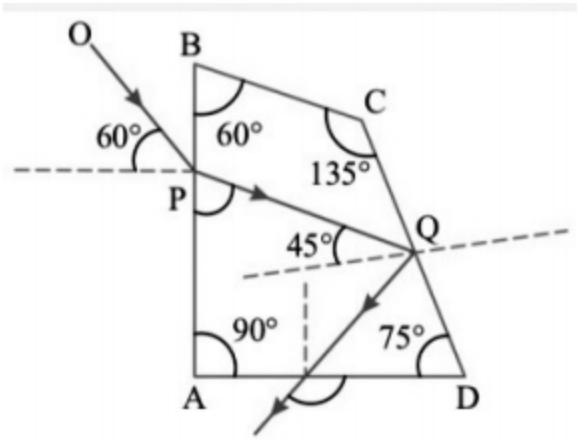
$A < \underline{90^\circ}$

37. A,B,C,D





38. A,B,C



By refraction at face AB

$1.\sin 60^0 = \sqrt{3}.\sin r_1$; So, $r_1 = 30^0$

this shows that the refracted ray is parallel to side BC of prism. For side 'CD' angle of incidence C will be 45^0, which can be calculated fromquadrilateral PBCQ. By refractin at face CD:

$\sqrt{3}\sin 45^0 = 1\sin r_2$; So, $\sin r_2 = \frac{\sqrt{3}}{\sqrt{2}}$

which is impossible, So, there will be T.I.R at face CD. Now, by geometry angle of incidence at AD

will be 30^0. Hence, angle between incident and emergent beams is 90^0

39. C,D

. he lens makers' formula is :

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

Where n_L = Refractive index of lens and
n_m = Refractive index of medium. In case of double concave lens, R_1 is negative and R_2 is positive.

Therefore $\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ will be negative.

For the lens to be diverging in nature, focal length 'f' should be negative or $\left(\frac{n_L}{n_m}-1\right)$ should be positive or $n_L > n_m$ but since $n_2 > n_1$(given), therefore the lens should be filled with L_2 and immersed in L_1.

SECTION V - (Numerical type)

40. 48

$S = 15\left(1-\frac{2}{3}\right) = 5cm$

for mirror

$u = -40cm$

$v = \frac{uf}{u-f} = \frac{-40\times 10}{-40-10} = \frac{-40\times 10}{-50} = 8cm$

$I_1 = I_2 = 48cm$

41. 48

$A = 74^\circ$

$i^\circ = 53^\circ$

$\delta_{et} = (2\times 53-74)+53-37 = 106-74+16$

$= 32+16 = 48$

42. 1.2

normal $-\hat{k}$

$$\hat{e_i} = \frac{2\hat{i}+4\hat{j}+\sqrt{5}\hat{k}}{\sqrt{4+16+5}}$$

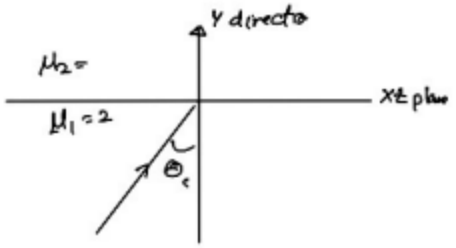
$$\hat{e_i} = \frac{2\hat{i}+4\hat{j}+\sqrt{5}\hat{k}}{5}$$

$$\hat{e_i} \cdot \hat{j} = \cos\theta_c = \frac{4}{5}$$

$$\theta_c = 37^\circ$$

$$\sin 37 = \frac{\mu_2}{\mu_1}$$

$$\mu_2 = \frac{3}{5} \times 2 = \frac{6}{5} = 1.2$$



SECTION VI - (Matrix match type)

43. A → PQRS, B → Q, C → PQRS, D → PQRS

A)
real as well as virtual image possible

A → p, q, r, s

B) Only virtual diminished images are possible

B → q

c) real and virtual images are possible

C → p, q, r, s

d) real and virtual images are possible

D → p, q, r, s