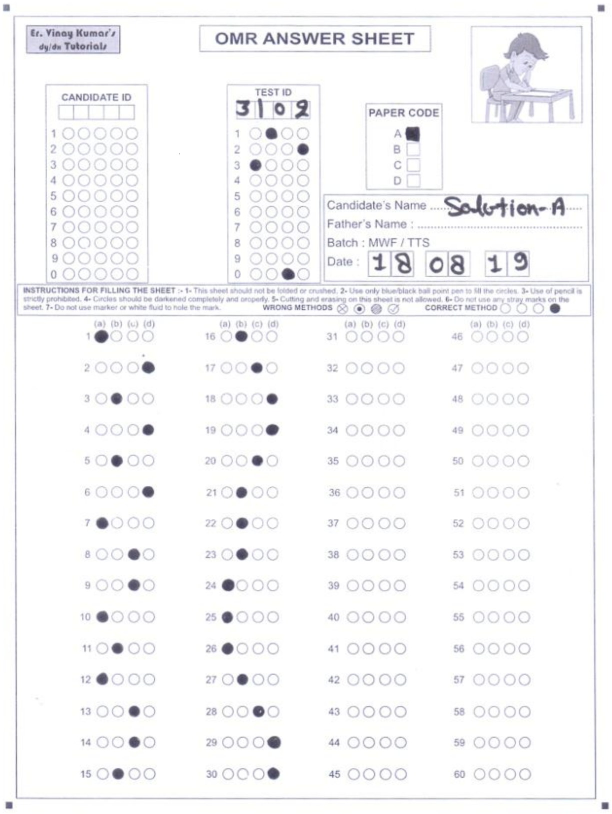
SET (A)



Q1. If the combination in figure (a) has focal length 24 cm, each lens has focal length $2\times 24 = 48\,cm$ (both lenses are identical) $\Rightarrow f = 2R$ (for plano convex glass lens) $\Rightarrow 48 = 2R \Rightarrow R = 24cm$

The lens of liquid

$$\Rightarrow f' = -\frac{R}{2(\mu-1)} = -\frac{24}{2(1.6-1)}$$

$$= -\frac{12}{0.6} \Rightarrow f' = -20cm$$

Focal length of combination :

$$\frac{1}{F} = \frac{1}{24} + \frac{1}{-20} = \frac{10-12}{240} = -\frac{2}{240}$$

$$\Rightarrow F = -120\,cm$$

Q3. For refraction on second surface

$\mu_o = \mu, \quad \mu_i = 1, \quad u = -2R, \quad v = -6R \quad R \Rightarrow -R$

$$\frac{\mu_i}{v} - \frac{\mu_o}{u} = \frac{\mu_i - \mu_o}{R} \Rightarrow \frac{1}{-6R} - \frac{\mu}{-2R} = \frac{1-\mu}{-R}$$

$$\Rightarrow -\frac{1}{6} + \frac{\mu}{2} = \mu - 1$$

$$\Rightarrow \frac{\mu}{2} = 1 - \frac{1}{6} \Rightarrow \frac{\mu}{2} = \frac{5}{6}$$

$$\Rightarrow \mu = \frac{10}{6} = \frac{5}{3} = 1.67$$

Q5. If the lens is diverging its power P should be negative

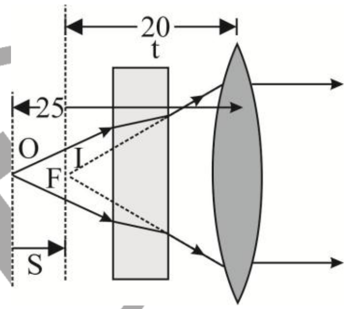
$$P < 0 \Rightarrow \frac{\mu_2 - \mu_1}{-2R} - \frac{\mu_2 - \mu_3}{-R} < 0$$

$$\Rightarrow -\frac{\mu_2 - \mu_1}{2R} + \frac{\mu_2 - \mu_3}{R} < 0$$

$$\Rightarrow \frac{\mu_2 - \mu_3}{R} < \frac{\mu_2 - \mu_1}{2R} \Rightarrow \mu_2 - \mu_3 < \frac{\mu_2 - \mu_1}{2}$$

$$\Rightarrow 2\mu_2 - 2\mu_3 < \mu_2 - \mu_1 \Rightarrow 2\mu_3 > \mu_1 + \mu_2$$

Q6. Due to slab the first image I_1 is formed at shift $\left[S = t\left(1 - \frac{1}{\mu}\right)\right]$.



This image I_1 is situated at focus of the lens to make finally refracted rays parallel.

shift $\Rightarrow S = 25 - 20 = 5$

$$S = t\left(1 - \frac{1}{\mu}\right) \Rightarrow 5 = t\left(1 - \frac{1}{3/2}\right)$$

$$\Rightarrow 5 = t\left(1 - \frac{2}{3}\right) \Rightarrow 5 = t \times \frac{1}{3} \Rightarrow t = 15\,cm$$

Q7. $u = -30, \; v = -60 \Rightarrow P = \frac{1}{v} - \frac{1}{u}$

$$\Rightarrow P = \frac{1}{-60} - \frac{1}{-30}$$

$$\Rightarrow P = \frac{1}{30} - \frac{1}{60} = \frac{2-1}{60} = \frac{1}{60}$$

$$\Rightarrow P = \frac{1}{60} \times 100 \Rightarrow P = +1.67D$$

Q8. $\frac{1}{f} = 0.4 \Rightarrow f = \frac{1}{0.4} = \frac{10}{4} = 2.5\,cm$

$R = 2f = 2 \times 2.5 = 5\,cm$

Q9. $fe = 4fo = 2$

$$Me = 1+\frac{D}{fe} = 1+\frac{24}{4} = 1+6 = 7$$

$$M = mo \times Me$$

$$M = \frac{fo}{fo+uo} \times Me$$

$$= \frac{2}{2+(-6)} \times 7 = \frac{2}{-4} \times 7 = -\frac{14}{4} = -3.5$$

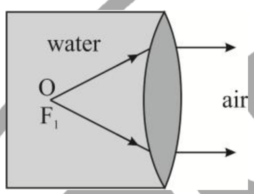
Q10. $f_1 = -\frac{R}{\mu_1 - 1}$, $f_2 = \frac{R}{\mu_2 - 1}$

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow \frac{1}{F} = -\frac{\mu_1 - 1}{R} + \frac{\mu_2 - 1}{R}$$

$$\Rightarrow \frac{1}{F} = \frac{1}{R}[-\mu_1 + 1 + \mu_2 - 1]$$

$$\Rightarrow \frac{1}{F} = \frac{1}{R}[\mu_2 - \mu_1] \Rightarrow F = \frac{R}{\mu_2 - \mu_1}$$

Q11. To form image at ∞ the object should be placed at first focus of the lens.



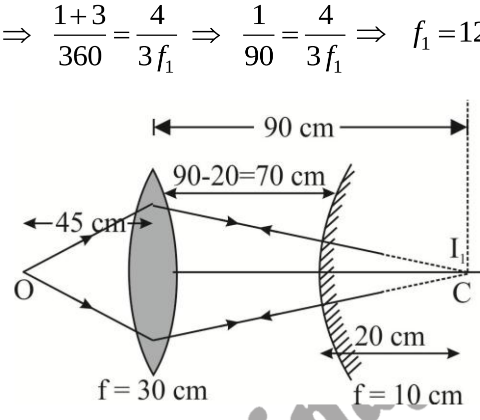
$$P = \frac{\mu - \mu_0}{R_1} - \frac{\mu - \mu_i}{R_2} = \frac{\mu_i}{f_2} = \frac{\mu_0}{f_1}$$

$$\Rightarrow \frac{\mu - \mu_0}{R_1} - \frac{\mu - \mu_i}{R_2} = \frac{\mu_0}{f_1}$$

$$\Rightarrow \frac{\frac{3}{2} - \frac{4}{3}}{+60} - \frac{\frac{3}{2} - 1}{-60} = \frac{\frac{4}{3}}{f_1} \Rightarrow \frac{1}{360} + \frac{1}{120} = \frac{4}{3f_1}$$

$$\Rightarrow \frac{1+3}{360} = \frac{4}{3f_1} \Rightarrow \frac{1}{90} = \frac{4}{3f_1} \Rightarrow f_1 = 120\,cm$$

Q12.



Position of image formed by the lens.

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{30} = \frac{1}{v} - \frac{1}{-45}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{30} - \frac{1}{45} = \frac{3-2}{90} \Rightarrow v = 90\,cm$$

To make the ray retrace its path the first image I_1 should be formed at centre of curvature of this mirror.

$\Rightarrow$ distance between lens and mirror $\Rightarrow d = 90 - 20 = 70cm$

Q13. Refraction on first surface :

$u = -2R,\ \mu_o = 1,\ \mu_i = \frac{3}{2}$

$R \Rightarrow +R$

$$\frac{\mu_i}{v} - \frac{\mu_o}{u} = \frac{\mu_i - \mu_o}{R} \Rightarrow \frac{3}{2v} - \frac{1}{-2R} = \frac{\frac{3}{2} - 1}{+R}$$

$$\Rightarrow \frac{3}{2v} = 0 \Rightarrow v = \infty$$

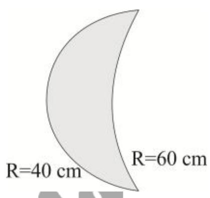
Refraction on second surface :

$u = \infty,\ \mu_o = \frac{3}{2},\ \mu_i = 1,\ R \Rightarrow -R$

$$\frac{\mu_i}{v} - \frac{\mu_o}{u} = \frac{\mu_i - \mu_o}{R} \Rightarrow \frac{1}{v} - \frac{3}{2(\infty)} = \frac{1 - \frac{3}{2}}{-R}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{2R} \Rightarrow v = 2R$$

Q14. Since the lens is concavo-convex hence its convex surface is more powerful i.e. itsradius of curvature is less (40 cm).



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

$$= \left(\frac{3}{2} - 1\right)\left(\frac{1}{+40} - \frac{1}{+60}\right) = \frac{1}{2} \times \left(\frac{3-2}{120}\right)$$

$$= \frac{1}{2} \times \frac{1}{120} \Rightarrow f = +240\,cm$$

Q15. (a) possible for virtual object

(c) & (d) are possible for real object

Q18. $\frac{f_s}{f} = \frac{(\mu - 1)}{\left(\frac{\mu}{\mu_s} - 1\right)} \Rightarrow \frac{f_s}{30} = \frac{\left(\frac{4}{3} - 1\right)}{\left(\frac{4/3}{5/4} - 1\right)}$

$$\Rightarrow \frac{f_s}{30} = \frac{1/3}{\left(\frac{16}{15} - 1\right)} \Rightarrow \frac{f_s}{30} = \frac{1/3}{1/15}$$

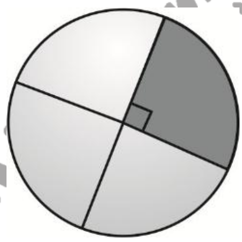
$\Rightarrow \dfrac{f_s}{30} = \dfrac{15}{3} \Rightarrow f_s = 150\, cm$

Q19. $\delta = \left(\dfrac{4}{3} - 1\right)A - \left(\dfrac{5}{4} - 1\right)A' + \left(\dfrac{3}{2} - 1\right)A = 0$

$\dfrac{A}{3} - \dfrac{A'}{4} + \dfrac{A}{2} = 0 \Rightarrow \dfrac{4A - 3A' + 6A}{12} = 0$

$\Rightarrow 10A = 3A' \Rightarrow \dfrac{A}{A'} = \dfrac{3}{10}$

Q20. The stop covers $\dfrac{1}{4}th$ area of the aperture hence the intensity which passes is $\left(I - \dfrac{I}{4}\right)$



$= \dfrac{3I}{4}$

Q21. $P = \dfrac{1}{f} \Rightarrow +10 = \dfrac{1}{f_1} \times 100$

$\Rightarrow f_1 = +10\, cm$

$+12.5 = \dfrac{1}{f_2} \times 100 \Rightarrow f_2 = \dfrac{100}{12.5} = +8cm$

for achromatic combination :

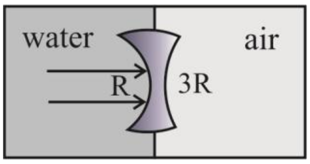
$d = \dfrac{f_1 + f_2}{2} = \dfrac{10 + 8}{2} \Rightarrow d = 9cm$

$P = P_1 + P_2 - dP_1P_2$

$= 10 + 12.5 - \dfrac{9}{100} \times 10 \times 12.5$

$\Rightarrow P = 11.25\, D$

Q22. $P = \dfrac{\mu - \mu_o}{R_1} - \dfrac{\mu - \mu_i}{R_2} = \dfrac{\frac{3}{2} - \frac{4}{3}}{-R} - \dfrac{\frac{3}{2} - 1}{+3R}$



$\Rightarrow P = -\dfrac{1}{6R} - \dfrac{1}{6R} = -\dfrac{2}{6R} = -\dfrac{1}{3R}$

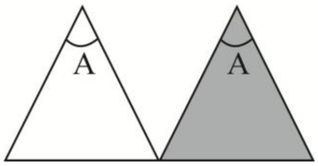
Q23. $f_c = (1 - n)F$

$\Rightarrow f_c = \left(1 - \dfrac{5}{6}\right)(-120)$

$= \dfrac{1}{6} \times (-120) = -20\, cm$

$f_f = \left(1 - \dfrac{1}{n}\right)F \Rightarrow f_f = \left(1 - \dfrac{6}{5}\right)(-120)$

$= \left(1 - \dfrac{1}{5}\right)(-120) = +24\, cm$



Q24. $\theta = \theta_1 + \theta_2$

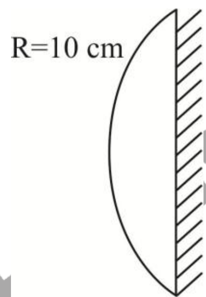
$= \omega\,(\mu - 1)\, A - \omega'\,(\mu' - 1)\, A$

$0.092^o = 0.03\,(1.6 - 1)\, A + 0.04\,(1.7 - 1)\, A$

$0.092^o = (0.03 \times 0.6 + 0.04 \times 0.7)\, A$

$0.092^o = 0.046\, A \Rightarrow A = 2^o$

Q25. $f_l = 2R = 20cm$



$f_m = \infty$

$\dfrac{1}{F} = \dfrac{1}{f_m} - \dfrac{2}{f_l} = \dfrac{1}{\infty} - \dfrac{2}{20}$

$= -\dfrac{1}{10} \Rightarrow F = -10\, cm$

$m = \dfrac{f}{f - u} \Rightarrow +2 = \dfrac{-10}{(-10) - u}$

$\Rightarrow -20 - 2\mu = -10$

$\Rightarrow 2u = -10 \Rightarrow u = -5\, cm$

Q27. $\dfrac{1}{f_v} = (\mu_v - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$ ....(1)

$\dfrac{1}{f_R} = (\mu_R - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$....... (2)

$\dfrac{(i)}{(2)} \Rightarrow \dfrac{f_R}{f_v} = \dfrac{(\mu_v - 1)}{(\mu_R - 1)}$

$\Rightarrow \dfrac{20}{f_v} = \dfrac{(1.6 - 1)}{(1.5 - 1)} \Rightarrow \dfrac{20}{f_v} = \dfrac{0.6}{0.5}$

$$f_v = \frac{5}{6} \times 20$$

$$= \frac{100}{6} = 16.67$$

Q29. $\frac{Me_{min}}{Me_{max}} = \frac{D/f}{1+D/f} \Rightarrow \frac{D}{f+D} = \frac{2}{3} \Rightarrow 3D = 2f + 2D$

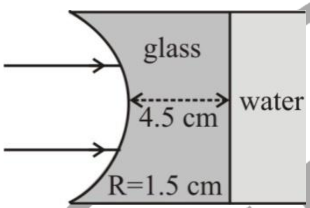
$\Rightarrow D = 2f$ …………. (1)

$P = \frac{100}{f} \Rightarrow f = \frac{100}{10} = 10\text{ cm}$ …………. (2)

From (1) & (2) : $D = 2 \times 10 = 20\text{ cm}$

$$M = \frac{D}{u} = \frac{20}{2.5} = 8$$

Q30. Refraction on spherical surface



$$\frac{\mu_i}{v} - \frac{\mu_o}{u} = \frac{\mu_i - \mu_o}{R}$$

$$\frac{3}{2v} - \frac{1}{\infty} = \frac{\frac{3}{2} - 1}{-1.5}$$

$$\frac{3}{2v} = \frac{-1}{3} \Rightarrow v = -4.5cm$$

Refraction on plane surface :

u = – (4.5 + 4.5) = – 9 cm

$$\frac{v}{u} = \frac{\mu_i}{\mu_o} \Rightarrow \frac{v}{-9} = \frac{4/3}{3/2} \Rightarrow v = -8cm$$