Ray Optics and Optical Instruments

SOLUTIONS

Exercise-I (Conceptual Questions)

1. $\angle i = \angle r$

$\because \angle i = 0, \quad \therefore \angle r = 0$

2. $\delta = 180 - 2i$

$\delta = 180 - 2 \times 30°$

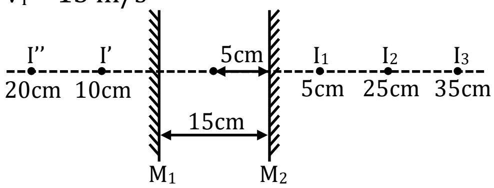
$\delta = 120°$

3. $n = \dfrac{360}{90} = 4$ (even number)

No. of images = 4 – 1 = 3

4. $V_I = V_0$, (with respect ot mirror)

$V_I = 15$ m/s

5. 

then ans. will be 5 cm, 25 cm, 35 cm

6. $\delta = 360° - 2\theta$ (for two deviation)

$\delta = 360° - 2 \times 40°$

$\delta = 280°$

7. Required minimum length of the mirror

$= \dfrac{H}{2} = \dfrac{6}{2} = 3$ feet

8. Minimum length of plane mirror required

$= \dfrac{H}{2} = \dfrac{180}{2} = 90\text{cm}$

9. $n = \dfrac{360°}{\theta} = \dfrac{360°}{45} = 8$

n is even so number of images = (n – 1) = 7

10. $m = \dfrac{f}{f-u}$

m = – 2, → Real, Inverted

$-2 = \dfrac{-50}{-50-u}$; u = – 75 cm

11. R = 25 cm

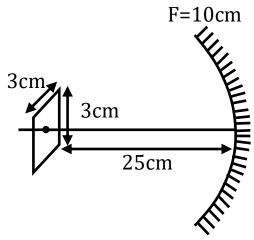
f = 12.5 cm

$m = \dfrac{f}{f-u} = \dfrac{12.5}{12.5-(-40)}$

m = 0.23

$m = \dfrac{\text{height of image}}{\text{height of object}}$

height of image = 0.23 × 7.5 = 1.78

12. 

Side of square = 3cm

$A_0 = 3 \times 3 = 9\text{ cm}^2$

$A_I = m^2 \times A_0$

$m = \dfrac{f}{f-u} = \dfrac{-10}{-10-(-25)} = \dfrac{-10}{15} = \dfrac{-2}{3}$

$A_I = \left(\dfrac{-2}{3}\right)^2 \times 9 = 4\text{ cm}^2$

13. $m = \dfrac{-1}{4}$; $m = \dfrac{f}{f-u}$; $-\dfrac{1}{4} = \dfrac{-12}{-12-u}$

u = –60 cm

14. $m = \dfrac{f}{f-u}$; $m = \dfrac{-30}{-30-(-90)}$

$m = \dfrac{-30}{60}$; $m = -\dfrac{1}{2}$ → Image size is smaller than object

$\Rightarrow m = \dfrac{-v}{u}$; $\dfrac{-1}{2} = \dfrac{-v}{-90}$

– v = 45; v = – 45 cm

15. $m = \dfrac{h_i}{h_o} = \dfrac{-3}{1.5} = -2$ (Real image)

$m = \dfrac{f}{f-u} = -2 = \dfrac{f}{f-(-15)}$

–2f – 30 = f

f = –10 cm

16. Erect diminished image formed by convex mirror.

17. $V_I = -m^2 \times V_0$

$m = \dfrac{f}{f-u} = \dfrac{-24}{-24-(-60)} = \dfrac{-24}{36} = \dfrac{-2}{3}$

$V_I = -\left(\dfrac{-2}{3}\right)^2 \times 9$;

V_I = –4 cm/sec (toward the mirror)

18. $m = \frac{f}{f-u}$

Image to be real and three times m = –3

$-3 = \frac{f}{f-(-20)}$

f = –15 cm

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

$\because$ R = 22 cm

$\therefore$ f = 11 cm

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

$\frac{1}{v}+\frac{1}{-14}=\frac{1}{11}$

v = +6.16 [Back side of mirror]

21. Focal length of spherical mirror does not depend on wavelength of light.

22. u = –10 cm, v= –20 cm

$m=-\frac{v}{u}\Rightarrow\frac{-(-20)}{-10}=-2$

$dv = -m^2 \times du$

$\Rightarrow$ $\Delta v = -4 \times 0.1$

$\Rightarrow$ $\Delta v = -0.4$ cm

–ve sign indicate object and image are moving opposite to each other

23. R = 2f; R = 2 × 20 = 40 cm

25. Frequency depend upon the source

26. $\sin\theta_c = \frac{1}{{}_R\mu_D}$; $\left[\because\ \mu \propto \frac{1}{\lambda}\right]$

$\sin\theta_C = \frac{\lambda_D}{\lambda_R}=\frac{3500Å}{7000Å}$; $\sin\theta_C = \frac{1}{2}$; $\theta_C = 30°$

27. Shifting = $t\left(1-\frac{1}{\mu}\right)=6\left(1-\frac{1}{1.5}\right)$

Shifting = 2 cm

28. ${}_{air}\mu_{glass} = \frac{v_{air}}{v_{glass}}$

$v_{air} = 2 \times 10^8 \times 1.5$ m/sec

$v_{air} = 3 \times 10^8$ m/s

${}_{air}\mu_{liquid} = \frac{v_{air}}{v_{liquid}} = \frac{3\times10^8}{2.5\times10^8} = 1.2$

29. $r=\frac{h}{\sqrt{\mu_w^2-1}}=\frac{4}{\sqrt{\left(\frac{5}{3}\right)^2-1}}=3m$

Diameter of disc = 6m

30. $\mu_R \sin i = \mu \sin\left(\frac{i}{2}\right)$

$1 \times 2\sin\left(\frac{i}{2}\right)\times\cos\left(\frac{i}{2}\right) = \mu \times \sin\left(\frac{i}{2}\right)$

$\cos\left(\frac{i}{2}\right)=\left(\frac{\mu}{2}\right)$

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

31. $\sin\theta_C = \frac{1}{\mu}$

VIBGYOR $\longrightarrow \lambda\uparrow$

$\longrightarrow \mu\downarrow$

$\longrightarrow \theta_C\uparrow$

$\mu \propto \frac{1}{\lambda}$

32. Apparent depth = $\frac{\text{Actual depth}}{\mu}$

and $\mu \propto \frac{1}{\lambda}$

33. from one side

$(d_{app})_1 = \frac{(d_{ac})_1}{\mu}$

$(d_{ac})_1 = \mu(d_{app})_1 = 1.5\times5 \Rightarrow 7.5cm$

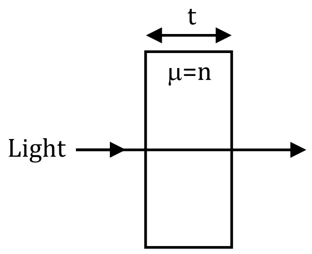
from second surface

$(d_{ac})_2 = \mu(d_{app})_2 = 1.5\times2 \Rightarrow 3.0cm$

Total $d_{ac} = (d_{ac})_1 + (d_{ac})_2 = 7.5+3.0 \Rightarrow 10.5cm$

34. Frequency doesn't change with change in medium

35.



$\mu=\frac{c}{v_m}\Rightarrow v_m=\frac{c}{\mu}=\frac{c}{n}$ ...(1)

$\because$ Velocity = $\frac{\text{displacement}}{\text{time}}=\frac{t}{\text{time}}=v_m$ ...(2)

(1) = (2)

$\frac{c}{n}=\frac{t}{\text{time}}\Rightarrow \text{time}=\frac{nt}{c}$

36. $\sin\theta_C = \frac{\mu_R}{\mu_D}$

$\theta_C = \sin^{-1}\left(\frac{\mu_R}{\mu_D}\right) = \sin^{-1}\left(\frac{\frac{4}{3}}{\frac{3}{2}}\right)$

$\theta_C = \sin^{-1}\left(\frac{8}{9}\right)$

37. $\sin\theta_C = \frac{1}{{}_a\mu_g} = \frac{2}{3}$; $\sin\theta_C = \frac{1}{{}_a\mu_\omega} = \frac{3}{4}$

$\Rightarrow C_w > C_g$

38. $\sin\theta_c = \frac{1}{\mu}$ & $\mu \propto \frac{1}{\lambda}$

42. If object will be invisible then R.I. of material and R.I. of medium should be same.

43. $\delta_m = (\mu_P - 1)\,A$

$\delta_m = (1.52 - 1) \times 4.5°$

$\delta_m = 0.52 \times 4.5°$

$\delta_m = 2.34°$

44. $\delta_m = 2i - A$

$e = i = \frac{3}{4} \times 60° \Rightarrow i = 45°$

$\delta_m = 2 \times 45° - 60°$

$\delta_m = 30°$

45. $\mu = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\frac{A}{2}}$; $\mu = \frac{\sin\left(\frac{30° + 60°}{2}\right)}{\sin\frac{60°}{2}}$;

$\frac{\sin 45°}{\sin 30°} = \frac{1}{\sqrt{2}} \times 2$; $\mu = \sqrt{2}$

46. $\sin\theta_C = \frac{1}{\mu}$; $\sin 45° = \frac{1}{\mu}$

$\mu = \sqrt{2}$

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

A is same for all prism

Here $\mu_1 < \mu_2 < \mu_3$

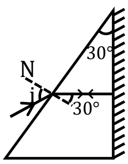
$\therefore \quad \delta_1 < \delta_2 < \delta_3$

49. Light should be incident $\perp$ on silvered surface

$\sin i = \mu \sin r$

$\sin i = \sqrt{2}\sin 30$

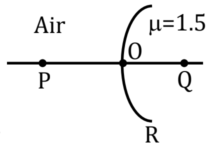
$i = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45°$



50. $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R} \Rightarrow \frac{1.5}{v} - \frac{1}{-15} = \frac{1.5 - 1}{30}$;

v = – 30 cm

51. PO = OQ ; u = v



$\frac{1.5}{u} - \frac{1}{-u} = \frac{1.5 - 1}{R}$

$\frac{1.5 + 1}{u} = \frac{0.5}{R}$; $\frac{2.5}{u} = \frac{0.5}{R}$

u = 5R

52. $P = \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$; $P = \frac{100}{20} + \frac{100}{25} = +9D$

53. $P = P_1 - P_2 \Rightarrow P = +2.50 - 3.75$

$P = -1.25$

$f = \frac{-100}{1.25} = -80$ cm

54. $P_{net} = P_1 + P_2$; $P_{net} = 3 - 5$; $P_{net} = -2D$

$f = -\frac{100}{2} = -50$cm

$\frac{1}{v} - \frac{1}{-50} = \frac{1}{-50}$; v = –25 cm

55. $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

$\Rightarrow P = \frac{1}{f} = \frac{100}{40} - \frac{100}{25} = 2.5 - 4$

$\Rightarrow P = -1.5$ D

56. $f = \sqrt{x_1 x_2}$

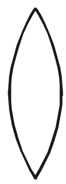
$10 = \sqrt{5x_2} \Rightarrow x_2 = 20$ cm

distance of image from lens = $x_2 + f = 30$ cm

57. $f = \frac{100}{5} = +20$ cm

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

$\frac{1}{20} = \frac{0.5 \times 2}{R}$; R = 20 cm



58. $f^2 = x_1 x_2$

$f^2 = 9 \times 25 \Rightarrow f = 15$ cm

59. $\frac{1}{f_{air}} = \{\mu_L - 1\}\left\{\frac{1}{R_1} - \frac{1}{R_2}\right\}$ ...(1)

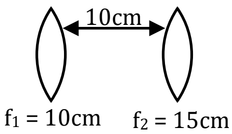
$\frac{1}{f_m} = \left\{\frac{\mu_L - \mu_m}{\mu_m}\right\}\left\{\frac{1}{R_1} - \frac{1}{R_2}\right\}$ ...(2)

Equation $\frac{(1)}{(2)} = \frac{f_m}{f_{air}} = \frac{(\mu_L - 1)}{\left(\frac{\mu_L - \mu_m}{\mu_m}\right)}$

$$\frac{f_m}{8} = \frac{\left(\frac{3}{2}-1\right)}{\left\{\frac{\frac{3}{2}-\frac{4}{3}}{\frac{4}{3}}\right\}} \Rightarrow \frac{\frac{1}{2}}{\frac{1}{8}} = 4$$

$f_m = 4 \times 8 = 32$ cm

60. $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$



$\frac{1}{f} = \frac{1}{10} + \frac{1}{15} - \frac{10}{10\times 15}$

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

f = 10 cm

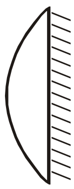
61. Power = $\frac{1}{\text{Focus}}$

due to immersed in water f↑

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

62. R.I ∝ no. of images

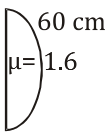
63. $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$



$\frac{1}{10} = (1.5-1)\left(\frac{1}{7.5} - \frac{1}{R_2}\right)$

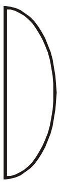
$R_2 = -15$ cm

64. $\frac{1}{f} = (1.6-1)\left(\frac{1}{60}\right)$



$\frac{1}{f} = \frac{0.6}{60} \Rightarrow f = 100$ cm

65. $\frac{1}{f} = (\mu_L - 1)\left\{\frac{1}{\infty} - \frac{1}{-R}\right\}$



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

$\Rightarrow \quad \frac{1}{30} = (\mu - 1)\frac{1}{10}$

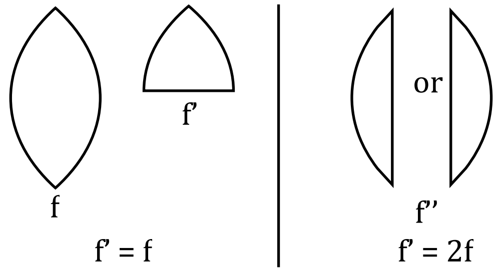
$\Rightarrow \quad \mu = \frac{1}{3} + 1 = \frac{4}{3} = 1.33$

66. $P = P_1 + P_2 = \frac{100}{80} + \frac{100}{(-50)}$

P = 1.25 – 2

P = – 0.75 D

68.



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

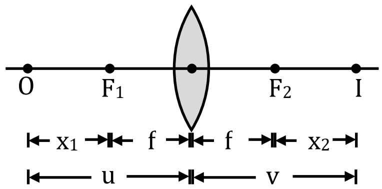
$f = \frac{R}{2(\mu-1)}$

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

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

∴ f' = f & f'' = 2f

69.



Here, x_1 = 25 cm, x_2 = 40 cm

According to Newton's formula

$f^2 = x_1 x_2 = (25)(40)$

$f = \sqrt{(25)(40)} = 10\sqrt{10}\text{ cm} = 32\text{cm}$

Object distance, $u = -(f + x_1) = -(32+25)$cm $= -57$cm

Image distance, $v = (f + x_2) = (32+40)$cm $= 72$cm

Magnification, $m = \frac{v}{u} = \frac{72}{-57} = -1.3$

70. $m = 1 + \frac{D}{f_e}$

$m = 1 + \frac{25}{2.5}$; m = 11

71. $m = \frac{-f_0}{f_e} = -8$

$|f_0| + |f_e| = 45$

$8f_e + f_e = 45$

$9f_e = 45$

$f_e = 5$ cm

$f_0 = 40$ cm

72. $m_e \times m_0 = 35$

$m_e \times 7 = 35$

$m_e = 5$

73. $MP = \frac{-f_0}{f_e}\left(1+\frac{f_e}{D}\right)$

$MP = \frac{-100}{10}\left(1+\frac{10}{25}\right)$

$MP = -14$

74. $|f_0| + |f_e| = 105$ and $-\frac{f_0}{f_e} = -20$; $f_0 = 20\, f_e$

Now $20\, f_e + f_e = 105 \Rightarrow 21\, f_e = 105$

$f_e = 5$ cm and $f_0 = 100$ cm

75. $m = 1+\frac{D}{f_e}$; $m = 1+\frac{25}{5}$

$m = 6$

77. $MP = \frac{\beta}{\alpha} = -\frac{f_0}{f_e} = \frac{\beta}{0.5} = -\frac{100}{2}$

$\beta = -25°$

78. $M = -\frac{f_0}{f_e} = -4$

$f_0 = 4f_e$ ....(i)

$L = |f_0| + |f_e|$

$10 = |f_0| + |f_e|$ ....(ii)

from (i) & (ii) equations

$10 = |4f_e| + |f_e|$

$f_e = 2$ cm

$f_0 = 8$ cm i.e. L_4, L_1

79. Image is at D distance

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

$5 = \frac{25}{f_e} \Rightarrow$ $f_e = 5$ cm or $= 0.05$ m

80. $MP = -\frac{f_0}{f_e}$

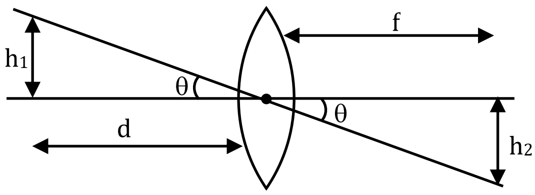
$-\frac{f_0}{20} = -10$ b

$f_0 = 200$ cm

OR

The focal length of objective lens is greater than eye piece so answer should greater than 20.

81.



$\tan\theta = \frac{h_1}{d} = \frac{h_2}{f}$

$h_2 = \frac{h_1 \times f}{d} = \frac{50\times 200\times 10^{-2}}{2\times 10^3} = 5\times 10^{-2}\,m$

$h_2 = 5$ cm

Exercise-II (Previous Year Questions)

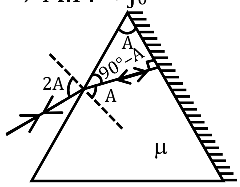
1. Magnifying power of Microscope $= \frac{LD}{f_0 f_e}$

$\Rightarrow$ M.P. $\propto \frac{1}{f_0}$

Magnifying power of Telescope $= \frac{f_0}{f_e}$

$\Rightarrow$ M.P. $\propto f_0$

2.



By Snell's law

(1) $\sin 2A = (\mu)\sin A \Rightarrow \mu = 2\cos A$

$2\sin A\cos A = \mu \sin A$

$2\cos A = \mu$

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

$\because \mu = \cot(A/2)$

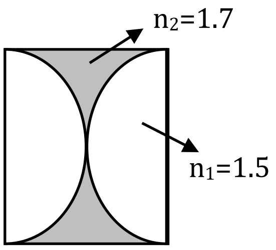
$\therefore \cot(A/2) = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$\Rightarrow \cos(A/2) = \sin\left(\frac{\delta_m + A}{2}\right)$

$\Rightarrow 90° - A/2 = \frac{\delta_m + A}{2}$

$\Rightarrow \delta_m = 180° - 2A$

4.



From lens maker's formula

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

we have $\frac{1}{f_1}=(1.5-1)\left(\frac{1}{20}\right)=\frac{1}{40}$

$$\frac{1}{f_2}=(1.5-1)\left(\frac{1}{20}\right)=\frac{1}{40}$$

& $\frac{1}{f_3}=(1.7-1)\left(\frac{2}{-20}\right)=-\frac{7}{100}$

Now $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}$

$$\Rightarrow \frac{1}{f}=\frac{1}{40}+\frac{1}{40}-\frac{7}{100}$$

$\Rightarrow$ f = – 50 cm

5. $i = 45°;\ A = 60°;\ \delta_m = 2i - A = 30°$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin A/2} = \frac{\sin 45°}{\sin 30°}=\frac{1}{\sqrt{2}}.\frac{2}{1}=\sqrt{2}$$

6. Using lens formula for objective lens

$$\Rightarrow \frac{1}{v_0}-\frac{1}{u_0}=\frac{1}{f_0} \Rightarrow \frac{1}{v_0}=\frac{1}{f_0}+\frac{1}{u_0}$$

$$\Rightarrow \frac{1}{v_0}=\frac{1}{40}+\frac{1}{-200}=\frac{+5-1}{200}$$

$\Rightarrow v_0 = 50$ cm

Tube length $\ell = |v_0| + f_e = 50 + 4 = 54$ cm.

7. For spherical mirrors

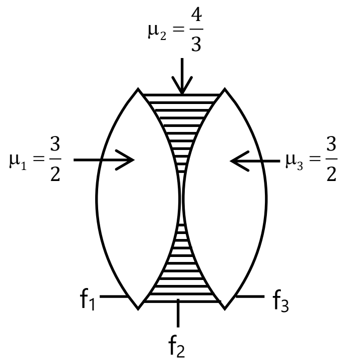
m = +ve $\Rightarrow$ virtual image

m = –ve $\Rightarrow$ real image

|m| > 1 $\Rightarrow$ magnified image

|m| < 1 $\Rightarrow$ diminished image

8.



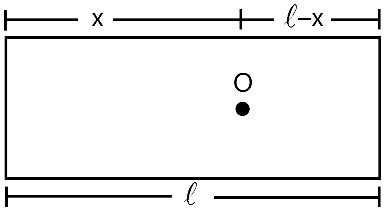
$$f_1=f_3=\frac{R}{2\left(\frac{3}{2}-1\right)} = R = f \text{ (given)}$$

$$f_2=\frac{-R}{2\left(\frac{4}{3}-1\right)}=\frac{-3}{2}R=-\frac{3}{2}f$$

$$\frac{1}{f_{eq}}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}=\frac{1}{f}+\left(-\frac{2}{3f}\right)+\frac{1}{f}$$

$$\Rightarrow \frac{1}{f_{eq}}=\frac{4}{3f} \Rightarrow f_{eq}=\frac{3f}{4}$$

9.



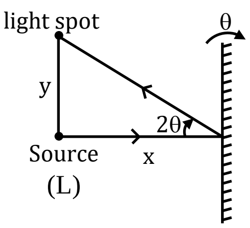
$\frac{x}{\mu}=5cm$ ... (i)

$\frac{\ell-x}{\mu}=3cm$ ... (ii)

From (i) and (ii)

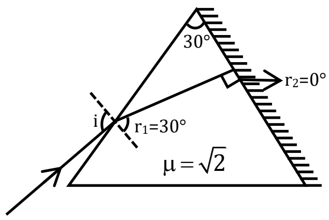
$\ell = (5+3)\mu = 12$cm

10.



$2\theta = \frac{y}{x}$; $\theta = \frac{y}{2x}$

11.

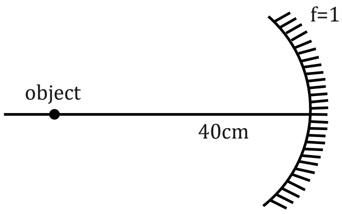


$r_2 = 0$, $r_1 = A = 30°$

By using snell's law

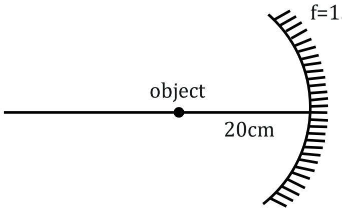
$\sin i = \sqrt{2}\sin 30° = \sqrt{2}\times\frac{1}{2} = \frac{1}{\sqrt{2}} \Rightarrow \angle i = 45°$

12. (i)



$$v_1 = \frac{uf}{u-f} = \frac{(-40)(-15)}{-40+15} = \frac{600}{-25} = -24\text{cm}$$

(ii)



$$v_2 = \frac{uf}{u-f} = \frac{(-20)(-15)}{-20+15} = -60 \text{ cm}$$

Displacement of image = $v_2 - v_1 = -36$ cm

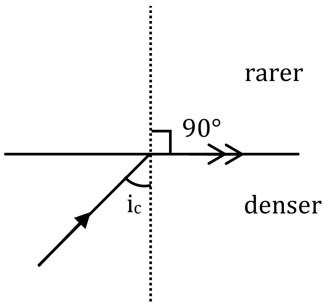
= 36 cm away from the mirror

13. Longest wavelength is of red colour.

14. $\frac{1}{F_1} = \frac{1}{f} + \frac{1}{f} \Rightarrow F_1 = f/2$

And $F_2 = f \Rightarrow \frac{F_1}{F_2} = \frac{1}{2}$

15. At critical angle



angle of refraction = 90°

16. Focal length does not change $\rightarrow$ Power does not change

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

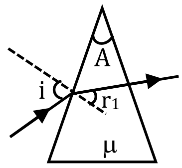
$\Rightarrow \frac{1}{25} = \left(\frac{1.5-1}{1}\right)\left(\frac{1}{R} - \frac{1}{(-2R)}\right)$

$\Rightarrow \frac{2}{25} = \frac{3}{2R} \Rightarrow R = \frac{75}{4} = 18.75$

I^{st} surface radius = 18.75 cm

II^{nd} surface radius = 37.50 cm

18.



Here $r_2 = 0$ so $r_1 = A$

Apply Snell's law $\sin i = \mu \sin r_1 = \mu \sin A$

for small angle

19. Spherometer is used to measure radius of curvature of the curved surface.

20. $P = \frac{100}{f} \Rightarrow f = \frac{100}{p} = \frac{100}{10} = 10\text{cm}$

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

$\Rightarrow 10 = \frac{10}{2(\mu-1)}$

$\Rightarrow (\mu-1) = \frac{1}{2} \Rightarrow \mu = \frac{1}{2} + 1 = \frac{3}{2}$

21. By using mirror formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

We have $\frac{1}{-1.5\,f} + \frac{1}{v} = \frac{1}{-f} \Rightarrow \frac{1}{v} = -\frac{1}{f} + \frac{1}{1.5\,f}$

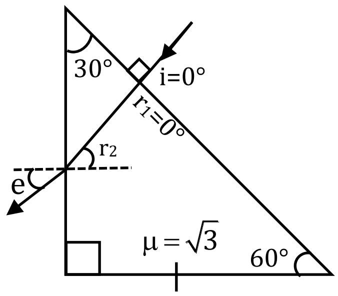
$\Rightarrow \frac{1}{v} = \frac{-1.5+1}{1.5\,f} = \frac{-0.5}{1.5\,f} \Rightarrow v = -3f$

22. $\sin\theta_C = \frac{1}{\mu}$

$\mu = \frac{1}{\sin\theta_C} = \frac{1}{\sin 45°} = \frac{1}{\left(1/\sqrt{2}\right)} = \sqrt{2}$

$\mu = \frac{c}{v} \Rightarrow v = \frac{c}{\mu} = \frac{3\times10^8}{\sqrt{2}}$ m/s

23.



$r_1 + r_2 = A = 30°$

$r_2 = 30°$ ($r_1 = 0°$)

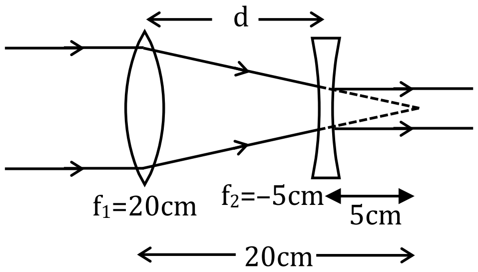
from Snell's law

$\sqrt{3}\sin r_2 = 1\times\sin e$

$\sqrt{3}\sin 30° = \sin e$

e = 60°

24.



$d = f_1 + f_2$
$= 20 - 5$
$= 15$ cm

28. Speed of light is air $V_1 = \frac{x}{t_1}$

speed of light is a medium $V_2 = \frac{10x}{t_2}$

$\sin\theta_c = \frac{V_2}{V_1} = \frac{10x}{t_2}\frac{t_1}{x}$

$\theta_c = \sin^{-1}\left(\frac{10t_1}{t_2}\right)$

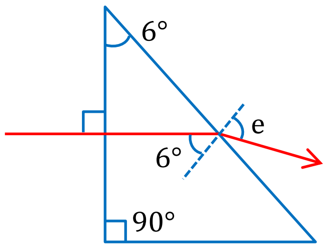
29. $\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2}$

$\frac{1}{f_{eq}} = \frac{1}{f} - \frac{1}{f}$

$f_{eq} = \infty$

30. Since lens is made of three materials so three μ and hence three images.

31.



$A = r_1 + r_2 = 6°$

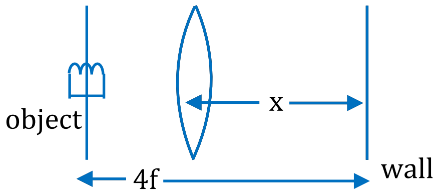
$\mu = 1.5 \; \frac{\sin e}{\sin r_2} = \frac{\sin e}{\sin 6}$

$\sin e = 1.5 \times 6°$
$e \simeq 9°$

32. $\sin i_c = \frac{1}{\mu} \propto \lambda$

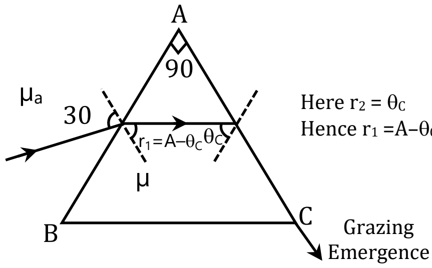
$i_c \propto \lambda$
Yellow, orange, red emerge from air.

33.



$x = 2f$
$f = x/2$

34.



By snell's law
$\mu_a \sin 30 = \mu \sin r_1$
$\Rightarrow$ (1) $\sin 30 = \mu \sin(A - \theta_C)$
$\Rightarrow$ $\sin 30 = \mu \sin(90 - \theta_C)$
$\Rightarrow$ $\sin 30 = \mu \cos \theta_C$

$\Rightarrow$ $\sin 30 = \mu \; \frac{\sqrt{\mu^2 - 1}}{\mu}$

$\Rightarrow$ $\frac{1}{2} = \sqrt{\mu^2 - 1}$ $\qquad \because \sin\theta_C = \frac{1}{\mu}$

$\Rightarrow$ $\frac{1}{4} = \mu^2 - 1$ $\qquad \cos\theta_C = \frac{\sqrt{\mu^2-1}}{\mu}$

$\Rightarrow$ $\mu^2 = 5/4$

$\Rightarrow$ $\mu = \frac{\sqrt{5}}{2}$

35. For Telescope –
Magnifying power

M.P. $= \frac{-fo}{fe} = \frac{-140}{5} = -28$

MP = –28

36. **Statement 1 is correct :-** Image is only formed by regular reflection not by irregular reflection.

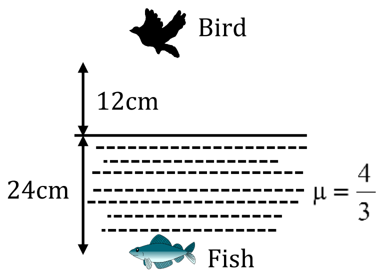
Statement 2 is correct :- The variety in colour of objects we see around us is due to the constituent colours of the light incident on them.

Exercise-III (Analytical Questions)

2. Simple microscope forms erect image while compound microscope form inverted image.

3. M.P $\propto \frac{1}{f}$ (for normal adjustment M.P = $\frac{D}{f}$)

4.



(A) $(d_{fb})_{surface} = \frac{24}{4/3} \times 1 = 18$ cm

(B) $(d_{bf})_{surface} = \frac{12}{1} \times \frac{4}{3} = 16$ cm

(C) $d_{fb} = 12 + \frac{24}{4/3} \times 1 = 12 + 18 = 30$ cm

(D) $d_{bf} = 24 + \frac{12}{1} \times \frac{4}{3} = 24 + 16 = 40$ cm

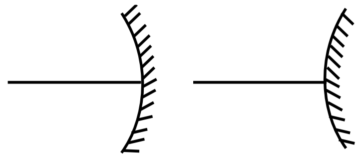
6. When mirror moves parallel to its plane, then image will not move.

7. $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ Both are same for thin lens.

8. On covering upper half of the lens its aperture decreases which results in decreasing of intensity but nature, position, shape and size of image remain same.

9. $M.P. = \frac{D}{f}$ and D may be different for different persons.

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



(A) u = –f, f = +f $\quad v = \frac{-f \times f}{-f - f} = \frac{+f}{2} \Rightarrow m = -\frac{v}{u} = \frac{1}{2}$

(B) u = –f, f = –f $\quad v = \frac{-f \times -f}{-f - (-f)} = \infty \Rightarrow m = \infty$

(C) u = –2f, f = –f $\quad v = \frac{-2f \times -f}{-2f - (-f)} = -2f \Rightarrow m = -1$

(D) u = –2f, f = +f $\quad v = \frac{-2f \times f}{-2f - f} = \frac{+2}{3} f \Rightarrow m = \frac{1}{3}$

11. For $A > 2\theta_C$; the light ray never crosses the prism for any angle of incidence.

14. $e = (A + \delta) - i = (30° + 30°) - 60° = 0$