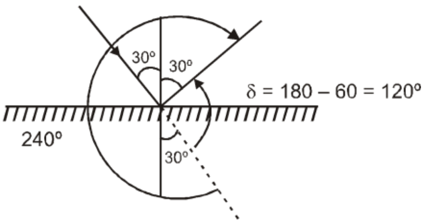
HINTS & SOLUTIONS

TOPIC : GEOMETRICAL OPTICS
EXERCISE # 1

SECTION (A)

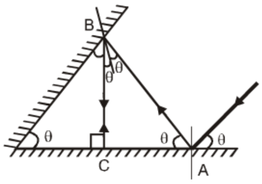
1. 11: 60 – 08 : 20 = 3 : 40

2.



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

4.



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

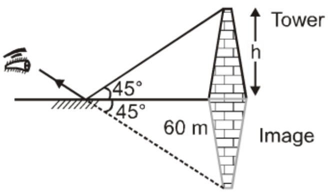
5. $n = \left(\frac{360}{72} - 1\right) = 4$

6. $L_{min} = \frac{H}{2} = \frac{180}{2} = 90$ cm

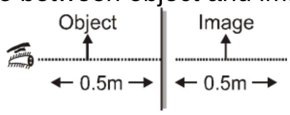
7. A thick mirror forms a number of images. Image is formed by front surface which is unpolished and hence, reflects only a small part of light, while second image is formed by polished surface which reflects most of intensity. Hence second image is brightest.

8. $\delta = (360 - 2\theta) = (360 - 2 \times 60) = 240°$

9.



10. Distance between object and image = 0.5 + 0.5 = 1 m



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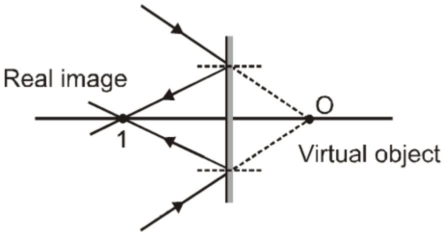
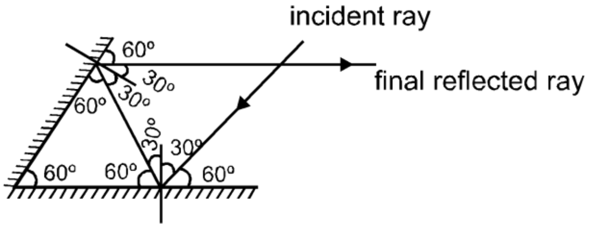
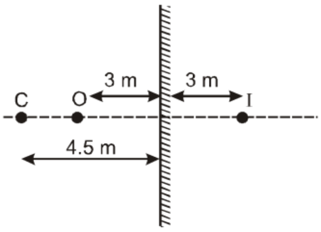


12.



final ray is II to first mirror.

13.



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

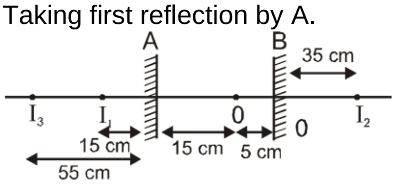
14. If time in object clock is T_1 & time in image clock is T_2 then,

$T_1 + T_2 = 12 : 00 : 00$

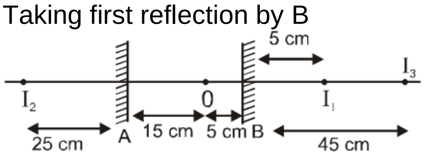
$4 : 25 : 37 + T_2 = 12 : 00 : 00$

$T_2 = 07 : 34 : 23$

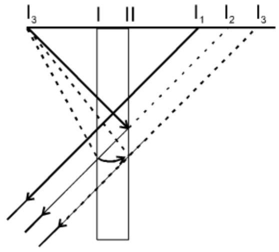
15. Taking first reflection by A.



Taking first reflection by B



16. A thick mirror forms a number of images. I_1 image is formed by front surface which is unpolished and hence, reflects only a small part of intensity of light ; while second image is formed by polished surface which reflects most of intensity. Hence, second image is brightest.



17. n = $\left(\frac{360^o}{\theta}\right)-1$ = $\left(\frac{360}{60}-1\right)$ = 5

18. – 1 = 3. = θ = 90º

19. The minimum size of plane mirror required for seeing full size image of man = $\frac{\text{Height of man}}{2}$
Given, height of man = 6 ft

Thus, minimum size of plane mirror = $\frac{6}{2}$ = 3 ft

SECTION (B)

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

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

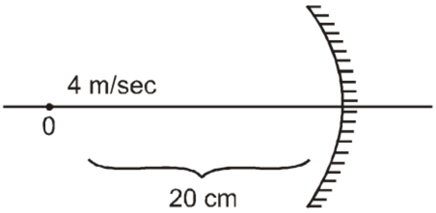
v = $\frac{f}{2}$

2. v = $\frac{u}{4}$ $\frac{1}{v}+\frac{1}{u}$ = $\frac{1}{f}$

u = 90 cm

4. When objects is at the centre of curvature C then its image is also at C

5.



f = 12 cm

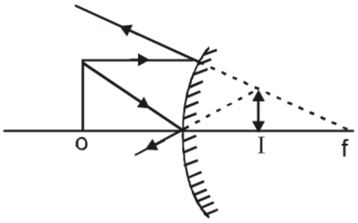
$\frac{1}{f}=\frac{1}{V}+\frac{1}{4}$ $\frac{1}{-12}=\frac{1}{V}+\frac{1}{-20}$ ⇒ $\frac{1}{V}=\frac{1}{20}-\frac{1}{12}$

⇒ 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.

⇒ 9 cm/sec away from mirror



6.

7. v = 2u

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

8. $m=+\frac{1}{m}=-\frac{\upsilon}{u}=-\frac{u}{n}$

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

By using mirror formula

11. $\frac{1}{O}=\frac{f}{f-u}$; where u N= f + x ∴ $\frac{1}{O}=-\frac{f}{x}$

12. Image formed by convex mirror is virtual for real object placed anywhere.

13. $m=\frac{f}{(f-u)} \Rightarrow \left(+\frac{1}{4}\right)=\frac{(+30)}{(+30)-u} \Rightarrow u=-90cm$

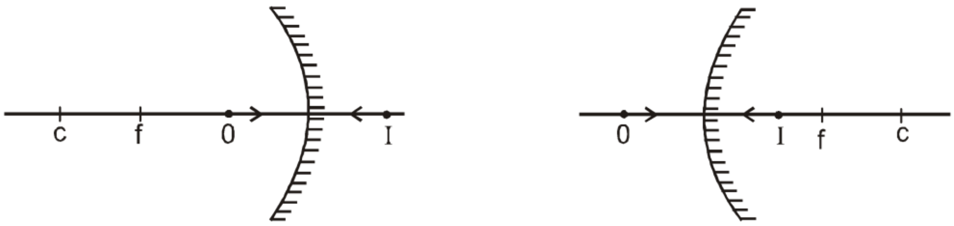
14. Plane mirror and convex mirror always foms erect images. Image formed by concave mirror may be erect or inverted dependinbg on position of object.

15. v = – 30, m = $-\frac{v}{u}$ = – 2 ∴ A′B′ = C′D′ = 2 × 1 = 2 mm

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

∴ length = 2 + 2 + 4 + 4 = **12 mm Ans.**

16.



only in above two cases image moves towards mirror.

17. 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 = $\frac{a^2}{4b}$.

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

Slope = – 1 intercept = (positive)

SECTION (C)

1. For TIR medium at refraction must be rarer.

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

3. t = $\frac{x}{v}$ = $\frac{x\mu}{c}$

5. 5 + 2 = $\frac{t_1}{1.5}$ + $\frac{t_2}{1.5}$

$\Rightarrow$ 7 × 1.5 = $t_1 + t_2$

10.5 = $t_1 + t_2$

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

7. μ = $\frac{\lambda_V}{\lambda_m} = \frac{6000}{4000}$ = 1.5

9. $\mu_d \sin i = \mu_r \sin 2i$

$\mu_d = 2\mu_r \cos i$

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

11. $\lambda_{medium} = \frac{\lambda_{air}}{\mu} = \frac{6000}{1.5} = 4000\,\mathring{A}$

12. Velocity and wavelength change but frequency remains same.

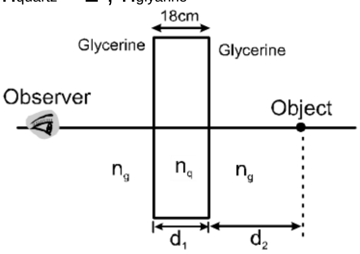
13. $\upsilon \propto \frac{1}{\mu}\, \mu_{rarer} < \mu_{denser}$

14. $\mu = \frac{h}{h'} \Rightarrow h' = \frac{8}{4/3} = 6 \quad m$

15. $_2\mu_1 \times _3\mu_2 \times _4\mu_3 = \frac{\mu_1}{\mu_2} \times \frac{\mu_2}{\mu_3} \times \frac{\mu_3}{\mu_4} \times \frac{\mu_1}{\mu_4} = \frac{\mu_1}{\mu_4} = {_4\mu_1} = \frac{1}{_1\mu_4}$

16. Colour of light is determined by its frequency and an frequency does not change, colour will also not change and will remains green.

24. $n_{quartz} = 2$; $n_{glyarine} = \frac{4}{3}$ $\quad \frac{n_{quartz} \text{ DokVZ}}{n_{glyarine} \text{ fXyl jhu}} = \frac{2}{4/3} = \frac{3}{2} = \mu_{rel}$

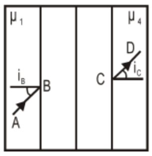


shift = $t\left(1-\frac{1}{\mu_{rel}}\right) = 18\left(1-\frac{1}{3/2}\right) = 6$ cm

25. i = 2r
1 sin i = n sin r
⇒ 2 sin i/2 cos i/2 = n sin i/2 ⇒ cos i/2 = (n/2) ⇒ i = 2 $\cos^{-1}$ (n/2)

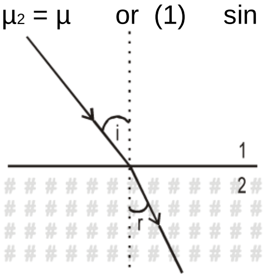
26. sin θ = $\frac{1}{\mu} = \frac{C_A}{C_B}$ ⇒ $C_B = \frac{V}{\sin\theta}$

27. Applying Snell's law at B and C,
μ sin i = constant
$\mu_1 \sin i_B = \mu_4$ sub i_C
But since AB | | CD



∴ $i_B = i_C$ or $\mu_1 = \mu_4$

The Snell's law, which the students read in their plus two syllabus $\mu = \frac{\sin\ i}{\sin\ r}$ comes from μ sin i = constant
μ_1 = $\mu_1 \sin i_1 = \mu_2 \sin i_2$
$\mu_2 = \mu$ or (1) sin i = μ sin r



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

28. Critical angle C = 30°

Refractive index

$\mu = \frac{1}{\sin C} = \frac{1}{\sin 30°} = 2$

∴ Also $\mu = \frac{c}{\upsilon}$ ∴ speed of light in medium

$\upsilon = \frac{c}{\mu} = \frac{3\times10^8}{2} = 1.5 \times 10^8$ m/s

29. When glass rod has same refractive index as liquid, the light rays are not bent at all. Hence glass rod in liquid appears invisible.

30. Here : Actual depth of liquid h = 6 cm, Refractive index of the liquid = $\frac{4}{3}$

Using the relation

$\mu = \frac{\text{actual depth (h)}}{\text{ap;parent depth (x)}}$

or $x = h \times \frac{3}{4} = 6 \times \frac{3}{4} = 4.5$ cm

Hence, the coin will appear at a depth of = 6 – 4.5 = 1.5 cm

31. Let real depth of the bubble from one side is x. Then

$\mu = \frac{x}{6} = \frac{15-x}{4}$

∴ X = 9 cm

Hence, $\mu = \frac{x}{6} = \frac{9}{6} = 1.5$

32. Refractive index medium $\mu = \frac{1}{\sin c}$ where C is critical angle.

Given, C = 30°

∴ $\mu = \frac{1}{\sin 30°} = \frac{1}{1/2} = 2$

From snell's law

$\mu = \frac{v_0}{v_m}$ where v_0 is speed of light in vacuum and v_m the velocitty in medium.

33. 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 θ > C

or sin θ > sin C but $\sin C = \frac{1}{\mu}$ and from figure, θ = 90° – r

So, $\sin (90° - r) > \frac{1}{\mu}$

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

From Snell's law,

$\frac{\sin 45°}{\sin r} = \mu \Rightarrow \sin r = \frac{1}{\sqrt{2}\,\mu} \quad \therefore \quad \cos r = \sqrt{1-\sin^2 r} = \sqrt{1-\frac{1}{2\mu^2}}$

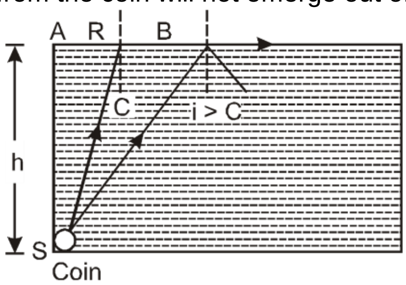
Thus, equation (i) becomes

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

or $\mu^2 - \frac{1}{2} = 1$ or $\mu = \sqrt{\frac{3}{2}}$

34. 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.

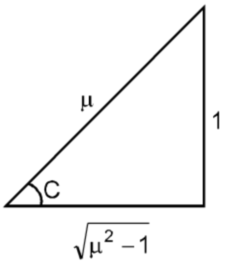


Therefore, minimum radius R corresponds to

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

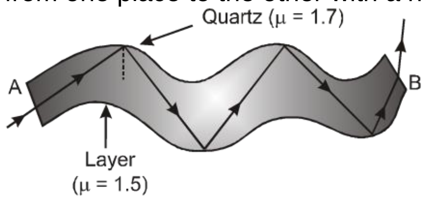
or $\mu^2 = \frac{25}{9}$ or $\mu = \frac{5}{3}$

But $\mu = \frac{c}{v}$ or $v = \frac{c}{\mu} = \frac{3\times10^8}{5/3} = 1.8 \times 10^8$ m/s

$\frac{360^o}{\theta}$

35. Optics fibres are based on total internal reflection.

36. An optical fibre is a device based on total internal reflection by which a light signal can be transferred from one place to the other with a negligible loss of energy.



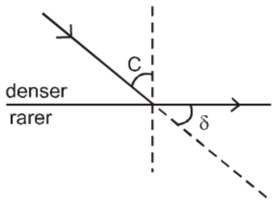
It consists of a very long and thin fibre of quartz glass.
When a light ray is incident at one end A of fibre making a small angle of incidence. It suffers multiple total internal reflections and finally it reaches the point B.

37. In the refraction phenomenon, frequency does not constant.

38. Total internal reflection is only possible when incidence angle is greater than critical angle.

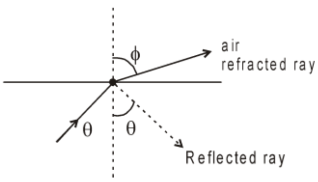
39. $\sin C = \frac{1}{\mu}$
$\mu \sin i = \sin r'$ [$r' = 90 - r$]
$\mu \sin r = \sin (90 - r)$
$\mu \sin r = \cos r$
$\frac{1}{\sin C} \sin r = \cos r$
$\sin C = \tan r$
$C = \sin^{-1} (\tan r)$

40.

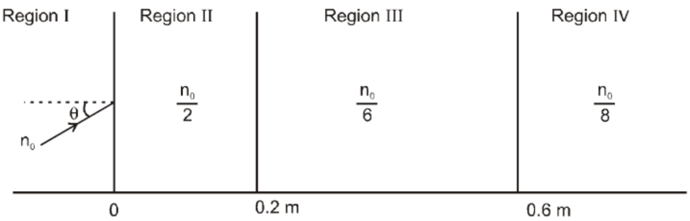


$\delta = 180^o - (90^o + C)$
$\delta = 90^o - C$

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



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



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

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

44. $1.5 \times t = 18 \times \frac{4}{3}$ thickness of glass = 16 cm

47. Refractive index n = $\upsilon = \frac{c}{n} = \frac{3\times10^8}{1.5} = 2 \times 10^8$ m/s

48. When light enters into glass from air its wavelength decreases. Because, $\lambda = \frac{\upsilon}{n}$ n remains same and υ decreases.

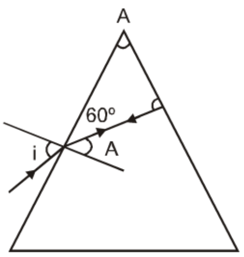
SECTION (D)

1. sin 30° = sin e
e = 45°
Deviation = 45° – 30° = 15°

2. i = e $r_1 = r_2 = \frac{A}{2} = 30°$
$\sin i = \sqrt{2} \sin 30°$
i = 45°

3. $r_1 + r_2 = 30°$ $\frac{\sqrt{3}}{2} = \mu \sin r_1$
$\mu \sin r_2 = \frac{1}{2} \Rightarrow \mu = \sqrt{3}$

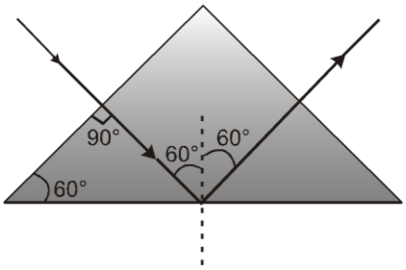
5. $r_2 = \sin^{-1}\left(\frac{1}{\mu}\right) = 45^o$
$r_1 = A - r_2 = 75^o - 45^o = 30^o$
$\frac{\sin i}{\sin r_1} = \sqrt{2} \Rightarrow \sin i = \sqrt{2} \sin 30 = \sqrt{2} \times \frac{1}{2} \Rightarrow i = 45^o$.

6.


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

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

7. Deviation by prism.
$\delta_1 = A(\mu - 1) = 4^o(1.5 - 1)$ ⇒ $\delta_1 = 2^o$
for plane mirror
$i = 2^o$ $\delta_2 = 180 - 21 = 176^o$ ⇒ $\delta = \delta_1 + \ = 178^o$



8.

9. $\dfrac{\sin\frac{A+\delta m}{2}}{\sin\frac{A}{2}}$ = μ, But $\frac{A+\delta_m}{2}$ = i = 45°

So $\frac{\sin \ 45°}{\sin \ (A/2)}\sqrt{2} \Rightarrow \frac{1}{2} = \sin\frac{A}{2} \Rightarrow$ A = 60°

$$\mu = \frac{\sin \ i}{\sin \ A/2} \Rightarrow \sqrt{2} = \frac{\sin \ i}{\sin\left(\frac{60}{2}\right)}$$

10.

$\Rightarrow \sqrt{2}$ x sin 30 = sin i i = 45°

11. By the hypothesis, we know that
$i_1 + i_2 = A + \delta$ 55° + 46° = 60° + δ δ = 41°
But $\delta_m < \delta$, so $\delta_m < 41°$

12. To avoid transmission
$A \geq 2\, i_c$ so $90^o \geq 2\sin^{-1}(1/\mu) \Rightarrow$ $\sin^{-1}(1/\mu) \geq 45^o$ ⇒ $\mu \geq \sqrt{2}$.

13. $\delta = (\mu - 1)A = 2°$
So by rotating mirror by 1° in clockwise direction, emergent ray after reflection will become horizontal.

14. $\delta = A = 2r = (2i - 2r)$ ⇒ i = A
$\sqrt{3} = \frac{\sin A}{\sin A/2} \Rightarrow \cos\frac{A}{2} = \frac{\sqrt{3}}{2}$ ⇒ $\frac{A}{2} = 30^o$ ⇒ $A = 2 \times 30 = 60^o$

15. 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)

16. Given: angle of prism A = 60° minimum deviation $\delta_m = 30°$

∴ Angle of incidence

$$i = \frac{A+\delta_m}{2} = \frac{60°+30°}{2} = 45°$$

17. $(n_p - 1) A_p = (n_Q - 1) A_Q$

$(1.54 - 1) 4° = (1.72 - 1) A_Q \Rightarrow A_Q = \frac{0.54\times 4}{0.72} = 3°$

18. Here : Refracting angle A = 60°,

minimum deviation δm = 38°.

The refractive index is given by the formula

$$\mu = \frac{\sin\frac{A+\delta m}{2}}{\sin\frac{A}{2}} = \frac{\sin\frac{60°+38°}{2}}{\sin\frac{60°}{2}} = \frac{\sin 49°}{\sin 30°} = \frac{0.7547}{0.5} = 1.5094$$

19. For prism

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

Here, A = 60°

$\Rightarrow \sqrt{3} \times \sin 30° = \sin\left(\frac{60°+\delta_m}{2}\right) \Rightarrow \sin\left(\frac{60°+\delta_m}{2}\right) = \sin 60° \Rightarrow 60° + \delta_\mu = 120° \Rightarrow \delta_m = 60°$

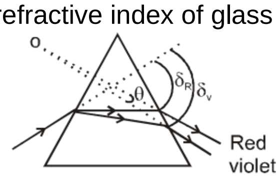
20. We know that wavelength of violet light is minimum and that of red light is maximum.

∴ $\lambda_R > \lambda_v$

From Cauchy's dispersion relation

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

So, $\mu_v > \mu_R$, ie, refractive index of glass for violet light is maximum. Hence, from the formula



$\delta_m = (\mu - 1) A$

where δ_m is angle of deviation and A the angle of prism, violet light deviates the most and red the least.

22. Apparent depth of mark as seen through a glass slab of thickness x and refractive index μ is

Apparent depth = $\frac{\text{Real detph}}{\text{Refractive index}}$ or $x' = \frac{x}{\mu} = \frac{3}{1.5} = 2$ cm

As image appears to be raised by 1 cm, therefore, microscope must be moved upward by 1 cm.

23. Angle of minimum deviation $D = (\mu - 1) A$

∵ $\mu_{blue} > \mu_{red}$

∴ $D_2 > D_1$

24. i > c for ITR

$\therefore 45^o > \sin^{-1}\left(\frac{1}{n}\right)$ $\Rightarrow n > \sqrt{2}$

SECTION (E)

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

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

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

V = – R for all values of μ .

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

4. 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

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

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

SECTION (F)

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

$\frac{1}{f}$ = 0 $\Rightarrow$ f = ∞

2. $\frac{1}{f}$ = (R1 = R, R2 = – R) $\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

3. From displacement method

O = $\sqrt{I_1 \; I_2}$

O = $\sqrt{9\times4}$ = 6 cm

4. $\because$ u < f

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

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

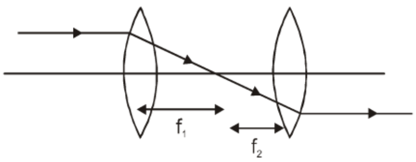
5. $n_{rel} < 1$

So, f is negative

6. Lens changes its behaviour if R.I. of surrounding becomes greater than R.I. of lens.

$\mu_{lens} < 1.33$

7.



Distance between lens is = $f_1 + f_2$

8. for vertical erect image by diverging lens.

u = – V_i,V = – V_i f = – V_i

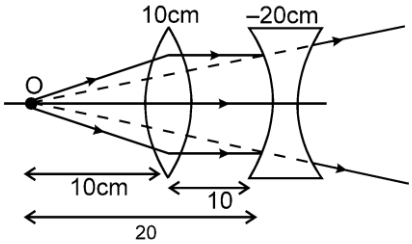
= – Vi and = + Vi

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

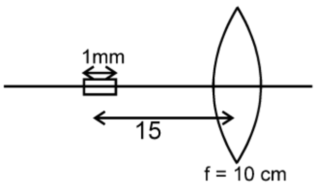
1 = $\frac{f}{V}-\frac{f}{4}$ $\frac{1}{f}=\frac{1}{x}$ + 1

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

9.



10.



$\frac{1}{10}$ = $\frac{1}{v}$ = – $\frac{1}{(-15)}$ $\Rightarrow$ v = + 30 cm

for small object dv = $\frac{v^2}{u^2}du$ = $\left(\frac{30}{15}\right)^2\times1$ = 4 mm

20. $\frac{1}{f}$ = (n_{rel} – 1) $\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

For air

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

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

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.**

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

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

f = 1.25 inch

23. m = $\frac{v}{u} = \frac{f}{f+u}$

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

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

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

24. For air

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

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

R = 10 × 2 × .52

For liquid

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

$$\frac{1}{f} = -\frac{.16}{1.68}\times\frac{2}{10\times2\times.52}$$

f = – 54.60 cm **Ans.**

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

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

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

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

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

27. $f_A = f_B = f_C = f_{net}$ ⇒ $P_A = P_B = P_C = P_{net} = P$

28. From displacement method, the length of object is given by

$O = \sqrt{I_1 I_2} = \sqrt{4\times16} = \sqrt{64} = 8$ cm

29. 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.

30. Using the relation for focal length of plano-convex lens

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

(Refractive index of material of lens $\mu = 1.5$, $R_1 = 20$ cm, $R_2 = \infty$)

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

$\frac{1}{f}=\frac{1}{40}$ or f = 40 cm

31. Biconvex lens is cut perpendicularly to the principal axis, it will become a plano-convex lens.

focal length of biconvex lens.

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

$$\Rightarrow \quad f = \frac{R}{2(n-1)} \qquad \ldots \text{(i)}$$

plano-convex lens.

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

$$f_1 = \frac{R}{(n-1)} \qquad \ldots \text{(ii)}$$

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 cecome half.

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

34. The lens formula can be written as

$$\frac{1}{f} = \frac{1}{v}+\frac{1}{u} \qquad \text{.... (i)}$$

Given, $v = d$

For equal size image

$|v| = |u| = d$

By sign convention, $u = -d$

$$\therefore \quad \frac{1}{f} = \frac{1}{d}+\frac{1}{d} \quad \text{or} \quad f = \frac{d}{2}$$

35. Initially, the focal length of equiconvex lens is

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

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

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

$$\text{Thus,} \quad \frac{1}{f} = (\mu-1)\left[\frac{1}{R}-\frac{1}{(-R)}\right] = (\mu-1)\left[\frac{1}{R}+\frac{1}{R}\right] = (\mu-1)\frac{2}{R} = \frac{1}{f'}$$

$\Rightarrow$ $f' = f$

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

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

$$\text{Thus,} \quad \frac{1}{f''} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) = (\mu-1)\left(\frac{1}{R}-\frac{1}{\infty}\right) = \frac{(\mu-1)}{R} = \frac{1}{2f}$$

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

36. From lens maker's formula

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

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

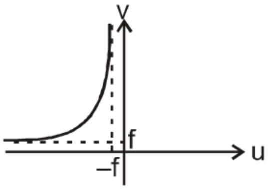
Dividing equation (i) by equation (ii), we get

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

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,

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

37. For a convex lens
u = –ve f = +ve
If v = ∞, u = f and if u = –∞ , v = f.



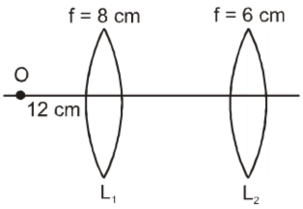
We have v = +ve and u = –ve and u and v are symmetrical. Hence graph is shown,

38. Image is always proportional to the size of object.

39. Minimum distance between object and image is 4f.

$4f \le d$ $\quad f \le \frac{d}{4}$

40.

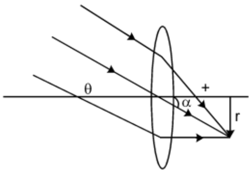


For L_1 : $\frac{1}{V} - \frac{1}{-12} = \frac{1}{8}$

V = 24 cm

For L_2 : Object is at focus image is inverted and real.

41. r = f tanα



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

42. Area of image = m^2 × area of object = 16 × 100 = 1600 cm^2

SECTION (G) :

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

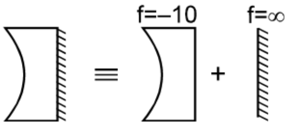
= $\frac{1}{25} + \frac{1}{-20} - \frac{d}{-500} = 0$ = $\frac{20-25}{500}$ = $-\frac{d}{500}$ ⇒ d = 5 cm.

2. P = $P_1 + P_2$
= + 4 + (– 3)
= + 1

3. $P_L = P_1 + P_2$

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

4.



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

10. $\frac{1}{10} = \left(\frac{3}{2}-1\right)\left(\frac{1}{R}-\frac{1}{\infty}\right)$ ⇒ $\frac{1}{2R} = \frac{1}{10}$ ⇒ R = 5 cm

Rays should extance the path ⇒ incident rays on mirror should be normal

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

⇒ $\frac{1}{d} = \frac{1}{10}$ ⇒ d = 10 cm

11. The effective focal length is 5 cm.

The height of final images is = $\frac{v}{u} \times O = \frac{f}{u+f} = \frac{5}{-7.5+5}$ × 1 = 2 cm

12. Power of convex lens

$p_1 = \frac{1}{\text{f(metre eM)}}$ D = $\frac{1}{0.40}$ = 2.5 D

power of concave lens

$p_2 = \frac{1}{(-0.25)}$ D = – 4D

∴ power of combination (in contact)

$p = p_1 + p_2 = +2.5\ D - 4D = -1.5D$

14. Focal length of combination of lenses placed in contact is

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

For convex lens, $f_1 = 25$ cm

For concave, lens $f_2 = -25$ cm

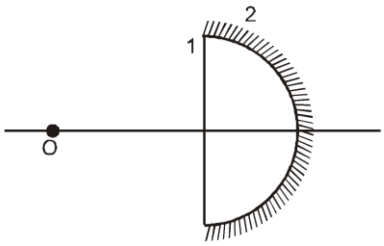
Hence $\frac{1}{F} = \frac{1}{25} + \frac{1}{-25} = \frac{1}{25} - \frac{1}{25} = 0$ ∴ $F = \frac{1}{0} = \infty$

Hence, power of combination,

$$P = \frac{1}{F} = 0\ D$$

Note : As a convex and a concave lens of same focal lens are placed in contact, so we get achromatism i.e., combination is free from chromatic aberration.

15. 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

16. When a ray falls on convex surface of a plano-convex lens, then it is first refracted and reflected from plane surface finally refracted from convex surface. Thus, two refractions and one reflection take place. So, focal length of plano-convex lens is

$$\frac{1}{F} = \frac{2}{f_\ell} + \frac{1}{f_m} \quad ....(i)$$

Here $f_m = \infty$

Now, $\frac{1}{f_\ell} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

⇒ $\frac{1}{f_\ell} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{\infty}\right) = \frac{(\mu - 1)}{R}$

∴ $\frac{1}{F} = \frac{2(\mu - 1)}{R} + \frac{1}{\infty} = \frac{2(\mu - 1)}{R}$

or $F = \frac{R}{2(\mu - 1)}$ ....(ii)

Given, $R = 20$ cm, $\mu = 1.5$

Hence, F = $\frac{20}{2(1.5-1)}$ = $\frac{20}{2\times0.5}$ = 20 cm

17. Power of first lens

$p_1 = \frac{100}{f_1} = \frac{100}{20}$ = 5 D power of second lens $p_2 = \frac{100}{25}$ = 4 D

Total power $p = p_1 + p_2 = 5 + 4 = 9$ D

SECTION (H)

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

2. μ_{red} = minimum

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

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

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

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

μ is greatest for voilet ⇒ C is minimum for voilet

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

μ is least for red ⇒ shift in least for red.

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

10. ω depends only on material property.

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

12. (3) is least so is least.

13. (4) We know that $\frac{\delta_v - \delta_r}{\delta_{mean}} = \omega$

Angular dispersion = $\delta_v - \delta_r = \theta = \omega\delta_{mean}$

14. (1) Because achromatic combination has same μ for all wavelengths.

16. $P = P_1 + P_2$
$2 = 5 + P_2$
$P_2 = -3$ D
$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = -\frac{P_2}{P_1} = \frac{3}{5}$

17. $\frac{\delta_\omega}{\delta_a} = \frac{({}_\omega\mu_g - 1)}{({}_a\mu_g - 1)} = \frac{\left(\frac{9}{8}-1\right)}{\left(\frac{3}{2}-1\right)} = \frac{1}{4}$

18. Since $A(\mu_y - 1) + A'(\mu_{y'} - 1) = 0 \Rightarrow \frac{A'}{A} = -\left(\frac{\mu_y - 1}{\mu_{y'} - 1}\right)$

20. When white light from sun falls on rain drops, sometimes a band of different colours in form of a circular arc is seen in the sky opposite the sun. This is called the rainbow.
The reason of origin of rainbow is that the small drops of water behave like a prism for the white sun light due to which refraction, dispersion and total internal reflection of white light occurs from the water drops. The rainbow is not seen after every rain, but is seen only when the light rays of particular colour suffer minimum deviation after one or two total internal reflections inside the small water drops.

21. $\mu_{blue} > \mu_{red}$

22. $\mu \propto \frac{1}{\lambda},\ \lambda_r > \lambda_\upsilon$

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

25. In any medium other than air or vacuum, the velocities of different colours are different. Therefore, both red and green colours are refracted at different angles of refraction. Hence, after emerging from glass slab through opposite parallel face, they appear at two different points and move in the two different parallel directions.

SECTION (I)

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

2. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{(-40)} - 0 = \frac{1}{f}$
f = – 40 cm
$P_L = \frac{1}{f_L} = -2.5$ D

3. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-25} - \frac{1}{-50}$

f = –50 cm ⇒ $P_L = \frac{1}{f_L} = -2D$

7. Since, the person is not able to see distant objects beyond 10 cm so he should use concave lens in his spectacles. Concave lens will form the image of object distant 30 cm, at 10 cm it means.

u = – 30 cm, v = – 10 cm

$\frac{1}{F} = \frac{1}{v} - \frac{1}{u} = \frac{1}{-10} - \frac{1}{-30} = -\frac{2}{30}$

or $\frac{1}{f} = -\frac{1}{15}$ So f = – 15 cm

Minus singe signifies that lens used is concave.

SECTION (J)

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

4. In normal adjustment

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

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

(eyepiece is concave lens)

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

6. $m = 1 + \frac{D}{f}$

9. For normal adjustment

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

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

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

10. $f = \frac{1}{p} = \frac{1}{2}$ metre

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

11. By using $m_\infty = \frac{(L_\infty - f_0 - f_e).D}{f_0 f_e}$ ⇒ $45 = \frac{(L_\infty - 1 - 5)\times 25}{1 \times 5}$ ⇒ $L_\infty = 15$ cm

12. For a compound microscope $m \propto \frac{1}{f_o f_e}$

13. For a compound microscope $f_{objective} < f_{eye\ piece}$

14. In microscope final image formed is enlarged which in turn increases the visual angle.

15. Magnifying power of a microscope $m \propto \frac{1}{f}$
Since $f_{violet} < f_{red}$; $\therefore m_{violet} > m_{red}$

16. $L_\infty = v_0 + f_e \Rightarrow 14 = v_0 + 5 \Rightarrow v_0 = 9$ cm
Magnifying power of microscope for relaxed eye
$m = \frac{v_0}{u_0} \cdot \frac{D}{f_e}$ or $25 = \frac{9}{u_0} \cdot \frac{25}{5}$ or $u_0 = \frac{9}{5} = 1.8$ cm

17. $m_\infty = \frac{v_0}{u_0} \times \frac{D}{f_e}$
From $\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0} \Rightarrow \frac{1}{(+1.2)} = \frac{1}{v_0} - \frac{1}{(-1.25)} \Rightarrow v_0 = 30$ cm $\therefore |m_\infty| = \frac{30}{1.25} \times \frac{25}{3} = 200$

19. When the final image is at the least distance of distinct vision, then
$m = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right) = \frac{200}{5}\left(1 + \frac{5}{25}\right) = \frac{200 \times 6}{5 \times 5} = -48$
When the final image is at infinity, then $m = -\frac{f_0}{f_e} = \frac{200}{5} = -40$

20. In terrestrial telescope erecting lens absorbs a part of light, so less constant image. But binocular lens gives the proper three dimensional image.

21. In this case $|m| = \frac{f_0}{f_e} = 5$ ...(i)
and length of telescope = $f_0 + f_e = 36$ ...(ii)
Solving (i) and (ii), we get $f_e = 6$ cm, $f_o = 30$ cm

22. $f_o = \frac{1}{1.25} = 0.8$ m and $f_e = \frac{1}{-20} = -0.05$ m
$\therefore |L_\infty| = |f_o| - |f_e| = 0.8 - 0.05 = 0.75$ m $= 75$ cm
and $|m_\infty| = \frac{f_0}{f_e} = \frac{0.8}{0.05} = 16$

23. Here : Focal power of first lens $p_1 = 0.5$ D, Focal power of second lens $p_2 = 20$ D, Using the relation for magnifying power
$m = \frac{f_0}{f_e} = \frac{p_2}{p_1} = \frac{20}{0.5} = 40$

24. $m_0 = 7$, $M = 35$, $m_e = ?$
From the formula, $M = m_0 \times m_e$
$35 = 7 \times m_e$
$m_e = 5$

25. The resolving power of a telescope is its ability to show two distant closely lying objects as just separate. The reciprocal of resolving power is the limit of resolution of the telescope.

Limit of resolution = $1.22\,\frac{\lambda}{d}$ rad

Where λ is wavelength and d the aperture (diameter). Hence, to reduce the limit of resolution of a telescope, we must use objective lens of large aperture (d). Larger the aperture of the objective lens, greater the resolving power of the telescope.

26. $\left|\frac{\theta}{\theta_0}\right| = \left|\frac{f_0}{f_e}\right| \Rightarrow \theta = \frac{f_0}{f_e}\,\theta_0 = \frac{100}{2} \times 0.5 = 25^\circ$

30. Magnification will be done by compound microscope only when focal length of object lens is less than focal length of eye lens.

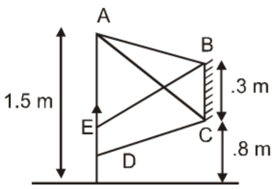
31. Larger aperture increases the amount of light gathered by the telescope increasing the resolution.

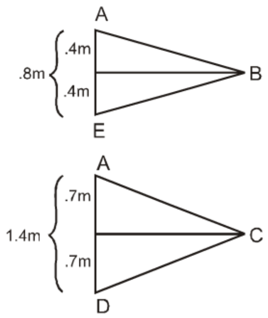
32. Resolution power $\alpha\ \frac{1}{\lambda} \Rightarrow \frac{(RP)_1}{(RP)_2} = \frac{\lambda_2}{\lambda_1} = \frac{5}{4}$

33. Objective of compound microscope is a convex lens. Convex lens forms real and enlarged image when an object is placed between its focus and lens.

EXERCISE # 2

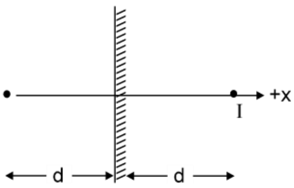
1



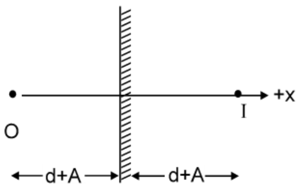


ED = AD – AE = 1.4 – .8 = .6 m

2.



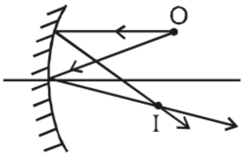
(i)



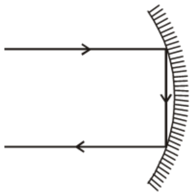
(ii)

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

Therefore Amplitude of SHM of image = 2A

3. 

4. The only possibility is by reflection from concave mirror as shown.



5. Using mirror formula,

$\frac{1}{-10} = \frac{1}{v} + \frac{1}{-15}$ ⇒ v = – 30 cm.

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

amplitude of image = 4 × 2 = 8 mm.

6. For m = 2

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

V = –2u ....(i)

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

⇒ $\frac{1}{f}$ = $\frac{1}{2u}$ ⇒ 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

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

& v = 3f

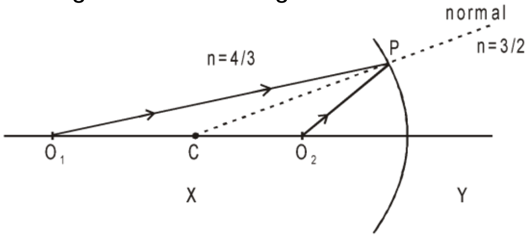
Distance between object & image = 3f – $\frac{3f}{2}$.

7. Displacement = $\frac{t\sin(i-r)}{\cos r}$

Since i and r are small angles.

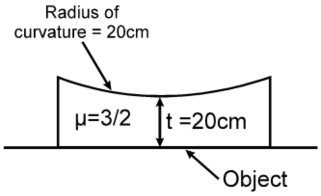
Displacement = t (i – r) = t i $\left(1-\frac{r}{i}\right)$ = t θ $\left(1-\frac{1}{n}\right)$ = $\frac{t\theta \quad (n-1)}{n}$

8. 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. Using formula of spherical surface taking 'B' as object

$\frac{\mu_2}{\infty} - \frac{\mu_1}{(-2\ R)} = \frac{\mu_2 - \mu_1}{-\ R}$ (R being the radius of the curved surface) $\Rightarrow$ $\frac{\mu_1}{\mu_2} = 2$



10.

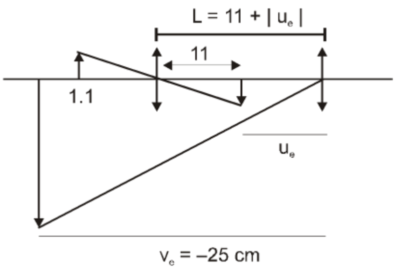
Considering refraction at the curved surface,

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.



11.

For objective

$\frac{1}{v_0} - \frac{1}{-1.1} = \frac{1}{1}$ $\Rightarrow$ $\frac{1}{v_0} = \frac{1}{11}$, v_0 = 11 cm

For eyepiece.

$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$ $\Rightarrow$ $\frac{1}{-25} - \frac{1}{u_e} = \frac{1}{5}$ $\Rightarrow$ $-\frac{1}{u_e} = \frac{6}{25}$ $\Rightarrow$ $-u_e = \frac{25}{6}$

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

12. 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

13. 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 small as possible but still it must be positive, therefore we must sellect the combination which has less radius of curvature for convex lens. Hence, option (1) is correct.

14. In relation for refractive index of prism is

$\mu = \frac{\sin\ i}{\sin\ r}$ … (1)

The condition for minimum deviation is $r = \frac{A}{2} = \frac{60°}{2} = 30°$putting the given values of $\mu = \sqrt{2}$ and $r = 30°$ in Eq. (i), we get

$\sqrt{2} = \frac{\sin i}{\sin\ 30°}$ or $\sin i\ \sqrt{2} \times \frac{1}{2} = \frac{1}{\sqrt{2}}$

$\sin i = \sin 45°$ ∴ $i = 45°$

15. 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, $\sin\theta \geq \frac{11}{13}$

16. Length of tube = 10 cm

$f_0 + f_e = 10$ cm

Magnification m = = 4

$f_0 = 4 f_E$

putting in Eq. (i),

$5f_e = 10$ cm, or $f_e = 2$ cm,

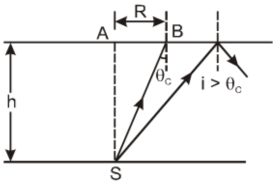
and $f_o = 8$ cm,

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

Hence, L_4 and L_1 will be used.

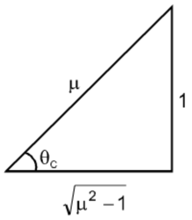
17. RP = so Δθ

18. The light from the source will not emerge out of water if angle of incidence is greater than critical angle. As shown in figure, $i > \theta_C$.



Therefore, minimum radius R corresponds to
$i = \theta_C$.
In ΔSAB

$\frac{R}{h} = \tan\theta_C \quad \therefore \quad R = h\tan\theta_C$



or $\quad R = \frac{h}{\sqrt{\mu^2-1}} = \frac{4}{\sqrt{\left(\frac{5}{3}\right)^2-1}} = \frac{4\times3}{\sqrt{25-9}} = \frac{4\times3}{4} = 3$ m

19. Laws of reflection are valid for all surfaces.
So statement (B) is incorrect.

EXERCISE # 3
PART - I

1. From the relation

$\frac{I}{O} = \frac{v}{u}$

Here, $O = 1.39\times10^9$, $v = 0.1$ m,
$u = 1.5\times10^{11}$ m

$\therefore \quad I = \frac{0.1}{1.5\times11^{11}}\times1.39\times10^9 = 9.2\times10^{-4}$ m

2. If two thin lenses of focal lengths f_1, f_2 are placed in contact coaxially, then equivalent focal length of combination is

$\frac{1}{F} = \frac{1}{f_1}+\frac{1}{f_2}-\frac{0}{f_1f_2} = \frac{1}{f_1}+\frac{1}{f_2}$

Power for the combination is

$P = \frac{1}{F} = \frac{1}{f_1}+\frac{1}{f_2} = \frac{f_1+f_2}{f_1f_2}$

3. For total internal reflection
$\sin i > \sin C$
where,
i = angle of incidence
C = critical angle

But, sin C = $\frac{1}{\mu}$

$\therefore$ $\quad \sin i > \frac{1}{\mu}$ $\quad$ or $\quad \mu > \frac{1}{\sin i}$

$\mu > \frac{1}{\sin 45^\circ}$ $\quad$ (i = 45º (Given)

$\mu > \sqrt{2}$

Hence, option (3) is correct

4. Focal length of the lens remains same. Intensity of image formed yb lens is proportional to area exposed to incident light from object.

i.e., $\frac{I_2}{I_1} = \frac{A_2}{A_1}$

Initial area, $\quad A_1 = \left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$

After blocking exposed area, $A_2 = \frac{\pi d^2}{4} - \frac{\pi (d/2)^2}{4}$

$= \frac{\pi d^2}{4} - \frac{\pi d^2}{16} = \frac{3\pi d^2}{16}$

$\therefore \quad \frac{I_2}{I_1} = \frac{A_2}{A_1} = \frac{\frac{3\pi d^2}{16}}{\frac{\pi d^2}{16}} = \frac{3}{4}$

or $\quad I_2 = \frac{3}{4} I_1 = \frac{3}{4} I \qquad (\because \quad I_2 = I)$

Hence focal length of a lens = f_1 intensity of the image =

5. Refractive index for medium M_1 is

$$\mu_1 = \frac{c}{v_1} = \frac{3 \times 10^8}{1.5 \times 10^8} = 2$$

Refractive index for medium M_2 is

$$\mu_2 = \frac{c}{v_2} = \frac{3 \times 10^8}{2.0 \times 10^8} = \frac{3}{2}$$

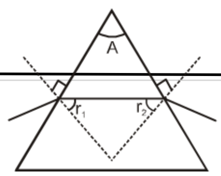
For total internal reflection

sini ≥ sinC $\quad$ where i = angle of incidence

C = critical angle

But sinC = $\frac{\mu_2}{\mu_1}$ $\Rightarrow$ $\sin i \geq \frac{\mu_2}{\mu_1} \geq \frac{3/2}{2}$ $\Rightarrow$ i > $\sin^{-1}\left(\frac{3}{4}\right)$

6. Angle of prism, A = $r_1 + r_2$



For minimum deviation
$r_1 = r_2 = r \quad \therefore \quad A = 2r$
Given, A = 60°

Hence, $r = \frac{A}{2} = \frac{60°}{2} = 30°$

7. Difference between apparent and eal depth of a pond is due to refraction
Other three are due to TIR.

8. $C = \frac{1}{\sqrt{\mu_0 \in_0}}$ So dimensions are LT^{-1}

9. R = 20 ⇒ $n_1 = 2$ ⇒ u = –30

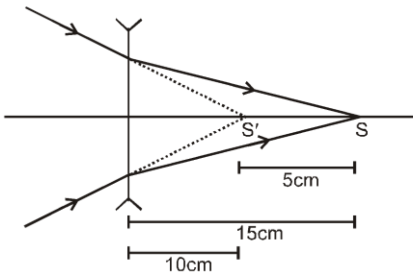
$\frac{1}{f} = \left(\frac{3}{2} - 1\right) \times \frac{2}{20}$ ⇒ f = 20

$m = \frac{v}{u} = -2$ ⇒ $\frac{1}{20} = \frac{1}{v} + \frac{1}{30}$ ⇒ $\frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{10}{600}$

v = 60

10. Deviation = zero
So, $\delta = \delta_1 + \delta_2 = 0$
$(\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$
$A_2(1.75 - 1) = -(1.5 - 1)15^o$
$A_2 = -\frac{0.5}{0.75} \times 15^o$
$A_2 = -10^o$.

11.



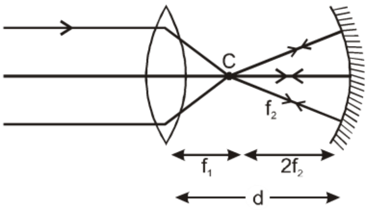
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ ⇒ u = 10 ⇒ v = 15

f = ? ⇒ $\frac{1}{15} - \frac{1}{10} = \frac{1}{f}$ ⇒ $\frac{10-15}{150} = \frac{1}{f}$ ∴ $f = -\frac{150}{5} = -30$ cm

12. $\frac{1}{f} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ here a f = ∞ so $\frac{1}{f} = 0$ so $\mu_g = \mu_m$

13. For normally emerge e = 0
Therefore $r_2 = 0$ and $r_1 = A$
snell's Law for Incident ray's
$1\sin i = \mu \sin r_1 = \mu \sin A$
For small angle
$i = \mu A$

14.



$d = f_1 + 2f_2$

15. M.P = g = $\frac{f_0}{f_e}$ ....(2)

$f_0 + f_e = 20$ ....(1)

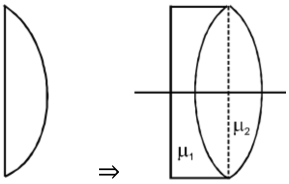
on solving $f_0 = 18$ cm

$f_e = 2$ cm

16. $(\mu_0\varepsilon_0)^{-1/2} = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ = C : speed of light

So dimension LT^{-1}

17.



$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right) + (\mu_2 - 1)\left(\frac{1}{\infty} - \frac{1}{R}\right) = \frac{(\mu_1 - 1)}{R} - \frac{(\mu_2 - 1)}{R} = \frac{1}{f} = \frac{\mu_1 - \mu_2}{R}$

18. Given $P_1 = 40$ D

$P_2 = 20$ D

$P = P_1 + P_2 = 60$ D

$\because$ $P = \frac{100}{f(\text{in cm})}$ So, $f = \frac{100}{60}$

$f = \frac{5}{3} = 1.67$ cm.

19. M.P. of a microscope = $\left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$

if $f_0 \uparrow \Rightarrow$ M.P. of the microscope will decrease

M.P. of telescope = $\frac{f_0}{f_e}$

if $f_0 \uparrow \Rightarrow$ M/O. of telescope will increase.

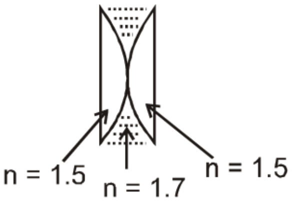
20. $\mu = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin(A/2)}$

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

Sin $\left(\dfrac{\delta_m + A}{2}\right) = \sin(90 + A/2)$

$\Rightarrow$ $\delta_{min} = 180^0 - 2A$

21.



$\dfrac{1}{f_1} = \left(\dfrac{1.5}{1} - 1\right)\left(\dfrac{1}{\infty} - \dfrac{1}{-20}\right)$

$\Rightarrow f_1 = 40$ cm

$\dfrac{1}{f_2} = \left(\dfrac{1.7}{1} - 1\right)\left(\dfrac{1}{-20} - \dfrac{1}{+20}\right)$

$\Rightarrow f_1 = -\dfrac{100}{7}$ cm

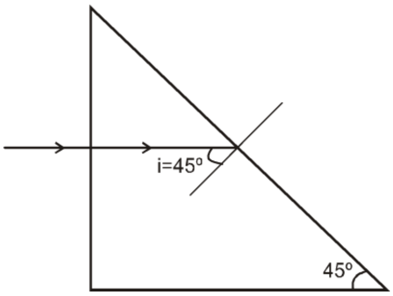
f_3 is also 40 cm

$\dfrac{1}{f_{eq}} = \dfrac{1}{f_1} + \dfrac{1}{f_2} + \dfrac{1}{f_3} \Rightarrow \dfrac{1}{f_{eq}} = \dfrac{1}{40} + \dfrac{1}{-100/7} + \dfrac{1}{40}$

$f_{eq} = -50$ cm

Ans is (2)

22.



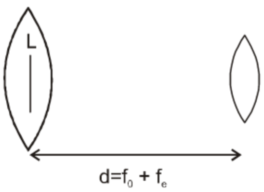
For TIR $i > i_c$ so $\sin i > \sin i_c$

$\sin 45^0 > \dfrac{1}{\mu} \Rightarrow \mu > \sqrt{2} \Rightarrow \mu > 1.414$

Since μ of green and voilet are greater than 1.414 so they will total internal refrected. But red colour will be vetracted

So Ans. is (3)

23.



Magnification by eyepiece

$m = \frac{f}{f+u}$ $\Rightarrow$ $-\frac{I}{L} = \frac{f_e}{f_e + (-(f_0 + f_e))}$ $\Rightarrow$ $\frac{I}{L} = \frac{f_e}{f_0}$ $\Rightarrow$ $m.p. = \frac{f_0}{f_e} = \frac{L}{I}$

24. (A) m = –2, so image is magnified and inverted. Which is possible only for concave mirror. since image is i inverted so it will be real.

(B) M = $-\frac{1}{2}$, so image is inverted and diminished. since image is inverted, so it will be real, and the mirror will be concave.

(C) M = +2, image is magnified so the mirror will be concave. Image is erect so it will be virtual.

(D) m = $+\frac{1}{2}$, image is erect so image will be virtual. Image is virtual and diminished, so the mirror should be convex.

Ans. will be (2)

25. Tube length = $v_0 + f_e$

for objective $\frac{1}{V_0} - \frac{1}{u_0} = \frac{1}{f}$

put u_0 = –200 and f = 40 cm we get v_0 = 50 cm

L = 54 cm

26. Give A = 60 and i = e = 60

δ_{min} = i + e – A = 45 + 45 – 60 = 30

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

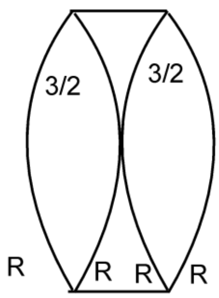
27. $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\Rightarrow$ $\frac{1}{-4m} - \frac{1}{\infty} = \frac{1}{f}$

$\Rightarrow$ f = – 4m

$\Rightarrow$ power = $\frac{1}{f}$ = $\frac{1}{-4}$ = – 0.25D

28.



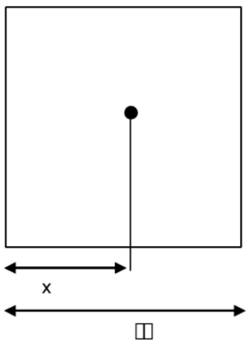
$$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\frac{2}{R} = \frac{1}{R}$$

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

So $$\frac{1}{f_{eq}} = \frac{1}{f} - \frac{2}{3f} + \frac{1}{f} = \frac{3-2+3}{3f} = \frac{4}{3f}$$

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

29.



$$\frac{x}{\mu} + \frac{(\ell - x)}{\mu} = 3 + 5$$

$\frac{\ell}{\mu} = 8$

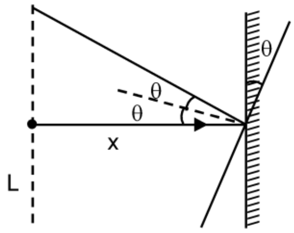
$\ell = 8 \times \frac{3}{2} = 12$ cm

30. $(\mu - 1) A - (\mu' - 1) A' = 0$

For zero deviation

$$A' = \frac{(\mu - 1)A}{(\mu' - 1)} = 6^o$$

31.

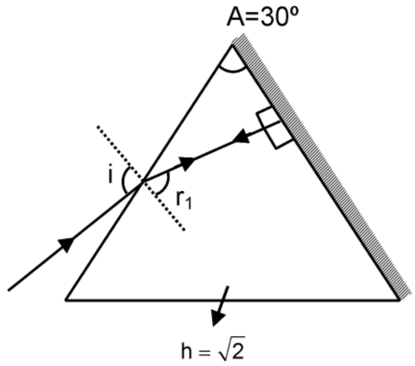


$\tan 2\theta = \frac{y}{x} = 2\theta$ ⇒ so $\theta = \frac{y}{2x}$

32. M.P. = $\frac{f_o}{f_e}$ and resolution power = $\frac{d_0}{1.22\lambda}$

For more magnification power (M.P.), f_o should be more and for more resolution power, d_o should be large.

33. To retrace the path, the ray should strike the second surface normally.

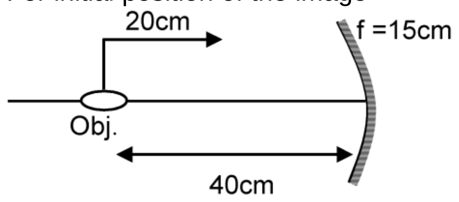


So $r_2 = 0$ $\Rightarrow$ $r_1 = A - r_2$

$r_1 = 30 - 0$ $\Rightarrow$ $r_1 = 30^o$

(1) $\sin i = \sqrt{2}\sin 30^o$ $\Rightarrow$ $i = 45^o$

34. For initial position of the image



$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ $\Rightarrow$ $\frac{1}{v}+\frac{1}{-40}=\frac{1}{-15}$ $\Rightarrow$ $v = -24$ cm

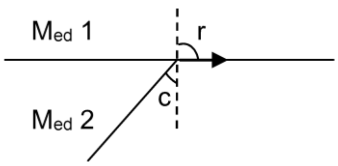
For final position of image

$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ $\Rightarrow$ $\frac{1}{v}+\frac{1}{-20}=\frac{1}{-15}$ $\Rightarrow$ $v = -60$

Displacement of image = 60 – 24 = 36 cm away from the mirror

35. To see the rainbow the sun should be on his backside

36.



Angle of reflection 90º

37.

$f_{eq} = f_1$ | $\frac{1}{f} = (1.5 - 1)2/R$

$\frac{1}{f_1}=\frac{1}{f}+\frac{1}{f}=\frac{2}{f}$ | $= \frac{1}{2}\times\frac{2}{R}=\frac{1}{R}$

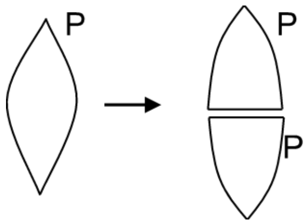
$f_1 = \frac{f}{2}=\frac{R}{2}$ | $\frac{1}{f_2}=\frac{1}{R}-\frac{1}{R}+\frac{1}{R}=\frac{1}{R}$

$f_2 = R$

with glycerin : focal length of concave lens is formed

$$\frac{1}{f'} = (m-1)\left(-\frac{1}{R}-\frac{1}{R}\right) = \frac{1}{2}\left(-\frac{2}{R}\right) = \frac{-1}{R} \quad \frac{f_1}{f_2} = \frac{R/2}{R} = \frac{1}{2}$$

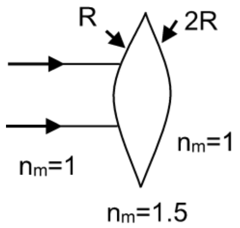
38.



If the lens is cut in longitudinal direction, the power will not change $\Rightarrow$ $P' = P$

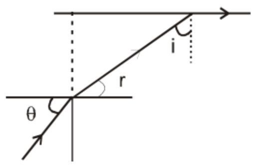
39. $\frac{1}{f} = \left(\frac{n_l}{n_m}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ $\Rightarrow$ $\frac{1}{+25} = \left(\frac{1.5}{1}-1\right)\left(\frac{1}{+R}-\frac{1}{-2R}\right)$

By solving R = 18.75 cm, 2R = 37.5 cm



PART - II

1.



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

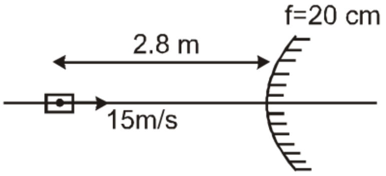
and $\frac{2}{\sqrt{3}}\sin i = \sin 90^o$

$\Rightarrow$ $i = 60^o$ ....(ii)

From (i) and (ii)

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

2. Mirror formula :



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

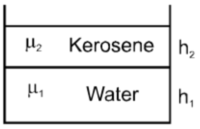
$$\frac{1}{v}+\frac{1}{20}+\frac{1}{280}$$

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

$v_I = -\left(\frac{280}{15\times 280}\right)^2 .15$ $\quad\therefore v_I = -\left(\frac{v}{u}\right)^2 .v_{om}$ $\quad\therefore v_I = \frac{-15}{15\times 15}$

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

3.



Apparent shift :

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

4. $\mu_R < \mu_B$

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

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

$f_R > f_B$.

5. Initially the object distance is 240 cm and the image distance is 12 cm so

$\frac{1}{f}=\frac{1}{12}+\frac{1}{240}=\frac{20+1}{240} \Rightarrow f = \frac{240}{21}$ m

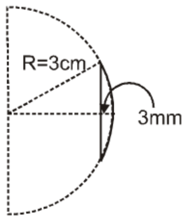
due to the slab, the shifting of the image will be:

shift = $1(1 - \frac{2}{3}) = \frac{1}{3}$ Now $v' = 12 - \frac{1}{3} = \frac{35}{3}$ 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

6. 

$3^2 + (R - 3mm)^2 = R^2$ ⇒ $3^2 + R^2 - 2R(3mm) + (3mm)^2 = R^2$ ⇒ $R \approx 15$ cm

$\frac{1}{f} = \left(\frac{3}{2}-1\right)\left(\frac{1}{15}\right)$ ⇒ f = 30cm

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

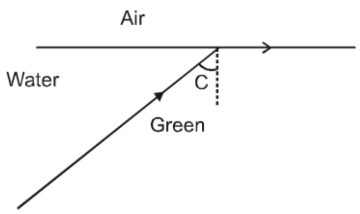
$\frac{1}{f} = \frac{1}{2x}$ ⇒ f = 2x here $\left(\frac{1}{x} = \frac{1}{R_1}-\frac{1}{R_2}\right)$ ⇒ $\frac{1}{f_1} = \left(\frac{3/2}{4/3}-1\right)\frac{1}{x}$

$\frac{1}{f_2} = \left(\frac{3/2}{5/3}-1\right)\left(\frac{1}{x}\right)$: ⇒ f_2 is negative. $\frac{1}{f_1} = \frac{1}{8x} = \frac{1}{4(2x)} = \frac{1}{4f}$

⇒ $f_1 = 4f$

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.

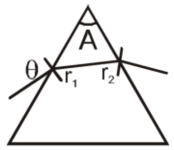
If lense is inserted in rarer medium the focal length increases.

9. 

here sin C = $\frac{1}{n_{water}}$ and $n_{water} = a + \frac{b}{\lambda^2}$

If frequency is less ⇒ λ is greater and hence R.I. (n_{water}) is less and therefore, critical angle increases.

10. For transmission $r_2 < i_C$



$A - r_1 < i_C$

$\sin(A - r_1) < \sin i_C$

$\sin(A - r_1) < \frac{1}{\mu}$ ⇒ $A - r_1 < \sin^{-1}\left(\frac{1}{\mu}\right)$ ⇒ $r_1 > A - \sin^{-1}\left(\frac{1}{\mu}\right)$

$\sin r_1 > \sin\left[A - \sin^{-1}\left(\frac{1}{\mu}\right)\right] \quad \therefore \quad \sin r_1 = \frac{\sin\theta}{\mu}$

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

11. $\theta = \frac{10}{x}$

$\theta_1 = \frac{10}{x}(20)$ Now 20 times nearer

12. When i = 35° and e = 79° then δ = 40°

$\delta = i + e - A$

$40° = 35 + 79 - A$

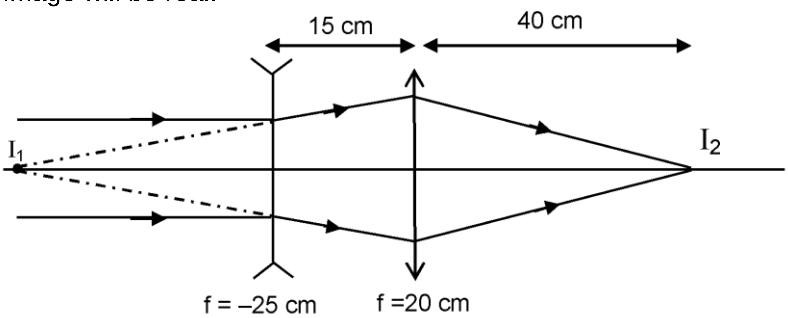
$A = 74°$

Since $i \neq e$ so δ_{min} will less than 40°

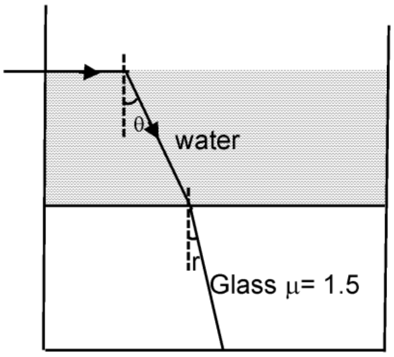
$n = \frac{\sin\left(\frac{\delta_{min} + A}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad \Rightarrow \quad n = \frac{\sin\left(\frac{40° + 74}{2}\right)}{\sin\left(\frac{74}{2}\right)} = \frac{\sin(57°)}{\sin(37°)} = \frac{0.84}{0.60} = 1.4$

Since δ_{min} will be less than 40° so

13. 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.



14.



$1.\sin 90° = \mu\sin\theta \Rightarrow \quad \sin\theta = \frac{1}{\mu}$

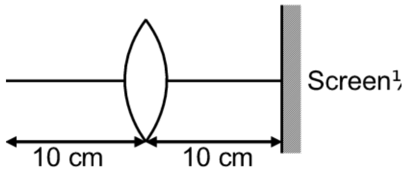
$\mu\sin\theta = 1.5 \sin r$

$\mu\tan\theta = 1.5 \Rightarrow \quad \tan\theta = \frac{1.5}{\mu}$

$\sin\theta = \frac{3}{\sqrt{9+4\mu^2}} = \frac{1}{\mu}$

$9\mu^2 = 9 + 4\mu^2 \Rightarrow \ \mu = \frac{3}{\sqrt{5}}$

15.



2f = 10 cm so f = 5 cm

Now due to glass plate shift = $t\left(1-\frac{1}{\mu}\right) = 1.5\left(1-\frac{2}{3}\right) = 0.5$cm

So new u = 10 – 0.5 = 9.5 cm

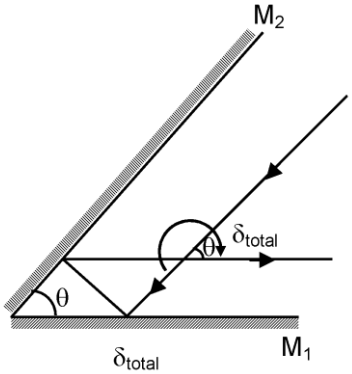
$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} \quad \Rightarrow \frac{1}{v} - \frac{1}{-9.5} = \frac{1}{5} \Rightarrow \quad \frac{1}{v} = \frac{1}{5} - \frac{1}{9.5}$ Ans $V = \left[\frac{47.5}{4.5}\right]$

So, shift $\frac{47.5}{4.5} - 10 = \left(\frac{2.5}{4.5}\right) = \frac{5}{9}$ cm away from the lens

16. $\delta_1 + \delta_2 = 360 - 2\theta = 180 + \theta$

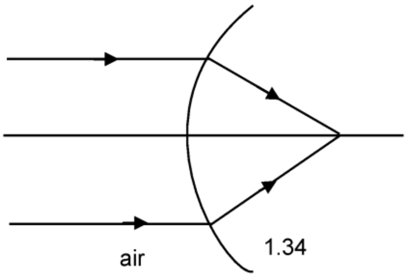
$3\theta = 180$

$\theta = 60°$



17. $\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right) \quad \Rightarrow \quad \frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right) \quad \Rightarrow \quad \frac{f_2}{f_1} = \frac{\mu_1 - 1}{\mu_2 - 1} = \frac{1}{2}$

$\Rightarrow 2\mu_1 - 2 = \mu_2 - 1 \quad \Rightarrow \quad 2\mu_1 - \mu_2 = 1$



18.

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

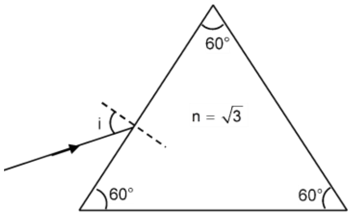
$$\therefore \frac{1.34}{v} = \frac{34}{780}$$

$$v = \frac{1.34 \times 780}{34} = 30.7\text{mm} = 3.07 \text{ cm} \cong 3.1\text{cm}$$

19. $\delta = A(\mu - 1)$ for thin prism, then more is the refractive index, more will be the deviation.

20. $\frac{dv}{dt} = \left(\frac{f}{f+u}\right)^2 \frac{du}{dt} \Rightarrow \frac{dv}{dt} = \left(\frac{0.3}{0.3-20}\right)^2 \times 5 = 1.16 \times 10^{-3}$ m/s towards lens

21.



$$n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} \Rightarrow \sqrt{3} = \frac{\sin\left(\frac{60^\circ+\delta_m}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)} \Rightarrow \frac{\sqrt{3}}{2} = \sin\left(\frac{60^\circ+\delta_m}{2}\right)$$

$$\Rightarrow 60^\circ = \frac{60^\circ+\delta_{min}}{2} \Rightarrow \delta_{min} = 60^\circ \Rightarrow i = \frac{A+\delta_{min}}{2} = \frac{60^\circ+60^\circ}{2} = 60^\circ$$

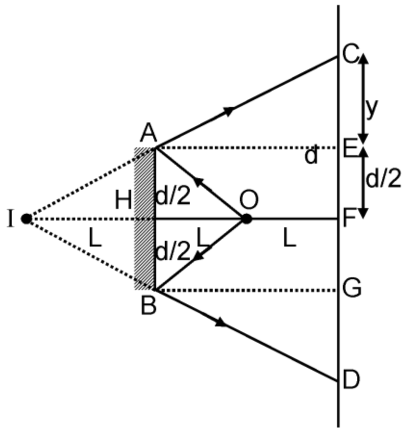
22. $\frac{1}{V} + \frac{1}{20} = \frac{1}{5} \Rightarrow \frac{1}{V} = \frac{1}{5} - \frac{1}{20} = \frac{4-1}{20} \Rightarrow V_1 = \frac{20}{3}$

distance of first image from B = $\frac{20}{3} - 2 = \frac{14}{3}$ cm for second lens

$$\frac{1}{V} - \frac{3}{14} = -\frac{1}{5} = \frac{15-14}{70} = \frac{1}{70}$$

70 cm from point B at right ; real

23.



By similar triangles

ΔAEC ~ ΔIHA

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

y = d   Total distance (CD) = $y + \frac{d}{2} + \frac{d}{2} + y$ = 3d

24. Focal length changes hence image is not formed on screen.

25. $\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{-R} - \frac{1}{\omega}\right)$ $\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{R} - \frac{1}{\omega}\right)$

When joined together

$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{\mu_2 - 1}{-R} + \frac{\mu_2 - 1}{R} = \frac{\mu_2 - \mu_1}{R}$

$f_{eq} = \frac{R}{\mu_2 - \mu_1}$