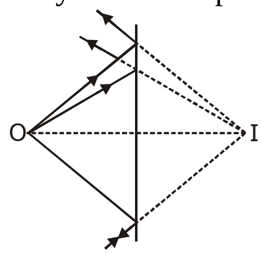
JEE Main Exercise

1. (b)
All the reflected rays meet at a point, when produced backwards.



2. (c)
Perpendicular distance between object & mirror is equal to perpendicular distance between image & mirror.
Fig.1 shows original condition when object distance is x & mirror is at mean and fig.2 shows final condition then mirror perform SHM of amplitude 2 cm.

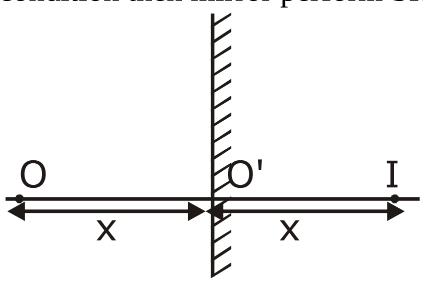


Fig. 1

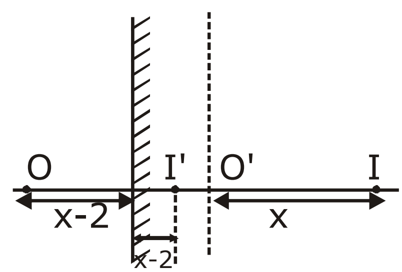
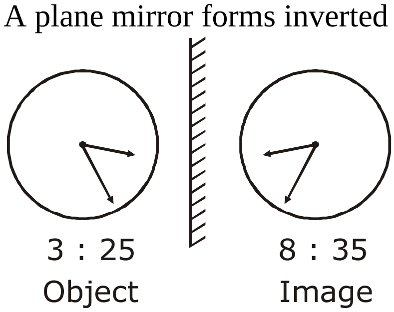


Fig. 2

II′ = O′I + OO′ – (OI′)
= x + x – 2 (x – 2)
II′ = 4 cm

3. (a)
A plane mirror forms inverted image of object line perpendicular to it.



4. (d)
Deviation produced by plane mirror is given by
$\delta = 180 - 2i$
here i = 90 – 60 = 30°
δ = 180 – 60 = 120°

5. (a)
There is a phase change of 180^o in reflection.

6. (c)
Only a portion of incident light is reflected by mirror and rest is transmitted in mid water. So intensity of reflected light is less than intensity of incident light & hence image formed is less bright.

7. (a)
By the laws of reflection angle of incidence = angle of reflection
$\angle i = \angle r$

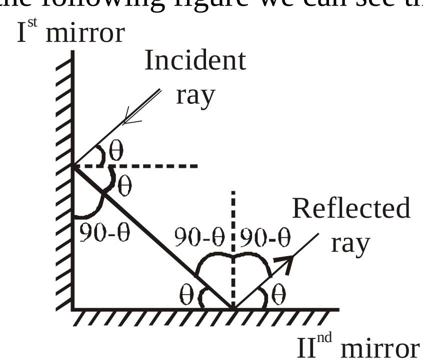
8. (b)
An image is called a real image if the rays after reflection or refraction actually meet hence converging rays from real image.
When rays actually meet real image is formed

9. (a)
All the reflected rays meet at a point, when produced backwards.

10. (b)
Lateral inversion refers to inverted image of object when kept in front of mirror.
Image of HOX appears same as HOX.

11. (b)
Perpendicular distance between object & mirror is equal to perpendicular distance between image & mirror.
Initially the separation between object and image is 200 cm. After 6s the mirror has moved 30 cm towards the object. Hence object-mirror separation is 70 cm. So object image separation is 140 cm.

12. (b)
From the following figure we can see that incident & reflected ray are parallel to one another.



13. (c)
First reflection = 3
Second reflection = 3
Third reflection = 1
Total = 7

14. (a)

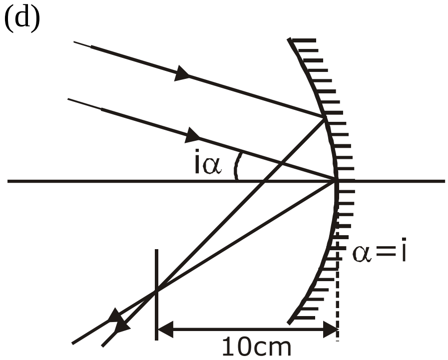
By the formula for the number of image formed $\frac{360}{\theta}-1$ where θ is angle between the mirror.

No. of images = $\frac{360}{\theta}-1=5$

15. (c)

Paraxial rays are considered because they form nearly a point image of a point source.

16. (d)



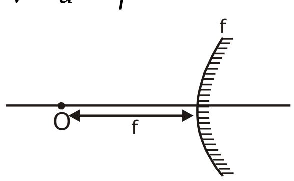
So diameter of the image = $f\alpha$

$$=10\times\left(1\times\frac{\pi}{180}\right)=\frac{\pi}{18}$$

17. (b)

Using mirror formula

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



Here $u = -f$, $f = +f$

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

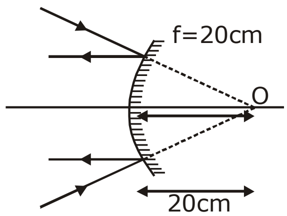
$$\Rightarrow \quad v=\frac{f}{2}$$

18. (a)

Using mirror formula

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

Here we have a virtual object so sign of u is positive.



Here $f = +20$
$u = 20$

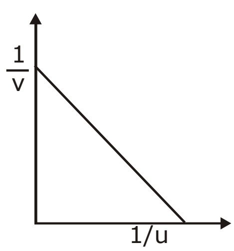
$$\frac{1}{v}+\frac{1}{20}=\frac{1}{20} \Rightarrow \frac{1}{v}=0$$
$$v=\infty$$

19. (b)

Using mirror formula

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

The equation is in the form of $y = mx + c$. On comparing we see that taking $\frac{1}{v}$ on y-axis and $\frac{1}{u}$ on x-axis than m (slope) is –1 and $\frac{1}{f}$ is intercept on y-axis.



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

20. (a)

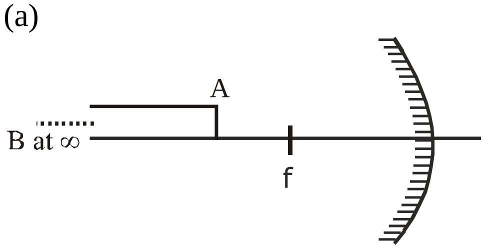


Figure shows a rod of infinite length with point A at distance u and B at infinity.
By using mirror formula we find the image of point A & B.
Point A

$u = -u$ $\quad f = -f$

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

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

Point B

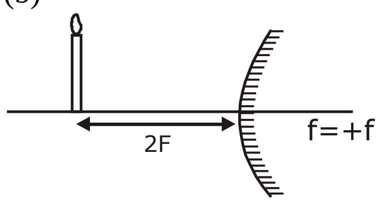
$u=-\infty \qquad f=-f$

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

$v=-f$.

$$\text{Distance }=\frac{uf}{u-f}-f=\frac{f^2}{u-f}$$

21. (b)



Taking $u = -2f$ & $f = +f$

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

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

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

$$m=-\frac{v}{u}=\frac{-2f/3}{-2f}=\frac{1}{3}$$

22. (b)

Magnification is –3 because image is real & inverted.

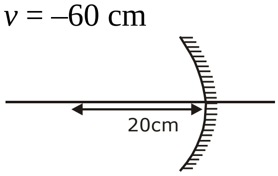
$$m=\frac{-v}{u}$$

$$-3=\frac{-v}{u}$$

$v = 3u$.

given u = –20 cm

v = –60 cm



By using mirror formula

$$\frac{1}{60}-\frac{1}{20}=\frac{1}{f}$$

$f=-15\,\text{cm}$

23. (d)
Here $u = -30$ cm, $f = -15$ cm
Object is at centre of curvature
$\Rightarrow$ image will be real and of same size.

24. (a)
By using mirror formula
$u = +x$; $f = -f$

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

$$\frac{1}{v} = \frac{1}{v} = \frac{-(x+f)}{xf} = -\text{ve (always)}$$

So if object virtual, image always real.

25. (a)
When object is real then image move from focus to pole.
So maximum distance $f = 20$ cm.

26. (c)

$$\frac{dv}{dt} = \frac{-v^2}{u^2}\frac{du}{dt}$$

$\Rightarrow \frac{dv}{dt}$ is opposite of $\frac{du}{dt}$
So, if $v = -$ve i.e. real image then away from mirror and if $v = +$ve i.e. virtual image then toward the mirror.

27. (d)
Irrespective of the type of mirror.

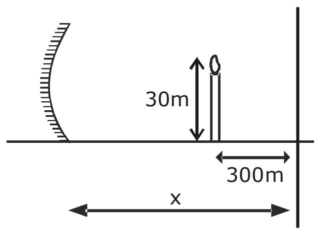
28. (d)
Focal length of the mirror is $R/2$ which depends on the sphere from which the mirror is cut out.

29. (b)
Only concave mirror forms larger image of an object.

30. (d)
Minimum distance between object and image is zero when image concides with the object i.e., object is placed at $2F$.

31. (b)
It is a convex mirror. It makes a virtual image always.

32. (c)



Magnification $= \frac{h_i}{h_0} = \frac{-v}{u}$

$\frac{h_i}{h_0} = \frac{-9}{3} = \frac{-v}{u}$

$3u = v$

$3(x - 300) = x$

$3x - 900 = x$

$2x = 900$

$x = 450$ cm.

33. (c)

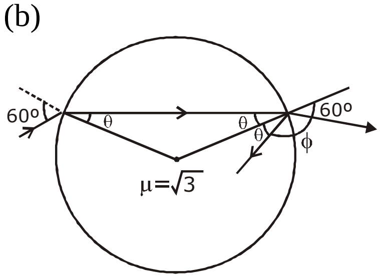
Velocity of light varies with medium. The relation between velocity & refractive index is given as

$\frac{n_2}{n_1} = \frac{v_2}{v_1}$

Where n is refractive index & v velocity of light in medium.

$\frac{\sin i}{\sin r} = \frac{H_2}{H_1} = \frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2}$

34. (b)



Applying Snell's law on surface of incidence

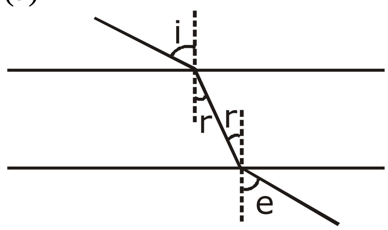
$\theta = \sin^{-1}\left(\frac{\sin 60}{\sqrt{3}}\right)$

$\phi = 180 - [60 + \theta]$

$\phi = 180 - \left[60^\circ + \sin^{-1}\left(\frac{\sin 60^\circ}{\sqrt{3}}\right)\right]$

$= 180^\circ - [60 + 30] = 90^\circ$

35. (a)



Incident angle and emergent angle will be same.

$\Rightarrow$ the angle between them is 0.

36. (a)

Shift by a glass slab of thickness t is given by $t\left(1-\frac{1}{\mu}\right)$

And shift is towards the path of incident light.

37. (c)

$i = 60°$

Displacement $= t\sec r \sin(i-r) = 5\sqrt{2}$

$$= 15\sec r\left[\frac{\sqrt{3}}{2}\cos r - \frac{\sin r}{2}\right] = 5\sqrt{3}$$

$$\Rightarrow \frac{\sqrt{3}}{2} - \frac{\tan r}{2} = \frac{1}{\sqrt{3}}$$

$\Rightarrow r = 30°$

Now, $\mu \sin r = \sin i$

$$\mu = \frac{\sqrt{3}}{2} \times \frac{1}{2} = \sqrt{3}$$

38. (a)

If light is travelling from medium B and suffers TIR it implies $\mu_B < \mu_A$.

$$\theta_C = \sin^{-1}\left(\frac{\mu_B}{\mu_A}\right)$$

$$\theta = \sin^{-1}\left(\frac{V_A}{V_B}\right) \qquad \left[\text{As } \frac{\mu_2}{\mu_1} = \frac{V_1}{V_2}\right]$$

$$\Rightarrow V_B = \frac{V_A}{\sin\theta} = \frac{V}{\sin\theta}$$

39. (a)

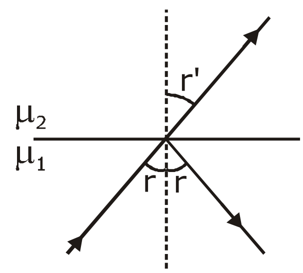
$r + r' = 90° \Rightarrow r' = (90 - r)$

$\mu_1 \sin r = \mu_2 \cos r$

$\tan r = \frac{\mu_2}{\mu_1}$

Critical angle $= \sin^{-1} \frac{\mu_2}{\mu_1}$

$= \sin^{-1}(\tan r)$



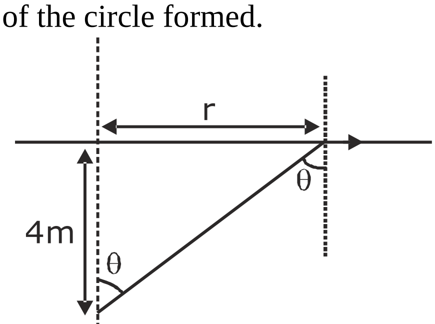
40. (c)

$\frac{\mu_A}{\mu_B} = \frac{V_B}{V_A} = \frac{2.5 \times 10^8}{2 \times 10^8} = 1.25$

$\theta_C = \sin^{-1}\left(\frac{1}{1.25}\right) = \sin^{-1}\left(\frac{4}{5}\right)$ [As $\theta_C = \sin^{-1} \frac{\mu_{rarer}}{\mu_{denser}}$]

41. (c)

In order to find the minimum diameter to block all the light we need to find the maximum radius of the circle formed.



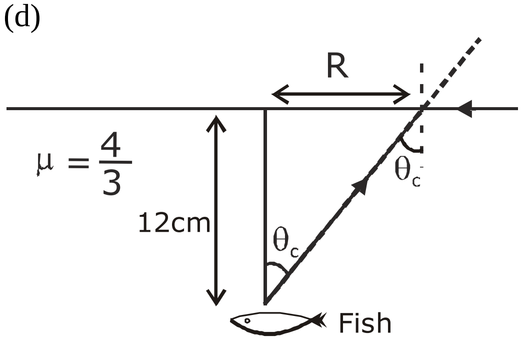
$\tan\theta = \frac{r}{4} \Rightarrow \sin^{-1}\frac{3}{5} = \theta$

$\tan^{-1}\frac{3}{4} = \theta \Rightarrow \frac{r}{4} = \frac{3}{4}$

[For radius to be maximum $\theta = \theta_C$] $\Rightarrow r = 3\,\text{m}$

Diameter = 6 m

42. (d)



$\tan\theta_C = \frac{R}{12}$ .....(1)

A ray of light interring at 90º from rarer medium makes an angle of refraction equal to critical angle in the denser medium and critical angle is given by

$\theta_C = \sin^{-1}\frac{3}{4}$

$\theta_C = \tan^{-1}\frac{3}{\sqrt{7}}$ .....(2)

Equation (1) & (2)

$\frac{3}{\sqrt{7}} = \frac{R}{12} \Rightarrow R = \frac{12\times 3}{\sqrt{7}}$

43. (c)

We know that formula for deviation

$\delta = i + e - A$ & $r_1 + r_2 = A$

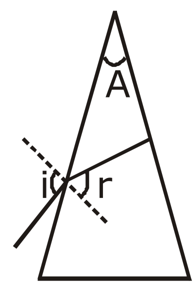
$i = i$ $r_0 = 0$ $r_1 + r_2 = A$

$e = 0$ $r_1 = A$

$A = A$

$1\sin i = \mu \sin A$

Because angles are small $i = \mu A$



44. (b)

For minimum deviation $i_{\min} = e$ and $r_1 = \frac{A}{2} = r_2 = r$

$\delta = i + e - A = (i_{\min} - r) = 38°$ ...(1)

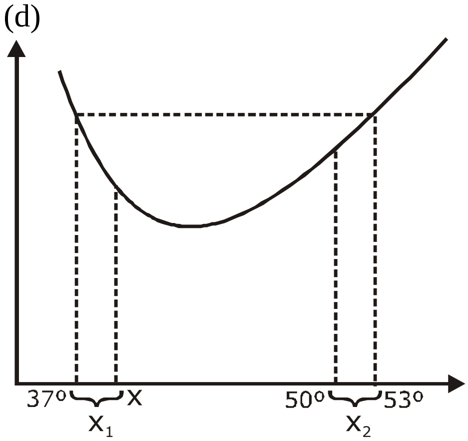
Now,

$44° = 42° + 62 - 2r \Rightarrow r = 38°$ ...(2)

From (1) and (2)

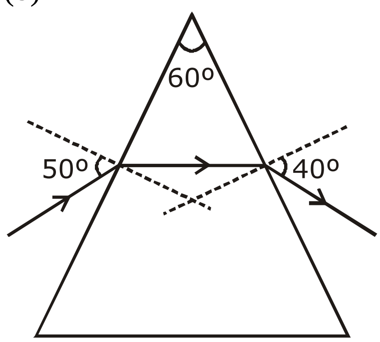
$i_{\min} = 90°$

45. (d)



In the graph for angle of deiration v/s angle of incidence the shift in angle of incidence on right side is more than that of left side $x_2 > x_1$. Hence only one angle is suitable e = 38º.

46. (b)

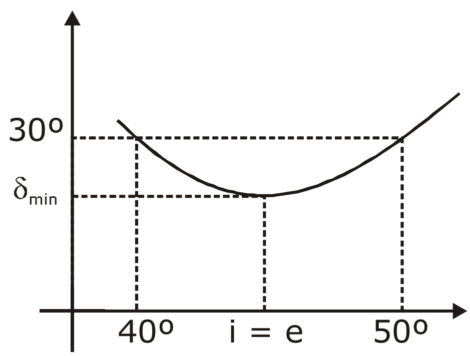


From the formula

$\delta = i + e - A$

$\delta = 50 + 40 - 60 = 30°$

$\delta_{min} < 30°$.



47. (c)

Using formula for relation between δ_{min} & A.

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

$$\sqrt{\frac{3}{2}} = \frac{\sin\left(\frac{90+\delta_{min}}{2}\right)}{\sin 45°}$$

$$\sin\left(\frac{90+\delta_{min}}{2}\right) = \frac{\sqrt{3}}{2}$$

$$\frac{90+\delta_{min}}{2} = 60° \Rightarrow \delta_{min} = 30°$$

48. (c)

$\delta_{min} = i + e - A$

$\delta_{min} = A$

So, $2A = 2i$

$i = A$

Now for refraction on first surface.

$\sin i = \mu \sin r_1$

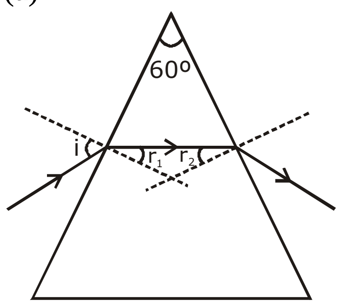
$\sin A = \dfrac{\mu \sin A}{2}$ [For minimum deviation $r_1 = r_2 = \dfrac{A}{2}$]

$2\cos\dfrac{A}{2}\sin\dfrac{A}{2} = \sqrt{3}\sin\dfrac{A}{2}$

$\cos\dfrac{A}{2} = \dfrac{\sqrt{3}}{2}$

$\dfrac{A}{2} = 30 \quad \Rightarrow \quad A = 60°$

49. (a)



For light be transmitted the ray should not suffer TIR at second refraction.

Hence $r_2 < \theta_C$.

If maximum value of r_2 is less than C then the ray will be always transmitted

$r_1 + r_2 = A$

$(r_2)_{max} = 60° - (r_1)_{min}$

For r_1 to be minimum i should be minimum

$\sin(i_{min}) = \sqrt{\dfrac{7}{3}}\sin(r_1)_{min}$

In limiting case $(r_2)_{max} = \theta_C$

$\theta_C = 60 - \sin^{-1}\left(\dfrac{\sin i_{min}}{\mu}\right)$

$\left(\sin^{-1}\left(\dfrac{1}{\mu}\right)\right) = \left[60 - \sin^{-1}\left(\dfrac{\sin i_{min}}{\mu}\right)\right]$

$\sin^{-1}\left(\dfrac{\sin i}{\mu}\right) = 60 - \sin^{-1}\sqrt{\dfrac{3}{7}}$

$\dfrac{\sin i}{\mu} = \dfrac{\sqrt{3}}{2}\cos\left(\sin^{-1}\sqrt{\dfrac{3}{7}}\right) - \dfrac{1}{2}\sqrt{\dfrac{3}{7}}$

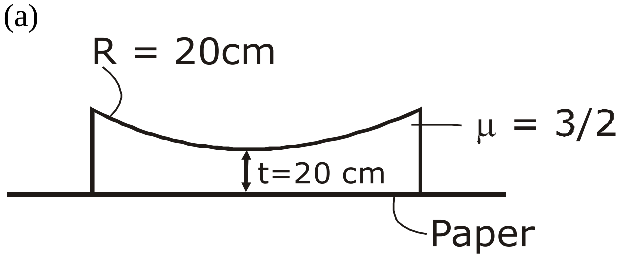
$\sin i = \sqrt{\dfrac{7}{3}}\left[\dfrac{\sqrt{3}}{2} \times \dfrac{2}{\sqrt{7}} - \dfrac{\sqrt{3}}{2\sqrt{7}}\right]$

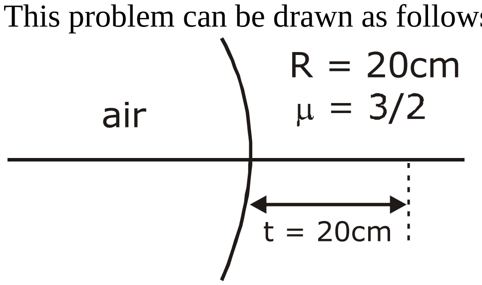
$\sin i = \left[1 - \frac{1}{2}\right] \Rightarrow i = 30°$

50. (d)
Given angle of incidence I_1
Given angle of emergence I_2
Condition for minimum devidation
$i = e \Rightarrow \therefore I_1 = I_2$

51. (a)
Using the given formula
$\delta = (n-1)A$ and $r_1 + r_2 = A$ and $\delta_{\min}$ $r_1 = r_2 = r = \frac{A}{2}$
Hence, $\delta_{\min} = r$.

52. (a)
Using the formula for refraction at spherical surface
$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$
$n_1 = \frac{3}{2}$
Here $n_1 = 1$
$u = 30$ cm
$R = +20$ cm
$\frac{1}{v} - \frac{3}{2 \times 30} = \frac{1 - 3/2}{20}$
$v = +40$ cm

53. (a)


This problem can be drawn as follows


$u = -20$ cm $R = +20$ cm

$n_1 = \frac{3}{2}$ $n_2 = 1$

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

$= \frac{1}{v} + \frac{3}{2 \times 20} = \frac{1 - 3/2}{20}$

$v = -10$ cm

54. (d)

We know that $P = IA$ & $P \times t = E$

Hence $IA = \frac{E}{t}$

Initially energy/sec $= I \times \pi \left(\frac{d}{2}\right)^2 = \frac{\pi d^2 I}{4}$

Now energy/sec $= \left[\pi \left(\frac{d}{2}\right)^2 - \pi \left(\frac{d}{4}\right)^2\right]$

$= I \pi d^2 \left[\frac{3}{16}\right]$

So, Now $\frac{\text{Final Intensity}}{\text{Initial Intensity}} = \frac{I \pi d^2 3/16}{I \pi d^2 / 4} = \frac{3}{4}$

Focus will not change.

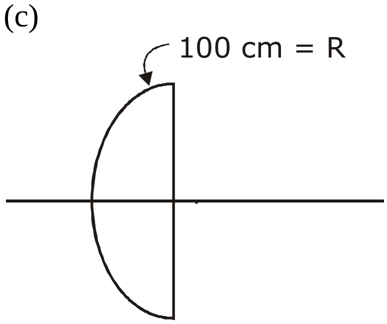
55. (d)

On cutting the less parallel to its principal axis

f does not changes

So P will not change.

56. (c)



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

$= \frac{1}{2}\left[\frac{1}{100} - \frac{1}{\infty}\right] = \frac{1}{200}$

$f = 200$ cm

57. (a)

Using the formula $P = \frac{1}{f\left(\text{in m}\right)}$

$p_1 = 2D$

$f_1 = \frac{100}{2} = +50\,\text{cm}$

$f_2 = -10$

$f_2 = -100\text{ cm}$

$\frac{1}{f_{eq}} = \left[\frac{1}{f_1} - \frac{1}{f_2}\right]$

$= \left[\frac{1}{50} - \frac{1}{100}\right] = \left[\frac{2-1}{100}\right] = \frac{1}{100}$

$f_{eq} = 100\text{ cm}$

58. (a)

We know that on cutting the lens into two parts perpendicular to its principal axis power of the two parts will be $P/2$ each. Let initial power of lens be P.

Then $\left(P_1\right)_f = \left(P_2\right)_f = \frac{P}{2}$

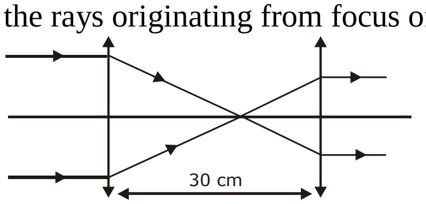
$P_f = \left(P_1\right)_f = \left(P_2\right)_f = P$

$\therefore\ P_i = P_f$

No change in power hence no change in focal length.

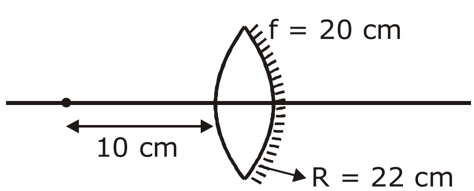
59. (b)

The rays coming from infinity parallel to principal axis and paraxial meet on focus after refraction and the rays originating from focus of the lens originate parallel to principal axis after refraction.



60. (b)

The focal length of mirror formed will be $f_m = \frac{R}{2}$



$f_m = -11\,\text{cm}$ [–ve sign as concave mirror is formed]

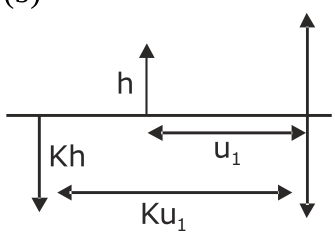
$f_\ell = 20\,\text{cm}$

$$\frac{1}{f_{eq}} = \frac{1}{f_m} - 2\left[\frac{1}{f_\ell}\right]$$

$$= \frac{-1}{11} - \frac{-2}{20} = \frac{-10-11}{110}$$

$$f_{eq} = \frac{-110}{21}$$

61. (b)



For case 1

$u = -u_1 \Rightarrow v = -ku_1 \Rightarrow f = -f$

$$\frac{1}{ku_1} + \frac{1}{u_1} = \frac{1}{f} \qquad ...(1)$$

For case 2

$u = -u_2 \Rightarrow v = ku_2 \Rightarrow f = -f$

$$-\frac{1}{ku_2} + \frac{1}{u_2} = \frac{1}{f} \qquad ...(2)$$

On solving (1) & (2)

$$f = \frac{1}{2}(u_1 + u_2)$$

62. (c)

From the formula

$h_0 = \sqrt{h_1 \times h_2} = \sqrt{8 \times 12.5} = 10\,\text{cm}$

63. (d)

All are true.

64. (d)

We know that $\theta_C = \sin^{-1}\frac{1}{\mu_{\text{glass}}}$ and μ_{glass} depends on wavelength of light $\mu_{\text{glass}} \propto \frac{1}{\lambda}$

When λ is minimum the m will be maximum & hence θ_C will be minimum.

λ is minimum for voilet hence θ_C is minimum for voilet light.

65. (c)

From the formula

$$\frac{\text{Appartent depth}}{\text{Real depth}} = \frac{n_{air}}{n_{glass}}$$

Apparent depth = Real depth $\times \frac{n_{air}}{n_{glass}}$

The letter which appear least raised has
maximum Apparent depth and hence it has minimum μ for glass.

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

for μ to be minimum λ should be maximum which is for Red.

66. (b)
Using formula

$\omega = \frac{n_v - n_R}{n_y - 1}$ $\qquad n_y = \frac{n_v + n_R}{2}$

$\omega = \frac{1.56 - 1.44}{1.5 - 1}$ $\qquad n_y = \frac{1.56 + 1.44}{2} = 1.5$

$\omega = \frac{0.12}{0.5} = 0.24$

67. (a)
1.6333 – 1 = 1.6161 = 0.0172

$n_y - 1$

$\frac{1.6333 - 1.6161}{1.6247 - 1} = 0.276$

68. (b)
Disp. $(n_v - n_R) A$

69. (b)
Ray of Red light bends minimum because it has maximum λ & minimum μ.

70. (a)

71. (c)

72. (d)

73. (c)

74. (a)

75. (c)

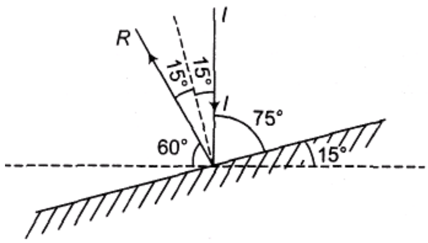
76. (b)

77. (a)

78. (a)

79. Image distance from plane mirror = object distance. Lateral magnifications = 1

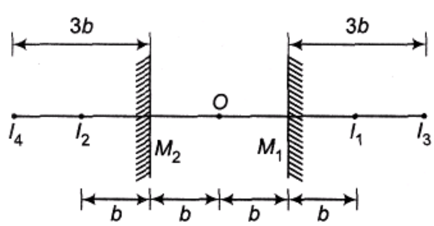
80.



I → Incident ray
R → Reflected ray
Angle of incidence = 15°
Angle between reflected ray and horizontal = 60°

81. Image from one mirror will behave like object for other mirror.

82.



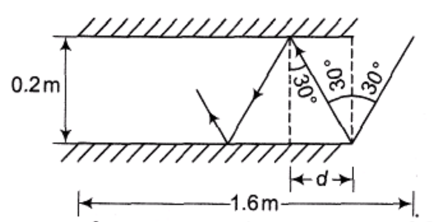
$OI_1 = OI_2 = 2b$

I_3 is the image of I_2 from mirror M_1 similarly I_4 is the image of I_1 from mirror M_2.

$OI_3 = OI_4 = 4b$

83. See point number - 3 of important points in reflection from plane mirror.

84.

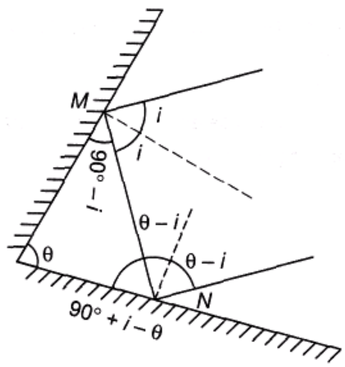


$$\frac{d}{0.2} = \tan 30° = \frac{1}{\sqrt{3}} \qquad \therefore \quad d = \frac{0.2}{\sqrt{3}}$$

$$N = \frac{1.6}{d} = 8\sqrt{3} = 13.85$$

Therefore, actual number of reflections required are 14.

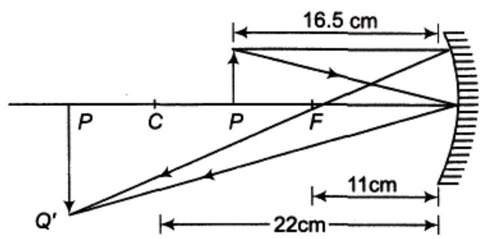
85.



$\delta_{total} = \delta_M + \delta_N$

$= (180 - 2i) + [180 - 2(\theta - 0] = 360 - 2\theta$

86. **(a)**



(b) Apply, $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ and

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

87. $f = \frac{R}{2} = -18$ cm

Let u = -x cm

Then $v = -\frac{x}{9}$ cm for real image of $\frac{1}{9}$th size.

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

we have, $\frac{1}{(-x/9)}+\frac{1}{(-x)}=\frac{1}{-18}$

Solving we get, x = 180 cm

88. Image is inverted. So, it should be real and v should be negative.

u = – 30 cm

Then, v = – 15 cm as magnification is half.

Now, applying the equations

$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}=\frac{1}{-15}+\frac{1}{-30}$

f = – 10 cm

89. (a) $f = \frac{R}{2} = -12$ cm

Let u = (- x) cm

Then, v = (+ 3x) cm as image is virtual and three times magnified.

Using the equation

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

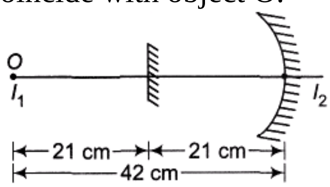
we have, $\frac{1}{3x}+\frac{1}{-x}=\frac{1}{-12}$ *

x = 8 cm

Similarly, other parts can be solved in the similar manner. For real image v should be negative and

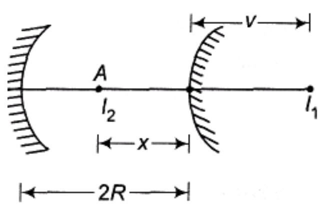
$|v| = m\,|u|$

90. O is placed at centre of curvature of concave mirror (= 42 cm). Therefore, image from this mirror I_1 will coincide with object O.



Now plane mirror will make its image I_2 at the same distance from itself.

91.



For convex mirror.

$$\frac{1}{v}+\frac{1}{-x}=\frac{1}{+R/2}$$

$\therefore$ $$\frac{1}{v}=\frac{2}{R}+\frac{1}{x}$$

or $$v=\frac{Rx}{R+2x}$$

Now applying mirror formula for concave mirror we have

$$\frac{1}{-(2R-x)}+\frac{1}{-(2R+v)}=\frac{1}{-R/2}$$

Solving this equation, we can find value of x.

92. Actual distance from one side = μ - times = 6 × 1.5 = 9 cm

From other side = 4 × 1.5 = 6 cm

$\therefore$ Total thickness = (9 + 6) cm = 15 cm

93. ${}_1\mu_2 \times {}_2\mu_3 \times {}_3\mu_1 = 1$

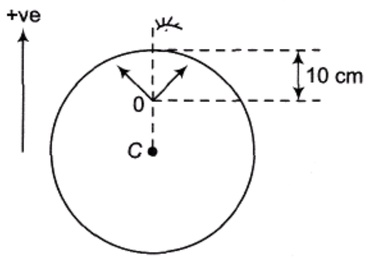
$\therefore \frac{4}{3}\times\frac{3}{2}=\frac{1}{{}_3\mu_1}={}_1\mu_3$ or ${}_1\mu_3 = 2$

94. $\mu=\frac{c}{v}=\frac{c}{f\lambda}$

$=\frac{3\times10^{8}}{6\times10^{14}\times300\times10^{-9}}$

= 1.67

95.



Using, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ we get,

$$\frac{1}{v} - \frac{1.5}{-10} = \frac{1-1.5}{-15}$$

Solving we get v = - 8.57 cm

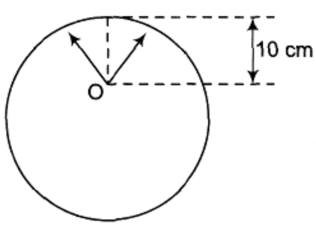
96.

(a) Using, $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ we get,

$$\frac{1.5}{v} - \frac{1.0}{-20} = \frac{1.5-1.0}{+6}$$

Solving we get v = + 45 cm Similarly other parts can be solved.

97.

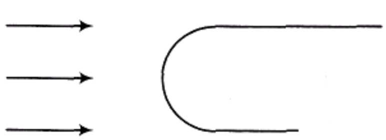


Using $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ we get

$$\frac{1}{v} - \frac{4/3}{-10} = \frac{1-4/3}{-15}$$

Solving we get v = -9.0 cm

98.



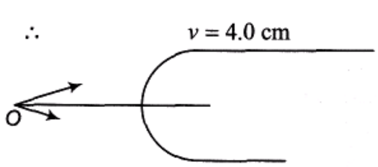
Using the equation,

$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$ we get,

$$\frac{1.44}{v} - \frac{1.0}{\infty} = \frac{1.44-1.0}{+1.25}$$

99.

$\therefore$



Using $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

we get, $\frac{1.635}{v} - \frac{1.0}{-9.0} = \frac{1.635-1.0}{+2.5}$

v = + 1.4 cm

Now, $m = \left(\frac{\mu_1}{\mu_2}\right)\left(\frac{v}{u}\right)$

$= \left(\frac{1.0}{1.635}\right)\left(\frac{1.14}{9.0}\right)$

= - 0.0777

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

$\therefore \frac{1}{-20} - \frac{1}{-60} = (1.65 - 1)\left(\frac{1}{-R} - \frac{1}{+R}\right)$

Solving we get, R = 39 cm

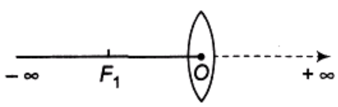
101. $\frac{1}{-50} - \frac{1}{u} = \frac{1}{+30}$

Solving we get u = - 18.75 cm

$m = \frac{v}{u} = \frac{(-50)}{(-18.75)} = 2.67$

I = $_m$(O) = 2.67 × 2 = 5.33cm

102.



When object is moved from O to F_1 its virtual, erect and magnified image should vary from O to -∞.

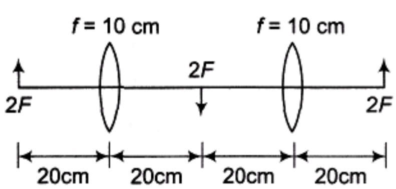
103. (a) $\frac{1}{f} = \left(\frac{1.3}{1.8} - 1\right)\left(\frac{1}{-20} - \frac{1}{+20}\right)$

f = +36cm

(b) Between O and F_1 image is virtual. Hence for real image.

| μ | < f or 36 cm

104.



105. It is just like a concave mirror

|f| = 0.2m |R|=0.4m Focal length of this equivalent mirror is

$\frac{1}{F} = \frac{2(\mu_2/\mu_1)}{R_2} - \frac{2(\mu_2/\mu_1 - 1)}{R_1}$ (extra points)

$= \frac{2(4/3)}{-0.4} - \frac{2(4/3 - 1)}{+0.4}$

or F= — 0.12 m or -12 cm

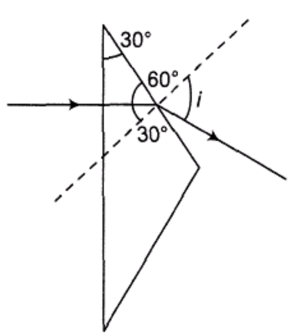
106. | R | = 0.5 m (from first case)
In the shown figure, object appears at distance
$d = u_e(0.2) + 0.2$
Now, for image to further coincide with the object,
d = |R| Solving we get, $\mu_e = 1.5$

107. $O = \sqrt{I_1 I_2}$ (Displacement method)
$= \sqrt{6 \times \frac{2}{3}}$
= 2 cm

108. Virtual, magnified and erect image is formed by convex lens.
Let u = -x
Then v =-3x
Now, $\frac{1}{-3x} - \frac{1}{-x} = \frac{1}{+12}$
x = 8 cm
Distance between object and image = 3x - x = 2x = 16 cm

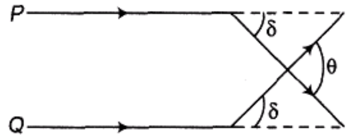
109. Diminished erect image is formed by concave lens.
Let u = - x then $v = -\frac{x}{2}$
Now, |u| - |v| = 20 cm $\frac{x}{2}$ =20 cm
or x = 40 cm
u = -40cm and v = -20cm
$\frac{1}{f} = \frac{1}{-20} - \frac{1}{-40}$
or f = -40cm

110. If object is placed at focus of lens (= 10 cm), rays become parallel and fall normal on plane mirror. So, rays retrace their path.

111.


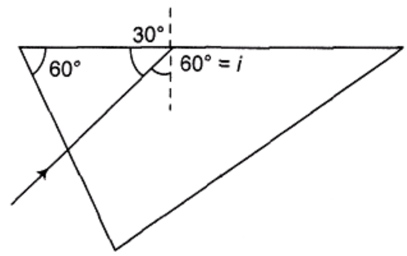
$\mu = \frac{\sin i}{\sin 30°}$
$\Rightarrow \sin i = \mu \sin 30°$
$= (1.6)\left(\frac{1}{2}\right) = 0.8$
$\Rightarrow$ i = 53°

P ray deviates from its original path by an angle, $\delta = i - 30° = 23°$



∴ Angle between two rays, $\theta = 2\delta$
$= 46°$

112.



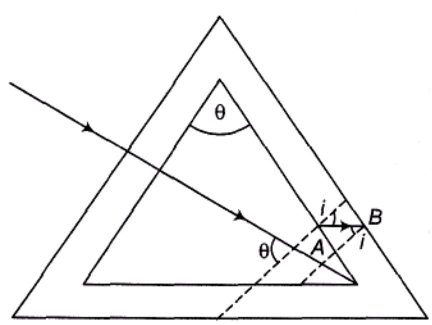
Critical angle = i = 60° = θ_c

$$\sin\theta_c = \frac{\mu_R}{\mu_D}$$

or $$\sin 60^\circ = \frac{\mu}{\sqrt{3}}$$

Solving we get, $\mu = 1.5$

113.



$$i = \theta_c$$

∴ $$\sin i = \sin\theta_c = \frac{1}{\mu_g} = \frac{2}{3}$$

Applying Snell's law at point A, We have

$$\mu_w \sin\theta = \mu_g \sin i$$

∴ $$\frac{4}{3}\sin\theta = \frac{3}{2}\times\frac{2}{3}$$

∴ $$\sin\theta = \frac{3}{4}$$

114. Deviation by prism,

$\delta = (\mu - 1)A$
$= (1.5 - 1)(4°)$
$= 2°$

Without prism ray of light is falling normal on the mirror.
So, they retrace their path. Prism has rotated it by 2°, so we should also rotate the mirror by 2° for again falling normally on it.

115. $\mu = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin(A/2)}, \delta_m = 30°$

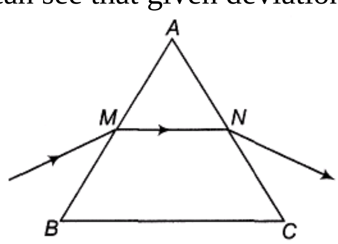
116. $i_1 = 0° \Rightarrow \quad r_1 = 0°$
or $r_2 = A$
Now $r_2 = \theta_c = A$
$\therefore \quad \sin A = \sin\theta_c = \dfrac{1}{\mu} = \dfrac{2}{3}$
or $\quad A = \sin^{-1}\left(\dfrac{2}{3}\right)$

117. $\delta = i_1 + i_2 - A$
$30° = 60° + i_2 - 30° \; i_2 = 0$ or $r_2 = 0.$
$\Rightarrow \quad r_1 = A = 30°$
Now, $\mu = \dfrac{\sin i_1}{\sin r_1} = \dfrac{\sin 60°}{\sin 30°} = \sqrt{3}$

118. $\sqrt{2} = \dfrac{\sin i_1}{\sin(i_1/2)} = \dfrac{2\sin(i_1/2)\cos(i_1/2)}{\sin(i_1/2)}$

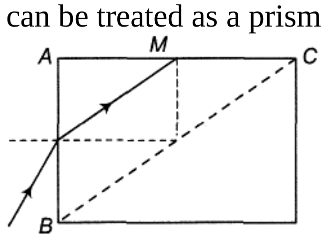
Solving this we get $i_1 = 90°$ and $r_1 = \dfrac{i_1}{2} = 45°$
At minimum deviation,
$r_2 = r_1 - 45°$
$A = r_1 + r_2 = 90°$

119. From $\mu = \sin\left(\dfrac{A+\delta_m}{2}\right) / \sin(A/2)$
We can see that given deviation is the minimum deviation.



At minimum deviation, MN is paralled to BC is $\angle B = \angle C$.

120. ABC can be treated as a prism with angle of prism A = 90°. Condition of no emergence is



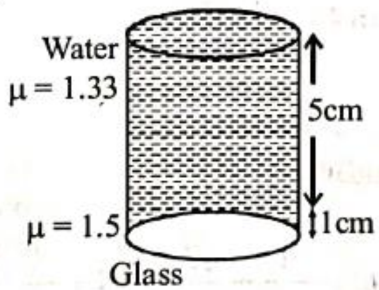
$A \geq 2\theta_c$ or $\sin\theta_c \leq \sin\left(\dfrac{A}{2}\right)$
or $\quad \dfrac{1}{\mu} \leq \sin 45°$ or $\dfrac{1}{\mu} \leq \dfrac{1}{\sqrt{2}}$
$\therefore \quad \mu \geq \sqrt{2}$

PYQ : JEE Main

MCQs with One Correct Answer

1. (c)

(c) Real depth = 5 cm + 1cm = 6 cm



Apparent depth $= \frac{d_1}{\mu_1} + \frac{d_2}{\mu_2} = \frac{5}{1.33} + \frac{1}{1.5}$

$\simeq 3.8 + 0.7 \simeq 4.5$ cm

$\therefore$ Shift = 6 cm – 4.5 cm $\cong$ 1.5 cm

So most appropriate option will be (c).

2. (b)

(b) Velocity of light in medium

$$V_{med} = \frac{3\,cm}{0.2ns} = \frac{3\times10^{-2}\,m}{0.2\times10^{-9}\,s} = 1.5\times10^{8}\,m/s$$

Refractive index of the medium

$$\mu = \frac{V_{air}}{V_{med}} = \frac{3\times10^{8}}{1.5\times10^{8}\,m/s} = 2$$

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

Condition of TIR is angle of incidence i must be greater than critical angle. Hence ray will suffer TIR in case of (B) $(i = 40° > 30°)$ only.

3. (c)

(c) One side of mirror is opaque and another side is reflecting this is not in case of lens hence, it is easier to provide mechanical support to large size mirrors than large size lenses. Reflecting telescopes are based on the same principle except that the formation of images takes place by reflection instead of refraction.

4. (d)

(d) If side of object square = ℓ
and side of image square = ℓ'

From question, $\frac{\ell'^2}{\ell^2} = 9$

or $\frac{\ell'}{\ell} = 3$

i.e., magnification m = 3
u = – 40 cm
v = 3 × 40 = 120 cm
f = ?

From formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{120} - \frac{1}{-40} = \frac{1}{f}$

or, $\frac{1}{f} = \frac{1}{120} + \frac{1}{40} = \frac{1+3}{120}$ $\therefore$ f = 30 cm

5. (c)

(c) For the prism as the angle of incidence (i) increases, the angle of deviation (δ) first decreases goes to minimum value and then increases.

6. (d)

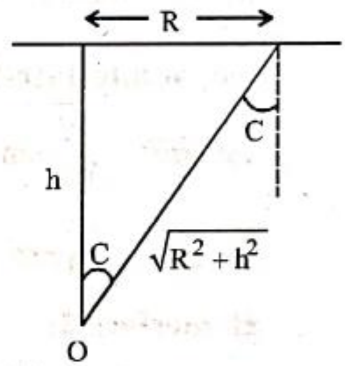
(d) Given, Focal length of objective, $f_0 = 30$ cm
focal length of eye lens, $f_e = 3.0$ cm
Magnifying power, M = ?
Magnifying power of the Galilean telescope,

$$M_D = \frac{f_0}{f_e}\left(1 - \frac{f_e}{D}\right) = \frac{30}{3}\left(1 - \frac{3}{25}\right) \quad [\because D = 25 \text{ cm}]$$

$$= 10 \times \frac{22}{25} = 8.8 \text{ cm}$$

7. (d)

(d) $\sin C = \frac{1}{\mu} = \frac{R}{\sqrt{R^2 + h^2}} = \frac{3}{4}$



$\Rightarrow \quad 16R^2 = 9R^2 + 9h^2$

$\Rightarrow 7R^2 = 9h^2$

$\Rightarrow \quad R = \frac{3}{\sqrt{7}} h = \frac{3}{\sqrt{7}} \times 15\,\text{cm}$

8. (d)

(d) Ist position:

$u = -x, v = +y$

$m_1 = \frac{v}{u} = \frac{+y}{-x}$

IInd position:

$u = -y, v = +x$

$m_2 = \frac{v}{u} = \frac{+x}{-y}$

Here, $\frac{m_1}{m_2} = \frac{3}{2} \Rightarrow \frac{y}{x} = \sqrt{\frac{3}{2}}$ ...(i)

Also, $y - x = 10$ ...(ii)

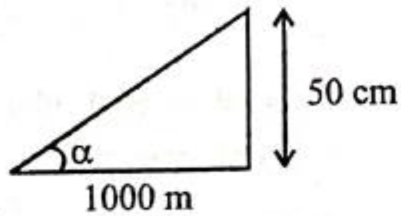
solving (i) & (ii), we get

$y = 44.5$ cm and $x = 54.5$ cm

So, $d = x + y = 99$ cm

9. (c)

(c) $M.P = \frac{f_0}{f_e} = \frac{150}{5} = 30$



$\tan\alpha = \frac{50}{1000} = \frac{1}{20}$

According to the question,
angle formed by the image of the tower is θ. We can write

$\tan\beta = \tan\theta$ ...(i)

$\tan\beta = (M.P)\tan\alpha$ [$\because$ α and β are small]

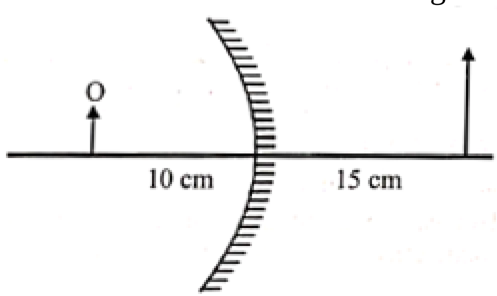
$= 30\times\frac{1}{20} = \frac{3}{2} = 1.5$

from (i), $\tan\theta = 1.5$

$\theta = \tan^{-1}(1.5) = 56.31°$

10. (c)

Convex mirror is used as a shaving mirror.



From question : $v = 15\text{ cm}, u = -10\text{ cm}$

Radius of curvature, $R = 2f = ?$

Using mirror formula, $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

Therefore radius of curvature, $R = 2f = -60\text{ cm}$

11. (d)

(d) $P = \frac{1}{f}$

$|P| = P_1 + P_2 = \frac{1}{f} + \frac{1}{f} = \frac{2}{f}$

As there is reflection happening, the power will have negative sign so

$$P = -\frac{2}{f} \Rightarrow f_{eff} = -\frac{f}{2}$$

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

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

12. (c)

(c) We know that $i + e - A = \delta$

$35° + 79° - A = 40°$ $\quad\therefore\quad A = 74°$

$$\text{But } \mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin A/2} = \frac{\sin\left(\frac{74+\delta_m}{2}\right)}{\sin\frac{74}{2}}$$

$$= \frac{5}{3}\sin\left(37° + \frac{\delta_m}{2}\right)$$

μ_{max} can be $\frac{5}{3}$. That is μ_{max} is less than $\frac{5}{3} = 1.67$

But δ_m will be less than 40°

$$\text{so } \mu < \frac{5}{3}\sin 57° < \frac{5}{3}\sin 60° \Rightarrow \mu = 1.5$$

13. (b)

(b) $M = \frac{\theta_2}{\theta_0}$, $20 = \frac{h/d_i}{h/d_0} \Rightarrow 20 = \frac{d_0}{d_i} \Rightarrow d_i = \frac{d_0}{20}$

14. (b)

(b) Given, radius of hemispherical glass R = 10 cm

$\therefore$ Focal length $f = \frac{10}{2} = -5$ cm

$u = (10 - 6) = -4$ cm.

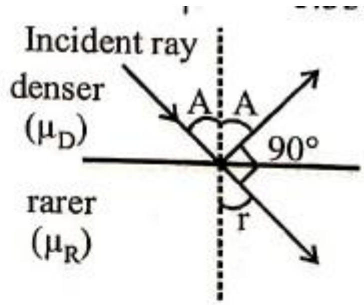
By using mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-4} = \frac{1}{-5} \Rightarrow v = 20 \text{ cm.}$$

Apparent height, $h_a = h_r \cdot \frac{\mu_r}{\mu_i} = 30 \times \frac{1}{1.5} = 20$ cm below flat surface.

15. (d)

(d)



From Snell's law, $\frac{\mu_R}{\mu_D} = \frac{\sin i}{\sin r}$ ..... (i)

If $\angle i = A$ and $\angle r = (90° - A)$

We also know that, $\sin\theta_C = \frac{\mu_R}{\mu_D}$

From equation (i), $\sin\theta_C = \frac{\sin A}{\sin(90° - A)}$

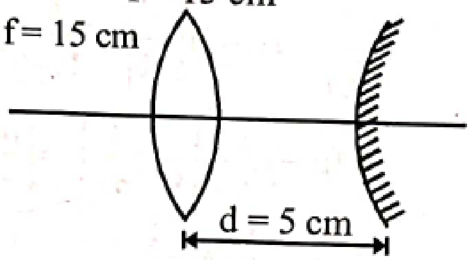
$\Rightarrow \sin\theta_C = \frac{\sin A}{\cos A}$

$\Rightarrow \sin\theta_C = \tan A \Rightarrow A = \tan^{-1}(\sin\theta_C)$

16. (a)

(a) Given, focal length of lens (f) = 15 cm
object is placed at a distance (u) = – 20 cm
By lens formula,

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}, u=-20\text{ cm}, \quad f=15\text{ cm}$$



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

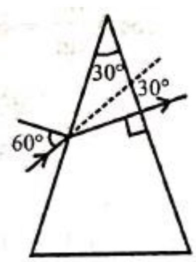
$$\Rightarrow \frac{1}{v}=\frac{4-3}{60}$$

v = 60 cm
for mirror, u = 55 cm
for the mirror to form image at 'O'

$$u=R=2f \Rightarrow f=\frac{R}{2}=27.5\text{cm}$$

17. (c)

(c) Angle of prism, A = 30°, i = 60°,
angle of deviation, δ = 30°
Using formula, δ = i + e – A



$\Rightarrow e=\delta+A-i$

$=30°+30°-60°=0°$

∴ Emergent ray will be perpendicular to the face
So it will make angle 90° with the face through which it emerges.

18. (a)

(a) For minimum spherical aberration separation,
$d=f_1-f_2=2$ cm
Resultant focal length = F = 10 cm

Using $\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$ and solving, we get f_1, f_2 as 18 cm and 20 cm respectively.

19. (c)

4. **(c)** For minimum deviation:

$$r_1 = r_2 = \frac{A}{2} = 30^o$$

by Snell's law $\mu_1 \sin i = \mu_2 \sin r$

$$1 \times \sin i = \sqrt{3} \times \frac{1}{2} = \frac{\sqrt{3}}{2} \Rightarrow i = 60$$

20. (c)

$$5 = -\frac{v}{u} \Rightarrow v = -5u$$

Using $\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{-5u} + \frac{1}{u} = \frac{1}{0.4}$

$\therefore \; u = 0.32\text{ m}$

21. (c)

(c) If v is the distance of image formed by mirror, then

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{-5} = \frac{1}{-20} \quad \therefore \; v = \frac{20}{3}\text{cm}$$

Distance of this image from water surface

$$= \frac{20}{3} + 5 = \frac{35}{3}\text{cm}$$

Using, $\frac{RD}{AD} = \mu$

$$\therefore \; AD = d = \frac{RD}{\mu} = \frac{(35/3)}{1.33} = 8.8\text{ cm}$$

22. (d)

(d) From the equation of line

$m = k_1 v + k_2 \quad (\because y = mx + c)$

$$\Rightarrow \frac{v}{u} = k_1 v + k_2 \quad \left(\because m = \frac{v}{u}\right)$$

$$\Rightarrow \frac{1}{u} = k_1 + \frac{k_2}{v} \quad \text{(Dividing both sides by v)}$$

$$\Rightarrow \frac{k_2}{v} = \frac{1}{u} - k_1 \Rightarrow \frac{k_2}{v} - \frac{1}{u} = -k_1$$

Comparing with lens formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$, we get

$$k_1=\frac{1}{-f}\Rightarrow f=-\frac{1}{k_1}=-\frac{1}{\text{slope of m - v graph}}$$

$$\therefore f=\frac{-1}{\text{slope of } m-v \text{ graph}}=-\frac{b}{c}$$

23. (a)

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

$=(1.5-1)\left(\frac{1}{-18}-\frac{1}{-18}\right)=\frac{1}{18}$

$\therefore f_{lens}=18$ cm

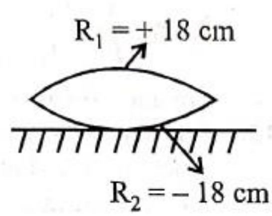
For liquid in between lens

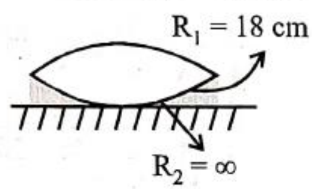
$\frac{1}{f_{liq}}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$=(\mu-1)\left(\frac{1}{-18}-\frac{1}{\infty}\right)=\left(\frac{\mu-1}{-18}\right)$

$\therefore \frac{1}{f}=\frac{1}{f_{liq}}+\frac{1}{f_{lens}}$

$\Rightarrow \frac{1}{27\text{cm}}=\frac{1}{18\text{cm}}-\frac{(\mu-1)}{18\text{cm}}\quad\Rightarrow \mu=\frac{4}{3}$





24. (b)

(b) We will have 3 phenomena one by one

(i) Refraction from lens.

(ii) Reflection from mirror

(iii) Refraction from lens

Ist refraction from lens

$u=-40, f=+20$ cm

$\Rightarrow V=+40$ cm (I_1), $m_1=-1$

Reflection from concave mirror

$u=-20$ cm, $f=-10$ cm

$\Rightarrow V=-20$ cm (I_2) and $m_2=-1$

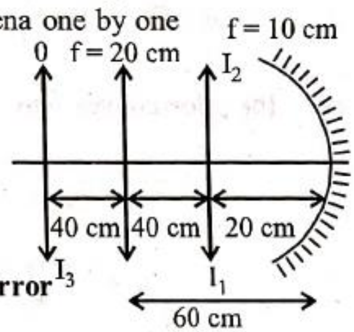
2nd refraction from lens

$u=-40$ cm, $f=+20$ cm

$\Rightarrow V=40$ cm (I_3) and $m_3=-1$

So, $M_{net}=-1\times-1\times-1=-1$

∴ Final image is formed at distance 40 cm from the convergent lens and is of same side as the object



25. (d)

(d) By lens formula

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{1}{v}-\frac{1}{(-20)}=\frac{10}{3}$$

$$\frac{1}{v}=\frac{10}{3}-\frac{1}{20}\Rightarrow\frac{1}{v}=\frac{197}{60}\Rightarrow v=\frac{60}{197}$$

Magnification of lens (m) is given by

$$m=\left(\frac{v}{u}\right)=\frac{\left(\frac{60}{197}\right)}{20}$$

velocity of image wrt. to lens is given by

$v_{I/L}=m^2v_{O/L}$

direction of velocity of image is same as that of object

$v_{O/L}=5$ m/s

$$v_{I/L}=\left(\frac{60\times1}{197\times20}\right)^2(5)=1.16\times10^{-3}\text{ m/s towards the lens}$$

26. (d)

(d) For telescope

Tube length (L) $=f_o+f_e=60$

and magnification $(m)=\frac{f_o}{f_e}=5\Rightarrow f_0=5f_e$

$\therefore\quad f_o=50$ cm and $f_e=10$ cm

Hence focal length of eye-piece, $f_e=10$ cm

27. (a)

(a) According question, $M=375$

$L=150$ mm, $f_0=5$ mm and $f_e=?$

Using, magnification, $M=\frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$

$$\Rightarrow 375=\frac{150}{5}\left(1+\frac{250}{f_e}\right)\quad(\because D=25\text{ cm}=250\text{ mm})$$

$$\Rightarrow 12.5=1+\frac{250}{f_e}\Rightarrow f_e=\frac{250}{11.5}=21.7\approx22\,mm$$

28. (b)

(b) As, $n = \sqrt{\mu_r \varepsilon_r} = \sqrt{\frac{4}{3} \times 3} = 2$

And, $\sin\theta_c = \frac{1}{n} = \frac{1}{2}$ $\therefore$ Critical angle, $\theta_c = 30°$

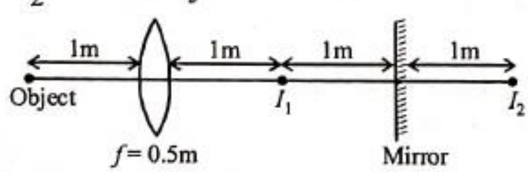
29. (a)

(a) Focal length of the convex lens, $f = 0.5$ m

Object is at $2f$ so, image (I_1) will also be at $2f$.

Image of I_1 i.e., I_2 will be 1 m behind mirror.

Now I_2 will be object for lens.



$\therefore u = (-1) + (-1) + (-1) = -3$ m

Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{+0.5} + \frac{1}{-3}$ or $v = \frac{3}{5} = 0.6$ m

Hence, distance of image from mirror

$= 2 + 0.6 = 2.6$ m and real.

30. (50)

(50) Given : Length of compound microscope, $L = 10$ cm

Focal length of objective $f_0 = 1$ cm and of eye-piece, $f_e = 5$ cm

$u_0 = f_e = 5$ cm

Final image formed at infinity (∞), $v_e = \infty$

$v_0 = 10 - 5 = 5$

Using lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0} \Rightarrow \frac{1}{5} - \frac{1}{u_0} = \frac{1}{1} \Rightarrow u_0 = -\frac{5}{4}$ cm

$\Rightarrow \frac{5}{4} = \frac{N}{40} \Rightarrow N = \frac{200}{4} = 50$ cm.

31. (a)

(a) According to prism formula,

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

Here, δ_m = angle of minimum deviation

A = angle of prism

We have given, $\delta_m = A$

$$\therefore \quad \mu = \frac{\sin A}{\sin A/2} \Rightarrow \mu = 2\cos\frac{A}{2} \Rightarrow A = 2\cos^{-1}\left(\frac{\mu}{2}\right)$$

32. (d)

Mirror will be convex mirror

$V_i = -m^2 v_0$

V_i is velocity of image w.r.t. mirror

V_0 is velocity of object w.r.t. mirror

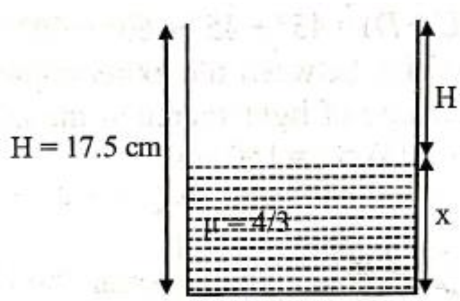
$V_0 = 40$ m/s

Magnification $m = \frac{f}{f-u} = \frac{10}{10+190} = \frac{1}{20}$

$v_i = -\frac{1}{20^2} \times 40 = -0.1$ m/s

33. (a)

(a)



For an observer outside the water, height of water

$$= \frac{x}{\mu_w} = \frac{x}{(4/3)} = \frac{3x}{4}$$

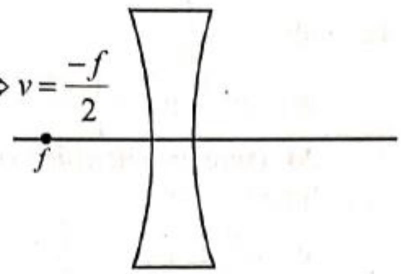
Now, $\frac{3x}{4} = \frac{17.5}{2} \Rightarrow x = \frac{35}{3} = 11.7$ cm

34. (c)

(c) $u=-f$

Using lens formula

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



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

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

35. (b)

(b) Focal length of plano-convex lens

$$\frac{1}{f_1}=(\mu_1-1)\left(\frac{1}{R}\right) \qquad [\because R_1=\infty \text{ and } R_2=-R]$$

Focal length of plano-concave lens

$$\frac{1}{f_2}=(\mu_2-1)\left(\frac{-1}{R}\right) \qquad [\because R_1=-R \text{ and } R_2=\infty]$$

Focal length of combination

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

$$\Rightarrow \frac{1}{f_{eq}}=\frac{(\mu_1-\mu_2)}{R} \Rightarrow \frac{R}{f_{eq}}=(\mu_1-\mu_2)$$

36. (d)

(d) In given case, medium 1 has refractive index 1.25 and medium 2 has refractive index 1.4.

From the refraction formula

$$\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R} \Rightarrow \frac{1.4}{v}-\frac{1.25}{-40}=\frac{1.4-1.25}{(-25)}$$

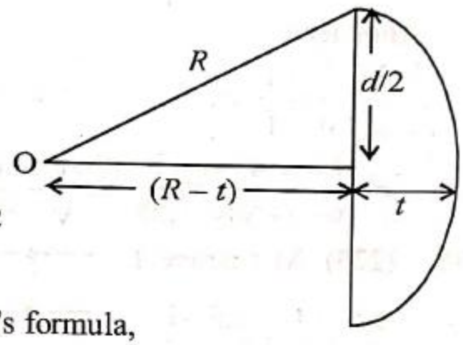
$$\Rightarrow \frac{1.4}{v}=\frac{-0.15}{25}\frac{-1.25}{40} \Rightarrow v=-37.58\text{cm}$$

37. (d)

(d) From figure,

$t = 0.3$ cm

$\frac{d}{2} = 3$ cm



So, $R^2 = (R - 0.3)^2 + 3^2$

$\Rightarrow \quad R = 15$ cm

Now from Lens maker's formula,

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

$$\Rightarrow \quad \frac{1}{f} = (\mu - 1) \times \frac{1}{R} \qquad [\because R_{flat} = \infty \text{ and } R_2 = -R]$$

$$\Rightarrow \quad \frac{1}{f} = \frac{(1.5 - 1)}{15} \Rightarrow f = 30 \text{ cm}$$

38. (c)

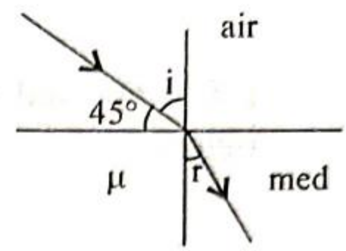
(c) $i = 45°, D = 15°$

$D = i - r$

$15° = 45° - r \Rightarrow r = 30°$

$n_1 \sin 1 = n_2 \sin r$ (from snells's law)

$1 \sin 45° = \mu \sin 30°$



39. (a)

(a) $n_d \sin i_c = n_r \sin 90°$ ($\because$ From Snell's law)

$$\sin i_c = \frac{n_r}{n_d} = \frac{v_d}{v_r} \qquad \left(\therefore v = \frac{c}{n}\right)$$

$$\sin i_c = \frac{1.5 \times 10^8}{2 \times 10^8} = \frac{1.5}{2}$$

$$\sin i_c = \frac{3}{4}$$

$$\tan i_c = \frac{3}{\sqrt{4^2 - 3^2}} \Rightarrow \frac{3}{\sqrt{7}}$$

The critical angle between them, $i_c = \tan^{-1}\left(\frac{3}{\sqrt{7}}\right)$

40. (a)

(a) $t_2 - t_1 = 5 \times 10^{-10}$

$$\Rightarrow \frac{d}{v_B} - \frac{d}{v_A} = 5\times10^{-10} \Rightarrow \frac{d\mu_B}{C} - \frac{d\mu_A}{C} = 5\times10^{-10}$$

$$\Rightarrow d\left(\frac{\mu_B}{C} - \frac{\mu_A}{C}\right) = 5\times10^{-10}$$

$$\Rightarrow d\left(\frac{2\mu_A}{C} - \frac{\mu_A}{C}\right) = 5\times10^{-10}$$

$$\Rightarrow d = \frac{5\times10^{-10}}{\frac{\mu_A}{C}} = 5\times10^{-10} V_A m$$

41. (d)

(d) We know that critical angle is given by

$$\sin C = \frac{\mu_r}{\mu_d} \text{ and } \mu \propto \frac{1}{V} \Rightarrow \frac{\mu_r}{\mu_d} = \frac{v_d}{v_r} = \frac{1.5\times10^{10}}{2\times10^{10}} = \frac{3}{4}$$

So, $\sin C = \frac{3}{4} \Rightarrow C = \sin^{-1}\left(\frac{3}{4}\right)$

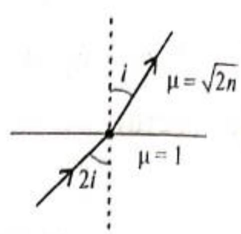
Therefore, for TIR

$$\theta > C \Rightarrow \theta > \sin^{-1}\left(\frac{3}{4}\right)$$

42. (d)

(d) Let $2i$ be angle of incidence

By Snell's law



$$\Rightarrow 1 \sin 2i = \sqrt{2n} \sin i$$

$$\Rightarrow 2 \sin i \cos i = \sqrt{2n} \sin i$$

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

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

43. (c)

(c) On going from rare to denser, frequency remain unchanged, whereas speed and wavelength decreases because $V \propto \frac{1}{\mu}$ and $\lambda \propto \frac{1}{\mu}$.

44. (d)

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

(μ_1 is refractive index of lens and μ_2 is of surrounding medium)

$$\Rightarrow 1.25 = (1.5 - \mu_2)\left(\frac{1}{0.2} + \frac{1}{0.4}\right)$$

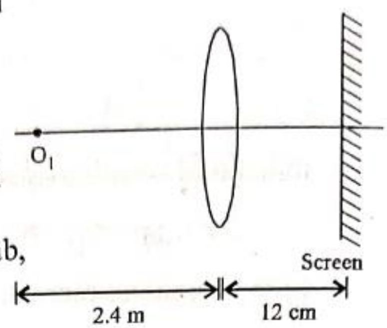
$$\Rightarrow \frac{1.25 \times 0.08}{0.6} = (1.5 - \mu_2) \Rightarrow \mu_2 = \frac{4}{3}$$

45. (b)

(b) Applying lens formula

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

$$\frac{1}{0.12} + \frac{1}{2.4} = \frac{1}{r} \Rightarrow \frac{1}{f} = \frac{210}{24}$$



Upon putting the glass slab, shift of image is

$$\Delta x = t\left(1 - \frac{1}{\mu}\right) = \frac{1}{3}\text{cm}$$

Now $v = 12 - \frac{1}{3} = \frac{25}{3}$ cm

Again apply lens formula

$$\frac{1}{0.12} + \frac{1}{u} = \frac{1}{f} = \frac{210}{24} \Rightarrow \frac{1}{u} = \frac{210}{24} - \frac{1}{0.12}$$

Solving we get $u = -5.6$ m

Thus shfit of object is $5.6 - 2.4 = 3.2$ m

46. (a)

(a) In primary rainbow red is at top and violoet is at bottom becuase violet colour has smallest wavelength and it suffer maximum refraction.

47. (a)

(a) We known that

$$\mu = \frac{\dfrac{\sin(A+\delta m)}{2}}{\sin\left(\dfrac{A}{2}\right)} \Rightarrow \cot\frac{A}{2} = \frac{\sin\left(\dfrac{A+\delta m}{1}\right)}{\sin\left(\dfrac{A}{2}\right)}$$

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

$$\Rightarrow \sin\left(\frac{\pi}{2}-\frac{A}{2}\right) = \sin\left(\frac{A}{2}+\frac{\delta m}{2}\right)$$

$$\Rightarrow \frac{\pi}{2}-\frac{A}{2} = \frac{A}{2}+\frac{\delta m}{2} \Rightarrow \frac{\pi}{2}-A = \frac{\delta m}{2}$$

$\therefore\ \delta m = \pi - 2A$

Numerical Value Answer

48. (1)

Distance of object, $u = -30$ cm

Distance of image, $v = 10$ cm

Magnification, $m = \frac{-v}{u} = \frac{(-10)}{-30} = \frac{1}{3}$

Speed of image $= m^2 \times$ speed of object $= \frac{1}{9} \times 9 = 1\ \text{cm s}^{-1}$

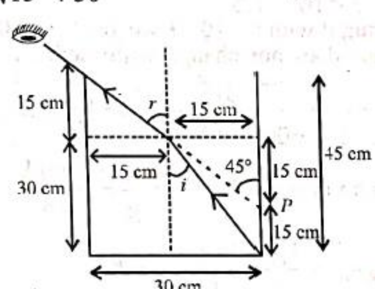
49. (158)

(158) From figure, $\sin i = \frac{15}{\sqrt{15^2+30^2}}$

$\sin r = \frac{15}{15} = 1 \Rightarrow r = 45°$

From Snell's law, $\mu \times \sin i = 1 \times \sin r$

$$\Rightarrow \mu \times \frac{15}{\sqrt{15^2+30^2}} = 1 \times \sin 45° = \frac{1}{\sqrt{2}}$$

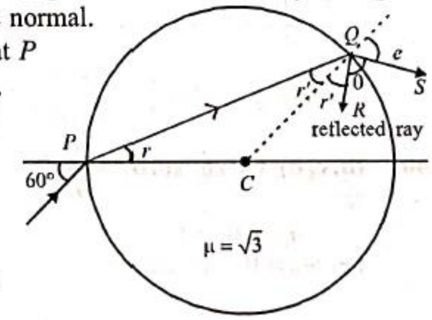


$$\therefore \mu = \frac{\dfrac{1}{\sqrt{2}}}{\dfrac{15}{\sqrt{1125}}} = 158 \times 10^{-2} = \frac{N}{100}$$

Hence, value of $N \simeq 158$.

50. (90)

(90.00) In the figure, QR is the reflected ray and QS is refracted ray. CQ is normal.



Apply Snell's law at P

$1\sin 60° = \sqrt{3}\sin r$

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

$\Rightarrow r = 30°$

From geometry,

$CP = CQ =$ radius

$\therefore r' = 30°$

Again apply snell's law at Q,

$\sqrt{3}\sin r' = 1\sin e \Rightarrow \frac{\sqrt{3}}{2} = \sin e \Rightarrow e = 60°$

From geometry

$r' + \theta + e = 180°$ (As angles lies on a straight line)

$\Rightarrow 30° + \theta + 60° = 180° \Rightarrow \theta = 90°$.

51. (476.19)

- **(476.19)** Given,

Distance between an object and screen, $D = 100$ cm

Distance between the two position of lens, $d = 40$ cm

Focal length of lens,

$$f = \frac{D^2 - d^2}{4D} = \frac{100^2 - 40^2}{4(100)} = \frac{(100+40)(100-40)}{4(100)} = 21 \text{ cm}$$

Power, $P = \frac{1}{f} = \frac{100}{21} = \frac{N}{100}$

$\therefore N = 476.19$.

52. (60)

(60) Given : $\mu = 1.5$; $R_{curved} = 30$ cm

Using, Lens-maker formula

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

For plano-convex lens

$R_1 \to \infty$ then $R_2 = -R$

$$\therefore f = \frac{R}{\mu - 1} = \frac{30}{1.5 - 1} = 60 \text{ cm}$$

53. (50)

(50)

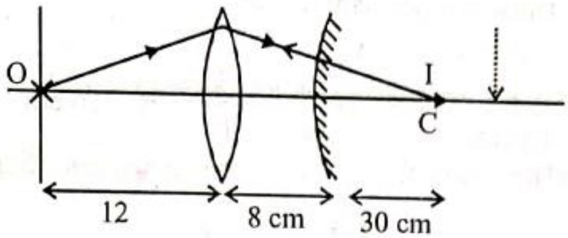


Image will coincide with object, if light fall perpendicularly to mirror. Which is possible if light converge at C of mirror. In the absence of mirror, light will be converging at centre of curvature. Distance = 12 + 8 + 30 = 50 cm

54. (15)

(15) $m=\frac{f}{f+u}$

As, $m_1=-m_2$

$$\frac{f}{f-10}=\frac{-f}{f-20}\Rightarrow f=15\text{ cm}$$

55. (60)

(60) Given $i=2r_1=A$

And at minimum deviation $r_1=r_2=\frac{A}{2}$

From Snell's law,

$\mu_1\sin i=\mu_2\sin r_1$

$\therefore 1.\sin i=\sqrt{3}\sin r_1$

$$\Rightarrow 1\sin A=\sqrt{3}\sin\frac{A}{2}\Rightarrow 2\sin\frac{A}{2}\cos\frac{A}{2}=\sqrt{3}\sin\frac{A}{2}$$

$$\Rightarrow \cos\frac{A}{2}=\frac{\sqrt{3}}{2}\Rightarrow\frac{A}{2}=30°\text{ or, }A=60°$$

Hence angle of prism = 60°

56. (12)

(12) Using $\delta=\delta_1\left(1-\frac{\omega_1}{\omega_2}\right)$

$$2=\delta_1\left(1-\frac{.02}{.03}\right)\Rightarrow\delta_1\left(\frac{1}{3}\right)\Rightarrow\delta_1=6$$

Also, $\delta_1=A(\mu_1-1)=A(1.5-1)\Rightarrow A=12°$

57. (25)

(25) In case of simple microscope,

Magnification, $m = 1 + \frac{D}{f_0}$ or, $6 = 1 + \frac{D}{f_0}$

$\Rightarrow \quad 5 = \frac{25}{f_0} \quad \therefore f_0 = 5\text{cm}$

As total magnification double using an eyepiece along with the given lens i.e, case of compound microscope,

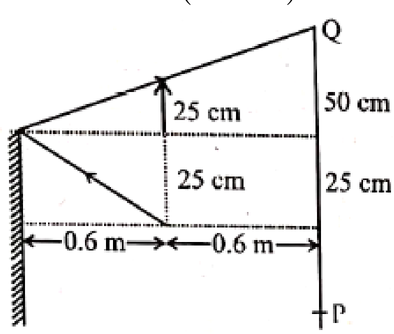
Magnification, $m = \frac{\ell . D}{f_0 . f_e}$

or, $12 = \frac{60 \times 25}{5 . f_e} \quad \therefore f_e = 25\text{cm}$

58. (150)

The distance between the extreme points where man can see the image of light source in the mirror,

$PQ = 2 \times (50 + 25)\text{ cm} = 150\text{ cm}$



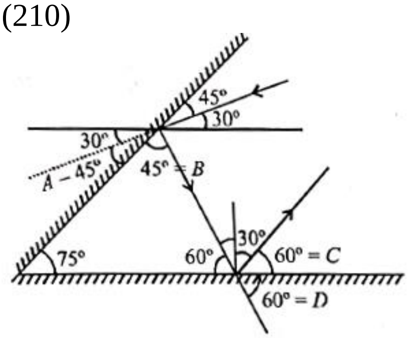
59. (400)

After 10 sec.

$u = -80\text{ cm}, \ f = -100\text{ cm}$

By mirror formula $\Rightarrow \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \Rightarrow v = 400\text{ cm}$

60. (210)

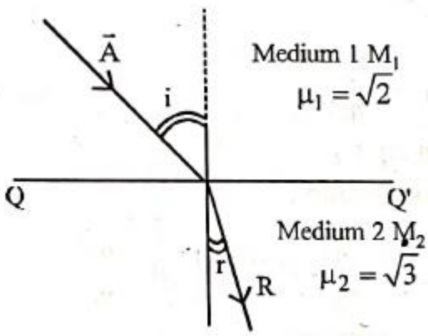


We have, $\delta = \delta_1 + \delta_2$

$= (A + B°) + (C + D) = 45° + 45° + 60° = 210°$

61. (15)

(15) $\vec{A} = 4\sqrt{3}\hat{i} - 3\sqrt{3}\hat{j} - 5\hat{k}$



As incident vector A makes i angle with normal z-axis and refracted vector R makes r angle with normal z-axis with help of direction cosine

$$i = \cos^{-1}\left(\frac{A_z}{A}\right) = \cos^{-1}\left(\frac{5}{\sqrt{(4\sqrt{3})^2 + (3\sqrt{3})^2 + 5^2}}\right)$$

$$\cos^{-1}\left(\frac{5}{10}\right) \Rightarrow i = 60°$$

By Snell's law, we have

$\sqrt{2}\sin 60° = \sqrt{3} \times \sin r \Rightarrow r = 45°$

Difference between i and $r = 60° - 45° = 15°$

62. (27)

(27) Using Snell's law at face AC

$\mu \sin 60° = n \times \sin 90°$

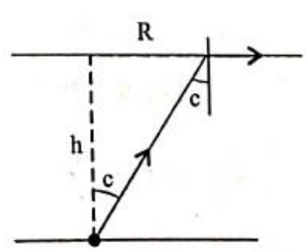
$1.5 \sin 60° = n \times \sin 90°$

$$1.5 \times \frac{\sqrt{3}}{2} = n = \frac{\sqrt{x}}{4} \Rightarrow 3\sqrt{3} = \sqrt{x} \Rightarrow x = 27$$

63. (9)

(9) We have, $\sin c = \frac{1}{\mu} = \frac{3}{4}$

So, $\tan c = \frac{3}{\sqrt{7}}$



Also, $\tan c = \frac{R}{h} \Rightarrow \frac{3}{\sqrt{7}} = \frac{R}{\sqrt{7}} \Rightarrow R = 3m$

So, area of illumination = $\pi \times 3^2 = 9\pi m^2$

64. (12)

(12) The formula of lateral shift in glass slab is given by

$$l = t\sin i\left[1 - \frac{\cos i}{\sqrt{\mu^2 - \sin^2 i}}\right] \Rightarrow 4\sqrt{3} = t\sin 60°\left[1 - \frac{\cos 60°}{\sqrt{3 - \frac{3}{4}}}\right]$$

$$\Rightarrow 4\sqrt{3} = t \times \frac{\sqrt{3}}{2}\left[1 - \frac{\frac{1}{2}}{\frac{3}{2}}\right] \Rightarrow 4\sqrt{3} = \frac{\sqrt{3}t}{2} \times \frac{2}{3}$$

$\Rightarrow t = 12$ cm

65. (15)

(15) By Newton's formula

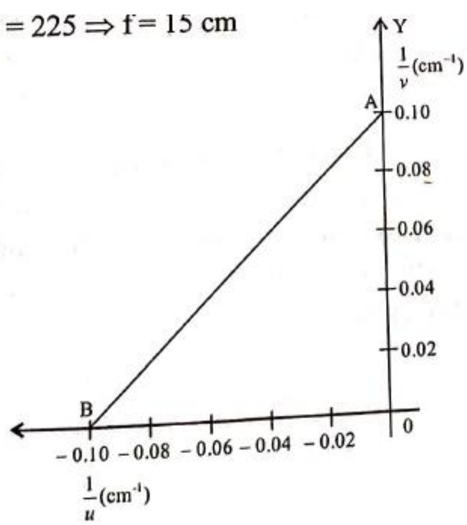
$vu = f^2$

$\Rightarrow f^2 = 225 \Rightarrow f = 15$ cm

66. (10)

$\Rightarrow f^2 = 225 \Rightarrow f = 15$ cm

(10)



For point B, $\frac{1}{u} = -0.10\,\text{cm}^{-1}$, $\frac{1}{v} = 0$

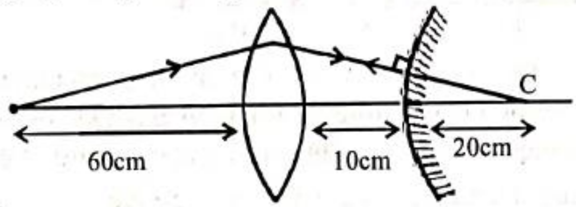
$\therefore$ Thus, u = –10 cm, v = ∞

i.e, f = 10 cm

$$\Rightarrow \frac{1}{10\text{ cm}} = (1.5 - 1)\left(\frac{2}{R}\right) = \frac{1}{R} \Rightarrow R = 10\text{ cm}$$

67. (10)

(10) The given figure shows the schematic diagram



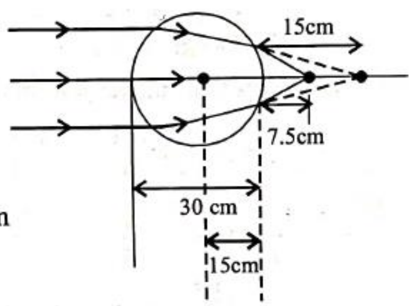
For lens

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

$$\Rightarrow \frac{1}{v}-\frac{1}{(-60)}=\frac{1}{20} \Rightarrow \frac{1}{v}+\frac{1}{60}=\frac{1}{20} \Rightarrow v = 30 \text{ cm}$$

68. (225)

(225) At surface 1



$$\frac{1.5}{v_1}-\frac{1}{\infty}=\frac{1.5-1}{15}$$

$$\frac{1.5}{v_1}=\frac{1}{30} \Rightarrow v = 45 \text{ cm}$$

For surface 2

$$\frac{1}{v}-\frac{1.5}{15}=\frac{1-1.5}{-15} \Rightarrow \frac{1}{v}-\frac{1}{10}=\frac{1}{30}$$

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

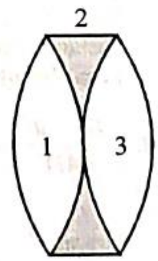
$\therefore\ v=\frac{30}{4} \Rightarrow v = 7.5$ cm. So required distance $= (15+7.5)$cm

$= 22.5$ cm $= 225$ mm.

69. (10)

(10) By lens maker formula,

$$\frac{1}{f} = ({}^{g}\mu_a - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$



For Lens 1:

$$\frac{1}{f_1} = (1.5-1)\left(\frac{1}{R} - \frac{1}{-R}\right)$$

$$\Rightarrow \frac{1}{f_1} = 0.5 \times \frac{2}{R}$$

$$\Rightarrow f_1 = R \Rightarrow R = 15 \text{ cm}$$

For Lens 2:

$$\frac{1}{f_2} = (1.25-1)\left(\frac{1}{-R} - \frac{1}{+R}\right)$$

$$= -0.25 \times \frac{2}{R} = -\frac{0.5}{R} = \frac{-1}{2R}$$

$$\therefore f_2 = -2R$$

For Lens 3:

Similarly like lens 1, $f_3 = R$

So, $\frac{1}{f_{net}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} = \frac{1}{R} + \frac{1}{-2R} + \frac{1}{R}$

$$= \frac{3}{2R} = \frac{2}{2 \times 15} = \frac{1}{10} \quad \therefore f_{net} = 10 \text{ cm}$$

70. (4)

(4) Deviation produced by glass prism for yellow light $= A(\mu_y - 1)$

$$\delta = A(\mu_y - 1) - A'(\mu_y' - 1) \quad (\because A_1 = 6°, A_2 = 5°)$$

$$= 6(1.5-1) - 5(1.55-1) = \frac{1}{4}$$

71. (45)

(45) Refractive index

$$\mu = \frac{\sin\left(\frac{A + \delta \sin}{2}\right)}{\sin\left(\frac{A}{2}\right)} \Rightarrow \sqrt{2} = \sin\frac{\left(\frac{60+\delta_{min}}{2}\right)}{\sin 30°}$$

$$\Rightarrow \frac{1}{2} = \sin\left(\frac{60+\delta_{min}}{2}\right) \Rightarrow 45° = \frac{60+\delta_{min}}{2}$$

$\Rightarrow \delta_{min} = 30°$

$\delta = i + e - A$

Here, $e = i$

So, $\delta_{min} = 2e - A \Rightarrow 2e = \delta_{min} + A$

$$e = \frac{\delta_{min} + A}{2} = \frac{30° + 60°}{2} = 45°$$