DPP - Daily Practice Problems

Date : | Start Time : | End Time :

PHYSICS

CP23

SYLLABUS : Ray Optics and Optical Instruments

Max. Marks : 120 **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 30 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. A car is fitted with a convex side-view mirror of focal length 20 cm. A second car 2.8 m behind the first car is overtaking the first car at a relative speed of 15 m/s. The speed of the image of the second car as seen in the mirror of the first one is :

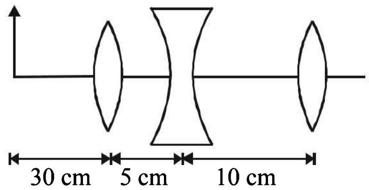
(a) $\frac{1}{15}$ m/s (b) 10 m/s

(c) 15 m/s (d) $\frac{1}{10}$ m/s

2. A fish looking up through the water sees the outside world contained in a circular horizon. If the refractive index of water is $\frac{4}{3}$ and the fish is 12 cm below the surface, the radius of this circle in cm is

(a) $36\sqrt{5}$ (b) $4\sqrt{5}$ (c) $36\sqrt{7}$ (d) $36/\sqrt{7}$

3. The position of final image formed by the given lens combination from the third lens will be at a distance of ($f_1 = +10$ cm, $f_2 = -10$ cm and $f_3 = +30$ cm).



(a) 15 cm (b) infinity (c) 45 cm (d) 30 cm

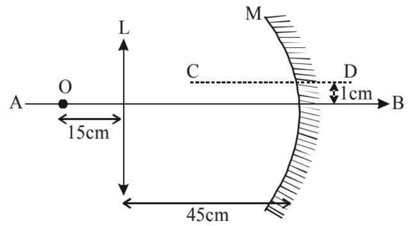
4. If the refractive index of the material of a prism is $\cot\frac{A}{2}$ and the angle of prism is A, then angle of minimum deviation is

(a) $\pi - 2A$ (b) $\pi - A$ (c) $\frac{\pi}{2} - 2A$ (d) $\frac{\pi}{2} - A$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

5. A telescope has an objective of focal length 100 cm and an eyepiece of focal length 5 cm. What is the magnifying power of the telescope when the final image is formed at the least distance of distinct vision ?
(a) 20 (b) 24 (c) 28 (d) 32

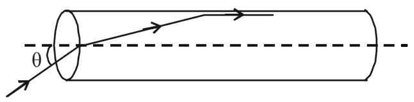
6. In the figure shown, L is a converging lens of focal length 10 cm and M is a concave mirror of radius of curvature 20cm. A point object O is placed in front of the lens at a distance 15 cm. AB and CD are optical axes of the lens and mirror respectively. The distance of the final image formed by this system from the optical centre of the lens is $x\sqrt{26}$ cm. Find the value of x in cm.
[The distance between CD and AB is 1 cm]



(a) 2 (b) 3 (c) 6 (d) 4

7. An object at 2.4 m in front of a lens forms a sharp image on a film 12 cm behind the lens. A glass plate 1 cm thick, of refractive index 1.50 is interposed between lens and film with its plane faces parallel to film. At what distance (from lens) should object shifted to be in sharp focus of film?
(a) 7.2m (b) 2.4m (c) 3.2m (d) 5.6m

8. A transparent solid cylindrical rod has a refractive index of $\frac{2}{\sqrt{3}}$. It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure.



The incident angle θ for which the light ray grazes along the wall of the rod is :

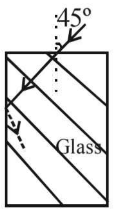
(a) $\sin^{-1}(\sqrt{3}/2)$ (b) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$
(c) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (d) $\sin^{-1}(1/2)$

9. A ray of light passes through an equilateral prism such that the angle of incidence is equal to the angle of emergence and the latter is equal to $\frac{3}{4}$th of angle of prism. The angle of deviation is
(a) 25° (b) 30° (c) 45° (d) 35°

10. Aperture of the human eye is 2 mm. Assuming the mean wavelength of light to be 5000 Å, the angular resolution limit of the eye is nearly
(a) 2 minute (b) 1 minute
(c) 0.5 minute (d) 1.5 minute

11. When a plane mirror is placed horizontally on a level ground at a distance of 60 *m* from the foot of a tower, the top of the tower and its image in the mirror subtend an angle of 90° at the eye. The height of the tower will be
(a) 30m (b) 60m (c) 90m (d) 120m

12. A light ray falls on a rectangular glass slab as shown. The index of refraction of the glass, if total internal reflection is to occur at the vertical face, is



(a) $\sqrt{3/2}$ (b) $\frac{(\sqrt{3}+1)}{2}$
(c) $\frac{(\sqrt{2}+1)}{2}$ (d) $\sqrt{5}/2$

13. A lens made of glass whose index of refraction is 1.60 has a focal length of + 20 cm in air. Its focal length in water, whose refractive index is 1.33, will be
(a) three times longer than in air
(b) two times longer than in air
(c) same as in air
(d) None of these

RESPONSE GRID	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ
	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	

14. For a prism kept in air it is found that for an angle of incidence 60°, the angle of Prism A, angle of deviation δ and angle of emergence 'e' become equal. Then the refractive index of the prism is

(a) 1.73 (b) 1.15 (c) 1.5 (d) 1.33

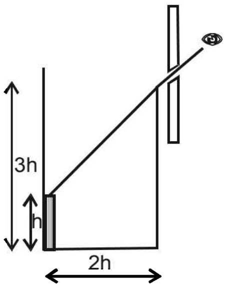
15. A person can see clearly only upto a distance of 30 cm. He wants to read a book placed at a distance of 50 cm from his eyes. What is the power of the lens of his spectacles ?

(a) –1.0 D (b) –1.33 D (c) –1.67 D (d) –2.0 D

16. An object is placed at a distance of 40 cm in front of a concave mirror of focal length 20 cm. The image produced is

(a) real, inverted and smaller in size
(b) real, inverted and of same size
(c) real and erect
(d) virtual and inverted

17. An observer can see through a pin-hole the top end of a thin rod of height h, placed as shown in the figure. The beaker height is 3h and its radius h. When the beaker is filled with a liquid up to a height 2h, he can see the lower end of the rod. Then the refractive index of the liquid is

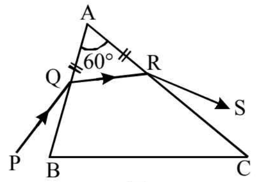


(a) $\frac{5}{2}$ (b) $\sqrt{\frac{5}{2}}$ (c) $\sqrt{\frac{3}{2}}$ (d) $\frac{3}{2}$

18. Two plano-concave lenses (1 and 2) of glass of refractive index 1.5 have radii of curvature 25 cm and 20 cm. They are placed in contact with their curved surface towards each other and the space between them is filled with liquid of refractive index 4/3. Then the combination is

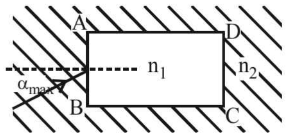
(a) convex lens of focal length 70 cm
(b) concave lens of focal length 70 cm
(c) concave lens of focal length 66.6 cm
(d) convex lens of focal length 66.6 cm

19. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in the figure and emerges from the other refracting face AC as RS such that AQ = AR. If the angle of prism A = 60° and the refractive index of the material of prism is $\sqrt{3}$, then the angle of deviation of the ray is



(a) 60° (b) 45°
(c) 30° (d) None of these

20. A rectangular glass slab *ABCD* of refractive index n_1 is immersed in water of refractive index $n_2 (n_1 > n_2)$. A ray of light is incident at the surface *AB* of the slab as shown. The maximum value of the angle of incidence α_{max} such that the ray comes out only from the other surface *CD* is given by



(a) $\sin^{-1}\left[\frac{n_1}{n_2}\cos\left(\sin^{-1}\left(\frac{n_2}{n_1}\right)\right)\right]$

(b) $\sin^{-1}\left[n_1\cos\left(\sin^{-1}\left(\frac{1}{n_2}\right)\right)\right]$

(c) $\sin^{-1}\left(\frac{n_1}{n_2}\right)$

(d) $\sin^{-1}\left(\frac{n_2}{n_1}\right)$

21. A microscope is focussed on a mark on a piece of paper and then a slab of glass of thickness 3 cm and refractive index 1.5 is placed over the mark. How should the microscope be moved to get the mark in focus again ?

(a) 4.5 cm downward (b) 1 cm downward
(c) 2 cm upward (d) 1 cm upward

RESPONSE GRID					
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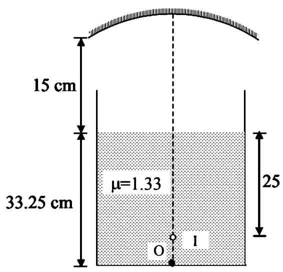
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ		

22. A container is filled with water (μ = 1.33) upto a height of 33.25 cm. A concave mirror is placed 15 cm above the water level and the image of an object placed at the bottom is formed 25 cm below the water level. Focal length of the mirror is



(a) 15 cm (b) 20 cm (c) –18.31 cm (d) 10 cm

23. The focal lengths of the objective and the eye piece of a compound microscope are 2.0 cm and 3.0 cm, respectively. The distance between the objective and the eye piece is 15.0 cm. The final image formed by the eye piece is at infinity. The two lenses are thin. The distance in cm of the object and the image produced by the objective, measured from the objective lens, are respectively

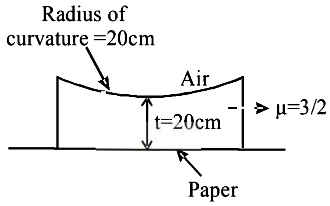
(a) 2.4 and 12.0 (b) 2.4 and 15.0
(c) 2.0 and 12.0 (d) 2.0 and 3.0

24. A rectangular block of glass is placed on a mark made on the surface of the table and it is viewed from the vertical position of eye. If refractive index of glass be μ and its thickness d, then the mark will appear to be raised up by

(a) $\frac{(\mu+1)d}{\mu}$ (b) $\frac{(\mu-1)d}{\mu}$

(c) $\frac{(\mu+1)}{\mu d}$ (d) $\frac{(\mu-1)\mu}{d}$

25. A planoconcave lens is placed on a paper on which a flower is drawn. How far above its actual position does the flower appear to be?



(a) 10 cm (b) 15 cm
(c) 50 cm (d) None of these

26. A thin prism of angle 15° made of glass of refractive index μ_1 = 1.5 is combined with another prism of glass of refractive index μ_2 = 1.75. The combination of the prism produces dispersion without deviation. The angle of the second prism should be

(a) 7° (b) 10° (c) 12° (d) 5°

27. A telescope consists of two thin lenses of focal lengths, 0.3 m and 3 cm respectively. It is focused on moon which subtends an angle of 0.5° at the objective. Then the angle subtended at the eye by the final image will be

(a) 5° (b) 0.25° (c) 0.5° (d) 0.35°

28. A bi-convex lens made of glass (refractive index 1.5) is put in a liquid of refractive index 1.7. Its focal length will

(a) decrease and change sign
(b) increase and change sign
(c) decrease and remain of the same sign
(d) increase and remain of the same sign

29. To get three images of a single object, one should have two plane mirrors at an angle of

(a) 60° (b) 90° (c) 120° (d) 30°

30. A thin convergent glass lens (μ_g = 1.5) has a power of + 5.0 D. When this lens is immersed in a liquid of refractive index μ, it acts as a divergent lens of focal length 100 cm. The value of μ must be

(a) 4/3 (b) 5/3 (c) 5/4 (d) 6/5

RESPONSE GRID	
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DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP23 - PHYSICS			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	40	Qualifying Score	50
Success Gap = Net Score – Qualifying Score			

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

DPP/CP23

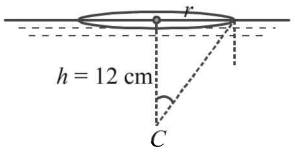
1. **(a)** From mirror formula

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \text{ so, } \frac{dv}{dt}=-\frac{v^2}{u^2}\left(\frac{du}{dt}\right)$$

$$\Rightarrow \frac{dv}{dt}=-\left(\frac{f}{u-f}\right)^2\frac{du}{dt}$$

$$\Rightarrow \frac{dv}{dt}=\frac{1}{15}\text{ m/s}$$

2. **(d)**



$$\sin C = \frac{1}{\mu}=\frac{1}{4/3}=\frac{3}{4}.$$

Now $r = h\tan C$

$$= 12\times\frac{3}{\sqrt{7}}=\frac{36}{\sqrt{7}}\text{ cm}$$

3. **(d)** For 1st lens, $u_1 = -30$, $f_1 = +10$cm,

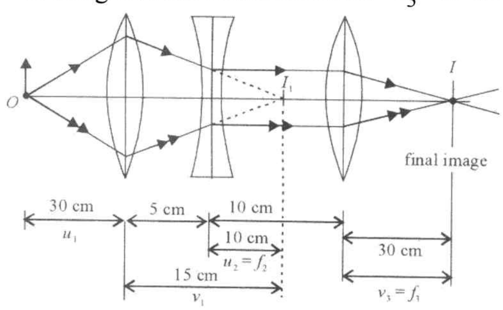
Formula of lens, $\frac{1}{v_1}+\frac{1}{30}=\frac{1}{10}$

or, $v_1 = 15$ cm at I_1 behind the lens.

The images I_1 serves as virtual object for concave lens. For second lens, which is concave, $u_2 = (15 - 5) = 10$ cm. I_1 acts as object. $f_2 = -10$ cm.

The rays will emerge parallel to axis as the virtual object is at focus of concave lens, as shown in the figure. Image of I_1 will be at infinity. These parallel rays are incident on the third lens viz the convex lens, $f_3 = +30$ cm. These parallel rays will be brought to convergence at the focus of the third lens.

$\therefore$ Image distance from third lens = f_3 = 30 cm



4. **(a)** We have,

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

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

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

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

or $\cos\frac{A}{2}=\cos\left[\frac{\pi}{2}-\left(\frac{A+\delta_m}{2}\right)\right]$

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

or $A=\pi-A-\delta_m \Rightarrow \delta_m=\pi-2A$.

5. **(b)** $f_0 = 100$ cm, $f_e = 5$ cm

When final image is formed at least distance of distinct vision (d), then

$$M=\frac{f_0}{f_e}\left(1+\frac{f_e}{d}\right)=\frac{100}{5}\left(1+\frac{5}{25}\right) \quad [\because D=25\text{ cm}]$$

$$M=20\times\frac{6}{5}=24$$

6. **(c)** I_1 is the image of object O formed by the lens.

$\frac{1}{v_1}-\frac{1}{u_1}=\frac{1}{f}$; $u_1=-15$, $f_1=10$

Solving we get, $v_1 = 30$ cm.

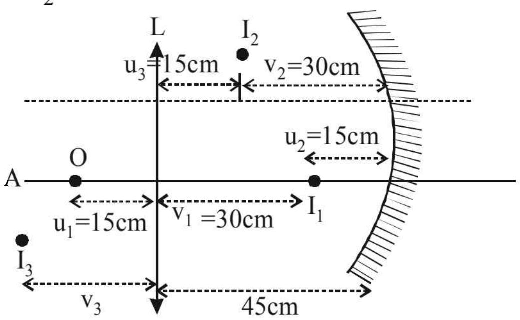
I_1 acts as source for mirror

$\therefore$ $u_2 = -(45 - v_1) = -15$ cm.

I_2 is the image formed by the mirror

$$\therefore \frac{1}{v_2}=\frac{1}{f_m}-\frac{1}{u_2}=-\frac{1}{10}+\frac{1}{15}$$

$\therefore$ $v_2 = -30$cm.



The height of I_2 above principal axis of lens is

$$=\frac{v_2}{u_2}\times 1+1=3\text{cm}.$$

I_2 acts as a source for lens, $u_3 = -(45 - v_2) = -15$ cm.

Hence, the lens forms an image I_3 at a distance $v_3 = 30$ cm to the left of lens.

The height of I_3 below the principal axis of lens

$$=\frac{v_3}{u_3}\times 3=6\text{ cm}.$$

$\therefore$ Required distance = $\sqrt{30^2+6^2}=6\sqrt{26}$ cm.

7. **(d)** The focal length of the lens

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{12}+\frac{1}{240}=\frac{20+1}{240}=\frac{21}{240}$$

$$f=\frac{240}{21}\text{cm}$$

$$\text{Shift}=t\left(1-\frac{1}{\mu}\right)$$

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

Now $v'=12-\frac{1}{3}=\frac{35}{3}$ cm

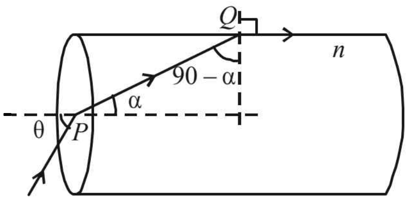
Now the object be distance u′.

$$\frac{1}{u'}=\frac{3}{35}-\frac{21}{240}=\frac{1}{5}\left[\frac{3}{7}-\frac{21}{48}\right]$$

$$\frac{1}{u'}=\frac{1}{5}\left[\frac{48-49}{7\times16}\right]$$

$$u'=-7\times16\times5=-560\text{ cm}=-5.6\text{ m}$$

8. **(c)**



Applying Snell's law at Q

$$n=\frac{\sin 90°}{\sin(90°-\alpha)}=\frac{1}{\cos\alpha}$$

$$\therefore \cos\alpha=\frac{1}{n}$$

$$\therefore \sin\alpha=\sqrt{1-\cos^2\alpha}=\sqrt{1-\frac{1}{n^2}}=\frac{\sqrt{n^2-1}}{n} \quad ...(1)$$

Applying Snell's Law at P

$$n=\frac{\sin\theta}{\sin\alpha}\Rightarrow \sin\theta=n\times\sin\alpha=\sqrt{n^2-1}\text{; from (1)}$$

$$\therefore \sin\theta=\sqrt{\left(\frac{2}{\sqrt{3}}\right)^2-1}=\sqrt{\frac{4}{3}-1}=\frac{1}{\sqrt{3}}$$

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

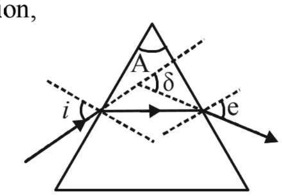
9. **(b)** From the fig.

Angle of deviation,

$\delta=i+e-A$

Here, e = i

and $e=\frac{3}{4}A$



$$\therefore \delta=\frac{3}{4}A+\frac{3}{4}A-A=\frac{A}{2}$$

For equilateral prism, A = 60°

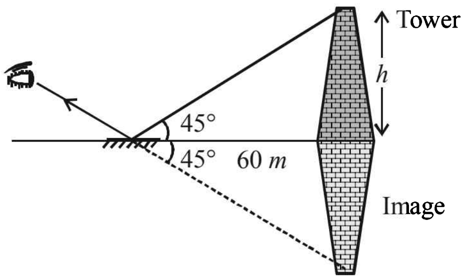
$$\therefore \delta=\frac{60°}{2}=30°$$

10. **(b)** If the angular limit of resolution of human eye is R then

$$R=\frac{1.22\lambda}{a}=\frac{1.22\times5\times10^{-7}}{2\times10^{-3}}\text{ rad}$$

$$=\frac{1.22\times5\times10^{-7}}{2\times10^{-3}}\times\frac{180}{\pi}\times60\text{ minute}=1\text{ minute}$$

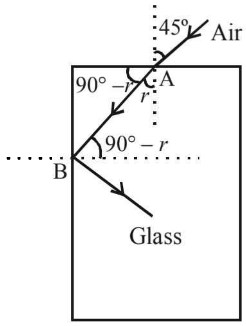
11. **(b)** $\tan 45°=\frac{h}{60}\Rightarrow h=60m$



12. **(a)** For point A, ${}_a\mu_g=\frac{\sin 45°}{\sin r}$

$$\Rightarrow \sin r=\frac{1}{\sqrt{2}\,{}_a\mu_g}$$

For point B, $\sin(90°-r)={}_g\mu_a$ where, $(90°-r)$ is critical angle.



$$\therefore \cos r={}_g\mu_a=\frac{1}{{}_a\mu_g}$$

$$\Rightarrow {}_a\mu_g=\frac{1}{\cos r}$$

$$=\frac{1}{\sqrt{1-\sin^2 r}}=\frac{1}{\sqrt{1-\frac{1}{2\,{}_a\mu_g^2}}}$$

$$\Rightarrow {}_a\mu_g^{\,2}=\frac{1}{1-\frac{1}{2\,{}_a\mu_g^2}}=\frac{2\,{}_a\mu_g^2}{2\,{}_a\mu_g^2-1}$$

$$\Rightarrow 2\,{}_a\mu_g^2-1=2\Rightarrow {}_a\mu_g=\sqrt{\frac{3}{2}}$$

13. **(a)** ${}_an_\ell=1.6$, ${}_an_w=1.33$

f = 20 cm

We have,

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

$$\frac{1}{20}=(1.6-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad .....(1)$$

Also, $\frac{1}{f'}=({}_w n_\ell -1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$$=\left(\frac{{}_a n_\ell}{{}_a n_w}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f'}=\left(\frac{1.6}{1.33}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \quad .....(2)$$

Dividing equation (1) by (2)

$$\Rightarrow \frac{f'}{20}=\frac{0.6}{(1.2-1)}$$

$$f'=\frac{0.6\times 20}{0.2}=60 \text{ cm.}$$

Hence it's focal length is three times longer than in air.

14. (a) Given $i=60°$

$A=\delta=e$

$\delta=i+e-A \Rightarrow \delta=i \quad (\because e=A)$

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

Here angle of deviation is min. ($\because i=e$)

$$\mu=\frac{\sin\left(\frac{60°+60°}{2}\right)}{\sin\frac{60°}{2}}=1.73$$

15. (b) $u=-50 \text{ cm}=-0.5 \text{ m}$

$v=-30 \text{ cm}=-0.3 \text{ m}$

$$P=\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{-1}{0.3}+\frac{1}{0.5}=\frac{-0.2}{0.15}=-1.33 \text{ D}.$$

16. (b) Object distance $u=-40$ cm

Focal length $f=-20$ cm

According to mirror formula

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \text{ or } \frac{1}{v}=\frac{1}{f}-\frac{1}{u}$$

$$\text{or } \frac{1}{v}+\frac{1}{-20}-\frac{1}{(-40)}=\frac{1}{-20}+\frac{1}{40}$$

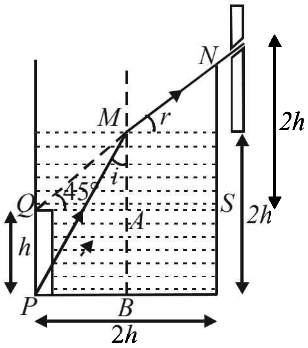
$$\frac{1}{v}=\frac{-2+1}{40}=-\frac{1}{40} \quad \text{or } v=-40 \text{ cm.}$$

Negative sign shows that image is infront of concave mirror. The image is real.

$$\text{Magnification, } m=\frac{-v}{u}=-\frac{(-40)}{(-40)}=-1$$

The image is of the same size and inverted.

17. (b) For the image of point P to be seen by the observer, it should be formed at point Q.



In ΔQNS,

$NS=QS=2h$

$\therefore \angle NQS=45°$

$\therefore r=45°$

At point M

$${}_2^1\mu=\frac{\sin r}{\sin i}=\frac{\sin 45°}{\sin i}=\frac{1}{\sqrt{2}\cdot\sin i} \quad ...(i)$$

In ΔPMB,

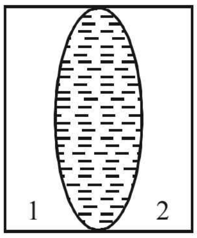
$PM^2=4h^2+h^2=5h^2$

$$\therefore \sin i=\frac{h}{\sqrt{5}\,h} \quad ...(ii)$$

From (i) and (ii)

$${}_2^1\mu=\sqrt{\frac{5}{2}}$$

18. (c) As shown in the figure, the system is equivalent to combination of three thin lens in contact



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

By lens maker's formula

$$\frac{1}{f_1}=\left(\frac{3}{2}-1\right)\left(\frac{1}{\infty}-\frac{1}{25}\right)=-\frac{1}{50}$$

$$\frac{1}{f_2}=\left(\frac{4}{3}-1\right)\left(\frac{1}{25}+\frac{1}{20}\right)=\frac{3}{100}$$

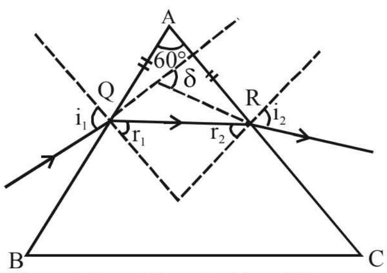
$$\frac{1}{f_3}=\left(\frac{3}{2}-1\right)\left(\frac{1}{-20}-\frac{1}{\infty}\right)=-\frac{1}{40}$$

$$\frac{1}{f}=\frac{1}{5}\left[-\frac{1}{10}+\frac{3}{20}-\frac{1}{8}\right]=\frac{1}{5}\left[\frac{-8+12-10}{80}\right]=\frac{1}{5}\left[\frac{-6}{80}\right]$$

$$\text{or} \quad f=-\frac{400}{6}\text{cm}=-66.6\text{cm}$$

Hence the system behaves as a concave lens of focal length 66.6 cm.

19. (a)



Given $AQ=AR$ and $\angle A=60°$

$\therefore \angle AQR=\angle ARQ=60°$

$\therefore r_1=r_2=30°$

Applying Snell's law on face AB.

$\sin i_1 = \mu \sin r_1$

$\Rightarrow \ \sin i_1 = \sqrt{3} \sin 30° = \sqrt{3} \times \frac{1}{2} = \frac{\sqrt{3}}{2}$

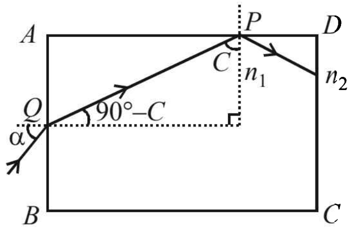
$\therefore \ i_1 = 60°$

Similarly, $i_2 = 60°$

In a prism, deviation

$\delta = i_1 + i_2 - A = 60° + 60° - 60° = 60°$

20. (a) The ray will come out from *CD* if it suffers total internal reflection at surface *AD*, i.e., it strikes the surface *AD* at critical angle *C* (the limiting case).



Applying Snell's law at *P*

$$n_1 \sin C = n_2 \text{ or } \sin C = \frac{n_2}{n_1}$$

Applying Snell's law at *Q*

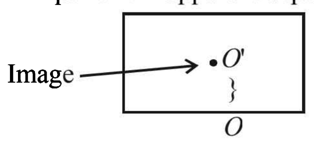
$$n_2 \sin \alpha = n_1 \cos C$$

$$\Rightarrow \sin \alpha = \frac{n_1}{n_2} \cos\left\{\sin^{-1}\left(\frac{n_2}{n_1}\right)\right\}$$

or $$\alpha = \sin^{-1}\left[\frac{n_1}{n_2} \cos\left\{\sin^{-1}\left(\frac{n_2}{n_1}\right)\right\}\right]$$

21. (d) In the later case microscope will be focussed for *O'*. So, it is required to be lifted by distance *OO'*.

OO' = real depth of O – apparent depth of *O*.



$$= 3 - \frac{3}{1.5} \quad \left[\mu = \frac{\text{real depth}}{\text{apparent depth}}\right]$$

$$= 3\left[\frac{1.5-1}{1.5}\right] = \frac{3 \times .5}{1.5} = 1 \text{ cm}$$

22. (c) The image *I* ' for first refraction (i.e., when the ray comes out of liquid) is at a depth of

$$= \frac{33.25}{1.33} = 25 \text{cm} \quad \left[\because \text{ Apparent depth} = \frac{\text{Real depth}}{\mu}\right]$$

Now, reflection will occur at concave mirror. For this *I'* behaves as an object.

$\therefore \quad u = -(15 + 25) = -40$ cm

and $v = -\left[15 + \frac{25}{1.33}\right]$

Where $\frac{25}{1.33}$ is the real depth of the image.

Using mirror formula we get

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}, \quad f = -18.31 \text{ cm}$$

23. (a) Here f_0 = 2 cm and f_e = 3 cm.

Using lens formula for eye piece

$$\Rightarrow \ \frac{-1}{u_e} + \frac{1}{\infty} = \frac{1}{3} \ \Rightarrow \ u_e = -3 \text{ cm}$$

But the distance between objective and eye piece is 15 cm (given)

$\therefore$ Distance of image formed by the objective $= v = 15 - 3 = 12$ cm.

Let u be the object distance from objective, then for objective lens

$$-\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \text{ or } \frac{-1}{u} + \frac{1}{12} = \frac{1}{2}$$

$$\Rightarrow \ \frac{-1}{u} = \frac{1}{2} - \frac{1}{12} = \frac{5}{12}, \ u = -\frac{12}{5} = -2.4 \text{ cm}$$

24. (b) Since $\frac{\text{Apparent depth}}{\text{Real depth}} = \frac{1}{\mu}$

$\Rightarrow$ Apparent depth = d/μ

So mark raised up = Real depth – Apparent depth

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

25. (a) 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.

26. (b) Deviation = zero

So, $\delta = \delta_1 + \delta_2 = 0$

$\Rightarrow (\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$

$\Rightarrow A_2(1.75 - 1) = -(1.5 - 1)\,15°$

$\Rightarrow A_2 = -\frac{0.5}{0.75} \times 15°$

or $A_2 = -10°$.

Negative sign shows that the second prism is inverted with respect to the first.

27. (a) Magnification

$$= \frac{f_0}{f_e} = \frac{\text{Angle subtended by final image on the eye}}{\text{Angle subtended by the object on eye (or objective)}}$$

$$\Rightarrow \ \frac{0.3\text{m}}{3\text{cm}} = \frac{\beta}{0.5°} \ \Rightarrow \ \frac{30\,\text{cm}}{3\text{cm}} = \frac{\beta}{0.5°}$$

$\Rightarrow \beta = 5°$

28. **(b)** From lens formula

$$\frac{1}{f_a} = ({}_a\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f_a} = (1.5 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(i)$$

When lens is immersed in liquid, then

$$\frac{1}{f_l} = ({}_l\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$${}_l\mu_g = \frac{{}_a\mu_g}{{}_a\mu_l} = \frac{1.5}{1.7} \Rightarrow \frac{1}{f_l} = \left(\frac{1.5}{1.7} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f_l} = \frac{-0.2}{1.7}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(ii)$$

Dividing eq. (i) by (ii), we get

$$\frac{f_l}{f_a} = \frac{0.5}{-\frac{0.2}{1.7}} = -4.25 \text{ or } f_l = -4.25 f_a$$

Hence, focal length will increase and will change in sign.

29. **(b)** When $\theta = 90°$ then $\frac{360}{\theta} = \frac{360}{90} = 4$

is an even number. The number of images formed is given by

$$n = \frac{360}{\theta} - 1 = \frac{360}{90} - 1 = 4 - 1 = 3$$

30. **(b)** $$\frac{P_a}{P_l} = \frac{\left(\frac{\mu_g}{\mu_a} - 1\right)}{\left(\frac{\mu_g}{\mu_l} - 1\right)} = \frac{+5}{-100/100} = -5$$

$$-5\left(\frac{\mu_g}{\mu_l} - 1\right) = \frac{\mu_g}{\mu_a} - 1$$

$$\frac{1.5}{\mu_l} - 1 = \frac{-1}{5}(1.5 - 1) = -0.1\,; \quad \mu_l = \frac{1.5}{0.9} = \frac{5}{3}$$