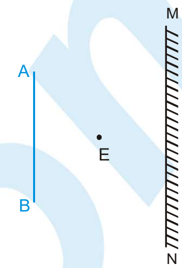
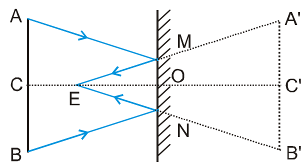
SOLVED EXAMPLES

Ex.1 Figure shows an object AB and a plane mirror MN placed parallel to object. Indicate the mirror length required to see the image of object if observer's eye is at E.



Sol. Required length of mirror = MN.

Δ MNE & ΔA'B'E are similar

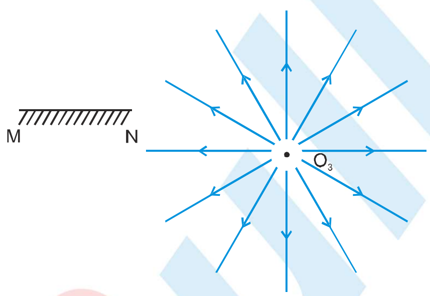


$$\frac{MN}{OE} = \frac{A'B'}{C'E}$$

$$\Rightarrow \quad MN = \frac{A'B'}{2} = \frac{AB}{2}.$$

Ex.2 See the following figure. Which of the objects shown in figure will not form its image in the mirror.

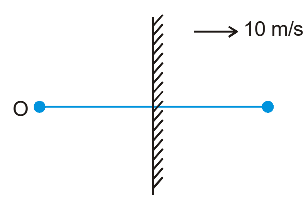
Sol.



No ray from O_3 is incident on reflecting surface of the mirror, so its image is not formed.

Ex.3 An object is kept fixed in front of a plane mirror which is moved by 10 m/s away from the object, find the velocity of the image.

Sol. $\vec{V}_{IM} = -\vec{V}_{OM}$

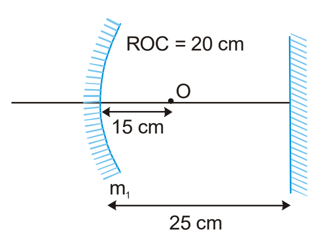


$$\vec{V}_{I,G} - \vec{V}_{M,G} = -\vec{V}_{O,G} + \vec{V}_{M,G}$$

$$\Rightarrow \quad \vec{V}_{M,G} = \frac{\vec{V}_{I,G} + \vec{V}_{O,G}}{2} = \frac{\vec{V}_{I,G}}{2} \qquad (\because \vec{V}_{O,G} = 0)$$

$$\frac{\vec{V}_{I,G}}{2} = 10\,\hat{i}\text{ m/s} \quad \Rightarrow \quad \vec{V}_{I,G} = 20\,\hat{i}\text{ m/s}$$

Ex.4 Find the position of final image after three successive reflections taking first reflection on m_1



Sol. 1st reflection at m1

$u = -15\text{cm}$

$f = -10\text{ cm}$

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} = \frac{-3+2}{30} = -\frac{1}{30}$$

$v = -30\text{ cm}$

2nd reflection at plane mirror :

$u = 5$ cm

$v = -5$ cm

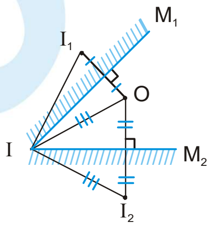
For III reflection on curved mirror again :

$u = -20$ cm

$$v = \frac{uf}{u-f} = \frac{(-20)\times(-10)}{-20+10} = \frac{200}{-10} = -20 \text{ cm}$$

Image is 20 cm right of m_1

Ex.5 Figure shows two inclined plane mirrors M_1 and M_2 and an object O. Its images formed in mirrors M_1 and M_2 individually are I_1 and I_2 respectively. Show that I_1 and I_2 and O lie on the circumference of a circle with centre at I. [This result can be extended to show that all the images will also lie on the same circle. Note that this result is independent of the angle of inclination of mirrors.]. I is the point of intersection of the mirrors.



Sol. Clearly,

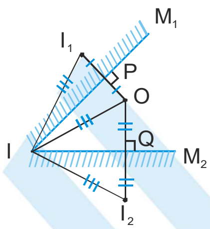
ΔIOQ and $\Delta I I_2Q$ are congruent

and ΔIOP and ΔII_1P are congruent

So, $II_1 = IO$ and $IO = II_2$

Hence, $II_1 = IO = II_2$

So, I_1 and I_2 and O lie on the circumference of a circle with centre I.



Ex.6 A small statue has a height of 1 cm and is placed in front of a spherical mirror . The image of the statue is inverted and is 0.5cm tall and located 10 cm in front of the mirror. Find the focal length and nature of the mirror.

Sol. We have $m = \frac{h_2}{h_1} = -\frac{0.5}{1} = -0.5$

$v = -10$ cm (real image)

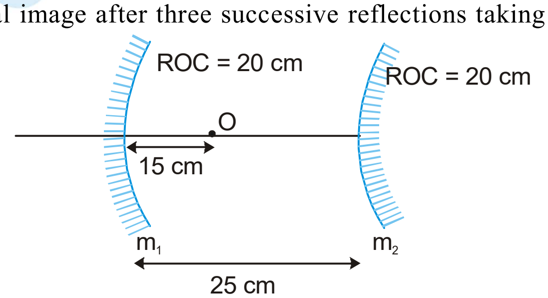
But $m = \frac{f-v}{f}$ $\quad -0.5 = \frac{f+10}{f}$ $\Rightarrow f = \frac{-20}{3}$ cm So, concave mirror.

Ans.

Ex.7 A coin is placed 10 cm in front of a concave mirror . The mirror produces a real image that has diameter 4 times that of the coin. What is the image distance.

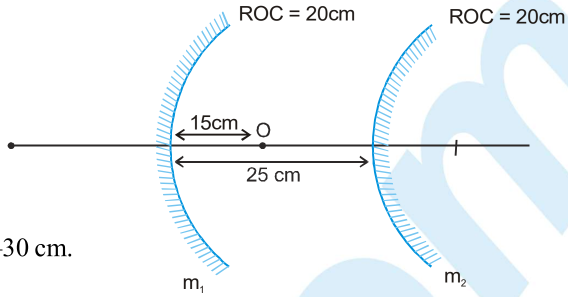
Sol. $m = \frac{d_2}{d_1} = -\frac{v}{u} \Rightarrow -4 = -\frac{v}{u} \Rightarrow v = 4u = 4\times(-10) = -40$ cm

Ex.8 Find the position of final image after three successive reflections taking first reflection on m_1.



Sol. 1^{st} reflection at mirror m_1 :

$u = -15$ cm, $f = -10$cm



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

$$\therefore \; v = \frac{uf}{u-f} = \frac{(-15)\times(-10)}{(-15)+10} = \frac{150}{-5} \text{ cm} = -30 \text{ cm.}$$

Thus, image is formed at a point 5 cm right of m_2 which will act as an object for the reflection at m_2

For 2^{nd} reflection at m_2

$u = 5$ cm, $f = 10$ cm

$$v = \frac{uf}{u-f} = \frac{5\times10}{5-10} = \frac{50}{-5} = -10 \text{ cm.}$$

3^{rd} reflection at m_1 again.

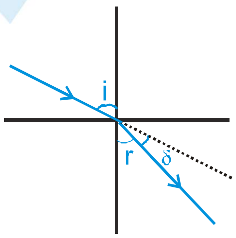
$u = -15$ cm $\quad f = -10$ cm

$$v = \frac{uf}{u-f} = \frac{-15\times(-10)}{(-15)+10} = -30 \text{ cm.}$$ **Ans.**

Image is formed at 30 cm right of m_1

Ex.9 A light ray deviates by 30^0 (which is one third of the angle of incidence) when it gets refracted from vacuum to a medium. Find the refractive index of the medium.

Sol. $\delta = i - r$



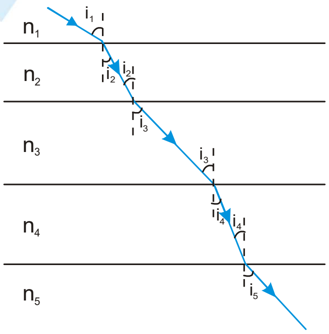
$\Rightarrow \quad \frac{i}{3} = i - r = 30^o. \quad \Rightarrow i = 90^o$

$\Rightarrow \quad 2i = 3r$

$\therefore \quad r = \frac{2i}{3} = 60^o$

So, $\quad \mu = \frac{\sin 90^o}{\sin 60^o} = \frac{1}{\sqrt{3}/2} = \frac{2}{\sqrt{3}}$ **Ans.**

Ex.10 A light passes through many parallel slabs one by one as shown in figure.



Prove that $n_1 \sin i_1 = n_2 \sin i_2 = n_3 \sin i_3 = n_4 \sin i_4 =$............**[Remember this].** Also prove that if $n_1 = n_4$ then light rays in medium n_1 and in medium n_4 are parallel.

Sol. We have,

$$\frac{\sin i_1}{\sin i_2} = \frac{n_2}{n_1}$$

$\Rightarrow$ $n_1 \sin i_1 = n_2 \sin i_2$ ....(i)

Similarly $n_2 \sin i_2 = n_3 \sin i_3$

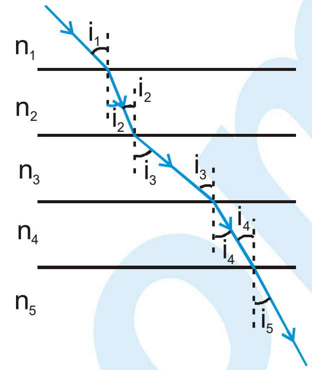
so on

So, $n_1 \sin i_1 = n_2 \sin i_2 = n_3 \sin i_3 = ...$

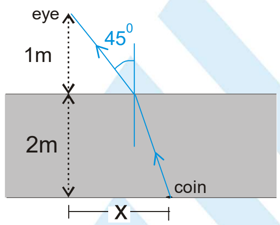
$n_1 \sin i_1 = n_4 \sin i_4 \Rightarrow \sin i_1 = \sin i_4 \quad (\therefore n_1 = n_2)$

So, $i_1 = i_4$

Hence, light rays in medium n_1 and in medium n_4 are parallel.



Ex.11 A coin lies on the bottom of a lake 2m deep at a horizontal distance x from the spotlight (a source of thin parallel beam of light) situated 1 m above the surface of a liquid of refractive index $\mu = \sqrt{2}$ and height 2m. Find x.

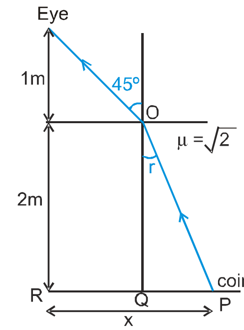


Sol. $\sqrt{2} = \dfrac{\sin 45^o}{\sin r}$

$\Rightarrow \sin r = \dfrac{1}{2} \quad \Rightarrow \quad r = 30^o$

$x = RQ + QP$

$= 1m + 2\tan 30^\circ m = \left(1 + \dfrac{2}{\sqrt{3}}\right) m$ **Ans.**

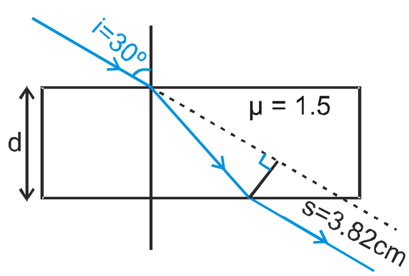


Ex.12 A ray of light falls at an angle of 30º onto a plane-parallel glass plate and leaves it parallel to the initial ray. The refractive index of the glass is 1.5. What is the thickness d of the plate if the distance between the rays is 3.82 cm? [Given : $\sin^{-1}\left(\dfrac{1}{3}\right) = 19.5^o$; $\cos 19.5^o = 0.94$; $\sin 10.5^o = 0.18$]

Sol.

Using $s = \dfrac{d \sin (i - r)}{\cos r}$

$\Rightarrow$ $d = \dfrac{3.82 \times \cos r}{\sin(30^o - r)}$ .... (1)

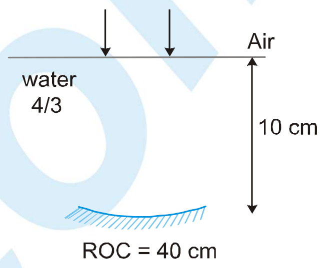


Also, $\quad 1.5 = \dfrac{\sin 30^\circ}{\sin r} \Rightarrow \sin r = \dfrac{1}{3}$

So, $\quad r = 19.5^\circ$

So, $\quad d = \dfrac{3.82 \times \cos 19.5^\circ}{\sin(30^\circ - 19.5^\circ)} = \dfrac{3.82 \times 0.94}{\sin 10.5^\circ} = \dfrac{3.82 \times 0.94}{0.18} = 19.948\ \text{cm} \approx 0.2\ \text{m}$

Ex.13 A concave mirror is placed inside water with its shining surface upwards and principal axis vertical as shown. Rays are incident parallel to the principal axis of concave mirror. Find the position of final image.



Sol. We have,

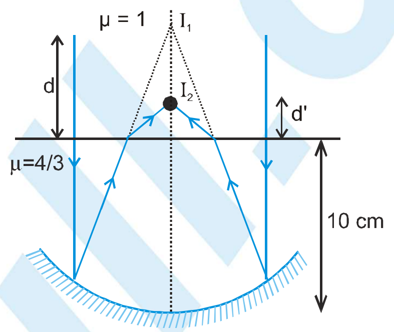
$u = -\infty, \quad f = -20\ \text{cm}$

So, $\quad v = -20\ \text{cm}$

So, $\quad d = 10\ \text{cm}$

$\therefore \quad d' = \dfrac{d}{\mu_{rel}} = \dfrac{10\ \text{cm}}{4/3}$

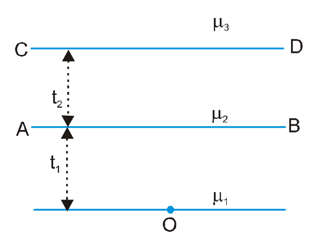
$= \dfrac{30}{4}\ \text{cm} = 7.5\ \text{cm}$ **Ans.**



Ex.14 An object lies 90 cm in air above water surface .It is viewed from water nearly normally. Find the apparent height of the object.

Sol. $d' = \dfrac{d}{n_{rel}} = \dfrac{d}{n_i / n_r} = \dfrac{90\ \text{cm}}{\frac{1}{4/3}} = \dfrac{90 \times 4}{3}\ \text{cm} = 120\ \text{cm}$ **Ans.**

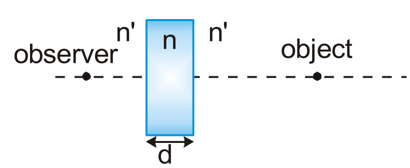
Ex.15 Find the apparent depth of object O below surface AB, seen by an observer in medium of refractive index μ_2



Sol. $d_{app.} = \dfrac{t_1}{\mu_1 / \mu_2}$

Ex.16 Prove that the shift in position of object due to parallel slab is given by shift

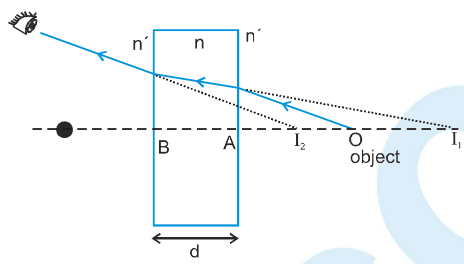
$= d\left(1 - \dfrac{1}{n_{rel}}\right)$ where $n_{rel} = \dfrac{n}{n'}$.



Sol. Because of the ray refraction at the first surface, the image of O is formed at I_1 . For this refraction, the real depth is AO = x and apparent depth is AI_1.

Thus : $AI_1 = \dfrac{AO}{n_i / n_r} = \dfrac{AO}{n'/n} = \dfrac{n(AO)}{n'}$.

The point I_1 acts as the object for the refraction of second surface. Due to this refraction, the image of I_1 is formed at I_2. Thus,



$BI_2 = \dfrac{(BI_1)}{(n/n')} = \dfrac{n'}{n}(BI_1)$

$= n'/n\,(AB + AI_1)$

$= \dfrac{n'}{n}\left[d + \dfrac{n}{n'}(AO)\right] = \dfrac{n'}{n}d + AO.$

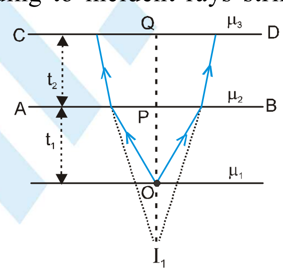
Net shift $= OI_2 = BO - BI_2$

$= d + (AO) - \dfrac{n'}{n}d - AO \quad = d\left(1 - \dfrac{n'}{n}\right) = d\left(1 - \dfrac{1}{n_{rel}}\right)$ where $n_{rel} = \dfrac{n}{n'}$. **Ans.**

Ex.17 In above question what is the depth of object corresponding to incident rays striking on surface CD in medium μ_2.

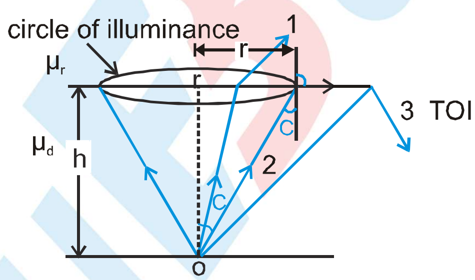
Sol. Depth of the object corresponding to incident ray striking on the surface CD in medium $\mu_2 = t_2 + PI_1$

$= t_2 + \dfrac{t_1}{\mu_1 / \mu_2}$



Ex.18 Find the radius of circle of illuminance, if a luminous object is placed at a distance h from the interface in denser medium.

Sol.



$\tan C = \dfrac{r}{h}$. $\quad\therefore\quad r = h \tan C.$

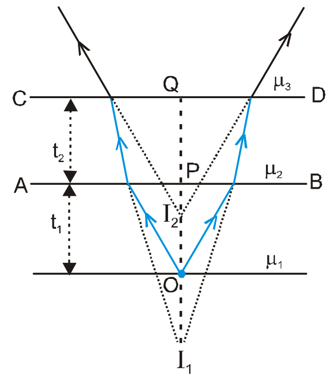
But $\quad C = \sin^{-1}\dfrac{1}{(\mu_d / \mu_r)}$

So, $\quad r = h \tan\left[\sin^{-1}\dfrac{1}{(\mu_d/\mu_r)}\right] = h.\dfrac{\mu_r}{\sqrt{\mu_d^2 - \mu_r^2}}$

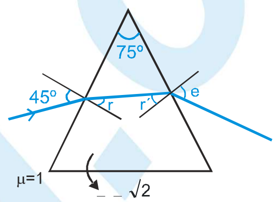
Ex.19 In above question if observer is in medium μ_3, what is the apparent depth of object seen below surface CD.

Sol. If the observer is in medium μ_3. apparent depth below surface CD $= QI_2$.

$$= \sum \frac{t_i}{(n_{rel})_i} \qquad = \frac{t_2}{\mu_2/\mu_3} + \frac{t_1}{\mu_1/\mu_3}$$



Ex.20 Find r, r′, e, δ for the case shown in figure.



Sol. Here $\theta = 180° - 75° = 105°$

$\sin 45° = \sqrt{2} \sin r$

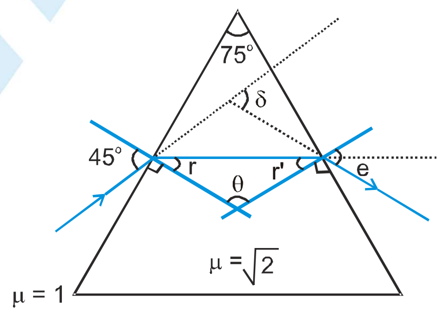
$\therefore\ r = \sin^{-1}\frac{1}{2} = 30°.$

$r' = 180° - (r + \theta) \quad = 180° - 30° - 105° = 45°$

$\sin e = \sqrt{2}\ \sin r'$

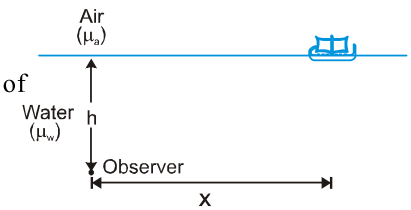
$\therefore\ \sin e = \sqrt{2} \times \sin 45° \quad = 1$

$\therefore\ \boxed{e = 90°}$

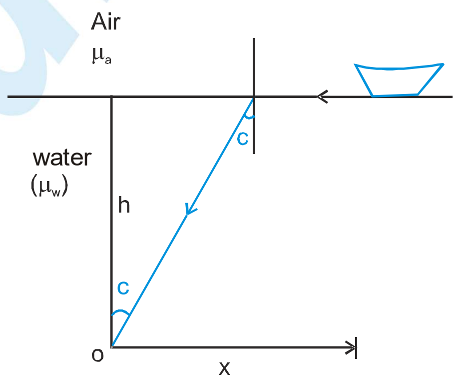


So, $\delta = i + e - A \qquad = 45° + 90° - 75° = 60°.$

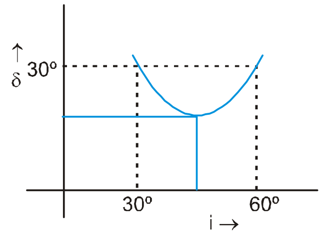
Ex.21 A ship is sailing in river. An observer is situated at a depth h in water (μ_w). If x >> h, find the angle made from vertical, of the line of sight of ship.



Sol. $C = \sin^{-1}\left(\frac{\mu_a}{\mu_w}\right)$



Ex.22 From the graph of angle of deviation δ versus angle of incidence i, find the prism angle

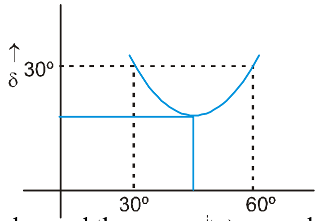


Sol. From the graph ;

$\delta = i + e - A.$

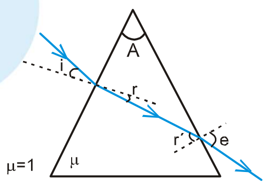
$30° = 30° + 60° - A$

$\therefore \quad \boxed{A = 60°}$



(use the result : If i and e are interchanged then we get same value of δ)

Ex.23 For the case shown in figure prove the relations $r' - r = A$ and $\delta = |(i - e) + A|$ (do not try to remember these relations because the prism is normally not used in this way).

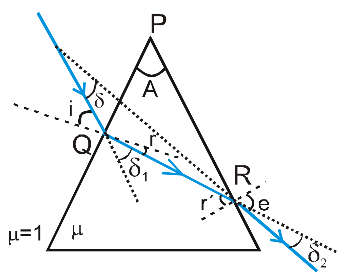


Sol. In Δ PQR,

$$A + \angle PQR + \angle QRP = 180°$$

$$= A + r + 90° + 90° - r' = 180°$$

$\therefore \quad \boxed{r^1 - r = A}$



Deviation after Ist refraction

$\delta_1 = (i - r)$ (anticlock wise)

Deviation after IInd refraction

$\delta_2 = (e - r')$ (clock wise)

Hence net deviation

$$\delta = \delta_1 - \delta_2$$
$$= (i - r) - (e - r') = i - e + A$$

Ex.24 The dispersive powers of crown and flint glasses are 0.03 and 0.05 respectively. The refractive indices for yellow light for these glasses are 1.517 and 1.621 respectively. It is desired to form an achromatic combination of prisms of crown and flint glasses which can produce a deviation of 1^0 in the yellow ray. Find the refracting angles of the two prisms needed.

Sol. $\omega_c = 0.03 = \dfrac{n_v - n_r}{n_y - 1}$ $\quad\therefore\ (n_v - n_r) = 0.03\,(1.5\,17 - 1) = 0.0155$

and, $\omega_f = 0.05 = \dfrac{n'_v - n'_r}{n'_y - 1}$ $\quad\therefore\ n'_v - n'_r = 0.05 \times (1.6\,21 - 1) = 0.031$

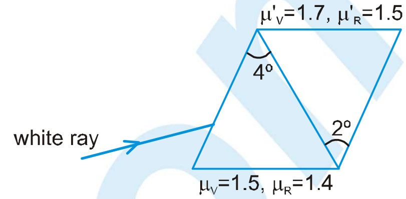
$$\theta = (n_v - n_r)A - (n'_v - n'_r)A = 0.0155\,A - 0.031\,A' \quad ....(1)$$

But $\quad \delta_{net} = 1$

So, $\quad (n_y - 1)A - (n'_y - 1)A' = 1 \qquad = 0.517A - 0.621A' = 1$ ....(2)

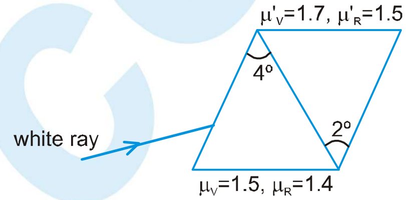
$\therefore \; A = 4.8°$ and $A' = 2.4°$

Ex.25 If two prisms are combined, as shown in figure, find the net angular dispersion and angle of deviation suffered by a white ray of light incident on the combination.



Sol. Net angular dispersion

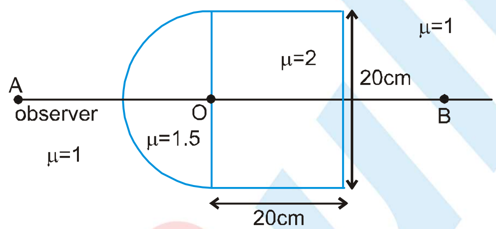
$$= (\delta_v - \delta_r) - (\delta'_v - \delta'_r)$$
$$= (\mu_v - \mu_r)A - (\mu'_v - \mu'_r)A'$$
$$= (1.5 - 1.4) \times 4° - (1.7 - 1.5) \times 2° = 0$$



$$\text{Angle of deviation} = \left(\frac{\mu_v + \mu_r}{2} - 1\right) A - \left(\frac{\mu'_v + \mu'_r}{2} - 1\right) A'$$

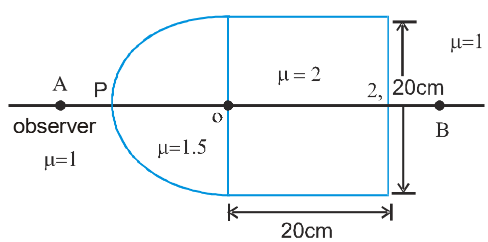
$$= \left(\frac{1.5 + 1.4}{2} - 1\right) \times 4° - \left(\frac{1.7 + 1.5}{2} - 1\right) \times 2° = 0.6°$$

Ex.26 See the situation shown in figure



(1) Find the position of image as seen by observer A.
(2) Find the position of image as seen by observer B.

Sol. **(i)** As seen by observer A .



R = – 10 cm.
u = – 10 cm.

So, $\quad \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}, \quad \frac{1}{v} - \frac{1.5}{(-10)} = \frac{1-1.5}{(-10)}$

v = –10 cm (at O)

(ii) As seen by observer B
R = ∞
u = – 20 cm

$$\frac{1}{v} - \frac{2.0}{-20} = \frac{1-2.0}{\infty}$$

v = – 10cm

image will be formed 10 cm right of O.

Ex.27 Find the focal length of a plano-convex lens with R_1 = 15 cm and $R_2 = \infty$. The refractive index of the lens material n = 1.5.

Sol. $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5-1)\left(\frac{1}{15} - \frac{1}{\infty}\right). = 0.5 \times \frac{1}{15}$

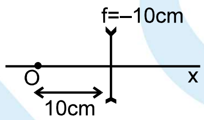
$\therefore \quad f = 30\text{ cm}.$

Ex.28 Find the focal length of a double-convex lens with R_1 = 15 cm and R_2 = –25 cm. The refractive index of the lens material n = 1.5.

Sol. $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (1.5-1)\left(\frac{1}{15} + \frac{1}{25}\right) = 0.5\left(\frac{10+6}{150}\right) = \frac{8}{150}.$

$f = \frac{150}{8} = 18.75\text{ cm}$

Ex.29 Figure shows a point object and a diverging lens. Find the final image formed.



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

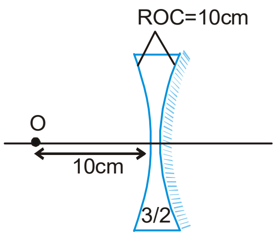
$$\frac{1}{v} = \frac{1}{-10} + \frac{1}{(-10)} = -\frac{2}{10}. \Rightarrow v = -5\text{ cm}$$

Ex.30 Find the focal length of a concavo-convex lens (positive meniscus) with R_1 = 15 cm and R_2 = 25 cm. The refractive index of the lens material n = 1.5.

Sol. $\frac{1}{f} = (1.5-1)\left(\frac{1}{15} - \frac{1}{25}\right) = 0.5\left(\frac{10-6}{150}\right). \quad \therefore f = \frac{300}{4} = 75\text{ cm}$

Ex.31 See the figure

Find the equivalent focal length of the combination shown in the figure and position of image.



Sol. For the concave lens

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \left(\frac{3}{2} - 1\right)\left(\frac{1}{-10} - \frac{1}{10}\right) = -\frac{1}{2} \times \frac{2}{10} = \frac{1}{10}$$

And, $f_m = \frac{R}{2} = \frac{10}{2} = 5\text{ cm}$

$\therefore \frac{1}{f_{eq}} = \frac{1}{f_m} - 2\frac{1}{f}$

$= \frac{1}{5} + 2 \times \frac{1}{10} = \frac{2}{5}$ $\boxed{f_{eq} = 2.5\text{ cm}}$ **Ans.**

Ex.32 An extended real object is placed perpendicular to the principal axis of a concave lens of focal length –10 cm, such that the image found is half the size of object.

(A) Find the object distance from the lens

(B) Find the image distance from the lens and draw the ray diagram

(C) Find the lateral magnification if object is moved by 1 mm along the principal axis towards the lens.

Sol. **(A)** We have, $f = -10$ cm.

$$m = \frac{h_2}{h_1} = 0.5 = \frac{v}{u}$$

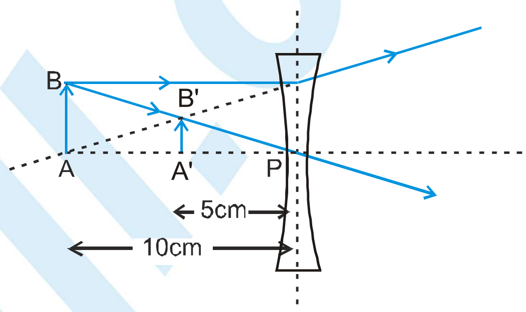
So, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ gives.

$$\Rightarrow \frac{1}{0.5u} - \frac{1}{u} = \frac{1}{-10} \qquad \therefore u = -10\text{cm}$$

(B) $\frac{v}{u} = 0.5.$

$\therefore v = 0.5 \times (-10)$ cm. $= -5$ cm

Ray diagram :-

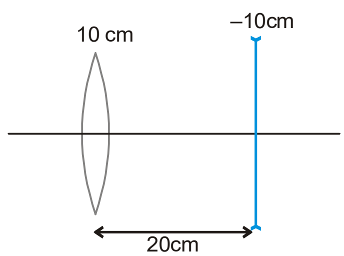


(C) $m = \frac{f}{f+u}$

$$\Rightarrow dm = \frac{-f}{(f+u)^2}\, du = \frac{(+10)}{(-10-10)^2}\,(0.1) = 0.0025 \text{ cm}$$

So, final lateral magnification (m+dm) = 0.5025 cm **Ans.**

Ex.33 Find the equivalent focal length of the system for araxial rays parallel to axis.



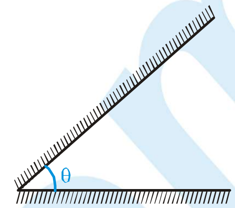
Sol. $\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2} = \frac{1}{10} + \frac{1}{-10} - \frac{20}{10(-10)} = \frac{1}{5}$

$\Rightarrow$ $f_{eq} = 5$ cm

Exercise # 1

[Single Correct Choice Type Questions]

1. Two mirrors are inclined at an angle θ as shown in the figure. Light ray is incident parallel to one of the mirrors. Light will start retracing its path after third reflection if :



(A) $\theta = 45°$ (B) $\theta = 30°$
(C) $\theta = 60°$ (D) all three

2. Two plane mirrors are inclined to each other at an angle 60^0. If a ray of light incident on the first mirror is parallel to the second mirror, it is reflected from the second mirror
(A) Perpendicular to the first mirror (B) Parallel to the first mirror
(C) Parallel to the second mirror (D) Perpendicular to the second mirror

3. A point object is kept in front of a plane mirror. The plane mirror is performing SHM of amplitude 2 cm. The plane mirror moves along the x-axis and x- axis is normal to the mirror. The amplitude of the mirror is such that the object is always infront of the mirror. The amplitude of SHM of the image is
(A) zero (B) 2 cm (C) 4 cm (D) 1 cm

4. An unnumbered wall clock shows time 04: 25: 37, where 1st term represents hours, 2nd represents minutes and the last term represents seconds. What time will its image in a plane mirror show.
(A) 08: 35: 23 (B) 07: 35: 23 (C) 07: 34: 23 (D) none of these a

5. A person's eye is at a height of 1.5 m. He stands infront of a 0.3m long plane mirror which is 0.8 m above the ground. The length of the image he sees of himself is:
(A) 1.5m (B) 1.0m (C) 0.8m (D) 0.6m

6. An object of height 1 cm is kept perpendicular to the principal axis of a convex mirror of radius of curvature 20 cm. If the distance of the object from the mirror is 20 cm then the distance (in cm) between heads of the image and the object will be:
(A) $\sqrt{\dfrac{6404}{9}}$ (B) $\sqrt{\dfrac{6414}{9}}$ (C) $\dfrac{40}{3}$ (D) none of these

7. Two plane mirrors are parallel to each other and spaced 20 cm apart. An object is kept in between them at 15 cm from A. Out of the following at which point(s) image(s) is/are not formed in mirror A (distance measured from mirror A):
(A) 15 cm (B) 25 cm (C) 45 cm (D) 55 cm

8. A plane mirror is moving with velocity $4\hat{i} + 5\hat{j} + 8\hat{k}$. A point object in front of the mirror moves with a velocity $3\hat{i} + 4\hat{j} + 5\hat{k}$. Here $\hat{k}$ is along the normal to the plane mirror and facing towards the object. The velocity of the image is :
(A) $-3\hat{i} - 4\hat{j} + 5\hat{k}$ (B) $3\hat{i} + 4\hat{j} + 11\hat{k}$ (C) $-3\hat{i} - 4\hat{j} + 11\hat{k}$ (D) $7\hat{i} + 9\hat{j} + 11\hat{k}$

9. A point object is kept between a plane mirror and a concave mirror facing each other. The distance between the mirrors is 22.5 cm. Plane mirror is placed perpendicular to principal axis of concave mirror. The radius of curvature of the concave mirror is 20 cm. What should be the distance of the object from the concave mirror so that after two successive reflections the final image is formed on the object itself ? (Consider first reflection from concave mirror)
(A) 5 cm (B) 15 cm (C) 10 cm (D) 7.5 cm

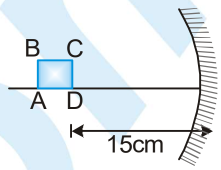
10. A luminous point object is moving along the principal axis of a concave mirror of focal length 12 cm towards it. When its distance from the mirror is 20 cm its velocity is 4 cm/s. The velocity of the image in cm/s at that instant is

(A) 6, towards the mirror (B) 6, away from the mirror

(C) 9, away from the mirror (D) 9, towards the mirror.

11. A square ABCD of side 1mm is kept at distance 15 cm infront of the concave mirror as shown in the figure. The focal length of the mirror is 10 cm.

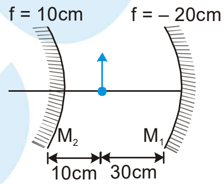
The length of the perimeter of its image will be (nearly):



(A) 8 mm (B) 2 mm

(C) 12 mm (D) 6 mm

12. In the figure shown find the total magnification after two successive reflections first on M_1 and then on M_2 .



(A) + 1 (B) – 2

(C) + 2 (D) – 1

13. A point object on the principal axis at a distance 15 cm in front of a concave mirror of radius of curvature 20 cm has velocity 2 mm/s perpendicular to the principal axis. The magnitude of velocity of image at that instant will be:

(A) 2 mm/s (B) 4 mm/s (C) 8 mm/s (D) 16 mm/s

14. A particle is moving towards a fixed spherical mirror. The image:

(A) must move away from the mirror

(B) must move towards the mirror

(C) may move towards the mirror

(D) will move towards the mirror, only if the mirror is convex.

15. The distance of an object from the focus of a convex mirror of radius of curvature ' a ' is ' b '. Then the distance of the image from the focus is:

(A) $b^2 / 4a$ (B) a / b^2 (C) $a^2 / 4b$ (D) $4b / a^2$

16. A point object at 15 cm from a concave mirror of radius of curvature 20 cm is made to oscillate along the principal axis with amplitude 2 mm. The amplitude of its image will be

(A) 2 mm (B) 4 mm (C) 8 mm (D) 16 mm

17. The largest distance of the image of a real object from a convex mirror of focal length 20 cm can be:

(A) 20 cm (B) infinite

(C) 10 cm (D) depends on the position of the object

18. I is the image of a point object O formed by spherical mirror, then which of the following statements is incorrect :

(A) If O and I are on same side of the principal axis, then they have to be on opposite sides of the mirror.

(B) If O and I are on opposite side of the principal axis, then they have to be on same side of the mirror.

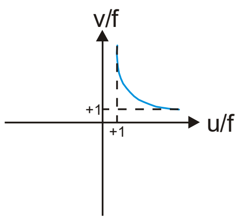
(C) If O and I are on opposite side of the principal axis, then they can be on opposite side of the mirror as well.

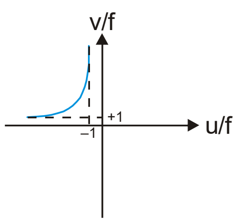
(D) If O is on principal axis then I has to lie on principal axis only.

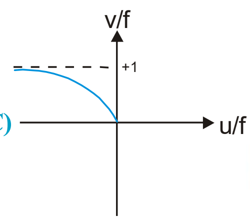
19. Which of the following can form erect, virtual, diminished image?

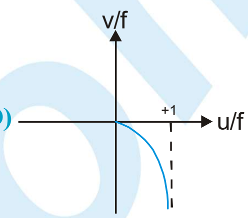
(A) plane mirror **(B)** concave mirror
(C) convex mirror **(D)** none of these

20. A real inverted image in a concave mirror is represented by graph (u, v, f are coordinates)

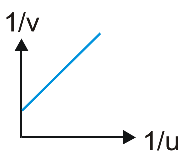
(A) 

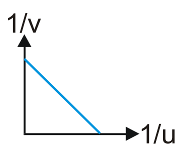
(B) 

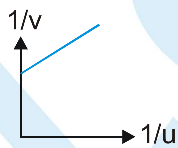
(C) 

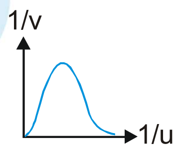
(D) 

21. An object is placed at a distance u from a concave mirror and its real image is received on a screen placed at a distance of v from the mirror. If f is the focal length of the mirror, then the graph between $1/v$ versus $1/u$ is

(A) 

(B) 

(C) 

(D) 

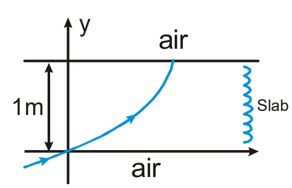
22. A ray of light passes from vacuum into a medium of refractive index n. If the angle of incidence is twice the angle of refraction, then the angle of incidence is:

(A) $\cos^{-1}(n/2)$ **(B)** $\sin^{-1}(n/2)$ **(C)** $2\cos^{-1}(n/2)$ **(D)** $2\sin^{-1}(n/2)$

23. The wavelength of light in vacuum is 6000 A° and in a medium it is 4000 A°. The refractive index of the medium is:

(A) 2.4 **(B)** 1.5 **(C)** 1.2 **(D)** 0.67

24. AZ ray of light travelling in air is incident at grazing incidence on a slab with variable refractive index, $n(y) = [k y^{3/2} + 1]^{1/2}$ where $k = 1\ m^{-3/2}$ and follows path as shown in the figure. What is the total deviation produced by slab when the ray comes out.

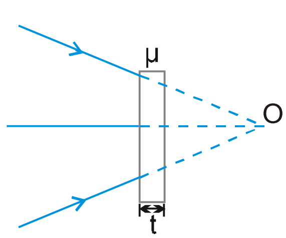


(A) 60° **(B)** 53°
(C) $\sin^{-1}(4/9)$ **(D)** no deviation at all

25. A ray of light is incident on a parallel slab of thickness t and refractive index n. If the angle of incidence θ is small, then the displacement in the incident and emergent ray will be:

(A) $\dfrac{t\theta(n-1)}{n}$ **(B)** $\dfrac{t\theta}{n}$ **(C)** $\dfrac{t\theta n}{n-1}$ **(D)** none

26. A beam of light is converging towards a point. A plane parallel plate of glass of thickness t, refractive index μ is introduced in the path of the beam as shown in the figure. The convergent point is shifted by (assume near normal incidence):



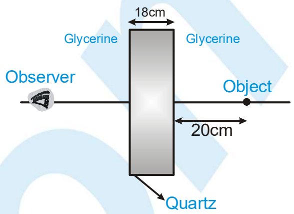
(A) $t\left(1-\dfrac{1}{\mu}\right)$ away **(B)** $t\left(1+\dfrac{1}{\mu}\right)$ away

(C) $t\left(1-\dfrac{1}{\mu}\right)$ nearer **(D)** $t\left(1+\dfrac{1}{\mu}\right)$ nearer

27. The critical angle of light going from medium A to medium B is θ. The speed of light in medium A is v. The speed of light in medium B is:

(A) $\dfrac{v}{\sin\theta}$ **(B)** $v\sin\theta$ **(C)** $v\cot\theta$ **(D)** $v\tan\theta$

28. Given that, velocity of light in quartz = 1.5×10^8 m/s and velocity of light in glycerine = $(9/4) \times 10^8$ m/s. Now a slab made of quartz is placed in glycerine as shown. The shift of the object produced by slab is



(A) 6 cm **(B)** 3.55 cm
(C) 9 cm **(D)** 2 cm

29. A prism having refractive index $\sqrt{2}$ and refracting angle 30º, has one of the refracting surfaces polished. A beam of light incident on the other refracting surface will retrace its path if the angle of incidence is:

(A) 0º **(B)** 30º **(C)** 45º **(D)** 60º

30. A ray of monochromatic light is incident on one refracting face of a prism of angle 75^0. It passes through the prism and is incident on the other face at the critical angle. If the refractive index of the material of the prism is $\sqrt{2}$, the angle of incidence on the first face of the prism is

(A) 30^0 **(B)** 45^0 **(C)** 60^0 **(D)** 0^0

31. The maximum refractive index of a material, of a prism of apex angle 90º, for which light may be transmitted is:

(A) $\sqrt{3}$ **(B)** 1.5 **(C)** $\sqrt{2}$ **(D)** None of these

32. A ray of light is incident at angle *i* on a surface of a prism of small angle A and emerges normally from the opposite surface. If the refractive index of the material of the prism is μ, the angle of incidence *i* is nearly equal to :

(A) A/μ **(B)** $A/(2\mu)$ **(C)** μA **(D)** $\mu A/2$

33. A prism of refractive index $\sqrt{2}$ has refracting angle 60º. Answer the following questions

(A) In order that a ray suffers minimum deviation it should be incident at an angle :

(A) 45^0 **(B)** 90^0 **(C)** 30^0 **(D)** none

(B) Angle of minimum deviation is :

(A) 45^0 **(B)** 90^0 **(C)** 30^0 **(D)** none

(C) Angle of maximum deviation is :

(A) 45^0 **(B)** $\sin^{-1}(\sqrt{2}\sin 15^\circ)$
(C) $30^\circ + \sin^{-1}(\sqrt{2}\sin 15^\circ)$ **(D)** none

34. There is a small black dot at the centre C of a solid glass sphere of refractive index μ. When seen from outside, the dot will appear to be located:

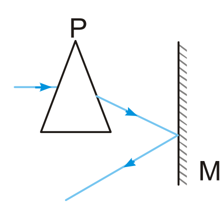
(A) away from C for all values of μ

(B) at C for all values of μ

(C) at C for $\mu = 1.5$, but away from C for $\mu \neq 1.5$

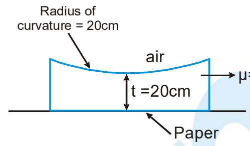
(D) at C only for $\sqrt{2} \leq \mu \leq 1.5$.

35. A prism having an apex angle of 4^0 and refractive index of 1.50 is located in front of a vertical plane mirror as shown in the figure. A horizontal ray of light is incident on the prism. The total angle through which the ray is deviated is:



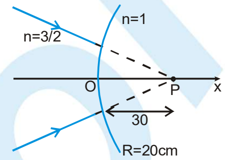
(A) 4^0 clockwise **(B)** 178^0 clockwise
(C) 2^0 clockwise **(D)** 8^0 clockwise

36. In the given figure a plano-concave 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

37. The image for the converging beam after refraction through the curved surface (in the given figure) is formed at:

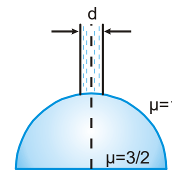


(A) $x = 40$ cm (B) $x = \frac{40}{3}$ cm

(C) $x = -\frac{40}{3}$ cm (D) $x = \frac{180}{7}$ cm

38. A convexo - concave diverging lens is made of glass of refractive index 1.5 and focal length 24 cm. Radius of curvature for one surface is double that of the other. Then radii of curvature for the two surfaces are (in cm):
(A) 6, 12 (B) 12, 24 (C) 3, 6 (D) 18, 36

39. A beam of diameter ' d ' is incident on a glass hemisphere as shown in the figure. If the radius of curvature of the hemisphere is very large in comparison to d, then the diameter of the beam at the base of the hemisphere will be:



(A) $\frac{3}{4}$ d (B) d (C) $\frac{d}{3}$ (D) $\frac{2}{3}$ d

40. When a lens of power P (in air) made of material of refractive index μ is immersed in liquid of refractive index μ_0. Then the power of lens is:

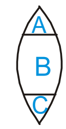
(A) $\frac{\mu - 1}{\mu - \mu_0}$ P (B) $\frac{\mu - \mu_0}{\mu - 1}$ P (C) $\frac{\mu - \mu_0}{\mu - 1} \cdot \frac{P}{\mu_0}$ (D) none of these

41. Two symmetric double convex lenses A and B have same focal length, but the radii of curvature differ so that $R_A = 0.9 R_B$. If $n_A = 1.63$, find n_B.
(A) 1.7 (B) 1.6 (C) 1.5 (D) 4/3

42. The diameter of the sun subtends an angle of 0.5^0 at the surface of the earth. A converging lens of focal length 100 cm is used to provide an image of the sun on to a screen. The diameter (in mm) of the image formed is nearly
(A) 1 (B) 3 (C) 5 (D) 9

43. A lens behaves as a converging lens in air and a diverging lens in water. The refractive index of the material is (refractive index of water = 1.33)
(A) equal to unity (B) equal to 1.33
(C) between unity and 1.33 (D) greater than 1.33

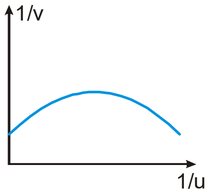
44. A thin symmetrical double convex lens of power P is cut into three parts, as shown in the figure. Power of A is:

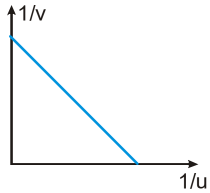


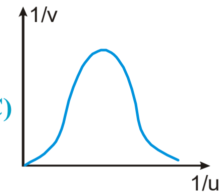
(A) 2 P (B) $\frac{P}{2}$ (C) $\frac{P}{3}$ (D) P

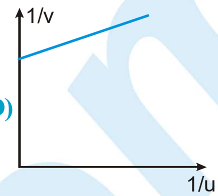
45. A thin lens of focal length f and its aperture diameter d, forms a real image of intensity I. Now the central part of the aperture upto diameter (d/2) is blocked by an opaque paper. The focal length and image intensity would change to :
(A) f/2, I/2 (B) f, I/4 (C) 3f/4, I/2 (D) f, 3I/4

46. An object is placed at a distance u from a converging lens and its real image is received on a screen placed at a distance of v from the lens. If f is the focal length of the lens, then the graph between $1/v$ versus $1/u$ is:

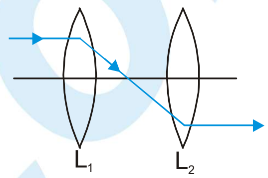
(A) 

(B) 

(C) 

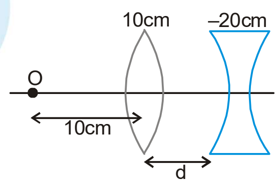
(D) 

47. In the figure given below, there are two convex lens L_1 and L_2 having focal length of f_1 and f_2 respectively. The distance between L_1 and L_2 will be



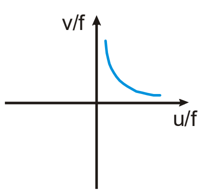
(A) f_1 **(B)** f_2
(C) $f_1 + f_2$ **(D)** $f_1 - f_2$

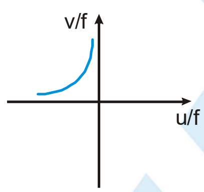
48. What should be the value of distance d so that final image is formed on the object itself. (focal lengths of the lenses are as given in the figure).

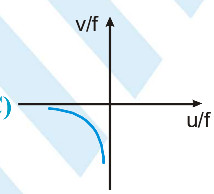


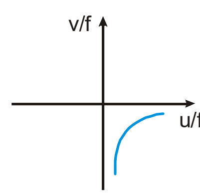
(A) 10 cm **(B)** 20 cm
(C) 5 cm **(D)** none of these

49. A virtual erect image by a **diverging lens** is represented by (u, v, f are coordinates)

(A) 

(B) 

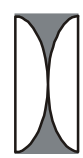
(C) 

(D) 

50. A biconvex lens is used to project a slide on screen. The slide is 2 cm high and placed at 10 cm from the lens. The image is 18 cm high. What is the focal length of the lens?
(A) 9 cm **(B)** 18 cm **(C)** 4.5 cm **(D)** 20 cm

51. A thin linear object of size 1 mm is kept along the principal axis of a convex lens of focal length 10 cm. The object is at 15 cm from the lens. The length of the image is:
(A) 1 mm **(B)** 4 mm **(C)** 2 mm **(D)** 8 mm

52. Two plano-convex lenses each of focal length 10 cm & refractive index $\frac{3}{2}$ are placed as shown in the figure. In the space left, water $\left(\text{R.I.}=\frac{4}{3}\right)$ is filled. The whole arrangement is in air. The optical power of the system is (in dioptre):



(A) 6.67 **(B)** - 6.67 **(C)** 33.3 **(D)** 20

53. The minimum distance between a real object and its real image formed by a thin converging lens of focal length f is
(A) 4f **(B)** 2f **(C)** f **(D)** f/2

54. In the above question the radius of curvature of the curved surface of plano-convex lens is :

(A) $\frac{280}{9}$ cm **(B)** $\frac{180}{7}$ cm **(C)** $\frac{39}{3}$ cm **(D)** $\frac{280}{11}$ cm

55. A plano-convex lens, when silvered at its plane surface is equivalent to a concave mirror of focal length 28 cm. When its curved surface is silvered and the plane surface not silvered, it is equivalent to a concave mirror of focal length 10 cm, then the refractive index of the material of the lens is:
(A) 9/14 **(B)** 14/9 **(C)** 17/9 **(D)** none

56. A convex lens of focal length 25 cm and a concave lens of focal length 20 cm are mounted coaxially separated by a distance d cm. If the power of the combination is zero, *d* is equal to
(A) 45 **(B)** 30 **(C)** 15 **(D)** 5

57. The focal length of a plano-concave lens is − 10 cm, then its focal length when its plane surface is polished is (n = 3/2):
(A) 20 cm **(B)** − 5 cm **(C)** 5 cm **(D)** none of these

58. Critical angle of light passing from glass to air is minimum for
(A) red **(B)** green **(C)** yellow **(D)** violet

59. The dispersion of light in a medium implies that :
(A) lights of different wavelengths travel with different speeds in the medium
(B) lights of different frequencies travel with different speeds in the medium
(C) the refractive index of medium is different for different wavelengths
(D) all of the above.

60 A plane glass slab is placed over various coloured letters. The letter which appears to be raised the least is:
(A) violet **(B)** yellow **(C)** red **(D)** green

61. All the listed things below are made of flint glass. Which one of these have greatest dispersive power (ω).
(A) prism **(B)** glass slab **(C)** biconvex lens **(D)** all have same ω

62. A medium has $n_v = 1.56$, $n_r = 1.44$. Then its dispersive power is:
(A) 3/50 **(B)** 6/25 **(C)** 0.03 **(D)** none of these

63. A simple microscope has a focal length of 5 cm. The magnification at the least distance of distinct vision is-
(A) 1 **(B)** 5 **(C)** 4 **(D)** 6

64. Light of wavelength 4000 Å is incident at small angle on a prism of apex angle 4º. The prism has $n_v = 1.5$ & $n_r = 1.48$. The angle of dispersion produced by the prism in this light is:
(A) 0.2º **(B)** 0.08º **(C)** 0.192º **(D)** None of these

65. The resolving power of a telescope is more when its objective lens has
(A) greater focal length **(B)** smaller focal length
(C) greater diameter **(D)** smaller diameter

66. In a compound microscope, the intermediate image is -
(A) virtual, erect and magnified **(B)** real, erect and magnified
(C) real, inverted and magnified **(D)** virtual, erect and reduced

67. The convex lens is used in-
(A) Microscope **(B)** Telescope **(C)** Projector **(D)** All of the above

68. A Galileo telescope has an objective of focal length 100 cm & magnifying power 50. The distance between the two lenses in normal adjustment will be
(A) 150 cm **(B)** 100 cm **(C)** 98 cm **(D)** 200 cm

69. The focal length of the objective of a microscope is
(A) arbitrary
(B) less than the focal length of eyepiece
(C) equal to the focal length of eyepiece
(D) greater than the focal length of eyepiece

70. The magnifying power of a simple microscope can be increased if an eyepiece of :
(A) shorter focal length is used
(B) longer focal length is used
(C) shorter diameter is used
(D) longer diameter is used

71. An astronomical telescope has an eyepiece of focal-length 5 cm. If the angular magnification in normal adjustment is 10, when final image is at least distance of distinct vision (25cm) from eye piece, then angular magnification will be :
(A) 10 **(B)** 12 **(C)** 50 **(D)** 60

72. Resolving power of a microscope depends upon
(A) the focal length and aperture of the eye lens
(B) the focal lengths of the objective and the eye lens
(C) the apertures of the objective and the eye lens
(D) the wavelength of light illuminating the object

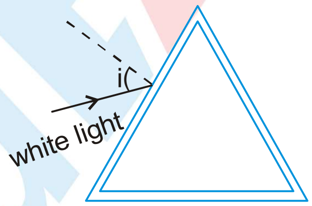
73. The focal lengths of the objective and eye-lens of a microscope are 1 cm and 5 cm respectively. If the magnifying power for the relaxed eye is 45, then the length of the tube is :
(A) 30 cm **(B)** 25 cm **(C)** 15 cm **(D)** 12 cm

74. A person with a defective sight is using a lens having a power of +2D. The lens he is using is
(A) concave lens with $f = 0.5$ m
(B) convex lens with $f = 2.0$ m
(C) concave lens with $f = 0.2$ m
(D) convex lens with $f = 0.5$ m

75. An object is placed 30 cm (from the reflecting surface) in front of a block of glass 10 cm thick having its farther side silvered. The final image is formed at 23.2 cm behind the silvered face. The refractive index of glass is :
(A) 1.41 **(B)** 1.46 **(C)** 200/ 132 **(D)** 1.61

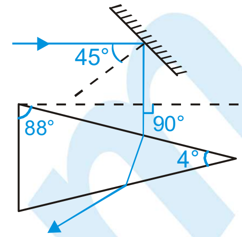
76. If the focal length of objective and eye lens are 1.2 cm and 3 cm respectively and the object is put 1.25 cm away from the objective lens and the final image is formed at infinity. The magnifying power of the microscope is :
(A) 150 **(B)** 200 **(C)** 250 **(D)** 400

77. A beam of white light is incident on hollow prism of glass as shown in figure. Then :



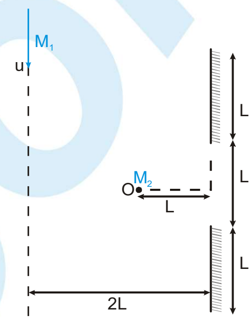
(A) the light emerging from prism gives no dispersion
(B) the light emerging from prism gives spectrum but the bending of all colours is away from base.
(C) the light emerging from prism gives spectrum, all the colours bend towards base, the violet the most and red the least.
(D) the light emerging from prism gives spectrum, all the colours bend towards base, the violet the least and red the most.

78. A ray of light strikes a plane mirror at an angle of incidence 45º as shown in the figure. After reflection, the ray passes through a prism of refractive index 1.50, whose apex angle is 4º. The angle through which the mirror should be rotated if the total deviation of the ray is to be 90º is :



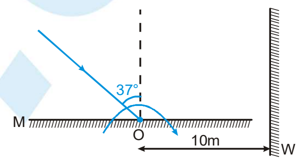
(A) 1^0 clockwise
(B) 1^0 anticlockwise
(C) 2^0 clockwise
(D) 2^0 anticlockwise

79. Two plane mirrors of length L are separated by distance L and a man M_2 is standing at distance L from the connecting line of mirrors as shown in figure. A man M_1 is walking in a straight line at distance 2 L parallel to mirrors at speed u, then man M_2 at O will be able to see image of M_1 for time:



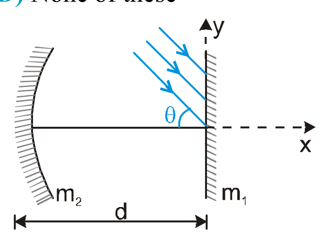
(A) $\frac{4L}{u}$
(B) $\frac{3L}{u}$
(C) $\frac{6L}{u}$
(D) $\frac{9L}{u}$

80. A light ray I is incident on a plane mirror M. The mirror is rotated in the direction as shown in the figure by an arrow at frequency 9/π rps. The light reflected by the mirror is received on the wall W at a distance 10 m from the axis of rotation. When the angle of incidence becomes 37º the speed of the spot (a point) on the wall is:



(A) 10 m/s
(B) 1000 m/s
(C) 500 m/s
(D) None of these

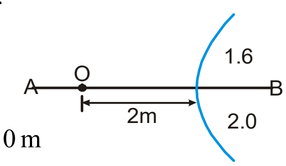
81. In the figure shown a thin parallel beam of light is incident on a plane mirror m_1 at small angle 'θ'. m_2 is a concave mirror of focal length 'f'. After three successive reflections of this beam the x and y coordinates of the image is



(A) $x = f - d, y = f\theta$
(B) $x = d + f, y = f\theta$
(C) $x = f - d, y = -f\theta$
(D) $x = d - f, y = -f\theta$

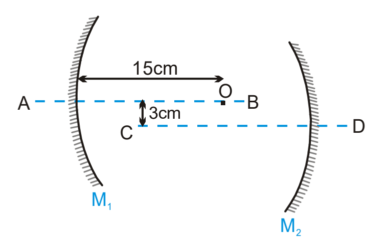
82. The distance between an object and its doubly magnified image by a concave mirror is:
[Assume f = focal length]
(A) 3 f/2
(B) 2 f/3
(C) 3 f
(D) depends on whether the image is real or virtual.

83. In the figure shown a point object O is placed in air. A spherical boundary of radius of curvature 1.0 m separates two media. AB is principal axis. The refractive index above AB is 1.6 and below AB is 2.0. The separation between the images formed due to refraction at spherical surface is:



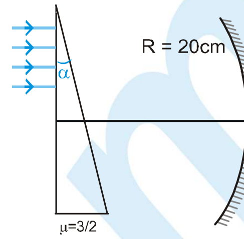
(A) 12 m
(B) 20 m
(C) 14 m
(D) 10 m

84. In the shown figure M_1 and M_2 are two concave mirrors of the same focal length 10 cm. AB and CD are their principal axes respectively. A point object O is kept on the line AB at a distance 15 cm from M_1. The distance between the mirrors is 20 cm. Considering two successive reflections first on M_1 and then on M_2. The distance of final image from the line AB is:



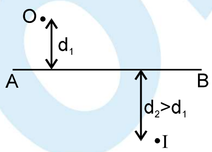
(A) 3 cm
(B) 1.5 cm
(C) 4.5 cm
(D) 1 cm

85. In the given figure a parallel beam of light is incident on the upper part of a prism of angle 1.8º and R.I. 3/2. The light coming out of the prism falls on a concave mirror of radius of curvature 20 cm. The distance of the point (where the rays are focused after reflection from the mirror) from the principal axis is: [use $\pi = 3.14$]



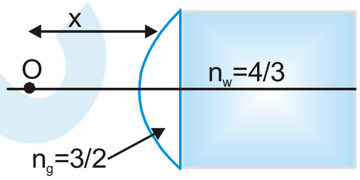
(A) 9 cm **(B)** 1.5 7 mm
(C) 3.14 mm **(D)** none of these

86. In the figure shown, the image of a real object is formed at point I. AB is the principal axis of the mirror. The mirror must be:



(A) concave and placed towards right of I
(B) concave and placed towards left of O
(C) convex and placed towards right of I

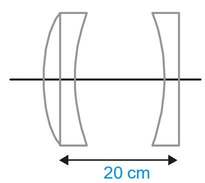
87. In the given figure an object ' O ' is kept in air in front of a thin plano convex lens of radius of curvature 10 cm. It's refractive index is 3/2 and the medium towards right of plane surface is water of refractive index 4/3. What should be the distance ' x ' of the object so that the rays become parallel finally.



(A) 5 cm **(B)** 10 cm
(C) 20 cm **(D)** none of these

88. For a prism of apex angle 45^0, it is found that the angle of emergence is 45^0 for grazing incidence. Calculate the refractive index of the prism.
(A) $(2)^{1/2}$ **(B)** $(3)^{1/2}$ **(C)** 2 **(D)** $(5)^{1/2}$

89. A symmetrical converging convex lens of focal length 10 cm & diverging concave symmetrical lens of focal length – 20 cm are cut from the middle and perpendicularly and symmetrically to their principal axis. The parts thus obtained are arranged as shown in the figure. The focal length of this arrangement will be:



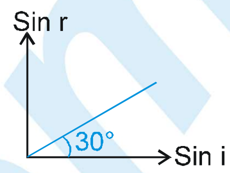
(A) ∞ **(B)** 20 cm
(C) 40 cm **(D)** 80 cm

90. The image (of a real object) formed by a concave mirror is twice the size of the object. The focal length of the mirror is 20 cm. The distance of the object from the mirror is (are)
(A) 10 cm **(B)** 30 cm **(C)** 25 cm **(D)** 15 cm

Exercise # 2

Part # I [Multiple Correct Choice Type Questions]

1. A ray of monochromatic light is incident on the plane surface of separation between two media x and y with angle of incidence 'i' in the medium x and angle of refraction 'r' in the medium y. The graph shows the relation between sin r and sin i.



(A) the speed of light in the medium y is $(3)^{1/2}$ times than in medium x.
(B) the speed of light in the medium y is $(1/3)^{1/2}$ times than in medium x.
(C) the total internal reflection can take place when the incidence is in x.
(D) the total internal reflection can take place when the incidence is in y.

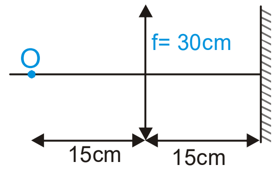
2. Which of the following statements are incorrect for spherical mirrors.
(A) a concave mirror forms only virtual images for any position of real object
(B) a convex mirror forms only virtual images for any position of a real object
(C) a concave mirror forms only a virtual diminished image of an object placed between its pole and the focus
(D) a convex mirror forms a virtual enlarged image of an object if it lies between its pole and the focus.

3. For the refraction of light through a prism kept in air
(A) For every angle of deviation there are two angles of incidence.
(B) The light travelling inside an isosceles prism is necessarily parallel to the base when prism is set for minimum deviation.
(C) There are two angles of incidence for maximum deviation.
(D) Angle of minimum deviation will increase if refractive index of prism is increased keeping the outside medium unchanged.

4. For refraction through a small angled prism, the angle of deviation ($n_{surrounding} < n_{prism}$)
(A) increases with the increase in refractive index of the prism.
(B) will be doubled if refractive index of the prism is doubled.
(C) is directly proportional to the angle of the prism .
(D) will decrease with the increase in refractive index of the prism.

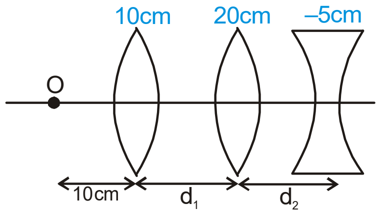
5. An equilateral prism deviates a ray through 40º for two angles of incidence differing by 20º. The possible angles of incidences are:
(A) 40^0 **(B)** 50^0 **(C)** 20^0 **(D)** 60^0

6. An object O is kept infront of a converging lens of focal length 30 cm behind which there is a plane mirror at 15 cm from the lens as shown in the figure.



(A) the final image is formed at 60 cm from the lens towards right of it
(B) the final image is at 60 cm from lens towards left of it
(C) the final image is real
(D) the final image is virtual.

7. The values of d_1 & d_2 for final rays to be parallel to the principal axis are : (focal lengths of the lenses are written above the respective lenses in the given figure)

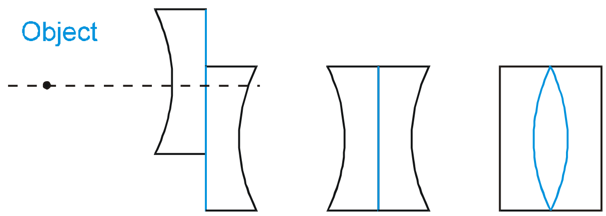


(A) $d_1 = 10$ cm, $d_2 = 15$ cm
(B) $d_1 = 20$ cm, $d_2 = 15$ cm
(C) $d_1 = 30$ cm, $d_2 = 15$ cm
(D) None of these

8. Which of the following cannot form real image of a real object ?

(A) concave mirror **(B)** convex mirror
(C) plane mirror **(D)** diverging lens

9. If a symmetrical biconcave thin lens is cut into two identical halves. They are placed in different ways as shown:



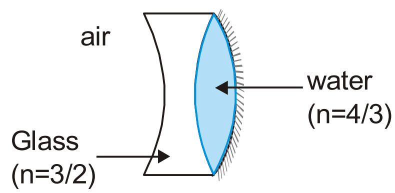
Fig(i) Fig(ii) Fig(iii)

(A) three images will be formed in case (i) **(B)** two images will be formed in the case (i)
(C) the ratio of focal lengths in (ii) & (iii) is 1 **(D)** the ratio of focal lengths in (ii) & (iii) is 2

10. By properly combining two prisms made of different materials, it is possible to

(A) have dispersion without average deviation **(B)** have deviation without dispersion
(C) have both dispersion and average deviation **(D)** have neither dispersion nor average deviation

11. In the figure shown the radius of curvature of the left & right surface of the concave lens are 10 cm & 15 cm respectively. The radius of curvature of the mirror is 15 cm.



(A) equivalent focal length of the combination is -18 cm
(B) equivalent focal length of the combination is +36 cm
(C) the system behaves like a concave mirror
(D) the system behaves like a convex mirror.

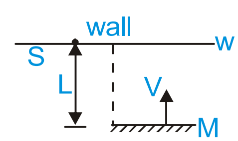
12. A narrow beam of white light goes through a slab having parallel faces

(A) The light never splits in different colours
(B) The emergent beam is white
(C) The light inside the slab is split into different colours
(D) The light inside the slab is white

13. A man wants to photograph a white donkey as a Zebra after fitting a glass with black streaks onto the lens of his camera.

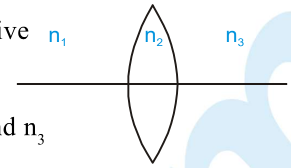
(A) The image will look like a white donkey on the photograph.
(B) The image will look like a Zebra on the photograph
(C) The image will be more intense compared to the case in which no such glass is used.
(D) The image will be less intense compared to the case in which no such glass is used.

14 A flat mirror M is arranged parallel to a wall W at a distance L from it as shown in the figure. The light produced by a point source S kept on the wall is reflected by the mirror and produces a light patch on the wall. The mirror moves with velocity v towards the wall.



(A) The patch of light will move with the speed v on the wall.
(B) The patch of light will not move on the wall.
(C) As the mirror comes closer the patch of light will become larger and shift away from the wall with speed larger than v.
(D) The width of the light patch on the wall remains the same.

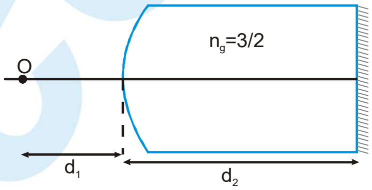
15. An equiconvex lens of refractive index n_2 is placed such that the refractive index of the surrounding media is as shown. Then the lens :



(A) must be diverging if n_2 is less than the arithmetic mean of n_1 and n_3
(B) must be converging if n_2 is greater than the arithmetic mean of n_1 and n_3
(C) may be diverging if n_2 is less than the arithmetic mean of n_1 and n_3
(D) will neither be diverging nor converging if n_2 is equal to arithmetic mean of n_1 and n_3

16. Two plane mirrors are inclined to each other with their reflecting faces making acute angle. A light ray is incident on one plane mirror. The total deviation after two successive reflections is:
(A) independent of the initial angle of incidence
(B) independent of the angle between the mirrors
(C) dependent on the initial angle of incidence
(D) dependent on the angle between the mirrors.

17. In the figure shown a point object O is placed in air on the principal axis. The radius of curvature of the spherical surface is 60 cm. I_f is the final image formed after all the refractions and reflections.



(A) If d_1 = 120 cm, then the 'I_f' is formed on 'O' for any value of d_2.
(B) If d_1 = 240 cm, then the 'I_f' is formed on 'O' only if d_2 = 360 cm.
(C) If d_1 = 240 cm, then the 'I_f' is formed on 'O' for all values of d_2.
(D) If d_1 = 240 cm, then the 'I_f' cannot be formed on 'O'.

18. Which of the following quantities related to a lens depend on the wavelength of the incident light?
(A) power
(B) focal length
(C) chromatic aberration
(D) radii of curvature

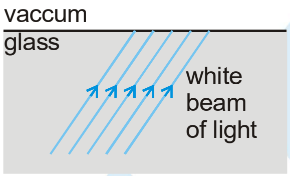
19. An object is kept on the principal axis of a convex mirror of focal length 10 cm at a distance of 10 cm from the pole. The object starts moving at a velocity 20 mm/sec towards the mirror at angle 30º with the principal axis. What will be the speed of its image and direction with the principal axis at that instant.

(A) speed = $5\dfrac{\sqrt{7}}{4}$ mm/sec
(B) speed = $\dfrac{5\sqrt{7}}{2}$ mm/sec
(C) $\tan^{-1}\left(\dfrac{2}{\sqrt{3}}\right)$ with the principal axis
(D) none of these

Part # II [Assertion & Reason Type Questions]

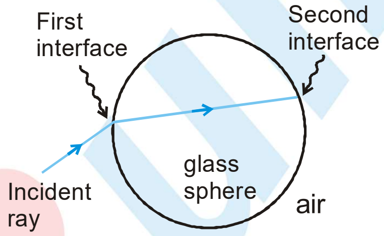
In each of the following questions, a Assertion of Statement -1 and Statement - 2 of Reason.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

1. **Statement-1 :** A white parallel beam of light is incident on a plane glass-vacuum interface as shown. The beam may not undergo dispersion after suffering deviation at the interface (The beam is not incident normally on the interface.)



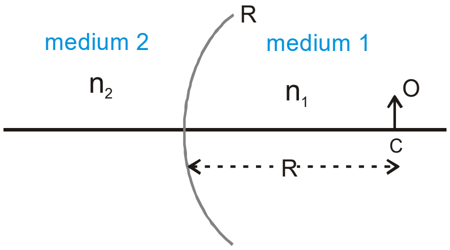
Statement 2 : Vacuum has same refractive index for all colours of white light.

2. **Statement-1 :** A ray is incident from outside on a glass sphere surrounded by air as shown. This ray may suffer total internal reflection at second interface.



Statement 2 : For a ray going from denser to rarer medium, the ray may suffer total internal reflection.

3. **Statement-1 :** A spherical surface of radius of curvature R separates two media of refractive index n_1 and n_2 as shown. If an object O (a thin small rod) is placed upright on principal axis at a distance R from pole (i.e., placed at centre of curvature), then the size of image is same as size of object.



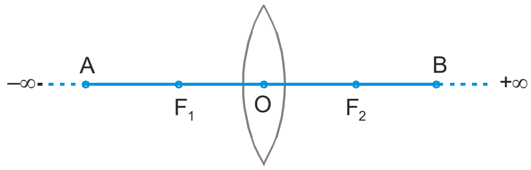
Statement-2 : If a point object is placed at centre of curvature of spherical surface separating two media of different refractive index, then the image is also formed at centre of curvature, i.e., image distance is equal to object distance.

4. **Statement-1 :** A point object moves near the principal axis of a fixed spherical mirror along a straight line. Then the image formed by the spherical mirror also moves along a straight line.

Statement-2 : For an incident ray on a fixed spherical mirror there is a fixed reflected ray. If a point object moves along this incident ray, its image will always lie on the given reflected ray. Further an incident ray can be drawn from the moving point object in its direction of velocity towards the mirror.

Exercise # 3 Part # I [Matrix Match Type Questions]

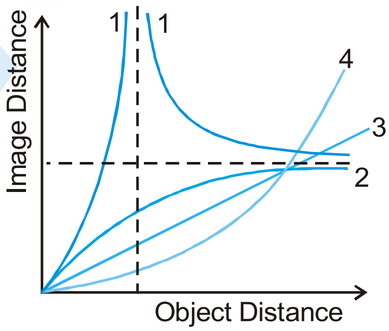
1. Consider the converging lens shown in figure :



Here O is the optic center, F_1 the first principal focus and F_2 the second 0principal focus. ($AF_1 = F_1O$ & $OF_2 = F_2B$)

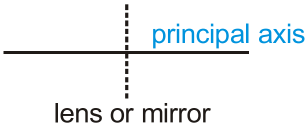
(A) Object lies between -∞ & F_1	**(J)** Image size is magnified	**(P)** Image lies between O & B
(B) Object lies between A and O	**(K)** Image size is diminished	**(Q)** Image does not lie between O & B
(C) Object lies between F_1 & +∞	**(L)** Image is inverted	**(R)** Image lies between -∞ & F_2
(D) Object does not lie between A and O	**(M)** Image is erect	**(S)** Image lies between F_2 & +∞

2. A small particle is placed at the pole of a concave mirror and then moved along the principal axis to a large distance. During the motion, the distance between the pole of the mirror and the image is measured. The procedure is then repeated with a convex mirror, a concave lens and a convex lens. The graph is plotted between image distance versus object distance. Match the curves shown in the graph with the mirror or lens that is corresponding to it. (Curve 1 has two segments)



Lens/Mirror	**Curve**
(A) Converging lens	**(P)** 1
(B) Converging Mirror	**(Q)** 2
(C) Diverging Lens	**(R)** 3
(D) Diverging Mirror	**(S)** 4

3. Column-I gives certain situations regarding a point object and its image formed by an optical instrument. The possible optical instruments are diverging and converging mirrors or lenses as given in Column-II. Same side of principal axis means both image and object should either be above the principal axis or both should be below the principal axis as shown in figure. Same side of optical instrument means both image and object should be either left of the optical instrument or both should be on right of the optical instrument as shown in figure. Match the statements in column-I with the corresponding statements in column-II .

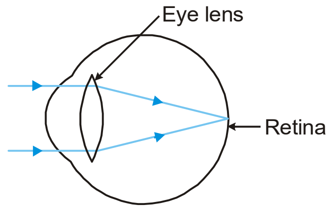


Column I	**Column II**
(A) If point object and its image are on same side of principal axis and opposite sides of the optical instrument then the optical instrument is	**(P)** Concave mirror
(B) If point object and its image are on opposite side of principal axis and same sides of the optical instrument then the optical instrument is	**(Q)** Convex mirror
(C) If point object and its image are on same side of principal axis and same sides of the optical instrument then the optical instrument is	**(R)** Diverging lens
(D) If point object and its image are on opposite side of principal axis and opposite sides of the optical instrument then the optical instrument is	**(S)** Converging lens

Part # II [Comprehension Type Questions]

Comprehension # 1

The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained the curvature of lens increases (that means radius of curvature decreases) and focal length decreases. For a clear vision the image must be on retina. The image distance is therefore fixed for clear vision and it equals the distance of retina from eye-lens. It is about 2.5 cm for a grown-up person (Refer the figure below).



A person can theoretically have clear vision of objects situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown-up person minimum distance of object should be around 25 cm.

A person suffering for eye defects uses spectacles (eye glass). The function of lens of spectacles is to form the image of the objects within the range in which person can see clearly. The image of the spectacle-lens becomes object for eye-lens and whose image is formed on retina.

The number of spectacle-lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle-lens is equal to the numerical value of the power of lens with sign. For example power of lens required is +3D (converging lens of focal length $\frac{100}{3}$ cm) then number of lens will be + 3.

For all the calculations required you can use the lens formula and lens maker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between eye lens and the spectacle lens.

1. Minimum focal length of eye lens of a normal person is

(A) 25 cm **(B)** 2.5 cm **(C)** $\frac{25}{9}$ cm **(D)** $\frac{25}{11}$ cm

2. Maximum focal length of eye lens of normal person is

(A) 25 cm **(B)** 2.5 cm **(C)** $\frac{25}{9}$ cm **(D)** $\frac{25}{11}$ cm

3. A nearsighted man can clearly see object only upto a distance of 100 cm and not beyond this. The number of the spectacles lens necessary for the remedy of this defect will be.

(A) +1 **(B)** – 1 **(C)** + 3 **(D)** – 3

4. A farsighted man cannot see object clearly unless they are at least 100 cm from his eyes. The number of the spectacles lens that will make his range of clear vision equal to an average grown up person

(A) + 1 **(B)** – 1 **(C)** + 3 **(D)** – 3

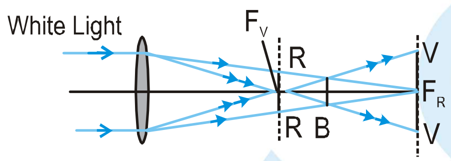
Comprehension # 2

Chromatic Aberration

The image of a white object in white light formed by a lens is usually coloured and blurred. This defect of image is called chromatic aberration and arises due to the fact that focal length of a lens is different for different colours. As R.I. μ of lens is maximum for violet while minimum for red, violet is focused nearest to the lens while red farthest from it as shown in figure.

As a result of this, in case of convergent lens if a screen is placed at F_V centre of the image will be violet and focused while sides are red and blurred. While at F_R, reverse is the case, i.e., centre will be red and focused while sides violet and blurred. The difference between f_V and f_R is a measure of the longitudinal chromatic aberration (L.C.A), i.e.,

L.C.A. $= f_R - f_V = -\,df$ with $df = f_V - f_R$ ....(1)



However, as for a single lens,

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \qquad \text{............(2)}$$

$$\Rightarrow \quad -\frac{df}{f^2} = d\mu\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \qquad \text{...........(3)}$$

Dividing Eqn. (3) by (2) ;

$$-\frac{df}{f} = \frac{d\mu}{(\mu - 1)} = \omega \qquad \left[\omega = \frac{d\mu}{(\mu-1)}\right] = \text{dispersive power} \quad \text{........(4)}$$

And hence, from Eqns. (1) and (4),

L.C.A. $= -df = \omega f$

Now, as for a single lens neither f nor ω can be zero, we cannot have a single lens free from chromatic aberration.

Condition of Achromatism :

In case of two thin lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \qquad \text{i.e.,} \qquad -\frac{dF}{F^2} = -\frac{df_1}{f_1^2} - \frac{df_2}{f_2^2}$$

The combination will be free from chromatic aberration if $dF = 0$

i.e., $$\frac{df_1}{f_1^2} + \frac{df_2}{f_2^2} = 0$$

which with the help of Eqn. (4) reduces to

$$\frac{\omega_1 f_1}{f_1^2} + \frac{\omega_2 f_2}{f_2^2} = 0 \qquad \text{i.e.,} \qquad \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0 \qquad \text{..........(5)}$$

This condition is called condition of achromatism (for two thin lenses in contact) and the lens combination which satisfies this condition is called achromatic lens, from this condition, i.e., from Eqn. (5) it is clear that in case of achromatic doublet :

(1) The two lenses must be of different materials.

Since, if $\omega_1 = \omega_2$, $\dfrac{1}{f_1} + \dfrac{1}{f_2} = 0$ i.e., $\dfrac{1}{F} = 0$ or $F = \infty$

i.e., combination will not behave as a lens, but as a plane glass plate.

(2) As ω_1 and ω_2 are positive quantities, for equation (5) to hold, f_1 and f_2 must be of opposite nature, i.e. if one of the lenses is converging the other must be diverging.

(3) If the achromatic combination is convergent,

$$f_C < f_D \quad \text{and} \quad \text{as} \quad -\frac{f_C}{f_D} = \frac{\omega_C}{\omega_D}, \ \omega_C < \omega_D$$

i.e., in a convergent achromatic doublet, convex lens has lesser focal length and dispersive power than the divergent one.

1. Chromatic aberration in the formation of images by a lens arises because :
(A) of non-paraxial rays.
(B) the radii of curvature of the two sides are not same.
(C) of the defect in grinding.
(D) the focal length varies with wavelength.

2. Chromatic aberration of a lens can be corrected by :
(A) providing different suitable curvatures of its two surfaces.
(B) proper polishing of its two surfaces.
(C) suitably combining it with another lens.
(D) reducing its aperture.

3. A combination is made of two lenses of focal lengths f and f' in contact ; the dispersive powers of the materials of the lenses are ω and ω'. The combination is achromatic when :
(A) $\omega = \omega_0, \omega' = 2\omega_0, f' = 2f$
(B) $\omega = \omega_0, \omega' = 2\omega_0, f' = f/2$
(C) $\omega = \omega_0, \omega' = 2\omega_0, f' = -f/2$
(D) $\omega = \omega_0, \omega' = 2\omega_0, f' = -2f$

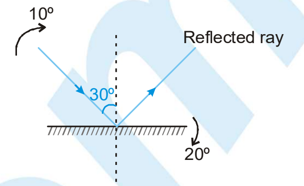
4. The dispersive power of crown and flint glasses are 0.02 and 0.04 respectively. An achromatic converging lens of focal length 40 cm is made by keeping two lenses, one of crown glass and the other of flint glass, in contact with each other. The focal lengths of the two lenses are :
(A) 20 cm and 40 cm
(B) 20 cm and –40 cm
(C) –20cm and 40 cm
(D) 10 cm and –20cm

5. Chromatic aberration in a spherical concave mirror is proportional to :
(A) f **(B)** f^2 **(C)** $1/f$ **(D)** None of these

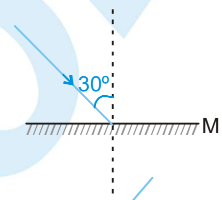
Exercise # 4

[Subjective Type Questions]

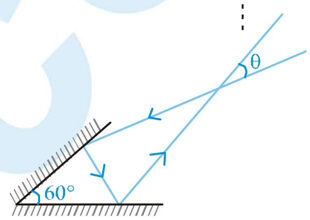
1. Figure shows a plane mirror on which a light ray is incident. If the incident light ray is turned by 10º and the mirror by 20º, as shown, find the angle turned by the reflected ray.



2. Find the angle of deviation (both clockwise and anticlockwise) suffered by a ray incident on a plane mirror, (as shown in figure) at an angle of incidence 30º.



3. A light ray is incident on a plane mirror, which after getting reflected strikes another plane mirror, as shown in figure. The angle between the two mirrors is 60º. Find the angle ‘θ’ shown in figure.

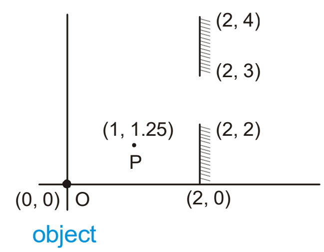


4. Two plane mirrors are placed as shown in the figure and a point object 'O' is placed at the origin

(a) How many images will be formed.

(b) Find the position(s) of image(s).

(c) Will the incident ray passing through a point 'P' (1, 1.25) take part in image formation.



5. Sun rays are incident at an angle of 24° with the horizon. How can they be directed parallel to the horizon using a plane mirror?

6. Find the diameter of the image of the moon formed by a spherical concave mirror of focal length 11.4 m. The diameter of the moon is 3450 km and the distance between the earth and the moon is 3.8×10^5 km.

7. A point source is at a distance 35 cm on the optical axis from a spherical concave mirror having a focal length 25 cm. At what distance measured along the optical axis from the concave mirror should a plane mirror (perpendicular to principal axis) be placed for the image it forms (due to rays falling on it after reflection from the concave mirror) to coincide with the point source?

8. A rod of length 5 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that the end farther from the pole is 15 cm away from it. Find the length of the image.

9. The radius of curvature of a convex spherical mirror is 1.2 m. How far away from the mirror is an object of height 1.2 cm if the distance between its virtual image and the mirror is 0.35 m? What is the height of the image? [Apply formula for paraxial rays]

10. A man uses a concave mirror for shaving. He keeps his face at a distance of 20 cm from the mirror and gets an image which is 1.5 times enlarged. Find the focal length of the mirror.

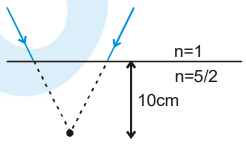
11. A converging beam of light rays is incident on a concave spherical mirror whose radius of curvature is 0.8 m. Determine the position of the point on the optical axis of the mirror where the reflected rays intersect, if the extensions of the incident rays intersect the optical axis 40 cm from the mirror's pole.

12. A point object is placed on the principal axis at 60 cm in front of a concave mirror of focal length 40 cm on the principal axis. If the object is moved with a velocity of 10 cm/s **(a)** along the principal axis, find the velocity of image **(b)** perpendicular to the principal axis, find the velocity of image at that moment.

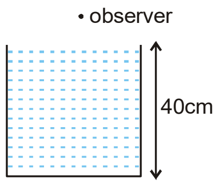
13. A light ray is incident at 45° on a glass slab. The slab is 3 cm thick, and the refractive index of the glass is 1.5. What will the lateral displacement of the ray be as a result of its passage through the slab? At what angle will the ray emerge from the slab?

14. A light ray falling at an angle of 60° with the surface of a clean slab of ice of thickness 1.00 m is refracted into it at an angle of 15°. Calculate the time taken by the light rays to cross the slab. Speed of light in vacuum = 3×10^8 m/s.

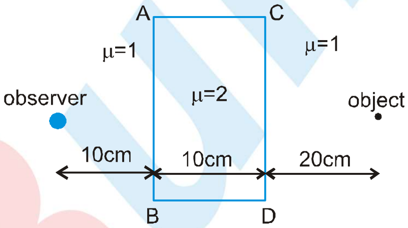
15. In the given figure rays incident on an interface would converge 10 cm below the interface if they continued to move in straight lines without bending. But due to refraction, the rays will bend and meet some where else. Find the distance of meeting point of refracted rays below the interface, assuming the rays to be making small angles with the normal to the interface.



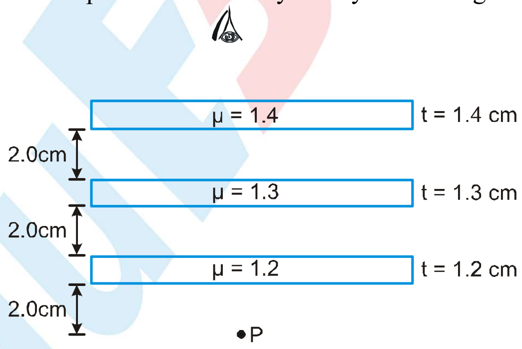
16. In the given figure an observer in air (n = 1) sees the bottom of a beaker filled with water (n = 4/3) upto a height of 40 cm. What will be the depth felt by this observer.



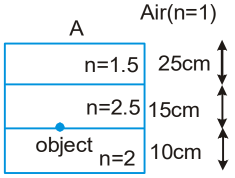
17. Find the apparent distance between the observer and the object shown in the figure and shift in the position of object.



18. Locate the image of the point P as seen by the eye in the figure.



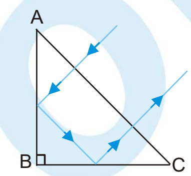
19. Find the apparent depth of the object seen by observer A (in the figure shown)



20. A point source is placed at a depth h below the surface of water (refractive index = μ). The medium above the surface of water is air (μ =1). Find the area on the surface of water through which light comes in air from water.

21. A small object is placed at the centre of the bottom of a cylindrical vessel of radius 3 cm and height $3\sqrt{3}$ cm filled completely with a liquid. Consider the ray leaving the vessel through a corner. Suppose this ray and the ray along the axis of the vessel are used to trace the image. Find the apparent depth of the image. Refractive index of liquid = $\sqrt{3}$.

22. At what values of the refractive index of a rectangular prism can a ray travel as shown in figure. The section of the prism is an isosceles triangle and the ray is normally incident onto the face AC.



23. Light goes from glass ($\mu = \frac{3}{2}$) to air. Find the angle of incidence for which the angle of deviation is 90º.

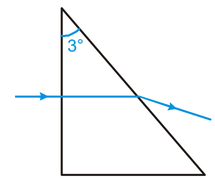
24. The cross section of a glass prism has the form of an equilateral triangle. A ray is incident onto one of the faces perpendicular to it. Find the angle θ between the incident ray and the ray that leaves the prism. The refractive index of glass is μ = 1.5.

25. A prism (n = 2) of apex angle 90° is placed in air (n = 1). What should be the angle of incidence so that light ray strikes the second surface at an angle of incidence 60º.

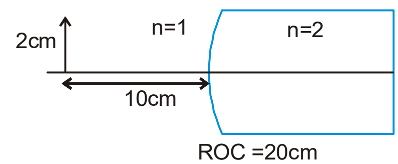
26. Find the angle of deviation suffered by the light ray shown in figure for following two conditions The refractive index for the prism material is μ = 3/2.

(i) When the prism is placed in air (μ = 1)

(ii) When the prism is placed in water (μ = 4/3)

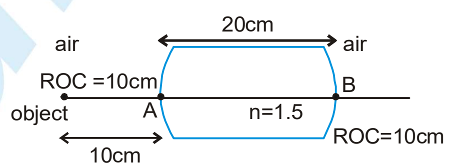


27. An extended object of size 2 cm is placed at a distance of 10 cm in air (n = 1) from pole, on the principal axis of a spherical curved surface. The medium on the other side of refracting surface has refractive index n = 2. Find the position, nature and size of image formed after single refraction through the curved surface.



28. A narrow parallel beam of light is incident paraxially on a solid transparent sphere of radius r kept in air. What should be the refractive index if the beam is to be focused **(a)** at the farther surface of the sphere, **(b)** at the centre of the sphere.

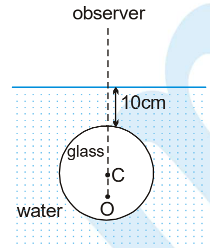
29. An object is placed 10 cm away from a glass piece (n = 1.5) of length 20 cm bounded by spherical surfaces of radii of curvature 10 cm. Find the position of final image formed after two refractions at the spherical surfaces.



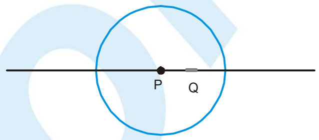
30. A point object lies inside a transparent solid sphere of radius 20 cm and of refractive index n = 2. When the object is viewed from air through the nearest surface it is seen at a distance 5 cm from the surface. Find the apparent distance of object when it is seen through the farthest curved surface.

31. Lenses are constructed by a material of refractive index 2. The magnitude of the radii of curvature are 20 cm and 30 cm. Find the focal lengths of the possible lenses with the above specifications.

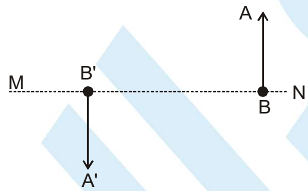
32. There is a small air bubble inside a glass sphere (μ = 1.5) of radius 5cm. The bubble is at 'O' at 7.5 cm below the surface of the glass. The sphere is placed inside water ($\mu = \frac{4}{3}$) such that the top surface of glass is 10 cm below the surface of water. The bubble is viewed normally from air. Find the apparent depth of the bubble.



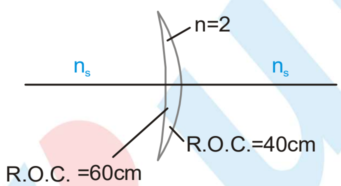
33. A small object Q of length 1 mm lies along the principal axis of a spherical glass of radius R = 10 cm and refractive index is 3/2. The object is seen from air along the principal axis from left. The distance of object from the centre P is 5 cm. Find the size of the image. Is it real, inverted?



34. Given an optical axis MN and the positions of a real object AB and its image A 'B', determine diagrammatically the position of the lens (its optical centre O) and its foci. Is it a converging or diverging lens? Is the image real or virtual?



35. Find the focal length of lens shown in the figure. Solve for three cases n_s = 1.5, n_s = 2.0, n_s = 2.5.



36. An object of height 1 cm is set at right angles to the optical axis of a double convex lens of optical power 5 D and 25 cm away from the lens. Determine the focal length of the lens, the position of the image, the linear magnification of the lens, and the height of the image formed by it.

37. A thin lens made of a material of refractive index μ_2 has a medium of refractive index μ_1 on one side and a medium of refractive index μ_3 on the other side. The lens is biconvex and the two radii of curvature has equal magnitude R. A beam of light travelling parallel to the principal axis is incident on the lens. Where will the image be formed if the beam is incident from **(a)** the medium μ_1 and **(b)** from the medium μ_3?

38. A pin of length 1 cm lies along the principal axis of a converging lens, the centre being at a distance of 5.5 cm from the lens. The focal length of the lens is 3 cm. Find the size of the image.

39. A lens placed between a candle and a fixed screen forms a real triply magnified image of the candle on the screen. When the lens is moved away from the candle by 0.8 m without changing the position of the candle, a real image one-third the size of the candle is formed on the screen. Determine the focal length of the lens.

40. A 2.5 dioptre lens forms a virtual image which is 4 times the object placed perpendicularly on the principal axis of the lens. Find the required distance of the object from the lens.

41. The radius of the sun is 0.75×10^9 m and its distance from the earth is 1.5×10^{11} m. Find the diameter of the image of the sun formed by a lens of focal length 40 cm.

42. A convex lens and a convex mirror are placed at a separation of 15 cm. The focal length of the lens is 25 cm and radius of curvature of the mirror is 80 cm. Where should a point source be placed between the lens and the mirror so that the light, after getting reflected by the mirror and then getting refracted by the lens, comes out parallel to the principal axis?

43. A diverging lens of focal length 20 cm is placed coaxially 5 cm towards left of a converging mirror of focal length 10 cm .Where should an object be placed towards left of the lens so that a real image is formed at the object itself ?

44. A converging lens of focal length 10 cm and a diverging lens of focal length 5 cm are placed 5 cm apart with their principal axes coinciding. A beam of light travelling parallel to the principal axis and having a beam diameter 5.0 mm, is incident on the combination. Show that the emergent beam is parallel to the incident one. Find the beam diameter of the emergent beam. Also find out the ratio of emergent and incident intensities.

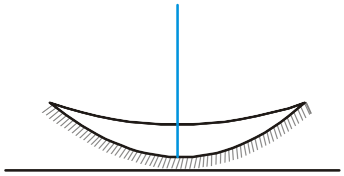
45. A point object is placed on the principal axis of a converging lens of focal length 15 cm at a distance of 30 cm from it. A glass plate ($\mu = 1.50$) of thickness 3 cm is placed on the other side of the lens perpendicular to the axis. Find the position of the image of the point object.

46. A point object is placed at a distance of 15 cm from a convex lens. The image is formed on the other side at a distance of 30 cm from the lens. When a concave lens is placed in contact with the convex lens, the image shifts away further by 30 cm. Calculate the focal lengths of the two lenses.

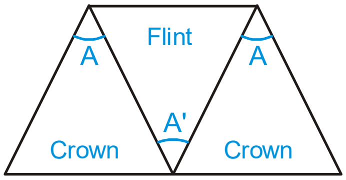
47. Two identical thin converging lenses brought in contact so that their axes coincide are placed 12.5 cm from an object. What is the optical power of the system and each lens, if the real image formed by the system of lenses is four times as large as the object?

48. A certain material has refractive indices 1.53, 1.60 and 1.68 for red, yellow and violet light respectively. **(a)** Calculate the dispersive power. **(b)** Find the angular dispersion produced by a thin prism of angle 6° made of this material.

49. The convex surface of a thin concavo-convex lens of glass of refractive index 1.5 has a radius of curvature 20 cm. the concave surface has a radius of curvature 60 cm. The convex side is silvered and placed on a horizontal surface as shown in figure. **(a)** Where should a pin be placed on the axis so that its image is formed at the same place? **(b)** If the concave part is filled with water ($\mu = 4/3$), find the distance through which the pin should be moved so that the image of the pin again coincides with the pin.



50. Three thin prisms are combined as shown in figure. The refractive indices of the crown glass for red, yellow and violet rays are μ_r, μ_y and μ_v respectively and those for the flint glass are μ_r', μ_y' and μ_v' respectively. Find the ratio A'/A for which **(a)** system produces deviation without dispersion (achromatic combination)and **(b)** system produces dispersion without deviation(direct vision arrangement).



51. A flint glass prism and a crown glass prism are to be combined in such a way that the deviation of the mean ray is zero. The refractive index of flint and crown glasses for the mean ray are 1.6 and 1.9 respectively. If the refracting angle of the flint prism is 6°, what would be the refracting angle of crown prism?

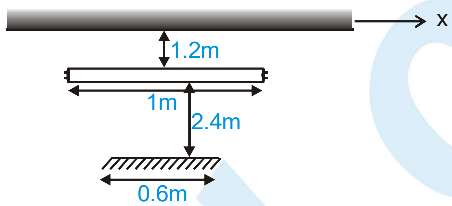
52. An angular magnification (magnifying power) of 30 X is desired using an objective of focal length 1.25cm and an eye-piece of focal length 5 cm. How will you set up the compound microscope?

53. A small telescope has an objective lens of focal length 144 cm and an eye-piece of focal length 6.0 cm. What is the magnifying power of the telescoped? What is the separation between the objective and the eye-piece?

54. A compound microscope consists of an objective lens of focal 2.0 cm and an eye-piece of focal length 6.25 cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at **(a)** least distance of distinct vision (25 cm), **(b)** infinity? What is the magnifying power of the microscope in each case ?

55. **(a)** A giant refracting telescope at an observatory has an objective lens of focal length 15 m. If an eye-piece of focal length 1.0 cm is used, what is the angular magnification of the telescope?
(b) If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.48×10^6 m and the radius of lunar orbit 3.8×10^8 m.

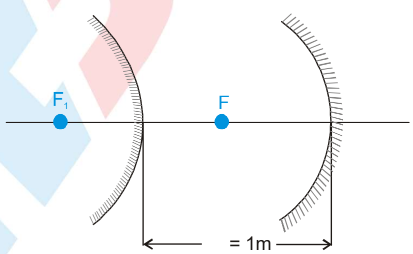
56. A fluorescent lamp of length 1 m is placed horizontally at a depth of 1.2 m below a ceiling. A plane mirror of length 0.6 m is placed below the lamp parallel to and symmetric to the lamp at a distance 2.4 m from it as shown in figure. Find the length (distance between the extreme points of the visible region along x-axis) of the reflected patch of light on the ceiling.



57. A plane mirror 50 cm long, is hung on a vertical wall of a room, with its lower edge 50 cm above the ground. A man stands infront of the mirror at a distance 2 m away from the mirror. If his eyes are at a height 1.8 m above the ground, find the length (distance between the extreme points of the visible region perpendicular to the mirror) of the floor visible to him due to reflection from the mirror.

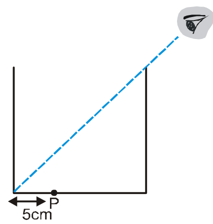
58. A burning candle is placed in front of a concave spherical mirror on its principal optical axis at a distance of (4/3)F from the pole of the mirror (here F is the focal length of the mirror). The candle is arranged at right angle to the axis. The image of the candle in the concave mirror impinges upon a convex mirror of focal length 2 F. The distance between the mirrors is 3F and their axes coincide. The image of the candle in the first mirror plays the part of a virtual object with respect to the second mirror and gives a real image arranged between the two mirrors. Plot this image and calculate the total linear magnification of the system.

59. Two spherical mirrors (convex and concave) having the same focal length of 36 cm are arranged as shown in figure so that their optical axes coincide. The separation between the mirrors is 1 m. At what distance from the concave mirror should an object be placed so that its images formed by the concave and convex mirrors independently are identical in size?



60. A convex mirror and a concave mirror each of focal length f are placed coaxially. They are separated by 4f and their reflecting surfaces face each other. A point object is kept on the principle axis at a distance x from the concave mirror such that final image after two reflections, first on the concave mirror, is on the object itself. Find x in terms of f.

61. A cylindrical vessel, whose diameter and height both are equal to 30 cm, is placed on a horizontal surface and a small particle P is placed in it at a distance of 5.0 cm from the corner. An eye is placed at a position such that the edge of the bottom is just visible (see figure). The particle P is in the plane of drawing. Up to what height should water be poured in the vessel to make the particle P visible? ($n_w = 4/3$)

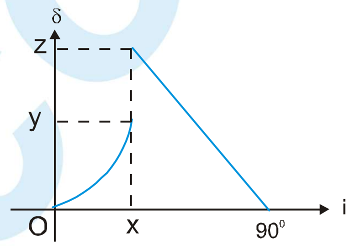


62. A concave mirror forms the real image of a point source lying on the optical axis at a distance of 50 cm from the mirror. The focal length of the mirror is 25 cm. The mirror is cut into two halves and its halves are drawn a distance of 1 cm apart (from each other) in a direction perpendicular to the optical axis. How will the images formed by the two halves of the mirror be arranged?

63. A container contains water upto a height of 20 cm and there is a point source at the centre of the bottom of the container. A rubber ring of radius r floats centrally on the water. The ceiling of the room is 2.0 m above the water surface. **(a)** Find the radius of the shadow of the ring formed on the ceiling if r = 15 cm. **(b)** Find the maximum value of r for which the shadow of the ring is formed on the ceiling. Refractive index of water = 4/3.

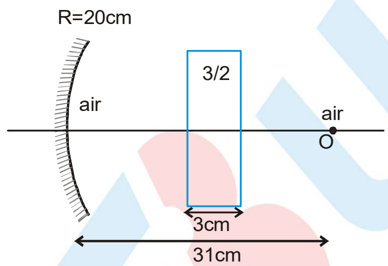
64. A fish is rising up vertically inside a pond with velocity 4 cm/s, and notices a bird, which is diving vertically downward and its velocity appears to be 16 cm/s (to the fish). What is the real velocity of the diving bird, if refractive index of water is 4/3?

65. (i) Light is incident from glass to air. The variation of the angle of deviation δ with the angle of incidence i for $0 < i < 90°$ is shown. Find the values of x,y and z, (in terms of critical angle C), shown in the figure.



(ii) Light is incident from glass $\left(\mu_g = \frac{3}{2}\right)$ to water $\left(\mu_w = \frac{4}{3}\right)$. Find the range of the angle of deviation for which there is only one angle of incidence for one deviation.

66. See the figure.



Find the distance (from the mirror) of final image formed by the system.

67. In an experiment performed with a 60° prism where angle of minimum deviation for sodium light is 60° in air. The following experiment was done. When sodium light enters at one face at grazing incidence from a certain liquid, it emerges from the other face (in air) at 60° from the normal to edge of the prism. Are the observations correct?

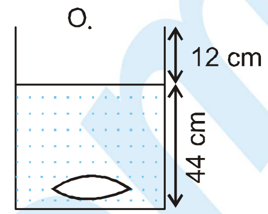
68. A light ray, going through a prism with the angle of prism 60°, is found to deviate by 30°. What limit on the refractive index can be put from these data?

69. A converging lens of focal length 15 cm and a converging mirror of focal length 10 cm are placed 50 cm apart with common principal axis. A point source is placed in between the lens and the mirror at a distance of 40 cm from the lens. Find the distance between the two images formed.

70. A hemispherical portion of the surface of a solid glass sphere (μ = 1.5) of radius r (surrounding is air) is silvered to make the inner side reflecting. An object is placed on the axis of the hemisphere at a distance 3r from the centre of the sphere. The light from the object is refracted at the unsilvered part, then reflected from the silvered part and again refracted at the unsilvered part. Locate the final image formed.

71. The focal lengths of a convex lens for red, yellow and violet rays are 100 cm, 99 cm and 98 cm respectively. Find the dispersive power of the material of the lens.

72. An object O is kept in air and a lens of focal length 10 cm (in air) is kept at the bottom of a container which is filled upto a height 44 cm by water. The refractive index of water is 4/3 and that of glass is 3/2. The bottom of the container is closed by a thin glass slab of refractive index 3/2. Find the position of the final image formed by the system (refer to figure shown below).



73. A thin prism of angle 5.0°, $\omega = 0.07$ and $\mu_y = 1.30$ is combined with another thin prism having $\omega = 0.08$ and $\mu_y = 1.50$. The combination produces no deviation in the mean ray. **(a)** Find the angle of the second prism. **(b)** Find the net angular dispersion produced by the combination when a beam of white light passes through it. **(c)** If the prisms are similarly directed, what will be the deviation in the mean ray? **(d)** Find the angular dispersion in the situation described in **(c)**.

Exercise # 5 — Part # I — [Previous Year Questions] [AIEEE/JEE-MAIN]

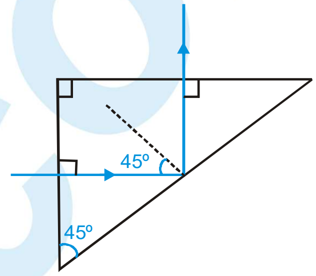
1. The image formed by an objective of a compound microscope is **[AIEEE-2003]**

(1) virtual and diminished **(2)** real and diminished
(3) real and enlarged **(4)** virtual and enlarged

2. To get three images of a single object, one should have two plane mirrors at an angle of **[AIEEE-2003]**

(1) 60º **(2)** 90º **(3)** 120º **(4)** 30º

3. A light ray is incident perpendicularly to one face to a 90º prism and is totally internally reflected at the glass-air interface. If the angle of reflec tion is 45º, we conclude that the refractive index n is **[AIEEE-2004]**



(1) $n < \frac{1}{\sqrt{2}}$ **(2)** $n > \sqrt{2}$

(3) $n > \frac{1}{\sqrt{2}}$ **(4)** $n < \sqrt{2}$

4. A plano convex lens of refractive index 1.5 and radius of curvature 30 cm is silvered at the curved surface. Now this lens has been used to from the image of an object. At what distance from this lens an object be placed in order to have a real image of the size of the object. **[AIEEE-2004]**

(1) 20 cm **(2)** 30 cm **(3)** 60 cm **(4)** 80 cm

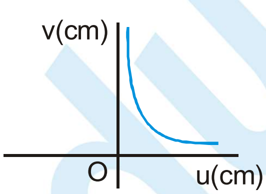
5. The refractive index of glass is 1.520 for red light and 1.525 for blue light. Let D_1 and D_2 be angles of minimum deviation for red and blue light respectively in a prism of this glass. Then, **[AIEEE-2006]**

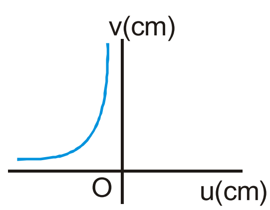
(1) D_1 can be less than or greater than D_2 depending upon the angle of prism
(2) $D_1 > D_2$
(3) $D_1 < D_2$
(4) $D_1 = D_2$

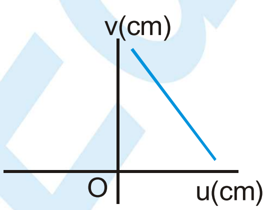
6. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by - **[AIEEE-2008]**

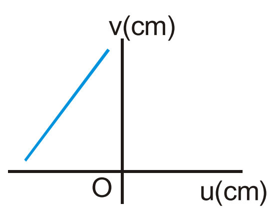
(1) a standard laboratory scale **(2)** a meter scale provided on the microscope
(3) a screw gauge provided on the microscope **(4)** a vernier scale provided on the microscope

7. A student measures the focal length of a convex lens by putting an object pin at a distance |u| from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like- **[AIEEE-2008]**

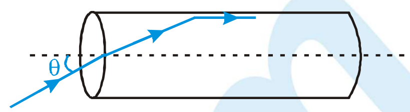
(1)


(2)


(3)


(4)


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. **[AIEEE-2009]**

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

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

9. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be: **[AIEEE-2009]**

(1) $\left(\frac{f}{2}, \frac{f}{2}\right)$ **(2)** (f, f) **(3)** (4f, 4f) **(4)** (2f, 2f)

10. 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 : **[AIEEE - 2011]**

(1) $\frac{1}{10}$ m/s **(2)** $\frac{1}{15}$ m/s **(3)** 10 m/s **(4)** 15 m/s

11. Let the x - z plane be the boundary between two transparent media. Medium 1 in $z \geq 0$ has refractive index of $\sqrt{2}$ and medium 2 with $z < 0$ has a refractive index of $\sqrt{3}$. A ray of light in medium 1 given by the vector $\vec{A} = 6\sqrt{3}\,\hat{i} + 8\sqrt{3}\,\hat{j} - 10\,\hat{k}$ in incident on the plane of separation. The angle of refraction in medium 2 is : **[AIEEE - 2011]**

(1) 30º **(2)** 45º **(3)** 60º **(4)** 75º

12. **Direction :**

The question has a paragraph followed by two statements, Statement –1 and Statement –2. Of the given four alternatives after the statements, choose the one that describes the statements.

A thin air film is formed by putting the convex surface of a plane-convex lens over a plane glass plate. With monochromatic light, this film gives an interference pattern due to light reflected from the top (convex) surface and the bottom (glass plate) surface of the film.

Statement –1 :

When light reflects from the air-glass plate interface, the reflected wave suffers a phase change of π

Statement –2 :

The centre of the interference pattern is dark.

(1) Statement –1 is true, statement –2 is false.
(2) Statement –1 is true, Statement –2 is true, Statement –2 is the correct explanation of Statement –1
(3) Statement –1 is true, Statement –2 is true, Statement –2 is not the correct explanation of Statement–1
(4) Statement–1 is false, Statement –2 is true

13. A beaker contains water up to a height h_1 and kerosene of height h_2 above water so that the total height of (water + kerosene) is $(h_1 + h_2)$. Refractive index of water is μ_1 and that of kerosene is μ_2. The apparent shift in the position of the bottom of the beaker when viewed from above is : **[AIEEE 2011]**

(1) $\left(1+\frac{1}{\mu_1}\right)h_1 - \left(1+\frac{1}{\mu_2}\right)h_2$ **(2)** $\left(1-\frac{1}{\mu_1}\right)h_1 + \left(1-\frac{1}{\mu_2}\right)h_2$

(3) $\left(1+\frac{1}{\mu_1}\right)h_2 - \left(1+\frac{1}{\mu_2}\right)h_1$ **(4)** $\left(1-\frac{1}{\mu_1}\right)h_2 + \left(1-\frac{1}{\mu_2}\right)h_1$

14. When monochromatic red light is used instead of blue light in a convex lens, its focal length will : **[AIEEE 2011]**

(1) increase (2) decrease
(3) remain same (4) does not depend on colour of light

15. An object 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 on film ? **[AIEEE 2012]**

(1) 7.2 m (2) 2.4 m (3) 3.2 m (4) 5.6 m

16. A thin convex lens made from crown glass $\left[\mu = \frac{3}{2}\right]$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal lengths is: **[JEE-MAIN - 2014]**

(1) $f_2 > f$ and f_1 becomes negative (2) f_1 and f_2 both become negative
(3) $f_1 = f_2 < f$ (4) $f_1 > f$ and f_2 becomes negative

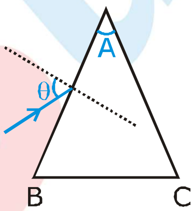
17. Assuming human pupil to have a radius of 0.25 cm and a comfortable viewing distance of 25 cm, the minimum separation between two objects that human eye can resolve at 500 nm wavelength is : **[JEE-MAIN - 2015]**

(1) 100 μm (2) 300 μm (3) 1 μm (4) 30 μm

18. On a hot summer night, the refractive index of air is smallest near the ground and increases with height from the ground. When a light beam is directed horizontally, the Huygens' principle leads us to conclude that as it travels, the light beam : **[JEE-MAIN - 2015]**

(1) bends downwards (2) bends upwards
(3) becomes narrower (4) goes horizontally without any deflection

19. Monochromatic light is incident on a glass prism of angle A. If the refractive index of the material of the prism is μ, a rav, incident at an angle θ, on the face AB would get transmitted through the face AC of the prism provided : **[JEE-MAIN - 2015]**



(1) $\theta > \cos^{-1}\left[\mu\sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$ (2) $\theta < \cos^{-1}\left[\mu\sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

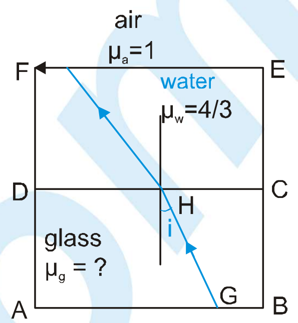
(3) $\theta > \sin^{-1}\left[\mu\sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$ (4) $\theta > \sin^{-1}\left[\mu\sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

20. An observer looks at a distant tree of height 10m with a telescope of magnifying power of 20. To the observer the tree appears : **[JEE-MAIN - 2016]**

(1) 10 times nearer. (2) 20 times taller. (3) 20 times nearer (4) 10 times taller.

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

1.(i) If ray of light (GH) is incident on the glass-water interface DC at an angle 'i'. It emerges in air along the water-air interface EF (see figure). If the refractive index of water μ_w is 4/3, the refractive index of glass μ_g is : **[JEE 2003]**



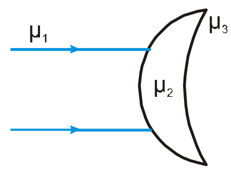
(A) $\dfrac{3}{4\sin\ i}$ **(B)** $\dfrac{1}{\sin\ i}$

(C) $\dfrac{4\sin\ i}{3}$ **(D)** $\dfrac{4}{3\ \sin\ i}$

(ii) A thin convex lens of focal length 30 cm forms an image 2 cm high, of an object at infinity. A thin concave lens of focal length 20 cm is placed 26 cm from the convex lens on the side of the image. The height of the image now is :

(A) 1.0 cm **(B)** 1.25 cm **(C)** 2 cm **(D)** 2.5 cm

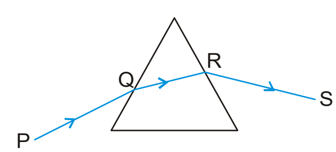
2. A meniscus lens is made of a material of refractive index μ_2. Both its surfaces have radii of curvature R. It has two different media of refractive indices μ_1 and μ_3 respectively, on its two sides (shown in the figure). Calculate its focal length for $\mu_1 < \mu_2 < \mu_3$, when light is incident on it as shown **[JEE 2003]**



3. A point object is situated at the centre of a solid glass sphere of radius 6cm and refractive index 1.5 . The distance of its virtual image from the surface of the sphere is. **[JEE 2004]**

(A) 4 cm **(B)** 6 cm **(C)** 9 cm **(D)** 12 cm

4. An equilateral prism is kept on a horizontal surface. A typical ray of light PQRS is shown in the figure. For minimum deviation **[JEE 2004]**



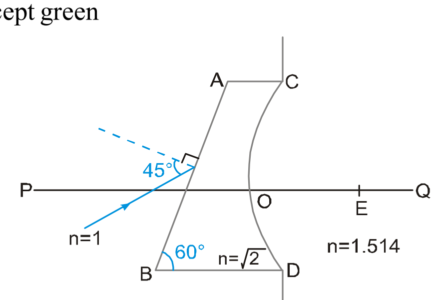
(A) the ray PQ must be horizontal
(B) the ray RS must be horizontal
(C) the ray QR must be horizontal
(D) any one of them can be horizontal

5. A ray of white light is incident on an interface between glass and air from glass towards air. The angle of incidence is such that the green light just suffers total internal reflection. The ray of light emerging from glass to air contains: **[JEE 2004 (Scr.)]**

(A) red, orange and yellow colours **(B)** violet, indigo and blue colour

(C) all colours **(D)** all colours except green

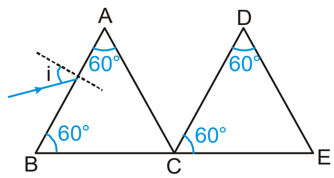
6. A ray of light in air is incident on face AB of an irregular block made of material with refractive index $\sqrt{2}$, as shown in figure. The face CD opposite to AB is a spherical surface of radius of curvature 0.4 m. From this face the refracted ray enters a medium of refractive index 1.514 and meets the axis PQ at point E.
Determine the distance OE, correct to two decimal places.



[JEE 2004]

7. An object is placed at a distance of 0.4 m from a lens having focal length 0.3 m. The object is moving towards the lens at a speed of 0.01 m/s. Find the rate of change of position of image and lateral magnification of image. **[JEE 2004]**

8. In the figure two triangular prisms are shown each of refractive index $\sqrt{3}$.

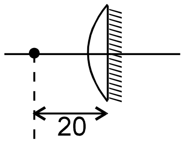


[JEE 2005]

(A) Find the angle of incidence on the face AB for minimum deviation from the prism ABC?

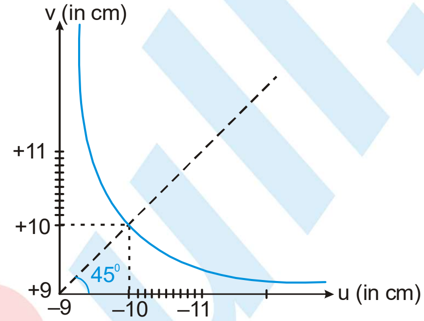
(B) Find the angle through which the prism DCE should be rotated about the edge passing through point C so that there should be minimum deviation from the system?

9. A point object is placed at a distance of 20 cm from a thin plano-convex lens of focal length 15 cm. The plane surface of the lens is now silvered.
The image created by the system is at : **[JEE 2006]**



(A) 60 cm to the left of the system. **(B)** 60 cm to the right of the system.
(C) 12 cm to the left of the system. **(D)** 12 cm to the right of the system.

10. The graph between object coordinate u and image coordinate v for a lens is given below. The focal length of the lens is: **[JEE 2006]**



(A) 5 ± 0.1 **(B)** 5 ± 0.05 **(C)** 0.5 ± 0.1 **(D)** 0.5 ± 0.05

11. A biconvex lens of focal length f forms a circular image of radius r of sun in focal plane. Then which option is correct: **[JEE 2006]**

(A) $\pi r^2 \propto f$
(B) $\pi r^2 \propto f^2$
(C) If lower half part is covered by black sheet, then area of the image is equal to $\pi r^2/2$
(D) if f is doubled, intensity will increase

12. A ray of light traveling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be : **[JEE - 2007]**

(A) only a reflected ray and no refracted ray
(B) only a refracted ray and no reflected ray
(C) a reflected ray and a refracted ray and the angle between them would be less than $180^\circ - 2\theta$
(D) a reflected ray and a refracted ray and the angle between them would be greater than $180^\circ - 2\theta$.

13. **Statement-1** **[JEE - 2007]**

The formula connecting u, v and f for a spherical mirror is valid only for mirrors whose sizes are very small compared to their radii of curvature.

Statement-2

Laws of reflection are strictly valid for plane surfaces, but not for large spherical surfaces.

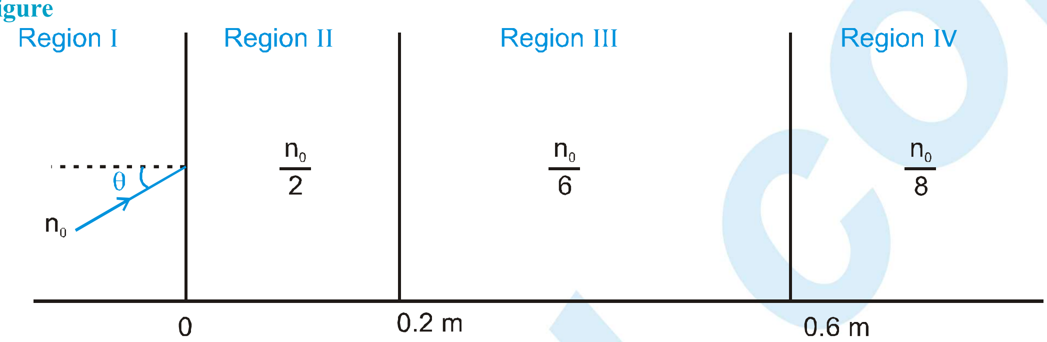
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

14. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60º). In the position of minimum deviation, the angle of refraction will be **[JEE 2008]**

(A) 30º for both the colours
(B) greater for the violet colour
(C) greater for the red colour
(D) equal but not 30º for both the colours

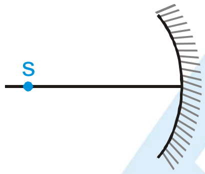
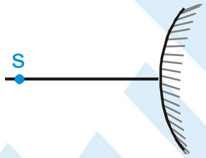
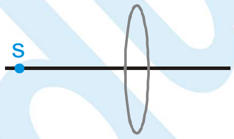
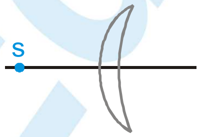
15. A light beam is traveling from Region I to Region IV (Refer Figure). The refractive index in Regions I, II, III and IV are n_0, $\frac{n_0}{2}$, $\frac{n_0}{6}$ and $\frac{n_0}{8}$, respectively. The angle of incidence θ for which the beam just misses entering Region IV is **[JEE 2008]**

Figure



(A) $\sin^{-1}\left(\frac{3}{4}\right)$ **(B)** $\sin^{-1}\left(\frac{1}{8}\right)$ **(C)** $\sin^{-1}\left(\frac{1}{4}\right)$ **(D)** $\sin^{-1}\left(\frac{1}{3}\right)$

16. An optical component and an object S placed along its optic axis are given in **Column I**. The distance between the object and the component can be varied. The properties of images are given in **Column II**. Match all the properties of images from **Column II** with the appropriate components given in **Column I**. **[JEE 2008]**

Column I		Column II	
(A)		**(P)**	Real image
(B)		**(Q)**	Virtual image
(C)		**(R)**	Magnified image
(D)		**(S)**	Image at infinity

17. A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4/3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, When the ball is 12.8 m above the water surface, the fish sees the speed of ball as [Take g = 10 m/s^2]

[JEE 2009]

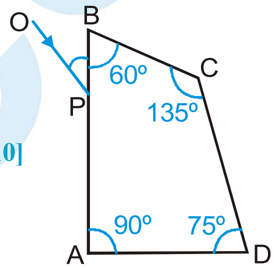
(A) 9 m/s **(B)** 12 m/s **(C)** 16 m/s **(D)** 21.33 m/s

18. A student performed the experiment of determination of focal length of a concave mirror by u-v method using an optical bench of length 1.5 meter. The focal length of the mirror used is 24 cm. The maximum error in the location of the image can be 0.2 cm. The 5 sets of (u, v) values recorded by the student (in cm) are : (42, 56), (48, 48), (60, 40), (66, 33), (78, 39). The data set(S) that **cannot** come from experiment and is (are) incorrectly recorded, is (are)

[JEE 2009]

(A) (42, 56) **(B)** (48, 48) **(C)** (66, 33) **(D)** (78, 39)

19. A ray OP of monochromatic light is incident on the face AB of prism ABCD near vertex B at an incident angle of 60º (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct ? **[JEE 2010]**



(A) The ray gets totally internally reflected at face CD

(B) The ray comes out through face AD

(C) The angle between the incident ray and the emergent ray is 90º

(D) The angle between the incident ray and the emergent ray is 120º

20. The focal length of a thin biconvex lens is 20cm. When an object is moved from a distance of 25cm in front of it to 50cm, the magnification of its image changes from m_{25} to m_{50}. The ratio $\frac{m_{25}}{m_{50}}$ is: **[JEE' 2010]**

21. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is

(A) Virtual and at a distance of 16 cm from mirror

(B) Real and at distance of 16 cm from the mirror

(C) Virtual and at a distance of 20 cm form the mirror

(D) Real and at a distance of 20 cm from the mirror

22. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 seconds. What is the speed of the object in km per hour. **[JEE 2010]**

23. A large glass slab ($\mu = 5/3$) of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R?

[JEE 2010]

24. Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transparent material of refractive index μ_2 between them as shown in figures in column II. A ray traversing these media is also shown in the figures. In Column I different relationships between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in Column II.

[JEE 2010]

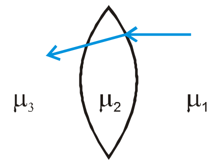
Column I | **Column II**

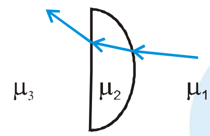
(A) $\mu_1 < \mu_2$

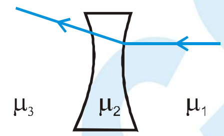
(B) $\mu_1 > \mu_2$

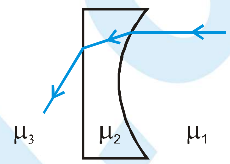
(C) $\mu_2 = \mu_3$

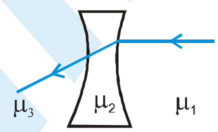
(D) $\mu_2 > \mu_3$

(P)


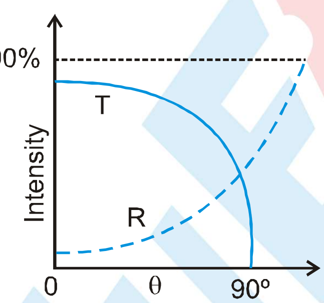
(Q)


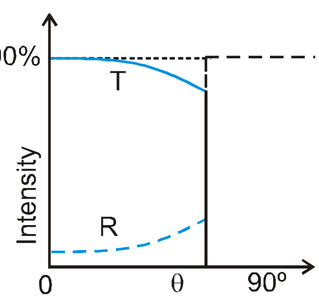
(R)


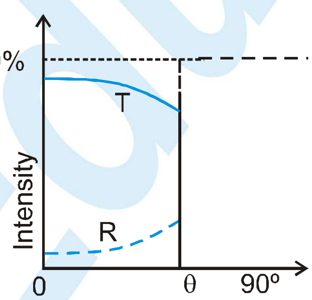
(S)


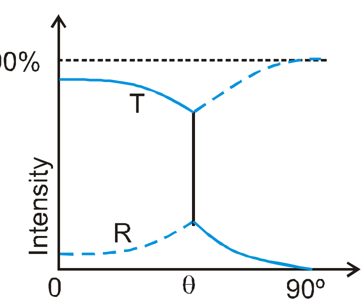
(T)


25. A light ray traveling in glass medium is incident on glass-air interface at an angle of incidence θ. The reflected (R) and transmitted (T) intensities, both as function of θ, are plotted. The correct sketch is **[JEE 2011]**

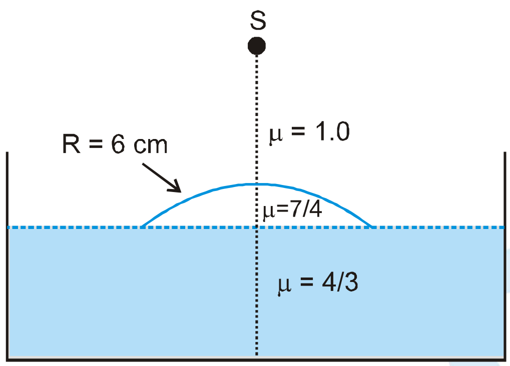
(A)


(B)


(C)


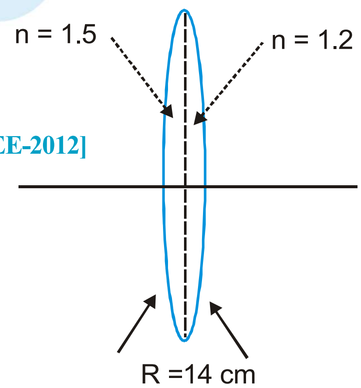
(D)


26. Water (with refractive index = $\frac{4}{3}$) in a tank is 18 cm deep. Oil of refractive index $\frac{7}{4}$ lies on water making a convex surface of radius of curvature 'R = 6 cm' as shown. Consider oil to act as a thin lens. An object 'S' is placed 24 cm above water surface. The location of its image is at 'x' cm above the bottom of the tank. Then 'x' is **[JEE 2011]**



27. A bi-convex lens is formed with two thin plano-convex lenses as shown in the figure. Refractive index n of the first lens is 1.5 and that of the second lens is 1.2. Both the curved surfaces are of the same radius of curvature R = 14 cm. For this bi-convex lens, for an object distance of 40 cm, the image distance will be **[IIT-JEE-2012]**

(A) –280.0 cm
(B) 40.0 cm
(C) 21.5 cm
(D) 13.3 cm



Paragraph for Question 28 and 29

Most materials have the refractive index, n > 1. So, when a light ray from air enters a naturally occurring material, then by Snells' law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, $n = \left(\frac{c}{v}\right) = \pm\sqrt{\varepsilon_r\mu_r}$ where c is the speed of electromagnetic waves in vacuum, v its speed in the medium, ε_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artificially prepared and are called meta-materials. They exhibit significantly different optical behavior, without violating any physical laws. Since n is negative, it results in a change in the direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials.

28. Choose the correct statement. **[IIT-JEE-2012]**

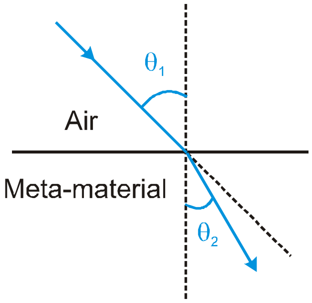
(A) The speed of light in the meta-material is $v = c|n|$

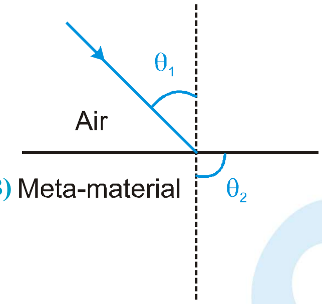
(B) The speed of light in the meta-material is $v = \frac{c}{|n|}$

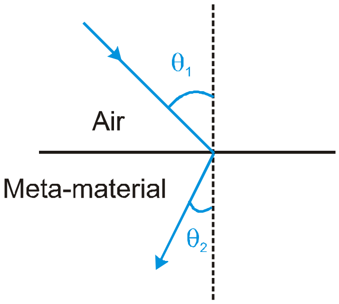
(C) The speed of light in the meta-material is v = c.

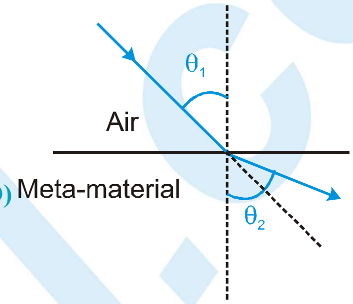
(D) The wavelength of the light in the meta-material (λ_m) is given by $\lambda_m = \lambda_{air}|n|$, where λ_{air} is the wavelength of the light in air.

29. For light incident from air on a meta-material, the appropriate ray diagram is : **[IIT-JEE-2012, Paper-2 : 3/66, –1]**

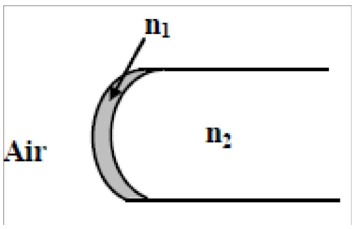
(A) 

(B) 

(C) 

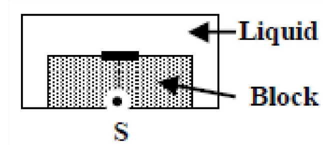
(D) 

30. A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$, as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film. Then **[IIT-JEE-2014]**



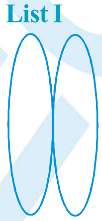
(A) $|f_1| = 3R$ **(B)** $|f_1| = 2.8\,R$ **(C)** $|f_2| = 2R$ **(D)** $|f_2| = 1.4R$

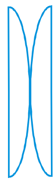
31. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is **[IIT-JEE-2014]**

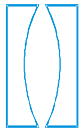


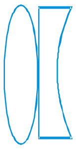
(A) 1.21 **(B)** 1.30 **(C)** 1.36 **(D)** 1.42

32. Four combinations of two thin lenses are given in List I. The radius of curvature of all curved surfaces is r and the refractive index of all the lenses is 1.5. Match lens combinations in List I with their focal length in List II and select the correct answer using the code given below the lists. **[IIT-JEE-2014]**

List I	List II
P. 	1. 2r

Q  2. r/2

R.  3. – r

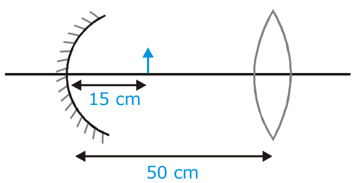
S.  4. r

Code:

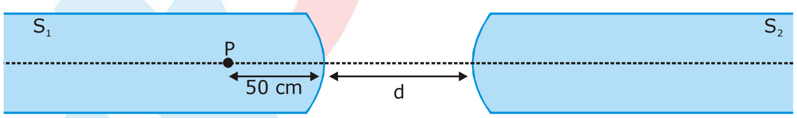
(A) P-1, Q-2, R-3, S-4 **(B)** P-2, Q-4, R-3, S-1

(C) P-4, Q-1, R-2, S-3 **(D)** P-2, Q-1, R-3, S-4

33. Consider a concave mirror and a convex lens (refractive index = 1.5) of focal length 10 cm each, separated by a distance of 50 cm in air (refractive index = 1) as shown in the figure. An object is placed at a distance of 15 cm from the mirror. Its erect image formed by this combination has magnification M_1. When the set-up is kept in a medium of refractive index 7/6, the magnification becomes M_2. The magnitude $\left|\frac{M_2}{M_1}\right|$ is **[IIT-JEE-2015]**

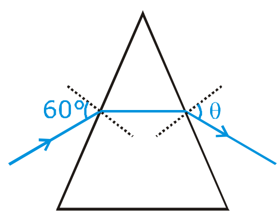


34. Two identical glass rode S_1 and S_2 (refractive index = 1.5) have one convex end of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes (shown by the dashed line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2. The distance d is



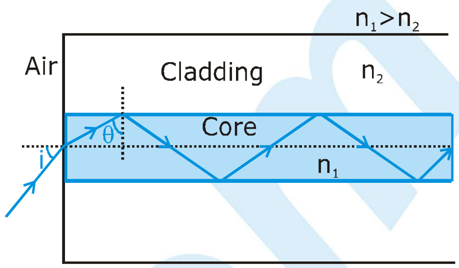
(A) 60 cm **(B)** 70 cm **(C)** 80 cm **(D)** 90 cm

35. A monochromatic beam of light is incident at 60° on one face of an equilateral prism of refractive index and emerges from the opposite face making an angle θ (n) with the normal (see the figure). For n = the value of θ is 60° and = m. The value of m is -



PARAGRAPH

Light guidance in an optical fiber can be understood by considering a structure comprising of thin solid glass cylinder of refractive index n_1 surrounded by a medium of lower refractive index n_2. The light guidance in the structure takes place due to successive total internal reflections at the interface of the media n_1 and n_2 as shown in the figure. All rays with the angle of incidence i less than a particular value i_m are confined in the medium of refractive index n_1. The numerical aperture (NA) of the structure is defined as $\sin i_m$.



36. For two structures namely S_1 with $n_1 = \sqrt{45}/4$ and $n_2 = 3/2$, and S_2 with $n_1 = 8/5$ and $n_2 = 7/5$ and taking the refractive index of water to be 4/3 and that of air to be 1, the correct option (s) is (are)

(A) NA of S_1 immersed in water is the same as that of S_2 immersed in a liquid of refractive index $\frac{16}{3\sqrt{15}}$

(B) NA of S_1 immersed in liquid of refractive index $\frac{16}{\sqrt{15}}$ is the same as that of S_2 immersed in water

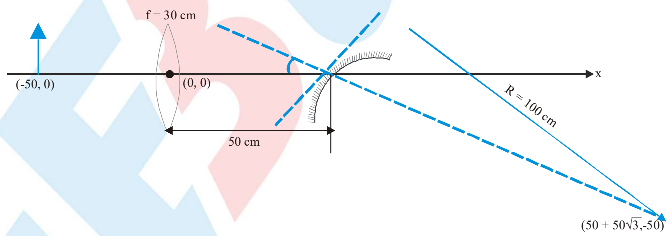
(C) NA of S_1 placed in air is the same as that of S_2 immersed in liquid of refractive index $\frac{4}{\sqrt{15}}$

(D) NA of S_1 placed in air is the same as that of S_2 placed in water

37. If two structures of same cross-sectional area, but different numerical apertures NA_1 and NA_2 ($NA_2 < NA_1$) are joined longitudinally, the numerical aperture of the combined structure is -

(A) $\frac{NA_1 NA_2}{NA_1 + NA_2}$ **(B)** $NA_1 + NA_2$ **(C)** NA_1 **(D)** NA_2

38. A small object is placed 50 cm to the left of a thin convex lens of focal length 30 cm. A convex spherical mirror of radius of curvature 100 cm is placed to the right of the lens at a distance of 50 cm. The mirror is tilted such that the axis of the mirror is at an angle $\theta = 30°$ to the axis of the lens, as shown in the figure. **[IIT-JEE-2016]**



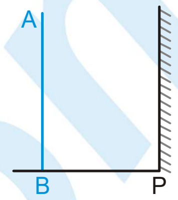
If the origin of the coordinate system is taken to be at the centre of the lens, the coordinates (in cm) of the point (x,y) at which the image is formed are

(A) $(0, 0)$ **(B)** $(50-25\sqrt{3}, 25)$ **(C)** $(25, 25\sqrt{3})$ **(D)** $(125/3, 25\sqrt{3})$

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

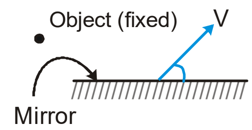
1. In the figure shown a person AB of height 170 cm is standing infront of a plane mirror. His eyes are at height 164 cm. At what distance from P should a hole be made in the mirror so that he cannot see the top of his head.



(A) 167 cm **(B)** 161 cm
(C) 163 cm **(D)** none of these

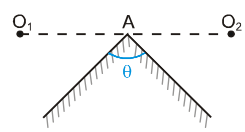
2. I is the image of a point object O formed by spherical mirror, then which of the following statement is incorrect:
(A) If O and I are on same side of the principal axis, then they have to be on opposite sides of the mirror.
(B) If O and I are on opposite side of the principal axis, then they have to be on same side of the mirror.
(C) If O and I are on opposite side of the principal axis, then they can be on opposite side of the mirror as well.
(D) If O is on principal axis then I has to lie on principal axis only.

3. An object and a plane mirror are shown in figure. Mirror is moved with velocity V as shown. The velocity of image is :



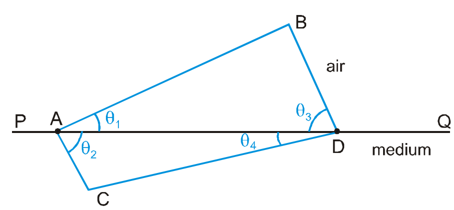
(A) 2 V $\sin\theta$ **(B)** 2 V
(C) 2V $\cos\theta$ **(D)** none of these

4. Two plane mirrors are joined together as shown in the figure. Two point objects O_1 and O_2 are placed symmetrically such that $AO_1 = AO_2$. The image of the two objects is common if :



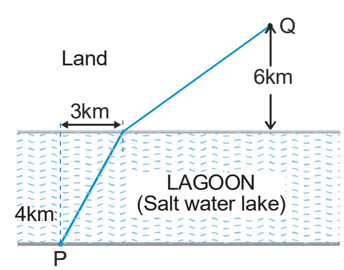
(A) $\theta = 60°$ **(B)** $\theta = 90°$
(C) $\theta = 30°$ **(D)** $\theta = 45°$

5. The following figure represents a wave front AB which passes from air to another transparent medium and produces a new wave front CD after refraction. The refractive index of the medium is (PQ is the boundary between air and the medium).



(A) $\dfrac{\cos\theta_1}{\cos\theta_4}$ **(B)** $\dfrac{\cos\theta_4}{\cos\theta_1}$
(C) $\dfrac{\sin\theta_1}{\sin\theta_4}$ **(D)** $\dfrac{\sin\theta_2}{\sin\theta_3}$

6. A man starting from point P crosses a 4 km wide lagoon and reaches point Q in the shortest possible time by the path shown in the figure. If the person swims at a speed of 3 km/hr and walks at a speed of 4 km/hr, then his time of journey is ($\mu_{\text{salt water}} = 4/3$) :



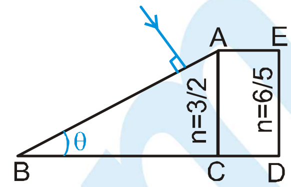
(A) 4hr, 10 min. **(B)** 4 hr and 30 min.
(C) 3 hr and 50 min **(D)** 5 hr and 10 min.

7. A mango tree is at the bank of a river and one of the branch of tree extends over the river. A tortoise lives in the river . A mango falls just above the tortoise. The acceleration of the mango falling from tree appearing to the tortoise is (Refractive index of water is 4/3 and the tortoise is stationary)

(A) g **(B)** $\dfrac{3g}{4}$ **(C)** $\dfrac{4g}{3}$ **(D)** None of these

8. In the figure ABC is the cross section of a right angled prism and ACDE is the cross section of a glass slab. The value of θ so that light incident normally on the face AB does not cross the face AC is

(given $\sin^{-1}(3/5) = 37^\circ$)



(A) $\theta \le 37^\circ$ **(B)** $\theta < 37^\circ$

(C) $\theta \le 53^\circ$ **(D)** $\theta < 53^\circ$

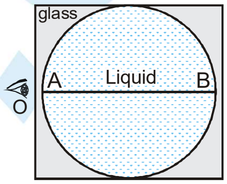
9. Refractive index of a prism is $\sqrt{\frac{7}{3}}$ and the angle of prism is 60°. The minimum angle of incidence of a ray that will be transmitted through the prism is :

(A) 30° **(B)** 45° **(C)** 15° **(D)** 50°

10. For a prism kept in air it is found that for an angle of incidence 60°, the angle of refraction '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

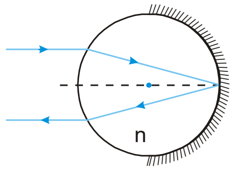
11. As shown in the figure the observer 'O' sees the distance AB as infinitely large. If refractive index of liquid is μ_1 and that of glass is μ_2, then $\frac{\mu_1}{\mu_2}$ is :



(A) 2 **(B)** 1/2

(C) 4 **(D)** None of these

12. A transparent cylinder has its right half polished so as to act as a mirror. A paraxial light ray is incident from left, that is parallel to principal axis, exits parallel to the incident ray as shown in the figure. The refractive index n of the material of the cylinder is :



(A) 1.2 **(B)** 1.5

(C) 1.8 **(D)** 2.0

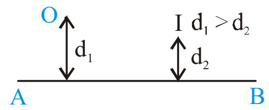
13. In the figure shown, the image of a real object O is formed at point I. AB is the principal axis of the mirror. The mirror must be:

(A) concave & placed towards right of I

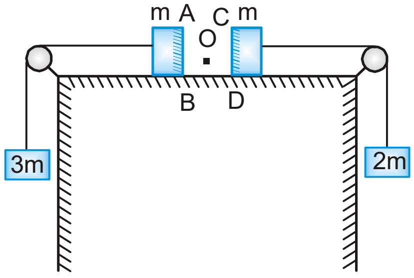
(B) concave & placed towards left of I

(C) convex & placed towards right of I

(D) convex & placed towards left of I.



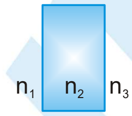
14. Two blocks each of mass m lie on a smooth table. They are attached to two other masses as shown in the figure. The pulleys and strings are light. An object O is kept at rest on the table. The sides AB & CD of the two blocks are made reflecting. The acceleration of two images formed in those two reflecting surfaces w.r.t. each other is:



(A) 5g/6 **(B)** 5g/3

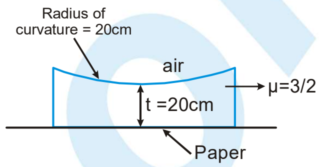
(C) g/3 **(D)** 17 g/6

15. The figure shows a parallel slab of refractive index n_2 which is surrounded by media of refractive indices n_1 and n_3. Light is incident on the slab at angle of incidence θ ($\neq 0$). The time taken by the ray to cross the slab is 't_1' if incidence is from 'n_1' and it is 't_2' if the incidence is from 'n_3'. Then assuming that $n_2 > n_1$, $n_2 > n_3$ and $n_3 > n_1$, then value of t_1/t_2.



(A) = 1 **(B)** > 1
(C) < 1 **(D)** cannot be decided

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

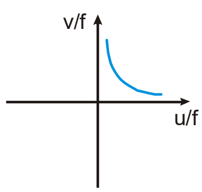


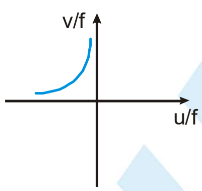
(A) 10 cm **(B)** 15 cm
(C) 50 cm **(D)** none of these

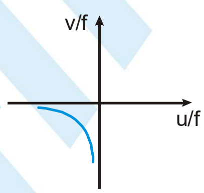
17. Two symmetric double convex lenses A and B have same focal length, but the radii of curvature differ so that, R_A = 0.9 R_B. If n_A = 1.63, find n_B.
(A) 1.7 **(B)** 1.6 **(C)** 1.5 **(D)** 4/3

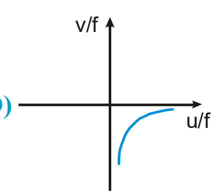
18. The distance between an object and the screen is 100 cm. A lens produces an image on the screen when the lens is placed at either of the positions 40 cm apart. The power of the lens is nearly:
(A) 3 diopters **(B)** 5 diopters **(C)** 2 diopters **(D)** 9 diopters

19. A virtual erect image by a **diverging lens** is represented by (u, v, f are coordinates)

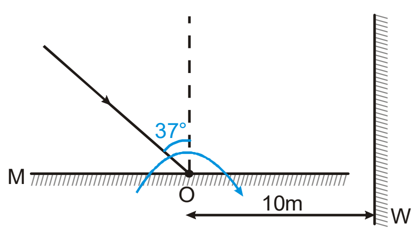
(A) 

(B) 

(C) 

(D) 

20. A light ray I is incident on a plane mirror M. The mirror is rotated in the direction as shown in the figure by an arrow at frequency $9/\pi$ rps. The light reflected by the mirror is received on the wall W at a distance 10 m from the axis of rotation. When the angle of incidence becomes 37º the speed of the spot (a point) on the wall is:

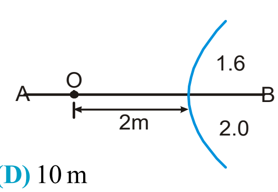


(A) 10 m/s **(B)** 1000 m/s
(C) 500 m/s **(D)** None of these

21. If a prism having refractive index $\sqrt{2}$, has angle of minimum deviation equal to the angle of refraction of the prism, then the angle of refraction of the prism is:
(A) 30º **(B)** 45º **(C)** 60º **(D)** 90º

22. A bird is flying up at angle $\sin^{-1}(3/5)$ with the horizontal. A fish in a pond looks at that bird when it is vertically above the fish. The angle at which the bird appears to fly (to the fish) is: [n_{water} = 4/3]
(A) $\sin^{-1}(3/5)$ **(B)** $\sin^{-1}(4/5)$ **(C)** 45º **(D)** $\sin^{-1}(9/16)$

23. In the figure shown a point object O is placed in air. A spherical boundary separates two media. AB is principal axis. The refractive index above AB is 1.6 and below AB is 2.0. The separation between the images formed due to refraction at spherical surface is :

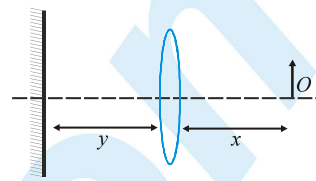


(A) 12 m **(B)** 21 m **(C)** 14 m **(D)** 10 m

24. Light of wavelength 4000 Å is incident at small angle on a prism of apex angle 4º. The prism has $n_v = 1.5$ & $n_r = 1.48$. The angle of dispersion produced by the prism in this light is :

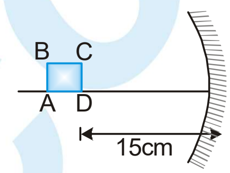
(A) 0.2º **(B)** 0.08º **(C)** 0.192º **(D)** none of these

25. A convex lens of focal length f and a plane mirror are y distance apart. An object O is kept on the principal axis of the lens at a distance x from the lens. The values of x and y for the final image of O to fall exactly (position & size) on the object 'O' :



(A) x = f, y = f **(B)** x = f, y = 2f
(C) x = 2f, y = f **(D)** x = 2f, y = 2f

26. A square ABCD of side 1mm is kept at distance 15 cm infront of the concave mirror as shown in the figure. The focal length of the mirror is 10 cm. The length of the perimeter of its image will be :

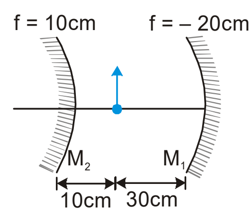


(A) 8 mm **(B)** 2 mm **(C)** 12 mm **(D)** 6 mm

27. A point object is kept in front of a plane mirror. The plane mirror is doing SHM of amplitude 2 cm. The plane mirror moves along the x-axis and x- axis is normal to the mirror. The amplitude of the mirror is such that the object is always infront of the mirror. The amplitude of SHM of the image is

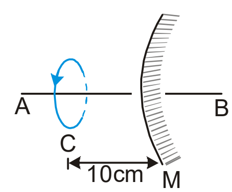
(A) zero **(B)** 2 cm **(C)** 4 cm **(D)** 1 cm

28. In the figure shown find the total magnification after two successive reflections first on M_1 & then on M_2



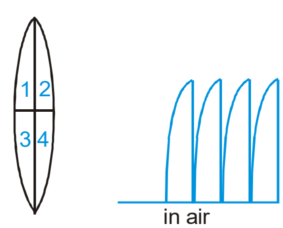
(A) +1 **(B)** – 2
(C) +2 **(D)** – 1

29. A particle revolves in clockwise direction (as seen from point A) in a circle C of radius 1 cm and completes one revolution in 2 sec. The axis of the circle and the principal axis of the mirror M coincide. Call it AB. The radius of curvature of the mirror is 21 cm. Then the direction of revolution (as seen from A) of the image of the particle and its speed is



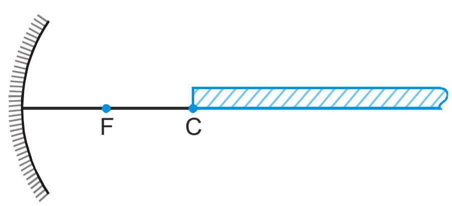
(A) Clockwise, 1.57 cm/s **(B)** Clockwise, 3.14 cm/s
(C) Anticlockwise, 1.57 cm/s **(D)** Anticlockwise, 3.14 cm/s

30. The given lens is broken into four parts and rearranged as shown in the figure. If the initial focal length is f then after rearrangement the equivalent focal length is



(A) f **(B)** $\frac{f}{2}$
(C) $\frac{f}{4}$ **(D)** 4f

31. An infinitely long rectangular strip is placed on the principal axis of a concave mirror as shown in the figure. One end of the strip coincides with centre of curvature as shown. The height of rectangular strip is very small in comparison to focal length of the mirror. Then the shape of image of strip formed by concave mirror is



(A) Rectangle **(B)** Trapezium **(C)** Triangle **(D)** Square

32. Figure I given below shows a glass vessel, partially filled with water. A narrow beam of light is incident vertically down into the water and passes straight through. Figure II shows the vessel glass tilted until the angle θ, such that the light is refracted along the lower surface of the glass. If refractive indices of air, water and glass are 1, $\frac{4}{3}$ and 1.5 respectively then :

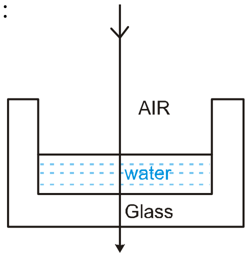


Figure 1

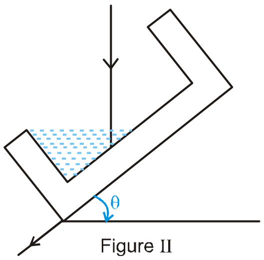


Figure II

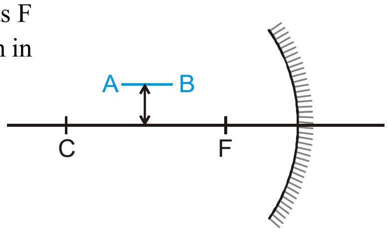
(A) $\sin\theta = \frac{3}{4}$ **(B)** $\cos\theta = \frac{3}{4}$ **(C)** $\sin\theta = \frac{8}{9}$ **(D)** $\cos\theta = \frac{8}{9}$

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

33. A particle is moving towards a fixed convex mirror. The image also moves. If V_i = speed of image and V_O = speed of the object, then

(A) $V_i \le V_O$ if $|u| < |F|$ **(B)** $V_i > V_O$ if $|u| > |F|$ **(C)** $V_i < V_O$ if $|u| > |F|$ **(D)** $V_i = V_O$ if $|u| = |F|$

34. An object AB is placed parallel and close to the optical axis between focus F and centre of curvature C of a converging mirror of focal length f as shown in figure.



(A) Image of A will be closer than that of B from the mirror.

(B) Image of AB will be parallel to the optical axis.

(C) Image of AB will be straight line inclined to the optical axis.

(D) Image of AB will not be straight line.

35. Which of the following statements is/are correct about the refraction of light from a plane surface when light ray is incident in denser medium. [C is critical angle]

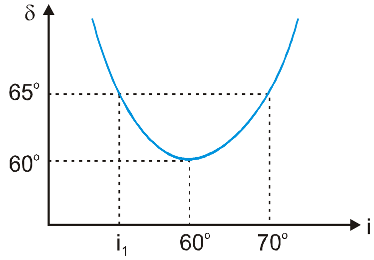
(A) The maximum angle of deviation during refraction is $\frac{\pi}{2} - C$, it will be at angle of incidence C.

(B) The maximum angle of deviation for all angle of incidences is $\pi - 2C$, when angle of incidence is slightly greater than C.

(C) If angle of incidence is less than C then deviation increases if angle of incidence is also increased.

(D) If angle of incidence is greater than C then angle of deviation decreases if angle of incidence is increased.

36. The angle of deviation (δ) vs angle of incidence (i) is plotted for a prism. Pick up the correct statements.



(A) The angle of prism is 60°

(B) The refractive index of the prism is $n = \sqrt{3}$

(C) For deviation to be 65° the angle of incidence $i_1 = 55°$

(D) The curve of 'δ' vs 'i' is parabolic

37. A luminous point object is placed at O, whose image is formed at I as shown in figure. Line AB is the optical axis. Which of the following statement is/are correct ?

(A) If a lens is used to obtain the image, then it must be a converging lens and its optical centre will be the intersection point of line AB and OI.

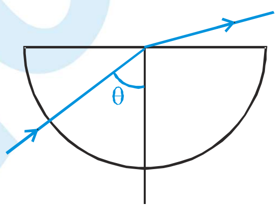
(B) If a lens is used to obtain the image, then it must be a diverging lens and its optical centre will be the intersection point of line AB and OI.

(C) If a mirror is used to obtain the image then the mirror must be concave and object and image subtend equal angles at the pole of the mirror.

(D) I is a real Image.

SECTION - III : ASSERTION AND REASON TYPE

38. **Statement-1 :** A beam of white light enters the curved surface of a semicircular piece of glass along the normal. The incoming beam is moved clockwise (so that the angle θ increases), such that the beam always enters along the normal to the curved side. Just before the refracted beam disappears, it becomes predominantly red.



Statement-2 : The index of refraction for light at the red end of the visible spectrum is more than at the violet end.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

39. **Statement-1 :** There exists two angles of incidence for the same magnitude of deviation (except minimum deviation) by a prism kept in air.

Statement-2 : In a prism kept in air, a ray is incident on first surface and emerges out of second surface. Now if another ray is incident on second surface (of prism) along the previous emergent ray, then this ray emerges out of first surface along the previous incident ray. This principle is called principle of reversibility of light.

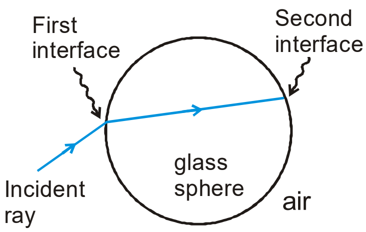
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

40. **Statement-1 :** A ray is incident from outside on a glass sphere surrounded by air as shown. This ray may suffer total internal reflection at second interface.



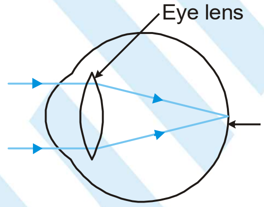
Statement 2 : For a ray going from denser to rarer medium, the ray may suffer total internal reflection.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

41. **Statement-1 :** Keeping a point object fixed, if a plane mirror is moved, the image will also move.
Statement-2 : In case of a plane mirror, distance of object and its image is equal from any point on the mirror.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained the curvature of lens increases (that means radius of curvature decreases) and focal length decreases. For a clear vision the image must be on retina. The image distance is therefore fixed for clear vision and it equals the distance of retina from eye-lens. It is about 2.5 cm for a grown-up person.



A person can theoretically have clear vision of objects situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown-up person minimum distance of object should be around 25 cm.
A person suffering for eye defects uses spectacles (Eye glass). The function of lens of spectacles is to form the image of the objects within the range in which person can see clearly. The image of the spectacle-lens becomes object for eye-lens and whose image is formed on retina.
The number of spectacle-lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle-lens is equal to the numerical value of the power of lens with sign. For example power of lens required is +3D (converging lens of focal length $\frac{100}{3}$ cm) then number of lens will be +3.

For all the calculations required you can use the lens formula and lens maker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between eye lens and the spectacle lens.

42. Minimum focal length of eye lens of a normal person is

(A) 25 cm **(B)** 2.5 cm **(C)** $\frac{25}{9}$ cm **(D)** $\frac{25}{11}$ cm

43. Maximum focal length of eye lens of normal person is

(A) 25 cm **(B)** 2.5 cm **(C)** $\frac{25}{9}$ cm **(D)** $\frac{25}{11}$ cm

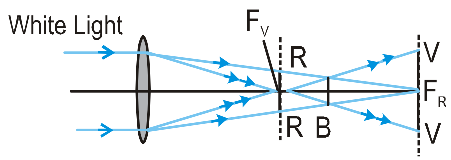
44. A nearsighted man can clearly see object only upto a distance of 100 cm and not beyond this. The number of the spectacles lens necessary for the remedy of this defect will be.

(A) +1 **(B)** – 1 **(C)** + 3 **(D)** – 3

Comprehension # 2

Chromatic Aberration

The image of a white object in white light formed by a lens is usually coloured and blurred. This defect of image is called chromatic aberration and arises due to the fact that focal length of a lens is different for different colours. As μ of lens is maximum for violet while minimum for red, violet is focused nearest to the lens while red farthest from it as shown in figure.



As a result of this, in case of convergent lens if a screen is placed at F_V centre of the image will be violet and focused while sides are red and blurred. While at F_R, reverse is the case, i.e., centre will be red and focused while sides violet and blurred. The difference between f_V and f_R is a measure of the longitudinal chromatic aberration (L.C.A), i.e.,

$$\text{L.C.A.} = f_R - f_V = -\,df \text{ with } df = f_V - f_R \qquad \text{............(1)}$$

However, as for a single lens,

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \qquad \text{............(2)}$$

$$\Rightarrow \qquad -\frac{df}{f^2} = d\mu\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \qquad \text{............(3)}$$

Dividing Eqn. (3) by (2) ;

$$-\frac{df}{f} = \frac{d\mu}{(\mu - 1)} = \omega \qquad \left[\omega = \frac{d\mu}{(\mu - 1)}\right] = \text{dispersive power} \quad \text{........(4)}$$

And hence, from Eqns. (1) and (4),

$$\text{L.C.A.} = -df = \omega f$$

Now, as for a single lens neither f nor ω can be zero, we cannot have a single lens free from chromatic aberration.

Condition of Achromatism :

In case of two thin lenses in contact

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

i.e., $$-\frac{dF}{F^2} = -\frac{df_1}{f_1^2} - \frac{df_2}{f_2^2}$$

The combination will be free from chromatic aberration if dF = 0

i.e., $$\frac{df_1}{f_1^2} + \frac{df_2}{f_2^2} = 0$$

which with the help of Eqn. (4) reduces to

$$\frac{\omega_1 f_1}{f_1^2} + \frac{\omega_2 f_2}{f_2^2} = 0$$

i.e., $\dfrac{\omega_1}{f_1} + \dfrac{\omega_2}{f_2} = 0$ ....(5)

This condition is called condition of achromatism (for two thin lenses in contact) and the lens combination which satisfies this condition is called achromatic lens, From this condition, i.e., from Eqn. (5) it is clear that in case of achromatic doublet :

(1) The two lenses must be of different materials.

Since, if $\omega_1 = \omega_2$, $\dfrac{1}{f_1} + \dfrac{1}{f_2} = 0$

i.e., $\dfrac{1}{F} = 0$

or $F = \infty$

i.e., combination will not behave as a lens, but as a plane glass plate.

(2) As ω_1 and ω_2 are positive quantities, for Eqn. (5) to hold, f_1 and f_2 must be of opposite nature, i.e., if one of the lenses is converging the other must be diverging.

(3) If the achromatic combination is convergent,

$f_C < f_D$

and as $-\dfrac{f_C}{f_D} = \dfrac{\omega_C}{\omega_D}$, $\omega_C < \omega_D$

i.e., in a convergent achromatic doublet, convex lens has lesser focal length and dispersive power than the divergent one.

45. Chromatic aberration in the formation of images by a lens arises because :

(A) of non-paraxial rays.

(B) the radii of curvature of the two sides are not same.

(C) of the defect in grinding.

(D) the focal length varies with wavelength.

46. A combination is made of two lenses of focal lengths f and f' in contact ; the dispersive powers of the materials of the lenses are ω and ω'. The combination is achromatic when :

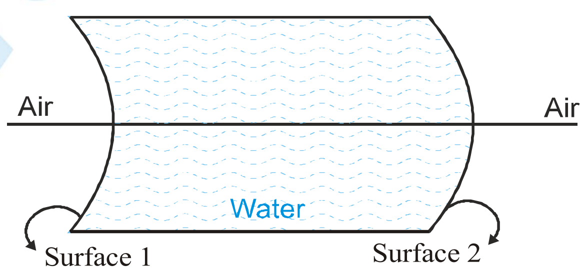
(A) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = 2f$
(B) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = f/2$
(C) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = -f/2$
(D) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = -2f$

47. The dispersive power of crown and flint glasses are 0.02 and 0.04 respectively. An achromatic converging lens of focal length 40 cm is made by keeping two lenses, one of crown glass and the other of flint glass, in contact with each other. The focal lengths of the two lenses are :

(A) 21 cm and 40 cm
(B) 21 cm and –40 cm
(C) –21cm and 40 cm
(D) 10 cm and –21cm

Comprehension # 3

All objects referred to the subsequent problems lie on the principle axis.



48. If light is incident on surface 1 from left, the image formed after the first refraction is definitely :

(A) Real for a real object **(B)** Virtual for a real object

(C) Real for a virtual object **(D)** Virtual for a virtual object

49. In above question if the object is real, then the final image formed after two refractions :

(A) may be real **(B)** may be virtual **(C)** must be virtual **(D)** both A and B

50. If light is incident on surface 2 from right then which of the following is true for image formed after a single refraction.

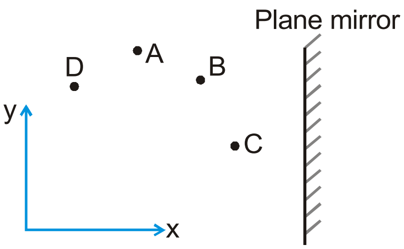
(A) Real object will result in a real image **(B)** Virtual object will result in a virtual image

(C) Real object will result in a virtual image **(D)** Virtual object will result in a Real image

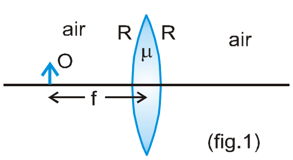
SECTION - V : MATRIX - MATCH TYPE

51. Four particles are moving with different velocities in front of stationary plane mirror (lying in y-z plane). At t = 0, velocity of A is $\vec{v}_A = \hat{i}$, velocity of B is $\vec{v}_B = -\hat{i} + 3\hat{j}$, velocity of C is $\vec{v}_C = 5\hat{i} + 6\hat{j}$, velocity of D is $\vec{v}_D = 3\hat{i} - \hat{j}$. Acceleration of particle A is $\vec{a}_A = 2\hat{i} + \hat{j}$ and acceleration of particle C is $\vec{a}_C = 2t\hat{j}$. The particle B and D move with uniform velocity (Assume no collision to take place till t = 2 seconds). All quantities are in S.I. Units. Relative velocity of image of object A with respect to object A is denoted by $\vec{V}_{A',A}$. Velocity of images relative to corresponding objects are given in column I and their values are given in column II at t = 2 second. Match column I with corresponding values in column II.

Column I	Column II
(A) $\vec{V}_{A',A}$	**(P)** $2\hat{i}$
(B) $\vec{V}_{B',B}$	**(Q)** $-6\hat{i}$
(C) $\vec{V}_{C',C}$	**(R)** $-12\hat{i} + 4\hat{j}$
(D) $\vec{V}_{D',D}$	**(S)** $-10\hat{i}$



52. An object O (real) is placed at focus of an equi-biconvex lens as shown in figure 1. The refractive index of lens is $\mu = 1.5$ and the radius of curvature of either surface of lens is R. The lens is surrounded by air. In each statement of column-I some changes are made to situation given above and information regarding final image formed as a result is given in column-II. The distance between lens and object is unchanged in all statements of column-I. Match the statements in column-I with resulting image in column-II.

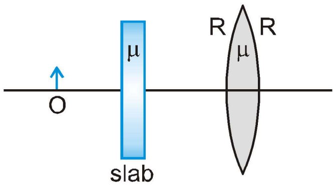


(fig.1)

Column-I	Column-II
(A) If the refractive index of the lens is doubled (that is, made 2μ) then	**(P)** final image is real
(B) If the radius of curvature is doubled (that is, made 2R) then	**(Q)** final image is virtual

(C) If a glass slab of refractive index $\mu = 1.5$ is introduced between the object and lens as shown, then

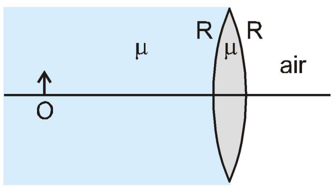
(R) final image becomes smaller in size in comparison to size of image before the change was made



(D) If the left side of lens is filled with a medium of refractive index $\mu = 1.5$ as shown, then

(S) final image is of same size of object.

(T) final image is of larger size of object



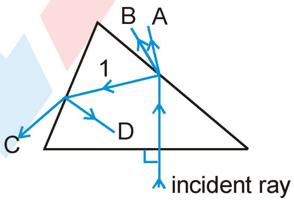
53. **Match the following :**

An object O is kept perpendicular to the principal axis of a spherical mirror. Each situation (A,B,C and D) gives object coordinate u in centimeters with sign, the type of mirror, and then the distance (centimeters, without sign) between the focal point and the pole of the mirror. On the right side information regarding the image is given. Correctly match the situations on the left side with the images described on the right side.

Situation	u	Mirror
A	–18	Concave, 12
B	–12	Concave, 18
C	–8	Convex, 10
D	–10	Convex, 8

Image	
(P)	Real, Errect, Enlarged
(Q)	Virtual, Erect, Diminished
(R)	Real Inverted, Enlarged
(S)	Virtual, Erect, Enlarged

54. A white light ray is incident on a glass prism, and it create four refracted rays A, B, C and D. Match the refracted rays with the colours given (1 & D are rays due to total internal reflection.):

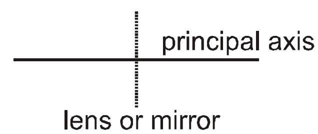


Ray			**Colour**
(A)	A	**(P)**	red
(B)	B	**(Q)**	green
(C)	C	**(R)**	yellow
(D)	D	**(S)**	blue

55. In each situation of column-I, an incident wavefront and its corresponding reflected or refracted wavefront is shown. In column-II the optical instrument used for reflection or refraction is given. Always take the optical instrument to the right of incident wavefront. The incident wavefront is moving towards right. Match each pair of incident and reflected/refracted wavefront in column-I with the correct optical instrument given in column-II.

Column-I Incident wavefront	Reflected/Refracted Wavefront	Column-II Optical instrument used

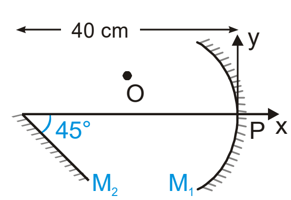
56. Column-I gives certain situations regarding a point object and its image formed by an optical instrument. The possible optical instruments are concave and convex mirrors or lenses as given in Column-II. Same side of principal axis means both image and object should either be above the principal axis or both should be below the principal axis as shown in figure. Same side of optical instrument means both image and object should be either left of the optical instrument or both should be on right of the optical instrument as shown in figure. Match the statements in column-I with the corresponding statements in column-II .



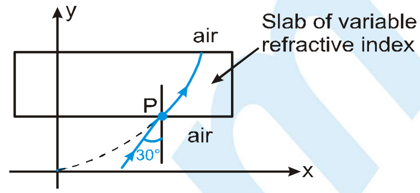
Column I	Column II
(A) If a point object and its image are on same side of principal axis and opposite sides of the optical instrument then the optical instrument is	**(P)** Concave mirror
(B) If a point object and its image are on opposite side of principal axis and same sides of the optical instrument then the optical instrument is	**(Q)** Convex mirror
(C) If a point object and its image are on same side of principal axis and same sides of the optical instrument then the optical instrument is	**(R)** Concave lens
(D) If a point object and its image are on opposite side of principal axis and opposite sides of the optical instrument then the optical instrument is	**(S)** Convex lens

SECTION - VI : INTEGER TYPE

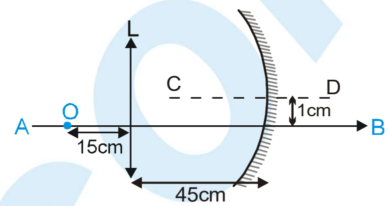
57. As shown in the figure, an object O is at the position (– 10, 2) with respect to the origin P. The concave mirror M_1 has radius of curvature 30 cm. A plane mirror M_2 is kept at a distance 40 cm infront of the concave mirror. Considering first reflection on the concave mirror M_1 and second on the plane mirror M_2. if x co-ordinate is $-x_0$ of the second image w.r.t. the origin P.then x_0 is



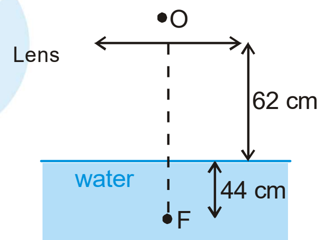
58. A ray of light travelling in air is incident at angle of incident 30° on one surface of a slab in which refractive index varies with y. The light travels along the curve $y = 4x^2$ (y and x are in metre) in the slab. if the refractive index of the slab at y = 1/2 m in the slab is $15/x_0$.then x_0 is



59. In the figure shown L is a converging lens of focal length 10cm and M is a concave mirror of radius of curvature 21cm. A point object O is placed in front of the lens at a distance 15cm. AB and CD are optical axes of the lens and mirror respectively. if the distance of the final image formed by this system from the optical centre of the lens is $6\sqrt{x}$ cm. then x is The distance between CD & AB is 1 cm.



60. A stationary observer O looking at a fish F (in water of, $\mu = 4/3$) through a converging lens of focal length 90.0 cm. The lens is allowed to fall freely from a height 62.0 cm with its axis vertical. The fish and the observer are on the principal axis of the lens. The fish moves up with constant velocity 100 cm/s. Initially it was at a depth of 44.0 cm. if the velocity with which the fish appears to move to the observer at t = 0.2 sec.is x/4 cms^{-1}.then x



ANSWER KEY

EXERCISE - 1

1. B	**2.** B	**3.** C	**4.** C	**5.** D	**6.** A	**7.** C	**8.** B	**9.** B	**10.** C	**11.** C	**12.** C	**13.** B
14. C	**15.** C	**16.** C	**17.** A	**18.** C	**19.** C	**20.** A	**21.** B	**22.** C	**23.** B	**24.** D	**25.** A	**26.** A
27. A	**28.** A	**29.** C	**30.** B	**31.** C	**32.** C	**33.**(a) (A) (b) (C) (c) (C)			**34.** B	**35.** B	**36.** A	**37.** A
38. A	**39.** D	**40.** C	**41.** A	**42.** D	**43.** C	**44.** D	**45.** D	**46.** B	**47.** C	**48.** A	**49.** D	**50.** A
51. B	**52.** A	**53.** A	**54.** A	**55.** B	**56.** D	**57.** C	**58.** D	**59.** D	**60.** C	**61.** D	**62.** B	**63.** D
64. D	**65.** C	**66.** C	**67.** D	**68.** C	**69.** B	**70.** A	**71.** B	**72.** D	**73.** C	**74.** D	**75.** C	**76.** B
77. A	**78.** B	**79.** C	**80.** B	**81.** D	**82.** A	**83.** A	**84.** B	**85.** B	**86.** B	**87.** C	**88.** D	**89.** D
90. A												

EXERCISE - 2 : PART # I

1. B, D	**2.** A,C, D	**3.** C,D	**4.** A,C	**5.** A,D	**6.** B,C	**7.** A,B,C	**8.** B,C,D	**9.** A,C
10. A,B,C	**11.** A,C	**12.** B,C	**13.** A,D	**14.** B,D	**15.** A,B,D	**16.** A,D	**17.** A,B	**18.** A,B,C
19. B,C								

PART # II

1. B **2.** D **3.** D **4.** A

EXERCISE - 3 : PART # I

1. $A \to L, S;\ B \to J, Q;\ C \to M, R;\ D \to K, P$ **2.** $A \to P;\ B \to P;\ C \to Q;\ D \to Q$

3. $A \to P, Q;\ B \to P, Q;\ C \to R, S;\ D \to R, S$

PART # II

Comp. # 1 1. D 2. B 3. B 4. C **Comp. # 2** 1. D 2. C 3. D 4. B 5. D

EXERCISE - 4

1. 30º clockwise **2.** 120º anticlockwise and 240º clockwise. **3.** 60º **4. (a)** 1 ; **(b)** (4, 0) ; **(c)** No

5. Mirror should be placed on the path of the rays at an $\angle$ of 78º or 12° to the horizontal **6.** 10.35 cm = $\frac{3933}{380}$ cm

7. $\frac{245}{4}$ cm = 61.25 cm **8.** Infinitely large. **9.** 84 cm, 0.5 cm **10.** 60 cm **11.** 0.2 m from the mirror

12. (a) 40 cm/s opposite to the velocity of object., **(b)** 20 cm/s opposite to the velocity of object.

13. $3\left(\frac{1}{\sqrt{2}}-\frac{1}{\sqrt{7}}\right)$cm = 9.9 mm, 45° **14.** $2/3 \times 10^{-8}$ sec **15.** 25 cm. **16.** 30 cm **17.** 35 cm ,Shift = 5 cm.

18. 0.9 cm above P **19.** $\frac{68}{3}$ cm **20.** $\frac{\pi h^2}{\mu^2 - 1}$ **21.** $\sqrt{3}$ cm **22.** $n > \sqrt{2}$ **23.** 45° **24.** $\theta = 60°$

25. 90º **26.** **(i)** 1.5°, **(ii)** $\frac{3°}{8}$ **27.** 40 cm from pole in the medium of refractive index 1, virtual, erect and 4 cm in size.

28. (a) 2, **(b)** not possible, it will focus close to the centre if the refractive index is large **29.** 50 cm right of B.

30. 80 cm **31.** ± 12 cm, ± 60 cm **32.** $\frac{27}{2}$ = 13.5 cm below the surface of water **33.** 8/3 mm, virtual at v = - 20, no inversion

34. Converging ; real **35.** 360 cm; ∞ ; – 600 cm **36.** 20 cm, 1 m, –4, 4 cm **37. (a)** $\frac{\mu_3 R}{2\mu_2 - \mu_1 - \mu_3}$ **(b)** $\frac{\mu_1 R}{2\mu_2 - \mu_1 - \mu_3}$

38. 1.5 cm **39.** 0.3 m **40.** 30 cm **41.** 0.4 cm **42.** $\frac{5}{3}$ cm from the lens **43.** 60 cm from the lens further away from the mirror **44.** 1.0 cm if the light is incident from the side of concave lens and 2.5 mm if it is incident from the side of the convex lens and the corresponding ratio of intensities are 1/4 and 4. **45.** 31 cm from the lens **46.** 10 cm for convex lens and 60 cm for concave lens **47.** 10 D , Optical power of each lens = 5 D. **48. (a)** $\frac{1}{4}$ = 0.25 **(b)** 0.90 **49. (a)** 15 cm from the lens on the axis **(b)** 1.14 cm towards the lens

50. (a) $\frac{2(\mu_v - \mu_r)}{\mu_v' - \mu_r'}$, **(b)** $\frac{2(\mu_y - 1)}{\mu_y' - 1}$ **51.** 4° **53.** 24; 150 cm

54. **(a)** $v_e = -2.5$ cm and $f_e = 6.25$ cm give $u_e = -5$ cm ; $v_0 = (15 - 5)$ cm = 10 cm.

$f_0 = u_0 = -2.5$ cm; Magnifying power = $\frac{10}{2.5} \times \frac{25}{5} = 20$

(b) $u_e = -6.25$ cm, $v_0 = (15 - 6.25)$ cm = 8.75, $f_0 = 2.0$ cm. Therefore
$u_0 = -(70/27) = -2.59$ cm.

Magnifying power = $\frac{v_0}{|u_0|} \times (25/6.25) = \frac{27}{8} \times 4 = 13.5$

55. **(a)** Angular magnification = $\frac{15}{0.01} = 1500$

(b) If d is the diameter of the image (in cm).

$\frac{d}{1500} = \frac{3.48 \times 10^6}{3.8 \times 10^8}$ i.e.~, d = 13.7 cm

56. 3 m **57.** 1.73 m = $\frac{45}{26}$ m **58.** –6 **59.** 86 cm **60.** $\left(3 - \sqrt{3}\right)$ f **61.** $\left(\frac{5\sqrt{23}}{\sqrt{23} - 3}\right)$ cm = 13.35 cm

62. At a distance of 50 cm from the mirror & 2 cm from each other **63. (a)** $\frac{169}{60}$ m = 2.8 m **(b)** $\frac{3}{5\sqrt{7}}$ m = 22.6 cm

64. 9 cm/s **65.** **(i)** x = C, y = 90°–C, z = 180°– 2C **(ii)** δ = (y, z) **66.** 16 cm on the right side of the mirror. **67.** No

68. $\frac{2}{\sqrt{3}} \le \mu \le \sqrt{2}$ **69.** 9 cm **70.** At the pole of reflecting surface of the sphere **71.** $\frac{99}{4900}$ **72.** 90 cm below the bottom of the container. **73. (a)** 3° **(b)** 0.015° **(c)** 3° **(d)** 0.225°

EXERCISE - 5 : PART # I

1. (3) **2.** (2) **3.** (2) **4.** (1) **5.** (3) **6.** (4) **7.** (2) **8.** (3) **9.** (4) **10.** (2) **11.** (2) **12.** (1) **13.** (2)
14. (1) **15.** (4) **16.** (4) **17.** (4) **18.** (2) **19.** (3) **20.** (2)

PART # II

1.(i)(B) **(ii)** (D) **2.** $f = \dfrac{\mu_3 R}{(\mu_3 - \mu_1)}$ **3.** B **4.** C **5.** A **6.** OE = 6.06 m **7.** $\dfrac{dv}{dt} = 0.09$ m/s; $\dfrac{dm}{dt} = -0.3\ sec^{-1}$
8. (a) i = 60° **(b)** 60° **9.** C **10.** B **11.** B **12.** C **13.** C **14.** A **15.** B
16. A→P,Q,R,S; B→Q; C→P,Q,R,S; (D)→P,Q,R,S **17.** C **18.** D **19.** A,B,C **20.** 6 **21.** B **22.** 3
23. 6 **24.** A→P,R ; B→Q,S,T ; C→P,R,T ; D→Q, S **25.** C **26.** 2 **27.** B **28.** B **29.** C **30.** A,C
31. C **33.** 007 **34.** B **35.** 2 **36.** A,C **37.** D **38.** C

MOCK TEST

1. A	**2.** C	**3.** A	**4.** B	**5.** C	**6.** A	**7.** C	**8.** B	**9.** A
10. A	**11.** A	**12.** D	**13.** D	**14.** D	**15.** C	**16.** A	**17.** A	**18.** B
19. A	**20.** B	**21.** D	**22.** C	**23.** A	**24.** D	**25.** D	**26.** C	**27.** C
28. C	**29.** A	**30.** B	**31.** C	**32.** A	**33.** A,C	**34.** A,C	**35.** A,B,C,D	**36.** A,B,C
37. A,C,D	**38.** C	**39.** D	**40.** D	**41.** D	**42.** D	**43.** B	**44.** B	**45.** D
46. D	**47.** B	**48.** B	**49.** D	**50.** D				

51. A→S; B→P; C→S; D→Q
52. A→P,R ; B→Q, R ; C→Q, R ; D→Q, R
53. A→R ; B→S; C→Q ; D→Q
54. A→P; B→R; C→Q, D→S
55. A→P, R; B→Q, S; C→Q ,R ; D→P, S
56. A→P, Q ; B→P, Q ; C→R, S ; D→R, S
57. 40 **58.** 10 **59.** 26 **60.** 91