PHYSICS

Geometrical Optics

Presented by

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Q 1.*(AIEEE 2011)*: Let the x-y plane be the boundary between two transparent media. Medium 1 in $z \geq 0$ has a 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 $A = 6\sqrt{3}i + 8\sqrt{3}j - 10k$ is incident on the plane of separation. The angle of refraction in medium 2 is?

a) 45^o
b) 60^o
c) 75^o
d) 30^o

Sol.1: ray is $A = 6\sqrt{3}i + 8\sqrt{3}j - 10k$

Here x-y plane is boundary between two media.

$\cos i = |[OZ/\sqrt{Ax^2+Ay^2+Az^2}]|$

$= [10/\sqrt{36x3+64x3+100}$

$= 10/\sqrt{400}$

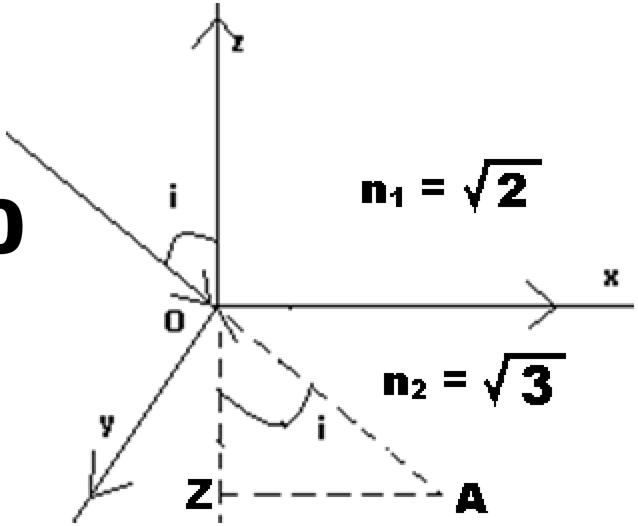
$= ½$

$\rightarrow \quad i = 60^0$

From Snell's law

$\sin i / \sin r = \sqrt{3}/\sqrt{2}$

$r = 45^o$



Ans (a)

Q 2. 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

a) Only 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 180-2θ

d) A reflected ray and a refracted ray and the angle between them would be greater than 180-2θ

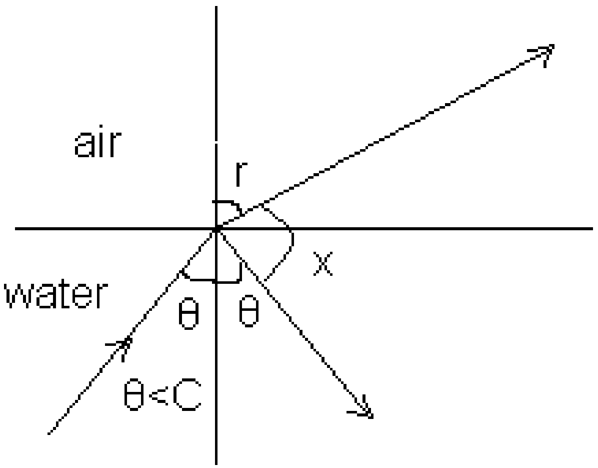
Sol.2:

Light is traveling from denser to rarer medium i.e. r > θ

X+r+ θ =180

X = 180 – r – θ

X < 180 - 2 θ |since r > θ



Ans (C)

Q.3 (IIT – JEE 2009): 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

(a) 9 ms^{-1}

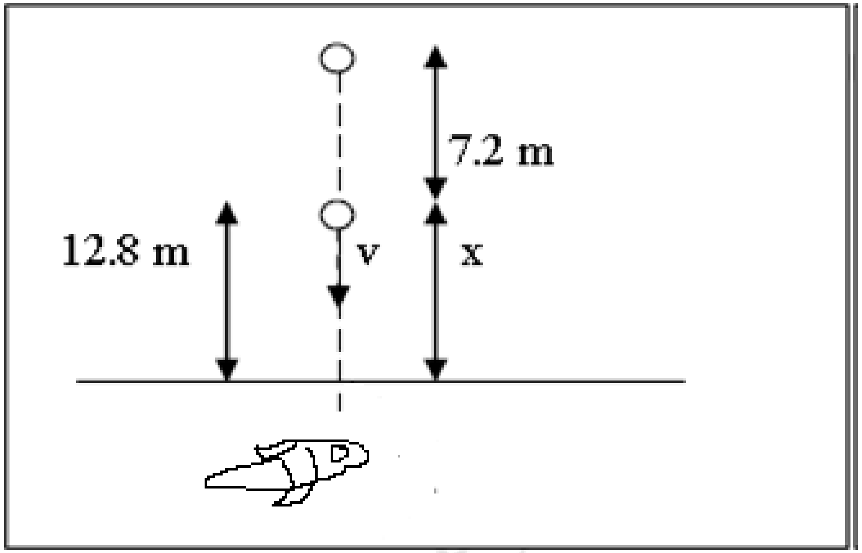
(b) 12 ms^{-1}

(c) 16 ms^{-1}

(d) 21.33 ms^{-1}

Sol.3 For freely falling body $v^2 = u^2 + 2gh$

$v = \sqrt{2gh} = \sqrt{2 * 10 * 7} = 12 ms^{-1}$



Ans = (c)

$u/v = 1/n$

or $v = n u$

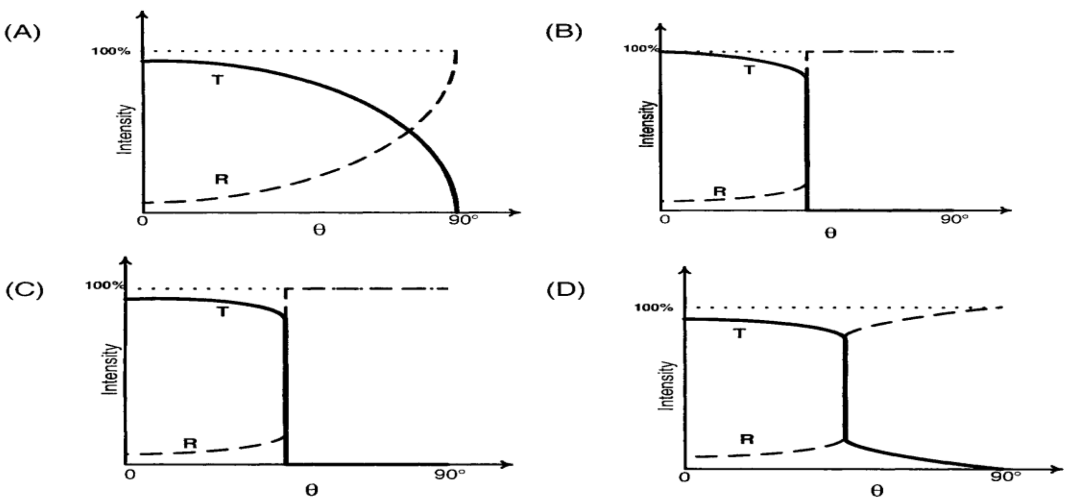
differentiating w.r.t. t

$dv/dt = n\, du/dt$

or v_{app} = n x real velocity

$= (4/3) \times 12 = 16\ ms^{-1}$

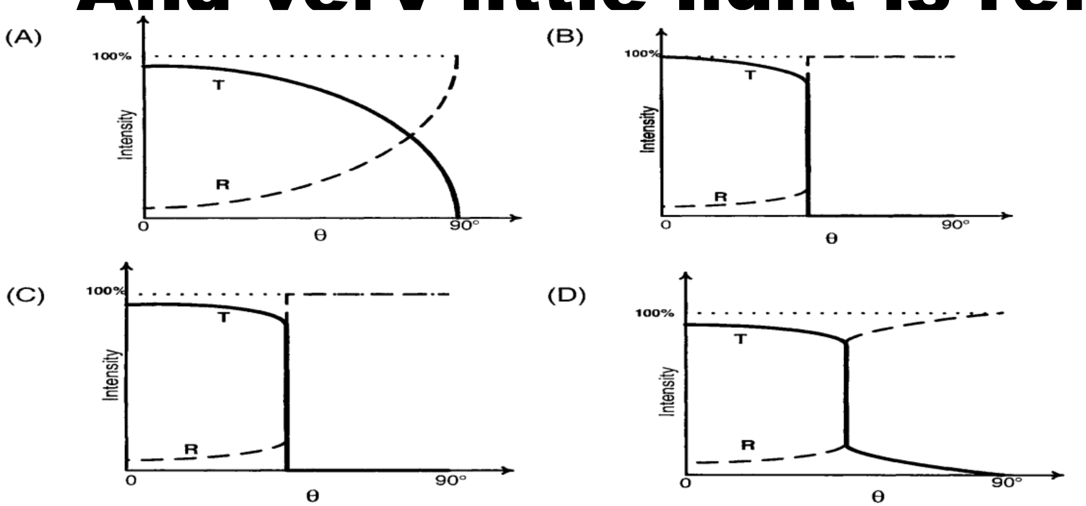
Q.4. (IIT-2011) **A light ray traveling in a glass medium is incident on a glass –air interface at an angle of incidence θ. The reflected (R) and transmitted (T) intensities, both as function of θ, are plotted. The correct sketch is**



Sol.4

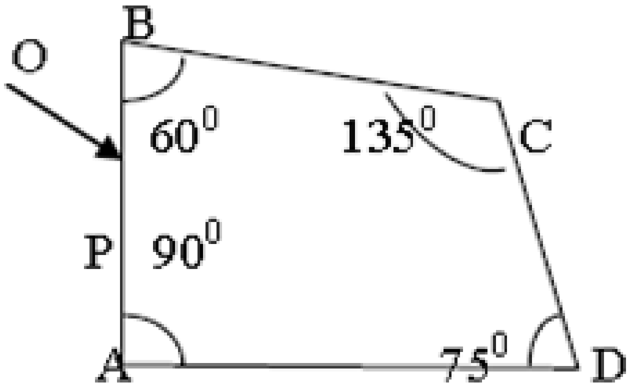
If the angle of incidence is greater than critical angle, no light is transmitted. Hence intensity of transmitted light become zero.

If θ<C, maximum light is transmitted. And very little light is reflected



Ans = (c)

Q.5. (IIT-2010)A ray OP of monochromatic light is incident on the face AB of prism ABCD near vertex B at an incident angle of 60^0. If the refractive index of the material of the prism is√3, which of the following is (are) correct?

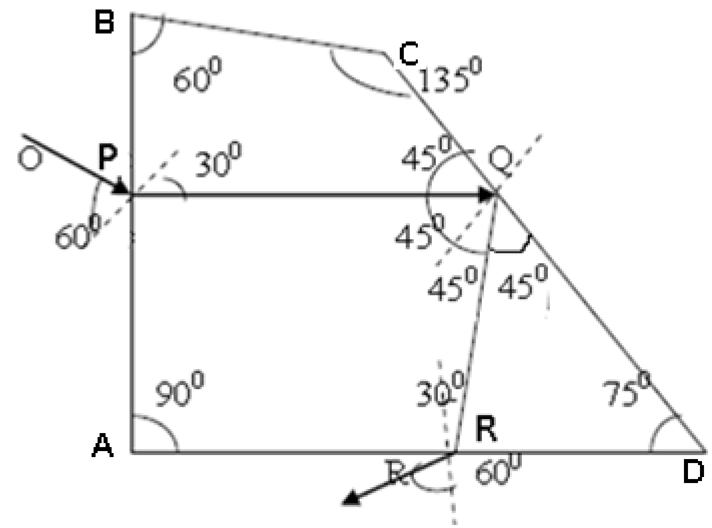


(a)The ray gets totally internally reflected at face CD

(b) The ray comes out through face AD

(c) The angle between the incident ray and the emergent ray is 120^0

(d)all the above



Sol.5

$\sqrt{3} = \sin 60^0 / \sin r$

so $r = 30^0$

Also, $\sin C = 1/\sqrt{3}$

At point Q,

angle of incidence $i = 45^0$

Since $\sin i = 1/\sqrt{2}$ is greater than $\sin C = 1/\sqrt{3}$,

Ray gets totally internally reflected at face CD.

Path of ray of light after point Q is shown in figure

Ans = (d)

Q.6 (IIT-JEE-2010) 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 the mirror

b) real and at a distance of 16 cm from the mirror

c) virtual and at a distance of 20 cm from the mirror

d)real and at a distance of 20 cm from the mirror

SOl. 6: Refraction at lens, (f=15)

Object is at 2f = 30cm therefore image is at 2f = 30 cm

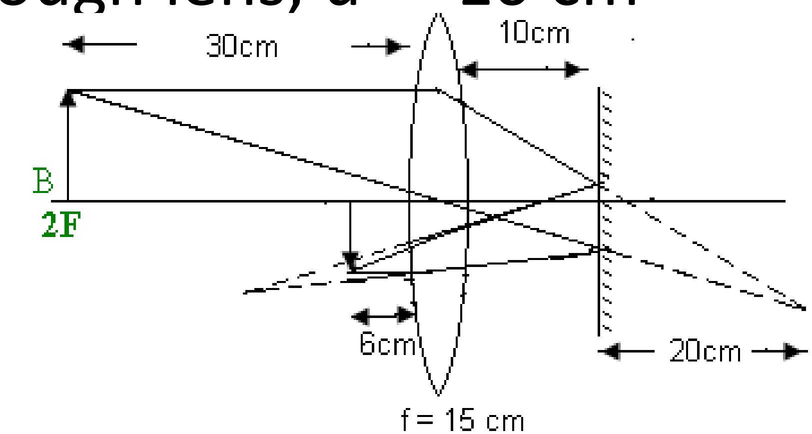
For reflection at mirror, virtual object is at 20cm behind the mirror.

Therefore image formed at 20cm in front of the mirror.

Again for refraction through lens, u = -10 cm

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

$$\frac{1}{v} = \frac{1}{15} + \frac{1}{10} = \frac{2+3}{30} = \frac{5}{30}$$



► v = 6 cm

The final real image is formed at 10+6 = 16 cm from the mirror.

Ans = (b)

Q.7 (IIT –JEE 2010): A large glass slab (n=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 value of R ?

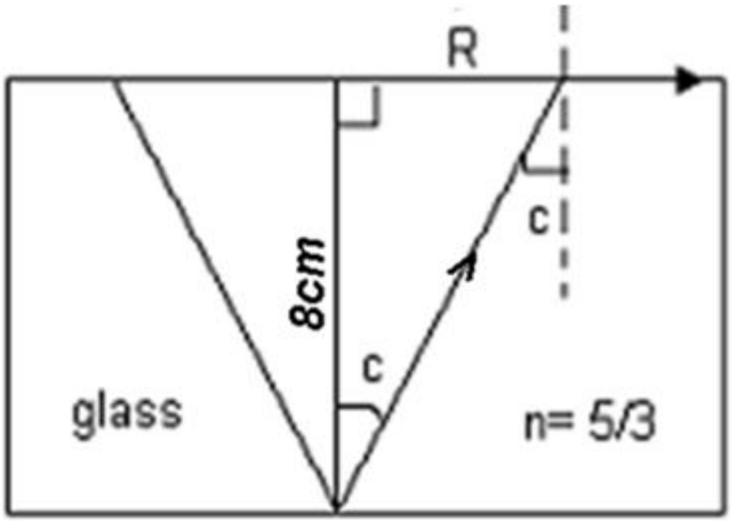
a) 4 cm

b) 6 cm

c) 8 cm

d) 5 cm

Sol.7



For critical angle C ,

$$\sin C = \frac{1}{n} = \frac{3}{5}$$

Also From figure ,

$$\tan C = \frac{R}{8} = \frac{3}{4}$$ | sides of the right angled triangle

Therefore R = 6 cm

Ans = (b)

Q.8. There is a dark spot just below a glass slab of refractive index 1.5 and of thickness 9cm. A beaker of water of refractive index 4/3 and containing of water of depth 12 cm is placed above the glass slab. When viewed vertically downwards, the dot appears to be at

a)10.5 cm
b)15 cm
c)18 cm
d)21 cm

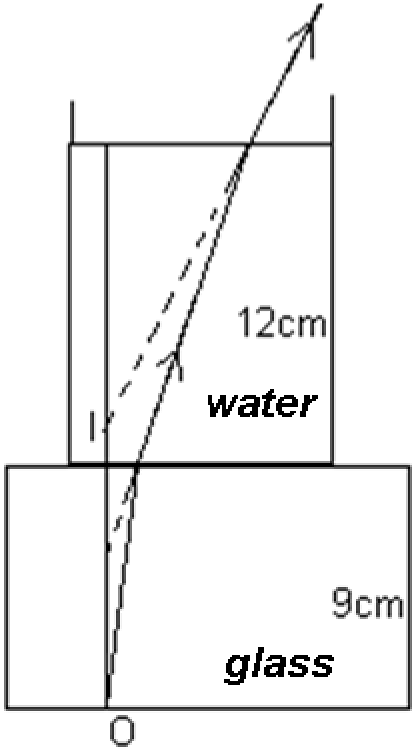
PHYSICS

Sol.8

For normal refraction throug[h] the multiple media;

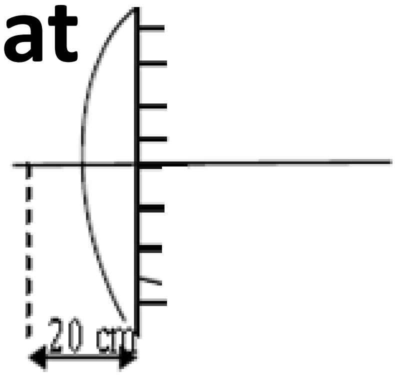
Apparent depth= $\frac{t_1}{n_1}+\frac{t_2}{n_2}$

$$=\frac{9}{1.5}+\frac{12}{\frac{4}{5}}=6+9=15\ cm$$



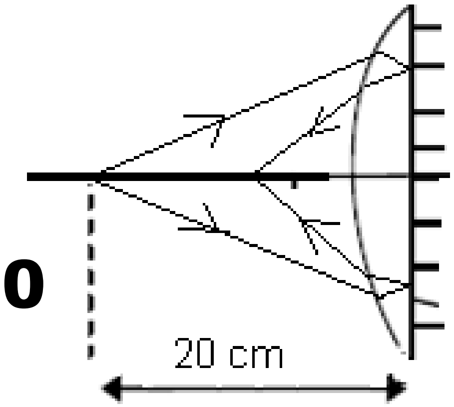
Ans (b)

Q.9 (IIT-JEE 2006)**: A point object is placed at 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**



(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

Sol.9



Refraction from lens :

$(1/v_1) = 1/f - 1/u_1 = 1/15 – 1/20 = 1/60$

$v_1 = 60$ cm

i.e. first image is formed at 60 cm to the right of lens system.

Reflection from mirror: After reflection from the mirror, the second image will be formed at a distance of $v_2 = 60$ cm to the left of lens system.

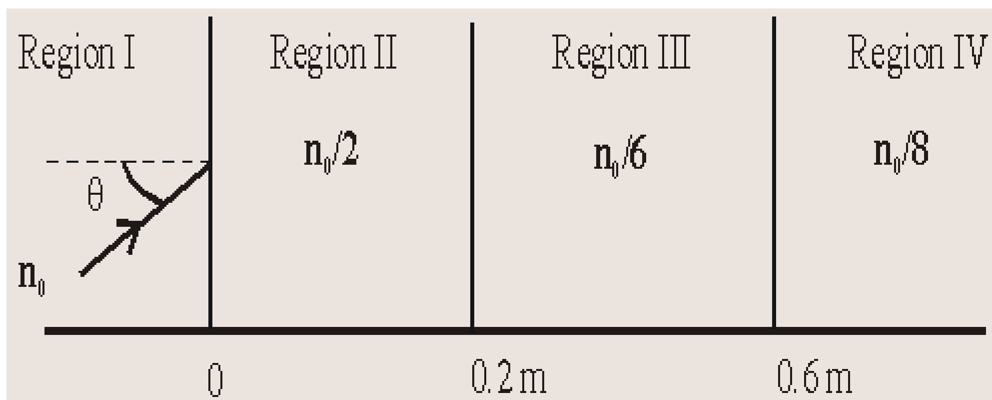
Refraction from lens:

$(1/v_3) = 1/f - (1/u_3) = 1/15 + 1/60 = 1/12$

$v_3 = 12$ cm Therefore, the final image is formed at 12 cm to the left of the lens system

Ans = (d)

Q.10 A light beam is travelling from region I to region IV (refer fig). The R.I in regions I, II, III and IV are n_o, $\frac{n_0}{2}$, $\frac{n_o}{6}$ and $\frac{n_o}{8}$ respectively. The angle of incidence θ for which the beam just misses entering region IV is



a. $\sin^{-1}\left(\frac{3}{4}\right)$

b. $\sin^{-1}\left(\frac{1}{8}\right)$

c. $\sin^{-1}\left(\frac{1}{3}\right)$

d. $\sin^{-1}\left(\frac{1}{4}\right)$

Sol.10

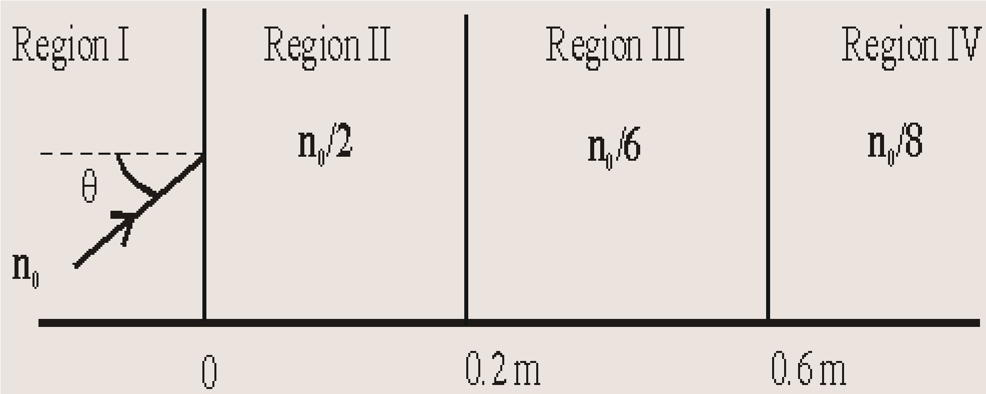
Refraction through the multiple parallel media,

$$n_1 \sin i_1 = n_2 \sin i_2 = n_3 \sin i_3 = n_4 \sin i_4 = \ldots$$

$$n_o \sin\theta_1 = \frac{n_o}{2}\sin\theta_2 = \frac{n_o}{6}\sin\theta_3 = \frac{n_o}{8}\sin 90$$

$$n_o \sin\theta_1 = n_o/8$$

$$\rightarrow \theta_1 = \sin^{-1}\left[\frac{1}{8}\right]$$



Ans = (b)

Q.11 (AIEEE 2011): A car is fitted with a convex side view mirror of focal length 20cm. A second car 2.8m behind the car is overtaking the first car with a relative speed of 15m/s. The speed of the image of the second car as seen in the mirror of the first one is

a) 1/15 m/s

b) 10 m/s

c) 15 m/s

d) 1/10 m/s

Sol.11

$1/u + 1/v = 1/f$

differentiating w.r.t. t

$-(1/u^2)(du/dt) - (1/v^2)(dv/dt) = 0$

$dv/dt = -(v^2/u^2)(du/dt)$

but $v/u = f/(u-f)$

$dv/dt = -[f/(u-f)]^2 (du/dt)$

$= \{-0.2/(2.8+0.2)\}^2 \times 15$

$= 1/15$ m/s

Ans = (a)

Q.12 A thin concave and a thin convex lenses are in contact. The ratio of the magnitude of power of two lenses is 2/3 and focal length of the combination is 30cm then focal length of individual lenses are

a. -15cm , 10cm
b. -75cm , 50cm
c. 75cm , -50cm
d. 75cm , 50cm

Sol.12

$$\left|\frac{P_{concave}}{P_{convex}}\right| = -\frac{2}{3} = \frac{f_{convex}}{f_{concave}}$$

$$\frac{1}{F} = \frac{1}{f_{concave}} + \frac{1}{f_{convex}}$$

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

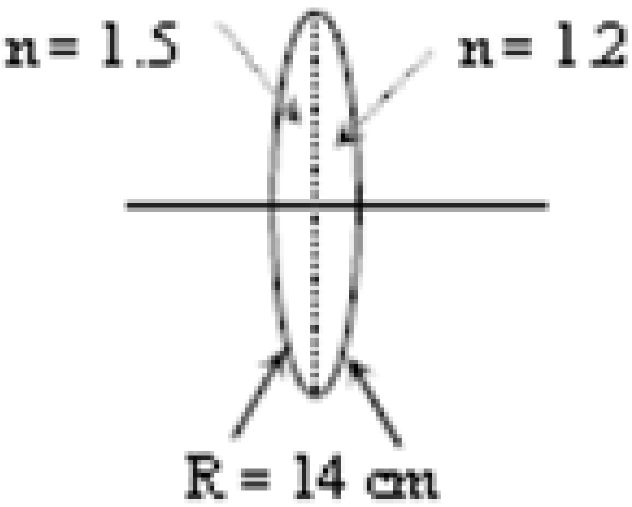
$$\frac{1}{30} = \frac{-2+3}{3f} = \frac{1}{3f}$$

$$f = 10cm$$

Where f is the focal length of convex lens

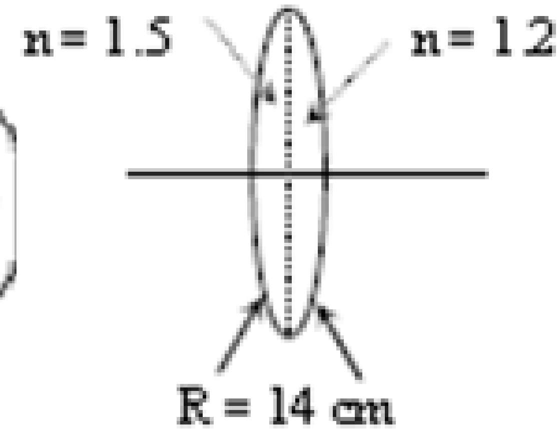
Ans = (a)

Q. 13.(IIT-2012) 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 surface are of the same radius of curvature R = 14 cm. For this bi-convex lens, for an object at distance of 40 cm, the image distance will be



a) - 280.0 cm
b) 40.0 cm
c) 21.5 cm
d) 13.3 cm

Sol.13



$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = (1.5-1)\left(\frac{1}{14}+0\right) + (1.2-1)\left(0+\frac{1}{14}\right)$$

$$= \frac{0.5}{14} + \frac{0.2}{14} = \frac{1}{20}$$

F = 20 cm

But for the combition of lenses **Ans (b)**

u=40cm = 2F

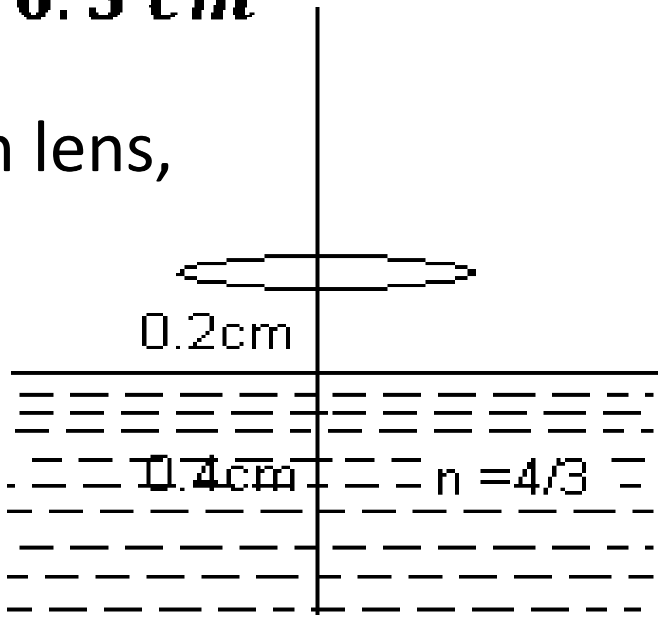
$\therefore$ v = 40 cm

Q.14 A small fish, 0.4 m below the surface of a lake, is viewed through a simple converging lens of focal length 3m. The lens is kept at 0.2 m above the water surface such that the fish lies on the optical axis of the lens. Find the distance of the image of the fish as seen by the observer (n_w = 4/3)

a. – 0.6 m b. –1m

c. + 0.6m d. 0.2m

Sol.14 $A\ d = \frac{r\ d}{n} = \frac{0.4}{4}\ x\ 3 = 0.3\ cm$



Apparent distance of the fish from lens,

u = 0.3 + 0.2 =0.5cm

f =3 m

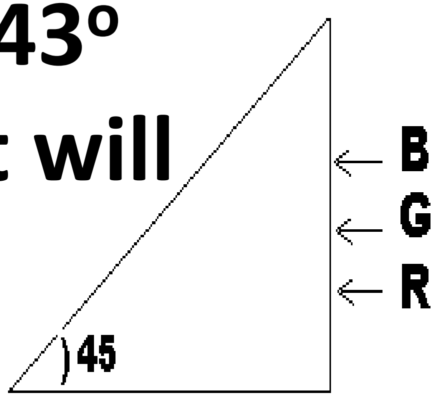
$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$= = \frac{1}{3} - \frac{1}{0.5} = \frac{1-6}{3} = \frac{-5}{3}$$

Ans = (a)

$$\rightarrow V = \frac{-3}{5} = -0.6\ m$$

Q. 15. Fig shows a mixture of blue, green and red colour rays incident on the right angled prism. The critical angles of the material of the prim for red, green and blue colours are 46°, 44° and 43° respectively. The arrangement will separate;



a) Red colour from green and blue

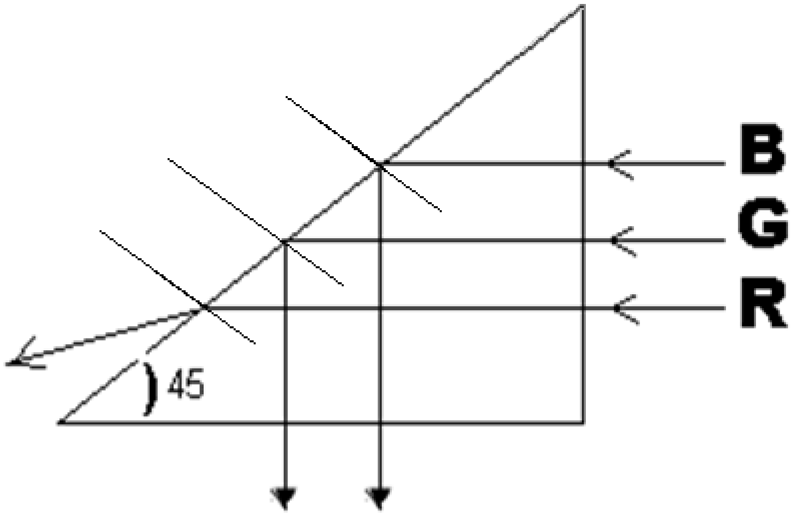
b) Blue colour from green and red

c) Green colour from red and blue

d) All the three colours

Sol.15

Since i = 45 which is greater than C for blue and green, they under go TIR. But red light gets refracted.



Ans = (a)

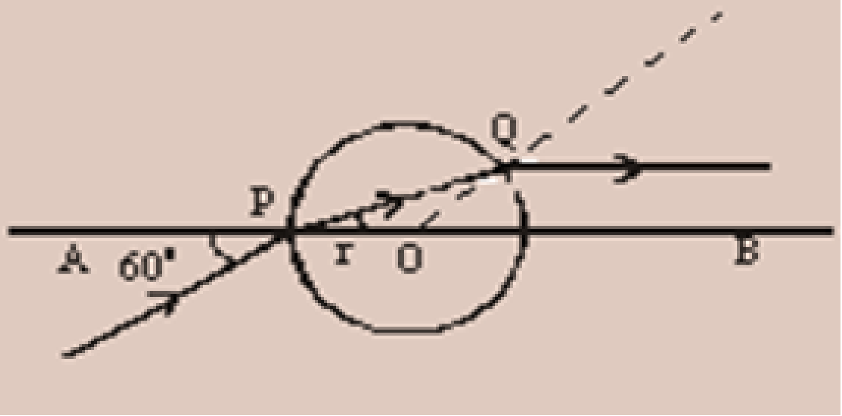
Q.16 Light is incident at 60^0 on a transparent sphere and emerges parallel to AOB. The index of refraction of the material of the sphere is

a) $2\sqrt{3}$

b) $\sqrt{3}$

c) $3\sqrt{2}$

d) $\sqrt{2}$



Sol.16

From the symmetry of the figure,

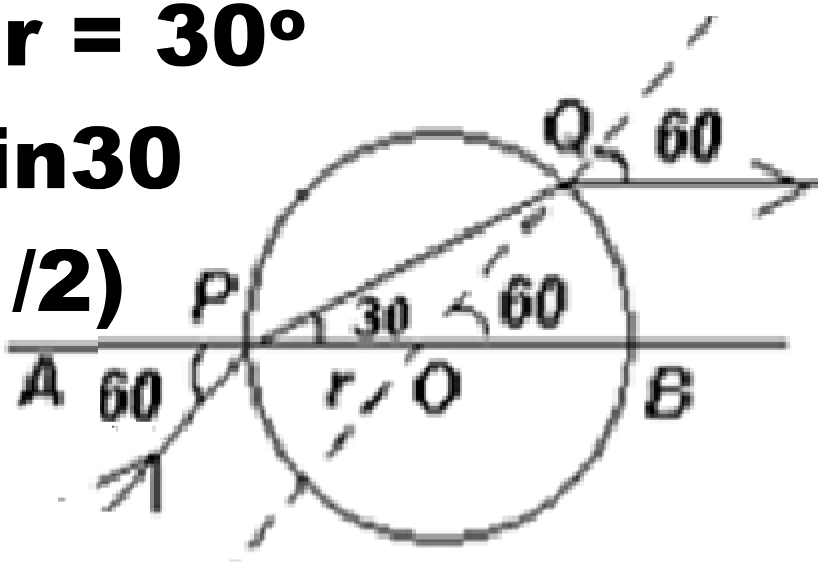
Angle of incidence i = 60°

Angle of refraction r = 30°

n= sini/sinr=sin60/sin30

=(√3/2)/(1/2)

=√3



Ans = (b)

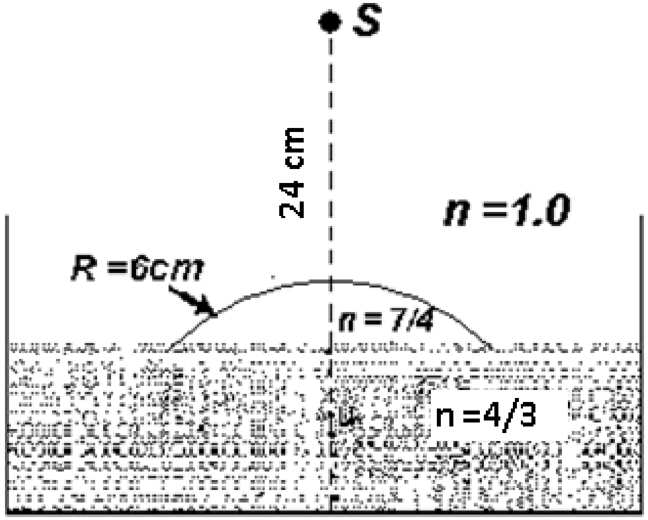
Q.17 (IIT-2011) Water (n =4/3) in a tank is 18cm deep. Oil (n=7/4) lies on water making a convex surface of radius of curvature 'R= 6cm' as shown. Consider oil to act as a thin lens. An object 'S' is placed 24cm above water surface. The location of its image is at 'x' cm above the bottom of the tank. Then 'x' is

a) 2 cm

b) 18 cm

c) 21 cm

d) 4 cm



Sol.17

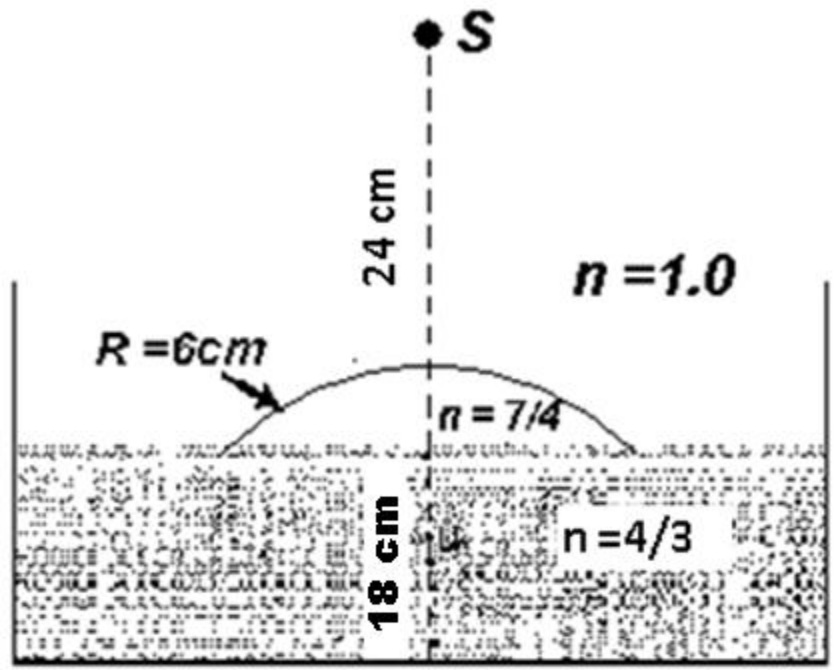
For the refraction through curved surface

$$\frac{n_1}{u}+\frac{n_2}{v}=\frac{n_1-n_2}{R}$$

$$\frac{1}{24}+\frac{7}{4v}=\frac{7/4-1}{6}=\frac{1}{8}$$

$$\frac{7}{4v}=\frac{1}{8}-\frac{1}{24}=\frac{1}{12}$$

$$v=\frac{7}{4}\times 12=21\ \text{cm}$$



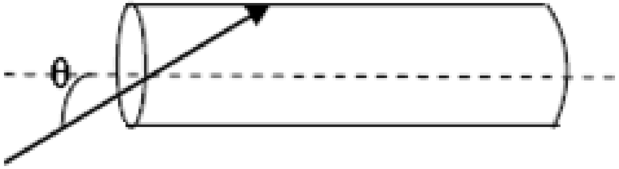
Ans = (a)

For refraction through oil-water interface,

$$ad=\frac{rd}{{}^{w}n_{o}}=\frac{21}{\frac{7}{4}\times\frac{3}{4}}=16\ \text{cm}$$

Therefore x = 18 - 16 = 2 cm

Q.18 (AIEEE 2009): A transparent solid cylindrical rod has a refractive index of $2/\sqrt{3}$. It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure. The incident angle θ for which the light ray grazes along the wall of the rod is



a)) $\sin^{-1}(1/2)$

(b) $\sin^{-1}(\sqrt{3}/2)$

(c) $\sin^{-1}(2/\sqrt{3})$

(d) $\sin^{-1}(1/\sqrt{3})$

Sol.18

$\sin c = \sqrt{3}/2$

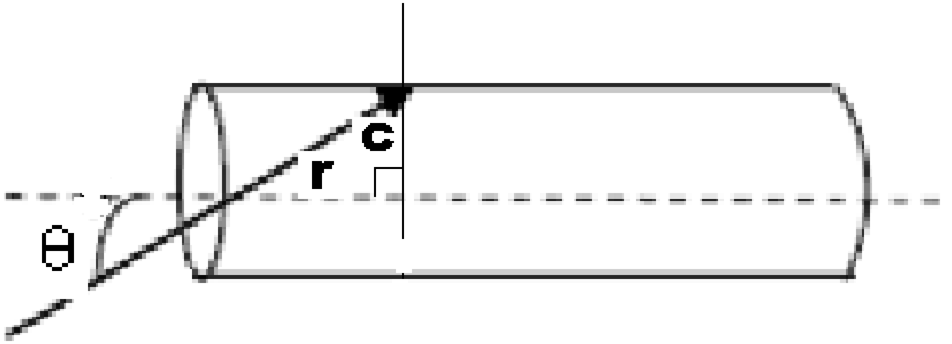
$\sin r = \sin(90^0 - c) = \cos c = ½$

From Snell's law,

$\sin \theta / \sin r = n_2/n_1$

$\sin \theta = (2/\sqrt{3}) x (1/2)$

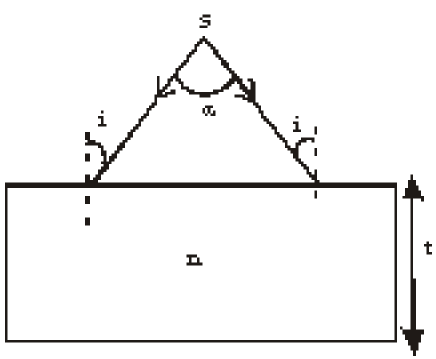
$\theta = \sin^{-1}(1/\sqrt{3})$



Ans = (d)

Q.19 A diverging beam of light from a point source S having divergence angle α, falls symmetrically on a glass slab as shown. The angles of incidence of the two extreme rays are equal. If the thickness of the glass slab is t and the refractive index n, then the divergence angle of the emergent beam is

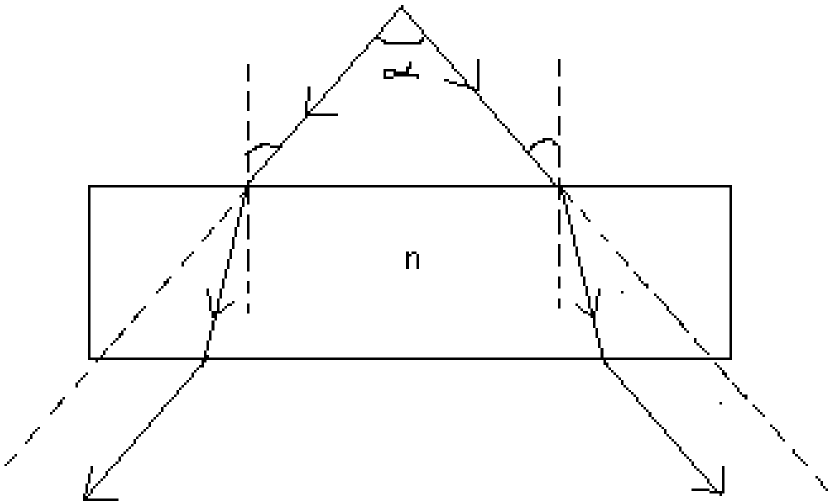
a. zero
b. α
c. $\sin^{-1}\left(\frac{1}{n}\right)$
d. $2\sin^{-1}\left(\frac{1}{n}\right)$



Sol.19

Only lateral shift take place and hence incident and emergent rays are parallel

→ divergent angle of emergent rays = α



Ans = (b)

Q.20 (IIT-JEE 2010): The focal length of a thin biconvex lens is 20 cm. When an object is moved from a distance of 25 cm in front of it to 50 cm, the magnification of its image changes from m_{25} to m_{50}. The ratio m_{25} / m_{50} is

a) 6

(b) 7

(c) 8

(d) 9

Sol.20

$1/u + 1/v = 1/f$

$(u/v) = u/f - 1$

$(u/v) = (u-f)/f$

$m = v/u = f/(u-f)$

$m_{25}/m_{50} = [20/(25-20)]/[20/(50-20)]$

$= 6$

Ans = (a)

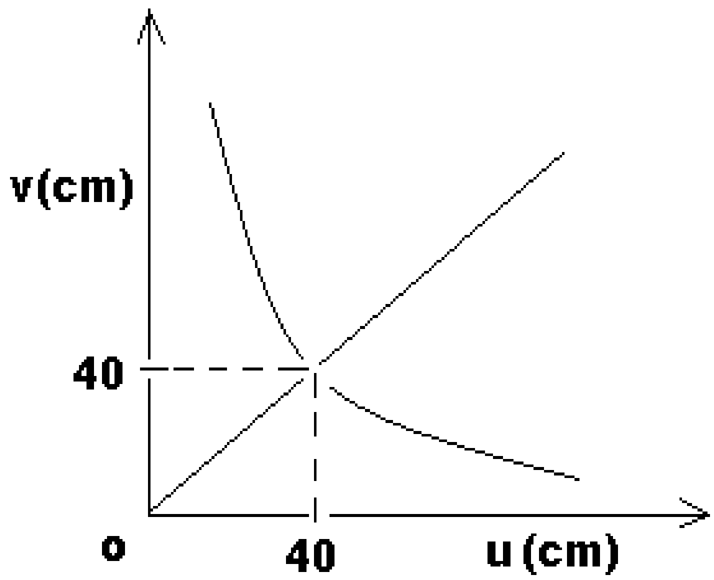
Q.21. The figure shows a graph of object distance u versus image distance v for a convex lens. The focal length of the lens is

a)10 cm

b)20 cm

c)40 cm

d)80 cm



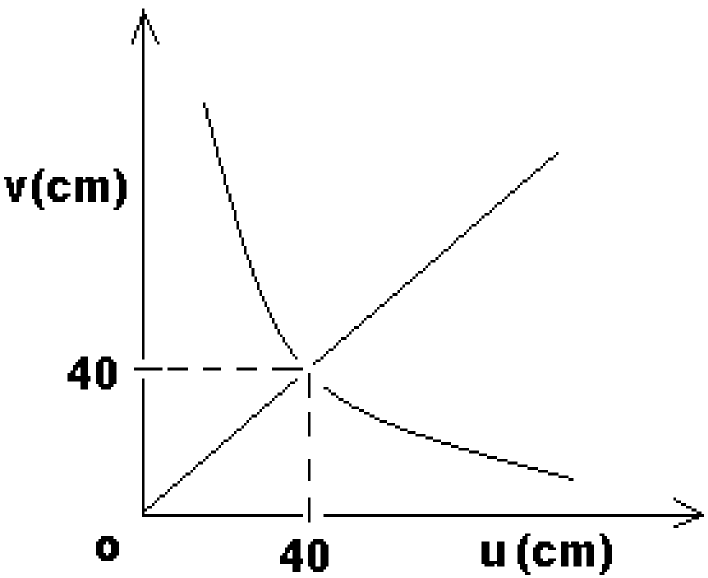
Sol.21

From figure,

when

$u = v = 40cm = 2f$

$\rightarrow f = 40 / 2 = 20cm$



Ans = (b)

Q.22. A convex lens of focal length f is immersed in water. Its focal length becomes (n_g=1.5 and n_w=1.33)

a)f

b)2f

c) 4f

d)f/4

Sol.22

In air $$\frac{1}{f} = (n_g - 1)\left[\frac{1}{r1} + \frac{1}{r_2}\right]$$

In water $$\frac{1}{f'} = \left(\frac{n_g}{n_w} - 1\right)\left[\frac{1}{r1} + \frac{1}{r_2}\right]$$

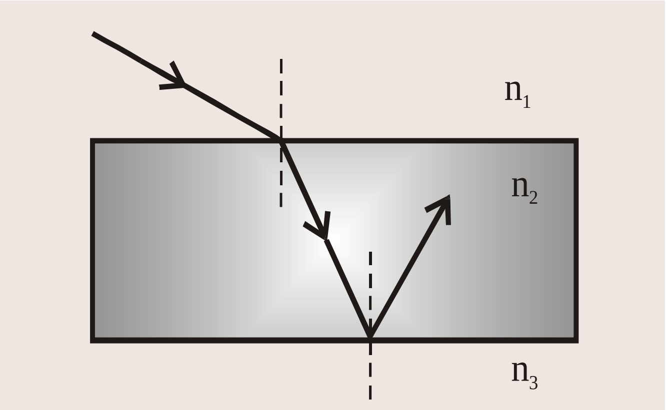
$$\frac{f'}{f} = \frac{(n_g - 1)}{(n_g - n_w)} \ x \ n_w$$

$$f' = \frac{0.5}{0.17} \, x \, 1.33 \, x \, f = 4f$$

Ans = (c)

Q.23. Light travelling through three transparent substances follows the path shown in figure. Arrange the indices of refraction in order from smallest to largest. Note that total internal reflection does occur on the bottom surface of medium 2.

a) $n_1 < n_2 < n_3$
b) $n_2 < n_1 < n_3$
c) $n_1 < n_3 < n_2$
d) $n_3 < n_1 < n_2$

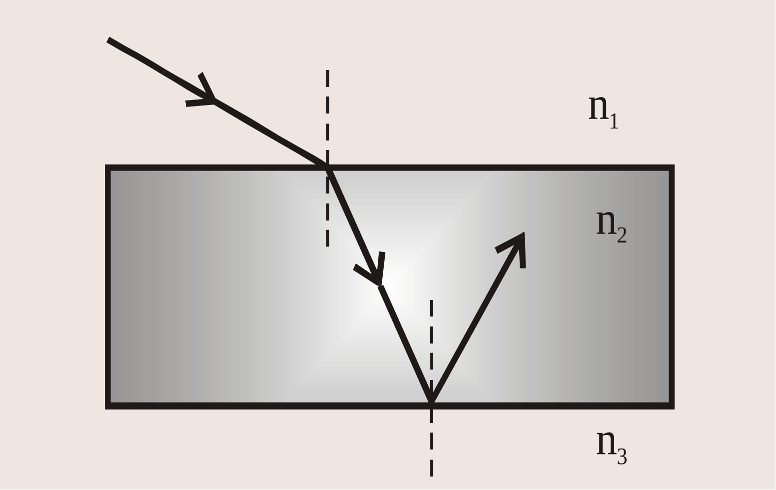


Sol.23

Due refraction at Ist face, ray bends towards the normal i.e. $n_2 > n_1$

At IInd face No TIR takes place → $n_2 < n_3$

→ $n_1 < n_2 < n_3$



Ans = (a)

Q.24. Suppose refractive index n is given as $n=A+B/\lambda^2$ where A and B are constants and λ is wavelength, then dimensions of B are same as that of

a)Wavelength

b)volume

c)pressure

d)area

Sol.24

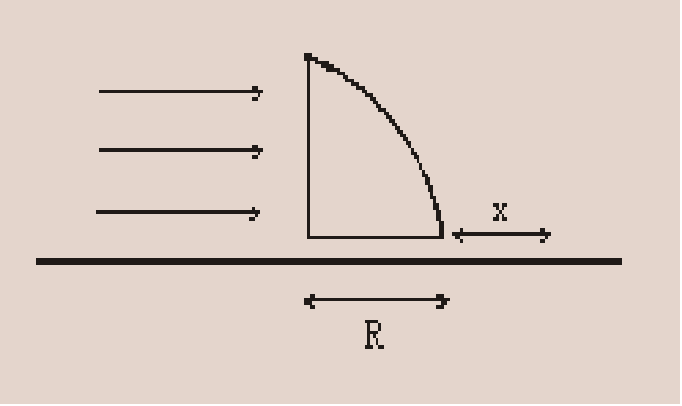
In equation $n=A+B/\lambda^2$,

Dimensions of B are same as that of $[\lambda]^2$ $=[L]^2$

i e the dimensions of B are same as that of area

Ans = (d)

Q.25 A uniform, horizontal beam of light is incident upon a prism as shown. The prism is in the shape of a quarter cylinder, of radius R = 5 cm, and has RI n = 1.5. A patch on the table top for a distance x from the cylinder is un illuminated. The value of x is,

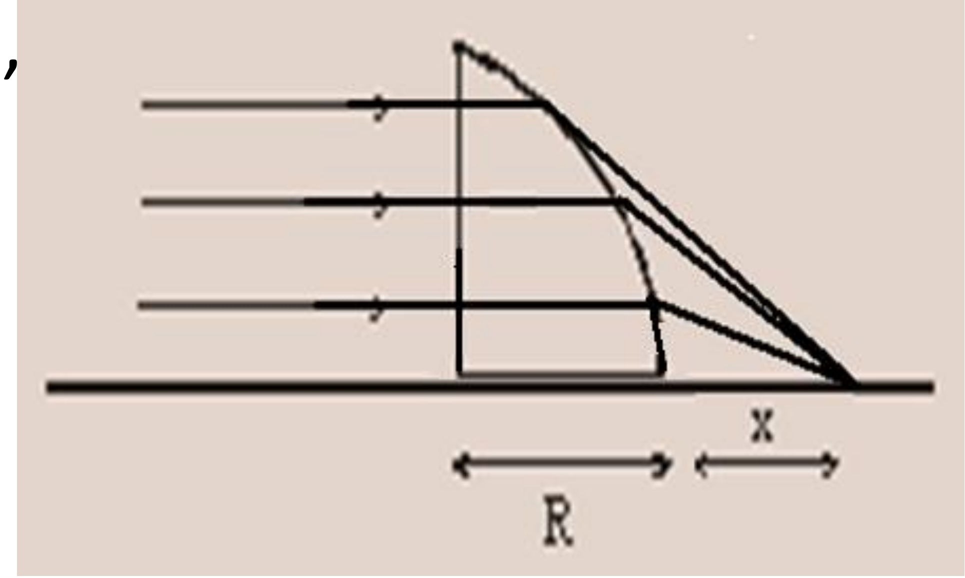


a)1.71 cm
b)2.24 cm
c)2.50 cm
d)10.0 cm

Sol.25

Since the rays are normal to the first surface, no deviation takes place.

At the IInd surface,



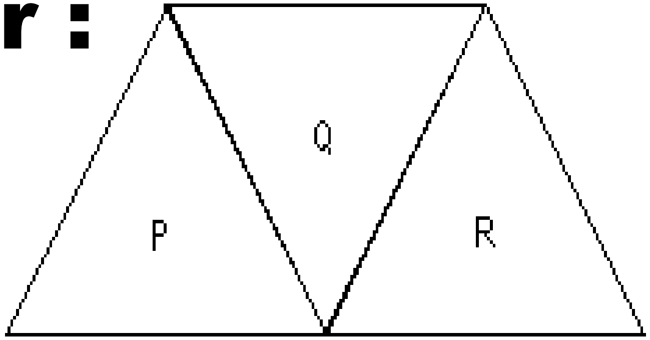
$$\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_1 - n_2}{R}$$

$$\frac{1.5}{\infty} + \frac{1}{v} = \frac{0.5}{5}$$

$$v = \frac{5}{0.5} = 10\ cm$$

Ans = (d)

Q.26 A given ray of light suffers minimum deviation in an equilateral prism P. Additional prisms Q and R of identical shape and material are now added to P, as shown in the figure. The ray will suffer :



a)same deviation

b)greater deviation

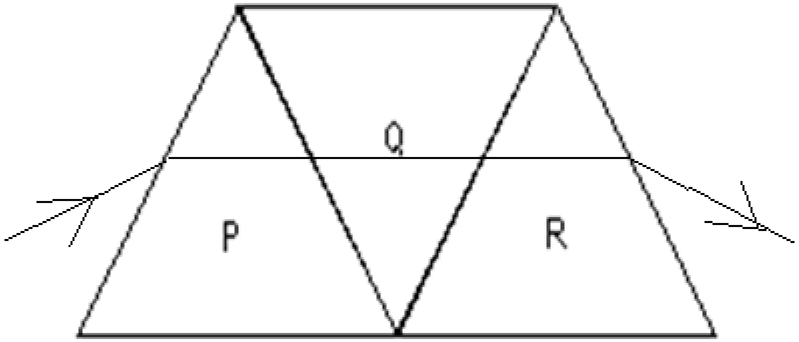
c)total internal reflection

d)no deviation

Sol.26

Addition of two identical prisms as in figure is same as addition of parallel sided slab.

Ans = (a)



PHYSICS

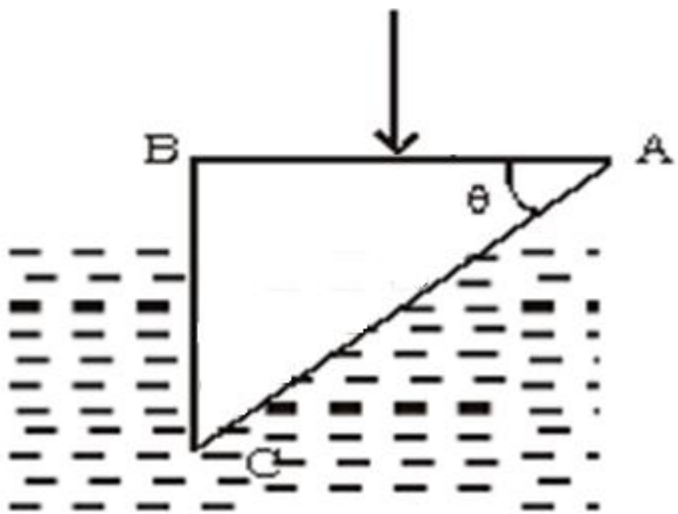
Q.27 A glass prism ABC of refractive index 1.5 is immersed in water of RI =4/3 as shown in fig. A ray of light incident normally on face AB is totally internally reflected at face AC if

a. $\sin\theta \geq \frac{8}{9}$

b. $\sin\theta \leq \frac{8}{9}$

c. $\sin\theta = \sqrt{\frac{3}{2}}$

d) $\frac{2}{3} < \sin\theta < \frac{8}{9}$



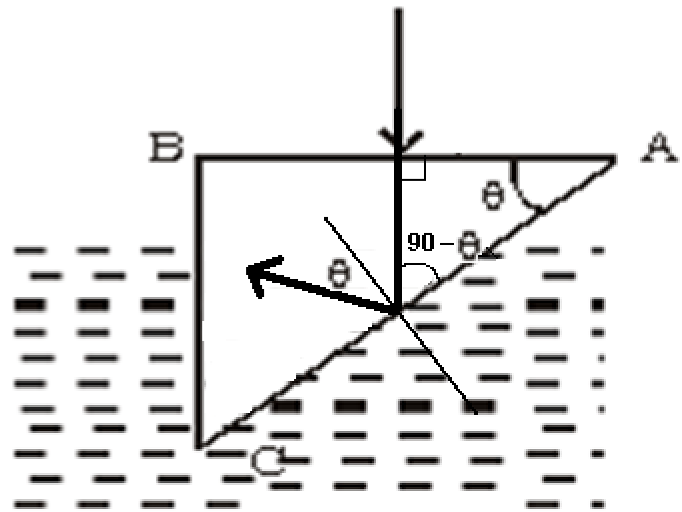
Sol.27

From fig. ϴ is the angle of incidence,

For TIR, ϴ > C

$$\sin\theta \geq \frac{n_w}{n_g} = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9}$$

$$\rightarrow \sin\theta \geq \frac{8}{9}$$



Ans = (a)

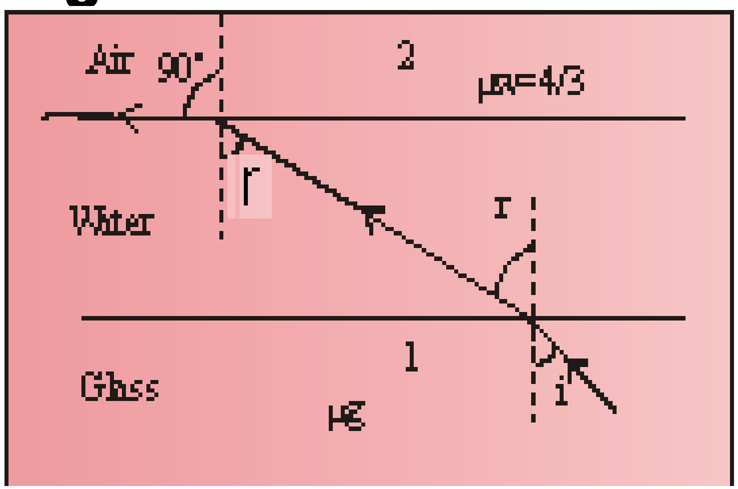
Q.28. A ray of light is incident at the glass water interface at an angle i, it emerges finally parallel to the surface of water. Then the value of n_g would be

a) $\frac{4}{3}\sin i$

b) $\frac{1}{\sin i}$

c) $\frac{4}{3}$

d) 1

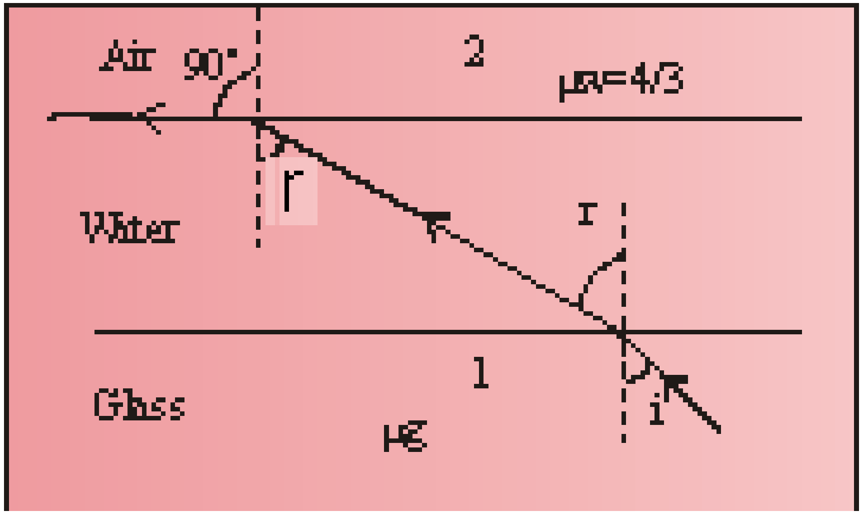


Sol.28

For refraction at glass-water interface

$$ {}_g n_w = \frac{n_w}{n_g} = \frac{\sin i}{\sin r} $$

$$ n_g = \frac{\sin r}{\sin i} \times n_w \quad \text{-------(1)} $$



For water –air interface,

$$ n_w = \frac{1}{\sin r} $$

$$ n_w \times \sin r = 1 $$

Equation (1) becomes

$$ n_g = \frac{1}{\sin i} $$

Ans = (b)

Q.29. An air bubble in side a glass slab (n=1.5) appears at 6cm when viewed from one side and 4 cm when viewed from opposite side. The thickness of the slab is

a)10 cm

b)6.67 cm

c)15 cm

d)12cm

Sol.29

$$n = \frac{\text{real thickness}}{\text{apparent thickness}} = \frac{t}{10}$$

t = 10 x n

= 10 x 1.5 = 15 cm

Ans (c)

Q.30. (AIEEE 2011): 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 n_1 and that of kerosene is n_2. The apparent shift in the position of the bottom of the beaker when viewed from above is

(a) $[1-(1/n_1)]\, h_2 + [1-(1/n_2)]\, h_1$

(b) $[1+(1/n_1)]h_1+[1+(1/n_2)]h_2$

(c) $[1-(1/n_1)]h_1 +[1-(1/n_2)]h_2$

(d) $[1+(1/n_1)]h_2-[1+(1/n_2)]h_1$

Sol.30

Apparent shift $\Delta h = [1-(1/n)]\ h$

so apparent shift produced by water

$\Delta h_1 = [1-(1/n_1)]\ h_1$

and apparent shift produced by kerosene

$\Delta h_2 = [1-(1/n_2)]\ h_2$

$\Delta h = \Delta h_1+\Delta h_2 = [1-(1/n_1)]\ h_1 + [1-(1/n_2)]\ h_2$

Ans = (c)

Q.31 Glass has RI n with respect to air and the critical angle for a ray of light going from glass to air is θ. If a ray of light is incident from air on the glass with angle of incidence θ, the corresponding angle of refraction is

a) $\sin^{-1}\left(\frac{1}{\sqrt{n}}\right)$

b) 90°

c) $\sin^{-1}\left(\frac{1}{n^2}\right)$

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

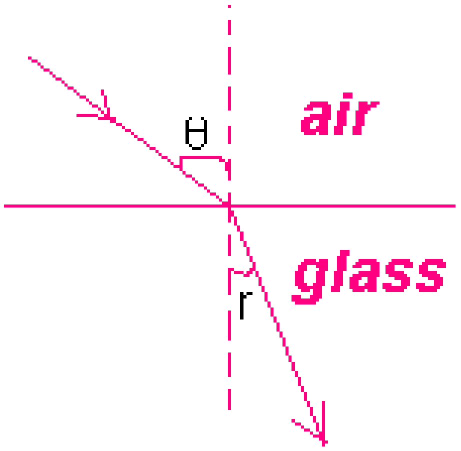
Sol.31

$$n_g = \frac{1}{\sin\theta} \rightarrow \sin\theta = \frac{1}{n_g}$$

$$\text{Also } n_g = \frac{\sin\theta}{\sin r}$$

$$\rightarrow \sin r = \frac{\sin\theta}{n_g} = \frac{1}{n^2}$$

$$\rightarrow \quad r = \sin^{-1}\left[\frac{1}{n^2}\right]$$



Ans = (c)

Q.32. A ray of light passes normally through a slab (n = 1.5) of thickness t. If the speed of light in vacuum is c then time taken by the ray to go across the slab will be;

a) $\frac{t}{c}$

b) $\frac{3}{2}\frac{t}{c}$

b) $\frac{2t}{3c}$

d) $\frac{4}{9}\frac{t}{c}$

Sol. 32 Time = $\frac{thickness}{vel.} = \frac{t}{v}$

But $n = \frac{c}{v} \rightarrow v = \frac{c}{n}$

$\rightarrow time = \frac{nt}{c} = \frac{3t}{2c}$ | n =1.5 = 3/2

Ans = (b)

Q.33 A glass slab of thickness 4cm contains the same number of waves as 5 cm of water when both are traversed by the same monochromatic light. If the refractive index of water is 4/3, what is the refractive index of glass?

a)5/3

b)5/4

c)16/15

d)1.5

Sol.33

RI of glass with respect to water is

$$ {}_{w}n_g = \frac{n_g}{n_w} = \frac{v_w}{v_g} = \frac{f\lambda_w}{f\lambda_g} = \frac{5/m}{4/m} = \frac{5}{4} $$

| same number of waves occupied in 5cm of water and 4cm of glass

$$ \rightarrow n_g = \frac{5}{4}\ x\ n_w = \frac{5}{4}\ x \frac{4}{3} = \frac{5}{3} $$

Ans = (a)

Q.34 A boat has green light (with wavelength λ = 500 nm) on its mast. What wavelength would be measured and what colour would be observed for this light as seen by a diver submerged in water (RI = 1.33) by the side of the boat?

a) Green λ = 500 nm

b) Red λ = 665 nm

c) Green λ = 376 nm

d) UV λ =376 nm

Sol.34 $n_w = \frac{c}{v} = \frac{\lambda a}{\lambda w}$

$$\lambda w = \frac{\lambda a}{n_w} = \frac{500}{4/3} = 125 \times 3 = 375 \text{ nm}$$

Colour of the light not changes when it pass from one medium to another

Ans = (c)

Q.35 A ray of light is incident normally on one of the faces of a prism of apex angle 30^0 and RI $\sqrt{2}$. The angle of deviation of the ray is

a) 0^0

b) 12.5^0

c) 15^0

d) 22.5^0

Sol.35

n = $\sqrt{2}$

$i_1 = r_1 = 0$

But $r_1 + r_2 = A = 30$

→ $r_2 = 30$

But $n = \frac{\sin i_2}{\sin r_2} = \frac{\sin i_2}{\sin 30}$

$\Rightarrow \sin i_2 = n \times \sin 30$

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

$\Rightarrow i_2 = 45$

$\therefore$ d = 0 + 45 - 30 = 15

Ans = (c)

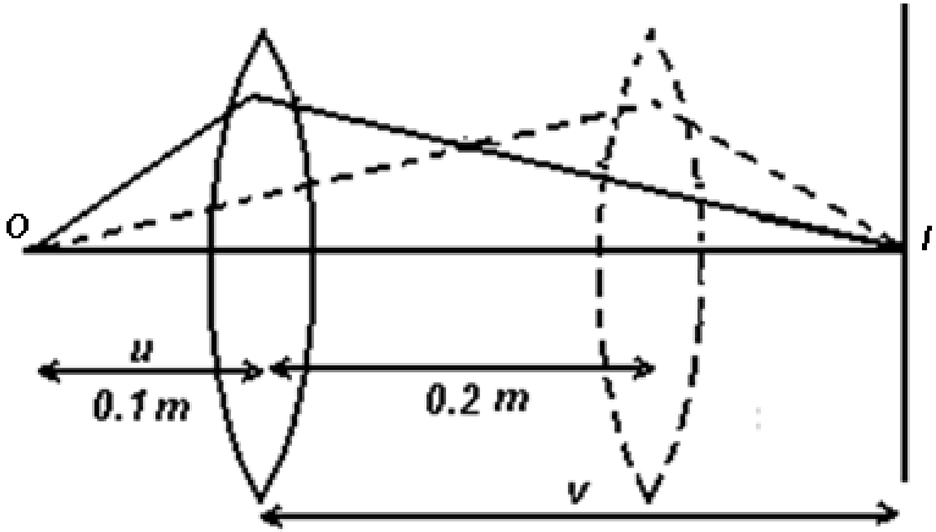
Q.36 A convex lens placed at a distance of 0.1m from an object produces a magnified image on the screen. Without disturbing the object or the screen, the lens is moved by 0.2 m, towards the screen and a diminished image is formed on the screen., the focal length of the lens must be

a)15 cm
b)20 cm
c)7.5 cm
d)10 cm

Sol.36

Here u = 0.1cm and v = 0.1 + 0.2 = 0.3cm

Therefore,



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

$$= \frac{1}{0.1} + \frac{1}{0.3}$$

$$= \frac{3+1}{0.3} = \frac{4}{0.3}$$

$$\rightarrow f = \frac{0.3}{4} = 0.075m$$

Ans = (C)

Q.37 If the RI of the material of a prism is $\cot\frac{A}{2}$ and the angle of prism is A, then angle of minimum deviation is

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

Sol.37

$$n = \cot\frac{A}{2}$$

$$n = \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$$

$$\rightarrow \sin\frac{A+D}{2} = n \; x \; \sin\frac{A}{2}$$

$$= \cot\frac{A}{2} \; x \; \sin\frac{A}{2}$$

$$= \frac{\cos\frac{A}{2}}{\sin\frac{A}{2}} \; x \; \sin\frac{A}{2} = \sin\left[\frac{\Pi}{2} - \frac{A}{2}\right]$$

$$A + D = \Pi - A$$
$$D = \Pi - 2A$$

Ans = (a)

Q.38 How much water should be filled in a container 15cm in height, so that it appears half filled when viewed from the top of the container? Given RI of water = 4/3.

a) 6.0cm

b) 7.5 cm

c) 8.0 cm

d)10.0 cm

Q.38

$$n = \frac{\text{real depth}}{\text{apparent depth}}$$

➔ real depth = n x apparent depth

$$= \frac{4}{3} \; x \; \frac{15}{2} = 10 \; cm$$

→ **Ans = (d)**

Q.39 If eye is kept at a depth h inside water of RI n and viewed outside, then the diameter of the circle through which the outer objects become visible, will be

a) $\frac{h}{\sqrt{n^2 - 1}}$

b) $\frac{h}{\sqrt{n^2 + 1}}$

c) $\frac{2h}{\sqrt{n^2 - 1}}$

d) $\frac{h}{\sqrt{n^2}}$

Sol.39

$$n = \frac{1}{\sin C}$$

Also from figure,

$$\sin C = \frac{R}{\sqrt{R^2 + h^2}}$$

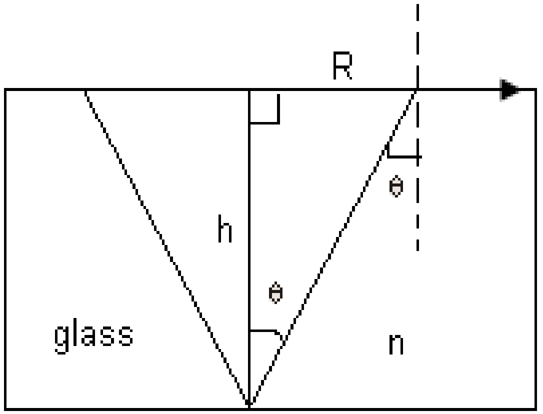
$$n = \frac{\sqrt{R^2+h^2}}{R} = \sqrt{1 + \left(\frac{h}{R}\right)^2}$$

$\rightarrow$ $$n^2 = 1 + \left(\frac{h}{R}\right)^2$$

$\rightarrow$ $$\frac{h}{R} = \sqrt{(n^2 - 1)}$$

$\rightarrow$ $$R = \frac{h}{\sqrt{(n^2-1)}}$$

$\rightarrow$ diameter = 2R = $$\frac{2h}{\sqrt{(n^2-1)}}$$



Ans =(c)

Q.40 A hallow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refractive indices n_1 and n_2 respectively ($n_2 > n_1 > 1$). The lens will diverge a parallel beam of light if it is filled with

a.air and placed in air

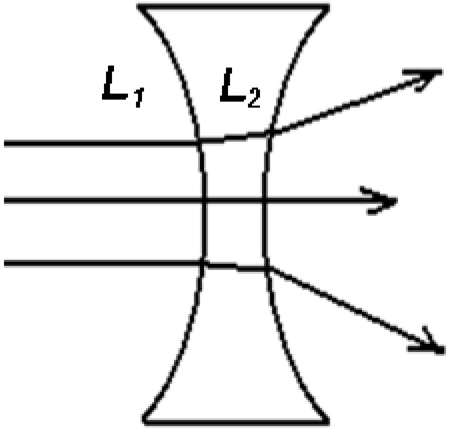
b.air and immersed in L_1

c. L_1 and immersed in L_2

d. L_2 and immersed in L_1

Sol.40

Since lens acts as diverging lens, RI of material in the lens must be greater than that of the surrounding



Ans = (d)

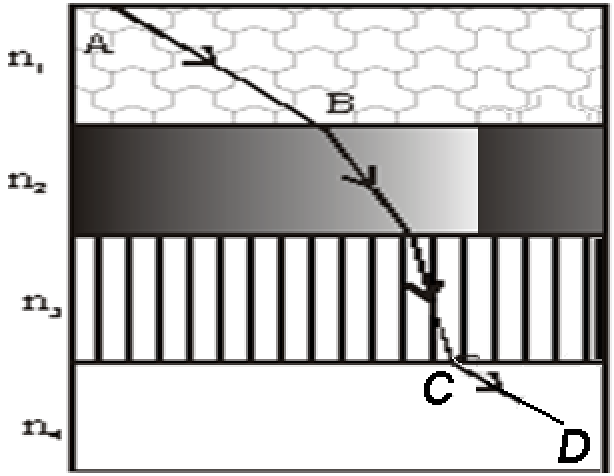
Q.41 A ray of light passes through four transparent media with refractive indices n_1, n_2, n_3 and n_4 as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we have

a) $n_1 = n_2$

b) $n_2 = n_3$

c) $n_3 = n_4$

d) $n_4 = n_1$



Sol.41

For refraction through the multiple parallel media,

$n_1 \sin i_1 = n_2 \sin i_2 = n_3 \sin i_3 = n_4 \sin i_1$

$\rightarrow n_1 = n_4$

Ans = (d)

Q.42 A swimmer under water observes a bird to be at a height of 0.3m above water. If the refractive index of water is 4/3, the actual distance of the bird above the water surface is

a) 0.225 m

b) 0.3 m

c) c. 0.15 m

d) 0.4 m

Sol.42

a d = 0.3 m

$n_w = 4/3$

$${}_w n_a = \frac{r\,d}{a\,d}$$

$$\Rightarrow r\,d = {}_w n_a \times a\,d$$

$$= \frac{1}{n_w} \times a\,d$$

$$= \frac{3}{4} \times 0.3$$

$$= \frac{0.9}{4} = 0.225 \text{ m}$$

Ans = (a)

Q.43 A ray of light is incident on a glass slab of thickness t, at an angle i, r is the angle of refraction in the glass slab. Distance travelled in the glass slab is

a) $t\cos r$

b) $t\tan r$

c) $t / \cos r$

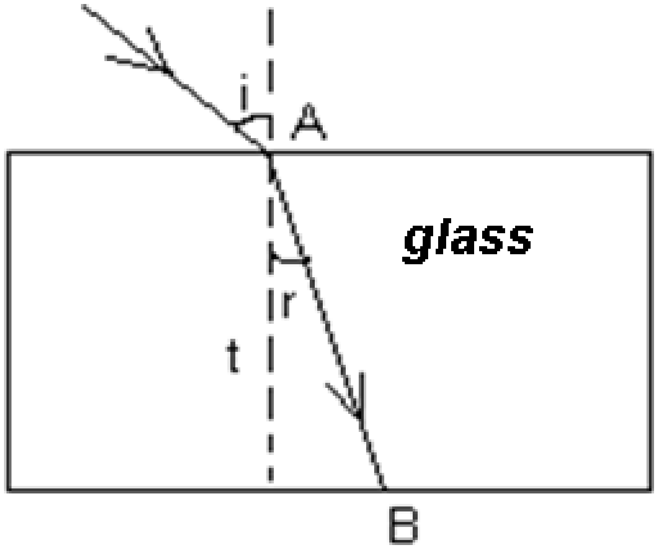
d) $t / \sin r$

Sol.43

In figure $\cos r = \frac{t}{AB}$

$\rightarrow$ $AB = \frac{t}{\cos r}$

Ans = (c)



Q.44. A graph of object distance *u* versus image distance *v* for a convex lens is

a) A straight line
b) a parabola
c) an ellipse
d) a rectangular hyperbola

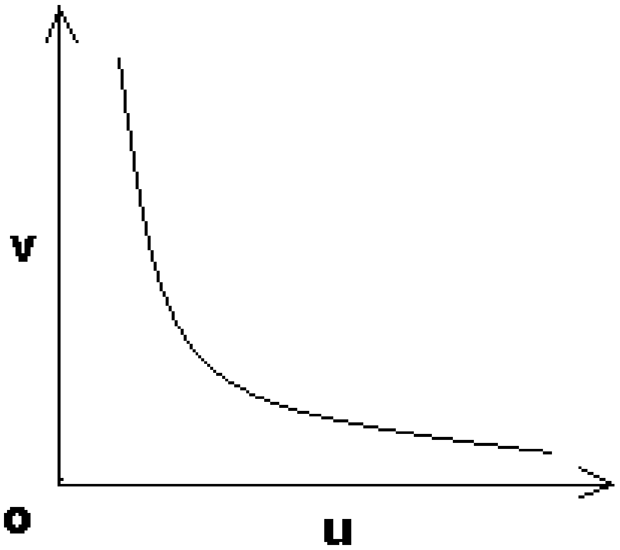
Sol.44

Lens equation

$1/u + 1/v = 1/f = \text{cont.}$

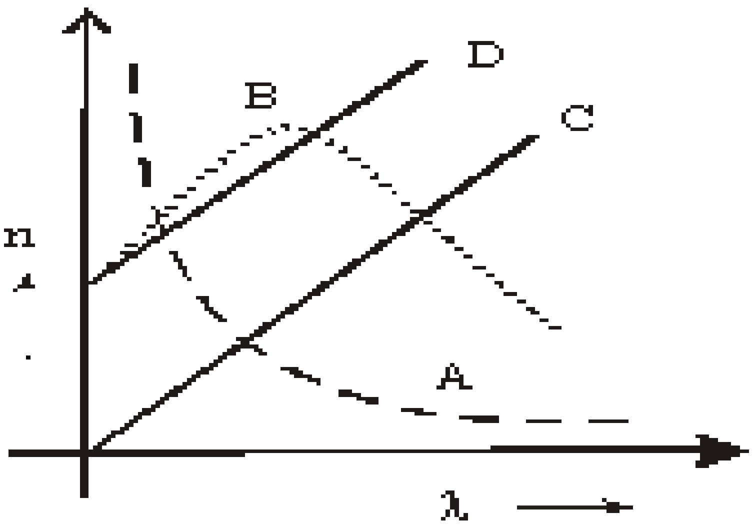
is the equation of

hyperbola



Ans = (d)

Q.45 The correct curve between refractive index n and wavelength λ will be



a) A

b) D

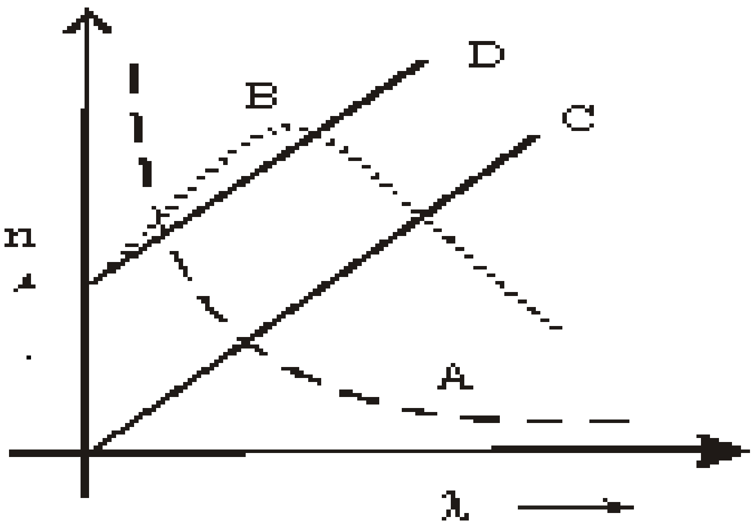
c) B

d) C

Sol.45

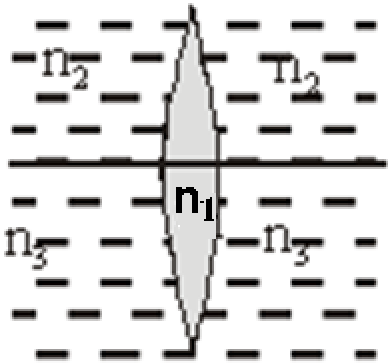
we known that

$$n = A + \frac{B}{\lambda^2}$$



Ans = (a)

Q. 46 A double convex lens, made of a material of RI n_1, is placed inside two liquids of RI's n_2 and n_3, as shown in the figure. $n_2 > n_1 > n_3$. A wide parallel beam of light is incident on the lens from the left. The lens will give rise to



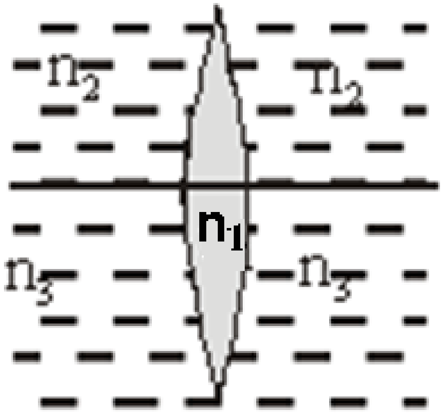
- A single convergent beam
- two different convergent beams
- Two different divergent beams
- a convergent and divergent beam

Sol.46

In medium of RI n_2 lens acts as diverging lens

In medium of RI n_3 lens acts as converging lens

Ans = (d)



Q.47. A double convex lens of focal length 'f' is cut into 4 equivalent parts. One cut is perpendicular to the axis and the other is parallel to the principal axis. Focal length of each part is

a) f/2

b) 4f

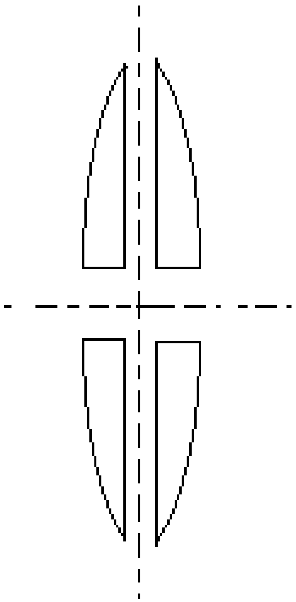
c) f

d) 2f

Sol.47

For given lens

$\frac{1}{f} = (n-1)\left[\frac{2}{r}\right]$ since $r_1 = r_2 = r$



For a piece of lens, $r_1 = r$ and $r_2 = \infty$

$$\frac{1}{F} = (n-1)\left[\frac{1}{r} + \frac{1}{\infty}\right]$$

$$= (n-1)\frac{1}{r}$$

$$= \frac{1}{2f}$$

F = 2f

Ans (d)

Q.48 A convex lens of refractive index n behaves as a convex lens of smaller power in a liquid of refractive index n_1 and as a concave lens in another liquid of refractive index n_2. Then relation between n , n_1, and n_2, is :

- $n = n_1 = n_2$
- $n > n_1 > n_2$
- $n_2 > n > n_1$
- $n_2 < n < n_1$

Sol.48

For convex lens $n > n_1$

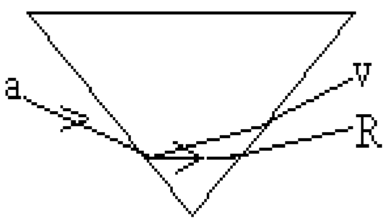
For diverging lens $n < n_2$

i.e. $n_2 > n > n_1$

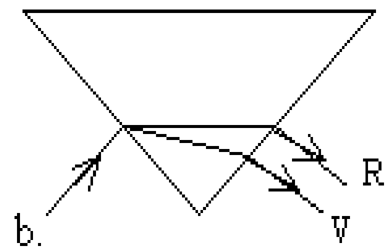
Ans = (c)

Q.49 Which of the following diagrams shows correctly the dispersion of white light by a prism?

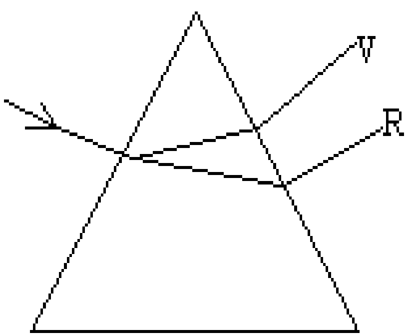
a)



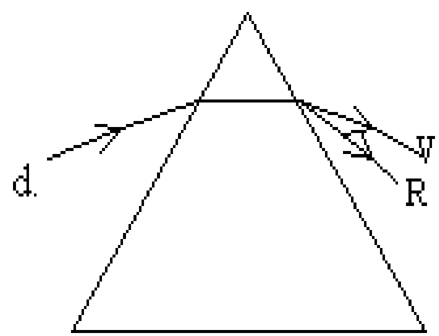
b)



c)



d)



Sol.49

For the dispersion of light, light must incident on one refracting surface from the base side and emerges from other side.

Ans = (a)

Q.50 For which of the following dispersive power is zero?

- lens
- slab
- prism
- none of these

Sol.50

Dispersive power is defined for a medium, and it is independent of the shape of the medium.

Ans = (d)

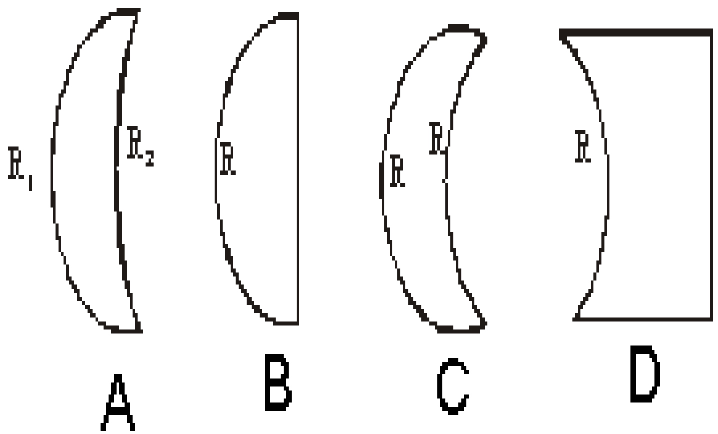
Q.51 Which one of the following spherical lenses does not exhibit dispersion? The radii of curvature of the surfaces of the lenses are as given in the diagrams.

a) A

b) B

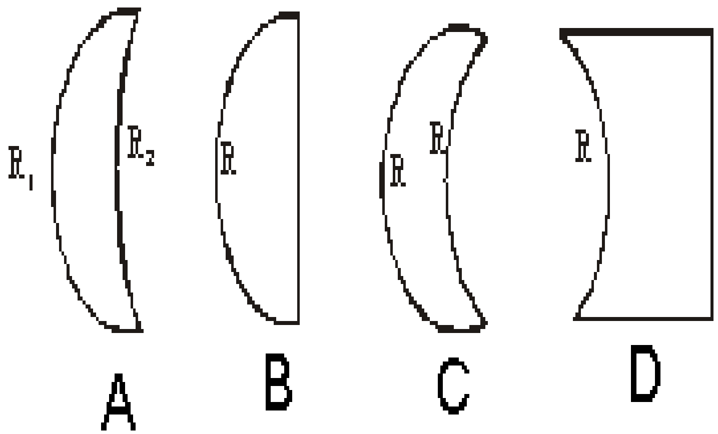
c) C

d) D



Sol.51

It is because radius of curvature of both surfaces are same but with opposite sign. From lens equation $f = \infty$



Ans = (c)

KEA

Q.52 Which of the following inequalities is satisfied by the angle of incidence i and RI n of the prism for total internal reflection

a. $\sin i > n$

b. $\sin i < n$

c. $n > \dfrac{1}{\sin i}$

d. $n < \dfrac{1}{\sin i}$

Sol.52

For TIR, $i > C$

$\rightarrow \sin i > \sin C$

$\rightarrow \sin i > 1/n$

Or $n > 1/\sin i$

Ans = (c)

Q.53 When a ray of light enters a medium of RI n then it is observed that the angle of refraction is half the angle of incidence. The value of angle of incidence will be

a. $2\sin^{-1}\left(\frac{n}{2}\right)$

b. $2\cos^{-1}(n)$

c. $\cos^{-1}\left(\frac{n}{2}\right)$

d. $2\cos^{-1}\left(\frac{n}{2}\right)$

Sol.53

Ans=(d)

$$r = \frac{i}{2}$$

$$n = \frac{\sin i}{\sin r} = \frac{\sin i}{\sin\frac{i}{2}} = \frac{2\sin\frac{i}{2} . x \cos\frac{i}{2}}{\sin\frac{i}{2}}$$

$$= 2\cos\frac{i}{2}$$

$$\rightarrow \cos\frac{i}{2} = \frac{n}{2}$$

$$\rightarrow i = 2\cos^{-1}\left[\frac{n}{2}\right]$$

Q.54A ray of light travelling in a transparent medium falls on a surface separating the medium from air, at an angle of incidence of 45^0. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible values of n from the following

a) 1.3
b) 1.41
c) 1.2
d) 1.6

Sol.54

For TIR, $i > C$

$\rightarrow \sin i > \sin C$

$\rightarrow \sin i > 1/n$

Or $n > 1/\sin i$

$n > 1/\sin 45$

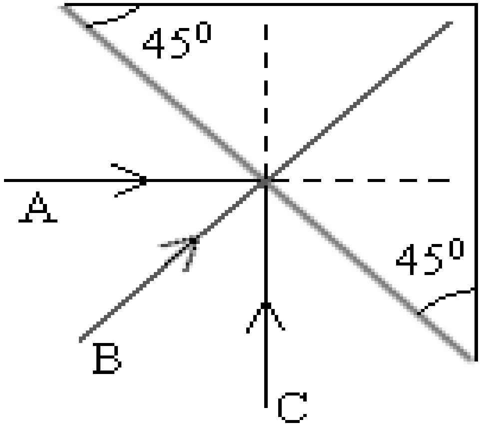
$n > \sqrt{2} = 1.41$

Ans = (d)

KEA

PHYSICS

Q.55 On a right angled prism, the rays A,B and C are incident, as shown in the figure. Before emerging from the prism, which ray or rays will experience total internal reflection?



a) A

b) B

c) C

d) none of these

Sol.55

Since the rays A and C bends towards normal and angle of incidence for the second face is less than C.

Ans = (b)

Q.56 If a glass rod is put in a beaker containing a colourless liquid, the glass rod immediately seems to disappear. It is so because

a) the liquid and the glass have the same colour

b) the glass and the liquid have the same refractive index

c) the glass and the liquid have the same density

d) the glass reflects the light transmitted by the liquid

Q.57 When light is refracted through a prism, maximum deviation occurs if,

a) the ray incident grazing the first face

b) the ray emerges out grazing its second face

c) either of the above happens

d) The angle of incidence is 45^o

Sol.57

d= $i_1 + i_2 - A$ is maximum if i_1 or i_2 is maximum.

i.e. ray incident grazing the surface or ray emerges grazing the surface suffers maximum deviation

Ans = (c)

Q.58 Two optical media of refractive indices n_1 and n_2 contain x and y waves of the same colour in the same thickness. Then their relative refractive index $_1n_2$ is equal to

- (y – x) / x
- x / (y – x)
- x – y
- y / x

Sol.58

| same length ‘t’ occupied x no. of waves in medium-1 and y no. of waves in medium-2

$$ {}_1n_2 = \frac{\lambda_1}{\lambda_2} = \frac{t/x}{t/y} = \frac{y}{x} $$

→ Ans = (d)

Q.59 A convex lens produces a real image m times the size of the object. What is the distance of the object from the lens?

a. $f\frac{m+1}{m}$

b. $f\frac{m-1}{m}$

c. $f(m-1)$

d. $f(m+1)$

Sol.59

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

$$\rightarrow v = m\,u$$

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

$$\rightarrow \frac{1}{u} + \frac{1}{mu} = \frac{1}{f}$$

$$\rightarrow \frac{1}{u}\left(1 + \frac{1}{m}\right) = \frac{1}{f}$$

$$\rightarrow u = \left(1 + \frac{1}{m}\right) f = f\,\frac{(m+1)}{m}$$

Ans = (a)

Q.60 A convex lens of focal length f_1 is put in contact with a concave lens of focal length f_2. The combination which will behave as a converging lens if

a. $f_1 > f_2$

b. $f_1 = f_2$

c. $\frac{1}{f_1} > \frac{1}{f_2}$

d. $f_1 = \frac{1}{f_2}$

Sol.60

For the combination of the lenses

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

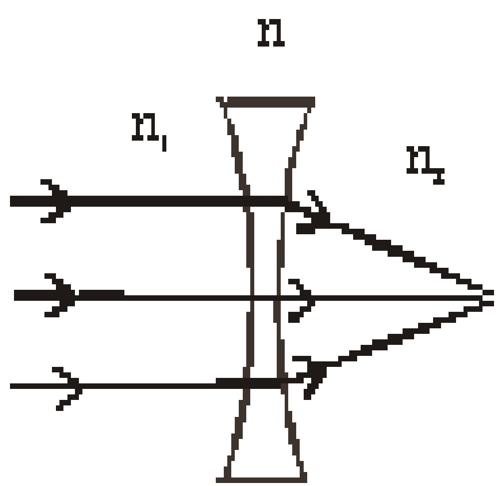
Since the combination acts as convex lens f is positive

Therefore from above equation $\frac{1}{f_1} > \frac{1}{f_2}$

Ans = (c)

Q.61 Rays of light are incident on a concave lens of refractive index n from a medium of refractive index n_1. After refraction it converges in a medium of refractive index n_{2-} (fig). The relation between n_1, n_2 and n is

- $n_1 = n < n_2$
- $n_1 = n > n_2$
- $n_1 < n = n_2$
- $n_1 > n = n_2$



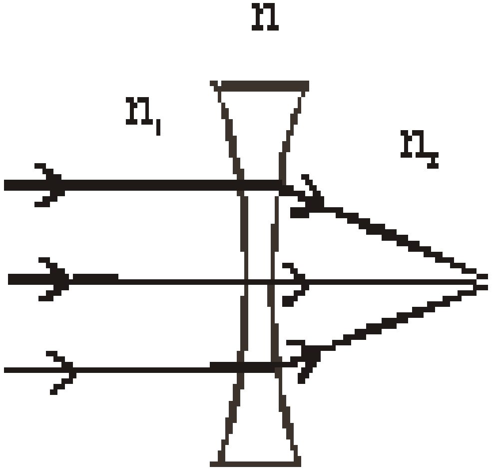
Sol.61

Rays are not deviated at the first face

Therefore $n_1 = n$

At the second face converging rays show that $n < n_2$

i.e. $n_1 = n < n_2$



Ans = (a)

Q 62. Two beams of red and violate colours are to pass separately through a prism (angle of prism is 60˚). In the position of minimum deviation, the angle of refraction will be

a) 30˚ for both colours

b) Greater for the violate colour

c) Greater for the red colour

d) Equal but not 30˚ for both the colours

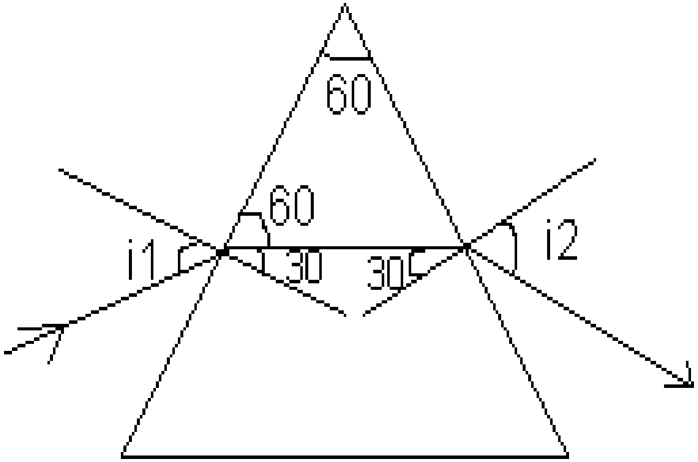
Sol.62 :

In minimum deviation position for equilateral prism,

$r_1 + r_2 = 60^\circ$

$2r = 60^\circ$ or $r = 30^\circ$

for any colour.



Ans (a)

Q.63 Light passing from air to glass is refracted, as is light passing from glass to air. However when you look out of a window at the view outside, the light does not seem to have been distorted. This is because

a) the angle of refraction is too small to observe
b) light incident upon the glass is partially reflected and this tends to mask the effect of refraction
c) the emergent ray is parallel to the incident ray and only displacement occurs
d) the window panel is too thin for refraction to occur

Sol.63

the emergent ray is parallel to the incident ray and only displacement occurs. Also displacement is very small as thickness of glass is very small

Ans (c)

Q.64 A camera is focused to take the picture of a girl standing 2m away from the camera lens. If the film is 10cm from the lens, the focal length of the lens expressed in cm is

a) 20

b) 9.5

c) 200

d) 10.0

Sol.64

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

$$= \frac{1}{2} + \frac{1}{0.1}$$

$$= \frac{1+20}{2} = \frac{21}{2}$$

$$\rightarrow f = \frac{2}{21} = 0.095\,m = 9.5\,cm$$

Ans = (b)

Q.65 Two plano-convex lenses, each having focal length of 0.4 m are pressed against each other at their plane faces. This forms a double convex lens. At what distance from this lens must an object be placed to obtain a real, inverted image with magnification one?

a) 0.8 m
b) 0.4 m
c) 0.2 m
d) 1.6 m

Sol.65

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{2}{0.2}$$

$$f = \frac{0.4}{2} = 0.2\,m$$

Magnification = m = $\frac{v}{u}$ **= 1**

i.e. v = u = 2f = 2 x 0.2 = 0.4 m

Ans = (b)

Q.66 The velocity of light in a piece of matter is v. The thickness of the piece is t and its refractive index is n. The distance travelled by light in air in time (t/v) is

a) nt
b) nt^2
c) nt^3
d) nt^4

Sol.66

$\frac{t}{v}$ = time taken by light to cover distance t in a medium

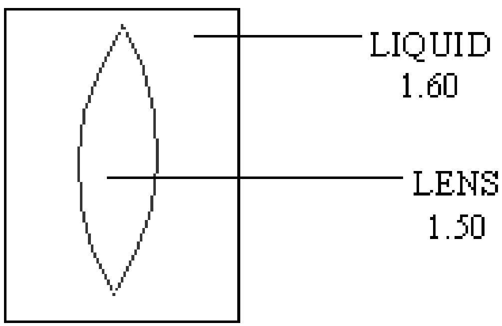
Distance traveled by light in air = n x distance traveled by it in a medium

= n x t = nt

Ans = (a)

Q.67 The figure shows a convergent lens placed inside a cell filled with a liquid. The lens has a focal length +20 cm, when in air and its material has refractive index 1.5. if the liquid has a refractive index 1.6, the focal length of the system is

a) +80 cm
b) –80 cm
c) –24 cm
d) –160 cm



Sol.67

F= 20cm , n = 1.5 , n_l = 1.6

In air, $$\frac{1}{f} = (n-1)\left[\frac{1}{r1} + \frac{1}{r_2}\right]$$

In liquid, $$\frac{1}{f'} = \left(\frac{n}{n_l} - 1\right)\left[\frac{1}{r1} + \frac{1}{r_2}\right]$$

Ans = (d)

$$\frac{f'}{f} = \frac{(n-1)}{(n-n_l)} \ x \ n_l$$

$$f' = \frac{0.5}{-0.1} \ x \ 1.66 \ x \ 20 = -160cm$$

Q.68 A water drop is placed on a glass plate. A convex lens of radii of curvature 0.2 m is placed on it. The focal length of the water lens is (RI of water = 4/3)

a)– 0.2 m

b)+0.6 m

c)– 0.6 m

d)+0.2 m

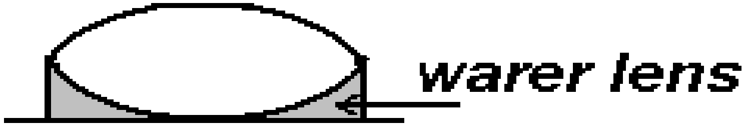
Sol.68

For water lens, r_1 = - 0.2m , r_2 = ∞ and n=4/3

$$\frac{1}{f} = \left(\frac{4}{3} - 1\right)\left(\frac{-1}{0.2}\right)$$

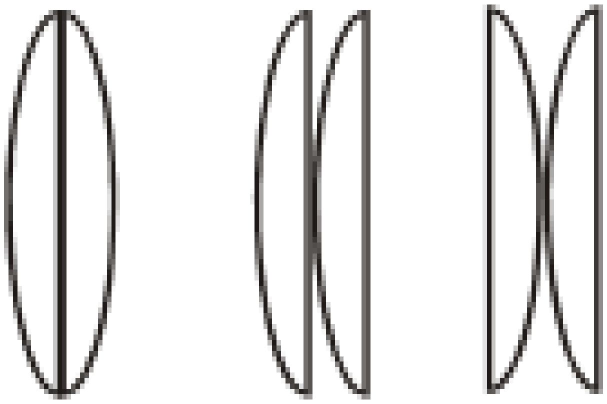
$$= \frac{-1}{3\ x\ 0.2}$$

$$f = -0.6m$$



Ans = (C)

Q.69 Two similar Plano -convex lenses are combined as shown in the figure. The ratio of their focal lengths will be



a) 2 : 1 : 1

b) 1 : 1 : 1

c) 2 : 1 : 2

d) 1 : 2 : 2

Sol.69

The equivalent focal length of the combination is

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

Which is same for all combinations of lens.

Ans = (b)

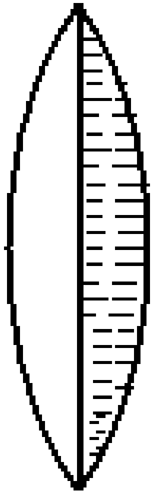
Q.70 The layered lens shown in fig. is made of two kinds of glass. A point source of light is placed on its principal axis. If reflections from the boundaries between layers are ignored, the lens will form

a) Only one image

b) Two images

c) No image at all

d) Infinite image



Sol.70

It is like a combination of two Plano – convex lenses.

Therefore only one image is formed.

Ans = (a)

Q.71 A double convex lens of focal length 'f' is cut into 4 equivalent parts. Both the cuts are mutually perpendicular and parallel to the principal axis. Focal length of each part is

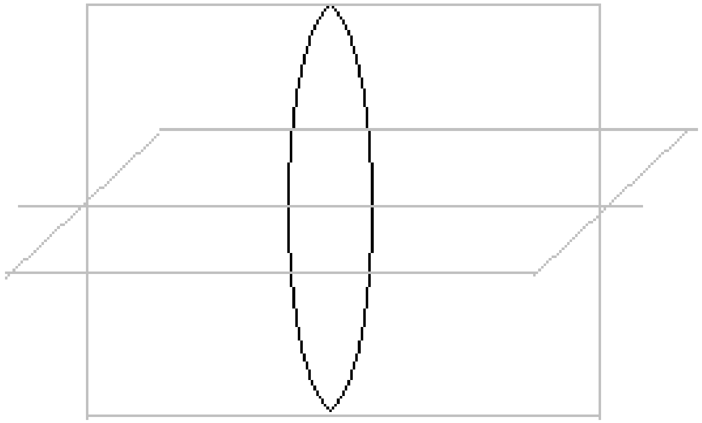
a) f/2

b) f

c) 2f

d) 4f

Sol.71



focal length of pieces of lens not changed as radii of curvature of lens not changed

Ans (b)

Q.72 A thin lens has focal length f, and its aperture has diameter d. It forms an image of intensity I. Now, the central part of the aperture up to diameter d/2 is blocked by an opaque paper. The focal length and image intensity will change to

a) f/2 and I/2
b) f and I/4
c) 3f/4 and I/2
d) f and 3I/4

Sol.72

Focal length not changes as radius of curvature of faces not changed

Area of lens exposed to the light = A/4

[$A=\pi d^2/4$ new area $A^1 = \pi(d/2)^2/4 = A/4$]

► Intensity of light = I/4

Ans (b)

Q.73 The sun's diameter is 1.4×10^9m and its distance from the earth is 10^{11}m. The diameter of its image, formed by a convex lens of focal length 2m will be

a) 0.7cm
b) 1.4cm
c) 2.8cm
d) Zero i.e point image

Sol.73

Magnification,

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

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

$$= \frac{2\ x\ 1.4\ x\ 10^9}{10^{11}}$$

$$= 2.8\ cm$$

Ans (c)