PHYSICS

Q.1 An unnumbered wall clock shows time 04 : 25 : 37, where 1st term represents hours, 2nd represents minutes & 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 **[C]**

Q.2 Two vertical plane mirrors are inclined at an angle of 60º with each other. A ray of light traveling horizontally is reflected first from one mirror and then from the other. The resultant deviation is -

(A) 60º (B) 120º

(C) 180º (D) 240º

Sol.[D] $\delta = 2\pi - 2\theta = 2\pi - 2\,\frac{\pi}{3} = \frac{4\pi}{3}$

Q.3 When a plane mirror is placed horizontally on level ground at a distance of 60 m from the foot of a tower, the top of the tower and its image in the mirror subtend an angle of 90º at the eye, placed at the mirror itself. The height of the tower is :

(A) 30 m (B) 60 m

(C) 90 m (D) 120 m **[B]**

Q.4 An object is initially at a distance of 100 cm from a plane mirror. If, the mirror approaches the object at a speed of 5 cm/s. Then after 6 s the distance between the object and its image will be :

(A) 60 cm (B) 140 cm

(C) 170 cm (D) 150 cm **[B]**

Q.5 A virtual image is formed by a plane mirror, when the pencil of light is incident on the mirror, then the incident pencil on the mirror is.

(A) diverging

(B) parallel

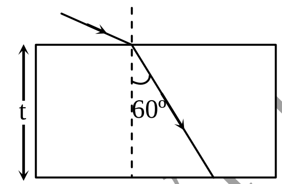
(C) converging

(D) all of the above **[A]**

Q.6 A ray of light is incident on a glass slab (μ = 1.5), thickness t, in such a manner that the angle of refraction is 60º. If the speed of light in vacuum is c, then the time taken to cross the slab will be -

(A) 3t/c (B) 3t/2c (C) 2t/c (D) t/c

Sol.[A]



$v = \frac{c}{\mu} = \frac{c}{1.5}$

Distance travel by ray to cross the slab

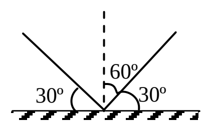
$= \frac{t}{\cos 60} = 2t$

$\therefore$ Time taken to cross slab = $\frac{2t}{c/1.5} = \frac{3t}{c}$

Q.7 A ray of light making an angle 30º with horizontal is incident on a plane mirror making an angle θ with horizontal. what should be the value of θ so that reflected ray goes vertically upwards -

(A) 20º (B) 25º (C) 30º (D) 35º

Sol. [C]



The reflected ray is to be rotated by 60º so mirror is to rotate by $\frac{60}{2}$ = 30º

$\therefore$ Mirror will make 30º with horizontal

Q.8 Time taken by the sunlight to pass through a window of thickness 4 mm whose refractive index is 1.5 is

(A) 2×10^{-8} sec (B) 2×10^{8} sec

(C) 2×10^{-11} sec (D) 2×10^{11} sec

Sol.[C] $t = \frac{d}{v_m} = \frac{d}{c_o/\mu_m} = \frac{d\mu_m}{c_o}$

$= \frac{4\times1.5\times10^{-3}}{3\times10^{8}} = 2 \times 10^{-11}$ sec

Q.9 Two plane mirrors are inclined at 120º to each-other. A ray of light is incident on either mirror at an angle of 50º is double reflected. The mirrors deviate the incident ray through an angle of -

(A) 120º (B) 100º (C) 80º (D) 60º

Sol. [A] $\delta = 360 - 2\theta$; $\theta = 120^\circ$

$\therefore\ \delta = 360 - 2 \times 120$

$\therefore\ \delta = 120^\circ$

.

Q.10 A clock hung on a wall shows time as 7 : 10 on the adjoining wall, there is a plane mirror then time shown by image of clock in mirror is -

(A) 5 : 40 (B) 4 : 50 (C) 7 : 10 (D) 5 : 50

Sol. [B] 12 : 00 – 7 : 10 = 4 : 50

Q.11 An object is placed between two plane mirrors set at 60º to each other. The maximum number of images seen will be :

(A) 2 (B) 3 (C) 5 (D) 6

[C]

Q.12 A light ray is incident on a plane mirror at an angle of 30º with the horizontal. At what angle with horizontal must a plane mirror be placed in its path so that it becomes vertically upwards after reflection ?

(A) 30º (B) 60º (C) 70º (D) 90º

[B]

Q.13 Find the angle between two plane mirrors such that a ray of light is incident on the first mirror and parallel to the second is reflected from the second mirror, parallel to the first mirror.

(A) 30º (B) 60º (C) 70º (D) 90º

[B]

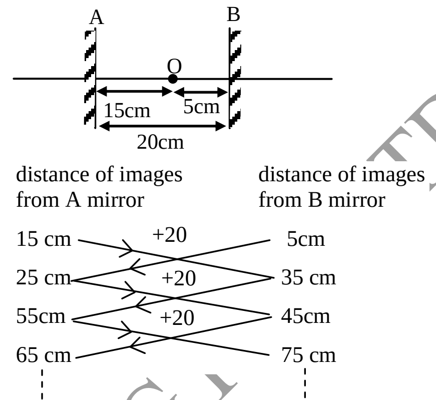
Q. 14 Two plane mirrors are parallel to each other and spaced 20 cm apart. An object is kept in between them 15cm from A. Out of the following at which point is an image not formed in mirror A (distance measured from the mirror A).

(A) 15 cm (B) 25 cm

(C) 45 cm (D) 55 cm

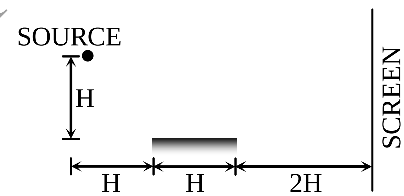
Sol. **[C]**

A and B are two plane mirror



Option (C) is correct

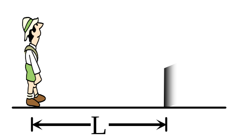
Q.15 A point source has been placed as shown in the figure. What is the length on the screen that will receive reflected light from the mirror ?



(A) 2 H (B) 3H (C) H (D) None

[A]

Q.16 A boy of height H is standing in front of mirror, which has been fixed on the ground as shown in figure. What length of his body can the man see in the mirror ? The length of the mirror is (H/2)–



(A) H (B) $H^2/(H^2 + L^2)^{1/2}$

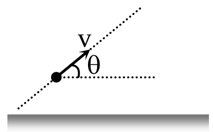
(C) Zero (D) $2H^2/L$ **[C]**

Q.17 A person's eye level is 1.5 m. He stands in front of 0.3 m long plane mirror which is 0.8m above the ground. The length of the image he sees of himself is –

(A) 1.5 m (B) 1.0 m

(C) 0.8 m (D) 0.6 m **[D]**

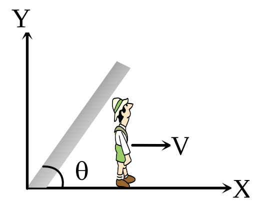
Q.18 A particle is moving in front of a plane mirror as shown in figure. The velocity of image with respect to object is –



(A) v sin θ (B) v cos θ

(C) 2 v sin θ (D) 2 v cos θ **[C]**

Q.19 A boy is walking under an inclined mirror at a constant velocity V m/s along the x-axis as shown in figure. If the mirror is inclined at an angle θ with the horizontal then what is the velocity of the image?



(A) V sin θi + V cos θj

(B) V cos θi + V sin θj

(C) V sin 2θi + V cos 2θj

(D) V cos 2θi + V sin 2θj **[D]**

Q.20 An object is approaching a plane mirror at 5 cm per second. A stationary observer sees the image. At what speed will the image approach the stationary observer ?

(A) 5 cm/second (B) 20 cm/second

(C) 10 cm/second (D) 15 cm/second

[B]

Q.21 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) $7\hat{i} + 9\hat{j} + 11\hat{k}$

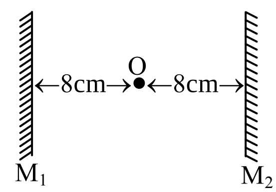
[B]

Q.22 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 **[C]**

Q.23 Figure below shows two plane mirrors and an object O placed between them. What will be distance of the first three images from the mirror M_2 -



(A) 2 cm, 8 cm, 14 cm

(B) 2 cm, 12 cm, 18 cm

(C) 2 cm, 18 cm, 22 cm

(D) 2 cm, 24 cm, 38 cm **[C]**

Q.24 A point object is placed midway between two plane mirrors distance 'a' apart. The plane mirrors form an infinite number of images due to multiple reflections. The distance between n^{th} order image formed in the two mirrors is -

(A) na (B) 2 na (C) $\frac{na}{2}$ (D) n^2 a

[B]

Q.25 Number of images of an object kept symmetrically between two mirrors inclined at angle 72º, would be-

(A) two (B) three (C) six (D) four

[D]

Q.26 Two plane mirrors are inclined to one another at an angle of 40^o. A point object is placed symmetrically in between them. The number of images formed due to reflection at both mirrors is -

(A) Infinite (B) 9 (C) 8 (D) 6

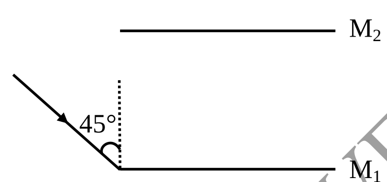
[C]

Q.27 If an object is placed unsymmetrically between two plane mirrors, inclined at an angle of 72^o, then the total number of images formed is -

(A) 5 (B) 4 (C) 2 (D) ∞

[A]

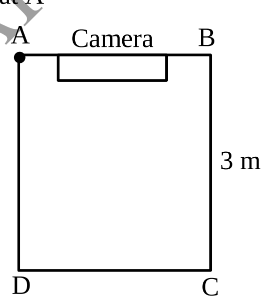
Q.28 Two plane mirrors M_1 and M_2 each have length 1 m and are separated by 1 cm. A ray of light is incident on one end of mirror M_1 at angle 45º. How many reflections the ray will have before going from the other end ?



(A) 50 (B) 51 (C) 100 (D) 101

[D]

Q.29 Figure shows a cubical room ABCD with the wall CD as a plane mirror. Each side of the room is 3m. We place a camera at the mid-point of the wall AB. At what distance should the camera be focussed to photograph an object placed at A -



(A) 1.5 m (B) 3 m

(C) 6 m (D) more than 6 m

[D]

Q.30 It is necessary to illuminate the bottom of a well by reflected solar beam when the light is incident at an angle of $\alpha = 40^o$ to the vertical. At what angle β to the horizontal should a plane mirror be placed ?

(A) 70º (B) 20º (C) 50º (D) 40º

[A]

Q.31 Mark the correct options -

(A) If the incident rays are converging, we have a real object

(B) If the reflected rays are converging, we have a real image

(C) The image of a virtual object is called a virtual image

(D) If the image is virtual, the corresponding object is called a virtual object **[B]**

Q.32 A point source of light is placed in front of a plane mirror -

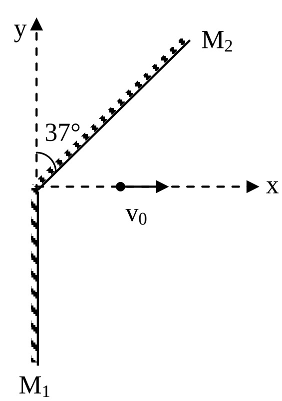
(A) All the reflected rays meet at a point when produced backward

(B) Only the reflected rays close to the normal meet at a point when produced backward

(C) Only the reflected rays making a small angle with the mirror, meet at a point when produced backward

(D) Light of different colours make different images **[A]**

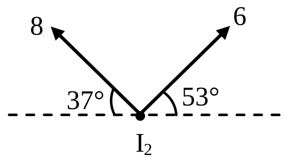
Q.33 A point object is moving with velocity $v_0 = 10\hat{i}$ m/s along x-axis as shown in figure. Relative velocity of its image in mirror M_1 with respect to mirror image velocity in M_2 is :
(Take sin 37° = 0.6)

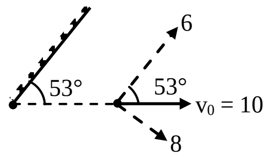


(A) 9 m/s (B) 10 m/s

(C) 12 m/s (D) 15 m/s **[C]**

Sol.





$\vec{v}_{1i} = -10\hat{i}$

$\vec{v}_{2i} = (6\cos 53° - 8\cos 37°)\hat{i} + (6\sin 53° + 8\sin 37°)\hat{j}$

$= (3.6 - 6.4)\ \hat{i} + (4.8 + 4.8)\ \hat{j}$

$= -2.8\,\hat{i} + 9.6\,\hat{j}$

$\vec{v}_{1/2} = -7.2\,\hat{i} - 9.6\ \hat{j}$

$v_{12} = \sqrt{7.2^2 + 9.6^2}$

$= 2.4\ \sqrt{3^2 + 4^2}$

= 12 m/s

Q.34 On reflection from a plane surface, the following gets changed -

(A) wavelength (B) frequency

(C) speed (D) amplitude **[D]**

Q.35 A wave or a pulse is reflected normally from the surface of a denser medium back into the rarer medium. The phase change caused by the reflection-

(A) 0 (B) π/2 (C) π (D) 3π/2

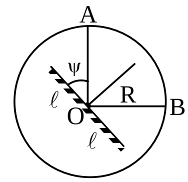
[C]

Q.36 A number of images of a candle flame can be seen in a thick mirror. The brightest image is -

(A) The first one (B) The second one

(C) The third one (D) The last one **[B]**

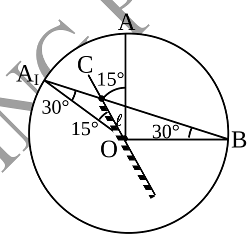
Q.37 The mirror of length 2 ℓ makes 10 revolutions per minute about the axis crossing its mid point O and perpendicular to the plane of the figure. There are a light source in point A and an observer in point B of the circle of radius R drawn around centre O (∠AOB = 90°). What is the proportion $\frac{R}{\ell}$ if the observer B first sees the light source when the angle of mirror with OA, ψ = 15° ?

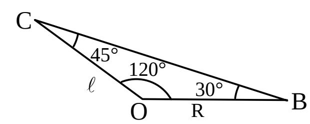


(A) $\sqrt{2}$ (B) $\frac{1}{\sqrt{2}}$

(C) $2\sqrt{2}$ (D) $\frac{1}{2\sqrt{2}}$ **[A]**

Sol.



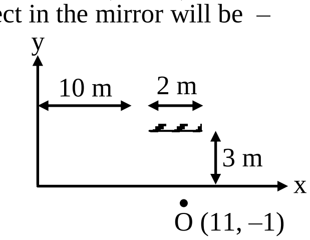


sine rule

$$\frac{R}{\sin 45°} = \frac{\ell}{\sin 30°}$$

$$\frac{R}{\ell} = \frac{\sin 45°}{\sin 30°} = \sqrt{2}$$

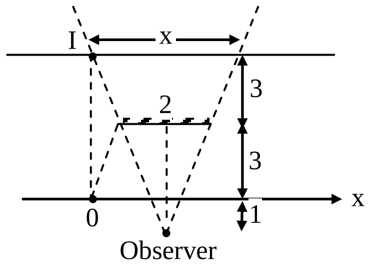
Q.38 A point object starts moving along x-axis with constant velocity 0.5 m/s in positive x-direction from origin. A plane mirror of length 2 m is placed parallel to x axis at a distance 3 m from x-axis and at a distance 10 m from y-axis as shown in figure. Time for which an observer positioned at (11, –1) m will see image of point object in the mirror will be –



(A) 7 sec (B) 8 sec

(C) 12 sec (D) 6 sec **[A]**

Sol.



$$\frac{x}{2} = \frac{7}{4}$$

x = 3.5 m

$$t = \frac{x}{v} = \frac{3.5}{0.5} = 7 \text{ sec}$$

Q.39 Given two identical watch glasses glued together, the rear one silvered. Using autocollimation as sketched (Fig.), sharp focus is obtained for L = 20 cm. Find L for sharp focus when the space between the glasses is subsequently filled with water, $n = \frac{4}{3}$.

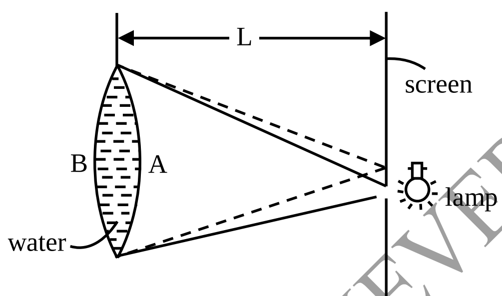


Fig.

(A) 6 cm (B) 8 cm

(C) 10 cm (D) 12 cm **[D]**

Sol. With air between the glasses, only the silvered watch glass reflects and converges the rays to form an image, i.e., the system acts as a concave mirror. The formula for a concave mirror

$$\frac{1}{u} + \frac{1}{v} = \frac{2}{r}$$

gives for u = v = 20 cm, r = 20 cm.

With water between the glasses, the incident light is refracted twice at A and reflected once at B before forming the final image. Note that the first image formed by A falls behind the mirror B and becomes a virtual object to B. Similarly the image formed by B is a virtual object to A. We therefore have

$$\frac{1}{L} + \frac{n}{x} = \frac{n-1}{20},$$

$$-\frac{1}{x} + \frac{1}{y} = \frac{1}{10},$$

$$-\frac{n}{y} + \frac{1}{L} = \frac{n-1}{20},$$

which yield L = 12 cm.

Thus, a sharp image will be formed at L = 12 cm.

Q.40 Two vertical plane mirrors are inclined at an angle of 60º with each other. A ray of light traveling horizontally is reflected first from one mirror and then from the other. The resultant deviation is -

(A) 60º (B) 120º

(C) 180º (D) 240º

Sol. **[D]** $\delta = 2\pi - 2\theta = 2\pi - 2\frac{\pi}{3} = \frac{4\pi}{3}$

Q.41 The index of refraction of glass can be increased by diffusing in impurities. It is then possible to make a lens of constant thickness. Given a disk of radius **a** and thickness **d**, find the radial variation of the index of refraction **n(r)** which will produce a lens with focal length F. You may assume a thin lens (d << a).

(A) $n(r) = n_0 - \frac{rF}{2d^2}$ (B) $n(r) = n_0 - \frac{rd}{2F^2}$

(C) $n(r) = n_0 - \frac{r^2}{2dF}$ (D) $n(r) = n_0 - \frac{r}{2F}$

[C]

Sol. Let the refractive index of the material of the disk be n and the radial distribution of the refractive index of the impurity-diffused disk be represented by n(r), with $n(0) = n_0$.

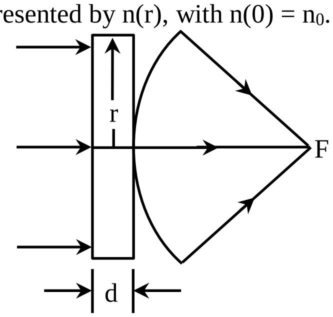


Fig.

Incident plane waves entering the lens refract and converge at the focus F as shown in Fig. We have

$$[n(r) - n_0]d = -\sqrt{F^2 + r^2} + F,$$

i.e., $n(r) = n_0 - \dfrac{\sqrt{F^2 + r^2} - F}{d}$.

For F >> r, we obtain

$$n(r) = n_0 - \frac{r^2}{2dF}.$$

Q.42 Rays of light strike a horizontal plane mirror at an angle of 45º. A second plane mirror is arranged at an angle θ with it. If the ray after reflection from the second mirror goes horizontally parallel to the first mirror then θ is-

(A) 45º (B) 60º (C) 67.5º (D) 135º

[C]

Q.43 Images formed by an object placed between two plane mirrors whose reflecting surfaces make an angle of 90º with one another lie on a -

(A) Straight line (B) Zig-Zag curve

(C) Circle (D) Ellipse **[C]**

Q.44 A beaded screen (Fig.) returns light back to the source if light focuses on its back surface. For use by skindivers in water ($n = \frac{4}{3}$), of what index material should the beads be made ideally?

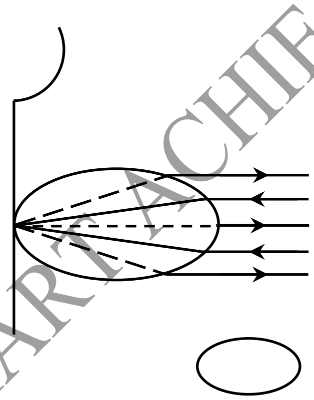


Fig.

(A) $\dfrac{3}{2}$ (B) $\dfrac{4}{3}$

(C) $\dfrac{5}{4}$ (D) $\dfrac{8}{3}$ **[D]**

Sol. Let the required index of refraction be 'n', (see Fig. (b)).

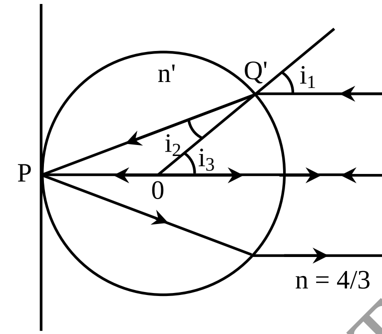


Fig. (b)

If a pencil of paraxial rays which are parallel to the axis, OP, strikes at P, the reflected rays will return back parallel to OP. Snell's law of refraction **n' sin i₂ = n sin i₁** for small angles i_1 and i_2 becomes $\mathbf{n' i_2 = n i_1}$. As $i_3 = i_1$, $i_3 = 2i_2$, we have $i_1 = 2i_2$. Therefore, $n' = 2n = \dfrac{8}{3}$.

Q.45 A line object 5 mm long is located 50 cm in front of a camera lens. The image is focused on the film plate and is 1 mm long. If the film plate is moved back 1 cm the width of the image blurs to 1 mm wide. What is the F-number of the lens?

(A) 7.33 (B) 8.33

(C) 10 (D) 12 **[B]**

Sol. Substituting u = 50 cm and $\dfrac{v}{u} = \dfrac{1}{5}$ in the Gaussian lens formula

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

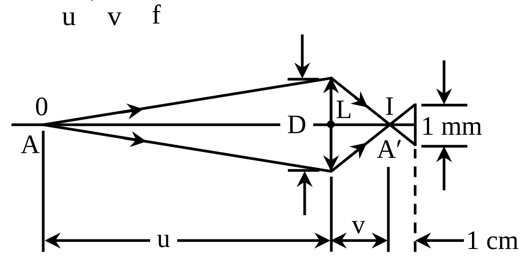


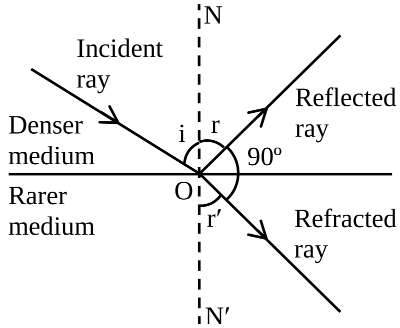
Fig.

gives f = 8.33 cm, v = 10 cm. From the similar triangles in Fig. we have

$$\frac{D}{v} = \frac{0.1}{1},$$

or D = 0.1 v = 1 cm. Therefore, F = f/D = 8.33.

Q.46 A ray of light from a denser medium strikes a rarer medium at an angle of incidence **i** as shown in figure. Refracted and reflected rays make an angle of 90º with each other. Angle of reflection and refraction are **r** and **r′**. Then critical angle is –



(A) $\sin^{-1}$ (sin i) (B) $\sin^{-1}$ (sin r)
(C) $\sin^{-1}$ (tan i) (D) $\sin^{-1}$ (tan r) **[D]**

Sol. From fig., $r + r' = 90^o$

$\therefore$ $r' = 90^o - r = 90^o - i$

When light travels from denser medium to rarer medium,

$$\frac{1}{\mu} = \frac{\sin i}{\sin r'} = \frac{\sin i}{\sin(90^o - i)} = \frac{\sin i}{\cos i}$$

$= \tan i$

Also, $\sin i_c = \dfrac{1}{\mu}$

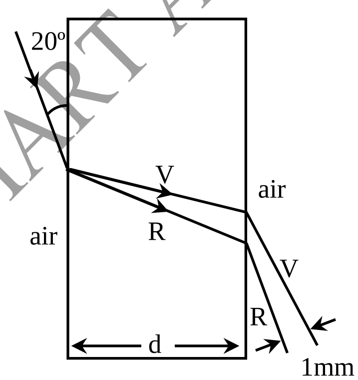
(if angle of incidence = critical angle)

$\therefore$ $\sin i_c = \tan i = \tan r$

$\therefore$ $i_c = \sin^{-1}(\tan i)$

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

Q.47 A white light is incident at 20º on a material of silicate flint glass slab as shown. $\boldsymbol{\mu}_{\textbf{voilet}}$ = 1.66 and $\boldsymbol{\mu}_{\textbf{r}}$ = 1.6. For what value of **d** will the separation be 1 mm in red and violet rays.



(a) $\dfrac{5}{3}$ cm (b) $\dfrac{10}{3}$ cm

(c) 5 cm (d) $\dfrac{20}{3}$ cm **[B]**

Sol. $\sin r_1 = \dfrac{\sin 70}{1.66} = \dfrac{.9397}{1.66}$ or $r_1 = 34^o30'$

$\sin r_2 = \dfrac{\sin 70}{1.6} = \dfrac{.9397}{1.6}$ or $r_2 = 36^o$

Using $y = \dfrac{t\sin(i - r)}{\cos r}$

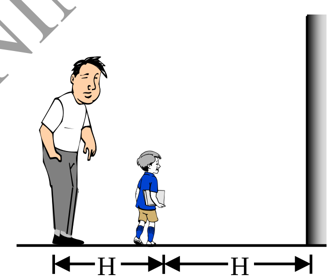
$$y_1 - y_2 = d\left[\frac{\sin(i - r_1)}{\cos r_1} - \frac{\sin(i - r_2)}{\cos r_2}\right]$$

$$0.1 = d\left[\frac{\sin 35^o30'}{\cos 34^o30'} - \frac{\sin 34^o}{\cos 36^o}\right]$$

$$\text{or } 0.1 = d\left[\frac{0.5807}{0.8241} - \frac{0.5592}{0.8090}\right] = d[0.71 - 0.68]$$

$$\text{or } d = \frac{0.1}{0.03} = \frac{10}{3}\text{ cm.}$$

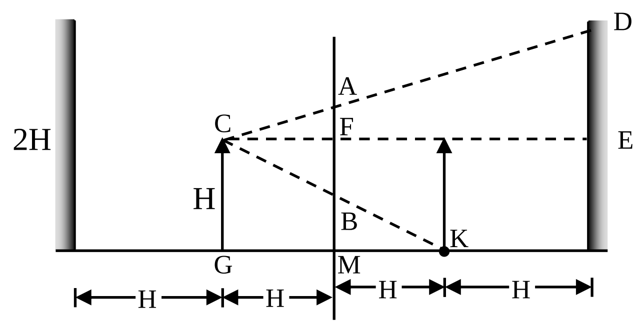
Q.48 A child is standing in front of a straight plane mirror. His father is standing behind him, as shown in the fig.



The height of the father is double the height of the child. What is the minimum length of the mirror required so that the child can completely see his own image and his father's image in the mirror? Given that the height of father is 2H.

(A) H/2 (B) 5H/6
(C) 3H/2 (D) None **(B)**

Sol.



AB is the required size of mirror

ΔAFC & CDE similar triangle

$\frac{DE}{AF} = \frac{CE}{CF}$ $\quad$ $AF = \frac{CF \times DE}{CE} = \frac{H \times H}{3H} = \frac{H}{3}$

ΔCKG & BMK similar Δ

$\therefore \frac{CG}{GK} = \frac{BM}{MK} \quad \Rightarrow \quad BM$

$= \frac{CG \times MK}{GK} = \frac{H \times H}{2H} = \frac{H}{2}$

size of mirror = AB

= AF + FB

$= \frac{H}{3} + (FM - BM)$

$= \frac{H}{3} + H - \frac{H}{2} \quad = \quad H\left[\frac{1}{2} + \frac{1}{3}\right] = \frac{5H}{6}$

Ans.

Q.49 Two plane mirrors are inclined at an angle of 50°. Then what is the number of images formed for an object placed in between the mirrors –

(A) 7

(B) 8

(C) 6

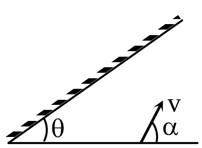
(D) question is absured **[A]**

Sol. Here $\theta = 50°$

therefore $n = \frac{360}{50} = 7.2$

The closest integer value of 7.2 is 7. Thus number of images formed is 7

Q.50 A plane mirror is inclined at an angle θ with the horizontal surface. A particle is projected with velocity v at angle α. Image of the particle is observed from the frame of the particle projected path of the image as seen by the particle is –



(A) parabolic path (B) straight line

(C) circular path (D) helical path **[C]**

Sol. At any instant velocity of particle can be resolved in two components, one parallel and other perpendicular to it. Parallel components of particle velocity and image velocity are identical and hence the path of light is straight line perpendicular to mirror