NEET Important Questions with Solutions from Ray Optics

Q.1. The angle of incidence for a ray of light at a refracting surface of a prism is 45^o. The angle of prism is 60^o. If the ray suffers minimum deviation through the prism, the angle of minimum deviation and refractive index of the material of the prism respectively, are:

A) $45^o; \frac{1}{\sqrt{2}}$

B) $30^o;\ \sqrt{2}$

C) $45^o; \sqrt{2}$

D) $30^o; \frac{1}{\sqrt{2}}$

Answer: $30^o;\ \sqrt{2}$

Solution: At minimum deviation $\delta_{min} = 2i - A$

$\delta_{min} = 2(45) - 60$

$\delta_{min} = 30^o$

Refractive index of material is

$$\mu = \frac{\sin\left(\frac{\delta_{min}+A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{30+60}{2}\right)}{\sin(30^o)}$$

$$\mu = \frac{\sin 45^o}{\sin 30^o} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} = \sqrt{2}$$

Q.2. Match the corresponding entries of column 1 with column 2. [Where m is the magnification produced by the mirror]

	Column 1		Column 2
(A)	$m = -2$	(a)	Convex mirror
(B)	$m = -\frac{1}{2}$	(b)	Concave mirror
(C)	$m = +2$	(c)	Real image
(D)	$m = +\frac{1}{2}$	(d)	Virtual image

A) A $\rightarrow$ b and c; B $\rightarrow$ b and c; C $\rightarrow$ b and d; D $\rightarrow$ a and d

B) A $\rightarrow$ a and c; B $\rightarrow$ a and d; C $\rightarrow$ a and b; D $\rightarrow$ c and d

C) A $\rightarrow$ a and d; B $\rightarrow$ b and c; C $\rightarrow$ b and d; D $\rightarrow$ b and c

D) A $\rightarrow$ c and d; B $\rightarrow$ b and d; C $\rightarrow$ b and c; D $\rightarrow$ a and d

Answer: A $\rightarrow$ b and c; B $\rightarrow$ b and c; C $\rightarrow$ b and d; D $\rightarrow$ a and d

Solution: $\mathrm{m}=\frac{-\mathrm{V}}{\mathrm{u}}=\frac{\mathrm{f}}{\mathrm{f}-\mathrm{u}}$

$\mathrm{m}=-2$ then "V" and "u" same given

$-2=\frac{\mathrm{f}}{\mathrm{f}-\mathrm{u}}=-2\mathrm{f}+2\mathrm{u}=\mathrm{f}$

$=3\mathrm{f}=2\mathrm{u}$

$\frac{+3\mathrm{f}}{2}=\mathrm{u}$

For the concave mirror, f negative, u negative use same for all.

Q.3. The refracting angle of a prism is A, and refractive index of the material of the prism is $\cot\left(\frac{A}{2}\right)$. The angle of minimum deviation is

A) $180^{\circ}-3\mathrm{A}$

B) $180^{\circ}-2\mathrm{A}$

C) $90^{0}-\mathrm{A}$

D) $180^{0}+2\mathrm{A}$

Answer: $180^{\circ}-2\mathrm{A}$

Solution: $\mu=\frac{\sin\left(\frac{\delta \mathrm{m}+\mathrm{A}}{2}\right)}{\sin\left(\frac{\mathrm{A}}{2}\right)}$

$\because\ \mu=\cot\left(\frac{\mathrm{A}}{2}\right)$

$\therefore \cot\left(\frac{\mathrm{A}}{2}\right)=\frac{\sin\left(\frac{\delta \mathrm{m}+\mathrm{A}}{2}\right)}{\sin \frac{\mathrm{A}}{2}}$

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

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

$\delta \mathrm{m}=\pi-2\mathrm{A}$

Q.4. In an astronomical telescope in normal adjustment a straight black line of the length L is drawn on inside part of objective lens. The eye-piece forms a real image of this line. The length of this image is l. The magnification of the telescope is:

A) $\frac{\mathrm{L}}{l}-1$

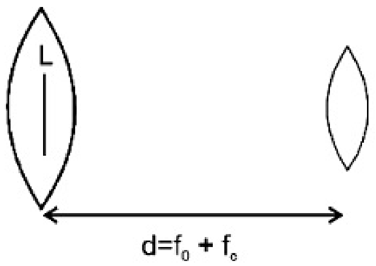
B) $\frac{\mathrm{L}+l}{\mathrm{L}-l}$

C) $\frac{\mathrm{L}}{l}$

D) $\frac{\mathrm{L}}{l}+1$

Answer: $\frac{L}{l}$

Solution:



Magnification by eyepiece

$\mathrm{m}=\frac{\mathrm{f}}{\mathrm{f}+\mathrm{u}}$

$-\frac{\mathrm{I}}{\mathrm{L}}=\frac{\mathrm{f_e}}{\mathrm{f_e}+(-(\mathrm{f_0}+\mathrm{f_e})}$

$\Rightarrow \quad \frac{\mathrm{I}}{\mathrm{L}}=\frac{\mathrm{f_e}}{\mathrm{f_0}}$

$\mathrm{m.p.} \quad =\frac{\mathrm{f_0}}{\mathrm{f_e}}=\frac{\mathrm{L}}{\mathrm{I}}$

Q.5. It the focal length of objective lens is increased then magnifying power of:

A) microscope will increase but that of telescope decrease

B) microscope and telescope both will increase

C) microscope and telescope both will decrease

D) microscope will decrease but that of telescope will increase

Answer: microscope will decrease but that of telescope will increase

Solution: M.P. of a microscope $=\left(\frac{L}{f_0}\right)\left(\frac{D}{f_e}\right)$
If $f_0 \uparrow \Rightarrow$ M.P. of the microscope will decrease
M.P. of telescope $=\frac{f_0}{f_e}$
If $f_0 \uparrow \Rightarrow \mathrm{M/O.}$ of telescope will increase.

Q.6. The angle of a prism is ' A '. One of its refracting surfaces is silvered. Light rays falling at an angle of incidence $2A$ on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ, of the prism is:

A) $2\sin A$

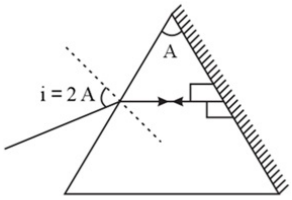
B) $2\cos A$

C) $\frac{1}{2}\cos A$

D) $\tan A$

Answer: $2\cos A$

Solution:



To retrace its path light rays should fall normally on the reflecting surface. So
$r_2 = 0$
$\Rightarrow r_1 = A - r_2 \Rightarrow r_1 = A$
Now applying snell rule between incident ray and refracted ray.
$(1)\sin(2A) = n\sin(A) \Rightarrow 2\sin A\cos A = n\sin A$
$\Rightarrow n = 2\cos A$

Q.7. Monochromatic light passes through a prism. Compares to that in air inside the prism the light's

A) speed and wavelength are different but frequency remains same.

B) speed and frequency are different but wavelength remains same.

C) frequency and wavelength are different but speed remains same.

D) speed, wavelength and frequency are all different.

Answer: speed and wavelength are different but frequency remains same.

Solution: When a light ray passes from one medium to another medium let's say from air to prism, the frequency (f) of the light ray remains the same but the velocity (v) and wavelength (λ) of the light ray changes because the frequency of the light wave is decided only by the source whereas the velocity and wavelength of a wave depends on the nature of the medium in which travels.

For a wave, the relation between the velocity, wavelength and frequency is $v = \lambda f$.

Q.8. Two plane mirrors are inclined at 70°. A ray incident on one mirror at angle θ after reflection falls on the second mirror and is reflected from there parallel to the first mirror. θ is:

A) 50°

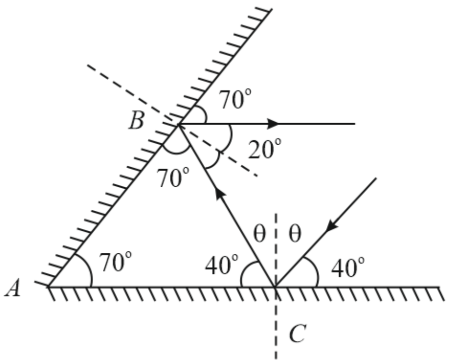
B) 45°

C) 30°

D) 55°

Answer: 50°

Solution:



As shown in the figure, two plane mirrors are inclined at 70°.

In triangle ABC, $\angle A=70^{\circ}$ and we know that the sum of all angles of triangles is 180°.

$\angle A=\angle B$ (Corresponding angles)

Thus, $\angle C=180^{\circ}-\left(70^{\circ}+70^{\circ}\right)=40^{\circ}$.

The incident ray at angle θ with the normal at C gets reflected with the same angle θ from first plane mirror as shown in the figure.

Since the normal line breaks the angle into two equal angles between the incidence ray and the reflected ray. So, $\angle i=\angle r=40^{\circ}$.

We know that the normal makes an angle 90° perpendicular to the surface of the mirror.

Hence $\theta=90^{\circ}-40^{\circ}=50^{\circ}$.

Q.9. If a prism having refractive index $\sqrt{2}$ has an angle of minimum deviation equal to the angle of refraction of the prism, then the angle of refraction of the prism is:

A) 30°

B) 45°

C) 60°

D) 90°

Answer: 90°

Solution: For the minimum angle of deviation δ_{m}, the expression for the refractive index of the prism is given as $\mu=\frac{\sin\left(\frac{A+\delta_{\mathrm{m}}}{2}\right)}{\sin\frac{A}{2}}$, here A is the angle of refraction of the prism.

Given, angle of minimum deviation equal to the angle of refraction of the prism, then $\delta_{\mathrm{m}}=A$, refractive index $\mu=\sqrt{2}$.

$$\sqrt{2}=\frac{\sin\left(\frac{A+A}{2}\right)}{\sin\frac{A}{2}}=\frac{\sin A}{\sin\frac{A}{2}}=\frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$

$$\frac{1}{\sqrt{2}}=\cos\frac{A}{2}\Rightarrow\frac{A}{2}=\frac{\pi}{4}$$

Hence, the angle of refraction of the prism $A=\frac{\pi}{2}=90^{\circ}$.

Q.10. A simple microscope has a focal length of $5\ \mathrm{cm}$. The magnification at the least distance of distinct vision is-

A) 1

B) 5

C) 4

D) 6

Answer: 6

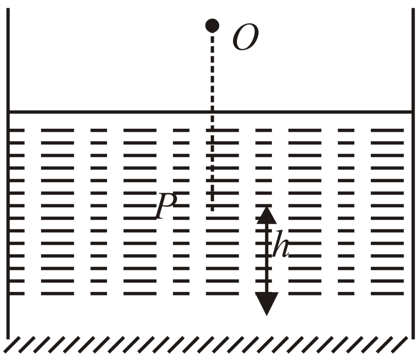
Solution: Given: Focal length of the lens $f=5\ \mathrm{cm}$, the distance of distinct vision is $D=25\ \mathrm{cm}$.

The magnification power of the simple microscope at the least distance of distinct vision is given by,

$m=1+\frac{D}{f}$

$\Rightarrow m=1+\frac{25}{5}=6.$

Q.11. A plane mirror is placed at the bottom of the tank containing a liquid of refractive index, μ. P is a small object at a height, h above the mirror. An observer, O vertically above P outside the liquid, sees P and its image in the mirror. The apparent distance between these two will be



A) $2\mu h$

B) $\frac{2h}{\mu}$

C) $\frac{2h}{\mu-1}$

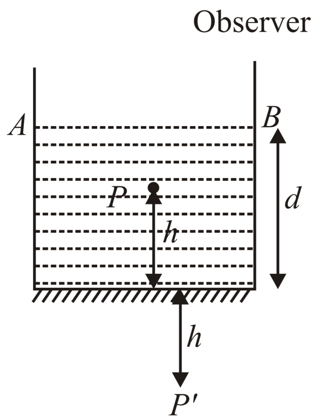
D) $h\left(1+\frac{1}{\mu}\right)$

Answer: $\frac{2h}{\mu}$

Solution: Let the depth of liquid in the tank be d.

The apparent depth of P from O,

$a=\frac{\text{Actual depth of } P}{\text{Refractive index}}=\frac{u}{\mu}$



$\Rightarrow a=\frac{d-h}{\mu}$

Now, the image of the object at P due to reflection from the mirror is formed at P', which is at equal distance from mirror (h) as it does not depend on the medium in reflection.

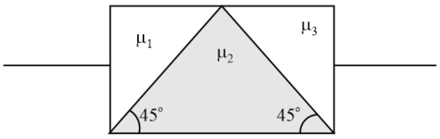
The apparent depth of the image at, P', $b=\frac{\text{Actual depth of } P'}{\text{Refractive index}}=\frac{u}{\mu}$

$\Rightarrow b=\frac{d+h}{\mu}$

The apparent distance between P and P',

$=b-a=\frac{2h}{\mu}$

Q.12. A rectangular block is composed of three different glass prisms (with refractive indices μ_1, μ_2 and μ_3) as shown in the figure below. A ray of light incident normal to the left face emerges normal to the right face. Then the refractive indices are related by-



A) $\mu_1^2+\mu_2^2=2\mu_3^2$

B) $\mu_1^2+\mu_2^2=\mu_3^2$

C) $\mu_1^2+\mu_3^2=2\mu_2^2$

D) $\mu_2^2+\mu_3^2=2\mu_1^2$

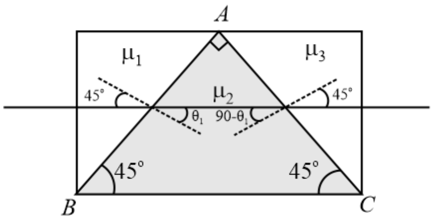
Answer: $\mu_1^2+\mu_3^2=2\mu_2^2$

Solution: Refraction is a phenomenon when light travels from one medium to other.

According to Snell's law,

$n_1 \sin(i) = n_2 \sin(r)$

where $n_1,\ i,\ n_2,\ r$ are incident medium, angle of incidence, refracted medium, angle of refraction.



Applying Snell's law for the boundary AB we get,

$\mu_1\ \sin(45^\circ) = \mu_2 \sin(\theta_1)$

$\frac{\mu_1}{\sqrt{2}} = \mu_2 \sin\left(\theta_1\right)$

Applying Snell's law for surface AC we get,

$\mu_2 \sin\left(90^\circ - \theta_1\right) = \mu_3 \sin\left(45^\circ\right)$

$\mu_2 \cos\left(\theta_1\right) = \frac{\mu_3}{\sqrt{2}}$

Combining these equations at both the boundaries we get,

Adding is done after squaring on both sides of both the equations.

$\left(\mu_2 \cos\left(\theta\right)\right)^2 + \left(\mu_2 \sin\left(\theta\right)\right)^2 = \frac{\mu_1{}^2}{2} + \frac{\mu_3{}^2}{2}$

$2\mu_2{}^2 = \mu^2{}_1 + \mu_3{}^2$

Q.13. The light ray is incident at an angle of 60° on a prism of angle 45°. When the light ray falls on the other surface at 90°, the refractive index of the material of prism μ and the angle of deviation δ are given by

A) $\mu = \sqrt{2},\ \delta = 30^\circ$

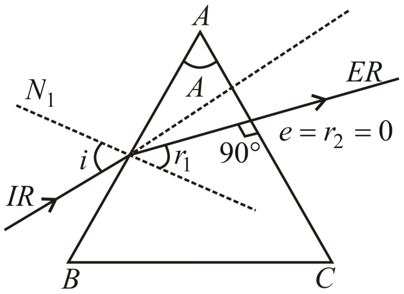
B) $\mu = 1.5,\ \delta = 15^\circ$

C) $\mu = \frac{\sqrt{3}}{2},\ \delta = 30^\circ$

D) $\mu = \sqrt{\frac{3}{2}},\ \delta = 15^\circ$

Answer: $\mu = \sqrt{\frac{3}{2}},\ \delta = 15^\circ$

Solution: From diagram, we can see that angle $e = r_2 = 0$.



And we have $A = r_1 + r_2$ or

$\Rightarrow r_1 = A = 45^\circ$

Applying Snell's law at first surface AB, we can write

$\mu \times \sin r_1 = \sin i$

$\Rightarrow \mu = \frac{\sin 60}{\sin 45} = \sqrt{\frac{3}{2}}$

And angle of deviation is

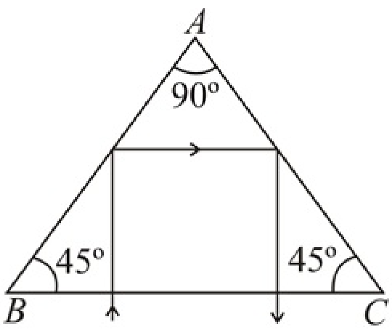
$i = r_1 + \delta$

$\Rightarrow \delta = i - r_1$

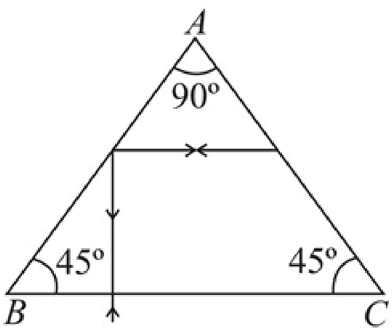
$\Rightarrow \delta = 15^\circ$

Q.14. The refractive index of a material of a prism of angles $45^\circ - 45^\circ - 90^\circ$ is 1.5. The path of the ray of light incident normally on the hypotenuse side is shown in the figure.

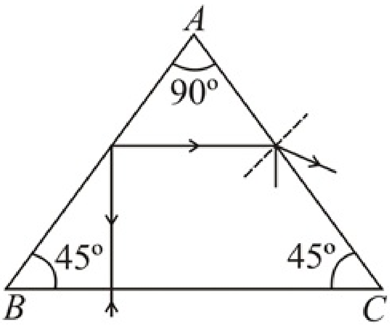
A)



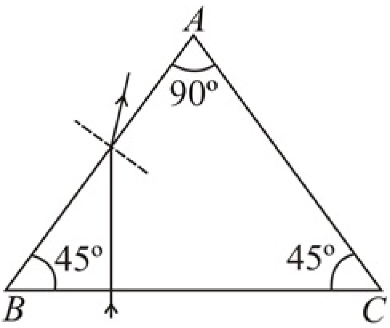
B)



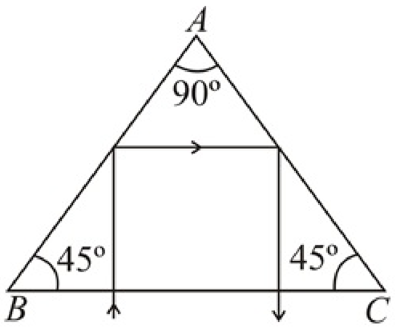
C)



D)



Answer:



Solution: According to the given conditions, for the side AB, the angle of incidence is 45°. Now, critical angle $\sin\theta_c = \frac{1}{\mu}$

$\Rightarrow \theta_c = \sin^{-1}\left(\frac{1}{1.5}\right) = \sin^{-1}(0.667) = 41.8^\circ$.

Since the critical angle is less than the incident angle, so the ray will suffer total internal reflection.

As angles on the side AB and BC are equal, so the ray will reflect again and came parallel to the incident ray on the side AC.

Thus, total internal reflection must take place at both the surfaces AB and AC.

Q.15. On a bright sunny day, a diver of height h stands at the bottom of a lake of depth H. Looking upward, he can see objects outside the lake in a circular region of radius R. Beyond this circle he sees the images of objects lying on the floor of the lake. If refractive index of waler is $\frac{4}{3}$, then the value of R is :

A) $\frac{3(H-h)}{\sqrt{7}}$

B) $3h\sqrt{7}$

C) $\frac{(H-h)}{\sqrt{\frac{7}{3}}}$

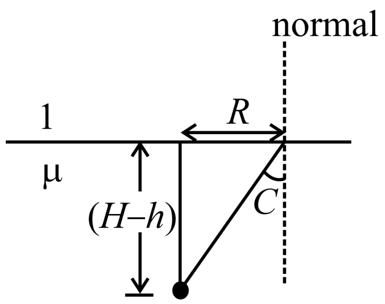
D) $\frac{(H-h)}{\sqrt{\frac{5}{3}}}$

Answer: $\frac{3(H-h)}{\sqrt{7}}$

Solution: In order to make the source invisible the opaque disc must cover up to a radius where critical angle of source ray is reached.

Critical angle is angle after which total internal reflection occurs.

Here we need to consider height from man's eye as light rays pass through eye. So height from eye is $H-h$.



Let c, R critical angle and radius of curvature respectively.

From the above diagram we get, $\sin(c)=\frac{R}{\sqrt{R^2+(H-h)^2}}$

Using the condition of Snell's law for critical angle we get,

$\mu\times\sin(c)=1\times\sin(90°)$

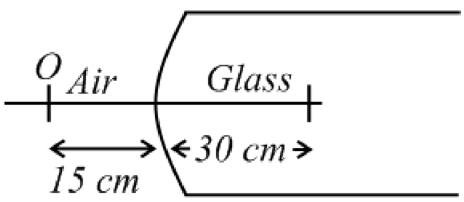
$\Rightarrow\sin(c)=\frac{1}{\mu}$

Substituting the value of this sine function in the previous equation we get,

$\frac{1}{\mu}=\frac{R}{\sqrt{R^2+(H-h)^2}}$

$\Rightarrow R=\frac{H-h}{\sqrt{\mu^2-1}}=\frac{3(H-h)}{\sqrt{7}}$

Q.16. A point object O is placed in front of a glass rod having spherical end of radius of curvature $30\ \text{cm}$. The image would be formed at



A) $30\ \text{cm}$ to the left.

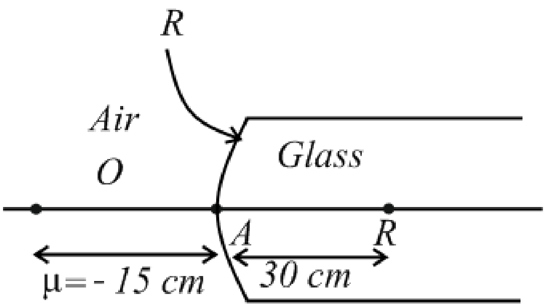
B) Infinity

C) $1\ \text{cm}$ to the right.

D) $18\ \text{cm}$ to the left.

Answer: $30\ \text{cm}$ to the left.

Solution: As shown in the diagram, for refraction at the curved surface, we know that $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$



Considering the refraction at the curved surface, object distance lying to the left will have a negative sign while any distance to the right will have a positive sign. (The centre of curved surface is considered as the origin of cartesian system)

$u = -15\ \text{cm},\ R = +30\ \text{cm}$

Substituting the values,

$\frac{1.5}{v} - \frac{1}{(-15)} = \frac{(1.5-1)}{+30}$

$\Rightarrow v = -30\ \text{cm}$

The negative sign indicates that image is to the left.

Q.17. Two plane mirrors, A and B, are parallel to each other and placed $20\ \text{cm}$ apart. An object is kept in between them at $15\ \text{cm}$ from A. Out of the following, at which point, an image is not formed in the mirror A? (Distance is measured from mirror A)

A) $15\ \text{cm}$

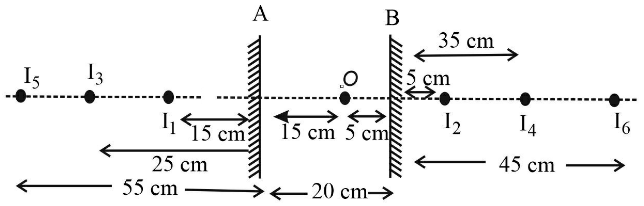
B) $25\ \text{cm}$

C) $45\ \text{cm}$

D) $55\ \text{cm}$

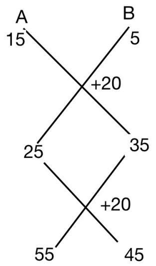
Answer: $45\ \text{cm}$

Solution:



As shown in the diagram, I_1 is the virtual image formed in the mirror A, of the real object (O), at a distance $15\ \mathrm{cm}$ behind the mirror A.
I_2 is the virtual image formed in mirror B of the real object (O) at a distance $5\ \mathrm{cm}$ behind mirror B.
Now, the image I_1 acts like virtual object (at a distance $35\ \mathrm{cm}$ from mirror B) to mirror B and its image is I_4, formed $35\ \mathrm{cm}$ behind the mirror B.

Now, the image I_2 acts like virtual object (at a distance $25\ \mathrm{cm}$ from mirror A) to mirror A and its image is I_3, formed $25\ \mathrm{cm}$ behind the mirror A.
The image I_4 acts like an object to the mirror A, which is at a distance $55\ \mathrm{cm}$ from mirror A. Its image is I_5, formed $55\ \mathrm{cm}$ behind the mirror A.
So, I_1,I_3 and I_5 are the images formed in the mirror A, at a distance $15\ \mathrm{cm}$, $25\ \mathrm{cm}$ and $55\ \mathrm{cm}$, respectively.
SHORT TRICK:



Just write down the initial distance below each mirror and add the distance between them like shown in the diagram. We will find the distances of images by viewing the values below each mirror such as $15\ \mathrm{cm}$, $25\ \mathrm{cm}$ and $55\ \mathrm{cm}$ are the distances of the images from the mirror A (obtained by seeing the values below the mirror A). Similarly, the values below the mirror B are $5\ \mathrm{cm}$, $35\ \mathrm{cm}$ and $45\ \mathrm{cm}$ are distances of images from the mirror B.

Q.18. If light travels a distance x in time t_1 in air and $10x$ distance in time t_2 in a certain medium, then find the critical angle for total internal reflection, of the medium.

A) $\sin^{-1}\left(\frac{20t_1}{t_2}\right)$

B) $\sin^{-1}\left(\frac{10t_1}{t_2}\right)$

C) $\sin^{-1}\left(\frac{t_1}{t_2}\right)$

D) $\sin^{-1}\left(\frac{t_2}{10t_1}\right)$

Answer: $\sin^{-1}\left(\frac{10t_1}{t_2}\right)$

Solution:

$$\mu=\frac{\frac{x}{t_1}}{\frac{10x}{t_2}}=\frac{t_2}{10t_1}$$

$$\sin\theta_c=\frac{1}{t_2/10t_1}=\frac{10t_1}{t_2}\Rightarrow\theta_c=\sin^{-1}\left(\frac{10t_1}{t_2}\right)$$

Q.19. A light ray from air is incident at one end of a glass fibre of refractive index 1.5 making an incidence angle of 60° on the lateral surface, so that it undergoes a total internal reflection. How much time would it take to traverse the straight fibre of length $2\ \mathrm{km}$?

A) $5.7\ \mu s$

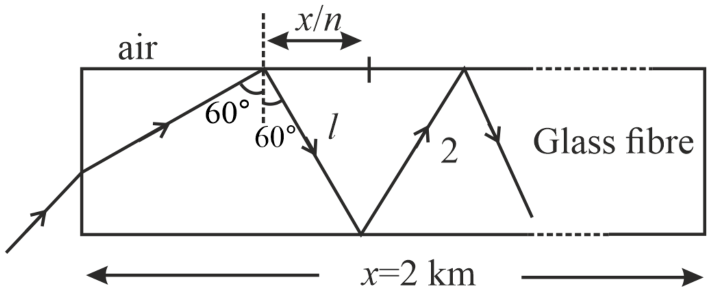
B) $5.6\ \mu s$

C) $11.547\ \mu s$

D) $11.235\ \mu s$

Answer: $11.547\ \mu s$

Solution:



The length of straight fibre, $x = 2\text{ km} = 2 \times 10^3\text{ m}$

Let the ray of light is reflected n times in the fibre.

The velocity of light in the glass fibre, $v = \frac{c}{\mu} = \frac{3\times10^8}{1.5} = 2 \times 10^8\text{ m s}^{-1}$

The path length of the ray of light in one reflection, $l = \frac{(x/n)}{\sin(60^\circ)} = \frac{2x}{\sqrt{3}n}$

Total path length $= nl = \frac{2x}{\sqrt{3}}$

Total time taken, $t = \frac{nl}{v} = \frac{2x}{\sqrt{3}v} = \frac{2\times2\times10^3}{\sqrt{3}\times2\times10^8} = 11.547\ \mu s$

Q.20. If a ray of light in a denser medium strikes a rarer medium at an angle of incidence i, the angles of reflection and refraction are respectively r and r'. If the reflected and refracted rays are at right angles to each other, the critical angle for the given pair of the medium is

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

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

C) $\tan^{-1}(\sin i)$

D) $\cot^{-1}(\tan i)$

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

Solution: We know that,

$\frac{I}{\mu} = \frac{\sin i}{\sin i'}$

But $r + r' = 90^o \;\; r' = 90^o - r$

$\Rightarrow \;\; \sin r' = \sin(90^o - r)$

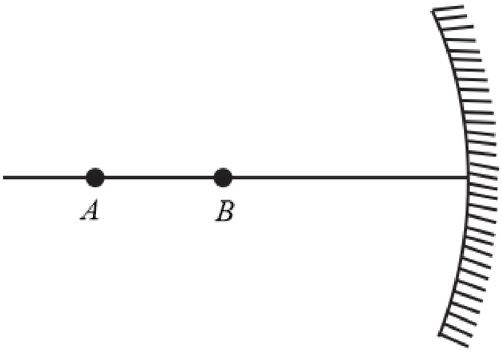
$\sin r' = \cos r \Rightarrow \sin r' = \cos i$

$\frac{1}{\mu} = \frac{\sin i}{\cos i} \Rightarrow \frac{1}{\mu} = \tan i \Rightarrow \sin i_C = \tan i = \tan r$

The critical angle for the pair of media

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

Q.21. A linear object AB is placed along the axis of a concave mirror. The object is moving towards the mirror with speed V. The speed of the image of the point A is $4V$ and the speed of the image of point B is also $4V$. If the centre of the line AB is at a distance L from the mirror, then the length of the object AB will be



A) $\frac{3L}{2}$

B) $\frac{5L}{3}$

C) L

D) $\frac{4L}{3}$

Answer: L

Solution: Lets take velocity of object to be V_O and velocity of the Image be V_I. Also, position of object u and image v are measured with respect to pole of the mirror.

Differentiating mirror formula with respect to time,

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{1}{f}\right) = \frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{1}{u}+\frac{1}{v}\right)$$
$$\Rightarrow 0 = \frac{\mathrm{d}}{\mathrm{d}u}\left(\frac{1}{u}\right)\frac{\mathrm{d}u}{\mathrm{d}t}+\frac{\mathrm{d}}{\mathrm{d}v}\left(\frac{1}{v}\right)\frac{\mathrm{d}v}{\mathrm{d}t}$$

Simplifying, we get :

$$\left(-1/v^2\right).V_I+\left(-1/u^2\right).V_O=0$$
$$\Rightarrow V_I=-\left(v^2/u^2\right).V_O \ \ldots(1)$$

We know, magnification:

$$m = -v/u$$

Using this in equation (1), we get

$$V_I = -m^2.V_O \ \ldots(2)$$

It is given that the speed of images of points A and B are 4 times the speed of the points themselves. This means, $\frac{V_I}{V_O} = -4$

Substituting in equation (2), we get,

$$m = \pm 2$$

When $m=-2$, the image is real and the other image is virtual. Knowing that for a concave mirror, a virtual image is formed when the object is closer than the focal length, A has $m=-2$.

Hence,

$$v_A=-2u_A,\ v_B=2u_B$$

Substituting this is the mirror formula,

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

we get,

$$1/u_A - 1/2u_A = 1/f$$
$$1/u_B + 1/2u_B = 1/f$$

Simplifying,

$$u_B = f/2$$
$$u_A = 3f/2$$

The distance of midpoint of AB from the mirror is :

$$\frac{3f/2+f/2}{2} = f \equiv L$$

The separation between the two ends of the object is :

$$\Rightarrow 3f/2 - f/2 = f$$

So, the length of the object is L.

Q.22. A point object is placed at a distance of $10\ \mathrm{cm}$ and its real image is formed at a distance of $20\ \mathrm{cm}$ from a concave mirror. If the object is moved by $0.1\ \mathrm{cm}$ towards the mirror, the image will shift by about

A) $0.4\ \mathrm{cm}$ away from the mirror.

B) $0.8\ \mathrm{cm}$ away from the mirror.

C) $0.4\ \mathrm{cm}$ towards the mirror.

D) $0.8\ \mathrm{cm}$ towards the mirror.

E) None of these

Answer: 0.4 cm away from the mirror.

Solution: From the relation,

Apply mirror formula

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

v is the distance of image from pole

u is the distance of object from pole

f is the focal length.

We have, $\frac{-dv}{v^2}-\frac{du}{u^2}=0$

$\therefore\ dv=\frac{v^2}{u^2}(-du)$

$=\left(\frac{20}{10}\right)^2(0.1)$

$=0.4\ \text{cm}$

Q.23. The angle of incidence for a ray of light at a refracting surface of a prism is 45°. The angle of prism is 60°. If the ray suffers deviation through the prism, the angle of minimum deviation and refractive index of the material of the prism respectively, are:

A) $45^\circ;\ \frac{1}{\sqrt{2}}$

B) $30^\circ;\ \sqrt{2}$

C) $45^\circ;\ \sqrt{2}$

D) $30^\circ;\ \frac{1}{\sqrt{2}}$

Answer: $30^\circ;\ \sqrt{2}$

Solution: Angle of incident is equal to the angle of emergence in the case of minimum deviation.

Given, $i=e=45^\circ$

Angle of prism, $A=60^\circ$

We know, $\delta_{\text{min}}=(i+e)-A$

$\Rightarrow \delta_{\text{min}}=(45^\circ+45^\circ)-60^\circ=30^\circ$

Now, refractive index, $n=\frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\frac{A}{2}}$

$\Rightarrow n=\frac{\sin(45^\circ)}{\sin(30^\circ)}=\frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}}=\sqrt{2}$

Q.24. 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?

A) 7.2 m

B) 2.4 m

C) 3.2 m

D) $5.6 \mathrm{~m}$

E) $4.8 \mathrm{~m}$

Answer: $5.6 \mathrm{~m}$

Solution: According to question, object distance, $u=-240 \mathrm{~cm}$ and image distance, $v=12 \mathrm{~cm}$

Using lens formula, for focal length of the lens,

$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{12}-\frac{1}{(-240)}$

$\Rightarrow f=\frac{240}{21} \mathrm{~cm}$

Shift in image position due to glass plate,

$s=\left(1-\frac{1}{\mu}\right) t=\left(1-\frac{1}{1.5}\right) \times 1 \mathrm{~cm}=\frac{1}{3} \mathrm{~cm}$

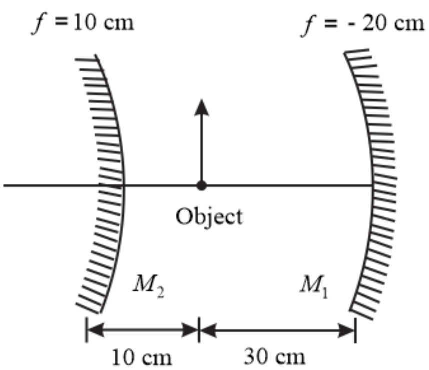
Now, to get back image on the film, lens has to form image at $\left(12-\frac{1}{3}\right) \mathrm{cm}=\frac{35}{3} \mathrm{~cm}$, such that the glass plate will shift the image on the film.

Using lens formula,

$\Rightarrow \frac{1}{u}=\frac{1}{v}-\frac{1}{f}=\frac{3}{35}-\frac{21}{240}=\frac{48 \times 3-7 \times 21}{1680}=-\frac{1}{560}$

$\Rightarrow u=-5.6 \mathrm{~m}$

Q.25. 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

Answer: $+2$

Solution: We have been asked to calculate magnification after two reflections. Here, the first image from M_1 is the object for M_2 :

We can calculate the position of images using mirror formula :

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

where $u,\ v$ and f are the positions of the object and the image and the focal length.

For the first reflection on M_1, the given values of the object distance and the focal length are:

$u_1=-30\ \text{cm}$
$f_1=-20\ \text{cm}$

Substituting in equation (1),

$\frac{1}{-30}+\frac{1}{v_1}=\frac{1}{-20}$
$\Rightarrow\ v_1\ =-60\ \text{cm}$

The magnification due to the first mirror,

$m_1\ =-\frac{v_1}{u_1}=-\frac{-60}{-30}\ =\ -2$

The first image forms $60\ \text{cms}$ in front of M_1, So, the object for M_2 is

$u_2=60-40=20\ \text{cm}$ behind the mirror.
So, for the second reflection :

$u_2=+20\ \text{cm}\ ;\ \ f_2=+10\ \text{cm}$
$\frac{1}{v_2}+\frac{1}{20}=\frac{1}{10}$
$\Rightarrow\ v_2=20\ \text{cm}$
$m_2=-\frac{v_2}{u_2}=-\frac{20}{20}=-1$

Total magnification is given by :

$m_{tot}=m_1\times m_2=(-2)\times(-1)=+2$

Practice more on Ray Optics