Physicsaholics

DPP – 6 (Geometrical Optics & Dispersion)

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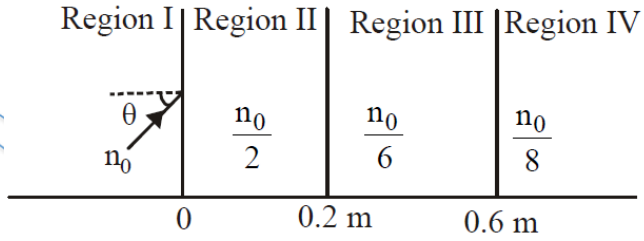
Q 1. Total internal reflection can take place only if
(a) light goes from optically rarer medium to optically denser medium
(b) light goes from optically denser medium to rarer medium
(c) the refractive indices of the two media are close to each other
(d) the refractive indices of the two media are widely different

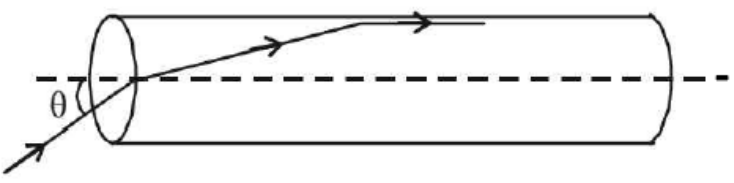
Q 2. For total internal reflection to take place, the angle of incidence i and the refractive index μ (relative to rarer medium) of the medium must satisfy the inequality
(a) $\frac{1}{\sin i} < \mu$ (b) $\frac{1}{\sin i} > \mu$ (c) $\sin i < \mu$ (d) $\sin i > \mu$

Q 3. A light beam is travelling from Region I to Region IV. The refractive index in Regions I, II, III and IV are n_o, $\frac{n_o}{2}$, $\frac{n_o}{6}$ 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) $sin^{-1}\left(\frac{1}{4}\right)$
(d) $sin^{-1}\left(\frac{1}{3}\right)$

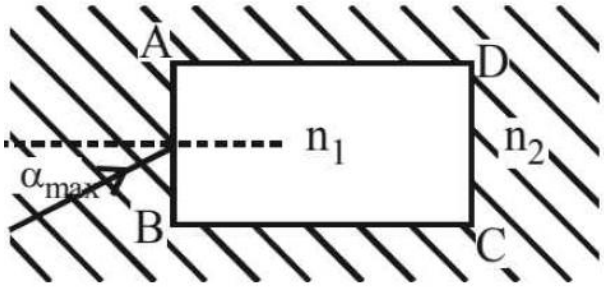
Q 4. A transparent solid cylindrical rod has a refractive index of $\frac{2}{\sqrt{3}}$. It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure. The incident angle θ for which the light ray grazes along the wall of the rod is:



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

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

Q 5. A rectangular glass slab ABCD of refractive index n_1 is immersed in water of refractive index $n_2(n_1 > n_2)$. A ray of light is incident at the surface AB of the slab as shown. The maximum value of the angle of incidence α_{max} such that the ray comes out only from the other surface CD is given by?



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

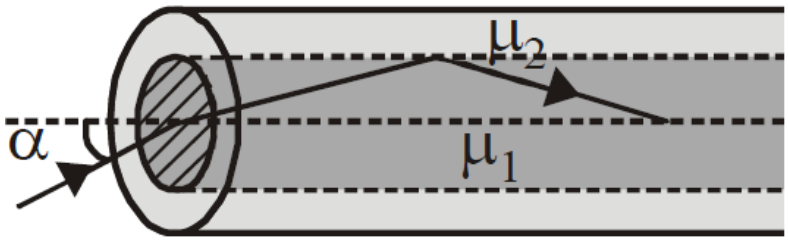
Q 6. A ray of light from a denser medium strikes a rarer medium at an angle of incidence i. If the reflected and refracted rays are mutually perpendicular to each other, what is the value of critical angle?
(a) $\tan^{-1}\left[\frac{1}{\tan i}\right]$
(b) $sin^{-1}[\tan i]$
(c) $sin^{-1}\left(\frac{1}{\sin i}\right)$
(d) None of these

Q 7. A cut diamond (or air bubble in water) shines brilliantly due to:
(a) Its molecular structure
(b) Absorption of light
(c) Total internal reflection
(d) Some inherent property

Q 8. A point source of light is placed 4 m below the surface of water of $\mu = \frac{5}{3}$. The minimum diameter of a disc, which should be placed over the source, on the surface of water to cut off all light coming out of water, is:
(a) 1 m (b) 6 m (c) 4 m (d) 3 m

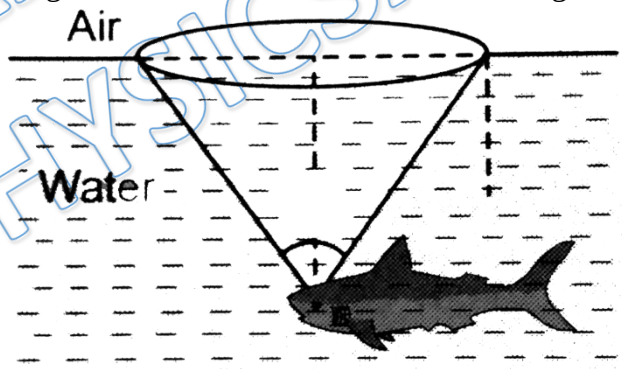
Q 9. A ray of light travels in a medium whose refractive index with respect to air is $\sqrt{2}$. When light is incident at an angle of 45° to the surface then which of the following is correct?
(a) angle of refraction is 45°
(b) total internal reflection takes place
(c) angle of refraction is 90°
(d) the path of ray is un deviated

Q 10. An optical fibre consists of core of μ_1 surrounded by a cladding of $\mu_2 < \mu_1$. A beam of light enters from air at an angle α with axis of fibre. The highest α for which ray can be travelled through fibre is



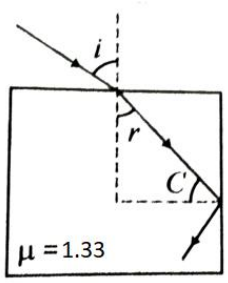
(a) $\cos^{-1}\sqrt{\mu_2^2 - \mu_1^2}$
(b) $sin^{-1}\sqrt{\mu_1^2 - \mu_2^2}$
(c) $\tan^{-1}\sqrt{\mu_1^2 - \mu_2^2}$
(d) $sec^{-1}\sqrt{\mu_1^2 - \mu_2^2}$

Q 11. A fish is a little away below the surface of a lake. If the critical angle is 49°, then the fish could see things above the water surface within an angular range of θ_o where



(a) $\theta = 49^o$ (b) $\theta = 90^o$
(c) $\theta = 98^o$ (d) $\theta = 24\frac{1^o}{2}$

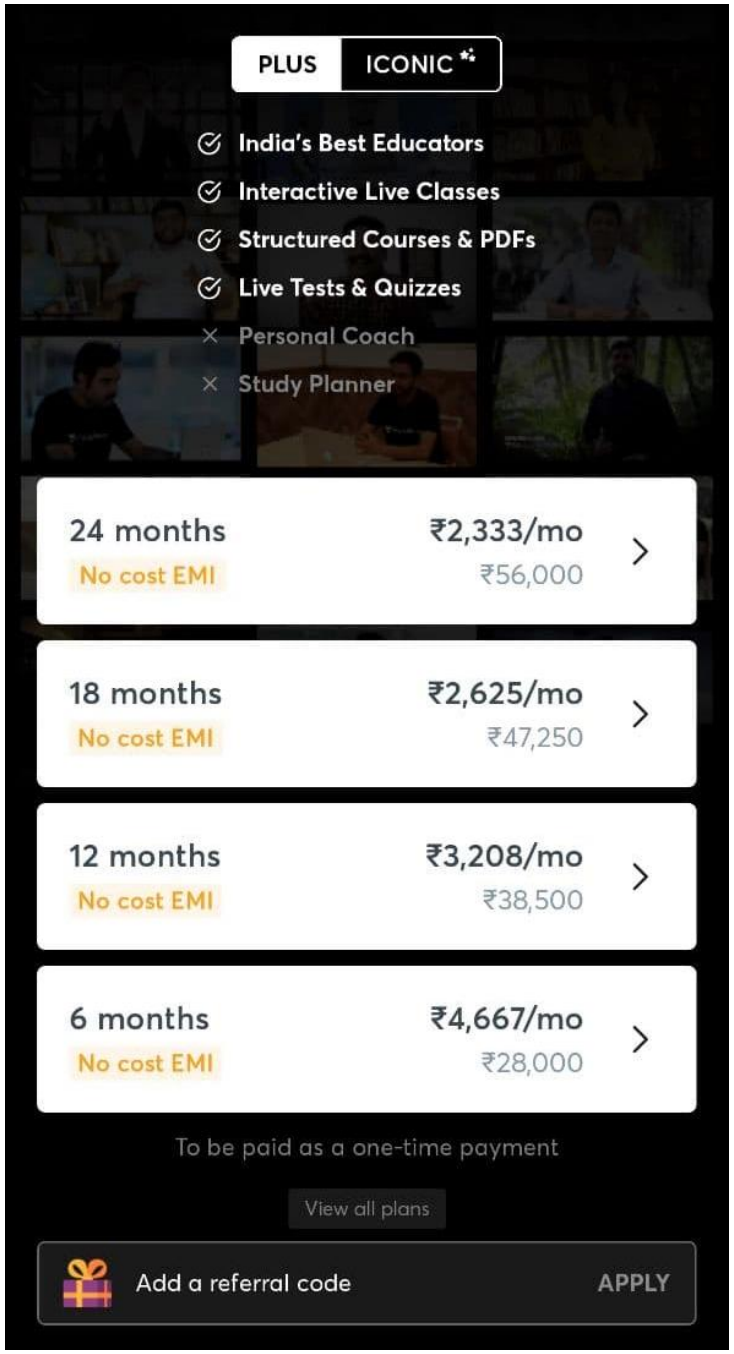
Q 12. Given a slab with index n=1.33 and incident light striking the top horizontal face at angle i as shown in figure. The maximum value of i for which total internal reflection occurs is



(a) $\sin^{-1}\sqrt{0.77}$ (b) $\cos^{-1}\sqrt{0.77}$
(c) $\sin^{-1} 0.77$ (d) $\sin^{-1}\sqrt{0.38}$

Answer Key

Q.1 b	**Q.2 a**	**Q.3 b**	**Q.4 c**	**Q.5 a**
Q.6 b	**Q.7 c**	**Q.8 b**	**Q.9 c**	**Q.10 b**
Q.11 c	**Q.12 a**			



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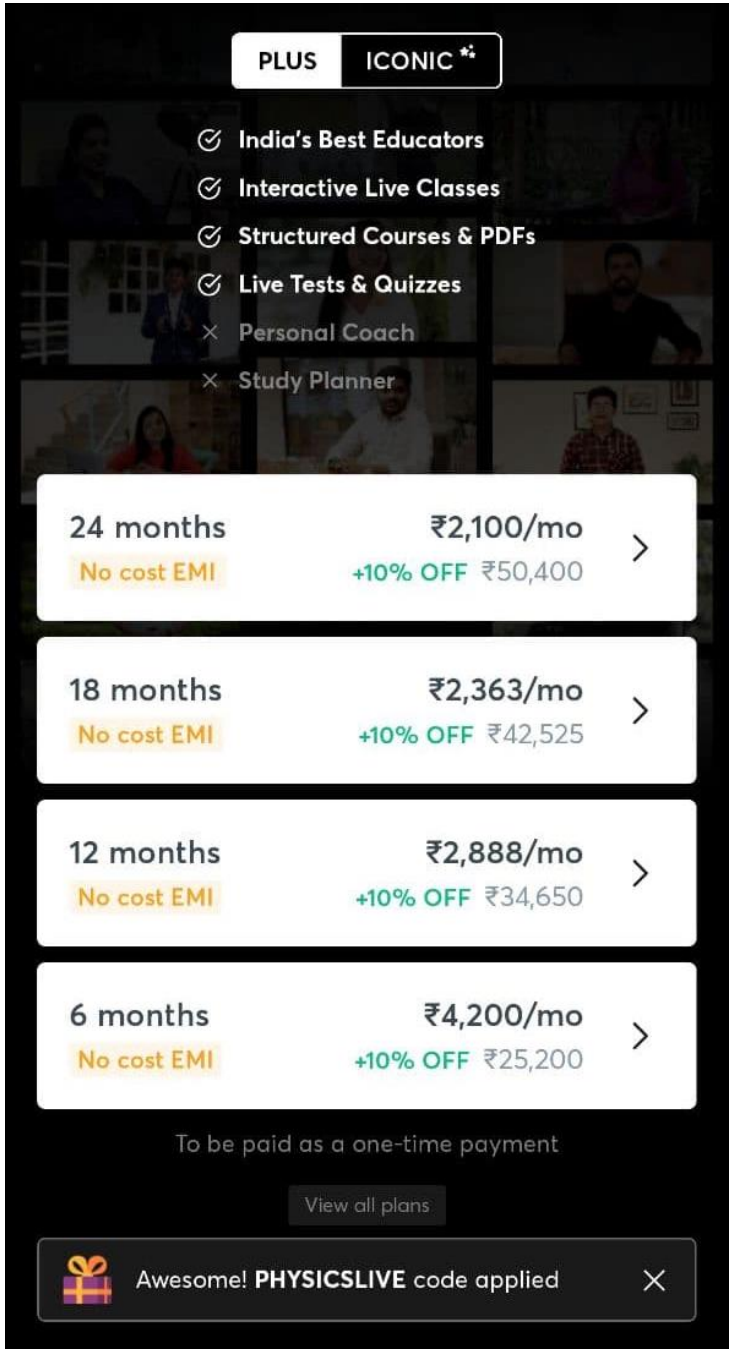


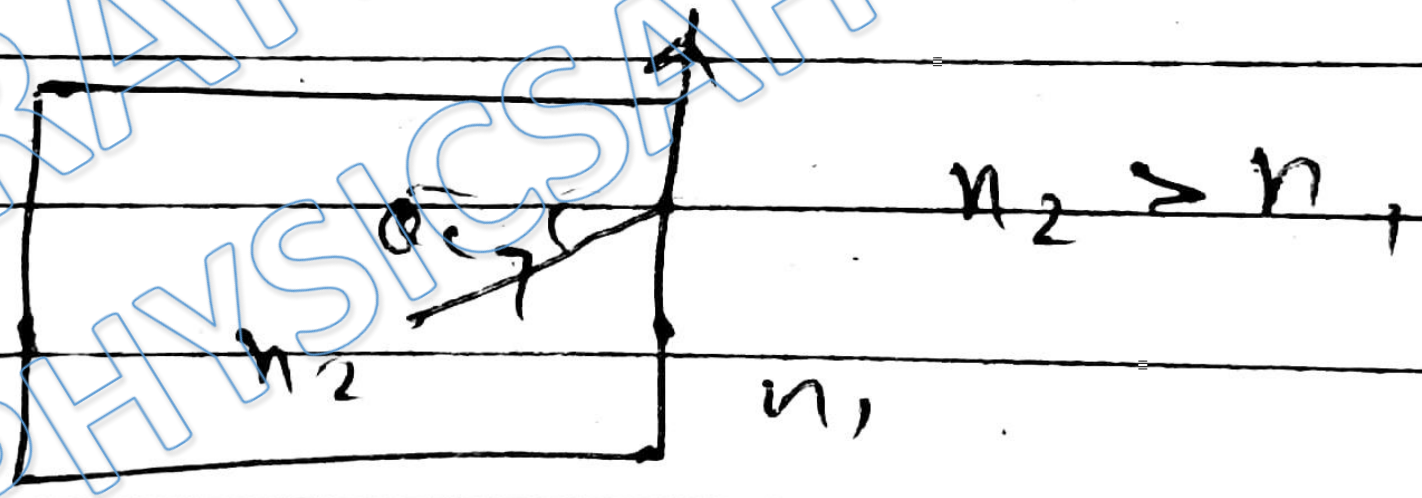
Written Solution

DPP-6 TIR & Optical Fiber

By Physicsaholics Team

Solution: 1

TIR takes place when light goes from denser medium to rarer medium.



Ans. b

Solution: 2

$$\sin\theta_c = \frac{1}{\mu}$$

θ_c = critical angle

for TIR

$$i \geq \theta_c$$

$$\sin i > \sin\theta_c$$

$$\sin i > \frac{1}{\mu}$$

$$\sin i > \frac{1}{\mu}$$

$$\boxed{\frac{1}{\sin i} < \mu}$$

Ans. a

Solution: 3

(8)

All region surfaces are parallel so we can apply refraction from region I to IV

$n_0 \sin\theta = \frac{n_0}{\beta} \sin\gamma$

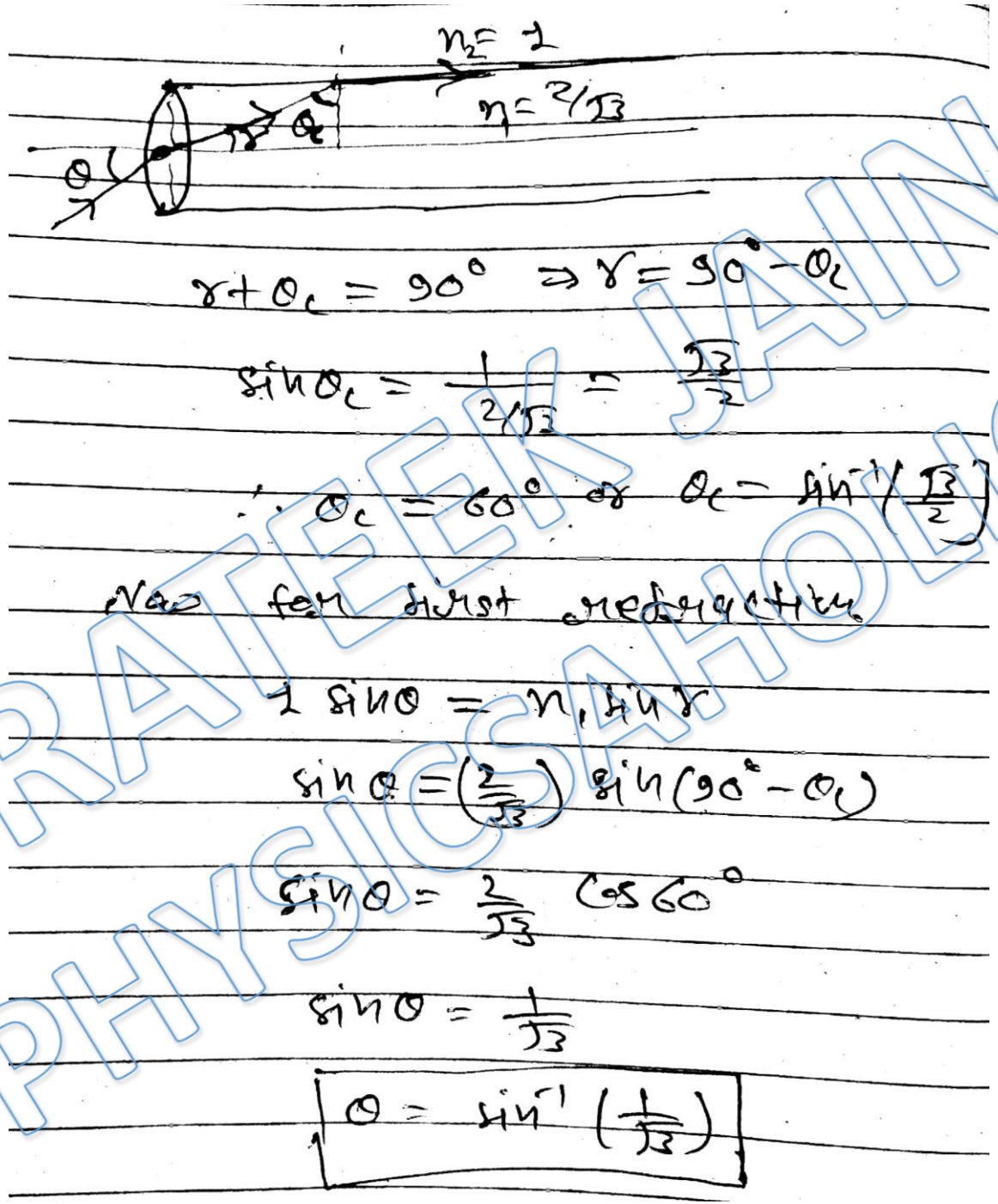
If $\gamma = 90^\circ$ [For Jus milying entering region IV]

$\sin\theta = \frac{n_0}{\beta} \frac{\sin 90^\circ}{n_0}$

$\sin\theta = \frac{1}{\beta} \Rightarrow \boxed{\theta = \sin^{-1}\left(\frac{1}{\beta}\right)}$

Ans. b

Solution: 4



$r + \theta_c = 90^\circ \Rightarrow r = 90^\circ - \theta_c$

$\sin\theta_c = \frac{1}{2/\sqrt{3}} = \frac{\sqrt{3}}{2}$

$\therefore \theta_c = 60^\circ$ or $\theta_c = \sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$

Now for first refraction

$1 \sin\theta = n_1 \sin r$

$\sin\theta = \left(\frac{2}{\sqrt{3}}\right) \sin(90^\circ - \theta_c)$

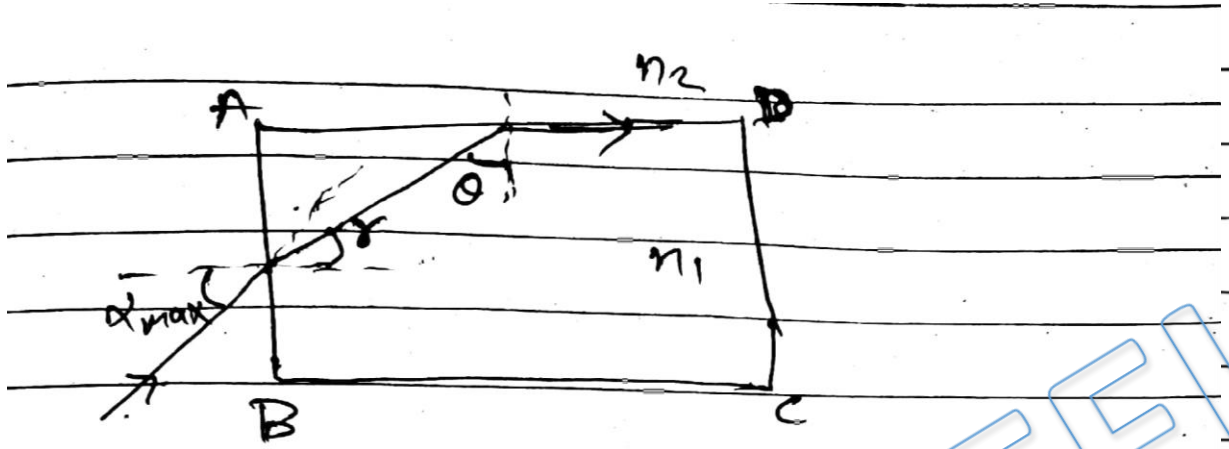
$\sin\theta = \frac{2}{\sqrt{3}} \cos 60^\circ$

$\sin\theta = \frac{1}{\sqrt{3}}$

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

Ans. c

Solution: 5



For light to come out from CD, θ should be $\Rightarrow \theta \geq \theta_c$

for critical angle

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

$$\theta + \gamma = 90^\circ$$

$$\gamma = 90^\circ - \theta$$

for refraction at surface AB

$$n_2 \sin\alpha_m = n_1 \sin\gamma$$

$$n_2 \sin\alpha_m = n_1 \sin(90-\theta)$$

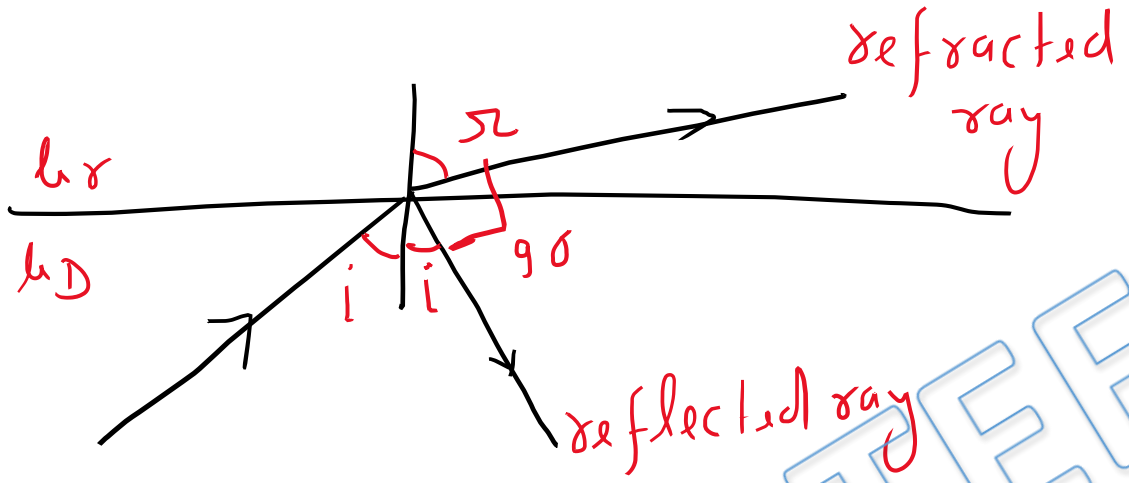
$$n_2 \sin\alpha_m = n_1 \cos\theta$$

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

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

Ans. a

Solution: 6



$i + r + 90 = 180$

$r = 90 - i$

$i_c = \sin^{-1}\left(\frac{\mu_r}{\mu_D}\right)$

$= \sin^{-1}\left(\frac{\sin i}{\sin r}\right)$

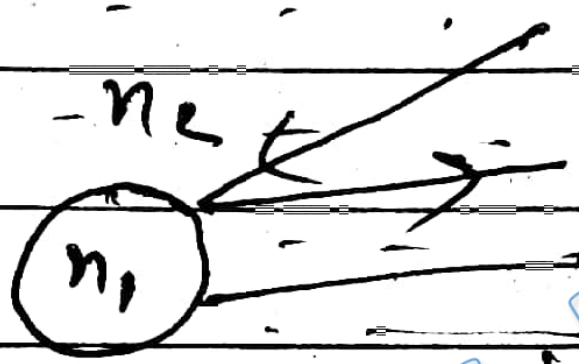
$= \sin^{-1}\left(\frac{\sin i}{\sin(90-i)}\right)$

$= \sin^{-1}\left(\frac{\sin i}{\cos i}\right)$

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

Ans. b

Solution: 7



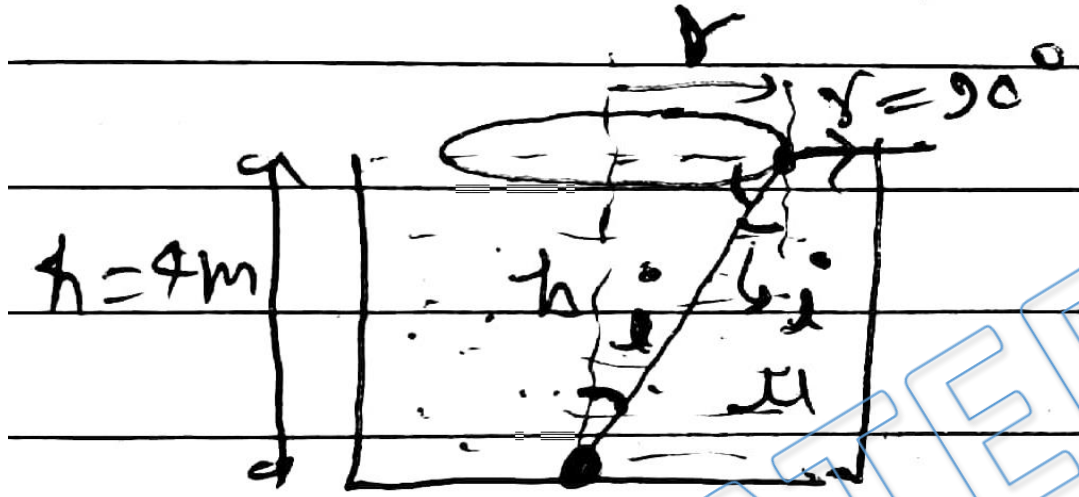
$\therefore n_2 > n_1$

So, when light incident on surface of air bubble from water (denser) medium, it's get reflected.

And Diamond also shines due to TIR

Ans. c

Solution: 8



$$\mu \sin i = 1 \sin 90^\circ$$

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

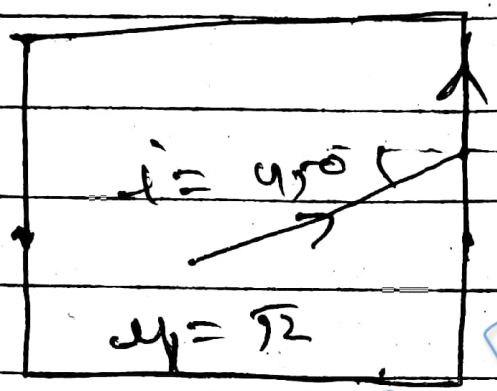
$$\frac{r}{\sqrt{r^2+h^2}} = \frac{3}{5}$$

$$\Rightarrow \frac{r^2}{r^2+h^2} = \frac{9}{25} \Rightarrow$$

$$\boxed{r = 3m} \Rightarrow \boxed{D = 2r = 6m}$$

Ans. b

Solution: 9



$\therefore \mu_1 \sin i = \mu_2 \sin r$

$\sqrt{2} \sin 45^\circ = 1 \sin r$

$\sqrt{2} \cdot \frac{1}{\sqrt{2}} = 1 \sin r$

$\sin r = 1$

$\boxed{r = 90^\circ}$

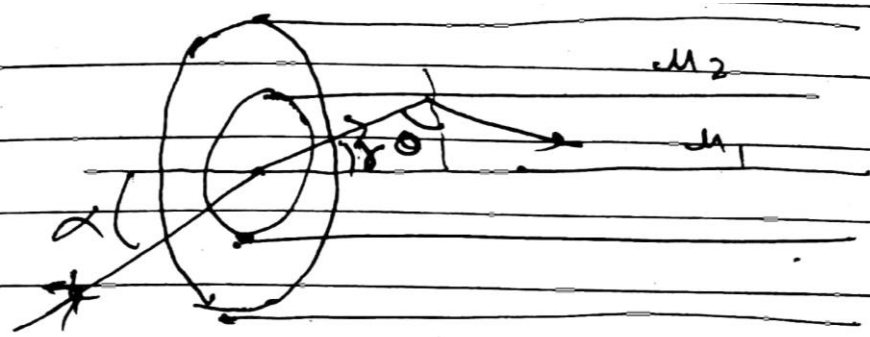
This is ($i = 45^\circ$) is critical angle.

if $i > 45^\circ$ then there will be TIR

so; $r = 90^\circ$ is the angle of refraction, for $i = 45^\circ$

Ans. c

Solution: 10



For $\alpha = \max$.

$\sin\theta = \frac{\mu_2}{\mu_1}$ [$\because$ TIR at interface of μ_1 & μ_2]

$\cos\theta = \sqrt{\frac{\mu_1^2 - \mu_2^2}{\mu_1^2}}$ [$\because \cos\theta = \sqrt{1-\sin^2\theta}$]

$\theta + r = 90^\circ$

$r = 90^\circ - \theta$

For refraction.

$1 \sin\alpha_m = \mu_1 \sin r$

$\sin r = \frac{\sin\alpha_m}{\mu_1}$

$\sin(90-\theta) = \frac{\sin\alpha_m}{\mu_1}$

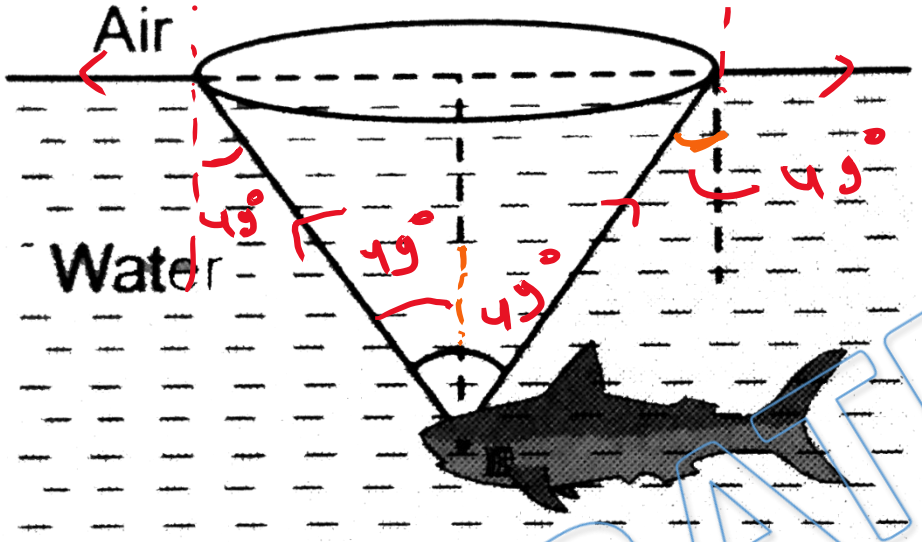
$\cos\theta = \frac{\sin\alpha_m}{\mu_1}$

$\sqrt{\frac{\mu_1^2 - \mu_2^2}{\mu_1^2}} = \frac{\sin\alpha_m}{\mu_1}$

$$\boxed{\alpha_m = \sin^{-1}\sqrt{\mu_1^2 - \mu_2^2}}$$

Ans. b

Solution: 11

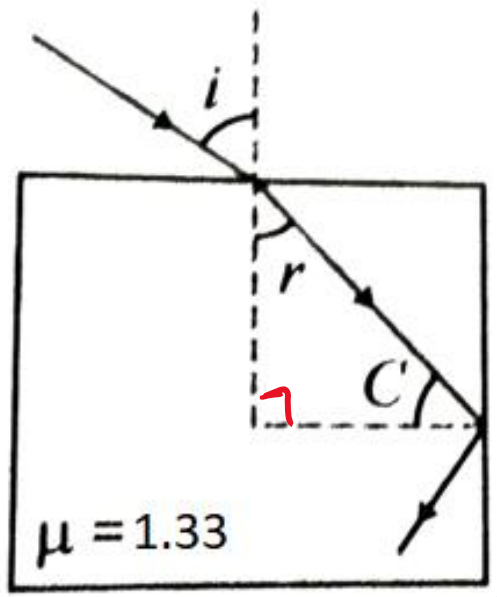


$\theta = 49° + 49°$

$\theta = 98°$ Ans.

Ans. c

Solution: 12



$1 \times \sin i = 1.33 \sin r$

$\sin i = 1.33 \sin(90 - C)$ $[\because C + r = 90^\circ]$

$\sin i = 1.33 \cos C$

$\sin i = 1.33 \times \frac{\sqrt{0.77}}{1.33}$

$\sin i = \sqrt{0.77}$

$i = \sin^{-1}(\sqrt{0.77})$ Ans

$C = 90 - r$

$\sin C = \frac{1}{1.33}$

$\cos C = \frac{\sqrt{(1.33)^2 - 1}}{(1.33)}$

$\cos C = \frac{\sqrt{0.77}}{1.33}$

Ans. a

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