Physicsaholics

DPP – 6 (Geometrical Optics)

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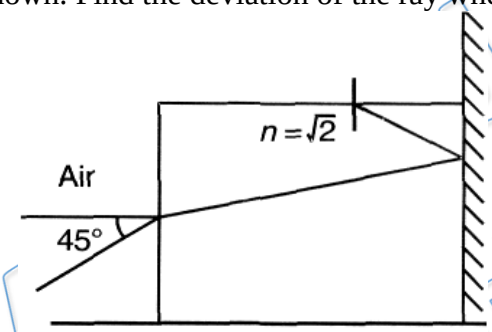
Q 1. Critical angle of glass is θ_1 and that of water is θ_2. The critical angle for water and glass surface would be :($\mu_g = 3/2$, $\mu_w = 4/3$)

(a) less than θ_2 (b) between θ_1 and θ_2

(c) greater than θ_2 (d) less than θ_1

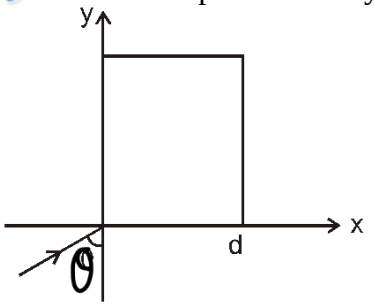
Q 2. Right face of the glass cube is silvered or shown. A ray of light incident on left face of the cube as shown. Find the deviation of the ray when it comes out of the glass cube



(a) 0° (b) 90°

(c) 180° (d) 270°

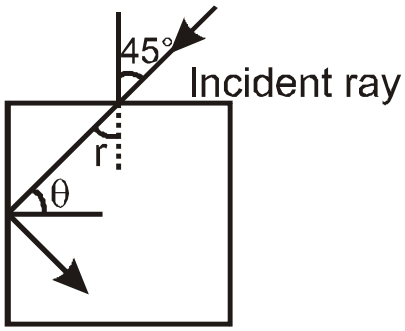
Q 3. A ray hits the y-axis making an angle q with y-axis as shown in the figure. The variation of refractive index with x-coordinate is $\mu = \mu_0\left(1 - \frac{x}{d}\right)$ for $0 \le x \le d\left(1 - \frac{1}{\mu_0}\right)$ and $m = m_0$ for $x < 0$, where d is a positive constant. The maximum x-coordinate of the path traced by the ray is



(a) d (1 – sin θ) (b) d (1 – cos θ)

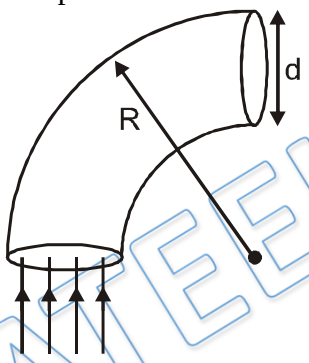
(c) d sin θ (d) d cos θ

Q 4. For the given incident ray as shown in figure, the condition of total internal reflection of the ray will be satisfied if the refractive index of block will be :



(a) $\frac{\sqrt{3}}{2}$ (b) $\frac{\sqrt{2}+1}{2}$ (c) $\sqrt{\frac{3}{2}}$ (d) $\sqrt{\frac{7}{6}}$

Q 5. A cylindrical optical fiber (quarter circular shape) of refractive index $\mu = 2$ and diameter d = 4mm is surrounded by air. A light beam is sent into the fiber along its axis as shown in figure. Then the smallest outer radius R (as shown in figure) for which no light escapes after first incident on curved surface of fiber is:

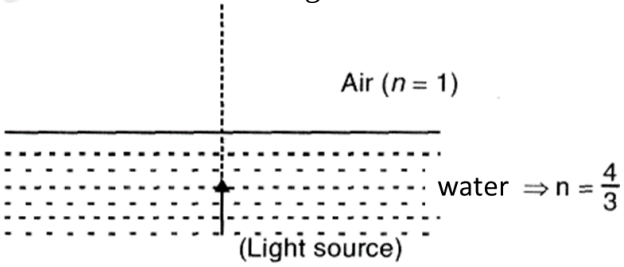


(a) 2mm (b) 4mm (c) 8 mm (d) 6 mm

Q 6. A bulb is placed at a depth of $2\sqrt{7}$ m in water and a floating opaque disc is placed over the bulb so that the bulb is not visible from the surface. What is the minimum diameter of the disc?

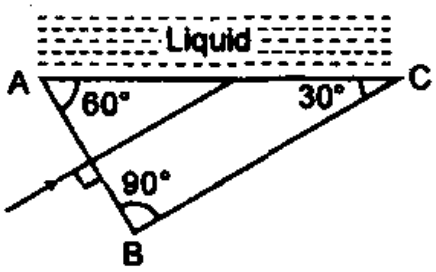
(a) 10 m (b) 12 m (c) 8 m (d) 6 m

Q 7. A light source is submerged inside water. It is moving in upward direction due to buoyancy force. Which of the following is incorrect?



(a) Percentage of light transferring from water to air is increasing
(b) Percentage of light transferring from water to air is constant
(c) Base area of light cone is increasing
(d) Base area of light cone is decreasing

Q 8. Light is incident normally on face AB of a prism as shown in figure. A liquid of refractive index μ is placed on face AC of the prism. The prism is made of glass of refractive index 3/2. The limits of μ for which total internal reflection takes place on face AC is:

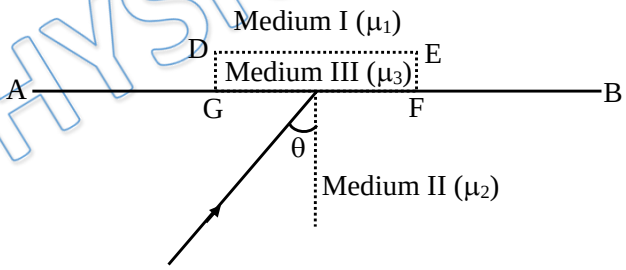


(a) $\mu > \frac{\sqrt{3}}{2}$ (b) $\mu < \frac{3\sqrt{3}}{4}$ (c) $\mu > \sqrt{3}$ (d) $\mu < \frac{\sqrt{3}}{2}$

Q 9. A ray of light travels from an optically denser to rarer medium. The critical angle for the two media is c. The maximum possible deviation of the ray will be
(a) π - c (b) π – 2c (c) 2c (d) π/2 + c

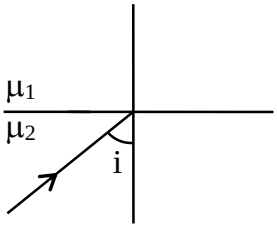
Q 10. A vertical pencil of rays comes from bottom of a tank filled with a liquid. When it is accelerated with an acceleration of 7.5 m/s^2, the ray is seen to be totally reflected by liquid surface. What is minimum possible refractive index of liquid?
(a) slightly greater than 4/3 (b) slightly greater than 5/3
(c) slightly greater than 1.5 (d) slightly greater than 1.75

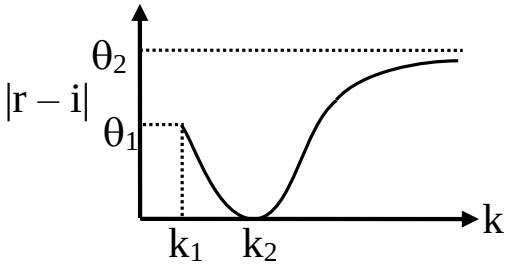
Q 11. Monochromatic light is incident on plane interface AB between two media of refractive indices μ_1 and μ_2 ($\mu_2 > \mu_1$) at angle θ shown in figure. The angle θ is infinitesimally greater than the critical angle for two media so that total internal reflection takes place. Now, if a transparent slab DEFG of uniform thickness and having refractive index μ_3 is introduced on the interface as shown in the figure, which of the following statements is/are correct?



(a) If $\mu_3 < \mu_1$, total internal reflection will take place at face GF
(b) If $\mu_3 > \mu_1$, light will refract into the slab
(c) If $\mu_3 > \mu_1$, total internal reflection will take place at face DE
(d) Light cannot be transmitted to medium I

Q 12. The figure shows a ray incident at an angle i = /3. If the plot drawn the variation of $|r - i|$ versus $\frac{\mu_1}{\mu_2}$= k,
(r = angle of refraction)



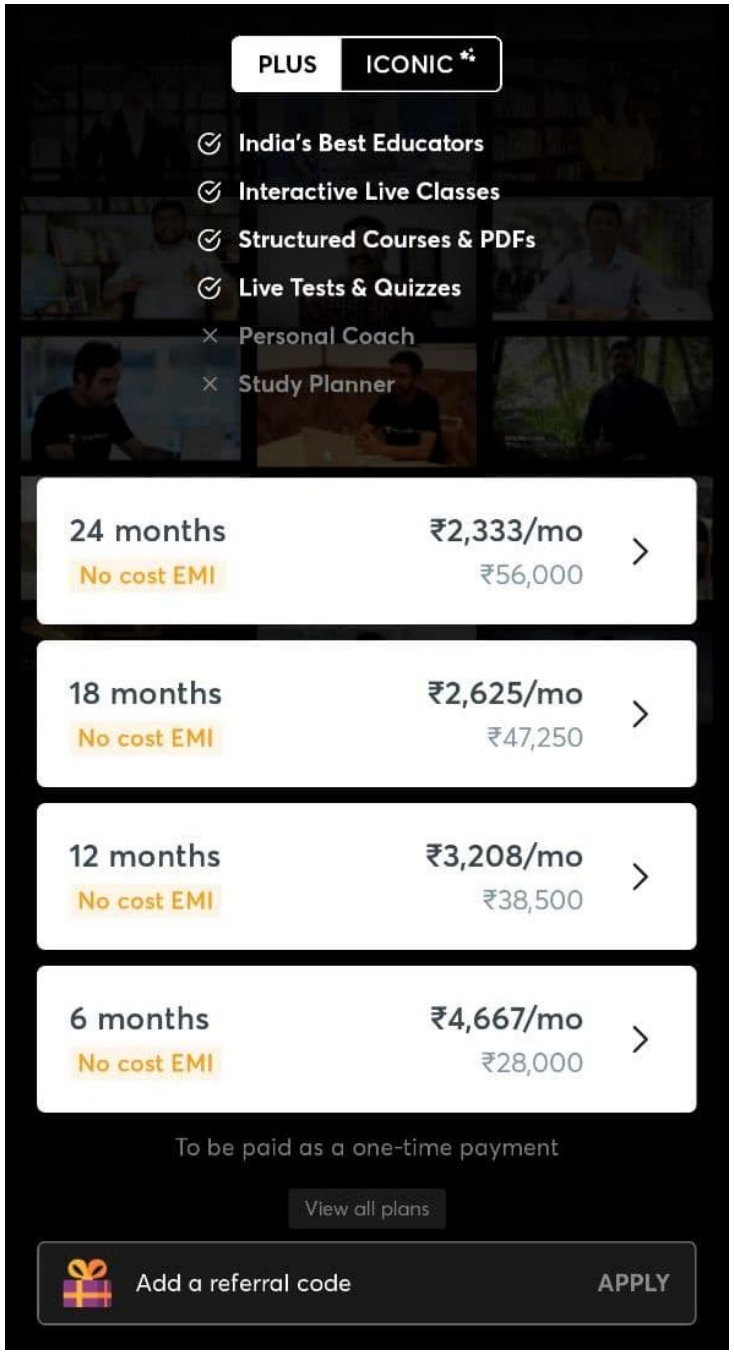


(a) the value of k_1 is $\frac{2}{\sqrt{3}}$
(b) the value of $\theta_1 = \pi/6$
(c) the value of $\theta_2 = \pi/3$
(d) the value of k_2 is 1

Q 13. Due to partial reflection a thick mirror forms large no of images. If image closest to observer is called first image, second closest image is called second image and so on. brightest image is
(a) First
(b) Second
(c) Third
(d) fourth

Answer Key

Q.1 c	**Q.2 c**	**Q.3 b**	**Q.4 c**	**Q.5 c**
Q.6 b	**Q.7 a, c**	**Q.8 b**	**Q.9 b**	**Q.10 b**
Q.11 a, b, c, d	**Q.12 b, c, d**	**Q.13 b**		



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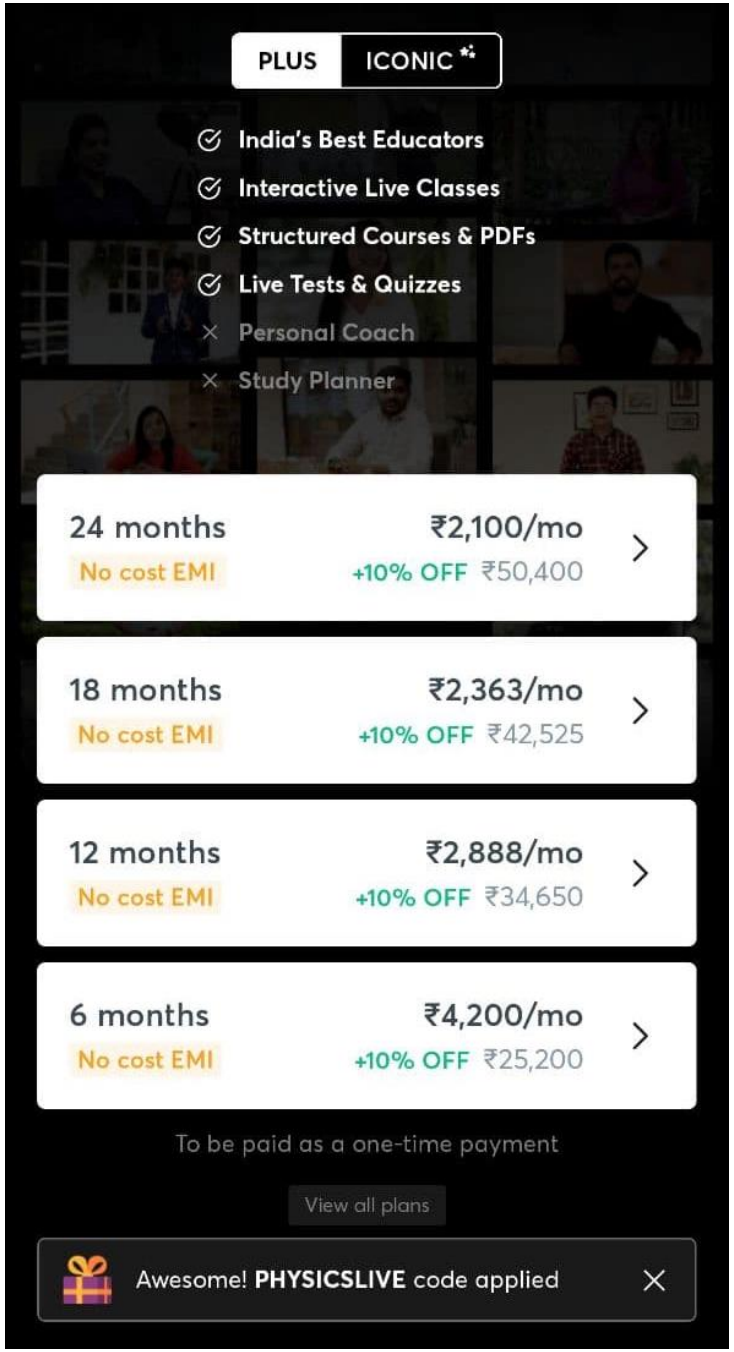


Written Solution

DPP 6 – Geometrical Optics :Total Internal Reflection & Optical Fiber

By Physicsaholics Team

Solution: 1

$$\theta_1 = \sin^{-1}\left(\frac{2}{3}\right) \quad , \quad \theta_2 = \sin^{-1}\left(\frac{3}{4}\right)$$

for water glass surface

$$\theta = \sin^{-1}\left(\frac{\mu_{rarer}}{\mu_{denser}}\right) = \sin^{-1}\left(\frac{4/3}{3/2}\right) = \sin^{-1}\left(\frac{8}{9}\right)$$

$\Rightarrow$ θ is greater than θ_1 & θ_2.

Ans (c)

Solution: 2

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

$\Rightarrow \quad \sin r = 1/2 \Rightarrow r = 30^\circ$

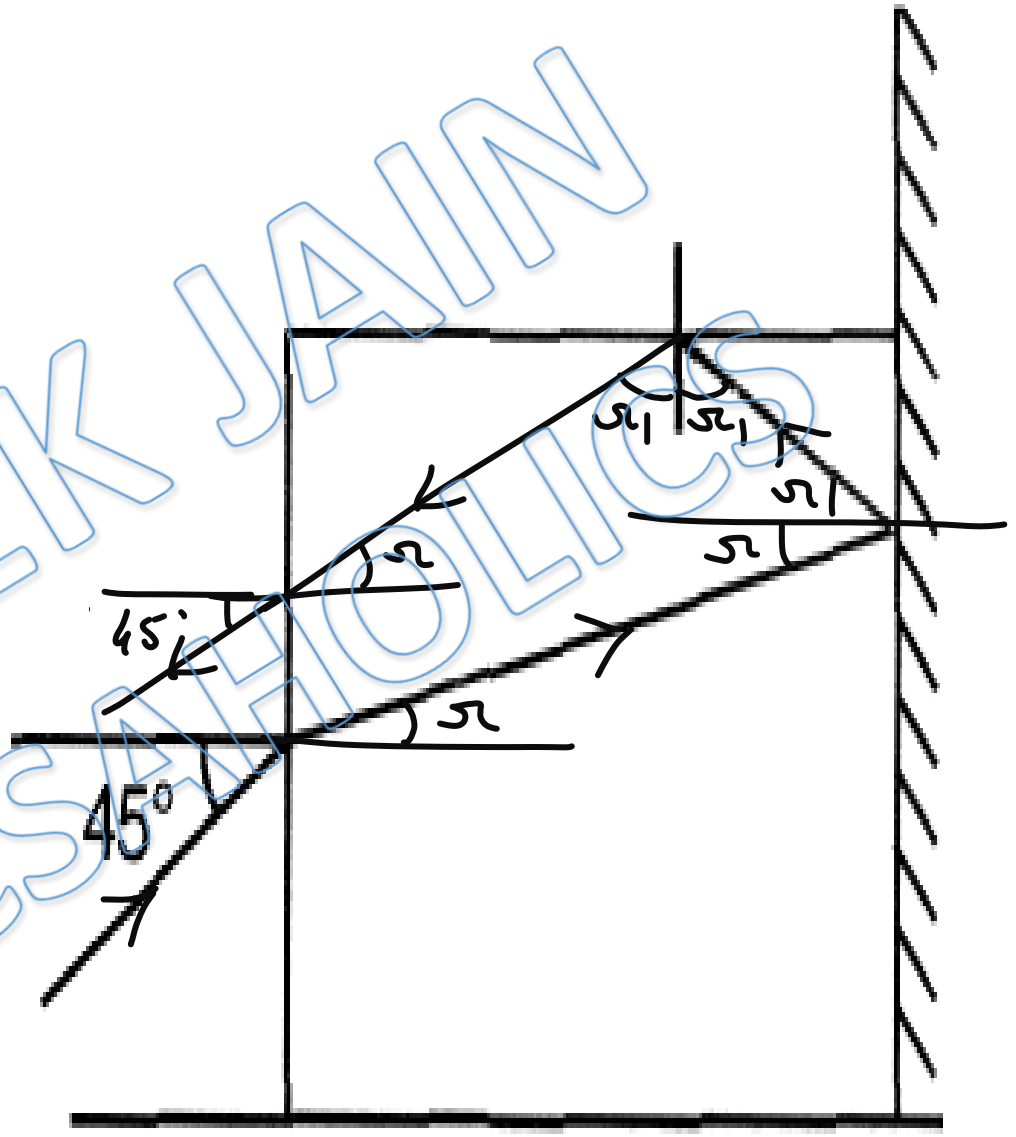
$\Rightarrow \quad r_1 = 90^\circ - 30^\circ = 60^\circ$

Critical angle $= \sin^{-1}\left(\frac{1}{\mu}\right)$

$= \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ$

Since $r_1 >$ critical angle

Ray will get reflected at top surface.



$\Rightarrow$ final emergent Ray is antiparallel to incident Ray.

ANS(C)

Solution: 3

for T.I.R. of Ray

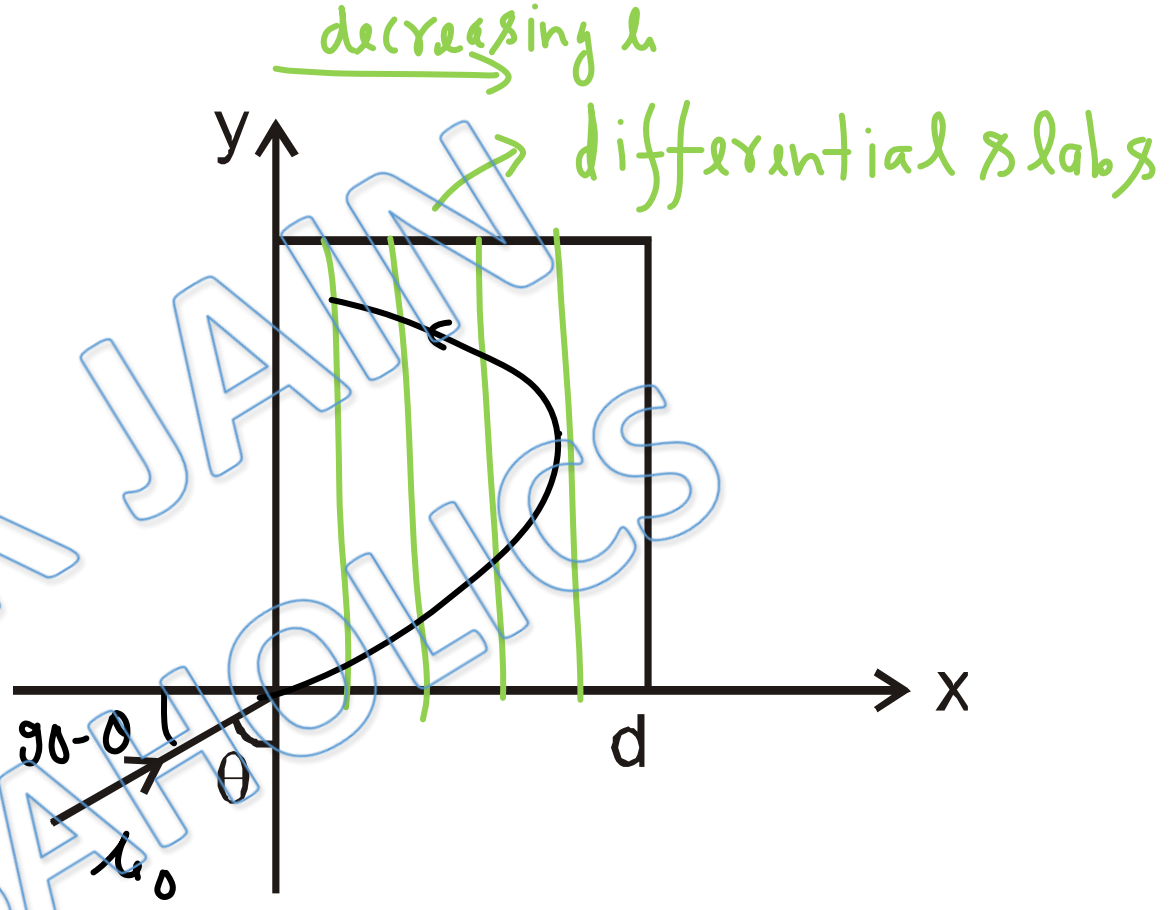
$$\mu_0 \sin(90-\theta) = \mu \sin 90$$

$$\Rightarrow \quad \mu = \mu_0 \cos\theta = \mu_0\left(1-\frac{x}{d}\right)$$

$$\Rightarrow \quad 1-\frac{x}{d} = \cos\theta$$

$$\Rightarrow \quad \frac{x}{d} = 1-\cos\theta$$

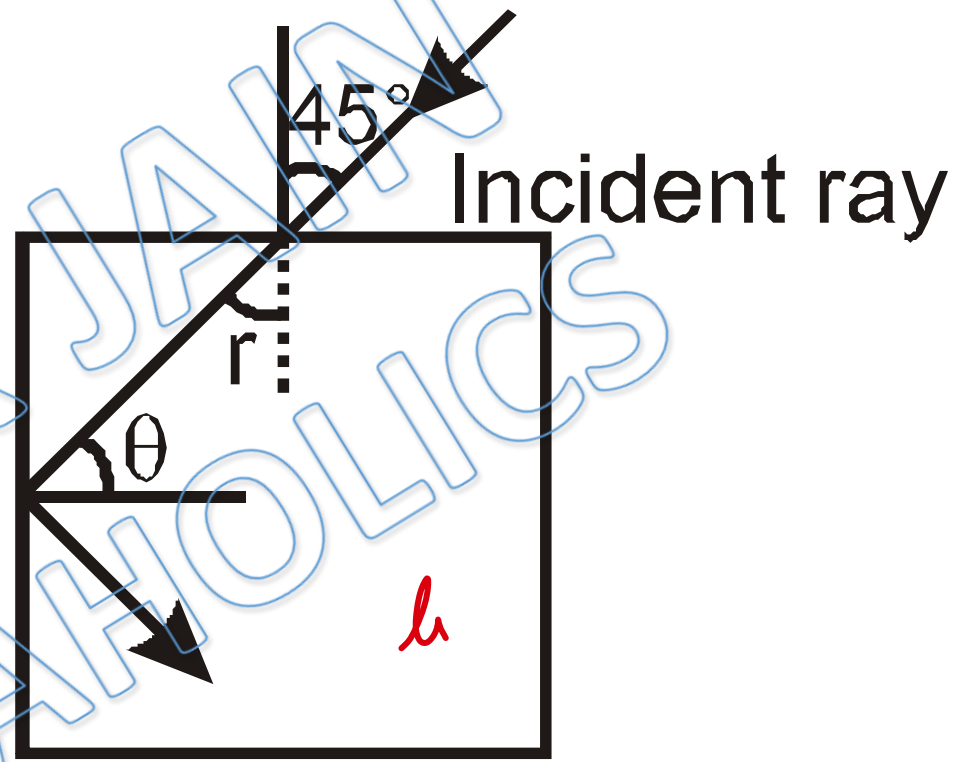
$$\Rightarrow \quad x = d(1-\cos\theta)$$



Ans(b)

Solution: 4 ANS (C)

$1 \sin 45^\circ = \mu \sin r \quad --(1)$



for T.I.R.

$\theta > \sin^{-1}\left(\frac{1}{\mu}\right)$

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

$\Rightarrow \sin(90 - r) > \frac{1}{\mu}$

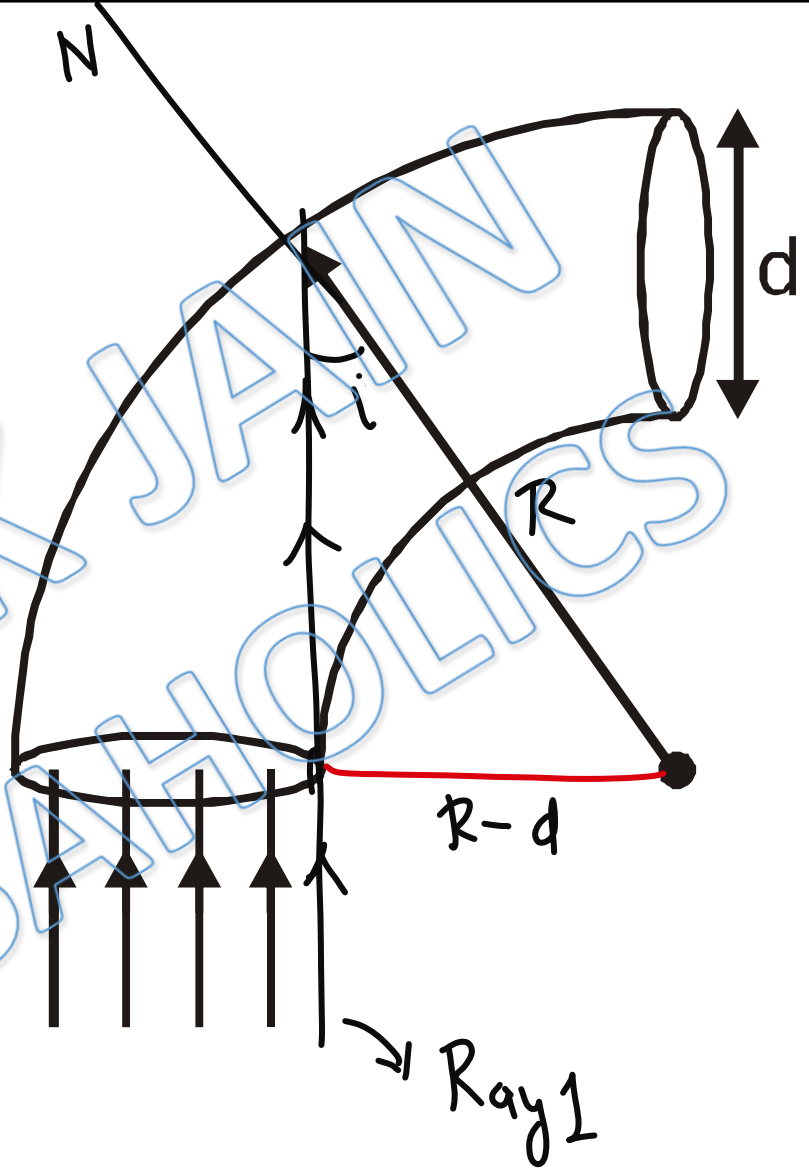
$\Rightarrow \cos r > \frac{1}{\mu}$

$\Rightarrow 1 - \sin^2 r > \frac{1}{\mu^2}$

$\Rightarrow 1 - \frac{1}{2\mu^2} > \frac{1}{\mu^2} \Rightarrow \frac{3}{2\mu^2} < 1 \Rightarrow \mu^2 > \frac{3}{2} \Rightarrow \mu > \sqrt{\frac{3}{2}}$

Solution: 5

If angle of incidence for Ray 1 is greater than i_c, then it will be greater than i_c for all Rays.



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

$$\Rightarrow \frac{R-d}{R} > \frac{1}{2}$$

$$\Rightarrow 2R - 2d > R \Rightarrow R > 2d$$

$$\Rightarrow R > 8\,mm$$

Ans(c)

Solution: 6

As shown in Fig, light from bulb will not emerge out of water if at the edge of disc –

$i > \theta_C$

or $\sin i > \sin \theta_C$ .....eq.(1)

Now if R is the radius of disc and h is the depth of bulb from it

$\sin i = \frac{R}{\sqrt{R^2+h^2}}$ and $\sin \theta_C = \frac{1}{\mu}$

So Eqn. (1) becomes

$$\frac{R}{\sqrt{R^2+h^2}} > \frac{1}{\mu}$$

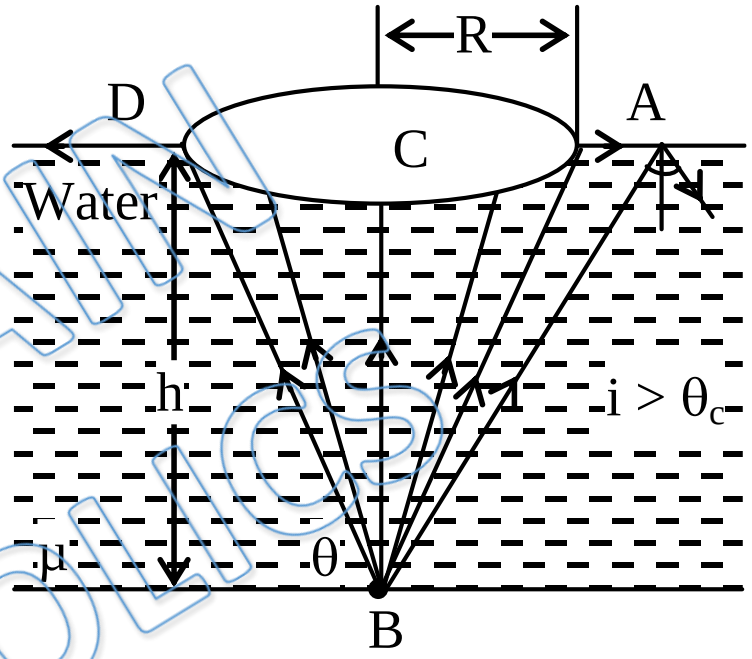
or $R > \frac{h}{\sqrt{\mu^2-1}}$ .....eq.(2)

Here $h = 2\sqrt{7}$m

and $\mu = (4/3)$

So $(R)_{min} = \frac{2\sqrt{7}}{\sqrt{(16/9)-1}} = 6$ m

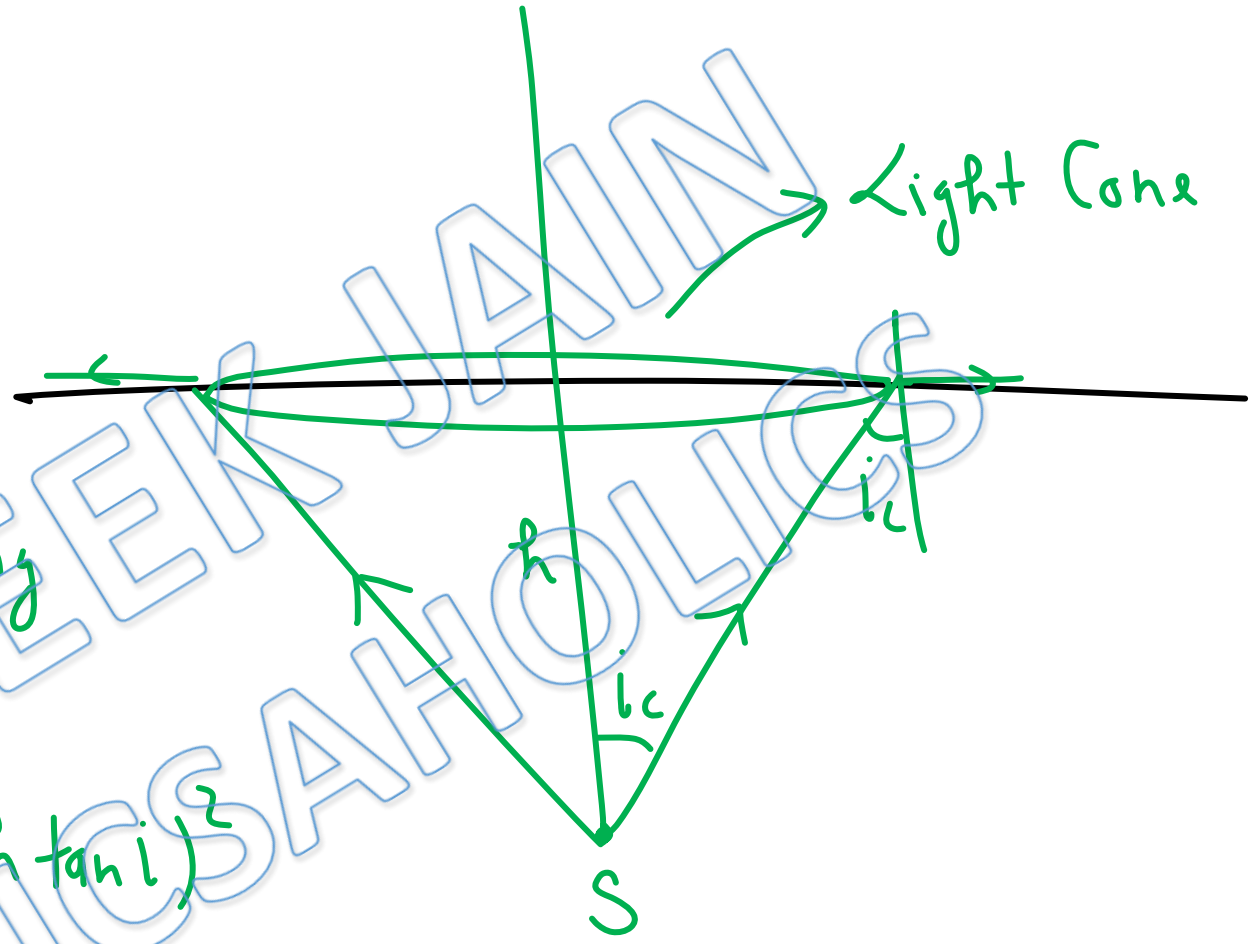
So diameter of disc = $2R = 2 \times 6 = 12$ m



Ans. b

Solution: 7

Semivertex angle of Cone is not changing with h. $\Rightarrow$ % of light transferring to air is Constant.

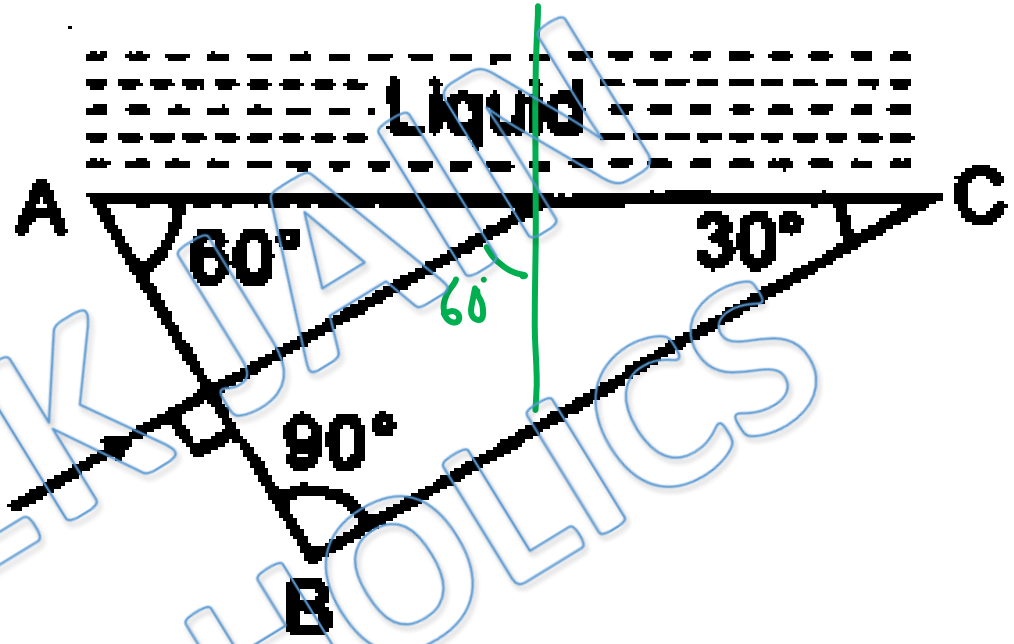


Base Area of Cone $= \pi (h \tan i)^2$

Base area decreases as source moves up.

Ans. a, c

Solution: 8



for T.I.R.

$$60^\circ > \sin^{-1}\left(\frac{\mu}{3/2}\right)$$

$$\Rightarrow \sin 60^\circ > \frac{2\mu}{3}$$

$$\Rightarrow \mu < \frac{3}{2} \times \frac{\sqrt{3}}{2}$$

$$\Rightarrow \mu < \frac{3\sqrt{3}}{4}$$

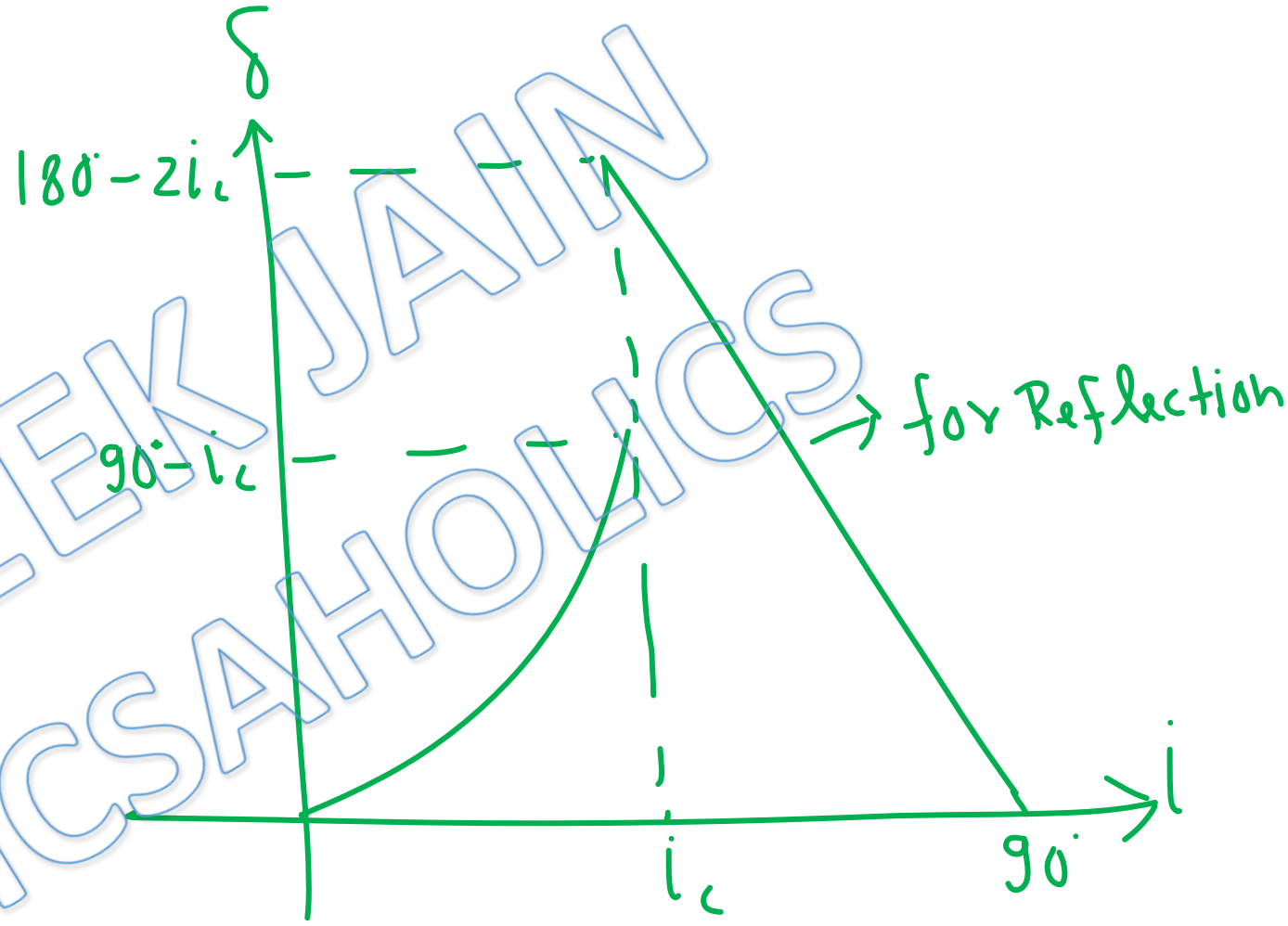
Ans(b)

Solution: 9

maximum deviation

$\delta = 180 - 2i_c$

$= \pi - 2c$



Ans(b)

Solution: 10

for vertical beam angle of incidence is $\theta = \tan^{-1}\left(\frac{a}{g}\right) = \tan^{-1}\left(\frac{7.5}{10}\right)$

$= \tan^{-1}\left(\frac{3}{4}\right) = 37^\circ$

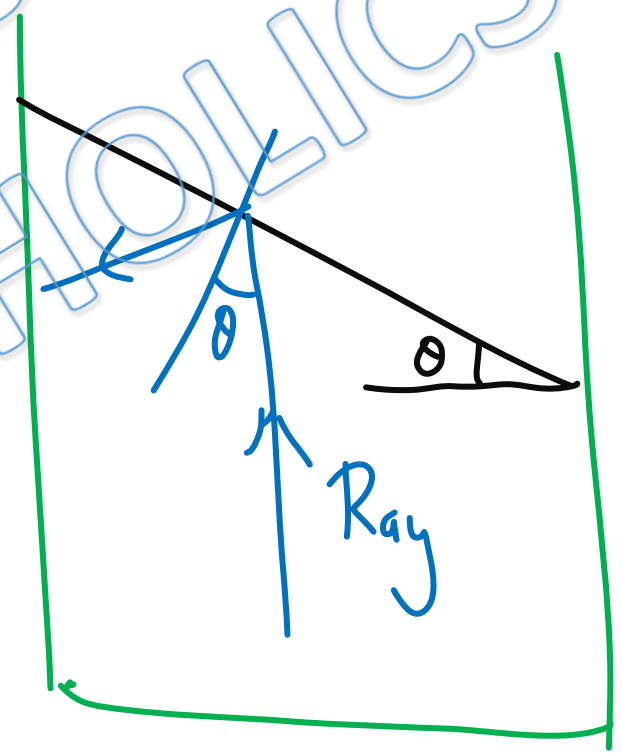
for T.I.R.

$\theta > i_c$

$\Rightarrow \sin\theta > \sin i_c$

$\Rightarrow \frac{3}{5} > \frac{1}{\mu}$

$\Rightarrow \mu > \frac{5}{3}$

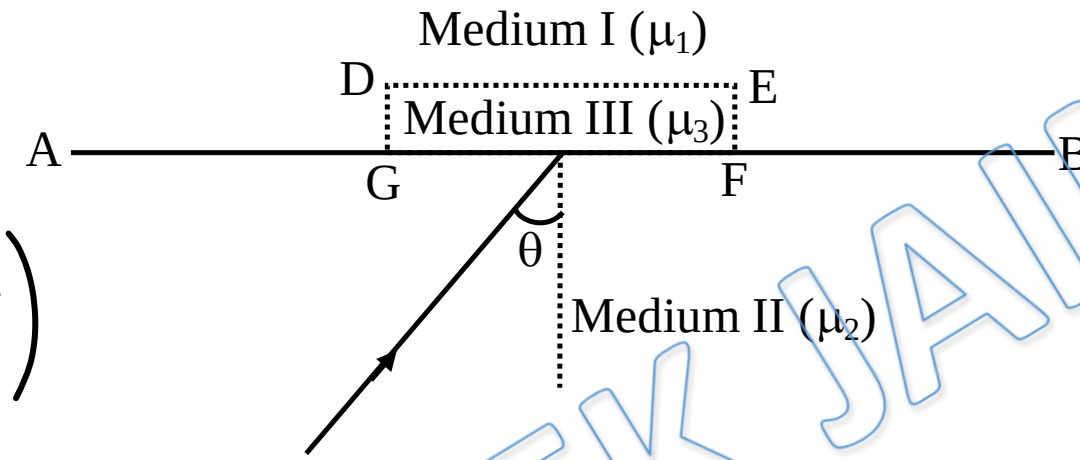


$a = 7.5\ m/s^2$

Ans(b)

Solution: 11

ANS-(a,b,c,d)

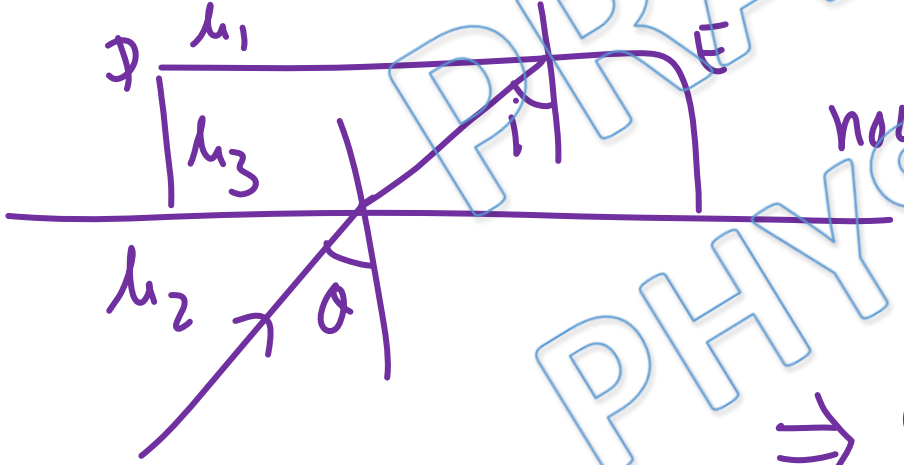


given

$\theta > \sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)$

If $\mu_3 < \mu_1 \Rightarrow$ Critical angle $= \sin^{-1}\left(\frac{\mu_3}{\mu_2}\right) < \theta \Rightarrow$ T.I.R. at AB

If $\mu_3 > \mu_1 \Rightarrow$ Critical angle for GF $= \sin^{-1}\left(\frac{\mu_3}{\mu_2}\right) > \theta \Rightarrow$ Refraction at GF



now for DE, Critical angle $= \sin^{-1}\left(\frac{\mu_1}{\mu_3}\right)$

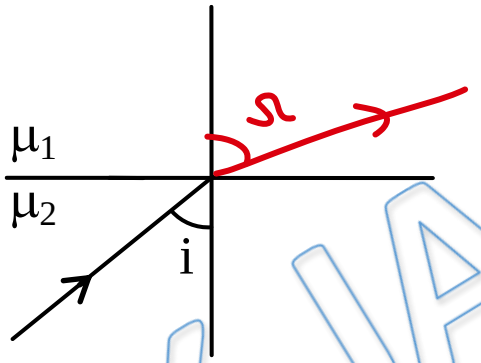
$\mu_3 \sin i = \mu_2 \sin\theta \Rightarrow \sin i = \frac{\mu_2}{\mu_3}\sin\theta > \frac{\mu_2}{\mu_3} \times \frac{\mu_1}{\mu_2}$

$\Rightarrow \sin i > \frac{\mu_1}{\mu_3} \Rightarrow i > \sin^{-1}\left(\frac{\mu_1}{\mu_3}\right) \Rightarrow$ T.I.R. at DE

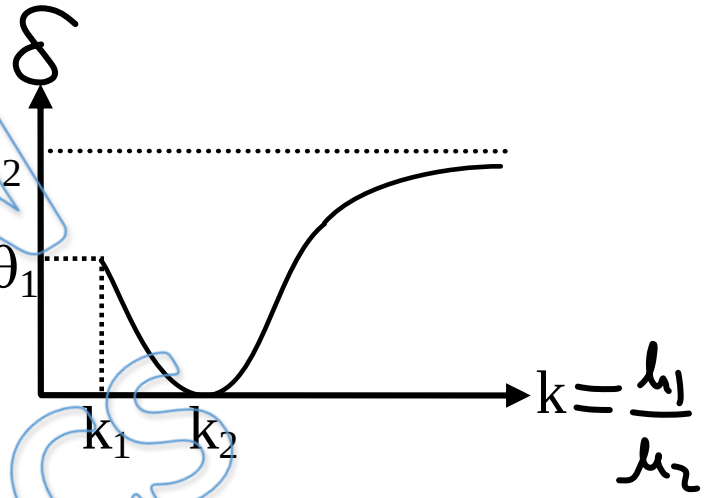
Solution: 12

at $K = K_2$, $\delta = 0$

$\Rightarrow \quad \mu_1 = \mu_2 \Rightarrow$ $K_2 = 1$



$i = \pi/3$



for $K < K_1$, There is no refraction

$\Rightarrow$ i is critical angle

$\Rightarrow \quad K_1 = \sin 60^\circ = \sqrt{3}/2$

At $K = K_1$, $r = 90^\circ \Rightarrow \delta = \theta_1 = 90 - 60^\circ = 30^\circ$

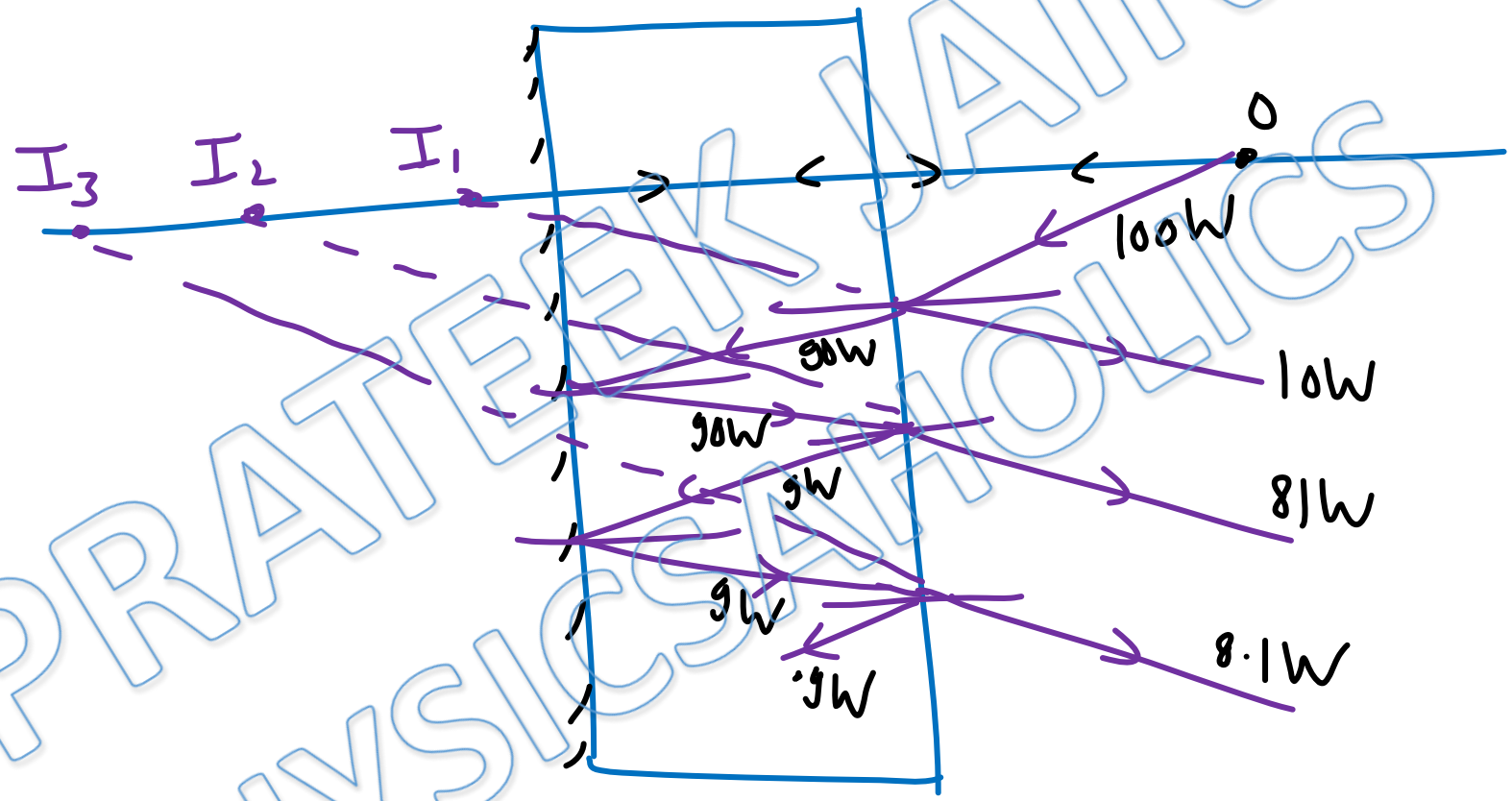
for very high K ($\mu_1 >> \mu_2$)

$r = 0 \Rightarrow \delta = \theta_2 = 60^\circ$

Ans (b, c, d)

Solution: 13

Let total incident Power is 100W & 10% energy is reflected in partial reflection but reflection by mirror is 100%.



Second image is brightest.

Ans. b

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