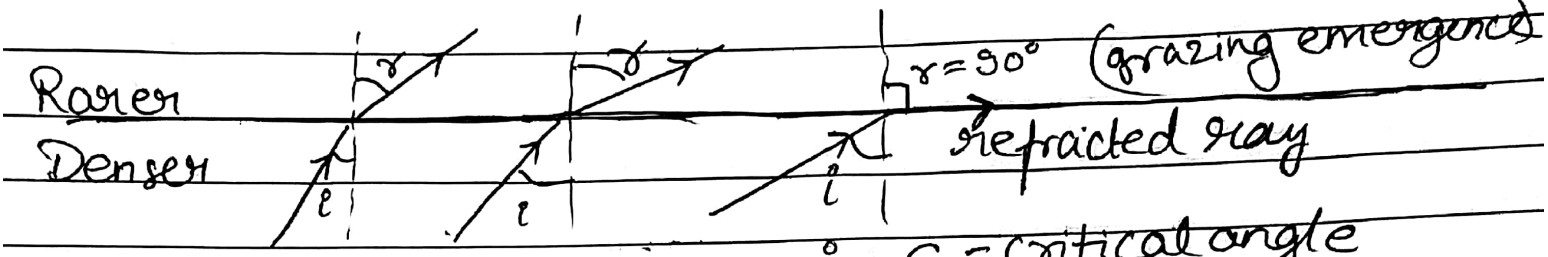
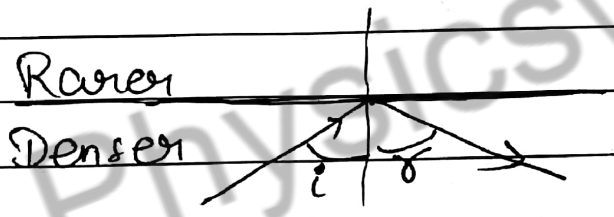
Ray optics -13

Critical Angle & Total Internal Reflection (TIR)



$i° = C$ = critical angle
$r = 90°$

if $i > C \Rightarrow$ Refraction stops
⇓ (TIR)
Total Internal Reflection occurs



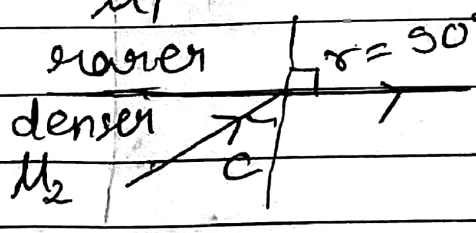
$\angle i = \angle r$
(without any mirror)

Conditions for TIR:

i) Rays should travel from denser to rarer medium
ii) $i° > C$

$i < C$ Refraction $i = C$ grazing emergence $i > C$ TIR

Calculation for C:



$\mu_2 \sin C = \mu_1 \sin 90°$
$\mu_2 \sin C = \mu_1$

$$\sin C = \frac{\mu_1}{\mu_2}$$ → Rarer / → Denser

$\mu_1 < \mu_2$

$\sin C = \frac{\mu_1}{\mu_2}$ → μ_1 → Rarer → Chota wala
μ_2 → Denser → Bada wala

$\frac{\mu_1}{\mu_2} < 1$ should be as $\sin\theta < 1$ always

if rarer medium μ_1 is air ($\mu_1 = 1$)

$$\boxed{\sin C = \frac{1}{\mu}}$$ → R.I of medium

Q) Find critical angle for glass-air interface
R.I of glass = 1.5

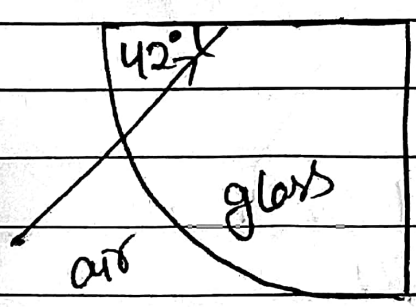
$$\sin C = \frac{1}{\mu} = \frac{1}{1.5} = \frac{2}{3}$$

$$C = \sin^{-1}\left(\frac{2}{3}\right) \approx 42^\circ$$

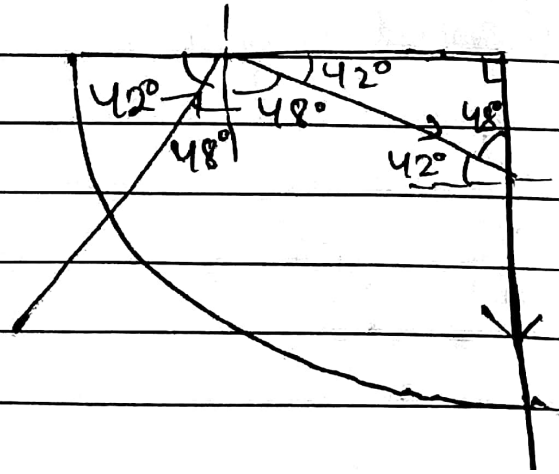
Remember: $i < c$ Refraction $i = c$ Grazing emergence $i > c$ TIR

Q) Complete the path of ray: $C = 42^\circ$ for glass

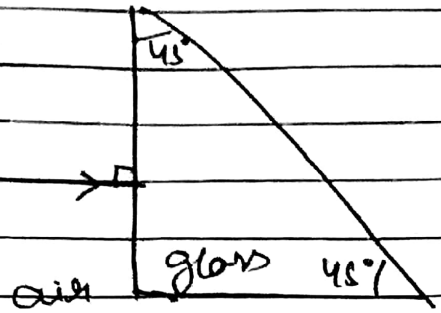
(1)



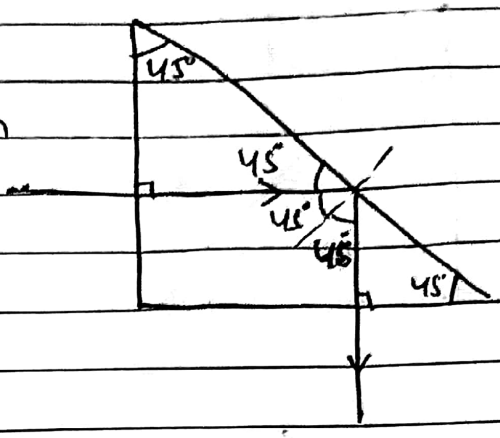
Solution:



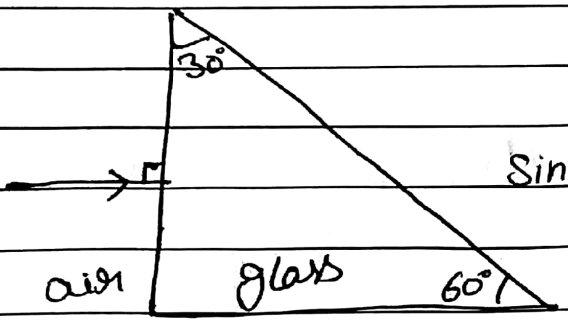
(2)



Solution



(3)

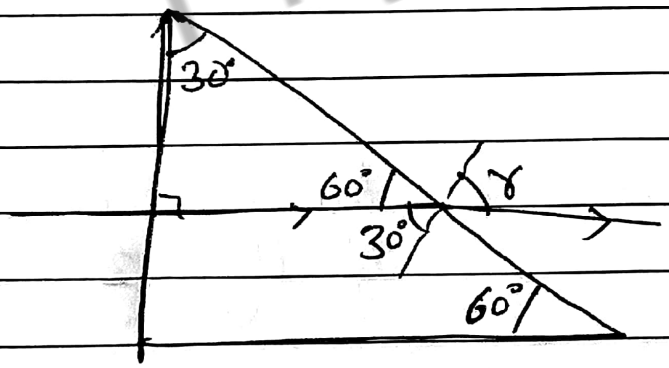


$\sin^{-1}\left(\frac{3}{4}\right) = 49°$

$\mu_g = \frac{3}{2}$

$C = 42°$

Solution



$\mu_g \sin 30° = \mu_a \sin\gamma$

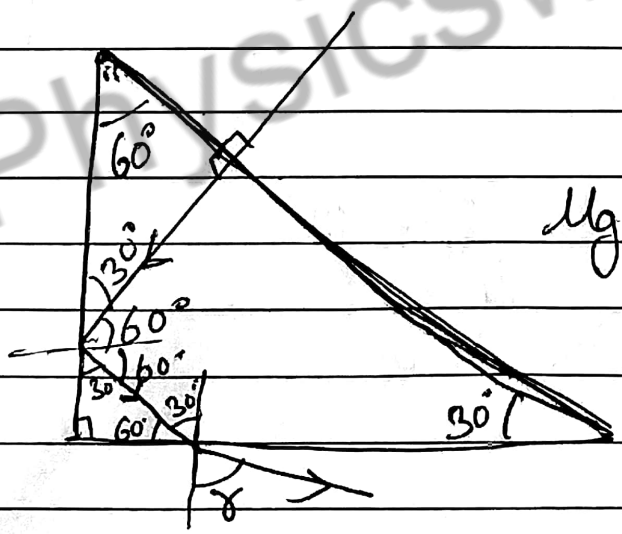
$\frac{3}{2} \times \frac{1}{2} = 1 \times \sin\gamma$

$\frac{3}{4} = \sin\gamma$

$\gamma = \sin^{-1}\left(\frac{3}{4}\right) = 49°$

(4)

Solution:



$\mu_g \sin 30° = \mu_a \sin\gamma$

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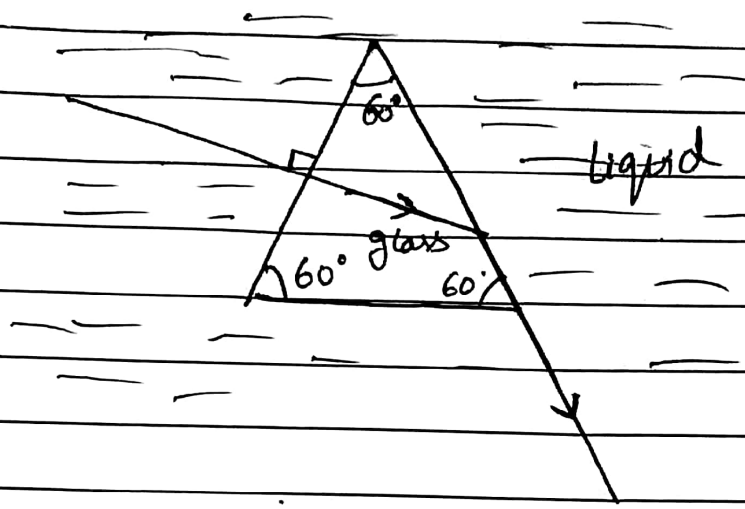
$\frac{3}{4} = \sin\gamma$

$\gamma = \sin^{-1}\left(\frac{3}{4}\right) \approx 49°$

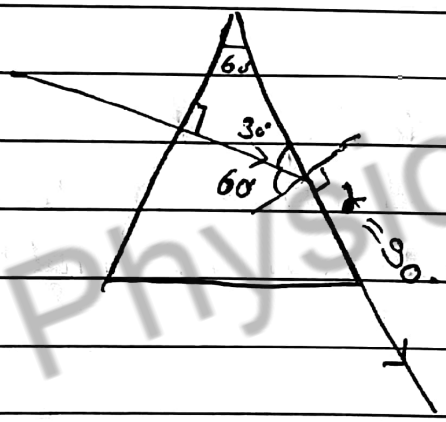
Q) Find the refractive index of liquid.

if $\mu_g = \sqrt{2}$

$\mu_l = ?$



Solution:



$\Rightarrow$ 60° is Critical angle

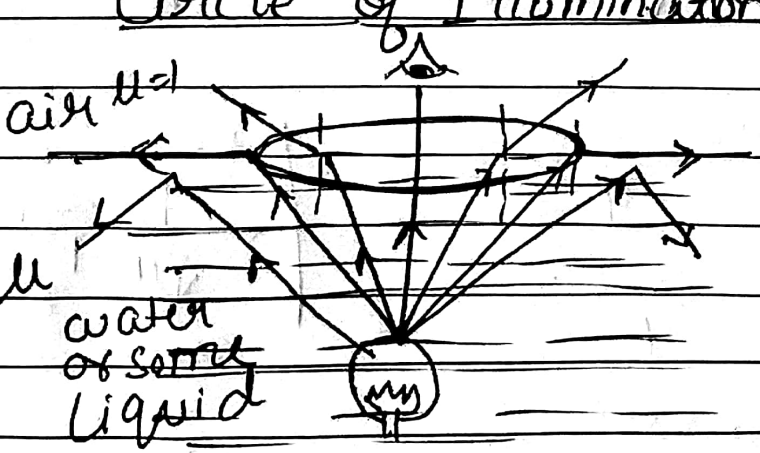
$\mu_g \sin C = \mu_l \sin 90°$

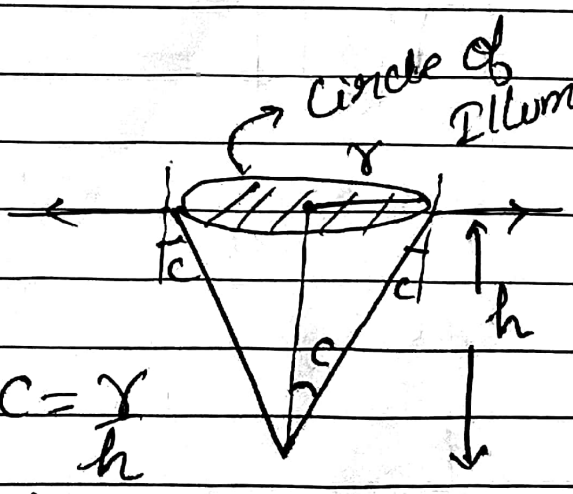
$\sqrt{2} \times \sin 60° = \mu_l \times 1$

$\sqrt{2} \times \frac{\sqrt{3}}{2} = \mu_l$

$\sqrt{\frac{3}{2}} = \mu_l$

Circle of Illumination:

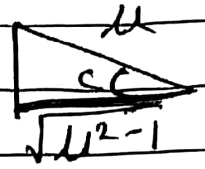




$\tan C = \frac{r}{h}$

$r = h \tan C$

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



$\Rightarrow \tan c = \frac{1}{\sqrt{\mu^2-1}}$

$r = h \tan c$

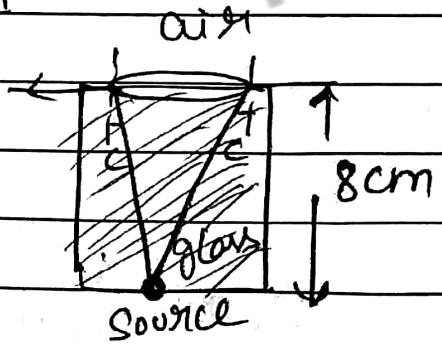
$r = h \times \frac{1}{\sqrt{\mu^2-1}}$

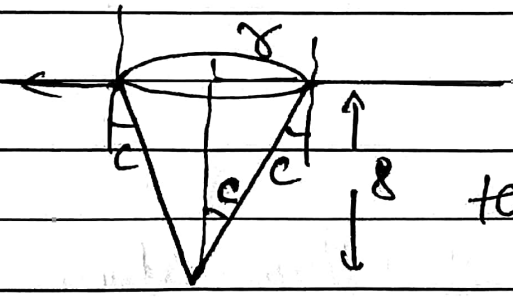
$$\boxed{r = \frac{h}{\sqrt{\mu^2-1}}}$$

Area of Circle Of Illumination $= \pi r^2 = \pi \left(\frac{h}{\sqrt{\mu^2-1}}\right)^2$

Q) A point source of light is kept below a glass slab of $\mu_g = \frac{5}{3}$. The thickness of slab is 8cm. Find the area through which light emerges out.

Solution

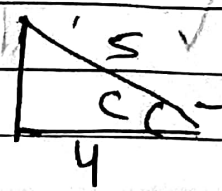




$\tan c = \frac{r}{8}$

$\sin c = \frac{1}{\mu_g}$

$\sin c = \frac{3}{5}$



$\tan c = \frac{3}{4}$

$\frac{r}{8} = \frac{3}{4}$

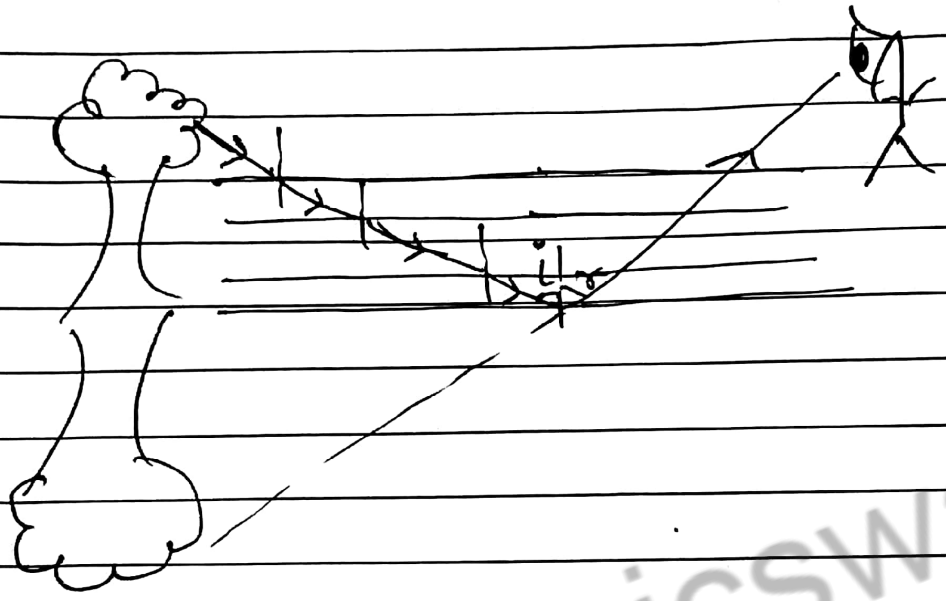
$r = 6\text{cm}$

$r = \frac{h}{\sqrt{\mu^2-1}} = \frac{8}{\sqrt{\left(\frac{5}{3}\right)^2-1}} = 6$

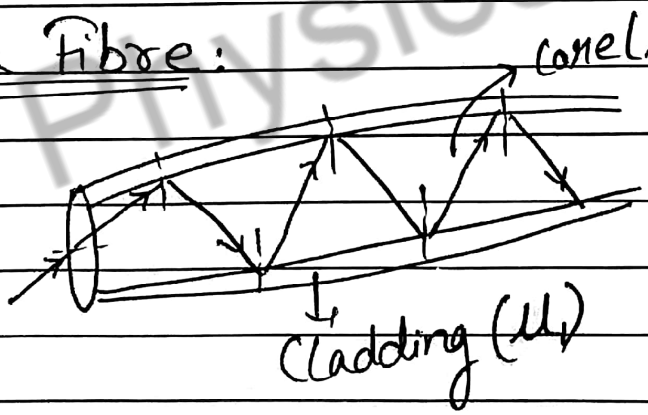
Area $= \pi(6)^2$

$A = 36\pi \text{cm}^2$

Mirage: On a hot summer noon in deserts, the layers of air near earth's surface are warmer & rarer as compared to layers above.



Optical Fibre:



Core (μ_2) > Cladding (μ_1)

Uses → i) transmission of audio & video signals
ii) transmission of electric signals