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A

DISPLACEMENT METHOD

⇒ To find the focal length of a convex lens

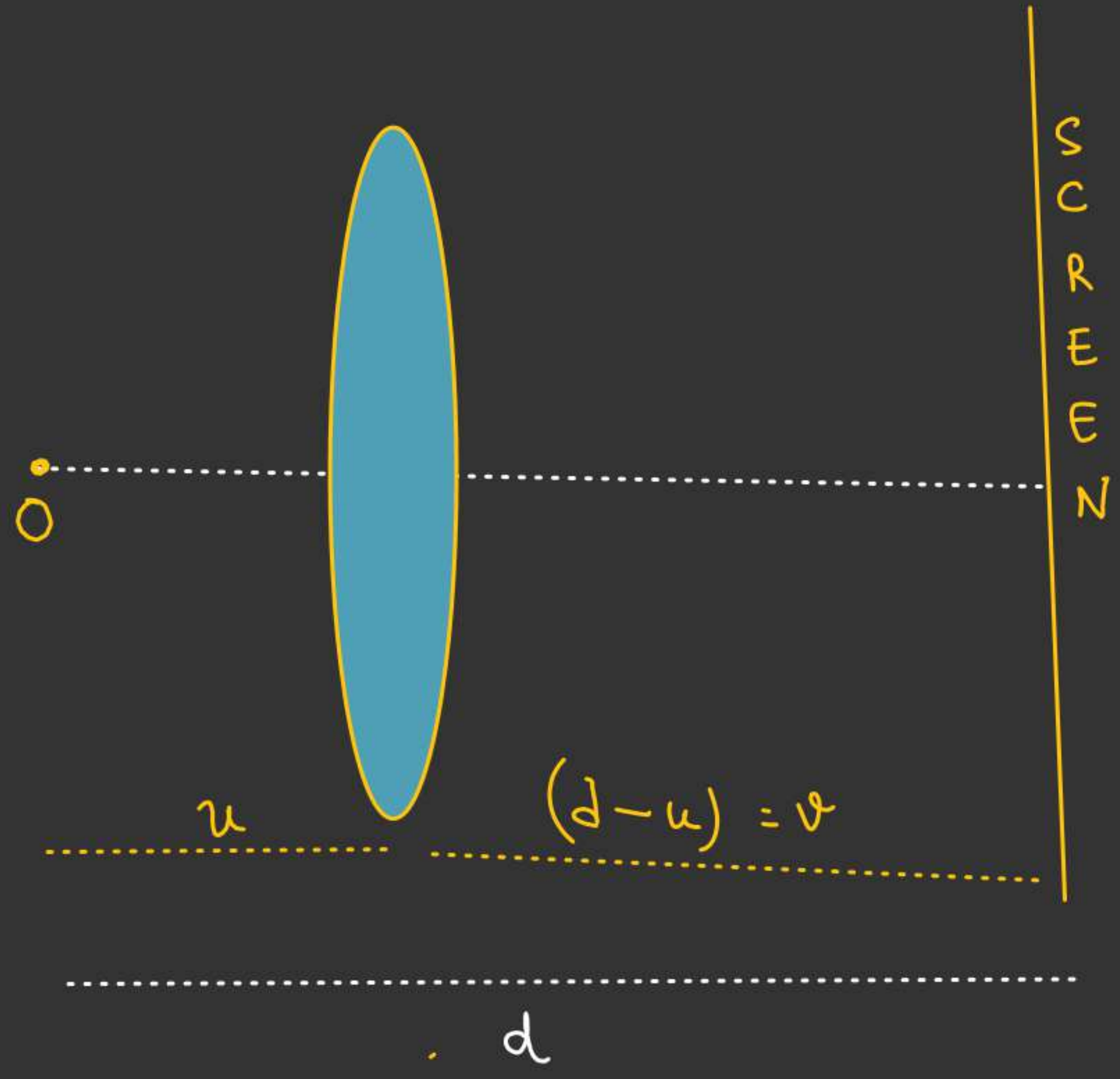
object and screen is fixed.

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

$$\frac{1}{(d-u)} - \frac{1}{(-u)} = \frac{1}{f}$$

$$\frac{1}{d-u} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{u+(d-u)}{(d-u)\,u} = \frac{1}{f}$$



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$$\frac{d}{u(d-u)} = \frac{1}{f}$$

$$df = du - u^2$$

$$\boxed{u^2 - du + df = 0}$$

Case-1 $\quad D < 0$

No real u exist so that we can get real image on the screen.

$$d^2 - 4df < 0$$

$$d < 4f$$

$$\left(f > \frac{d}{4}\right)$$

Case-2 $\quad D = 0$.

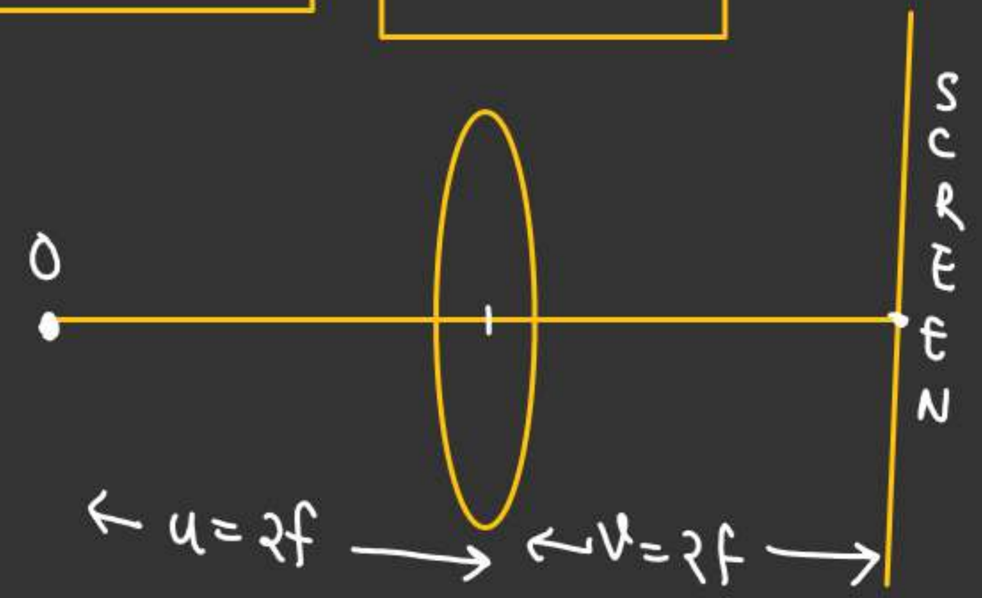
$$d^2 = 4df$$

$$\boxed{d = 4f} \Rightarrow$$ [Min. distance b/w object & screen for real image.]

↳ Only one position of lens for real image.

$$u = \frac{d \pm \sqrt{d^2 - 4df}}{2}$$

$$\boxed{u = \frac{d}{2}} \qquad \boxed{u = 2f}$$



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Case-3 $D > 0 \Rightarrow d^2 > 4df$.

$\boxed{d > 4f}$

$u^2 - du + df = 0$

$$u = \frac{d \pm \sqrt{d^2 - 4df}}{2}$$

$$u = \frac{d \pm \sqrt{d(d-4f)}}{2}$$

$$u_1 = \frac{d + \sqrt{d(d-4f)}}{2}$$

$$v_1 = (d - u_1)$$

$$v_1 = d - \frac{d}{2} - \frac{1}{2}\sqrt{d(d-4f)}$$

$$= \frac{d - \sqrt{d(d-4f)}}{2} = u_2$$

$$u_2 = \frac{d - \sqrt{d(d-4f)}}{2}$$

$$v_2 = \frac{d + \sqrt{d(d-4f)}}{2} = u_1$$

Magnification

$$m_1 = \frac{h_{I_1}}{h_o} = \left(\frac{v_1}{u_1}\right)$$

$$m_2 = \frac{h_{I_2}}{h_o} = \left(\frac{v_2}{u_2}\right) \qquad \left[\begin{array}{l} v_1 = u_2 \\ v_2 = u_1 \end{array}\right.$$

$$(m_1 \times m_2) = \frac{h_{I_1} \times h_{I_2}}{(h_o)^2} = \left(\frac{v_1}{u_1} \times \frac{v_2}{u_2}\right)$$

$$\frac{h_{I_1} \times h_{I_2}}{(h_o)^2} = 1$$

$$\boxed{h_o = \sqrt{h_{I_1} \times h_{I_2}}}$$

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$m = 2$. (given)

Find $[u, v, f \& d]$

$$\begin{bmatrix} v' = u \\ u' = v \end{bmatrix}$$

$u + d + v' = D$

$u + d + u = D$

$2u = D - d$

$u = \left(\frac{D-d}{2}\right)$ ✓

$v = D - u = D - \left(\frac{D-d}{2}\right) = \left(\frac{D+d}{2}\right)$ ✓

$|m| = 2 = \frac{|v|}{|u|}$ ✓

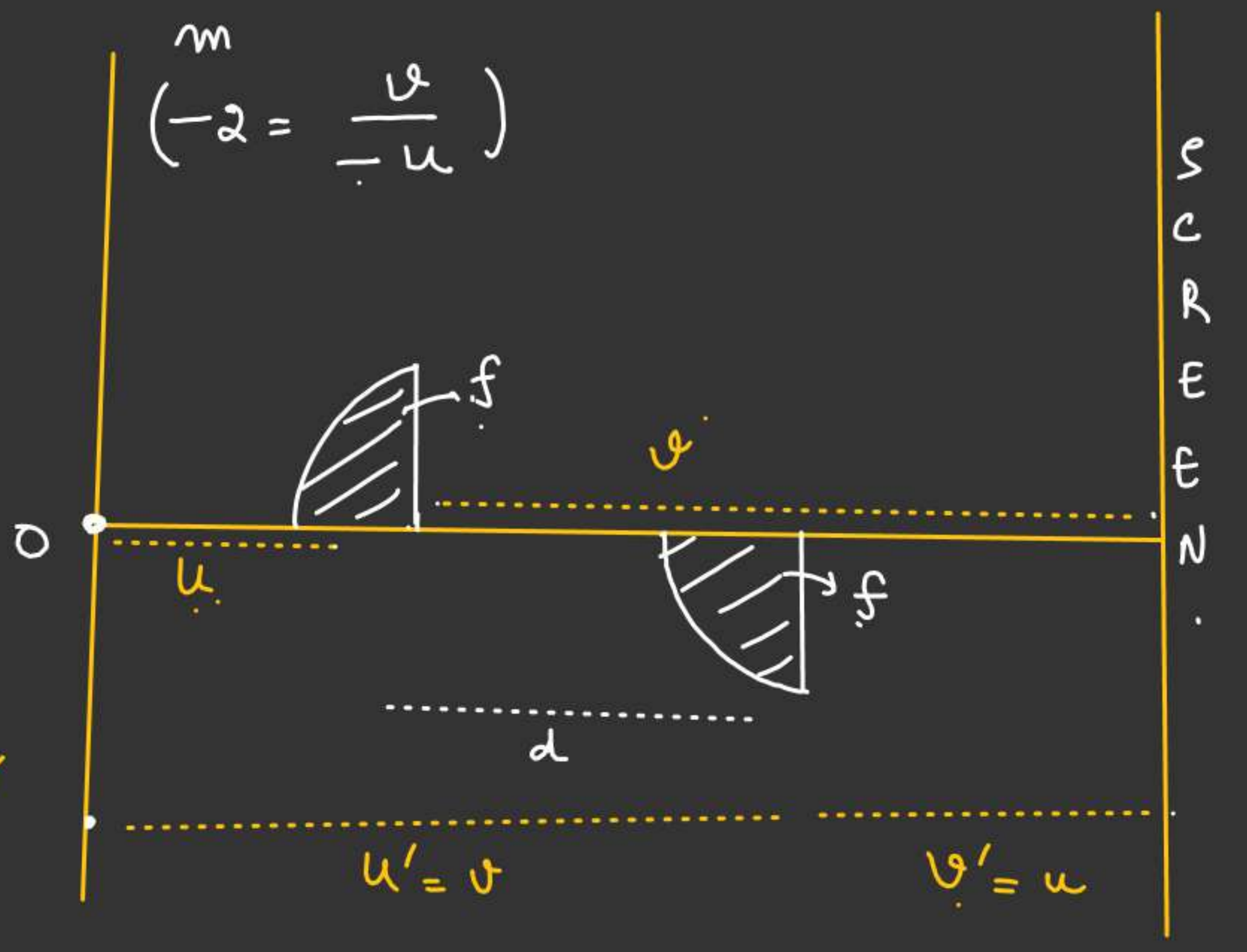
$$\frac{D+d}{D-d} = 2$$

$D + d = 2D - 2d$

$\Rightarrow 3d = D$

$\Rightarrow d = \frac{D}{3} = \frac{1.8}{3} = 0.6m$

$$\begin{bmatrix} u = \frac{1.8 - 0.6}{2} = 0.6m \\ v = \frac{1.8 + 0.6}{2} = \frac{2.4}{2} = 1.2m \end{bmatrix}$$



$D = 1.8m$.

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

$f = \frac{uv}{u-v} = \frac{-0.6 \times 1.2}{-0.6 - 1.2} = \frac{+0.72}{1.8}$

$f = 0.4$

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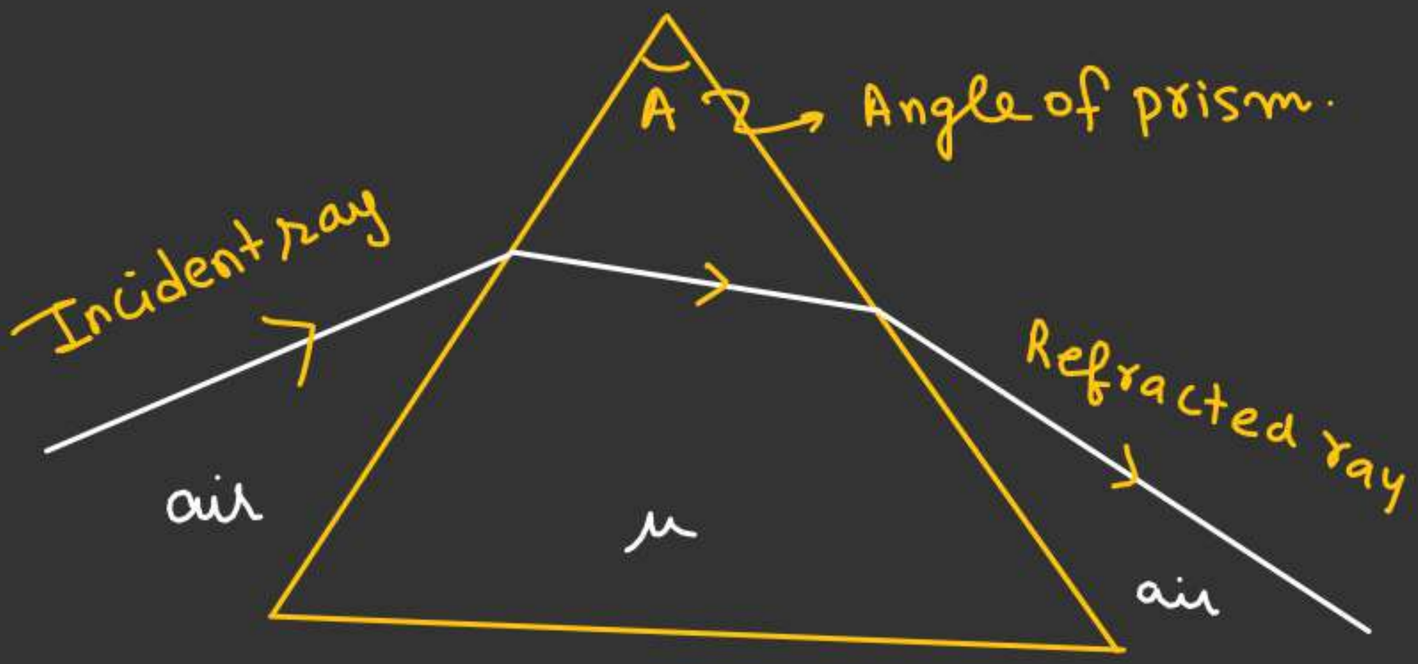
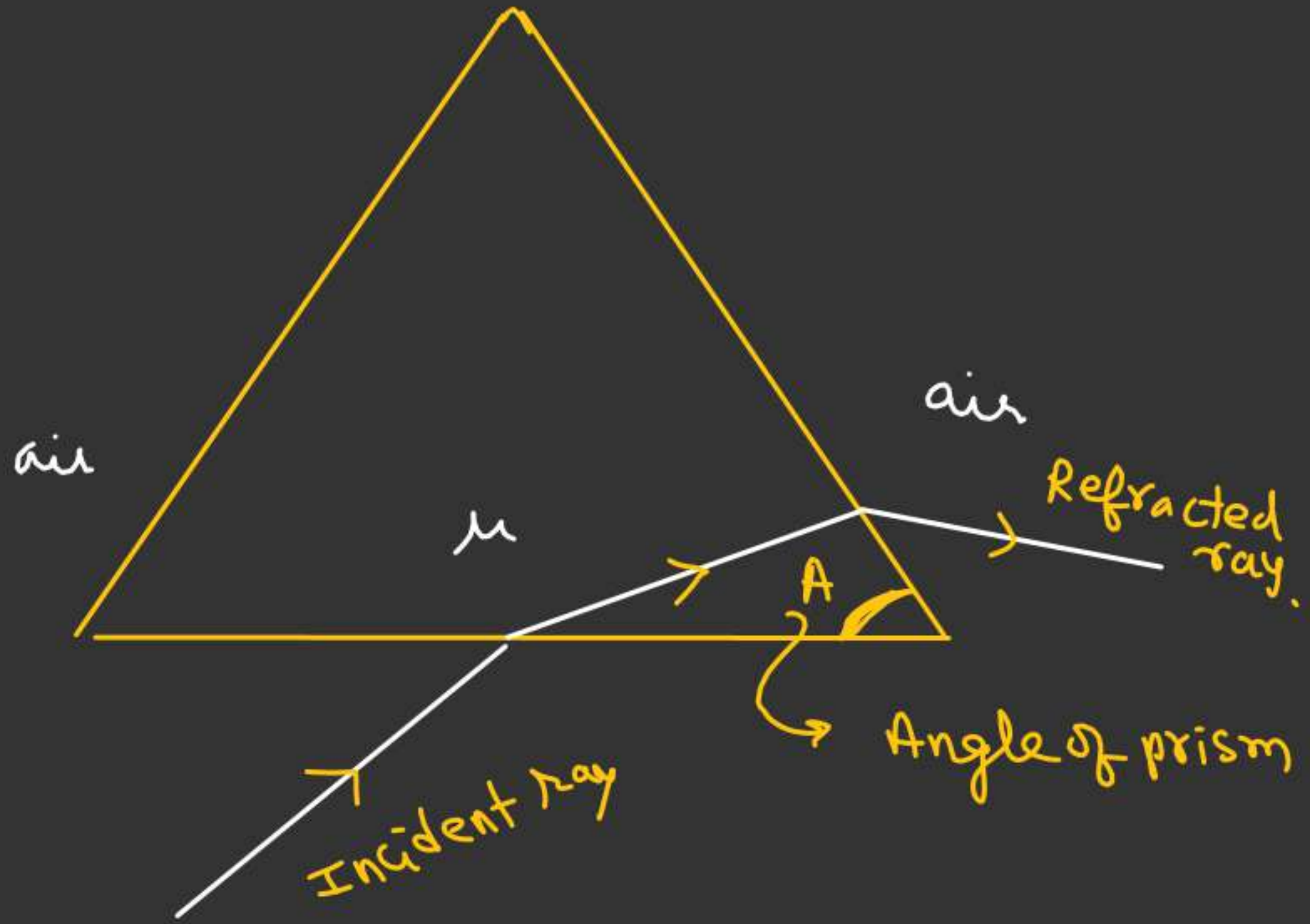
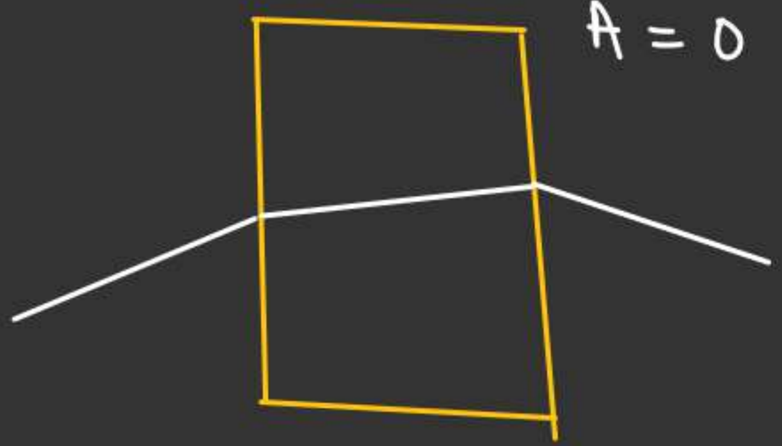
PRISM

Angle of prism







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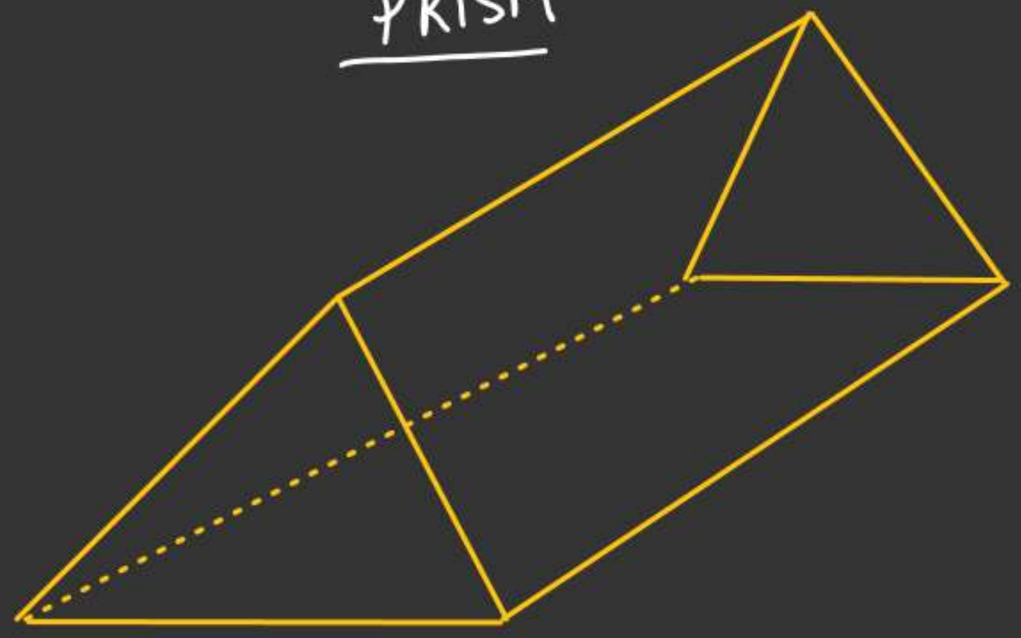
PRISM



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PRISM

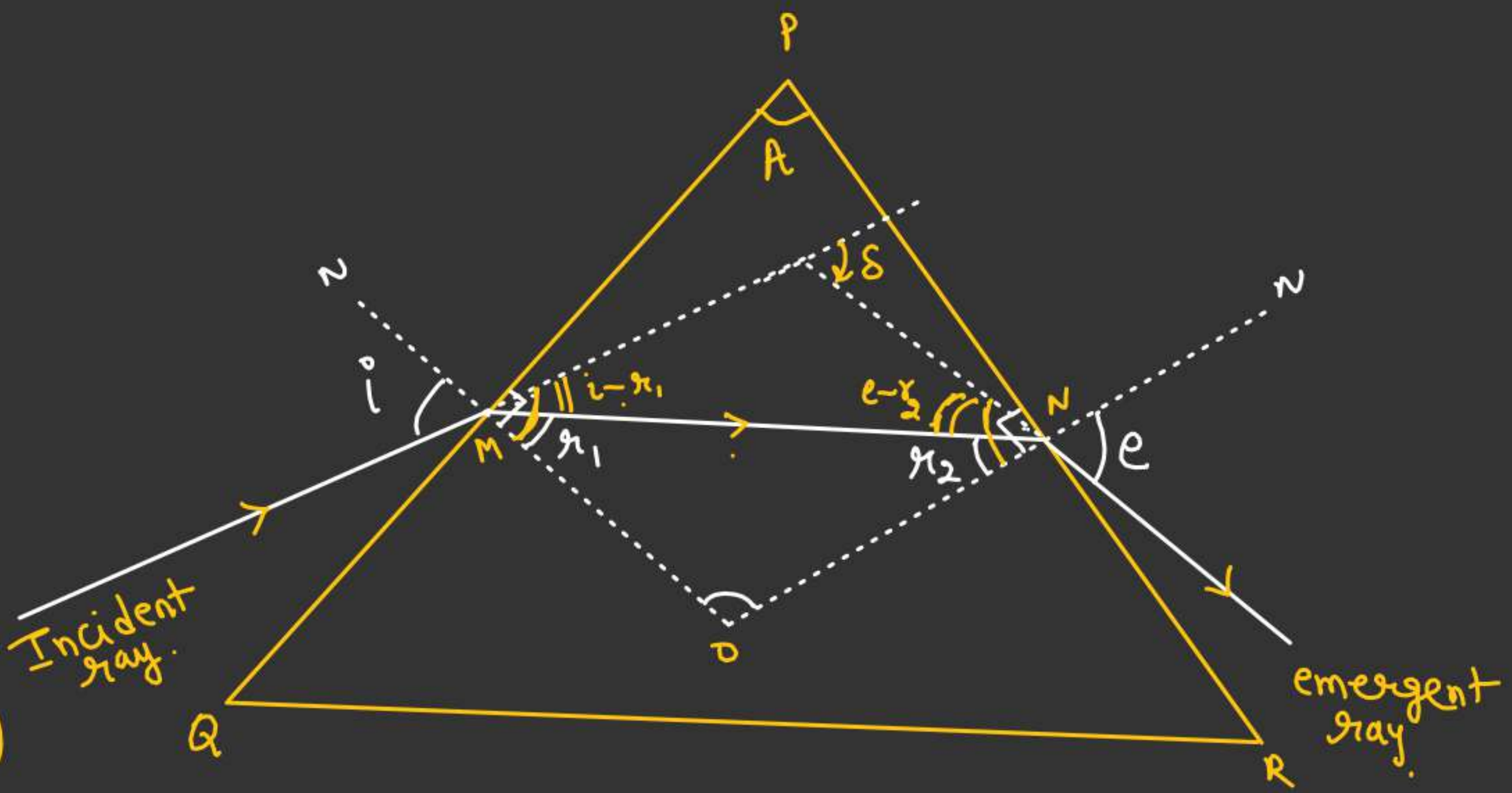
In ΔMON

$\angle MON = 180^\circ - (r_1 + r_2)$ — ①

In ▱ PMON

$\angle A + \angle MON = 180^\circ$ - ②

$$\boxed{A = (r_1 + r_2)}$$ ★★



$\delta = (i - r_1) + (e - r_2)$

$\delta = (i + e) - (r_1 + r_2)$

$$\boxed{\delta = (i + e) - A}$$ ★★

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PRISM

$$\boxed{\delta = (i+e) - A}$$

For Small angle prism.

Snell's Law at PQ

$1 \cdot \sin i = \mu \cdot \sin r_1$

$\underline{i = \mu r_1}$

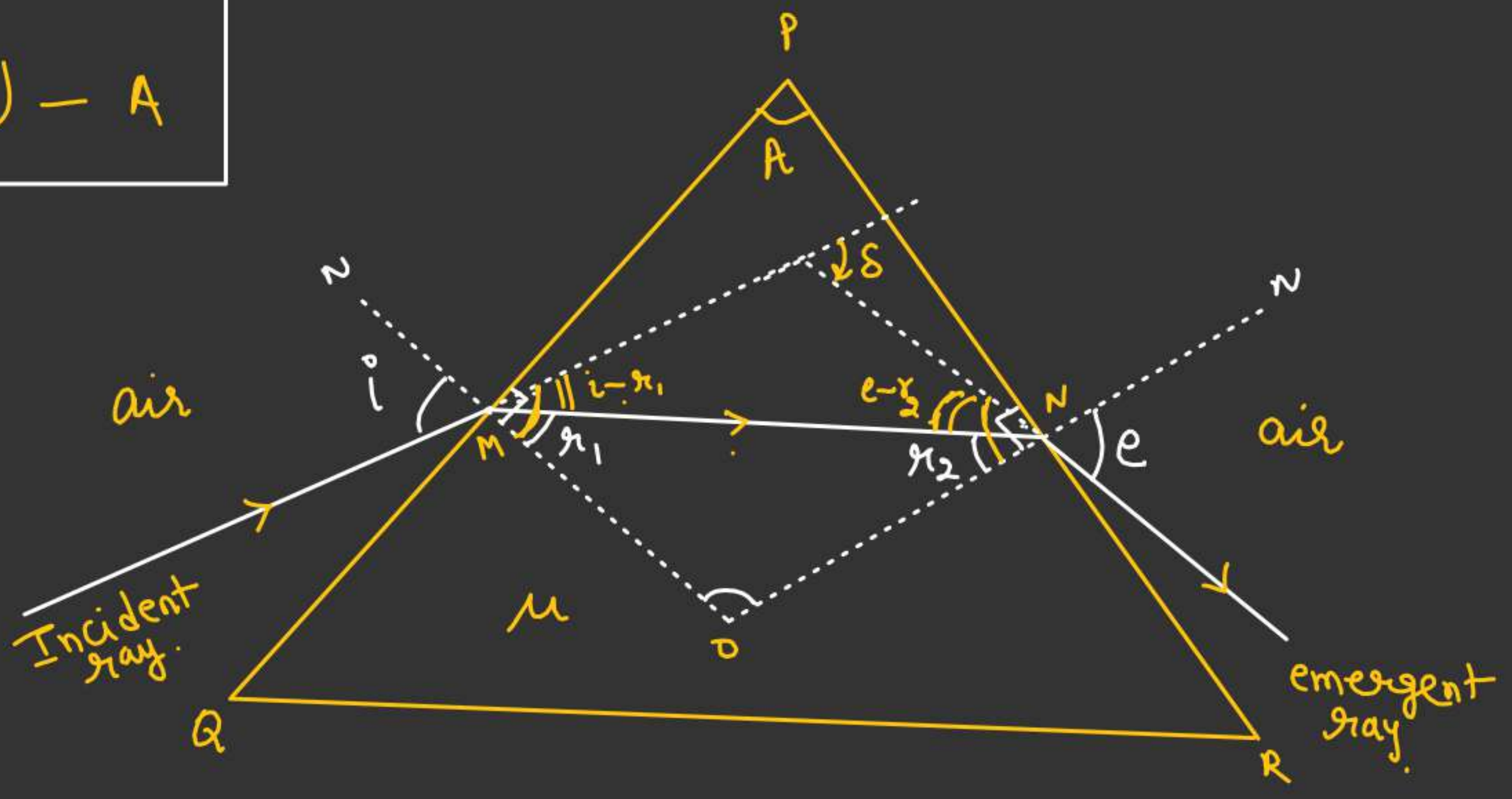
Snell's law at PR

$\mu \sin r_2 = (1) \sin e$

$\underline{\mu r_2 = e}$

$\delta = \mu(r_1 + r_2) - A$

$$\boxed{\delta = (\mu - 1)A}$$



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Condition for min. Angle of deviation

Condition : $i = e$

$r_1 = r_2$

$$\delta = (i + e - A)$$

$$A = (r_1 + r_2)$$

If $r_1 = r_2 = r$.

$r = (A/2)$

$i = e$.

$\delta_{min} = 2i - A$

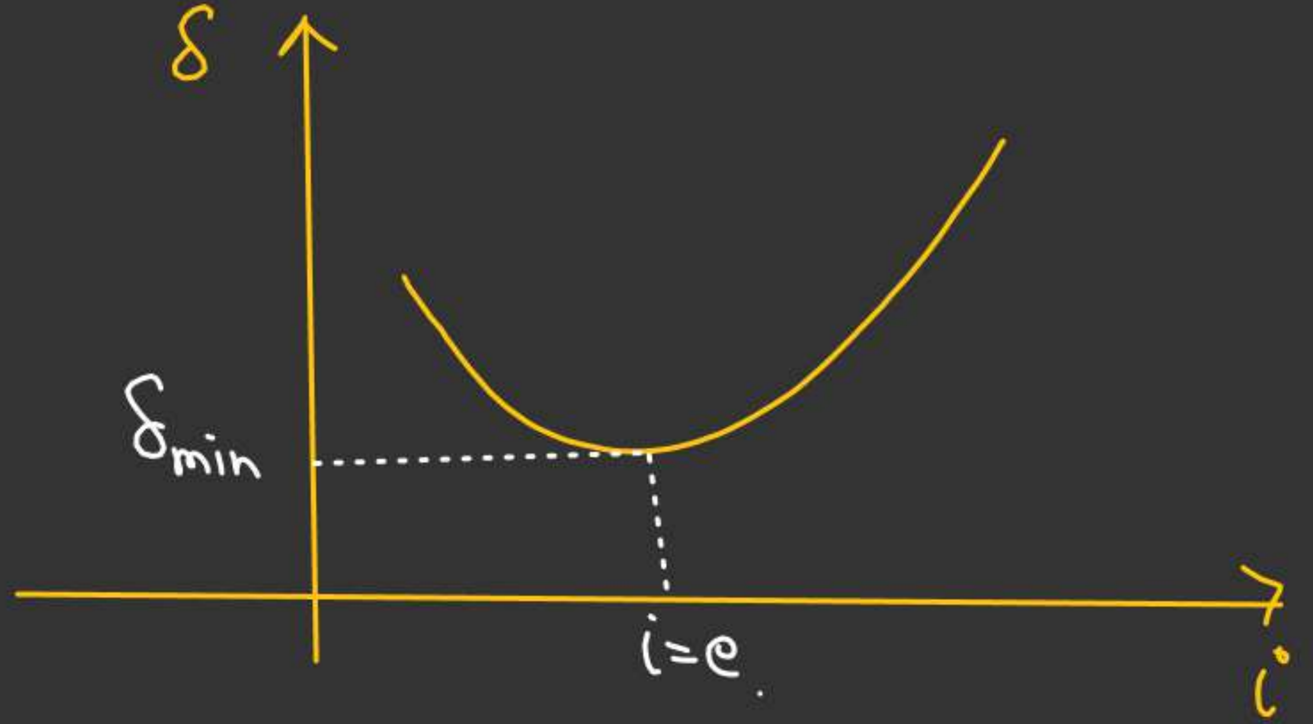
$i = \left(\frac{\delta_{min} + A}{2}\right)$

By Snell's law

$1 \cdot \sin i = \mu \cdot \sin r$

$$\sin\left(\frac{A + \delta_{min}}{2}\right) = \mu \sin(A/2)$$

$$\boxed{\mu = \frac{\sin\left(\frac{A + \delta_{min}}{2}\right)}{\sin(A/2)}}$$



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Case of Normal Incidence

For light ray to come out

$A = r_1 + r_2$

$r_2 < \theta_c$

$r_2 = A$

$$\boxed{A < \theta_c}$$

$\sin A < \sin\theta_c$

$\sin A < \frac{1}{\mu}$

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

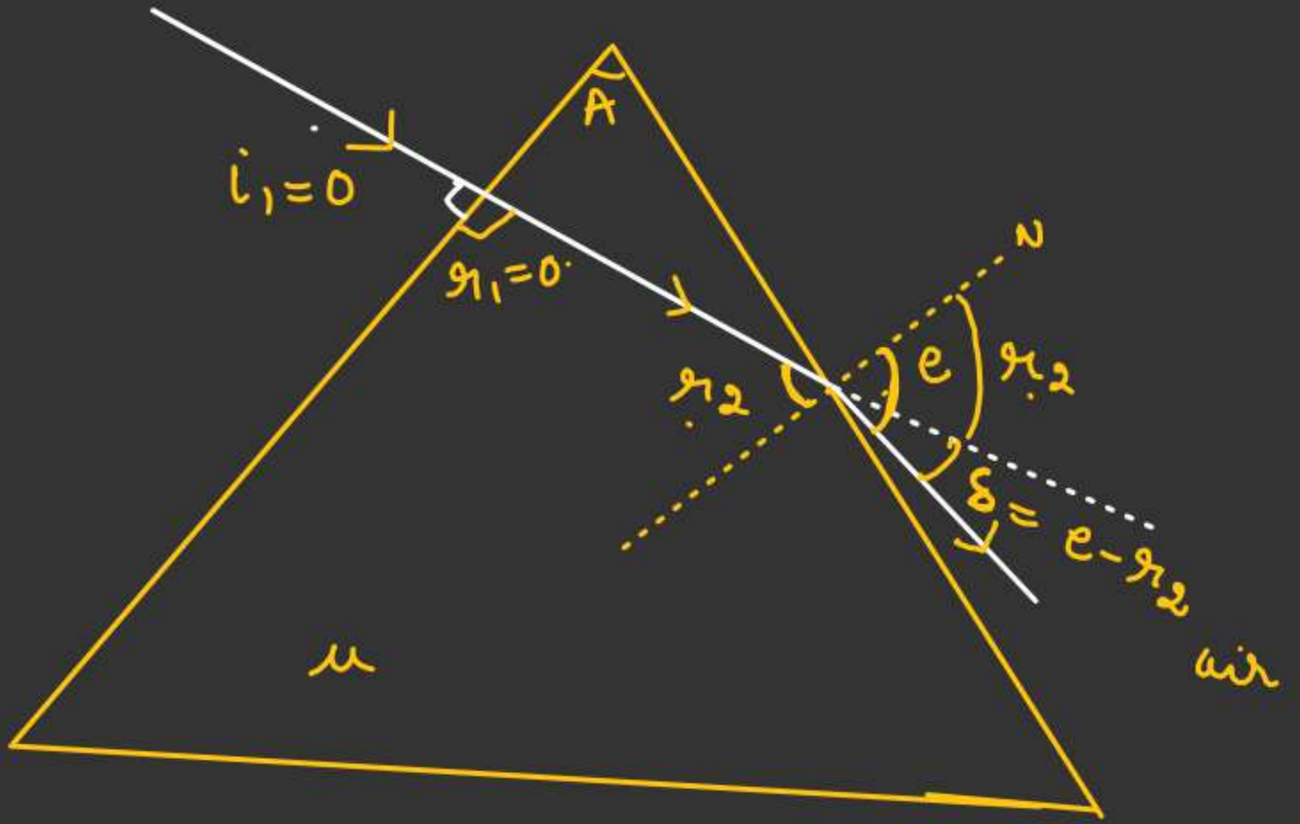
$\mu < \operatorname{cosec} A$

$\delta = e - r_2$

By Snell's law

$\mu \cdot \sin r_2 = 1 \cdot \sin e$ air

$e = \sin^{-1}[(\mu \sin r_2)]$



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Case of grazing incidence

(Path of reversibility)

$r_1 = \theta_c$

$$\delta = (90 - r_1) + (e - r_2)$$

$$\delta = 90 + e - (r_1 + r_2)$$

$$\boxed{\delta = 90 + e - A}$$

$e = ??$

By Snell's law

$\mu \sin r_2 = 1 \cdot \sin e$

$r_2 = A - r_1$

$r_2 = (A - \theta_c)$

$$\mu \sin(A - \theta_c) = \sin e$$

$$e = \sin^{-1}\left[\mu \sin(A - \theta_c)\right] \checkmark$$