

PRAYAS

JEE 2025



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Lecture-13

Physics

Ray optics



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Topics *to be covered*

1 Prism

2

3

4

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Prism

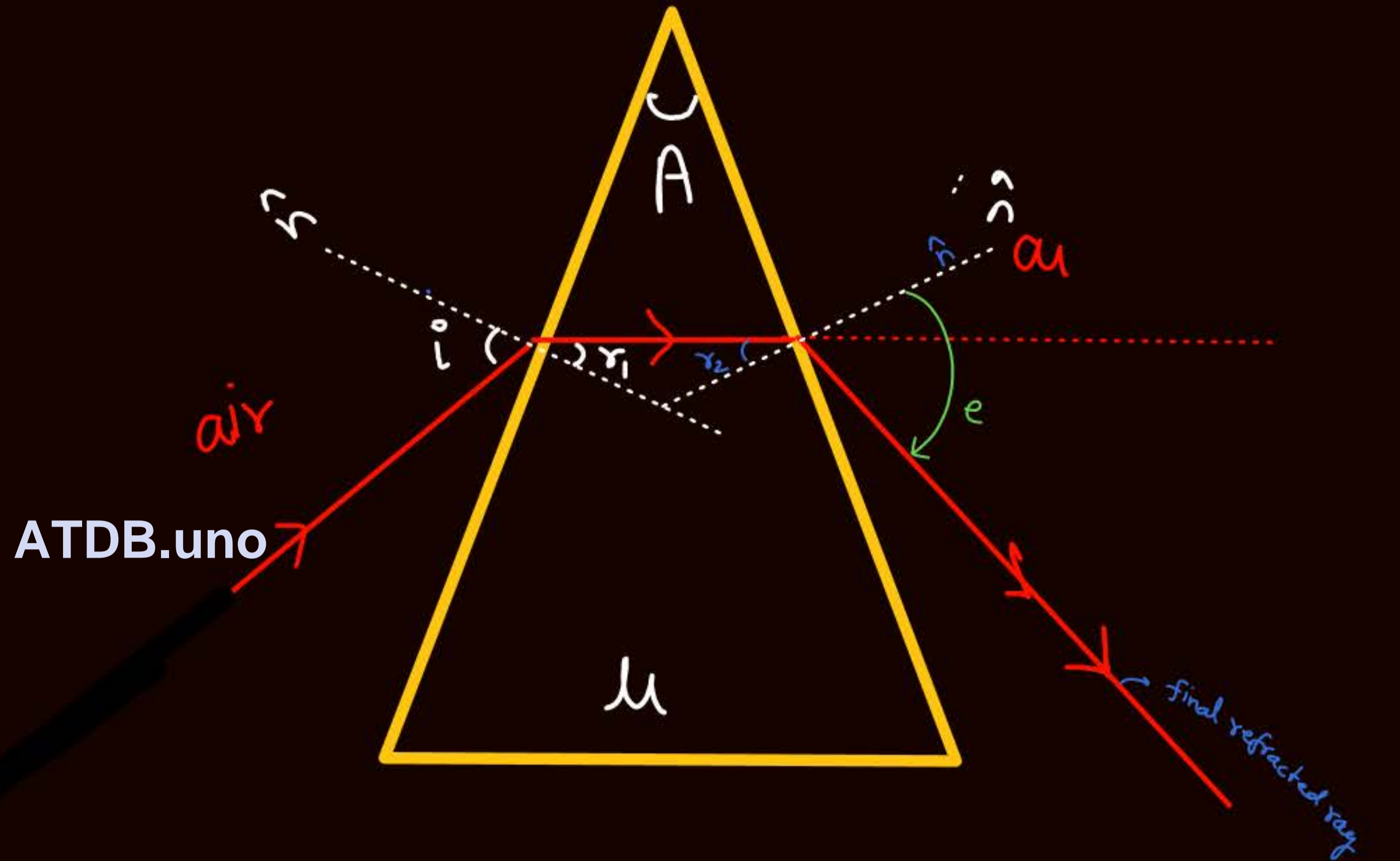
Angle of prism = A

① $1 \cdot \sin i = \mu \sin r_1$

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

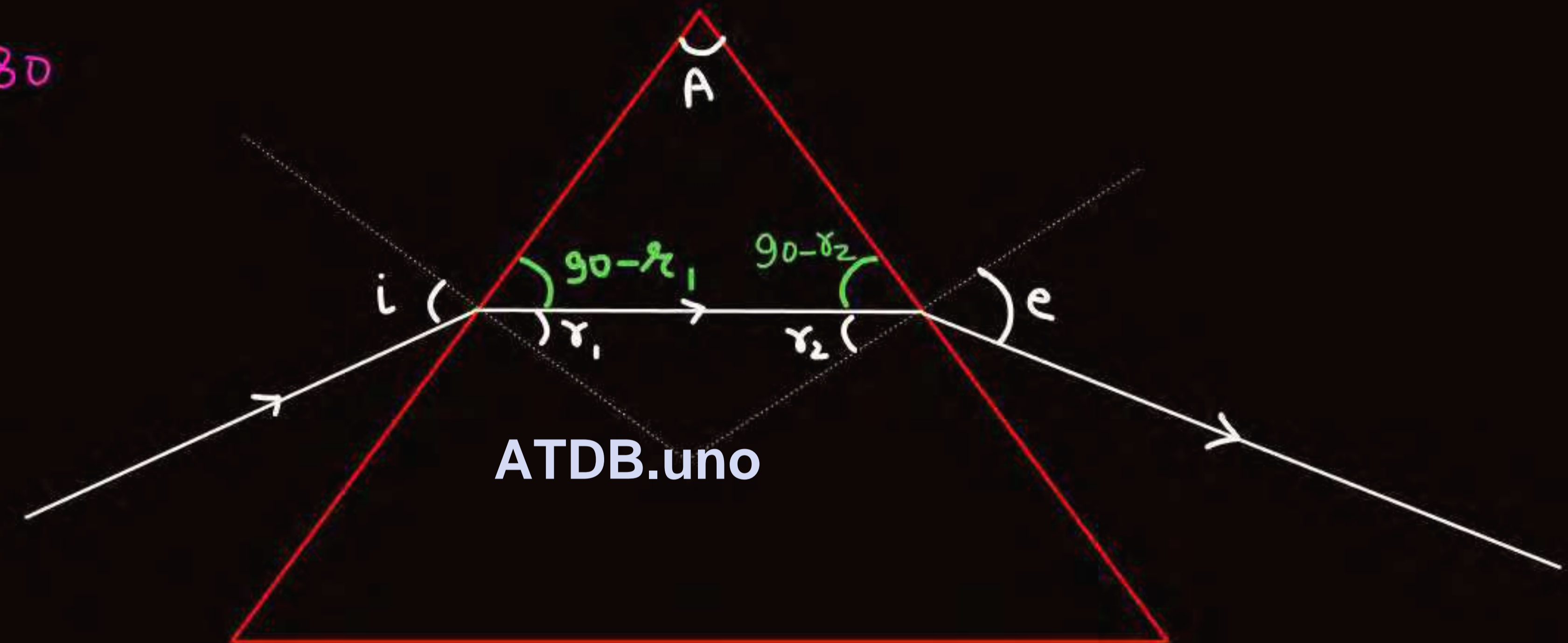
② $r_1 + r_2 = A$

③ $\delta_{\text{net}} = i + e - A$



$$A + 90 - r_1 + 90 - r_2 = 180$$

$$A = r_1 + r_2$$

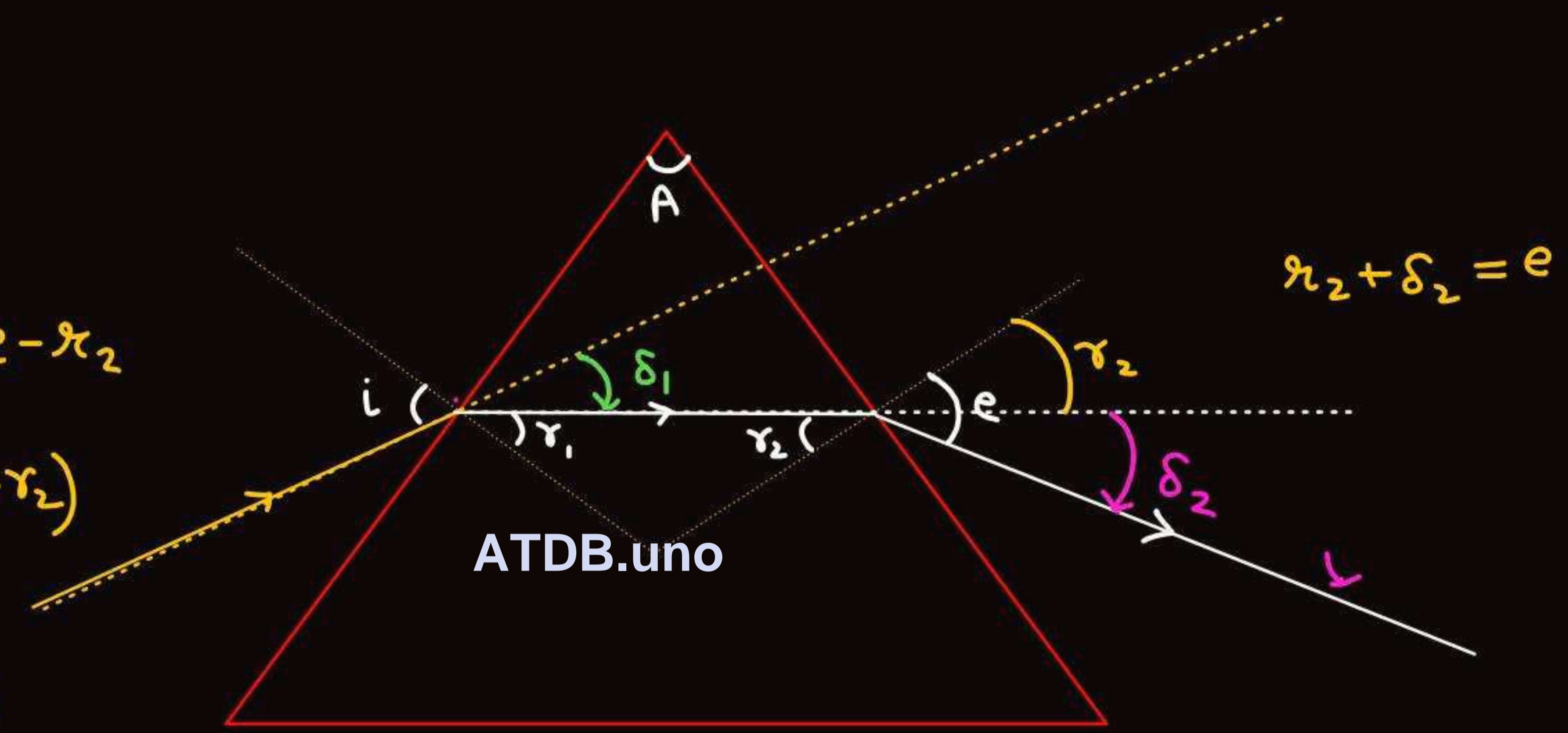


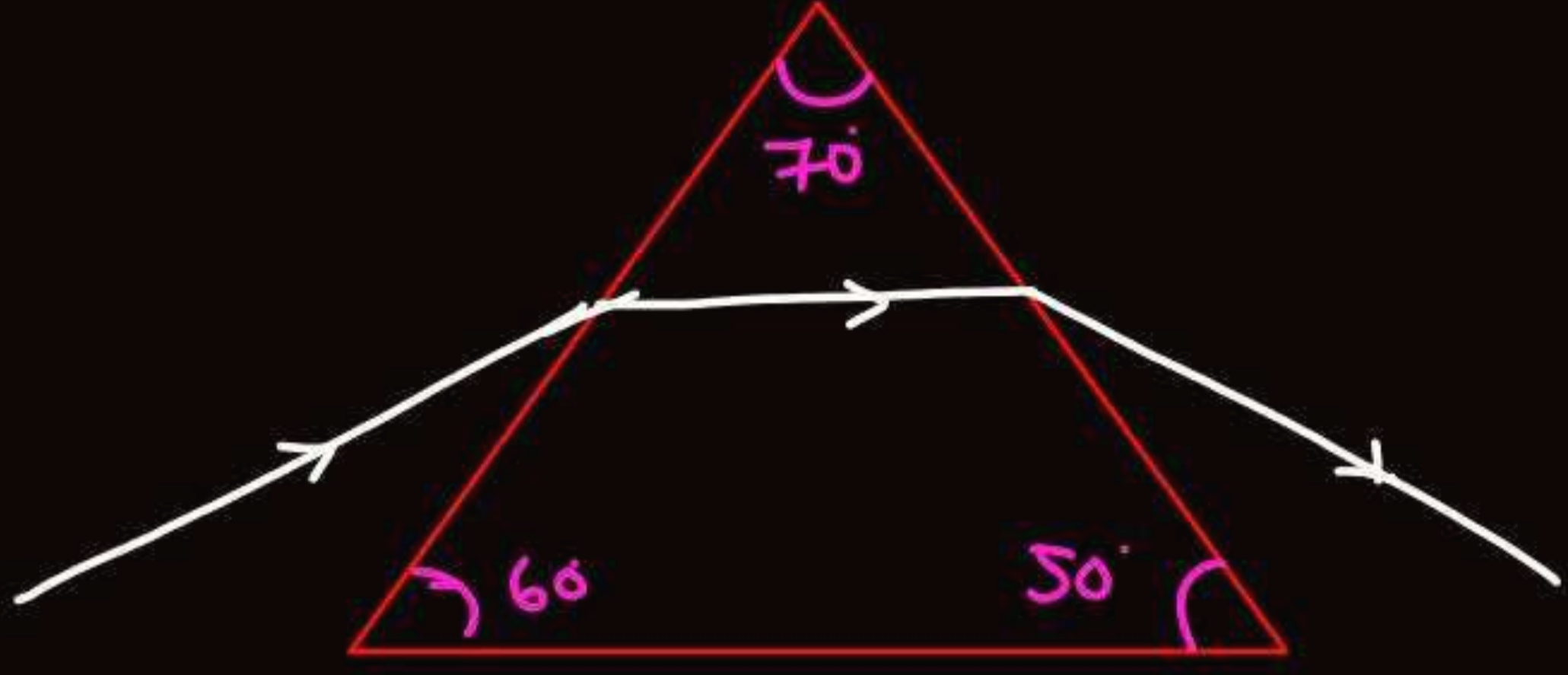
$$\delta_{net} = \delta_1 + \delta_2$$

$$\delta_{net} = i - r_1 + e - r_2$$

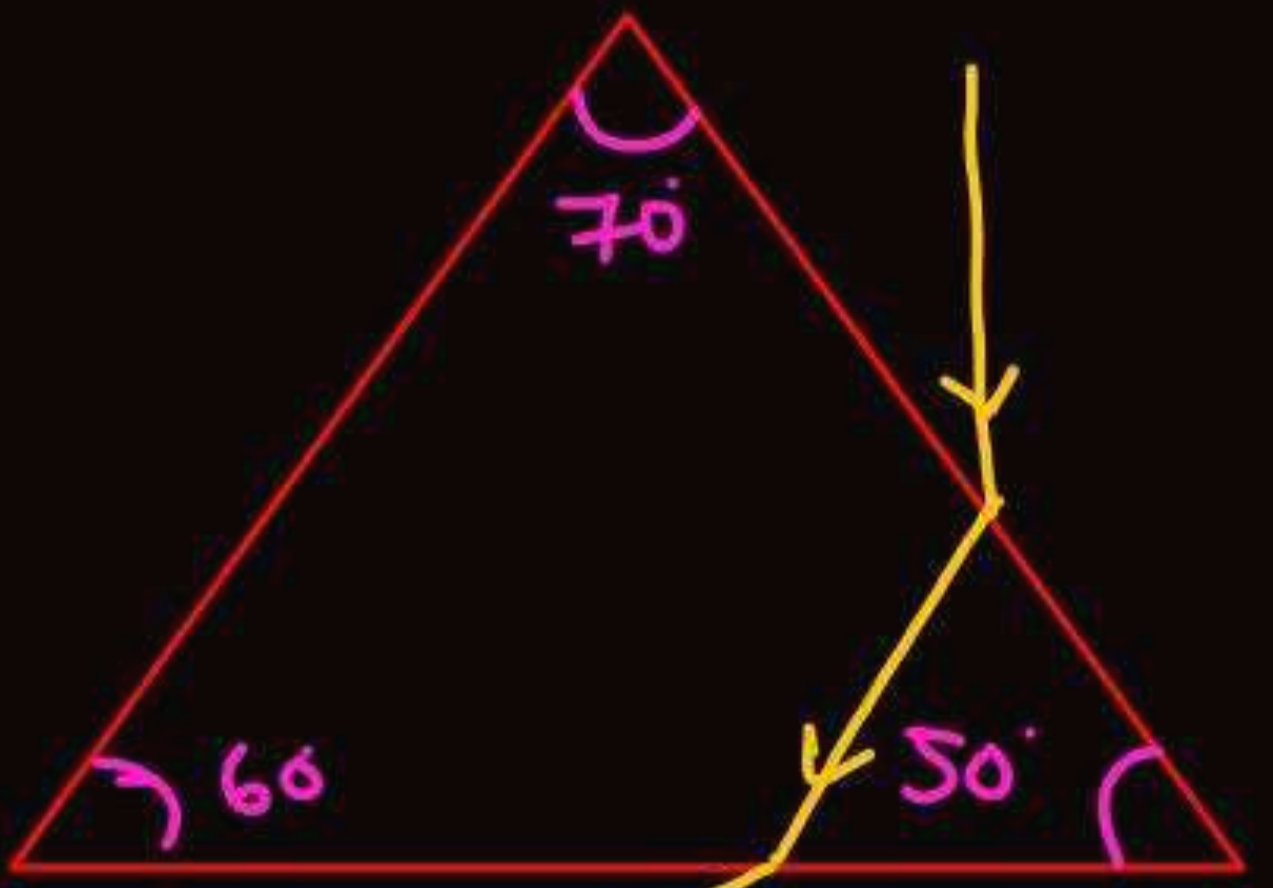
$$\delta_{net} = i + e - (r_1 + r_2)$$

$$\delta_{net} = i + e - A$$

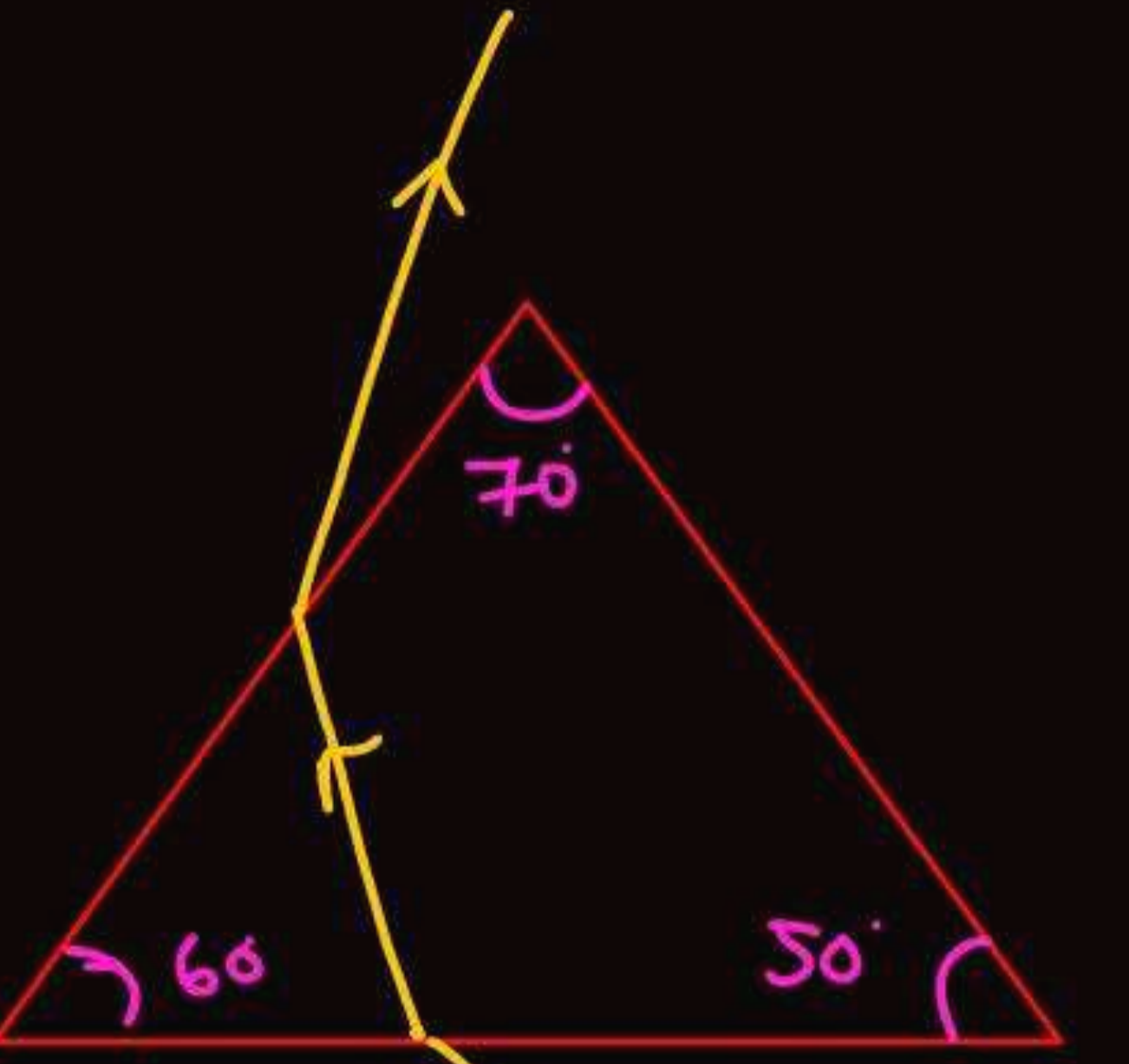




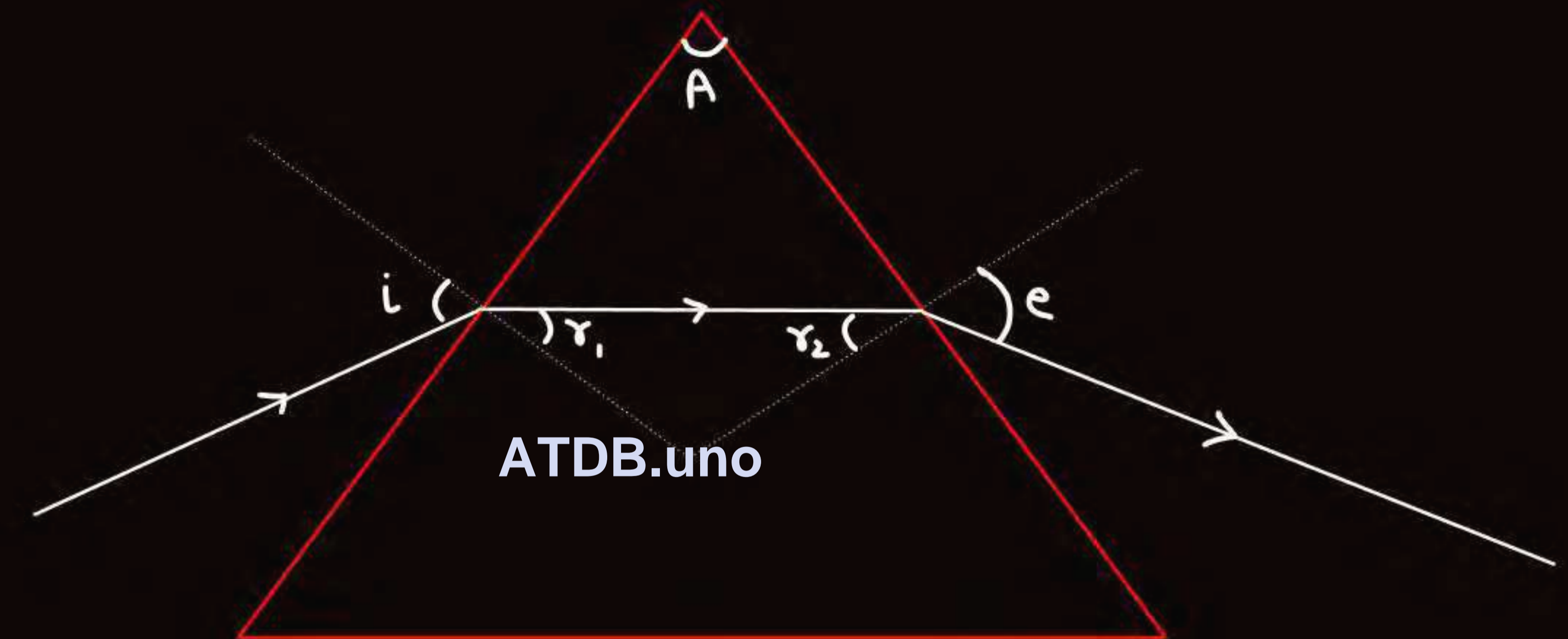
Angle of prism = 70°
 (Refracting angle)



Angle of prism = 50°



Angle of prism = 60°



Q find $\delta_{net} = ?$

Solⁿ $\delta_{net} = i + e - A$

$i = 60^\circ$
 $A = 60^\circ$

* $1 \cdot \sin 60 = \sqrt{3} \sin r_1$

$r_1 = 30^\circ$

* $r_1 + r_2 = A$
 $30 + r_2 = 60$

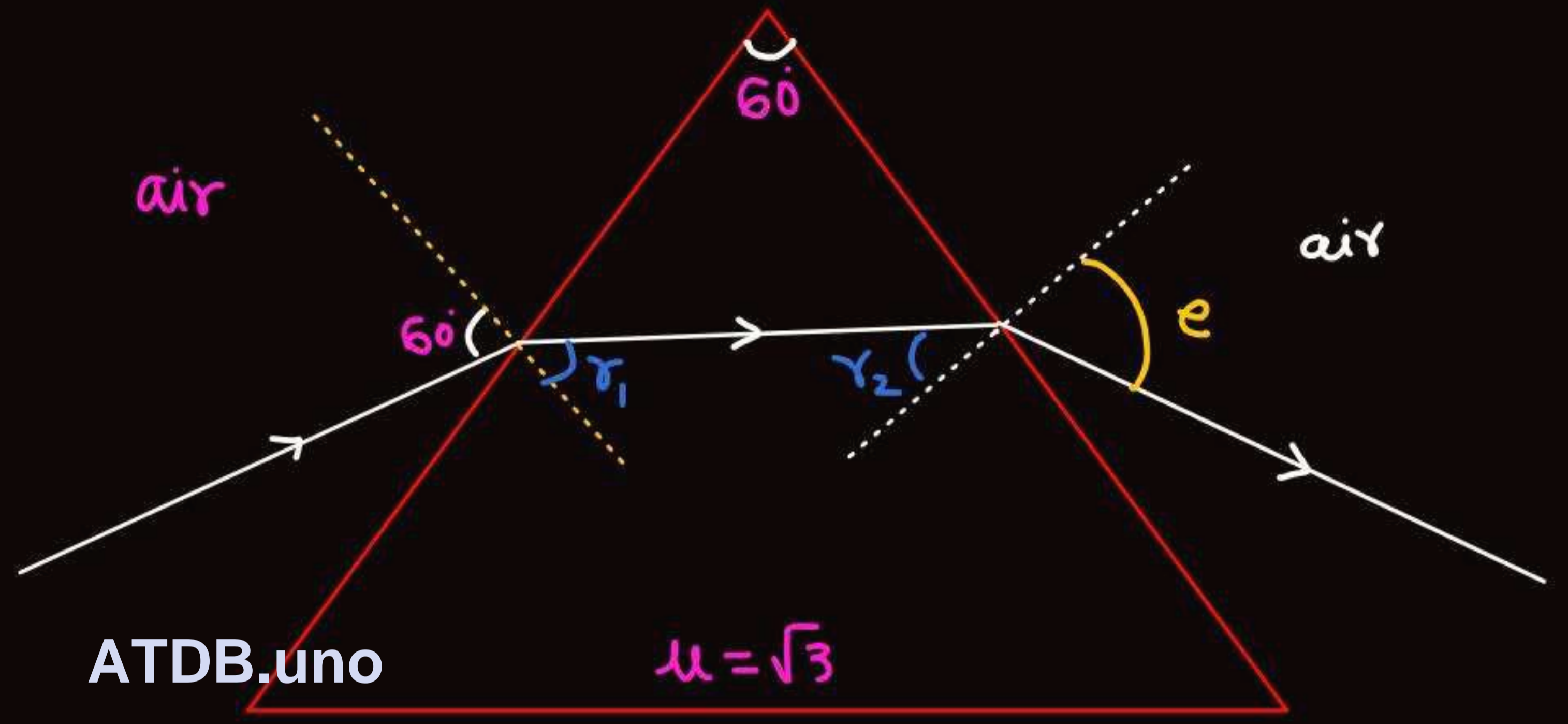
$r_2 = 30^\circ$

* $\mu \sin r_2 = 1 \cdot \sin e$
 $\sqrt{3} \sin 30 = 1 \times \sin e$

$e = 60^\circ$

$\delta_{net} = i + e - A$
 $= 60 + 60 - 60$

$\delta_{net} = 60$



Q find $\delta_{net} = ?$

$$\delta = i + e - A = 60 + e - 60$$

$$\textcircled{1} \quad 1 \times \sin 60 = \sqrt{3} \sin r_1$$

$$r_1 = 30^\circ$$

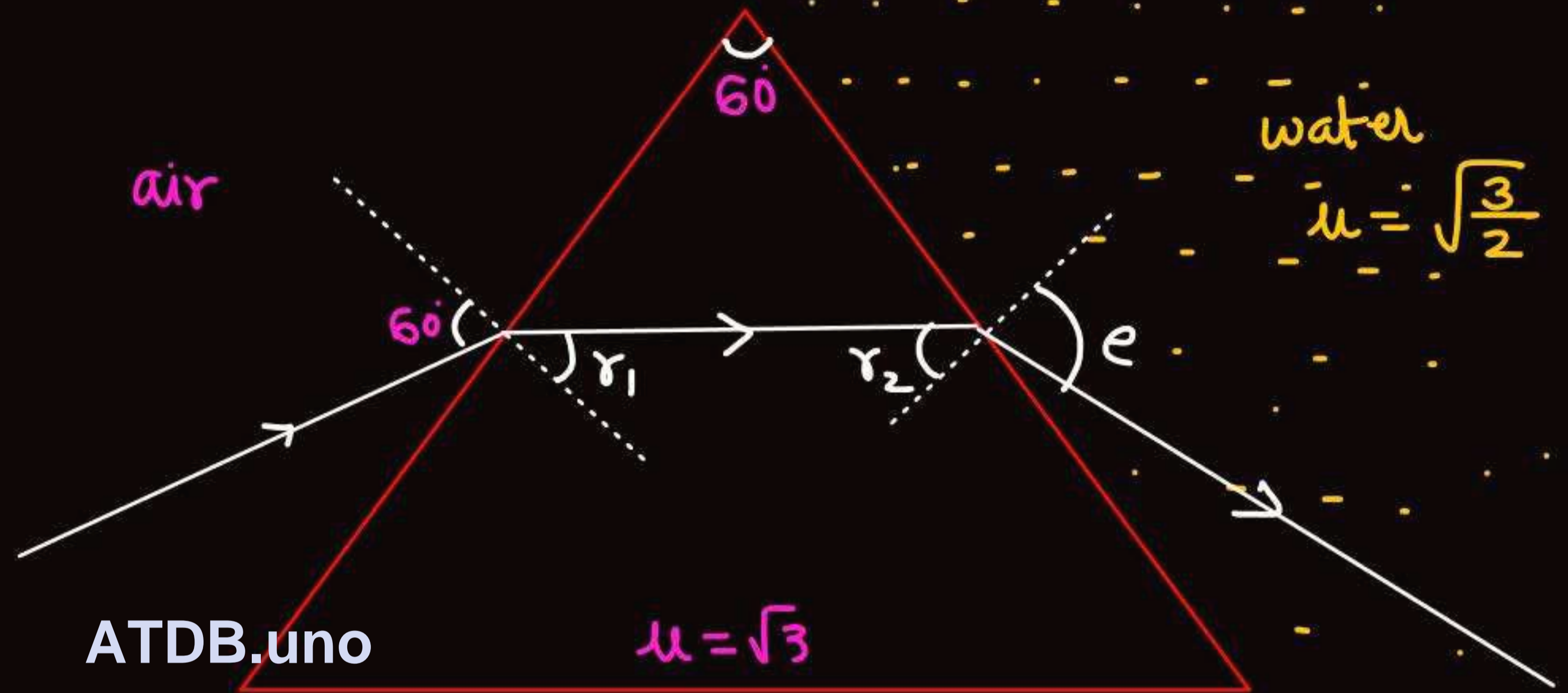
$$\textcircled{2} \quad r_1 + r_2 = A \Rightarrow r_2 = 30^\circ$$

$$30 + r_2 = 60$$

$$\textcircled{3} \quad \sqrt{3} \sin 30 = \sqrt{\frac{3}{2}} \sin e$$

$$\frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{\sqrt{2}} \sin e$$

$$e = 45^\circ$$



$$\delta = 60 + 45 - 60 = 45^\circ$$

Q Find the angle of incident for which grazing emerges.

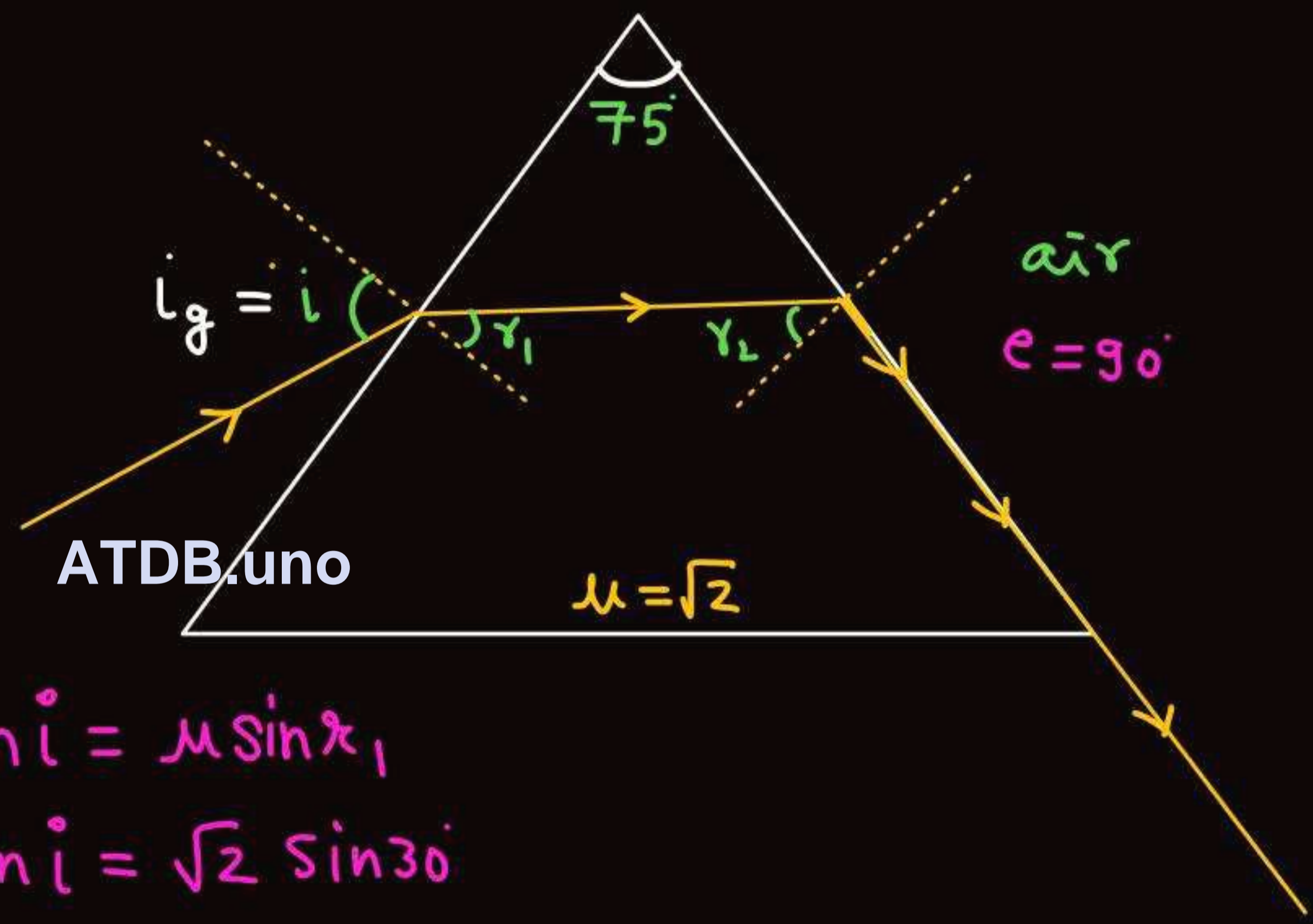
Solⁿ

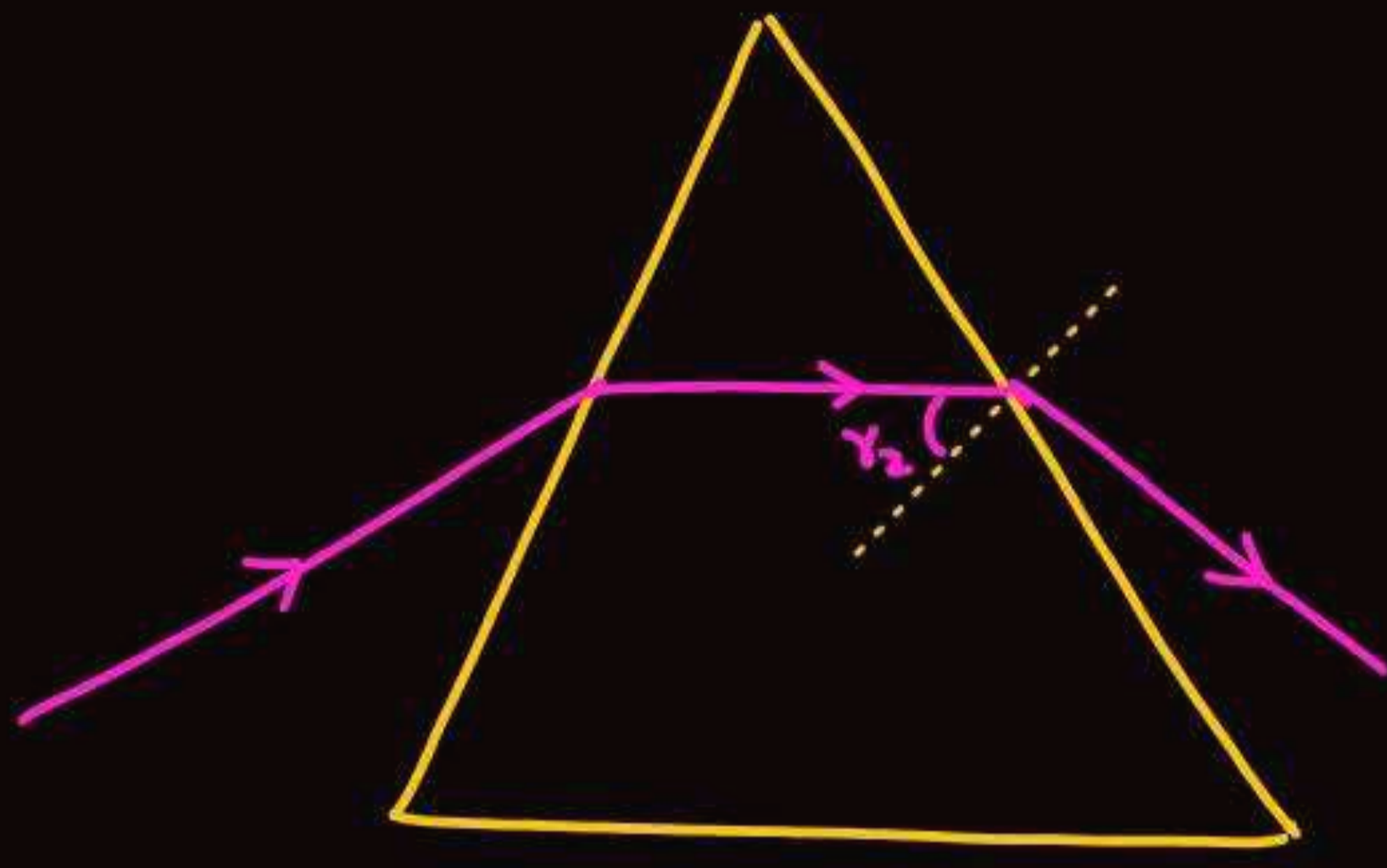
$r_2 = \theta_c$ $e = 90^\circ$
 $\sin \theta_c = \frac{1}{\sqrt{2}}$, $\theta_c = 45^\circ$

$r_2 = 45^\circ$
 $r_1 + r_2 = A$
 $r_1 + 45^\circ = 75^\circ$

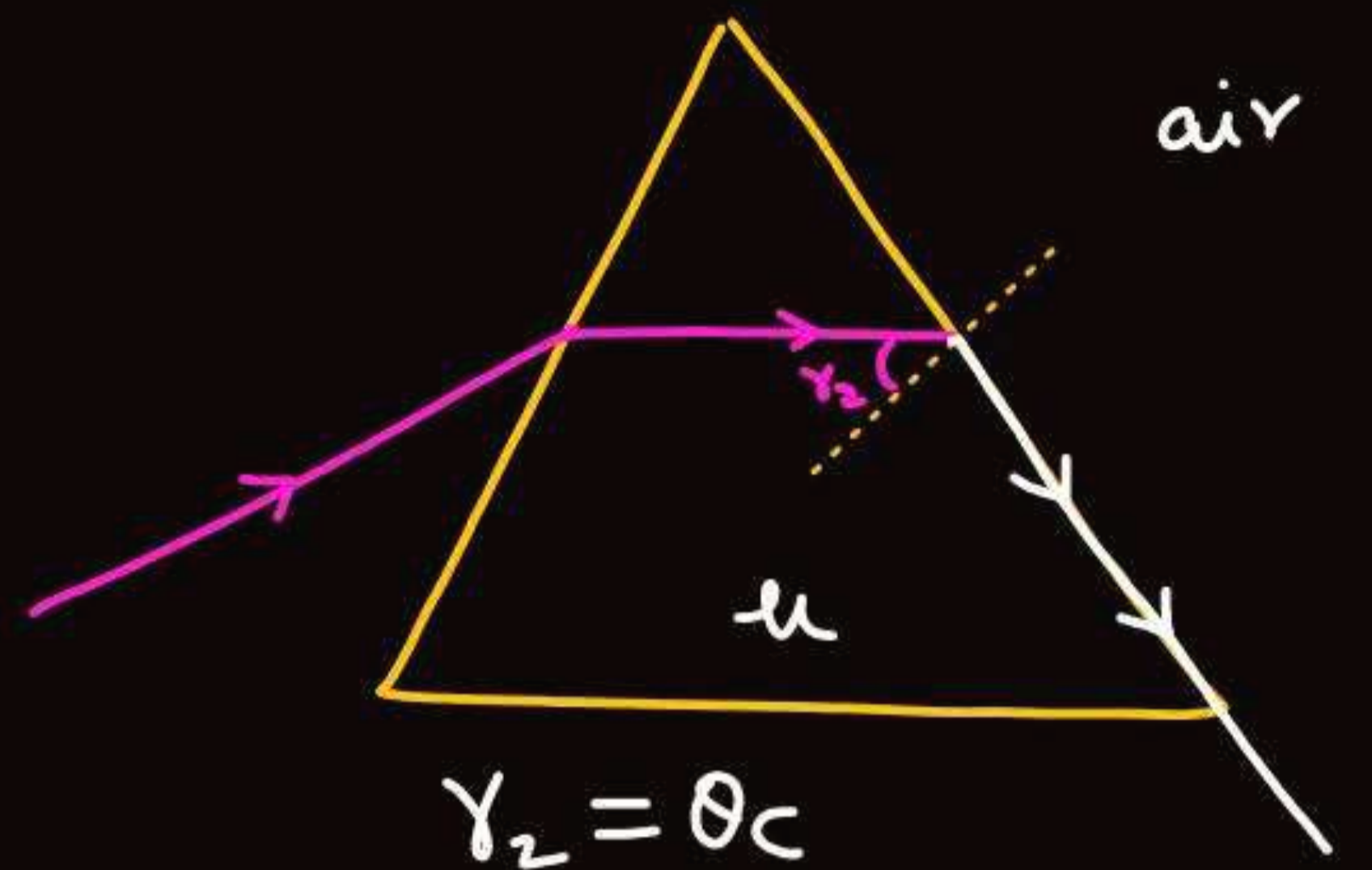
$r_1 = 30^\circ$

$1 \cdot \sin i = \mu \sin r_1$
 $\sin i = \sqrt{2} \sin 30^\circ$
 $i = 45^\circ$

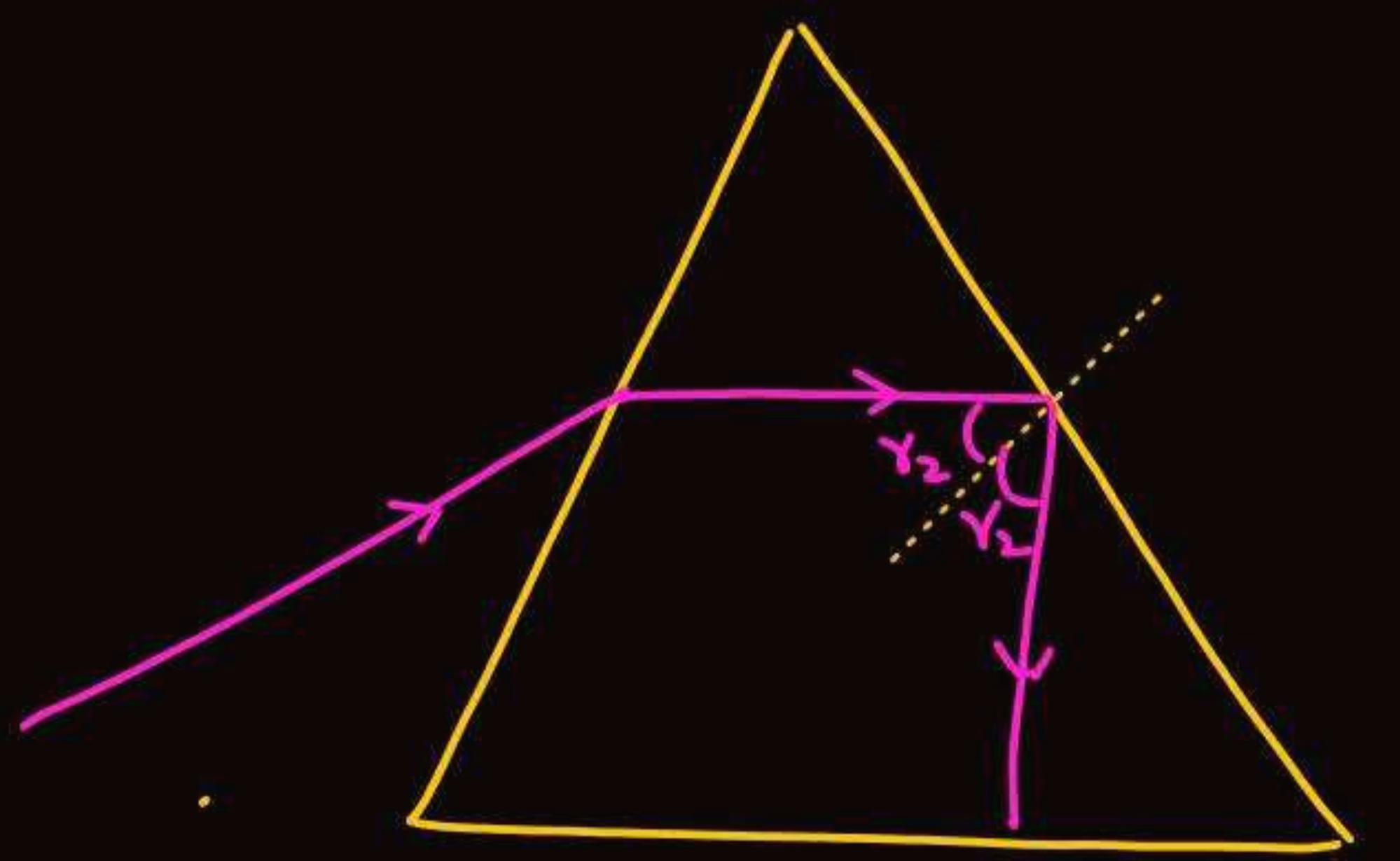




If $\gamma_2 < \theta_c$



$\gamma_2 = \theta_c$
 |||
 $e = 90^\circ$
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$\gamma_2 > \theta_c$



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

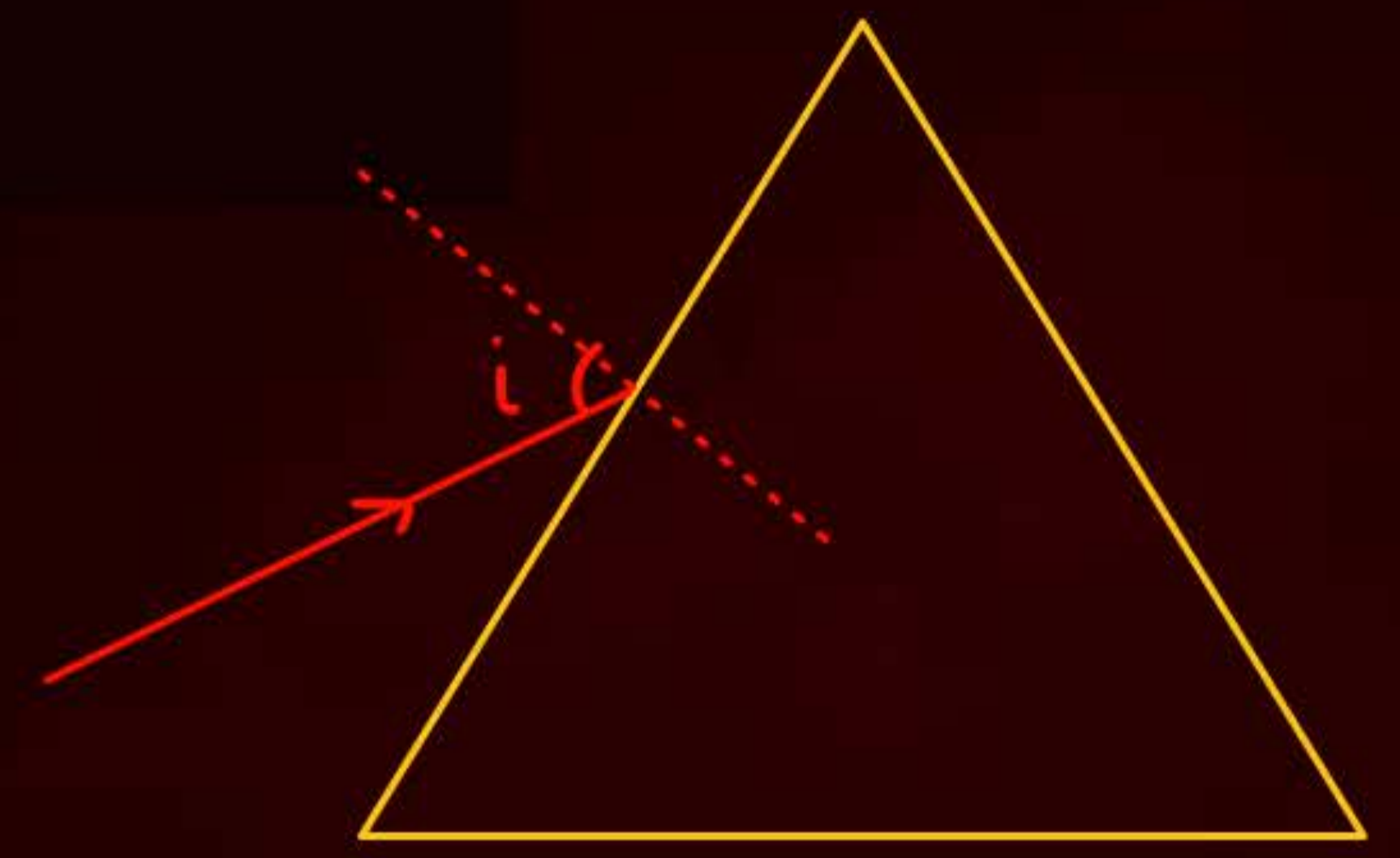
$$\mu \sin r_2 = 1 \cdot \sin e$$
$$1 \cdot \sin i = \mu \sin r_1$$

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

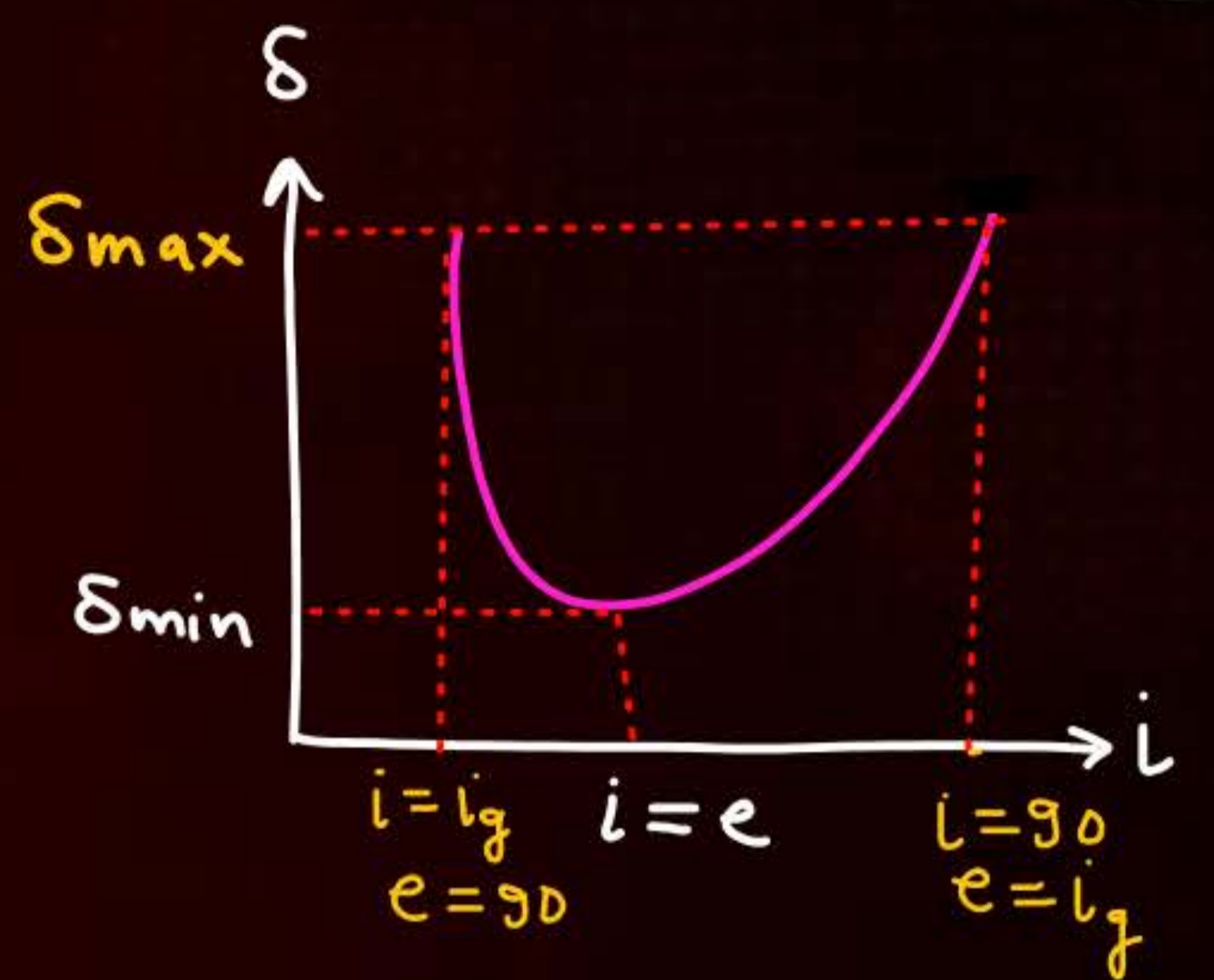
$$e = \sin^{-1}[\mu \sin(A - r_1)]$$

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

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



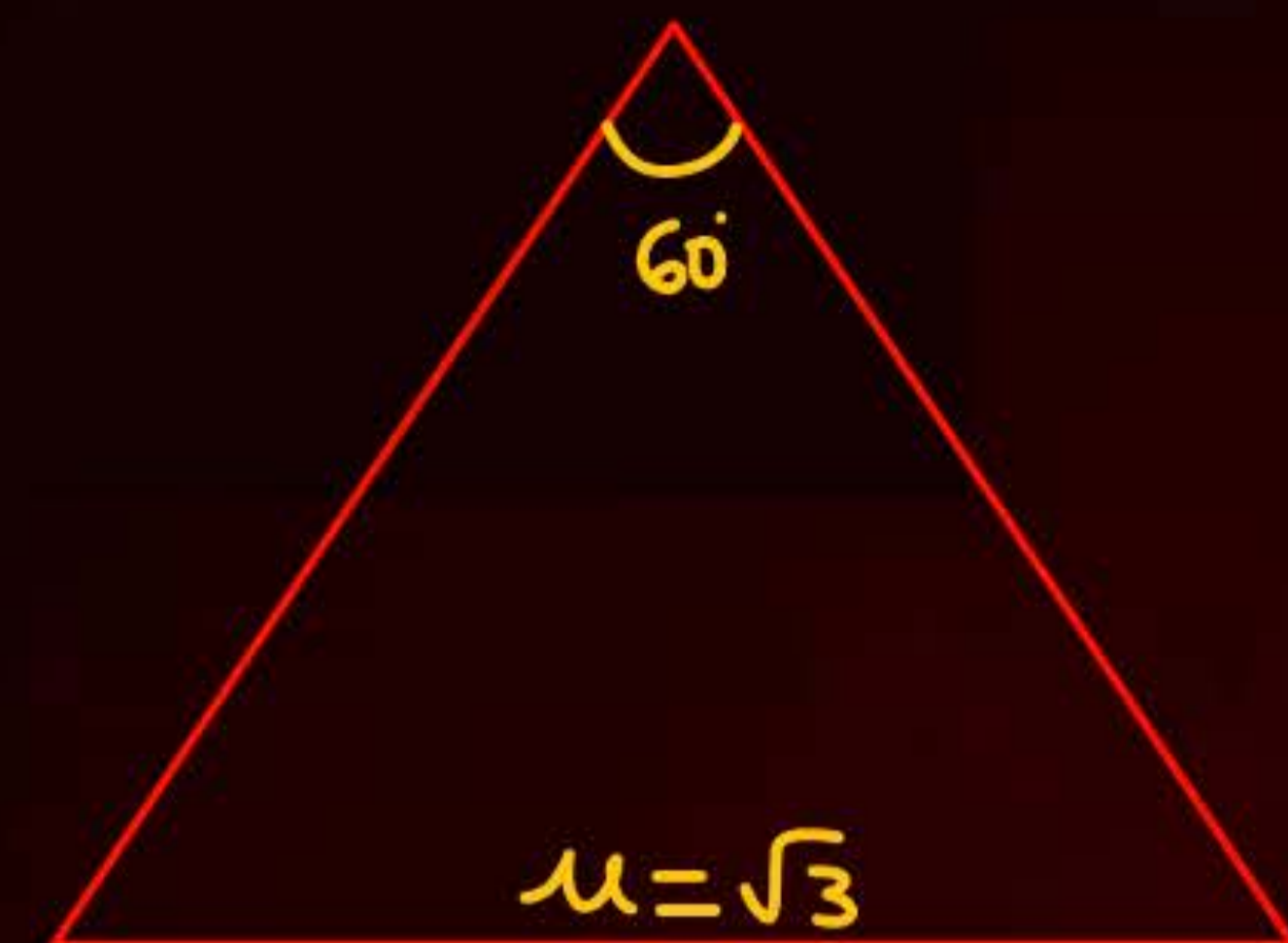
$$\delta = i + \sin^{-1}\left(\frac{\mu \sin(A - \sin^{-1}(\frac{1}{\mu} \sin i))}{\mu}\right) - A$$



- * parabola X
- * symmetric X



Q find $\delta_{\min} = ?$



Solⁿ

$$A = 60^\circ$$

$$\mu = \sqrt{3}$$

$$r_1 = A/2 = \frac{60}{2} = 30^\circ$$

$$\delta_{\min} = i + e - A = i + i - A$$

$$\delta_{\min} = 2i - A = 2 \times 60 - 60 = 60^\circ$$

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

$$\sin i = \sqrt{3} \sin 30^\circ$$

$$i = 60^\circ$$



Q find i in $\delta_{\min} = 30^\circ$



or

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

$$\mu = \frac{\sin\left(\frac{30 + 60}{2}\right)}{\sin\left(\frac{60}{2}\right)} = \frac{1}{\sqrt{2}} \times \frac{1}{\frac{1}{2}}$$

$$\mu = \sqrt{2}$$

Solⁿ

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

$$30 = 2 \times i - 60$$

$$i = 45^\circ$$

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

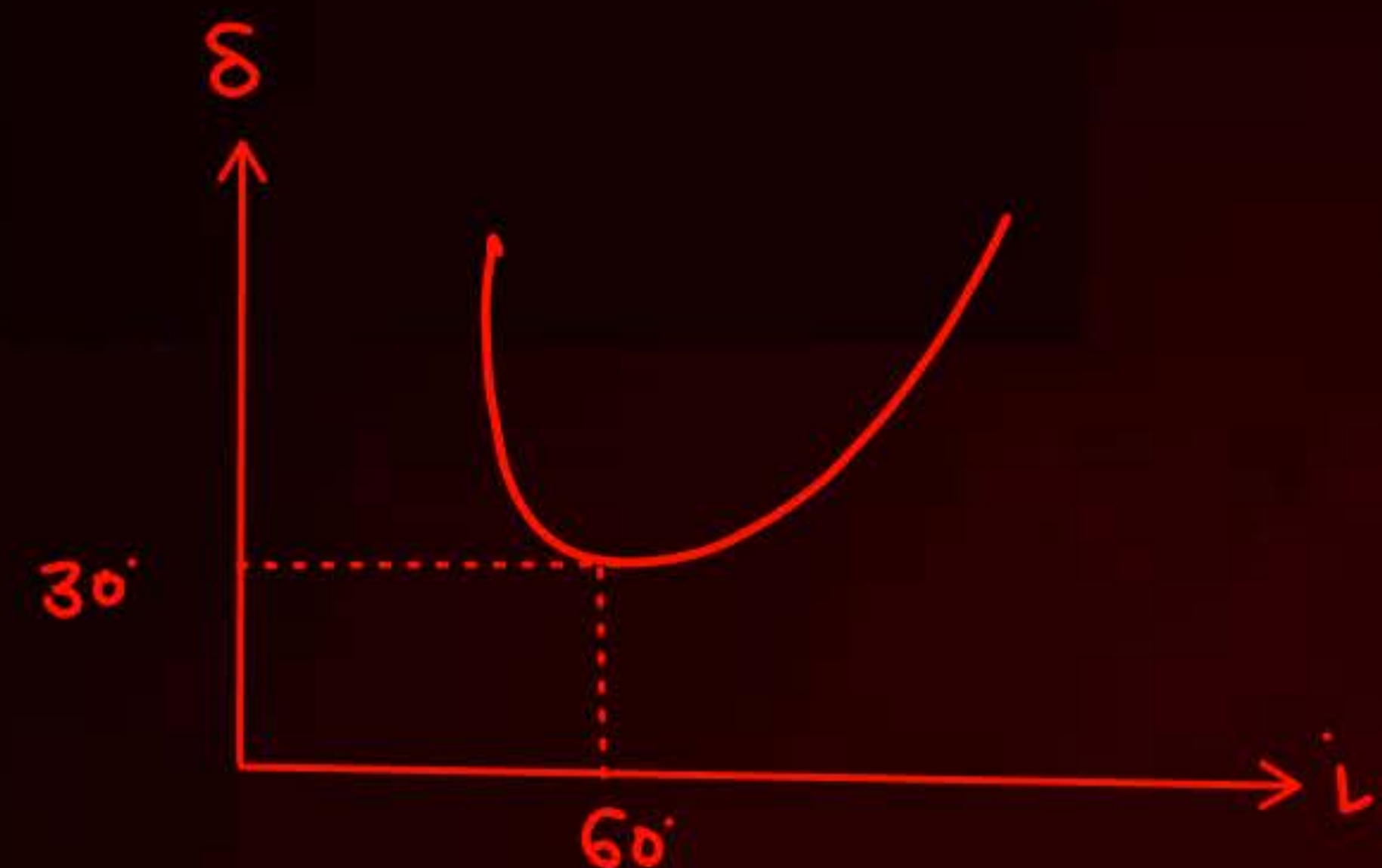
$$\frac{1}{\sqrt{2}} = \mu \sin 30$$

$$\mu = \sqrt{2}$$

$$r_1 = \frac{A}{2} = 30$$



Q find μ of prism



Solⁿ

$$\delta_{\min} = 30 \quad i = e = 60$$

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

$$30 = 2 \times 60 - A$$

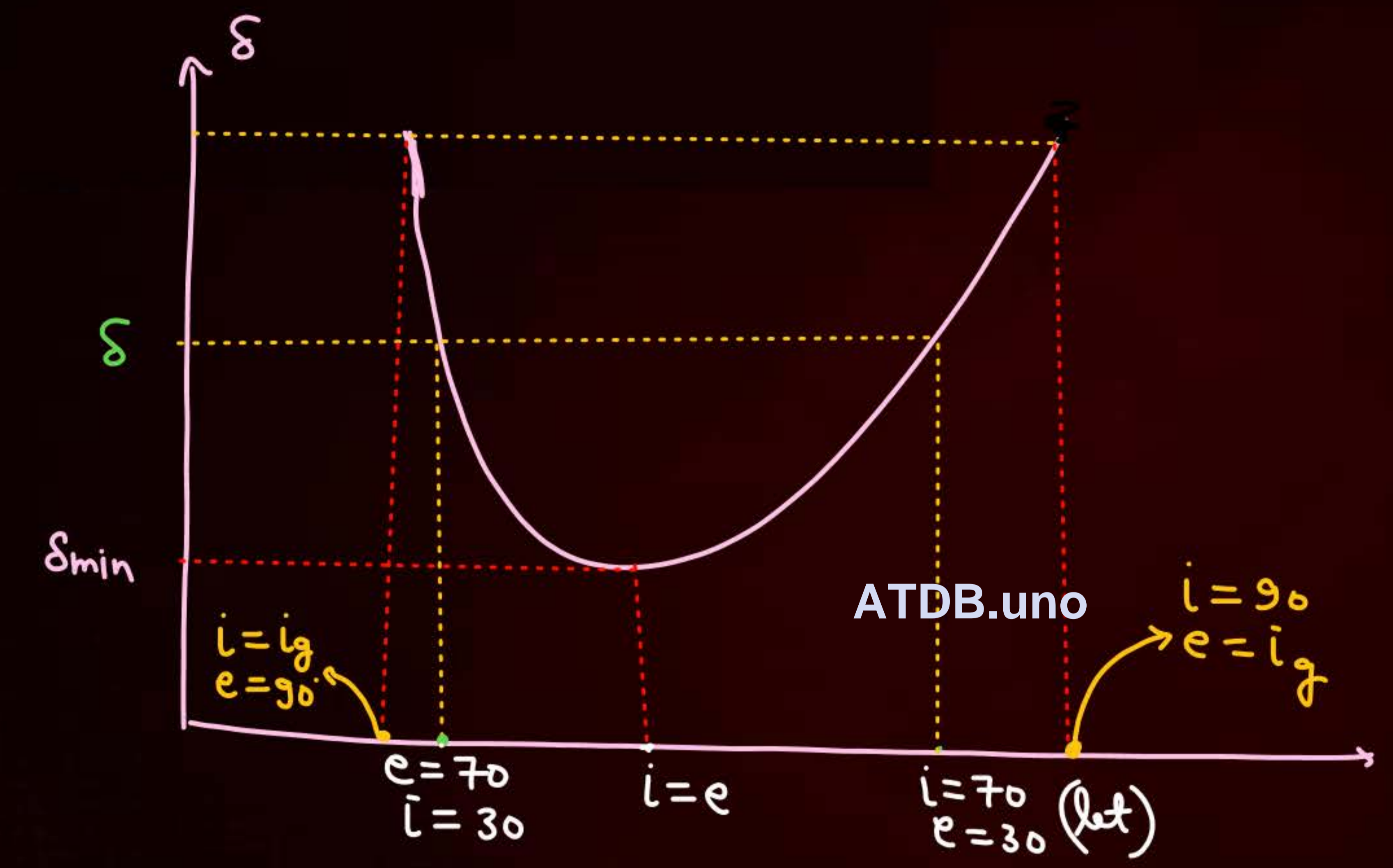
$$\boxed{A = 90^\circ} \quad r_1 = A/2 = 45^\circ$$

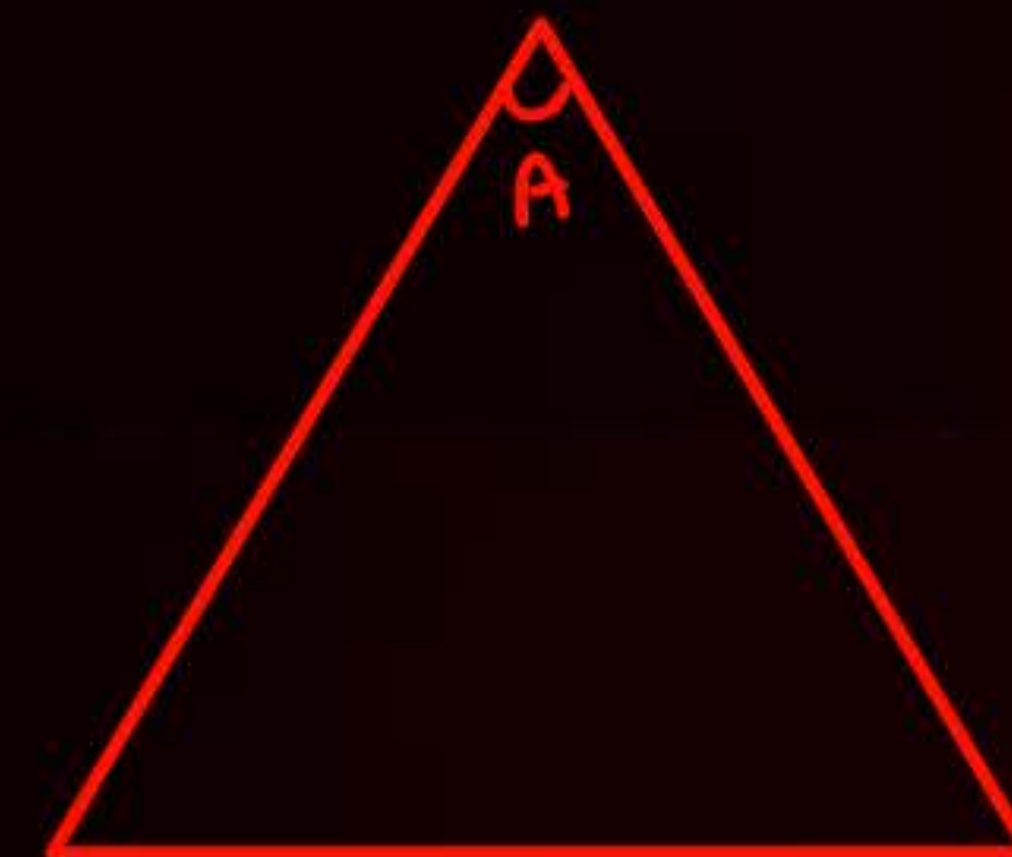
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$$1 \cdot \sin i = \mu \sin r_1$$

$$1 \times \sin 60 = \mu \sin 45^\circ$$

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





for min deviation

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

$$i = \frac{\delta_{\min} + A}{2}$$

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

$$\mu = \frac{\sin i}{\sin r_1} = \frac{\sin\left(\frac{\delta_{\min} + A}{2}\right)}{\sin(A/2)} \quad (r_1 = A/2)$$

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

Thin lens

* $\angle A$ is very small (r_1 & $r_2 \rightarrow$ very small)

$$r_1 + r_2 = A$$

$$\begin{aligned} * \quad 1 \cdot \sin i &= \mu \sin r_1 \longrightarrow i \approx \mu r_1 \\ \mu \sin r_2 &= 1 \cdot \sin e \longrightarrow \mu r_2 \approx e \end{aligned}$$

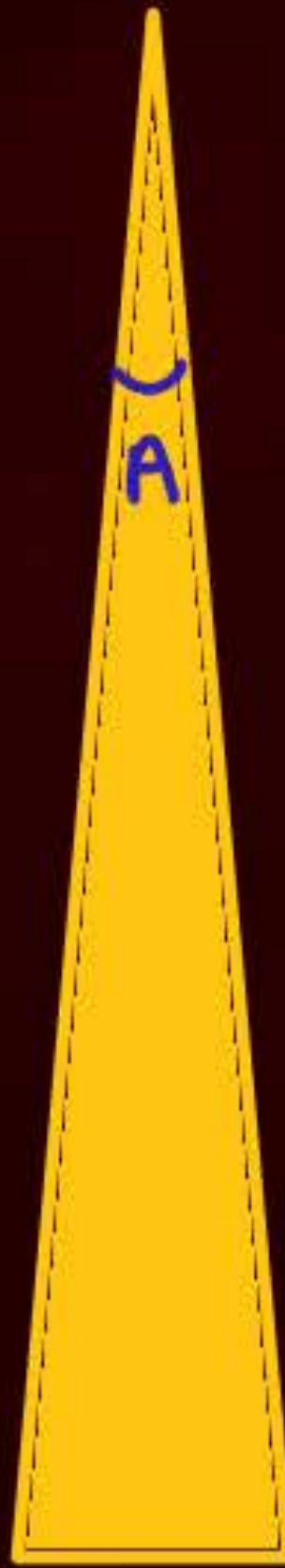
$$\delta = i + e - A = \mu r_1 + \mu r_2 - A$$

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

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

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$$\sin \theta \approx \theta$$



Q



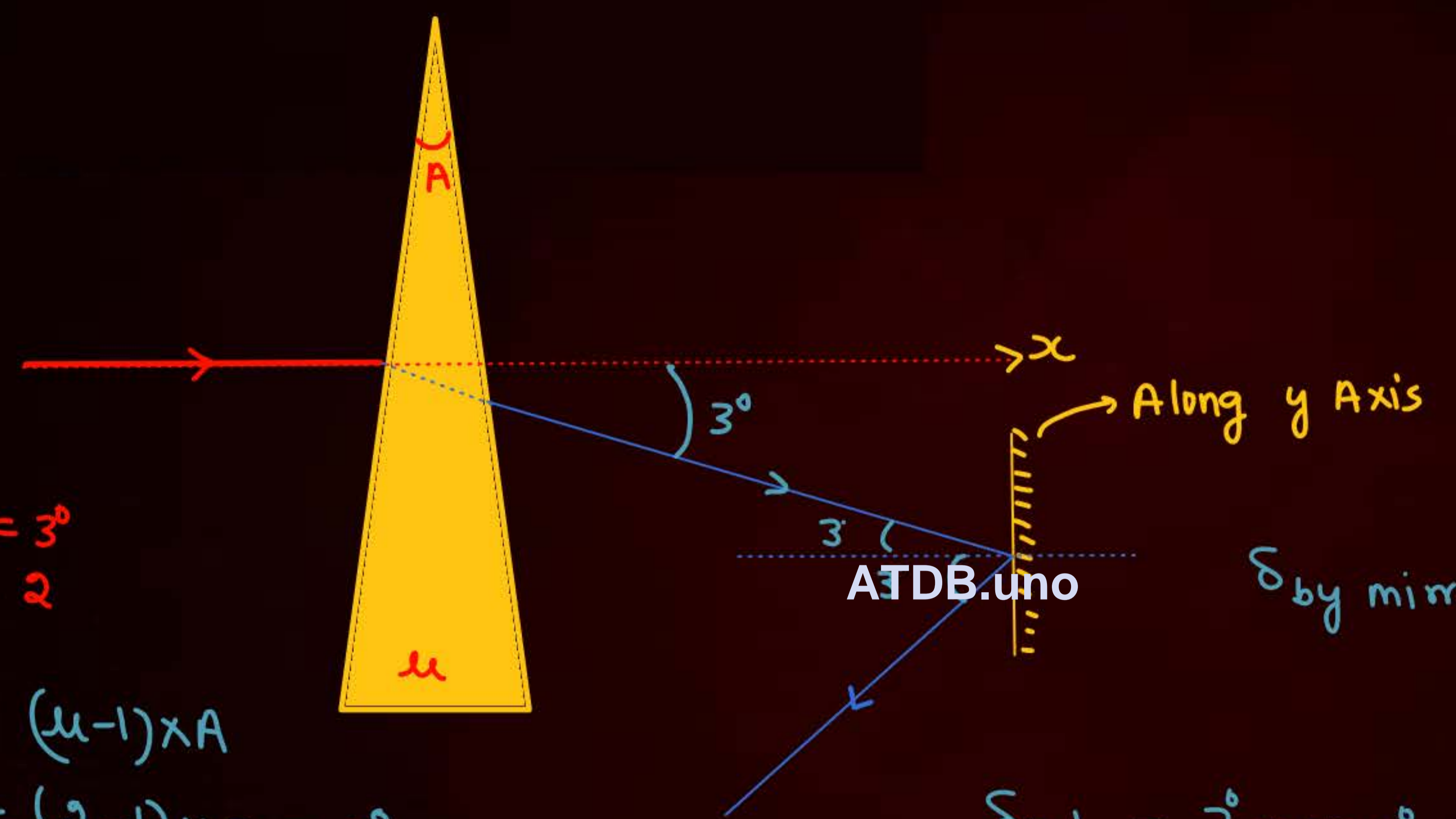
$$\delta = (\mu - 1) \times A = (2 - 1) \times 3$$

$$\boxed{\delta = 3^\circ}$$





Q



$\angle A = 3^\circ$
 $\mu = 2$

$\delta = (\mu - 1) \times A$
 $= (2 - 1) \times 3 = 3^\circ$

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$\delta_{\text{by mirror}} = 180 - 2i$
 $= 180 - 2 \times 3^\circ = 174^\circ$

$\delta_{\text{net}} = 3^\circ + 174^\circ = 177^\circ \text{ (cw)}$



Q find max deviation

Solⁿ $\delta_{max} \Rightarrow i = i_g \quad e = 90^\circ$

$$r_2 = \theta_c = 45^\circ$$

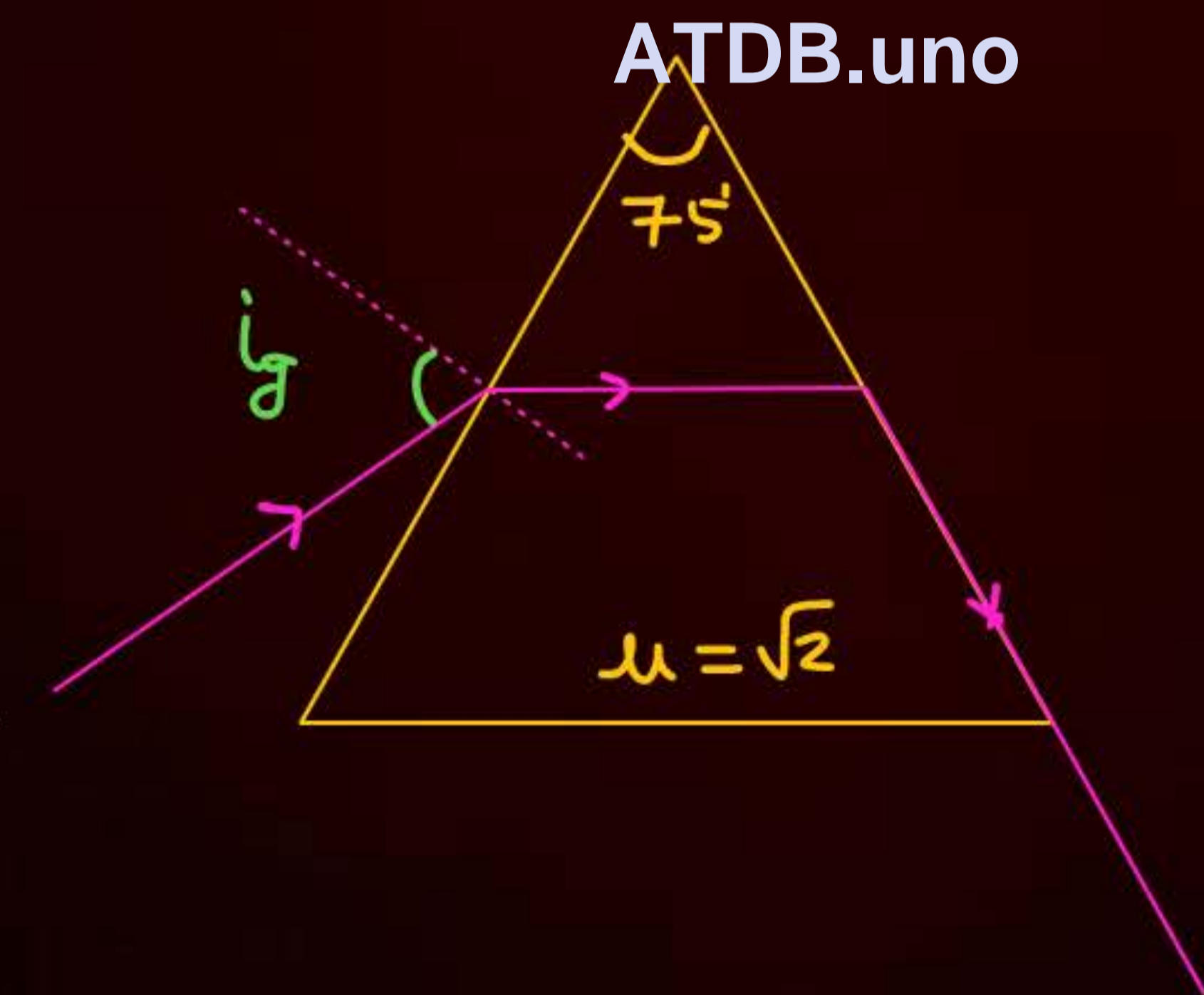
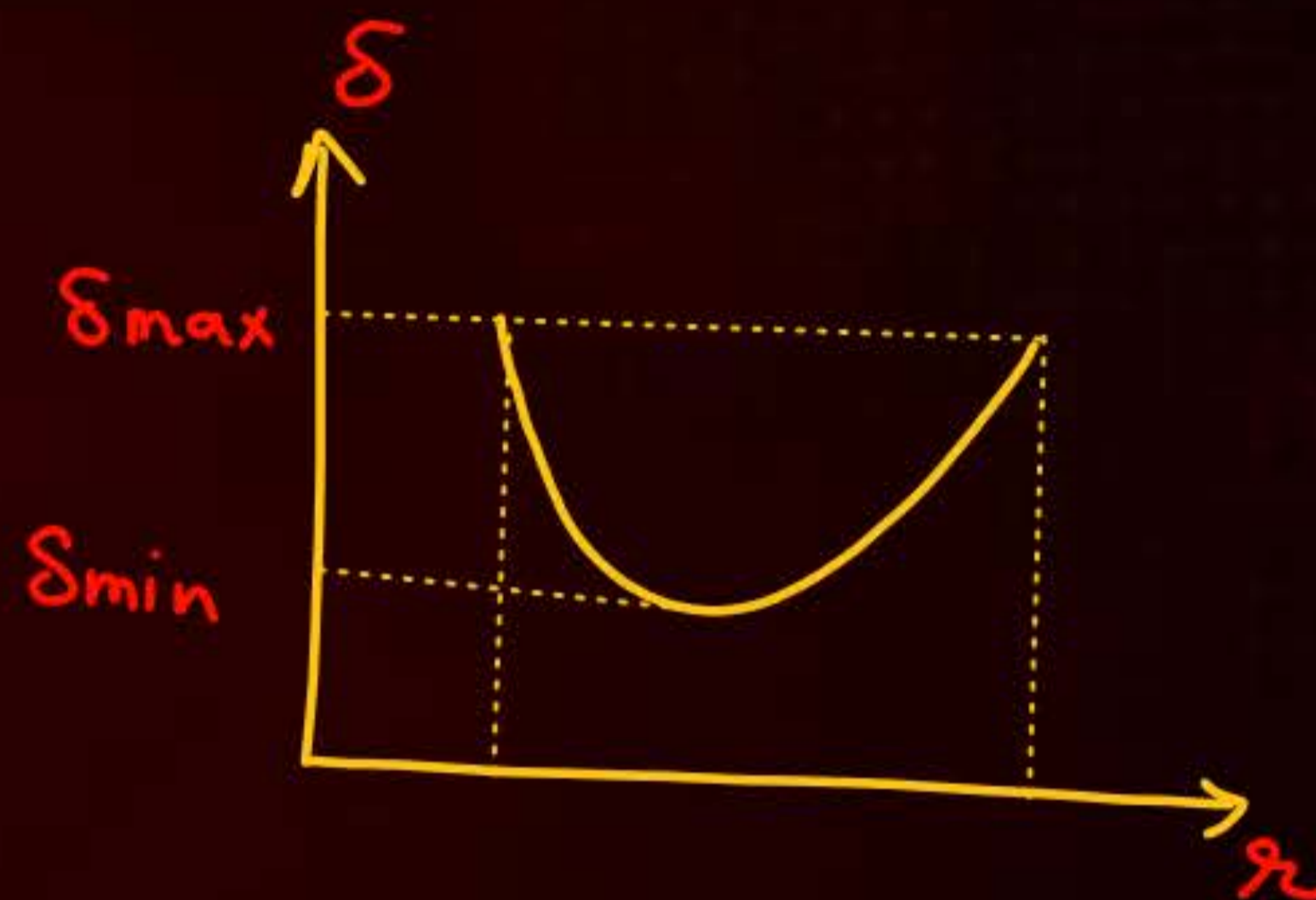
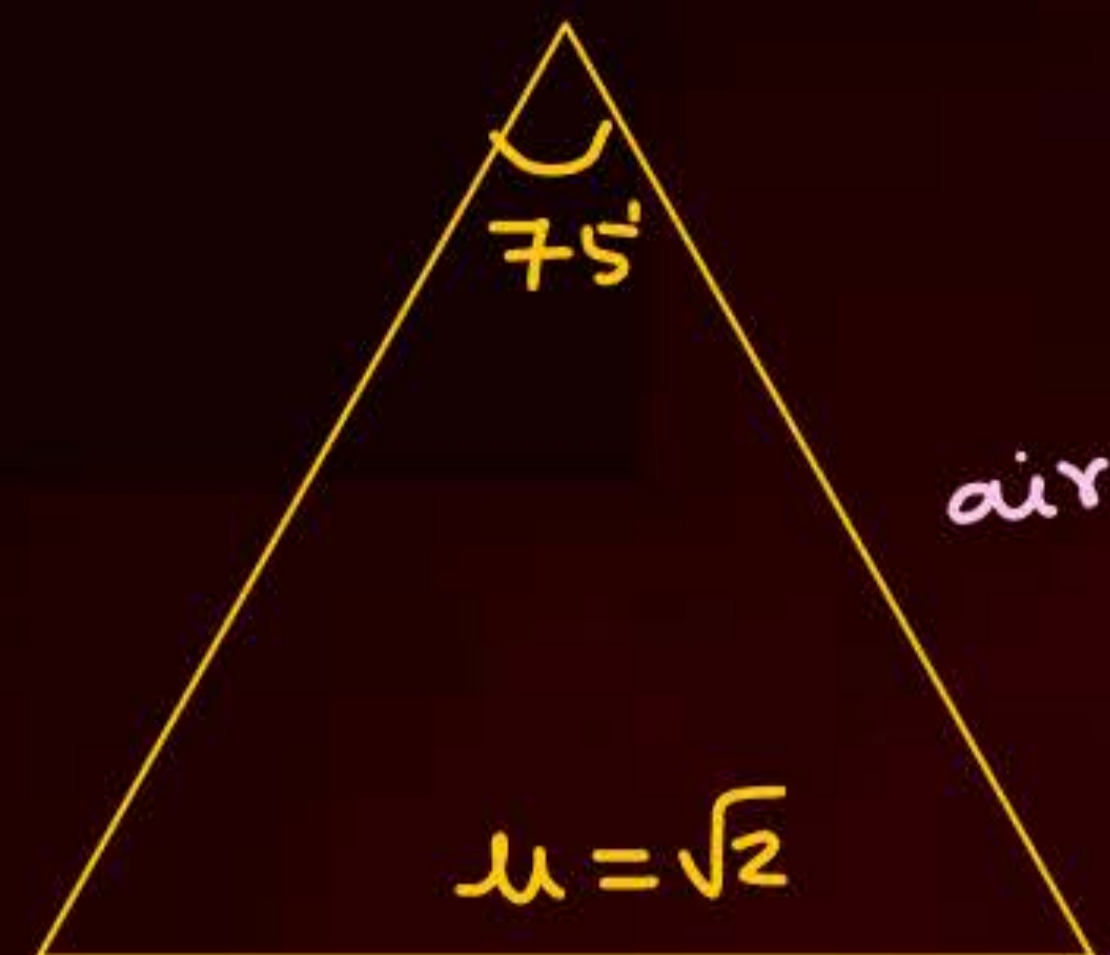
$$r_1 = 75 - 45 = 30^\circ$$

$$1 \times \sin i = \sqrt{2} \sin r_1$$

$$i = i_g = 45^\circ$$

$$\delta_{max} = i + e - A$$

$$= 45 + 90 - 75 = 60^\circ$$





$$r_1 + r_2 = A, \quad 1 \cdot \sin i = \mu \sin r_1$$

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

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

$$\delta_{\min} \Rightarrow i = e, \quad r_1 = r_2 = A/2$$

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

$$\delta_{\max} \Rightarrow i = i_g \quad \text{or} \quad e = i_g$$

$$e = 90^\circ \quad \text{or} \quad i = 90^\circ$$

$$\delta_{\max} = i + e - A = i_g + 90 - A$$

Thin lens

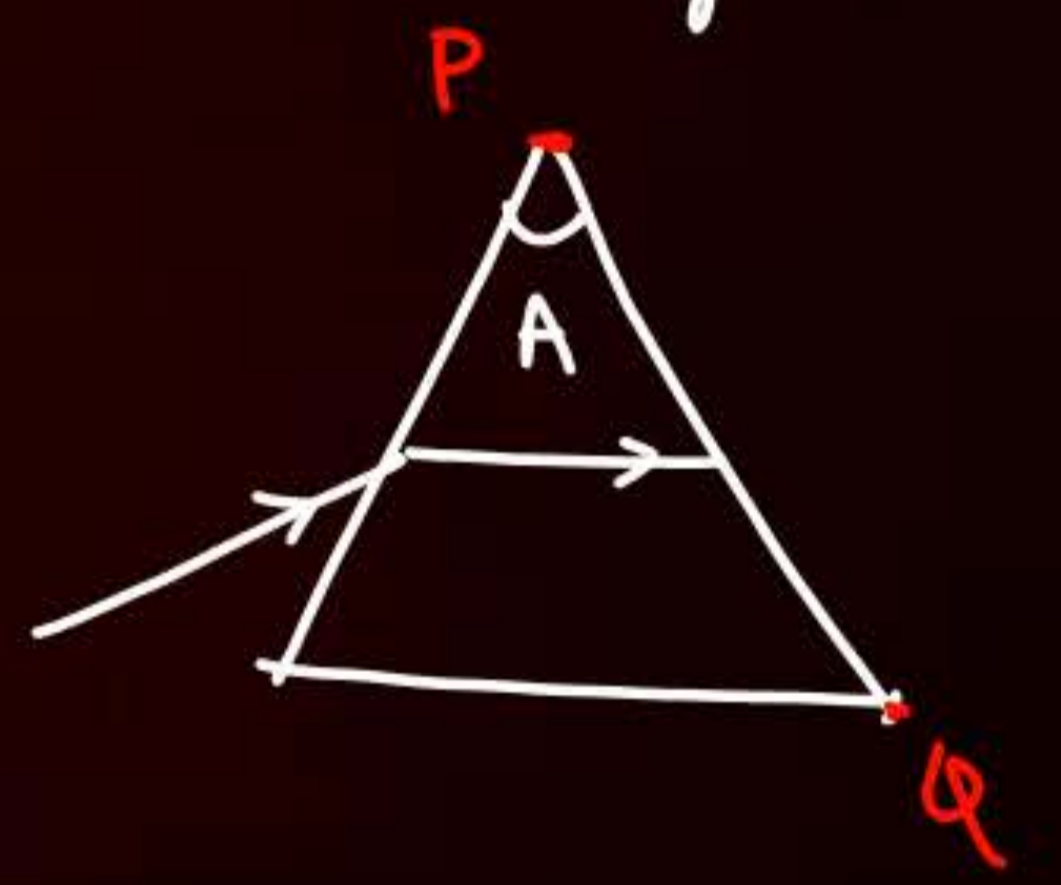
$$\delta = (\mu - 1) A$$

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

$h = d \tan \delta$
thin prism
 $\therefore \Delta$

$A > 2\theta_c$ All Rays TIR
At P θ

$A < \theta_c$ All out
through P θ



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Q find μ_{\min} so that no-rays emerge out

Solⁿ

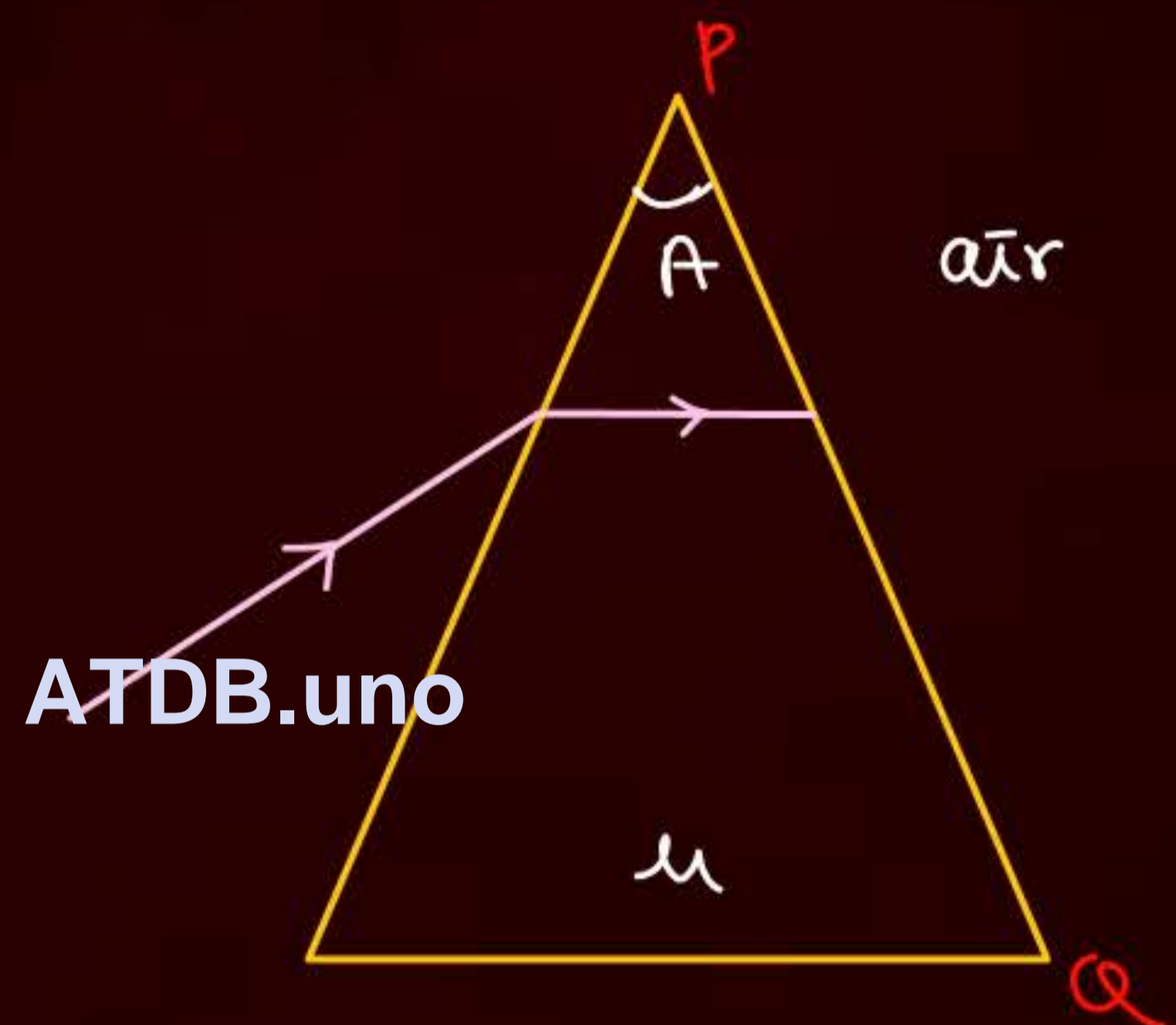
$$A > 2\theta_c$$

$$\frac{A}{2} > \theta_c$$

$$\sin \frac{A}{2} > \sin \theta_c$$

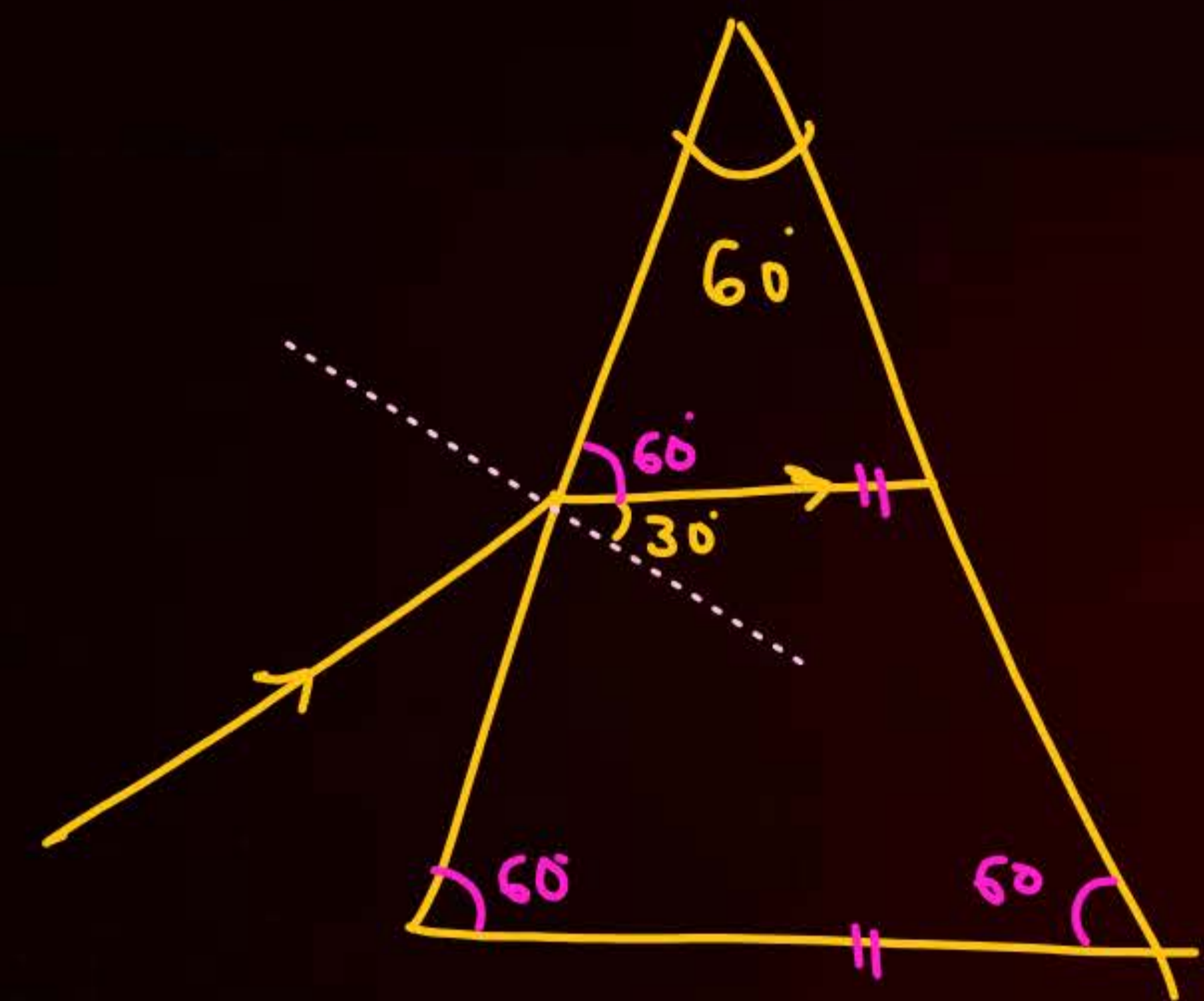
$$\sin \frac{A}{2} > \frac{1}{\mu}$$

$$\mu > \operatorname{cosec} \frac{A}{2}$$



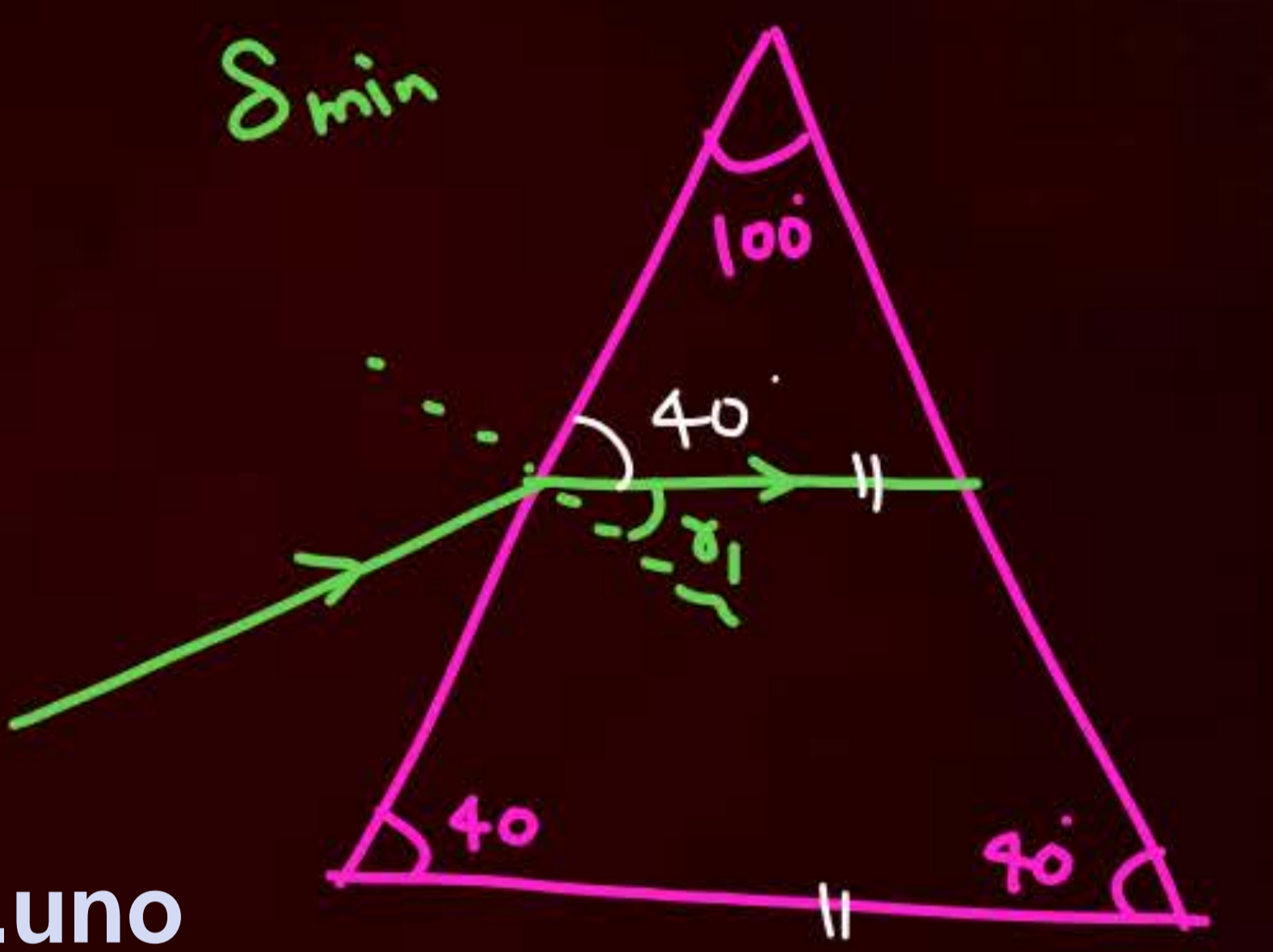


δ_{min} Equilateral



$$\delta_1 = A/2 = 30^\circ$$

δ_{min} isosceles



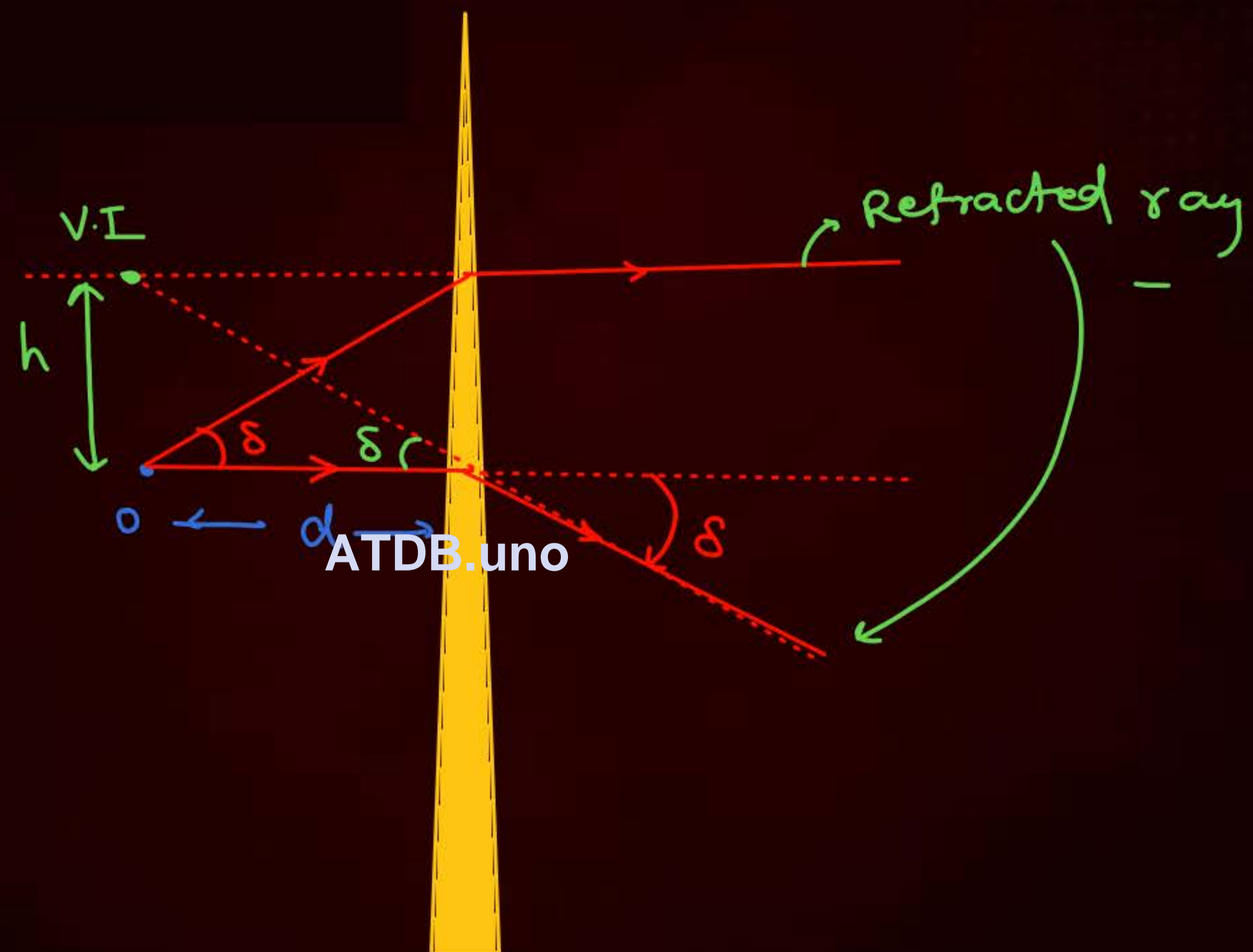
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$$\delta_1 = \frac{100}{2} = 50$$



$$\tan \delta = \frac{h}{d}$$

$$h = d \tan \delta$$



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THANK YOU

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