PRAYAS

JEE 2025

Lecture-13

Physics

[redacted] Ray optics

By- Saleem Ahmed Sir

Topics *to be covered*

1. Prism
2.
3.
4.

Prism

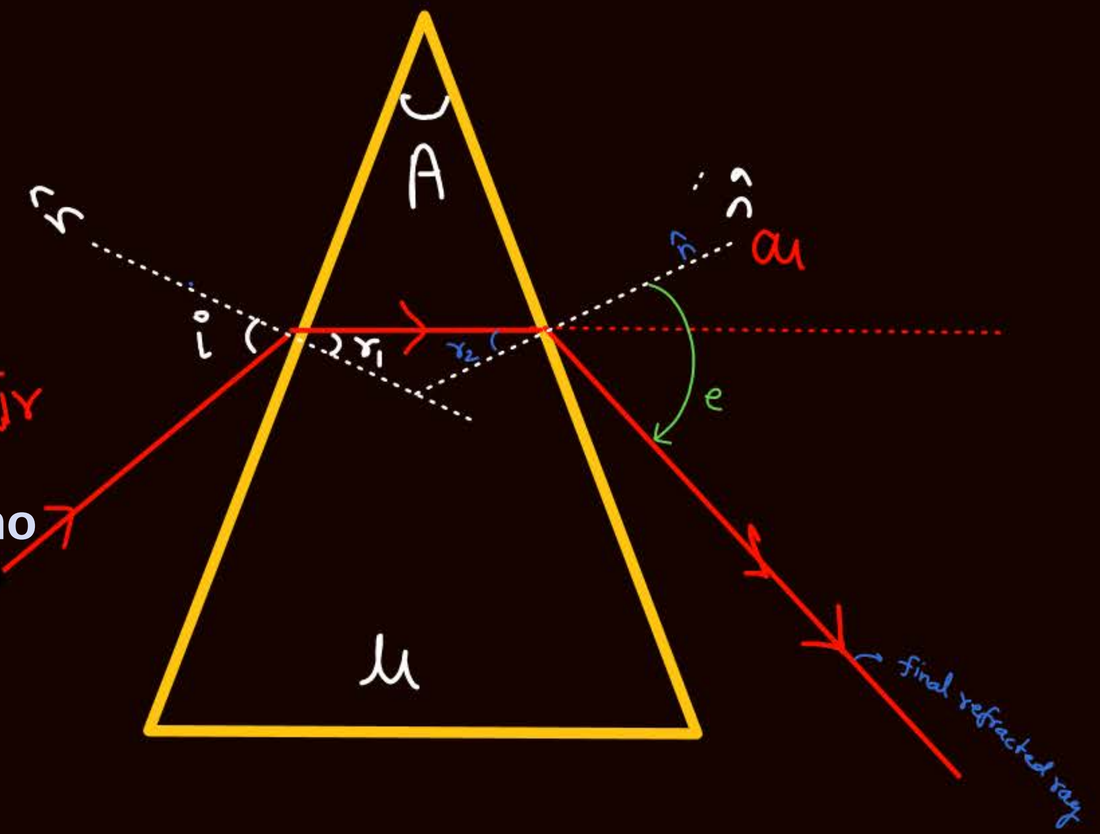
Angle of prism $\equiv A'$

① $1 \cdot \sin i = \mu \sin r_1$

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

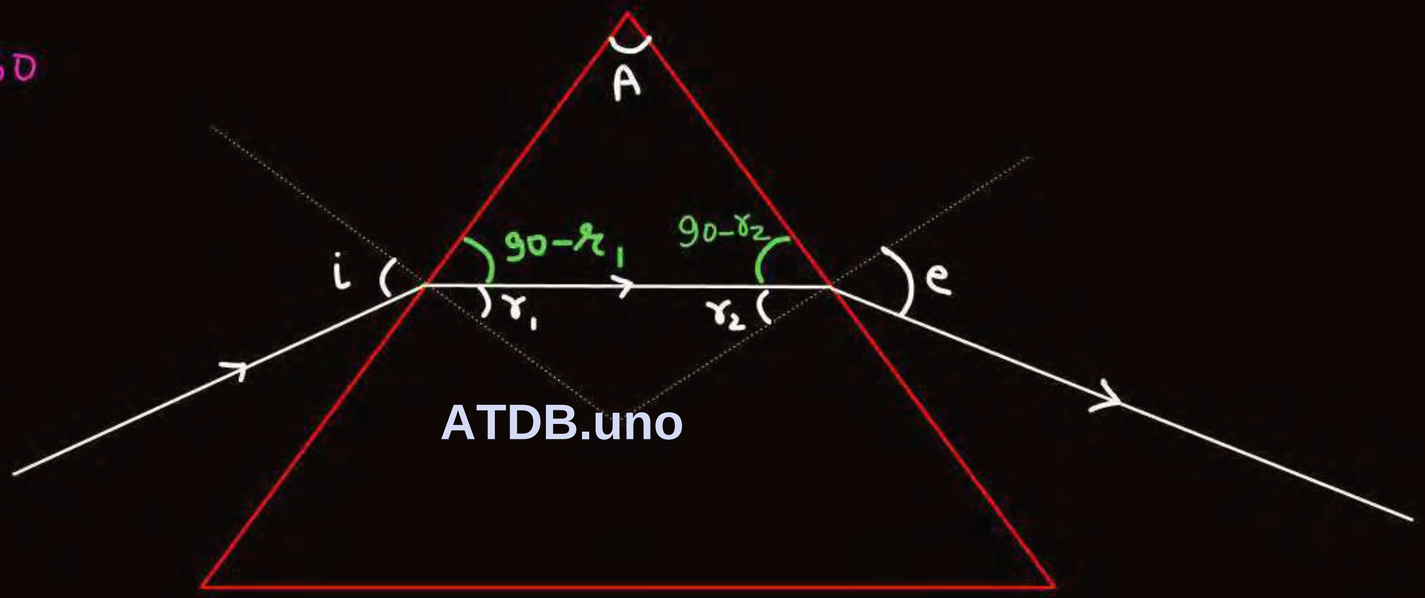
② $r_1 + r_2 = A$

③ $\delta_{net} = i + e - A$



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

$$A = r_1 + r_2$$

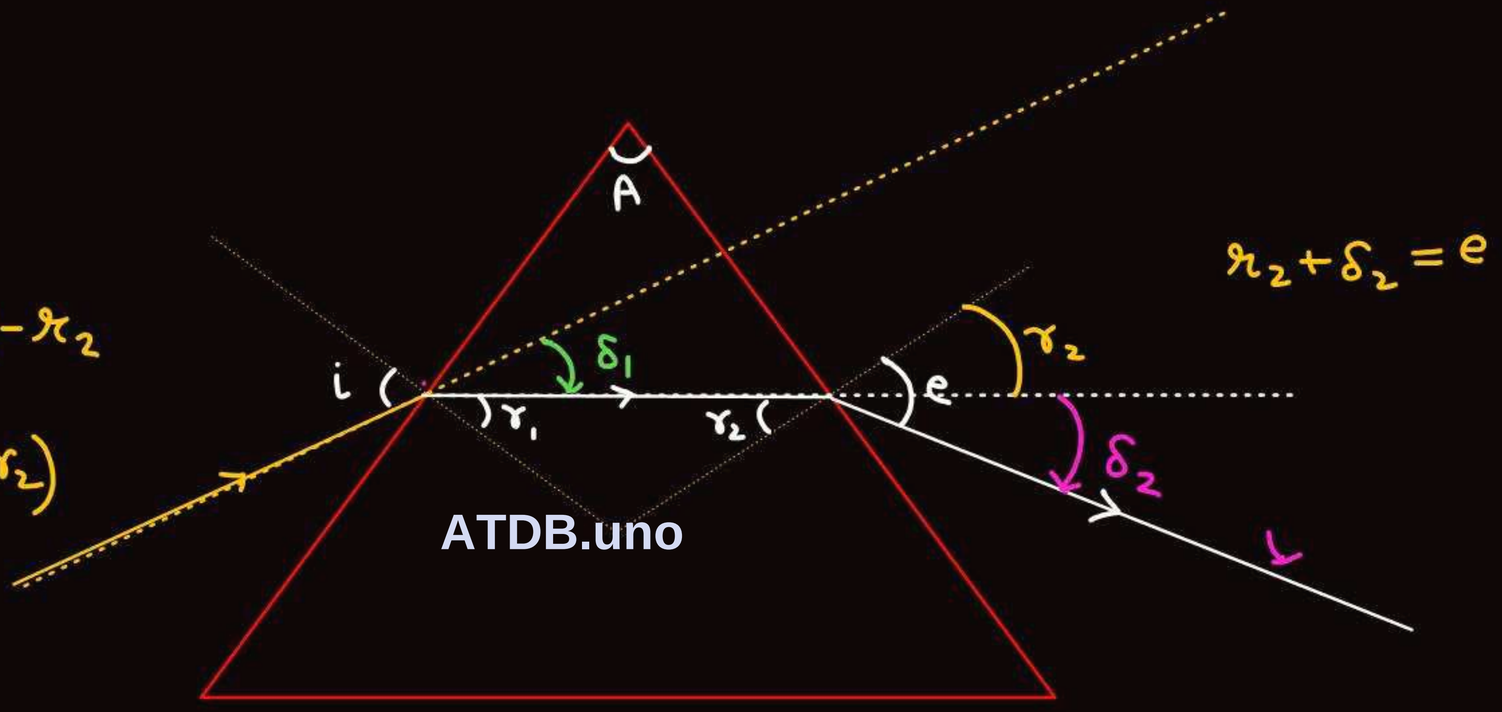


$$\delta_{net} = \delta_1 + \delta_2$$

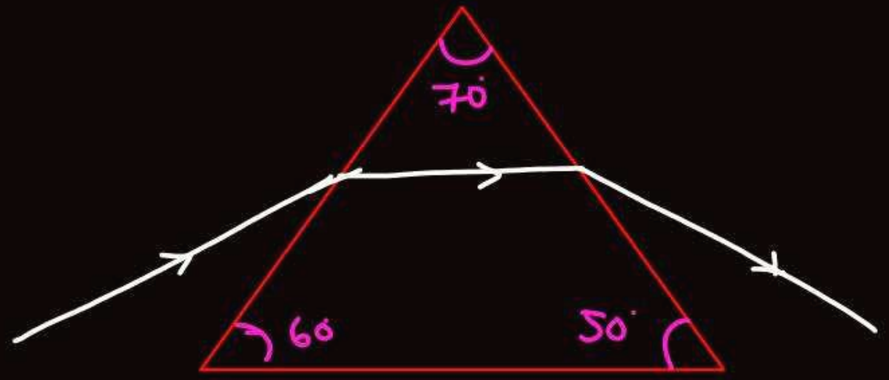
$$\delta_{net} = i - r_1 + e - r_2$$

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

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

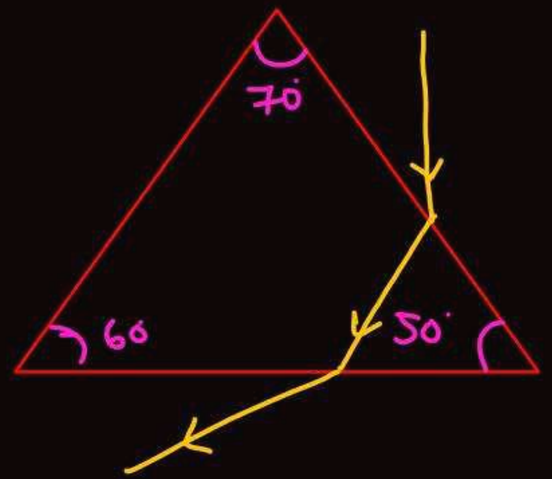


$$r_2 + \delta_2 = e$$

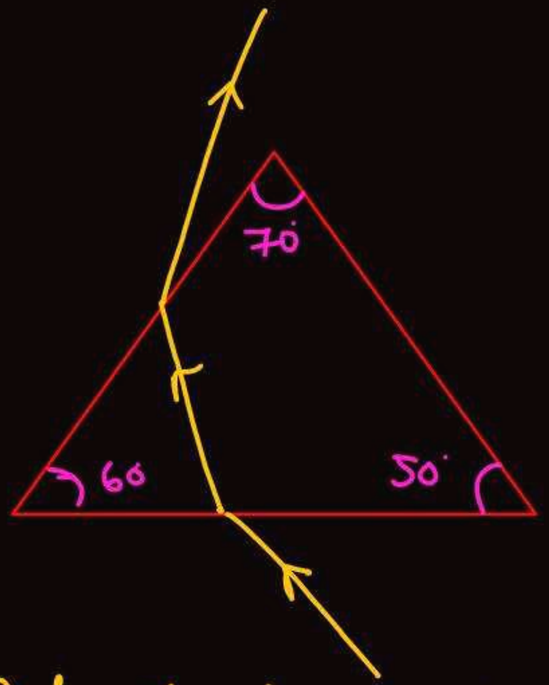


Angle of prism = 70°

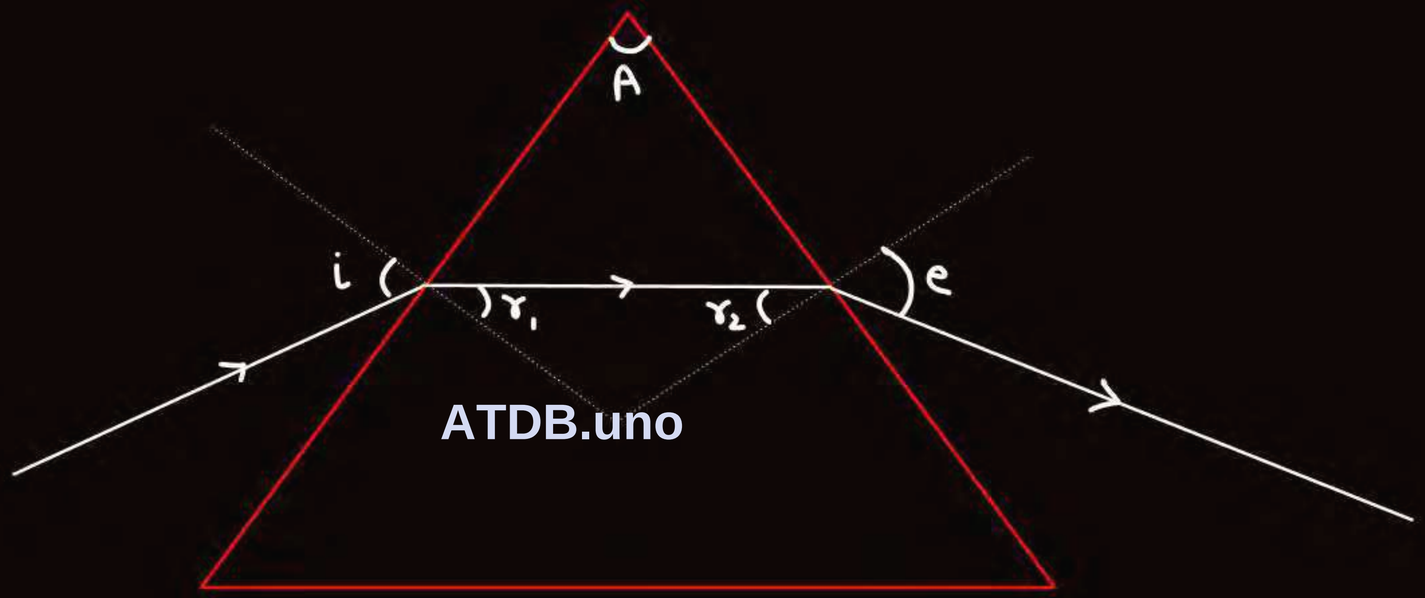
(Refracting angle)



Angle of prism = 50°



Angle of prism = 60°

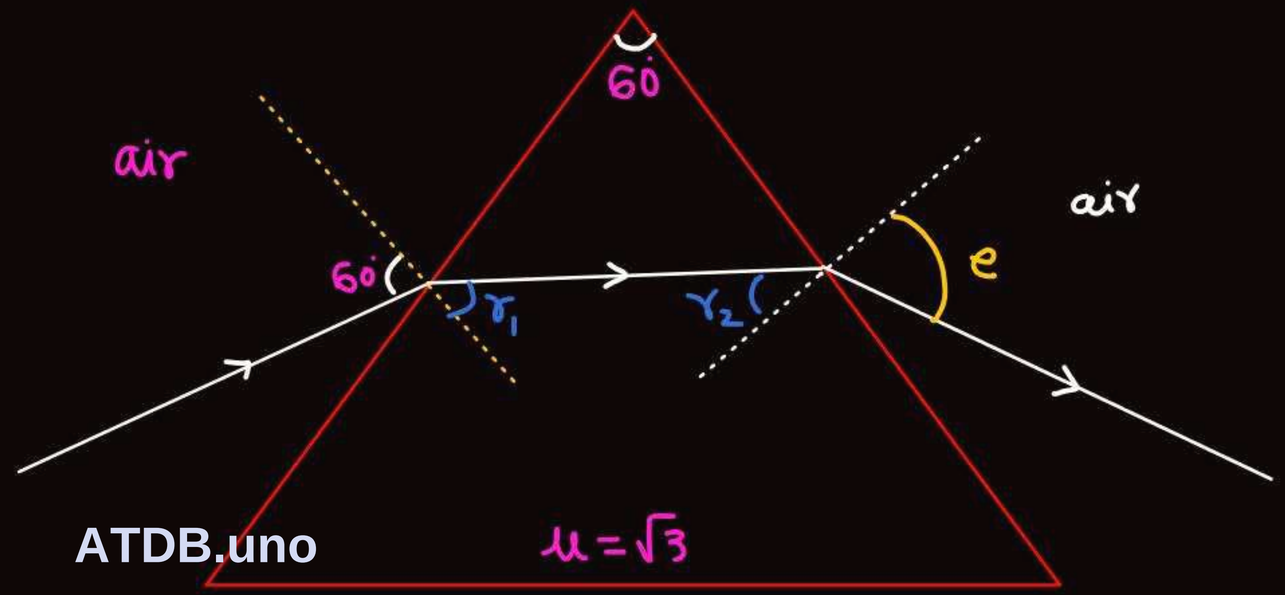


Q find $\delta_{net} = ?$

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

$i = 60^\circ$

$A = 60^\circ$



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

$r_1 = 30^\circ$

* $r_1 + r_2 = A$

$30 + r_2 = 60$

$r_2 = 30^\circ$

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

$\sqrt{3} \sin 30^\circ = 1 \times \sin e$

$e = 60^\circ$

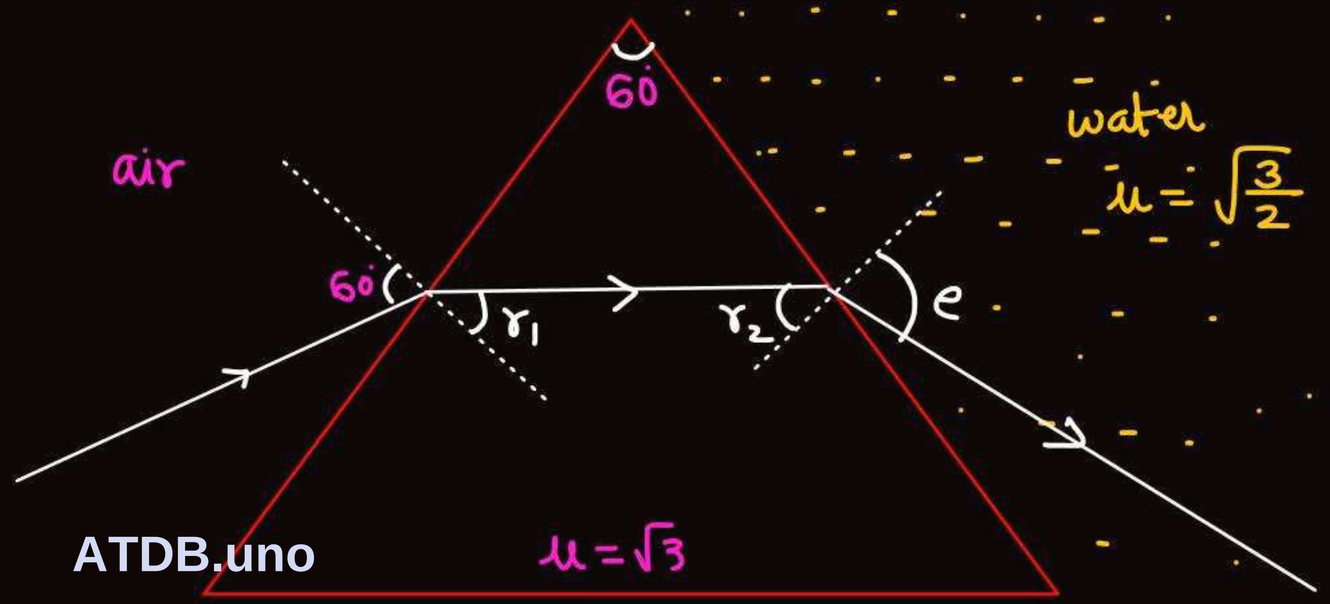
$\delta_{net} = i + e - A$

$= 60 + 60 - 60$

$\delta_{net} = 60$

Q find $\delta_{net} = ?$

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



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

$r_1 = 30°$

② $r_1 + r_2 = A \Rightarrow r_2 = 30°$

$30 + r_2 = 60°$

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

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

$e = 45°$

$\delta = 60 + 45 - 60 = 45°$

Q Find the angle of incident for which grazing emerges.

Soln

$r_2 = \theta_c$ $\quad e = 90^\circ$

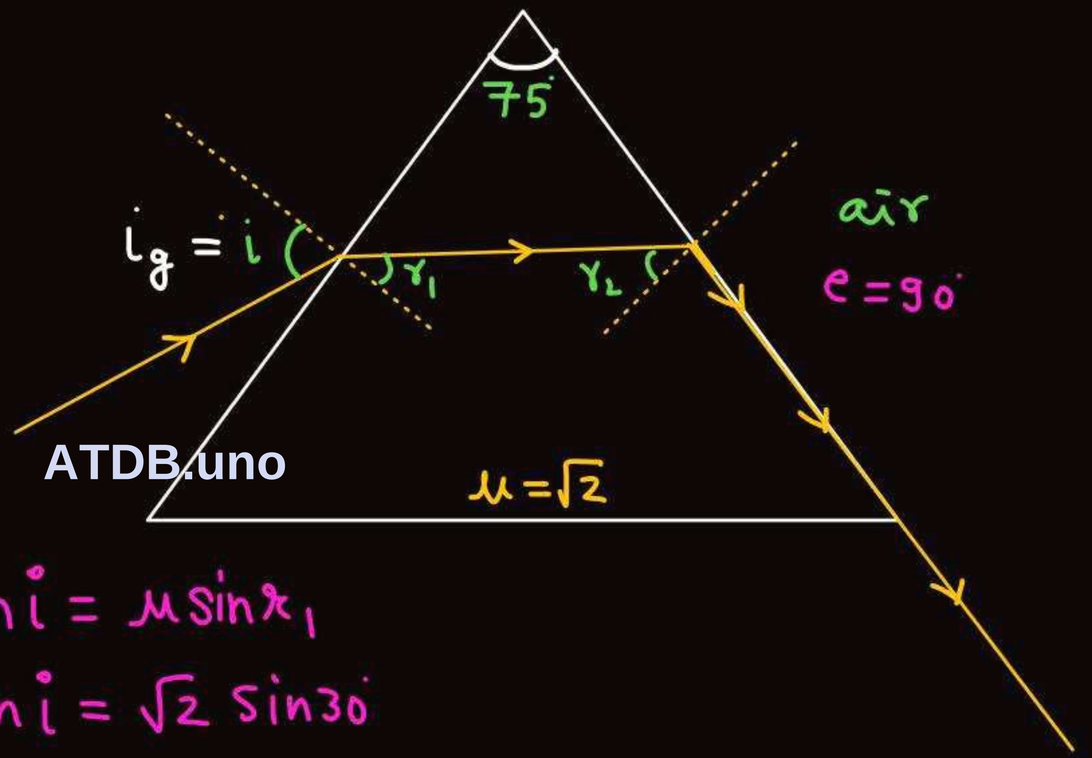
$\sin\theta_c = \frac{1}{\sqrt{2}}$, $\boxed{\theta_c = 45^\circ}$

$r_2 = 45^\circ$

$r_1 + r_2 = A$

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

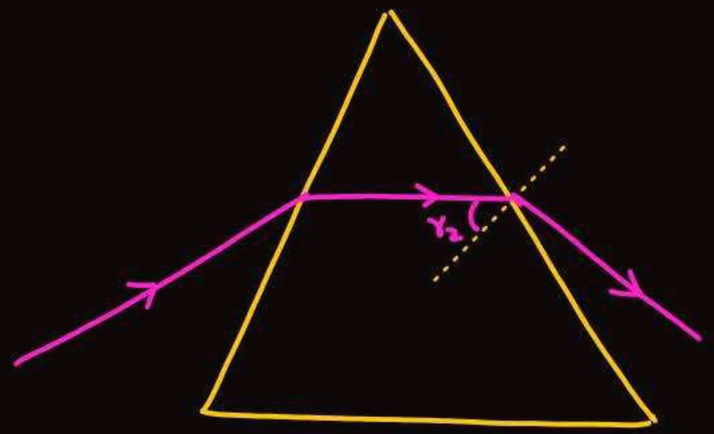
$\boxed{r_1 = 30^\circ}$



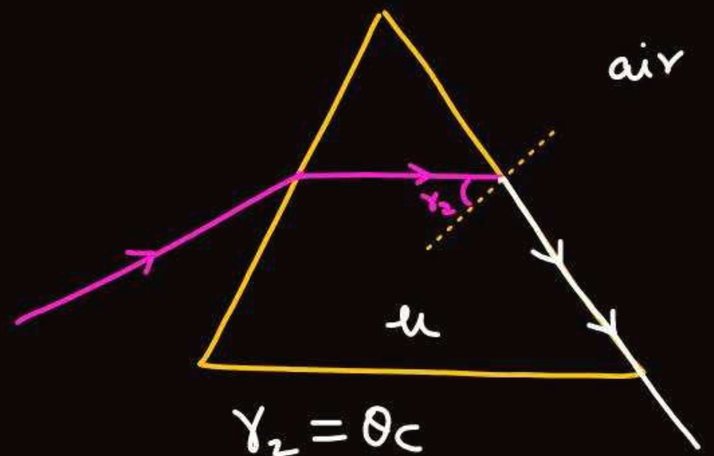
$1 \cdot \sin i = \mu \sin r_1$

$\sin i = \sqrt{2} \sin 30^\circ$

$\boxed{i = 45^\circ}$



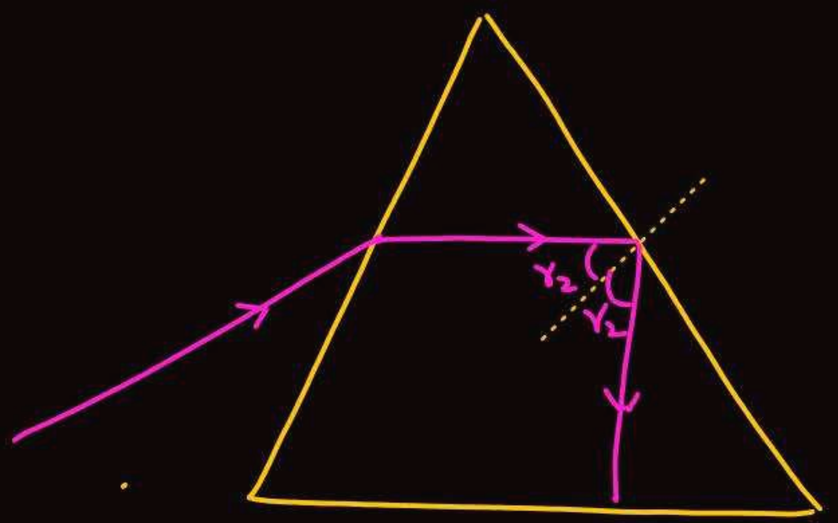
If $r_2 < \theta_c$



$r_2 = \theta_c$

|||

$e = 90°$



$r_2 > \theta_c$

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

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

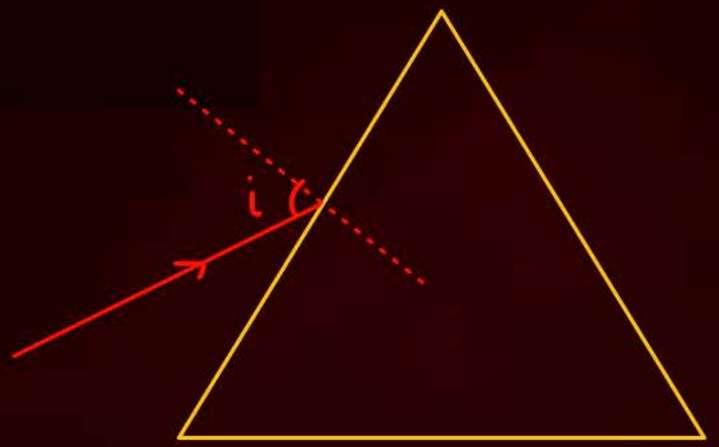
$$1 \cdot \sin i = \mu \sin r_1$$

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

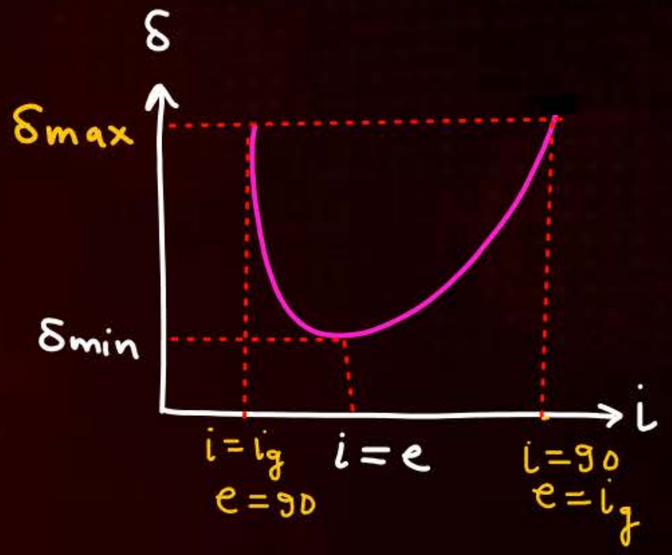
$$e = \sin^{-1}\left[\mu \sin(A - r_1)\right]$$

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

$$e = \sin^{-1}\left[\text{कदद}_2\right]$$



$$\delta = i + \sin^{-1}(\text{कदद}_2) - A$$



* parabola X
* symmetric X

Q

find $\delta_{min} = ?$

Sol^n

$A = 60°$

$\mu = \sqrt{3}$

$r_1 = A/2 = \frac{60}{2} = 30°$

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

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

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

$\sin i = \sqrt{3} \sin 30°$

$i = 60°$

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

Sol^n

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

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

$$\boxed{i = 45^\circ}$$

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

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

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

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

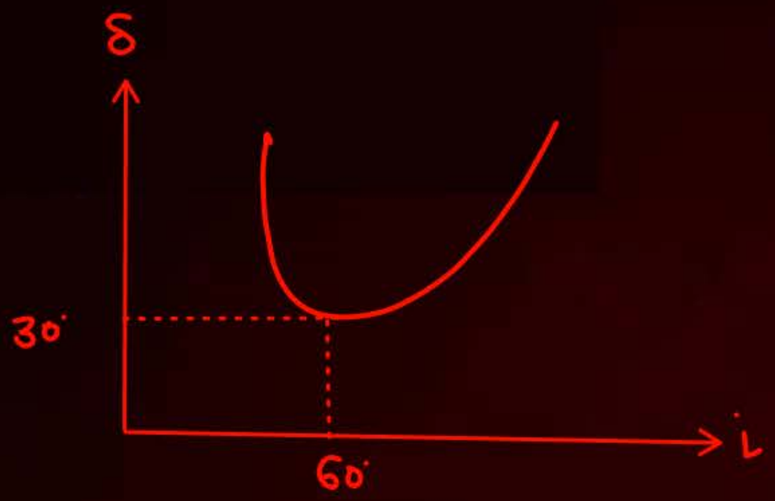
Or

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

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

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

Q find μ of prism



Sol^n

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

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

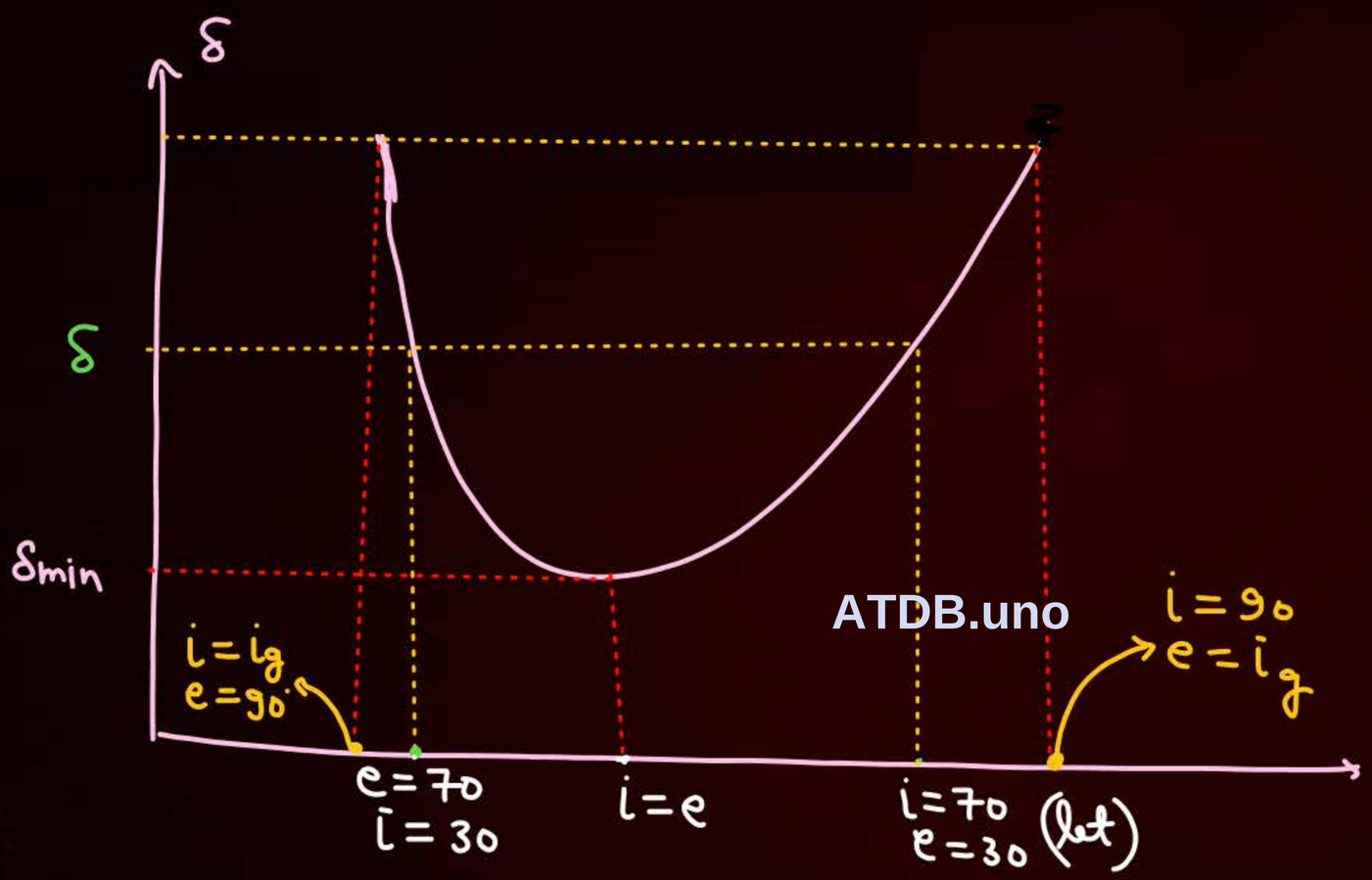
$30 = 2 \times 60 - A$

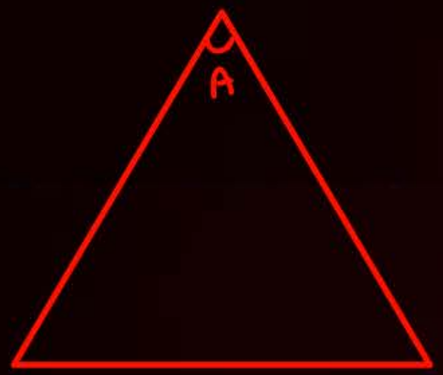
$\boxed{A = 90^\circ} \qquad r_1 = A/2 = 45^\circ$

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

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

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





for min deviation

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

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

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

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

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

Thin lens

$\sin\theta \approx \theta$

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

$$r_1 + r_2 = A$$

* $1 \cdot \sin i = \mu \sin r_1 \longrightarrow i \approx \mu r_1$

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

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

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

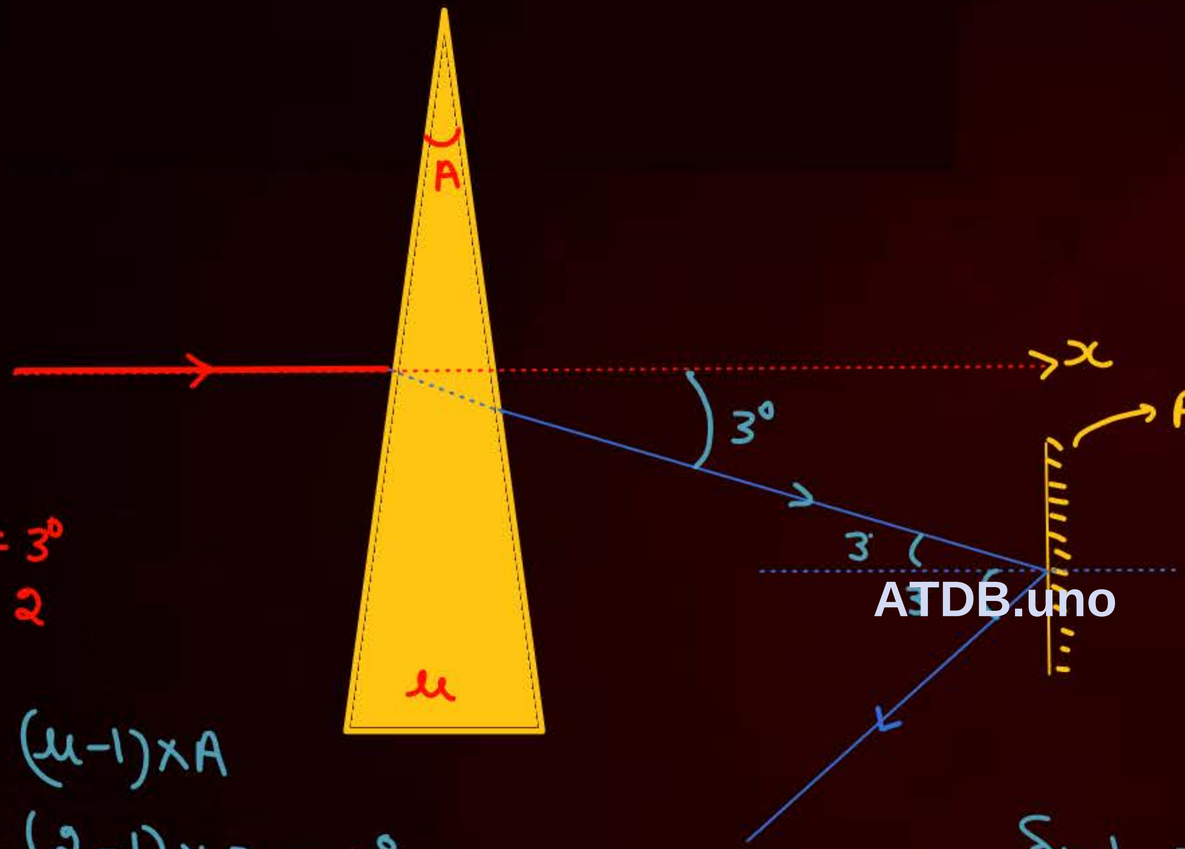
$$\boxed{\delta = (\mu - 1)A}$$

Q

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

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

Q



Along y Axis

$\angle A = 3°$

$\mu = 2$

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

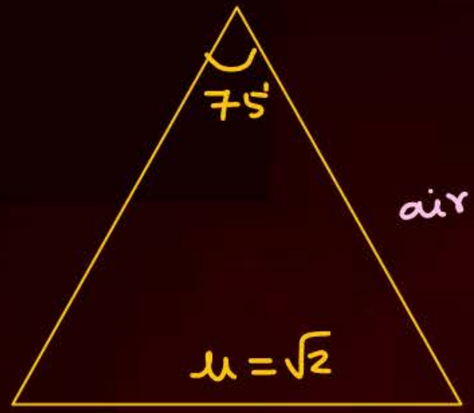
$= (2-1) \times 3 = 3°$

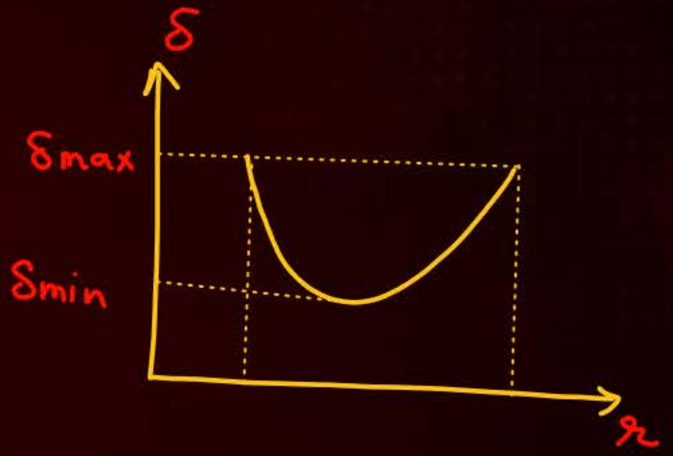
$\delta_{by\ mirror} = 180 - 2i$

$= 180 - 2 \times 3° = 174°$

$\delta_{net} = 3° + 174° = 177°$ (cw)

Q Find max deviation





Soln $\delta_{max} \equiv i = i_g \quad e = 90°$

$r_2 = \theta_c = 45°$

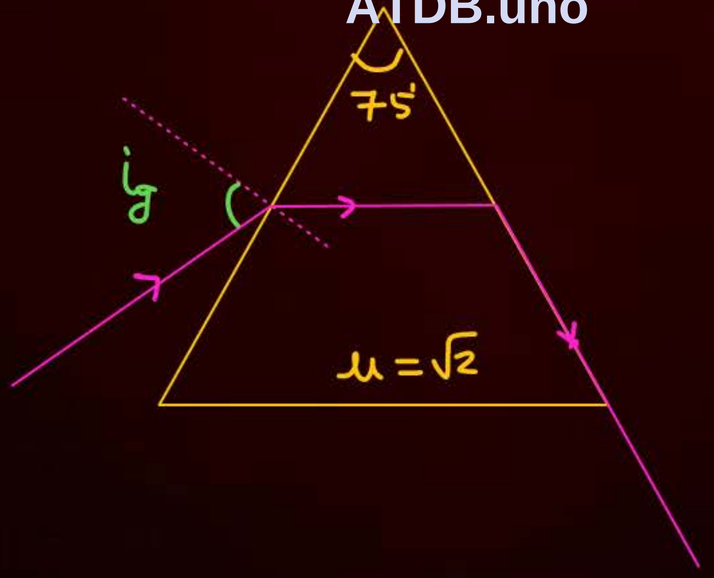
$r_1 = 75 - 45 = 30°$

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

$i = i_g = 45°$

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

$= 45 + 90 - 75° = 60°$



$r_1 + r_2 = A$,

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

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

$\delta = i + e - A$

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

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

$\delta_{max} \Rightarrow i = i_g$, $e = 90^\circ$ or $e = i_g$, $i = 90^\circ$

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

Thin lens

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

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

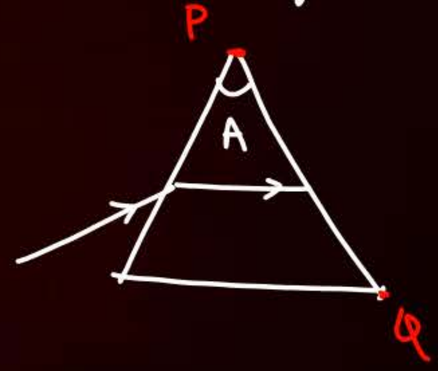
$h = d \tan \delta$

thin prism

$\because \Delta$

$A > 2\theta_c$ All Rays TIR At PQ

$A < \theta_c$ All out through PQ



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

Soln

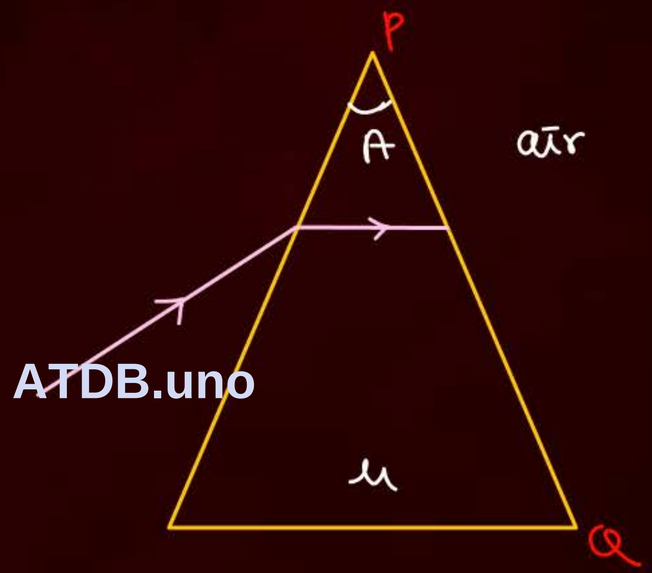
$$A > 2\theta_c$$

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

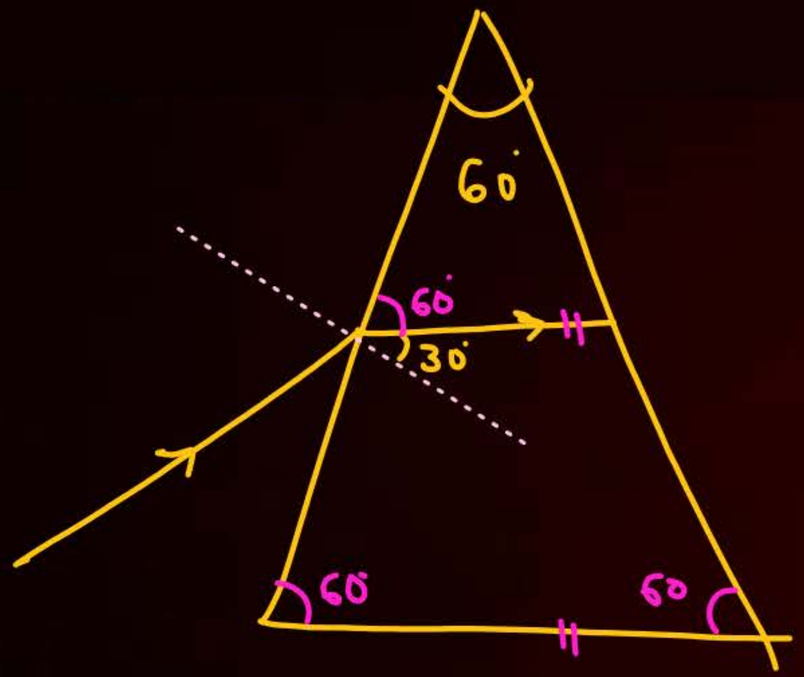
$$\sin\frac{A}{2} > \sin\theta_c$$

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

$$\boxed{\mu > \text{Cosec } A/2}$$



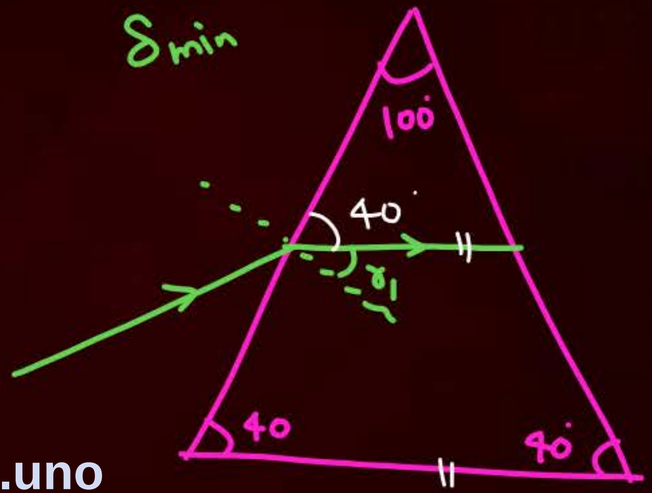
δ_{min} Equilateral



$r_1 = A/2 = 30°$

isosceles

δ_{min}

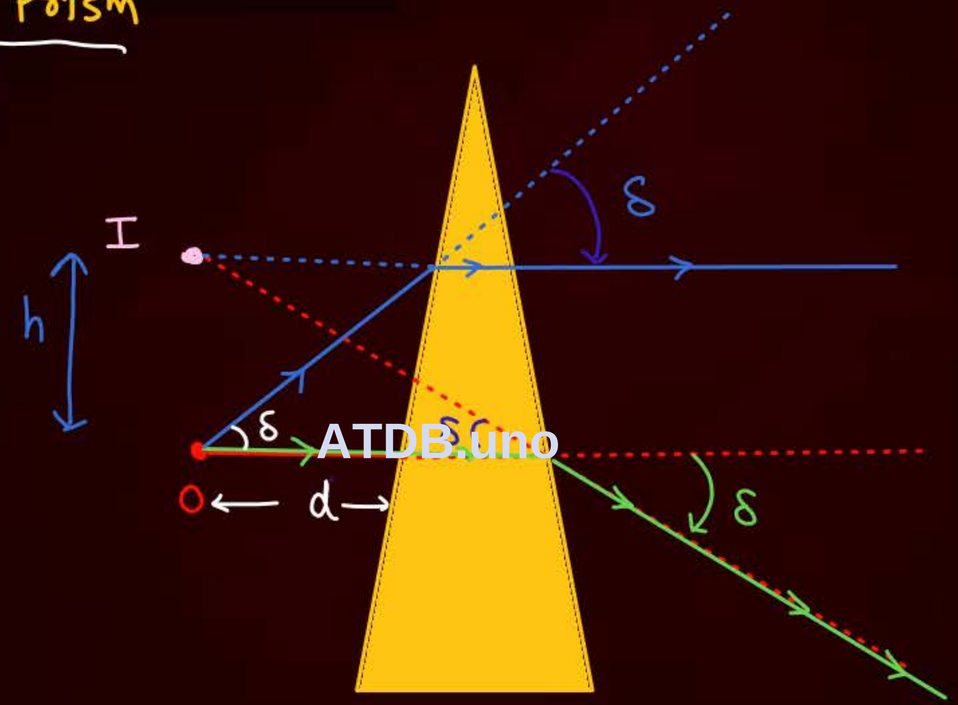


$r_1 = \frac{100}{2} = 50$

Image formed by thin Prism

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

$$h = d\tan\delta$$



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

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