

PRAYAS

JEE 2025



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Lecture - 02

Physics

Wave optics - 02



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Topics *to be covered*

1

Interference

2

YDSE

3

4

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$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \phi$$

$$I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 \equiv C \cdot I \Rightarrow \Delta x = n\lambda$$

$$I_{\min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 \equiv D \cdot I \Rightarrow \Delta x = (\text{odd}) \frac{\lambda}{2}$$

$$\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$$

If

$$I_1 = I_2 = I_0 \Rightarrow I_{\max} = 4I_0 \equiv C \cdot I$$

$$I_{\min} = 0 \Rightarrow D \cdot I$$

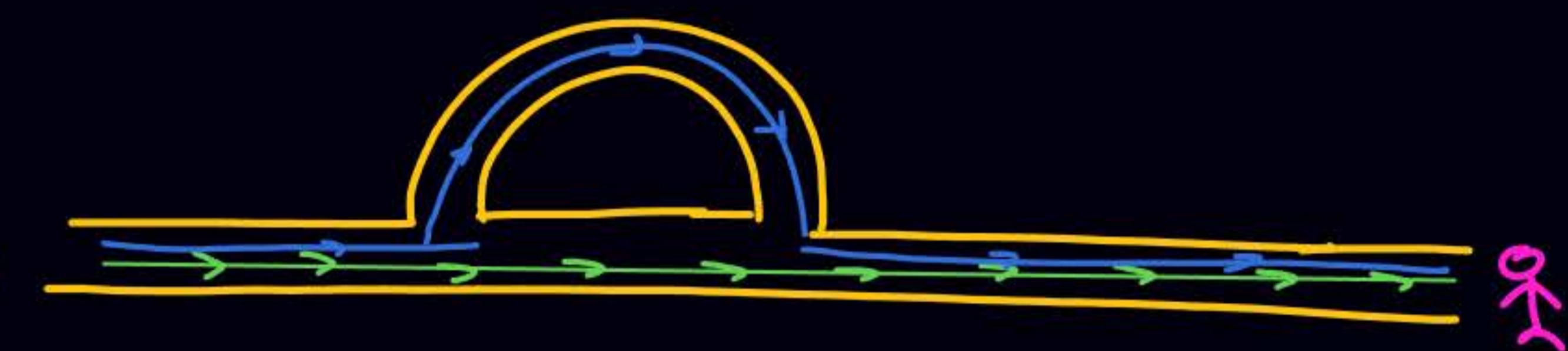
$$I = 4I_0 \cos^2(\phi/2)$$

If source are incoherent

$$I = I_1 + I_2$$



Q
sound



find λ so that we observe
(D.I) (minima)

$$\Delta x = \pi R - 2R = (\text{odd}) \frac{\lambda}{2} \text{ (minima)}$$
$$= n\lambda \text{ (maxima)}$$

for D.I $\Rightarrow \lambda = \frac{2(\pi R - 2R)}{(\text{odd})}$

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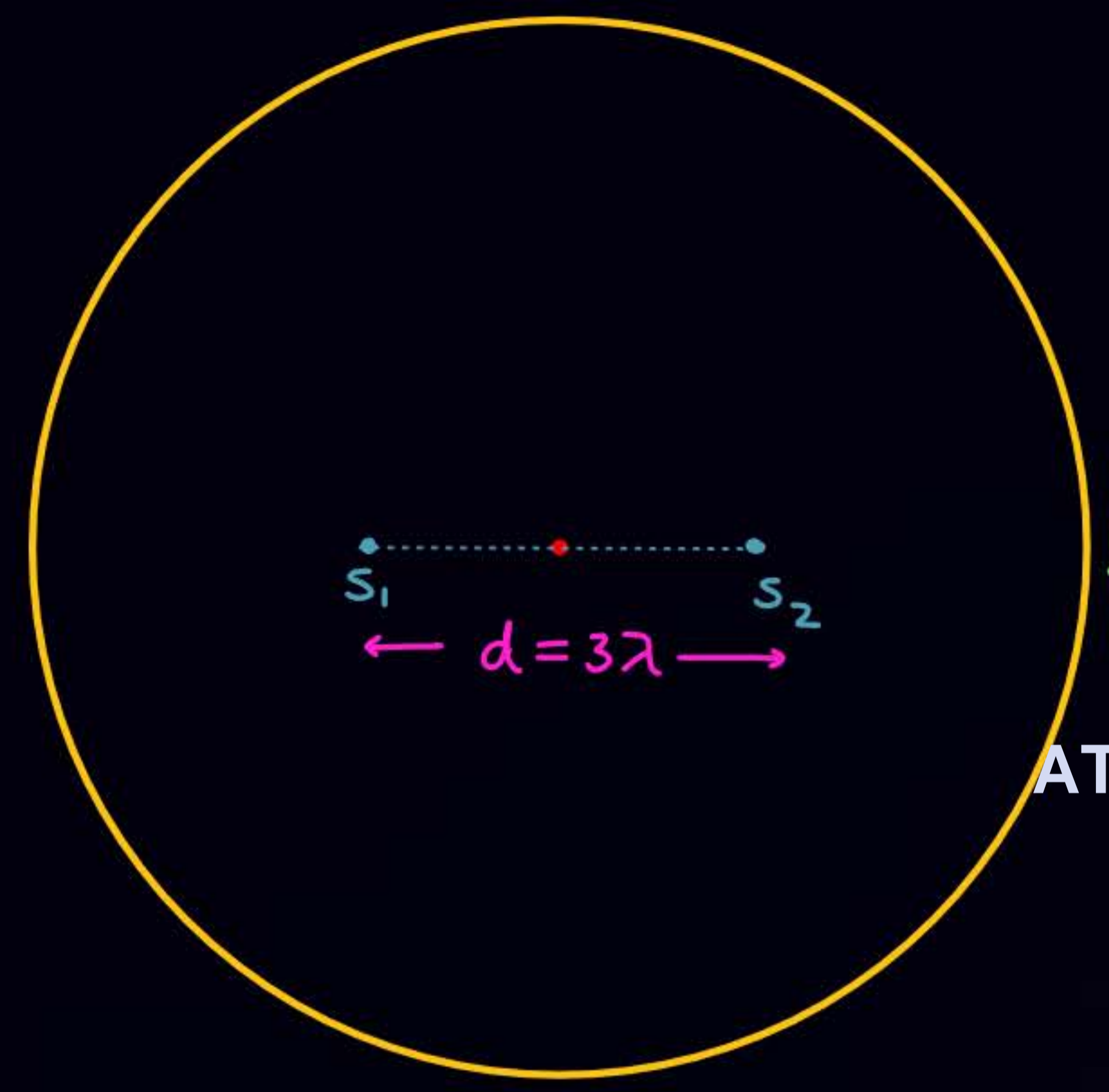
max \rightarrow $= 1$

Cohesent
Sound source
light source
Q



find no. of max & minima formed on
Circular track

Solⁿ



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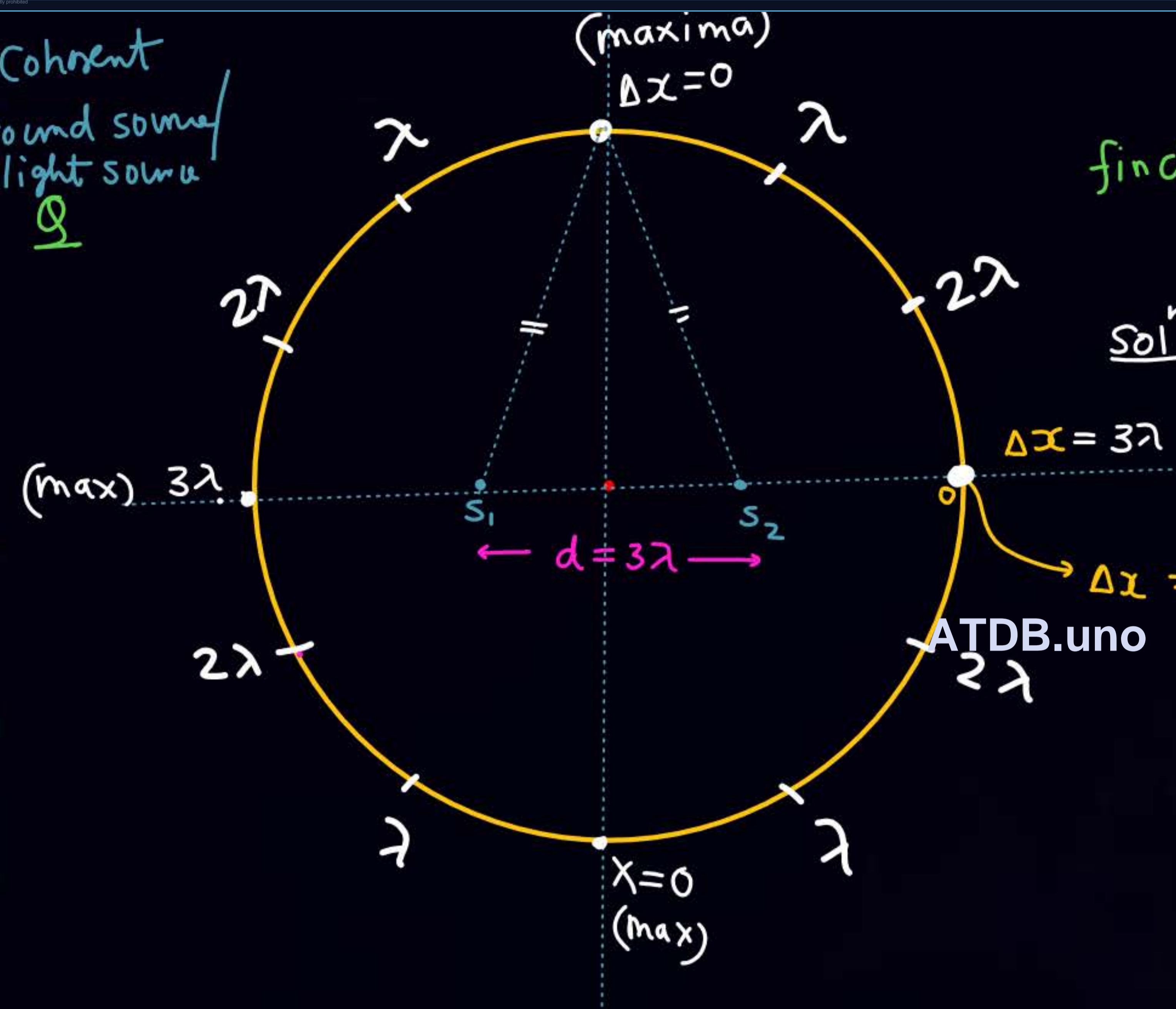


Cohesent
Sound source
light source
Q

find no. of max & minima formed on
Circular track

Solⁿ

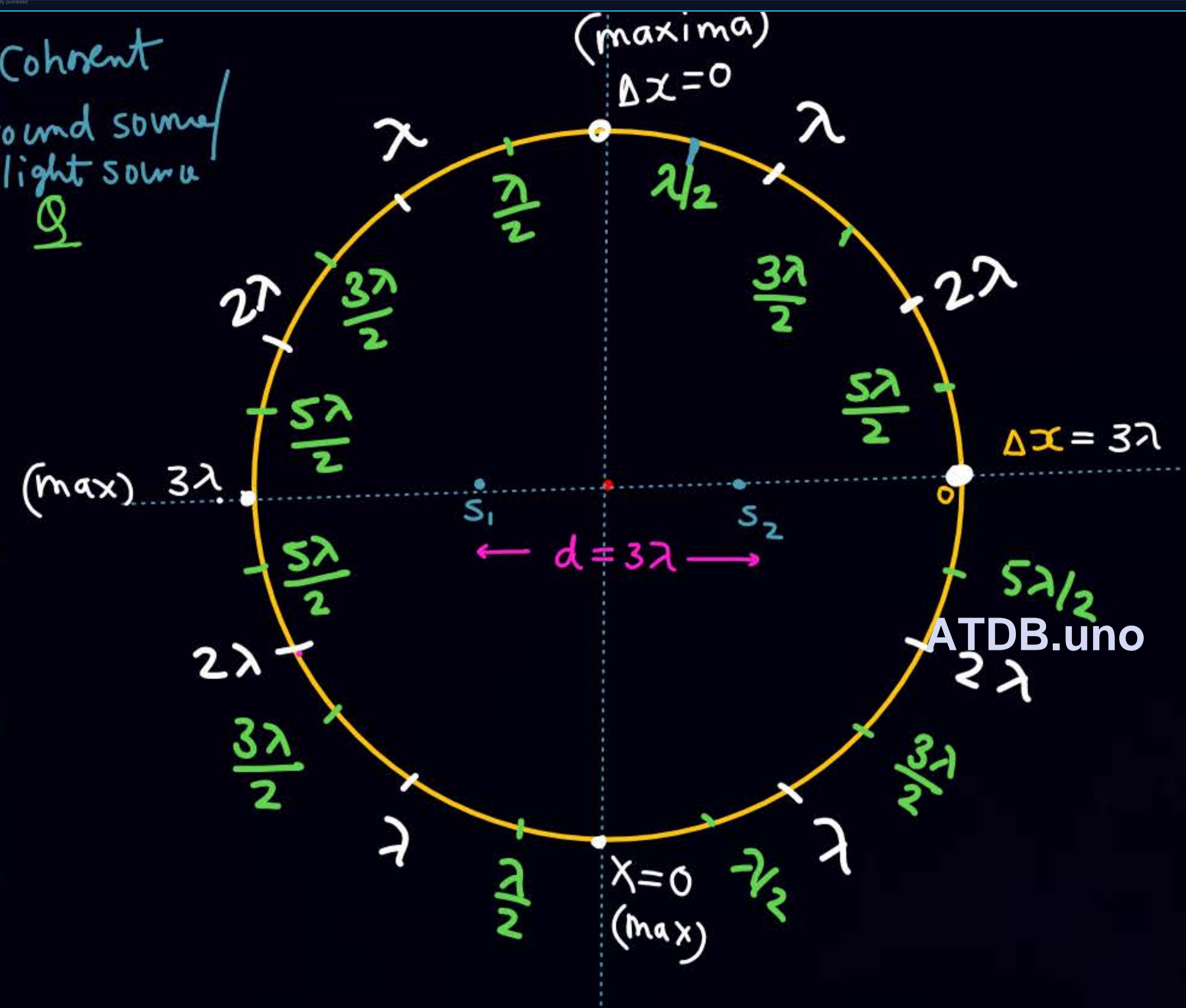
No. of maxima = 12



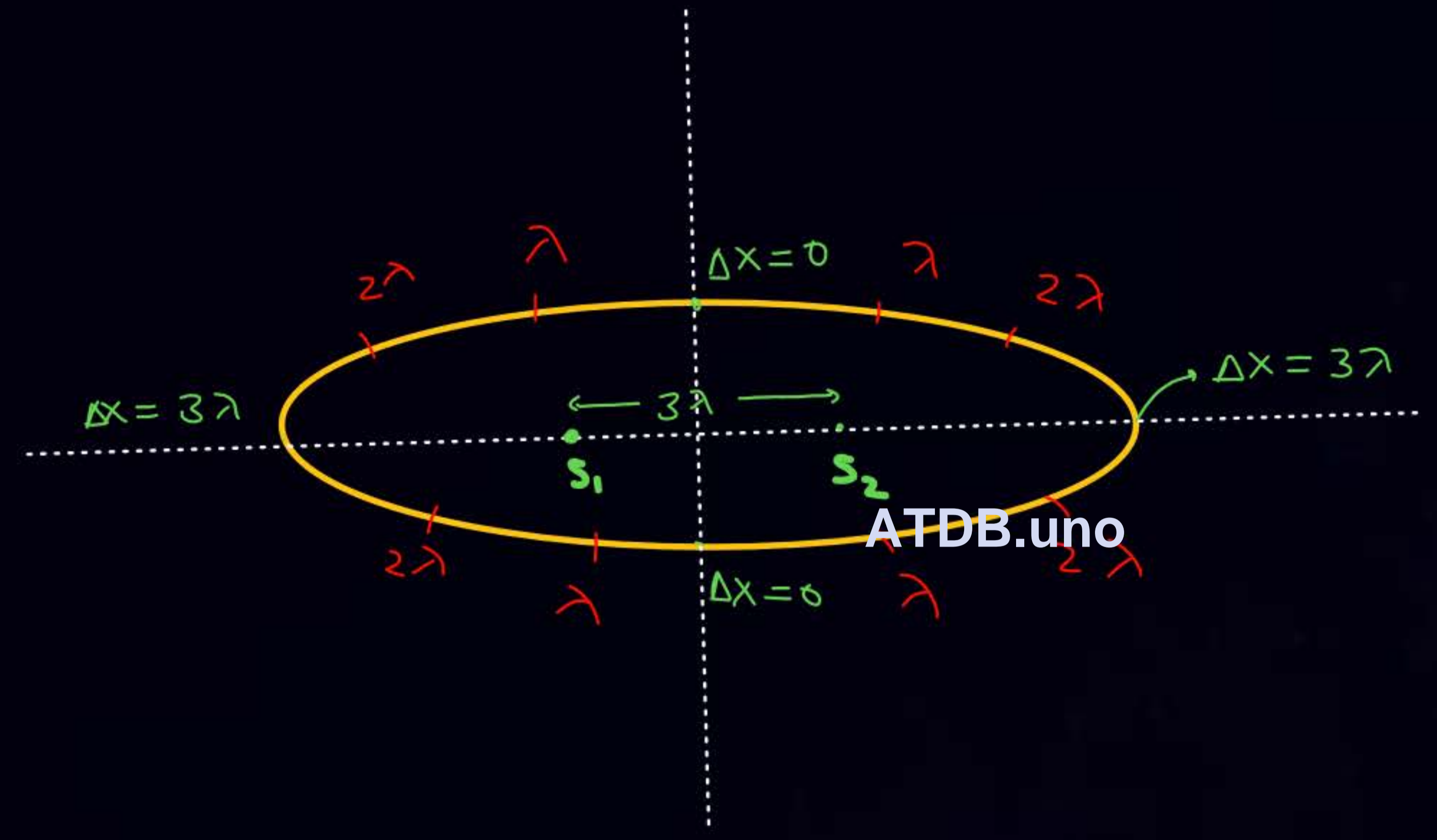
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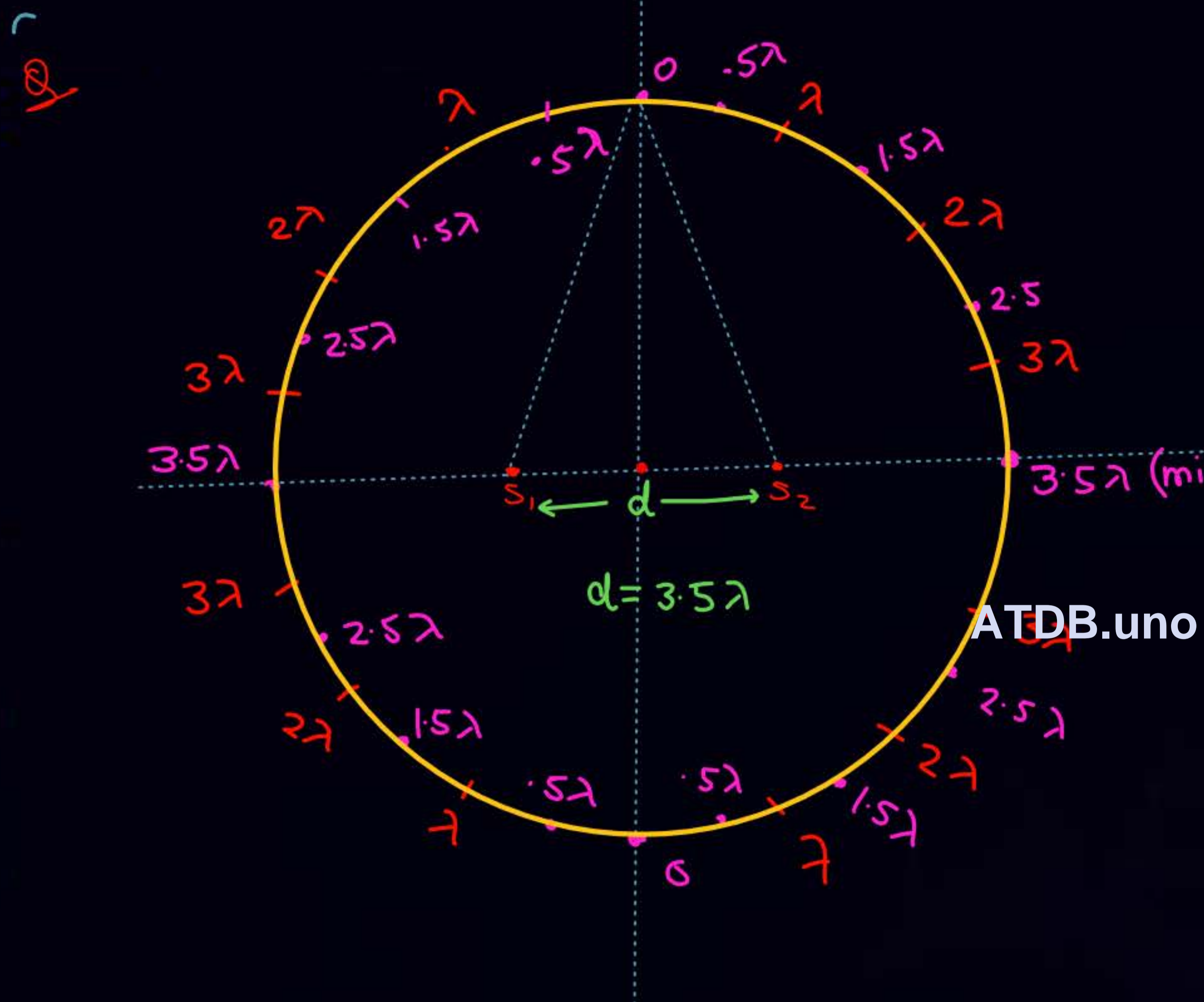
Cohesent
Sound source
light source
Q



No. of maxima = 12
No. of minima = 12



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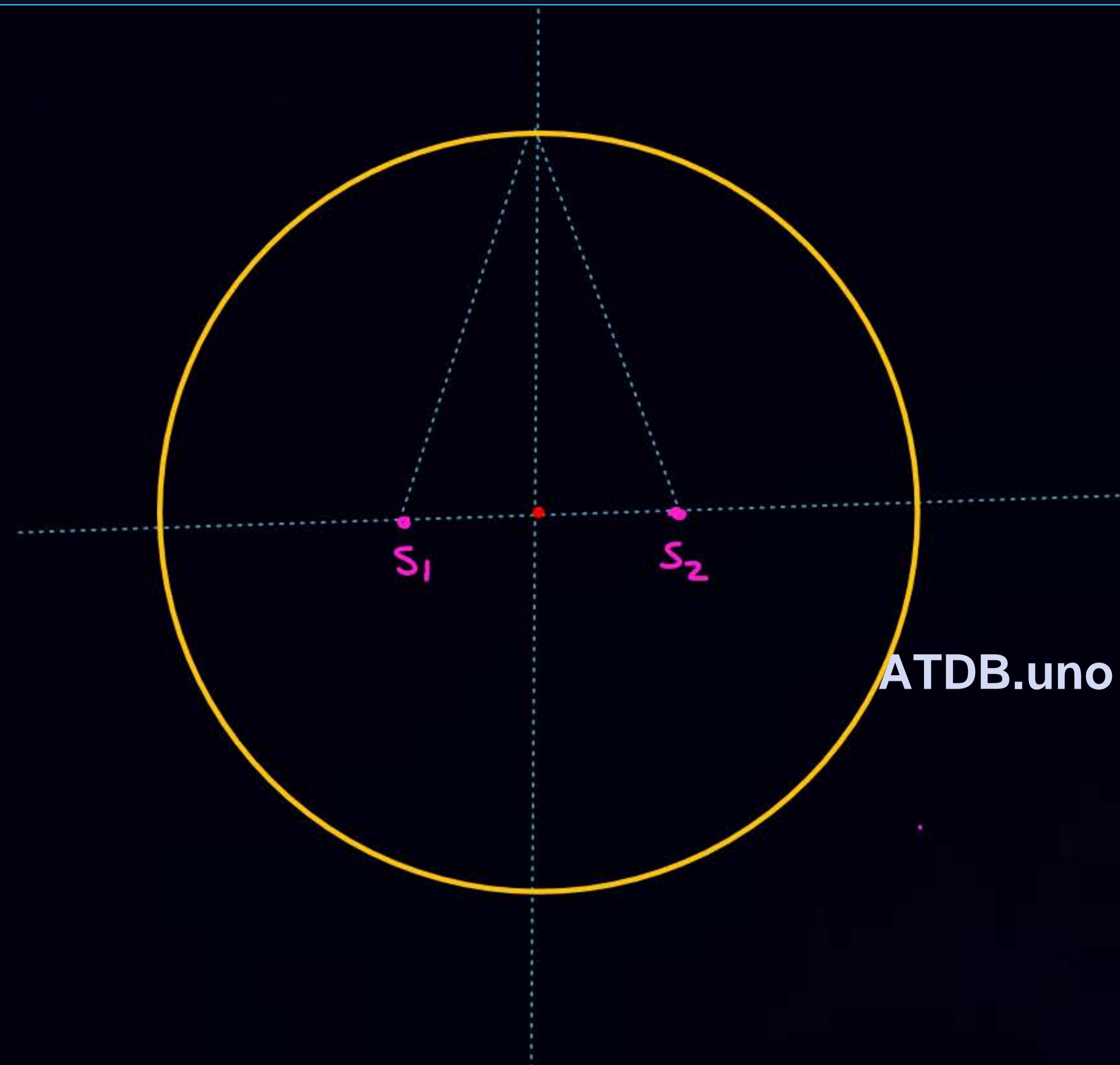


No. of max = 14

No. of min = 14

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Q



	No. of max	No. of min
$d = 3\lambda$	12	12
$d = 3.5\lambda$	14	14
$d = 3.8\lambda$	14	16
$d = 3.2\lambda$	14	12
$d = 4\lambda$	16	16



Q

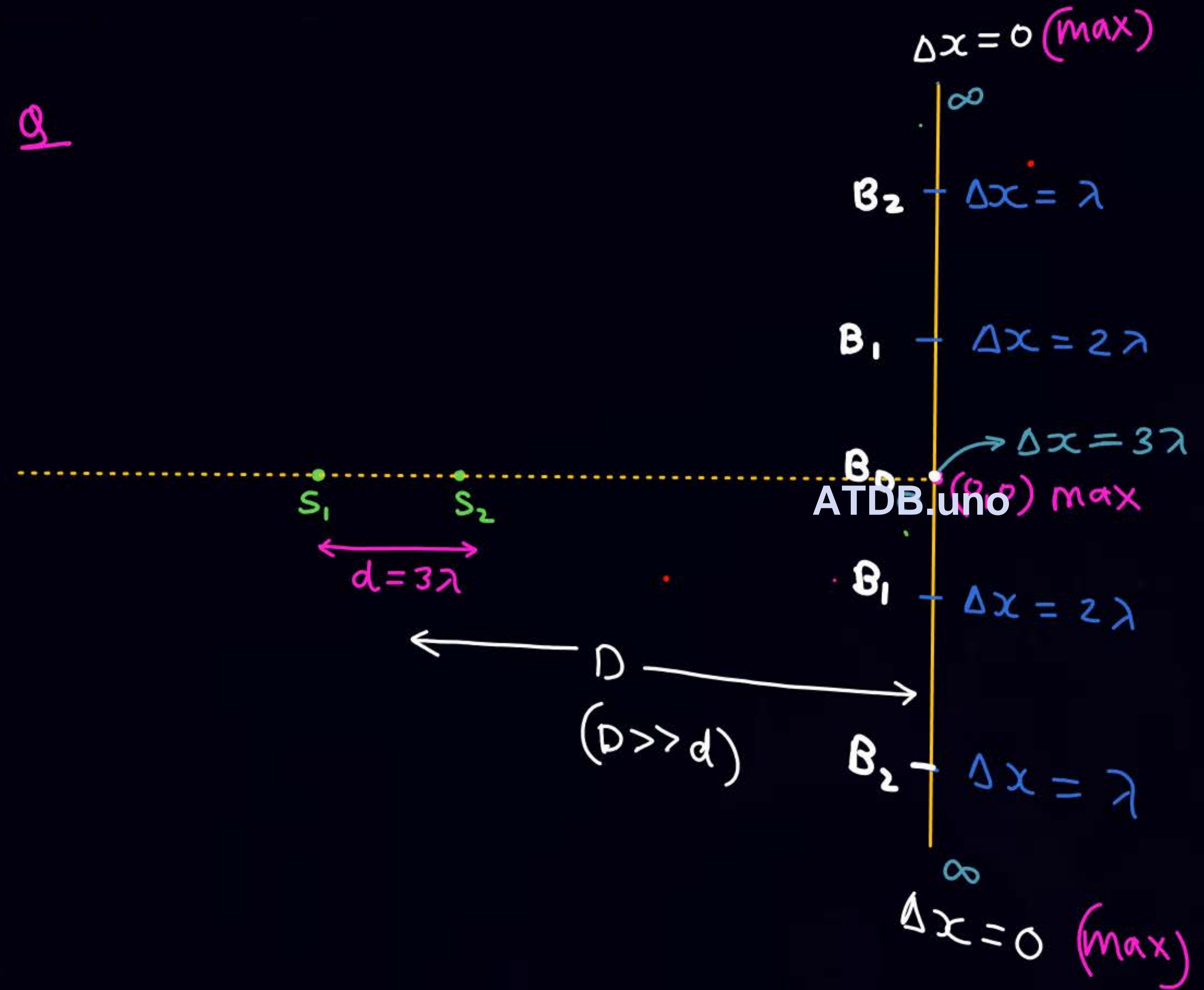


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① No. of maxima & minima formed on screen
 ↳ (Layer)



Q



① No. of maxima & minima formed on screen
 → (Layer) enough
 maxima = 5
 minima = 6



Q find location of a point whose intensity is 75% of max intensity (y_{\min})

Soj $I_{\max} = 4I_0$
 $75\% I_{\max} = 3I_0$

$$I = 4I_0 \cos^2(\phi/2)$$

$$3I_0 = 4I_0 \cos^2(\phi/2)$$

$$\cos^2(\phi/2) = \frac{3}{4}$$

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$$\cos(\phi/2) = \pm \frac{\sqrt{3}}{2}$$

$$\frac{\phi}{2} = 30^\circ, 150^\circ,$$

$$\phi = 60^\circ, 300^\circ$$

$$\phi = \frac{\pi}{3}, \frac{5\pi}{3}$$

$$\Delta x = \frac{\Delta \phi}{2\pi} \cdot \lambda$$

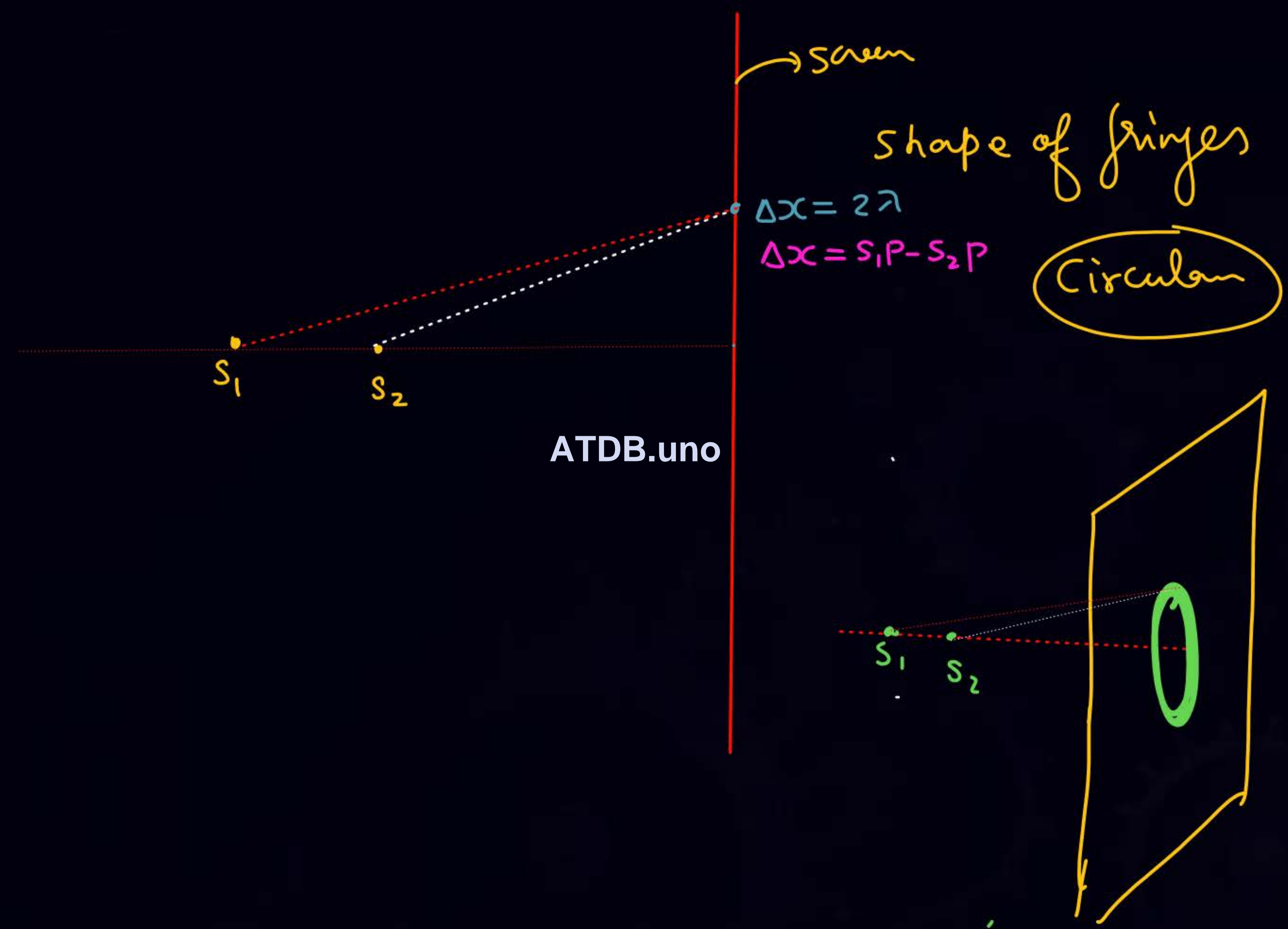
$$\Delta x_1 = \frac{5\pi}{3} \cdot \frac{\lambda}{2\pi} = \frac{5\lambda}{6}$$

$$\Delta x = d \cos \theta$$

$$\frac{5\lambda}{6} = 3\lambda \cos \theta$$

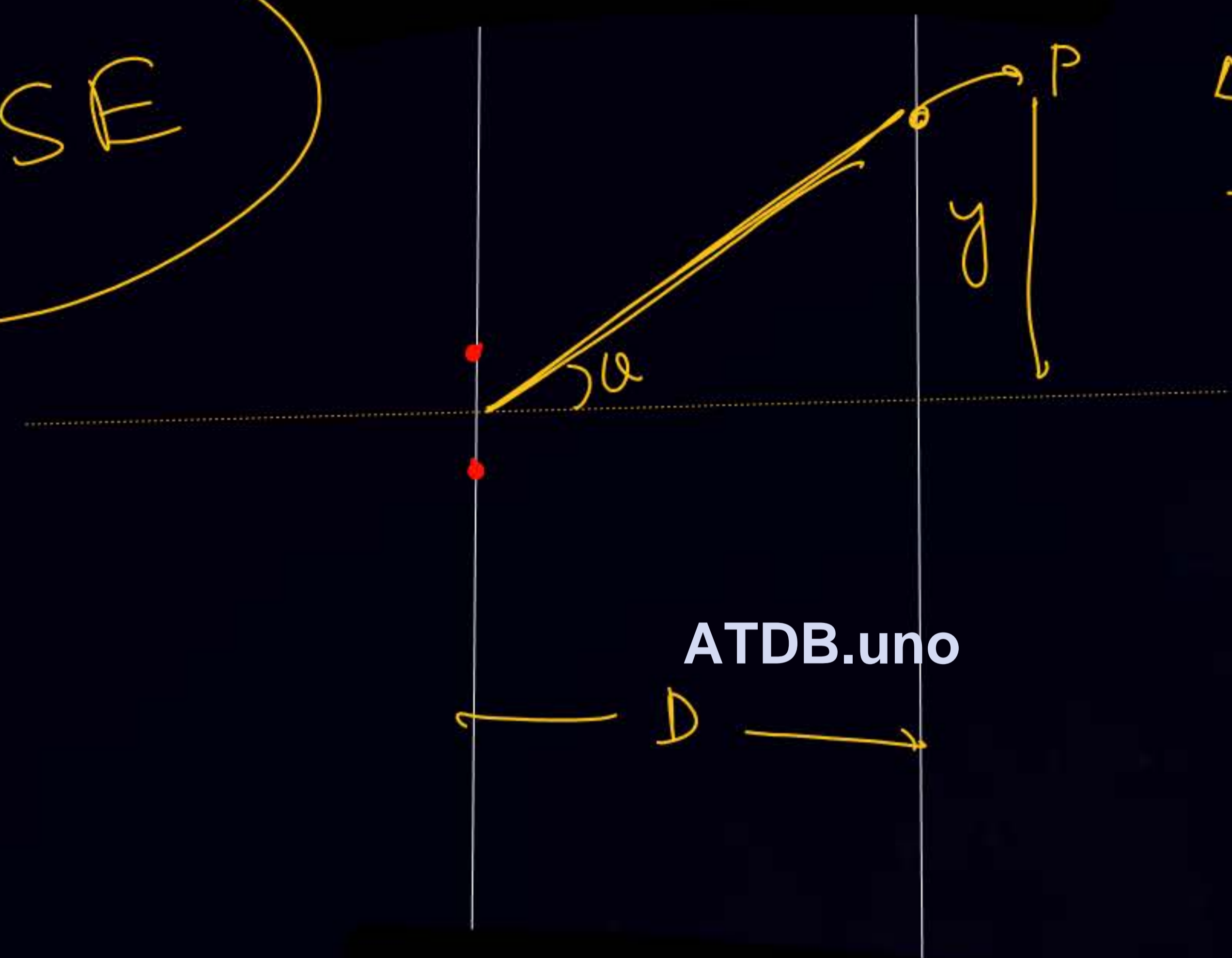
$$\cos \theta = \frac{5}{18}$$

$$\tan \theta = \sqrt{1 - \left(\frac{5}{18}\right)^2} = \frac{y}{D}$$





YDSE



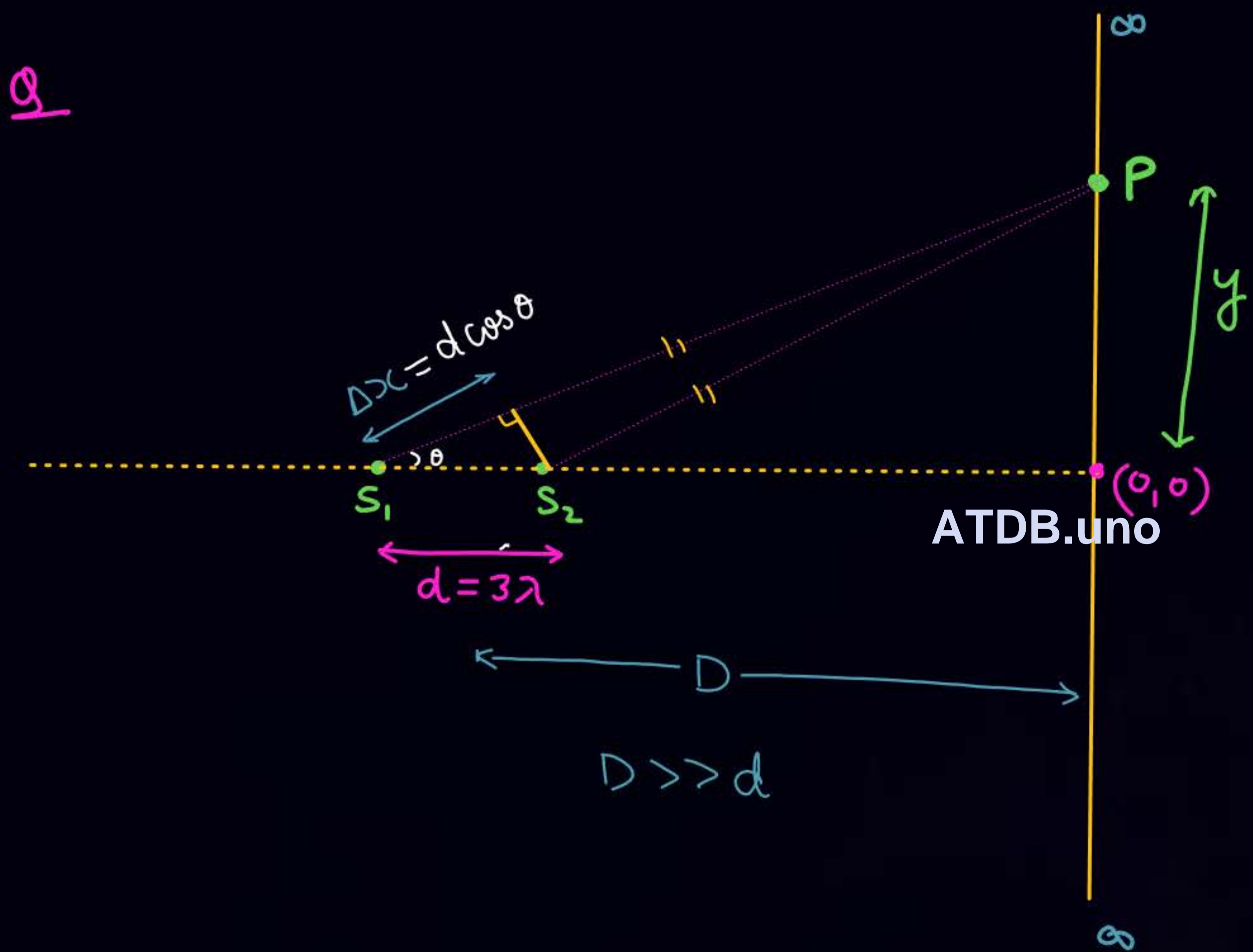
$$\Delta x = \checkmark$$

$$\tan \theta = \checkmark = y/D$$

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Q



At P' $\Delta x = S_1P - S_2P = d \cos \theta$

$$\Delta x = d \cos \theta$$

$$\tan \theta = \frac{y}{D}$$

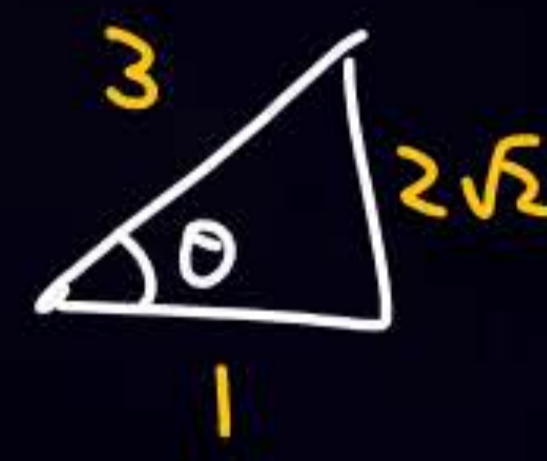
location of 2nd Bright above origin

$$\Delta x = \lambda$$

$$\Delta x = d \cos \theta = \lambda$$

$$3\lambda \cos \theta = \lambda$$

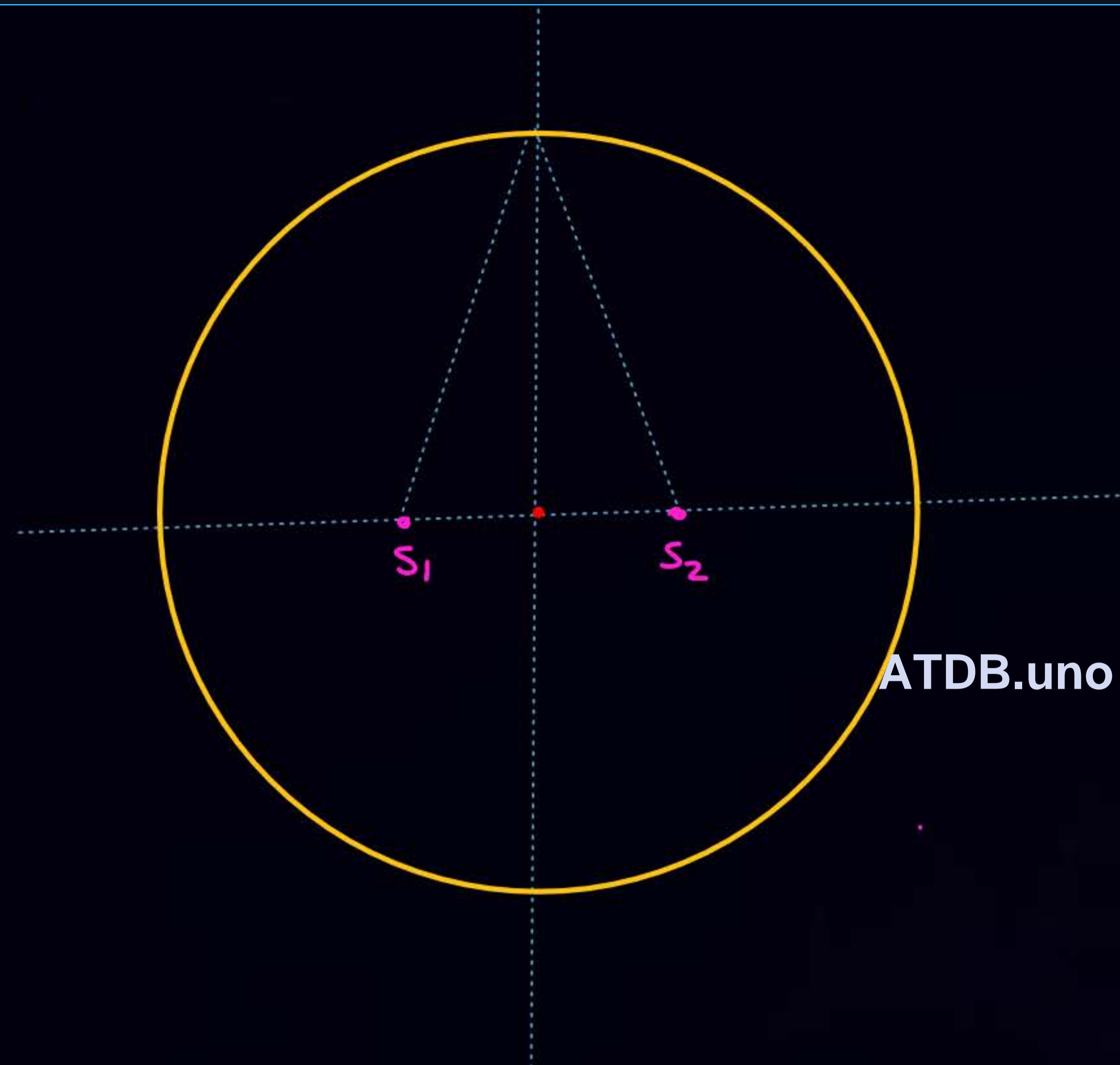
$$\cos \theta = \frac{1}{3}$$



$$y = D \tan \theta = D \frac{2\sqrt{2}}{3}$$

(D = 1m)
let

Q



	No. of max	No. of min
$d = 3\lambda$	12	12
$d = 3.5\lambda$	14	14
$d = 3.8\lambda$	14	16
$d = 3.2\lambda$	14	12
$d = 4\lambda$	16	16



$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \phi$$

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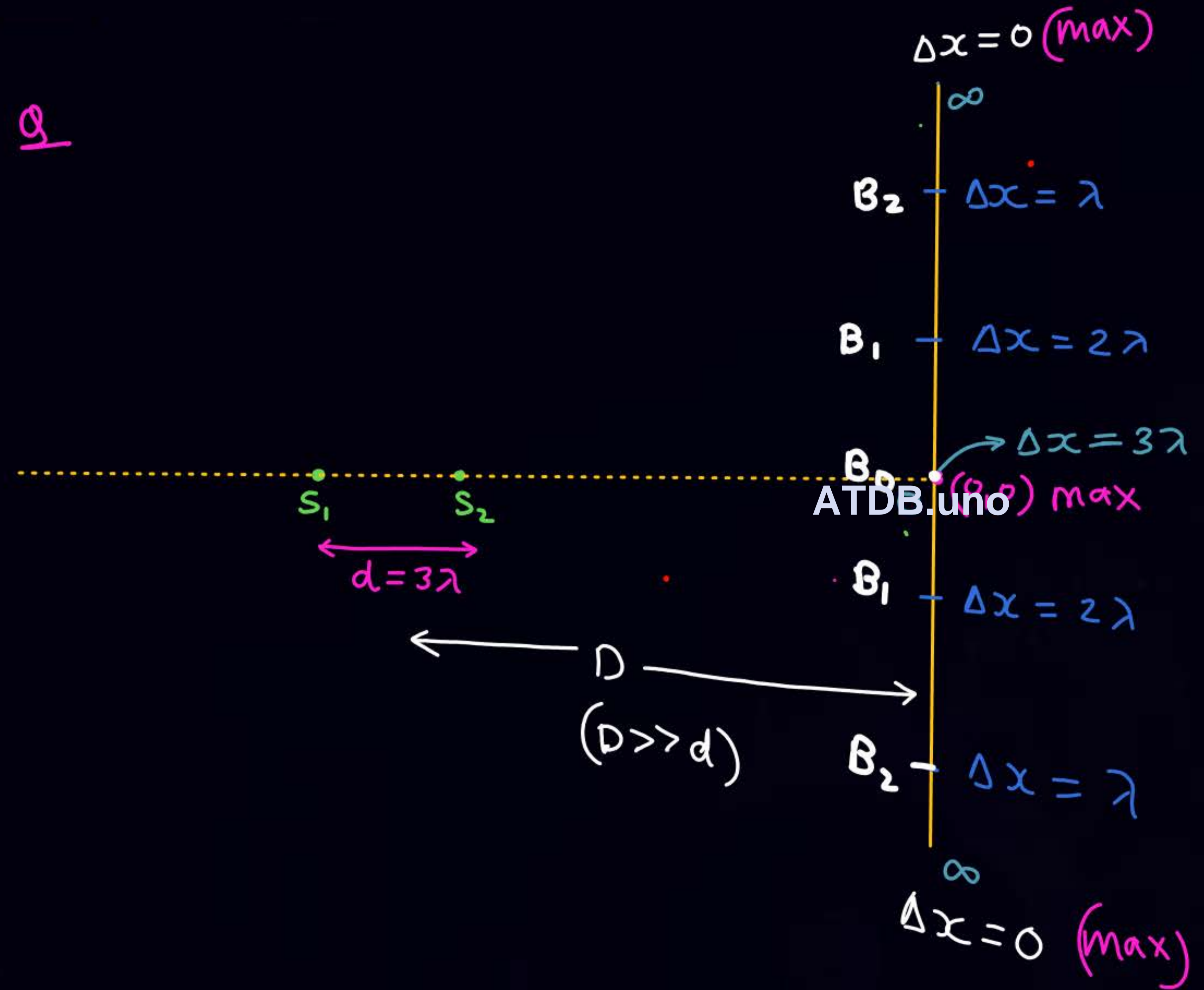
$$I_{\min} = 0 \Rightarrow D \cdot I$$

$$I = 4I_0 \cos^2(\phi/2)$$

If source are incoherent
 $I = I_1 + I_2$



Q



① No. of maxima & minima formed on screen
 → (Layer) enough
 maxima = 5
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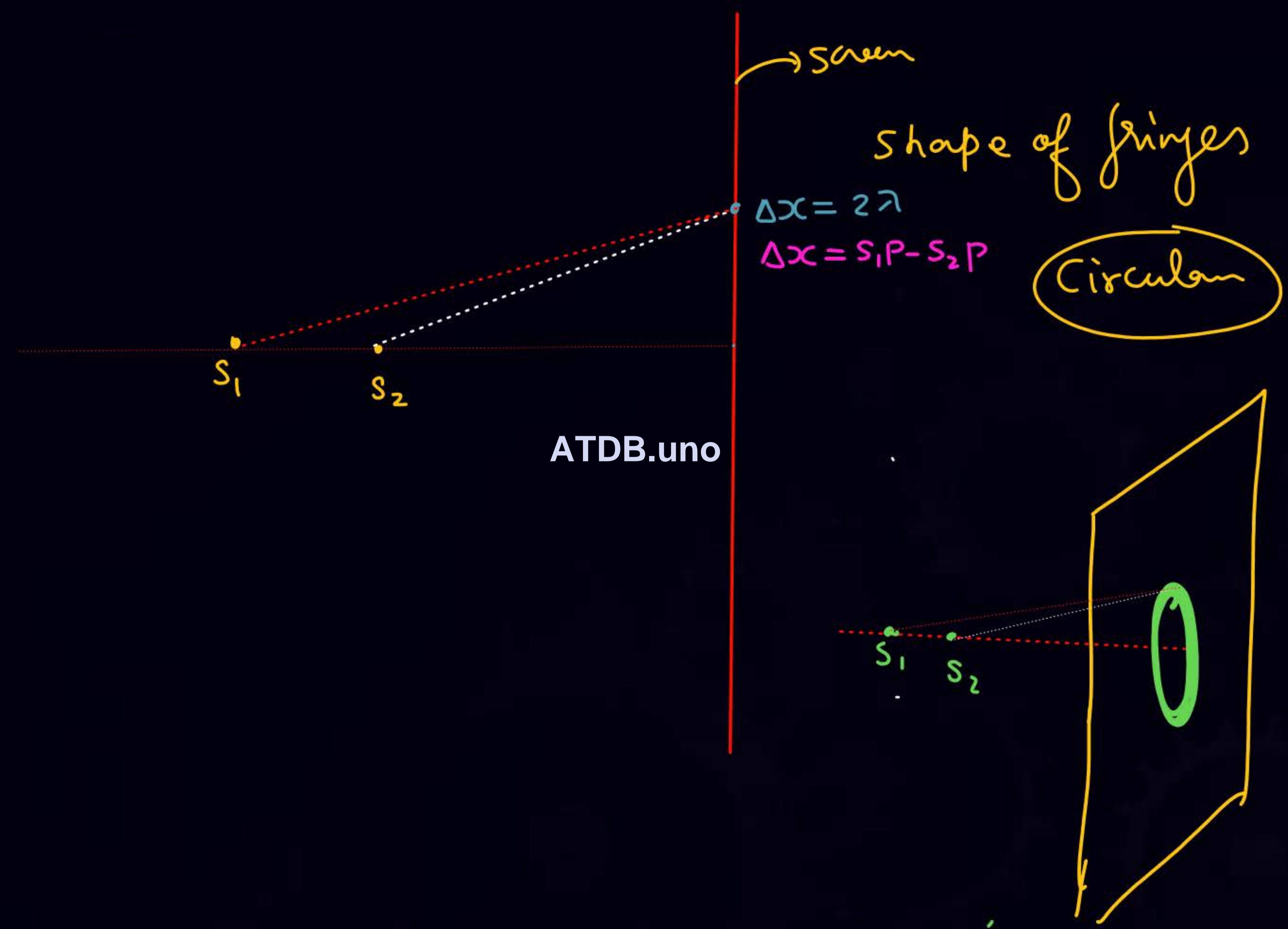
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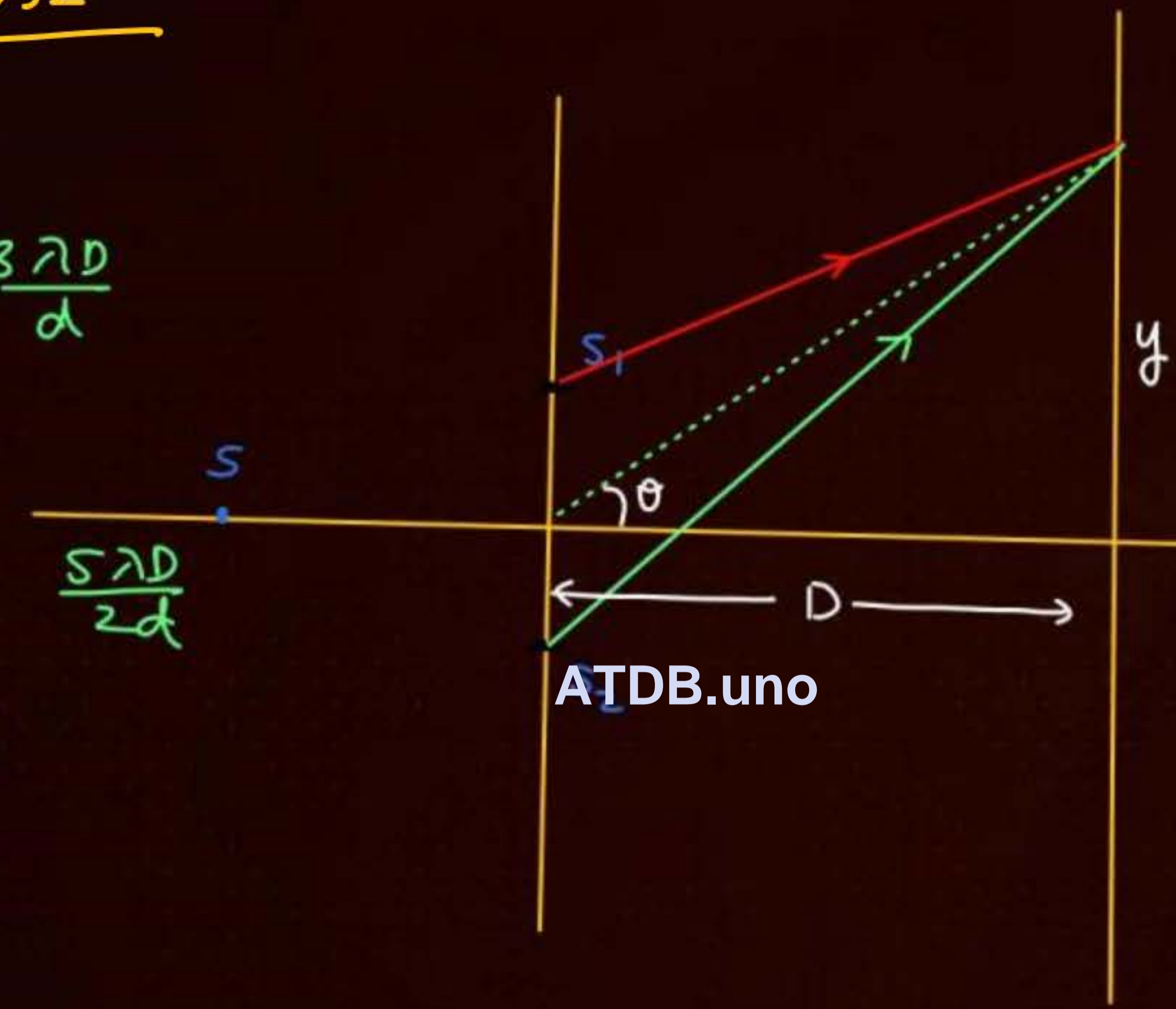
Y DSE

Location of maxima

$$y = \frac{\lambda D}{d} \quad \frac{2\lambda D}{d} \quad \frac{3\lambda D}{d}$$

Location of minima

$$y = \frac{1\lambda D}{2d} \quad \frac{3\lambda D}{2d} \quad \frac{5\lambda D}{2d}$$



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$$\Delta x = d \sin \theta$$

$$\tan \theta = \frac{y}{D}$$

$\theta \rightarrow$ very small

$$\Delta x = d \cdot \frac{y}{D}$$

$$y = \Delta x \frac{D}{d}$$

$$\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$$

$$I_{net} = 4I_0 \cos^2 \left[\frac{\Delta \phi}{2} \right]$$



Q In YDSE exp screen is placed at a distance 1m .
distance b/w two slit S_1 & S_2 is 0.1mm and monochromatic
light of wavelength 400nm is used.

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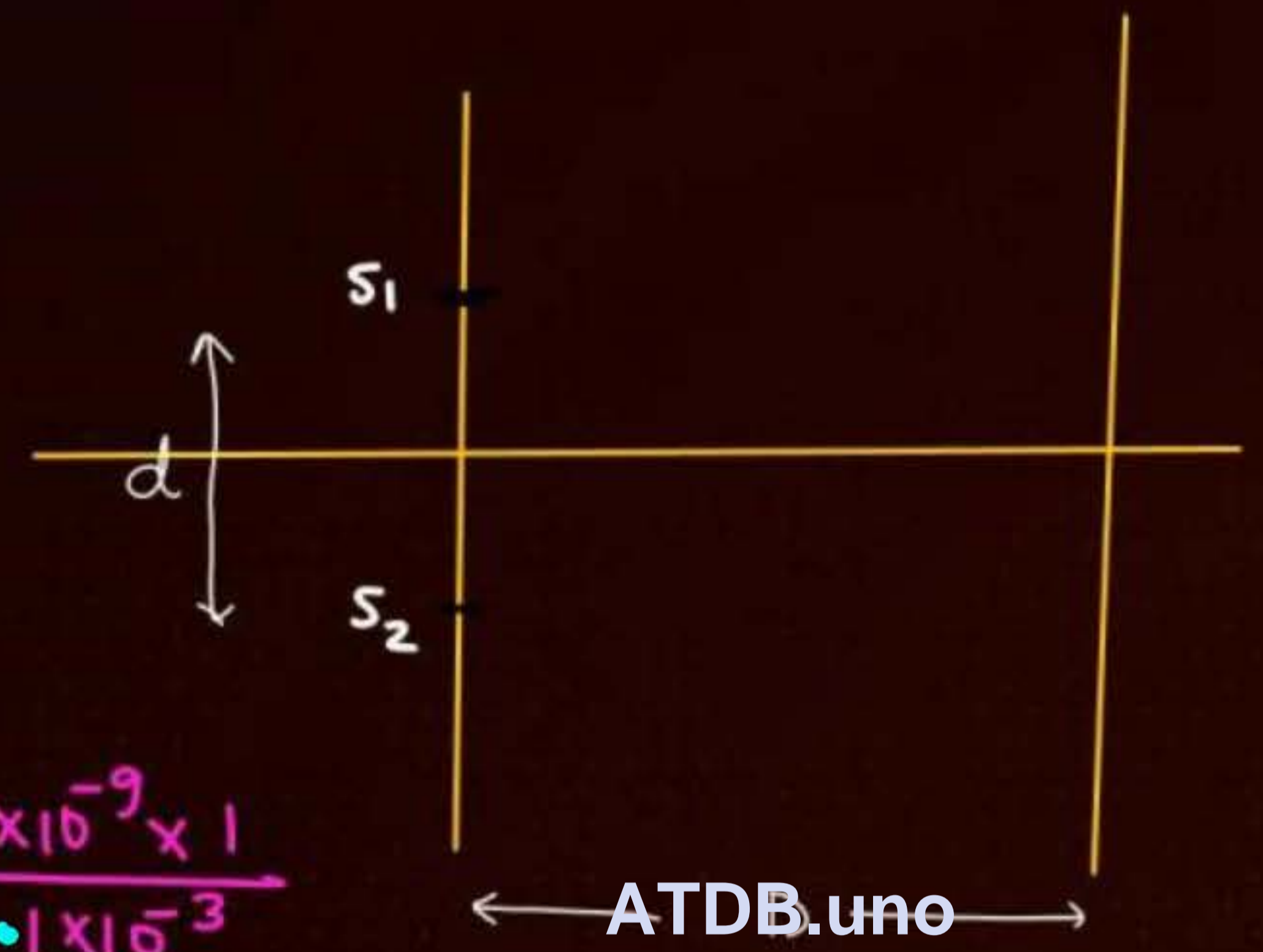


Q $d = 0.1 \text{ mm}$
 $D = 1 \text{ m}$
 $\lambda = 400 \text{ nm}$

find

① fringe width

$$\beta = \frac{\lambda D}{d} = \frac{400 \times 10^{-9} \times 1}{0.1 \times 10^{-3}} = 4 \text{ mm}$$

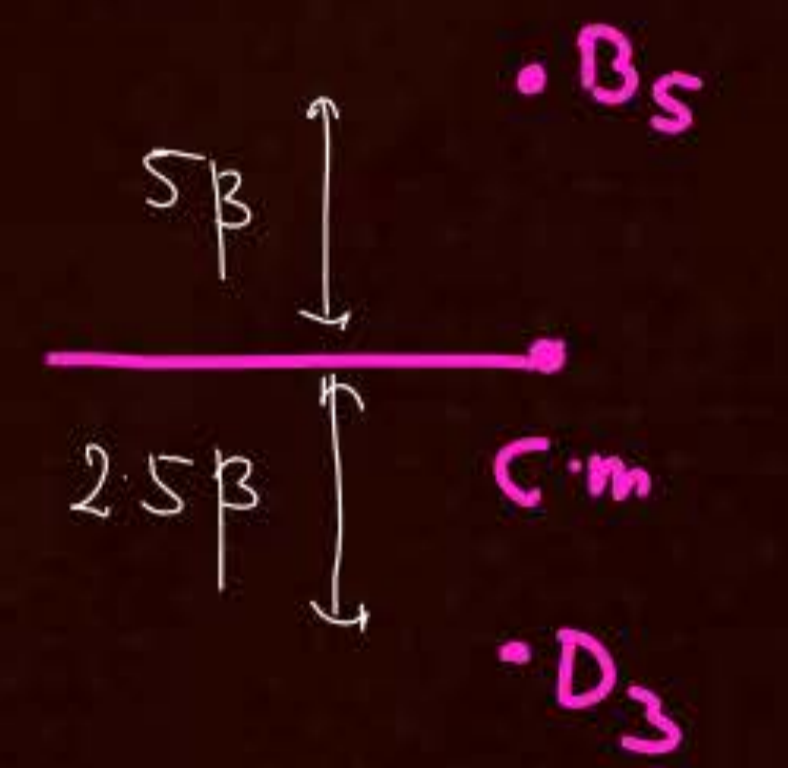


③ Gap b/w 5th max above C.m & 3rd min below C.m.

$$= 5\beta + 2.5\beta = 7.5\beta$$

$$= 7.5 \times 4 \text{ mm}$$

$$= \underline{30 \text{ mm}}$$



② Location of 9th Bright above C.m $\Rightarrow B_9 = 9 \lambda D / d = 36 \text{ mm}$

" " 7th Dark " C.m $\Rightarrow D_7 \Rightarrow 6.5 \frac{\lambda D}{d} = 6.5 \times 4 = 26 \text{ mm}$

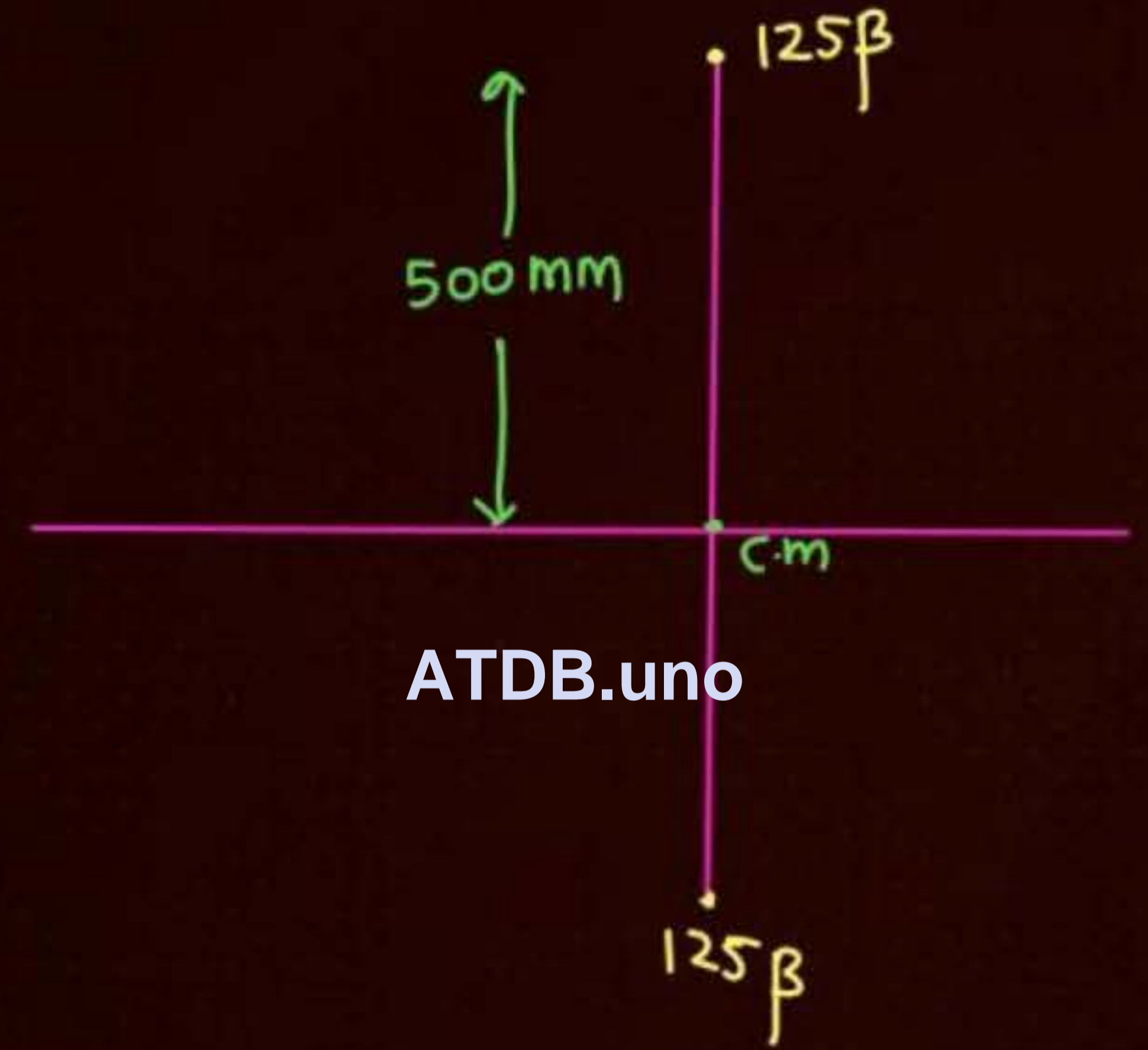
③ ⑥ Angular width $= \alpha \approx \frac{\lambda}{d} = \frac{400 \times 10^{-9}}{1 \times 10^{-4}}$



④ find no. of max & min if screen length is 1m.

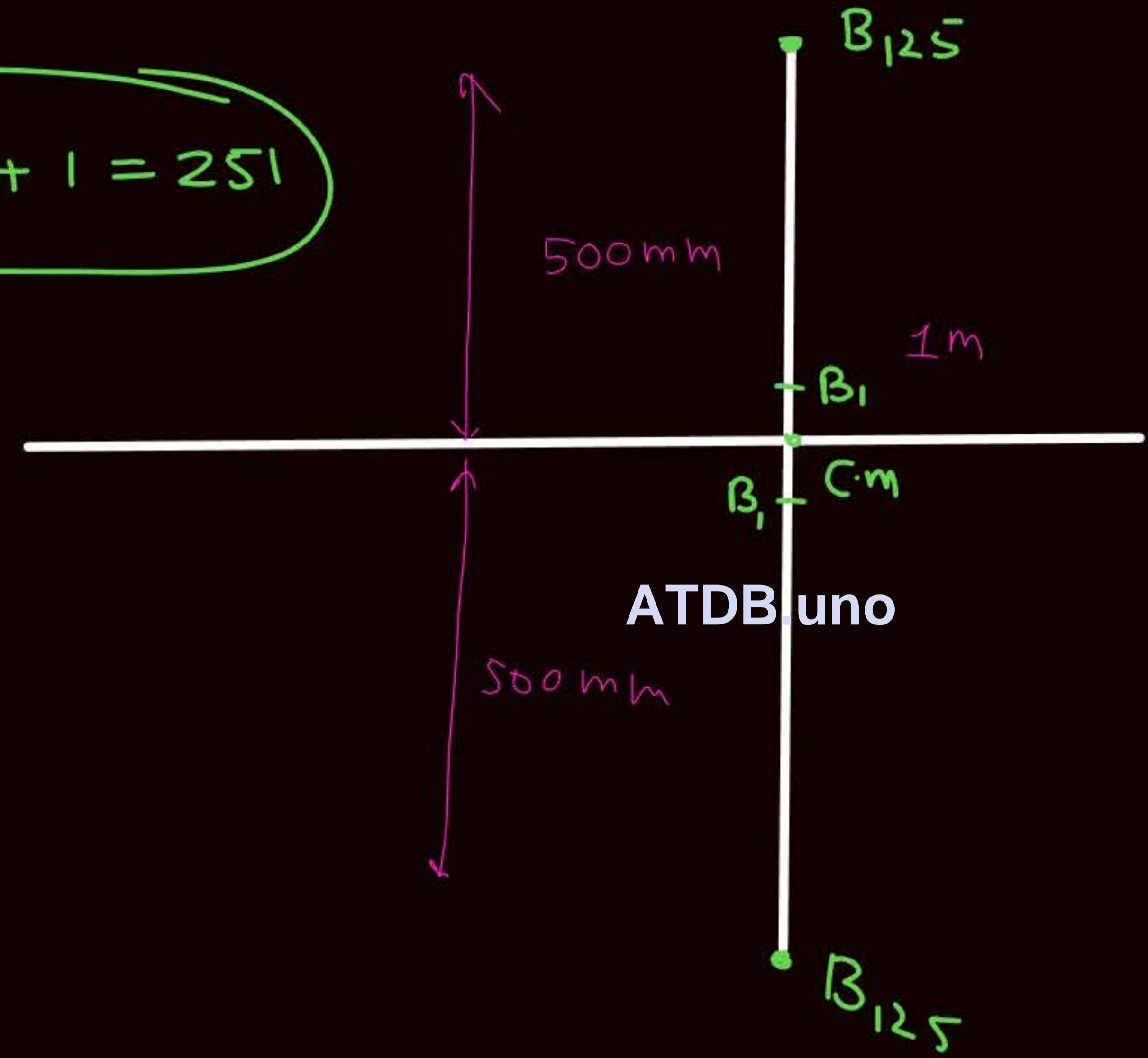
$\beta = 4\text{mm}$

$\Rightarrow 125 + 125 + 1 = 251$





$$125 + 125 + 1 = 251$$



$$\beta = 4\text{mm}$$



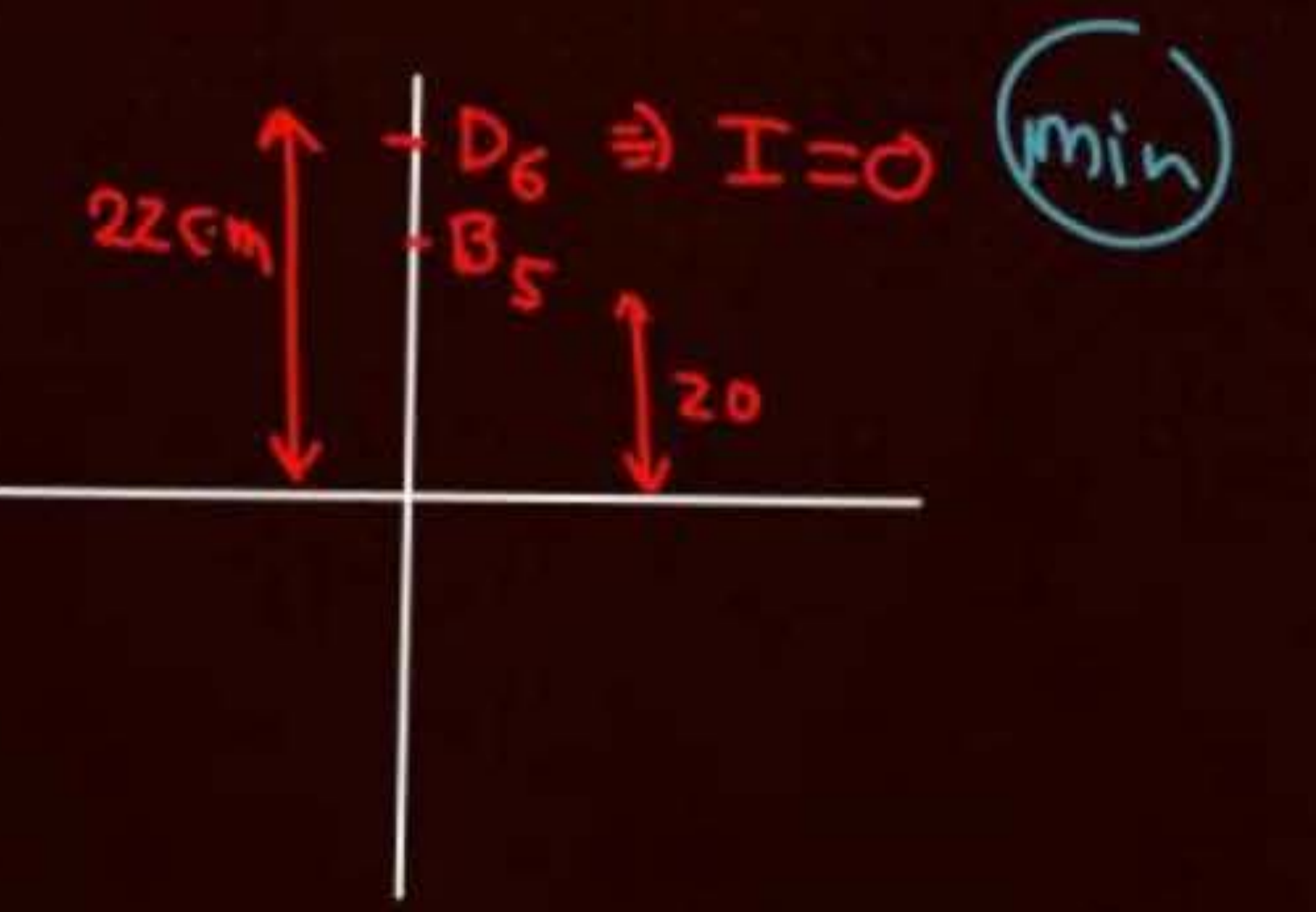
⑤ find Intensity at a point 16mm above C.m.

$\beta = 4\text{mm}$



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⑤ find Intensity at a point 22mm above C.m.



Q find location of points when Intensity is half of the max intensity



$$I = 4I_0 \cos^2(\phi/2)$$

$$2I_0 = \frac{4I_0}{2} = 4I_0 \cos^2(\phi/2)$$

$$\cos(\phi/2) = \pm \frac{1}{\sqrt{2}}$$

$$\frac{\phi}{2} = 45, 135, 225, \dots$$

$$\phi = 90, 270, 450$$

$$\phi = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \frac{7\pi}{2}, \dots$$

$$\Delta x = \checkmark$$

$$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$$

$$\Delta x_1 = \frac{\lambda}{2\pi} \left(\frac{\pi}{2} \right) = \frac{\lambda}{4}$$

$$\Delta x_2 = 3\lambda/4 - - -$$

$$\Delta x = d \cdot \frac{y}{D}$$

$$y = \Delta x \cdot \frac{D}{d}$$

$$y_1 = \frac{\lambda}{4} \frac{D}{d} = \frac{\beta}{4} = 1 \text{ mm}$$

$$y_2 = 3 \text{ mm}$$

Q find location of points when Intensity is half of the max intensity



$$I = 4I_0 \cos^2(\phi/2)$$

$$2I_0 = \frac{4I_0}{2} = 4I_0 \cos^2(\phi/2)$$

$$\cos(\phi/2) = \pm \frac{1}{\sqrt{2}}$$

$$\frac{\phi}{2} = 45, 135, 225, \dots$$

$$\phi = 90, 270, 450$$

$$\phi = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}, \frac{7\pi}{2}, \dots$$

$$\Delta x = \checkmark$$

$$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$$

$$\Delta x_1 = \frac{\lambda}{2\pi} \left(\frac{\pi}{2} \right) = \frac{\lambda}{4}$$

$$\Delta x_2 = 3\lambda/4 - - -$$

$$\Delta x = d \cdot \frac{y}{D}$$

$$y = \Delta x \cdot \frac{D}{d}$$

$$y_1 = \frac{\lambda}{4} \frac{D}{d} = \frac{\beta}{4} = 1 \text{ mm}$$

$$y_2 = 3 \text{ mm}$$

* Q find location of points when Intensity is 75% of the max intensity



$3I_0$

$$I_{max} = 4I_0$$

$$75\% \text{ of } I_{max} = 3I_0$$

$$\Delta x = \frac{\Delta \phi}{2\pi} \cdot \lambda$$

$$y = \Delta x \cdot \frac{D}{d}$$

$$I = 4I_0 \cos^2(\phi/2)$$

$$3I_0 = 4I_0 \cos^2(\phi/2)$$

$$\frac{3}{4} = \cos^2(\phi/2)$$

$$\cos(\phi/2) = \pm \frac{\sqrt{3}}{2}$$

$$\Delta \phi/2 = 30^\circ, 150^\circ, 210^\circ, \dots$$

$$\Delta \phi = 60^\circ, 300^\circ, 420^\circ, \dots$$

$$\Delta \phi \equiv \frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \dots$$

$$\Delta x = \frac{\pi \lambda}{3 \cdot 2\pi}, \frac{5\pi \lambda}{3 \cdot 2\pi}$$

$$\Delta x \equiv \frac{\lambda}{6}, \frac{5\lambda}{6}, \dots$$

$$y \Rightarrow \frac{\lambda D}{6d}, \frac{5\lambda D}{6d}$$

$$y \Rightarrow \beta/6, 5\beta/6,$$

$$y = \frac{2}{3} \text{ mm}, \frac{10}{3} \text{ mm}$$

* Q find location of points when Intensity is 25% of the max intensity

$$I_0 = 4I_0 \cos^2 \phi/2$$

$$\cos \phi/2 = \pm \frac{1}{2}$$





50% $I = 4I_0 \cos^2 \phi/2$

$2I_0 = 4I_0 \cos^2 \phi/2$

$\cos \phi/2 = \pm \frac{1}{\sqrt{2}}$

$\phi/2 = 45', 135', \dots$

$\phi = 90', 270' \dots$

$\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$

$\Delta x_1 = \frac{\lambda}{2} \cdot \frac{1}{2\pi} = \frac{\lambda}{4\pi}$

$\Delta x_2 = \frac{3\lambda}{4}$

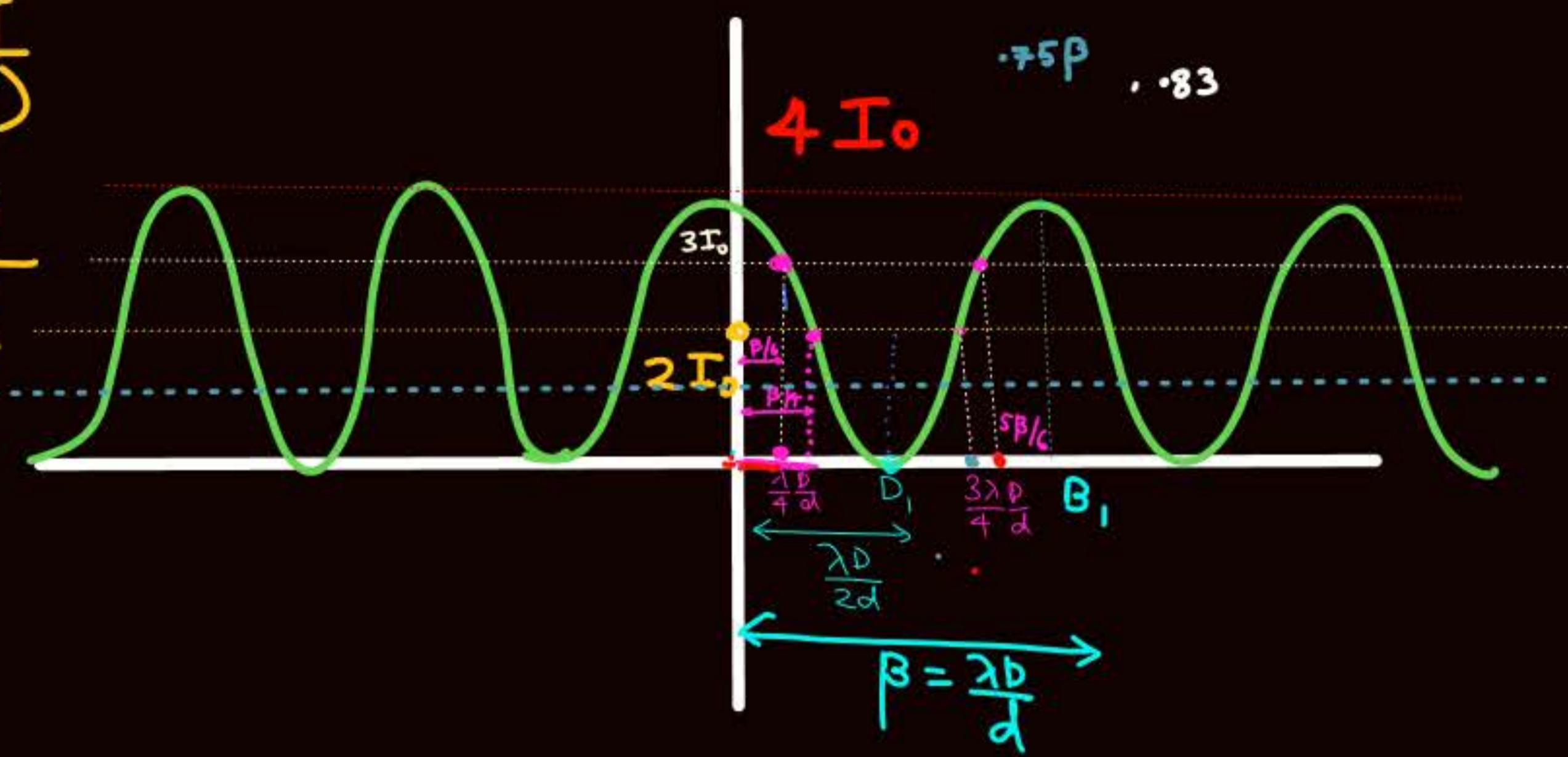
$\Delta x = d \cdot \frac{y}{D}$

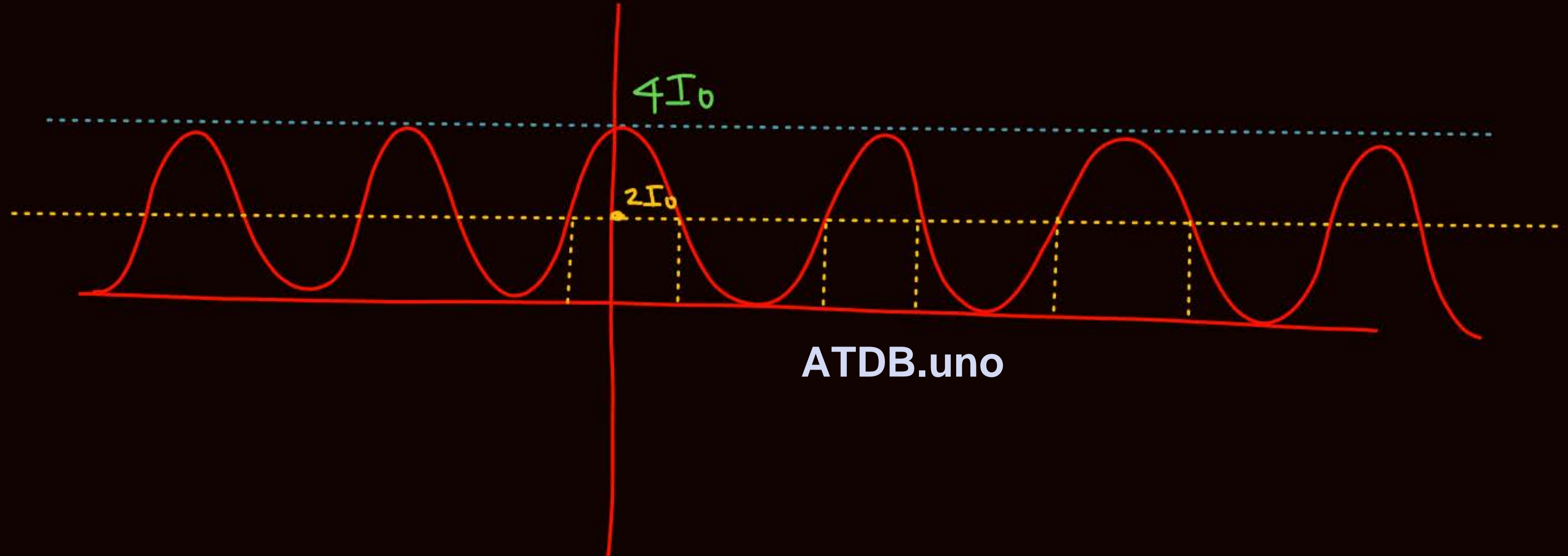
$y = \Delta x \cdot \frac{D}{d}$

$y_1 = \frac{\lambda D}{4d}$

$y_2 = \frac{3\lambda D}{4d}$

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Q If white light is used \Rightarrow (C.M \equiv white) colorful fringes.

Q If whole system dipped in water $\mu_w = 2$

$\beta_{air} = 4 \text{ mm (Let)}$,

$$\beta = \frac{\lambda D}{d}$$

$$\beta_{in \text{ water}} = \frac{\beta_{air}}{\mu} = \frac{4}{2} = 2 \text{ mm}$$

- $v = f\lambda$
- $f \longrightarrow$ same
 - $v \longrightarrow v/\mu$
 - $c \longrightarrow c/\mu$
 - $\lambda \longrightarrow \lambda/\mu$
 - $\beta \longrightarrow \beta/\mu$

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$\beta_{water} = 2 \text{ mm}$
 Q $\mu_w = 2$ No. of max on screen 1 m



No. of max = $250 + 250 + 1 = 501$

No. of min = $250 + 250 = 500$



$I \propto \text{width}$

Change

S_1	$3I_0$
S_2	I_0

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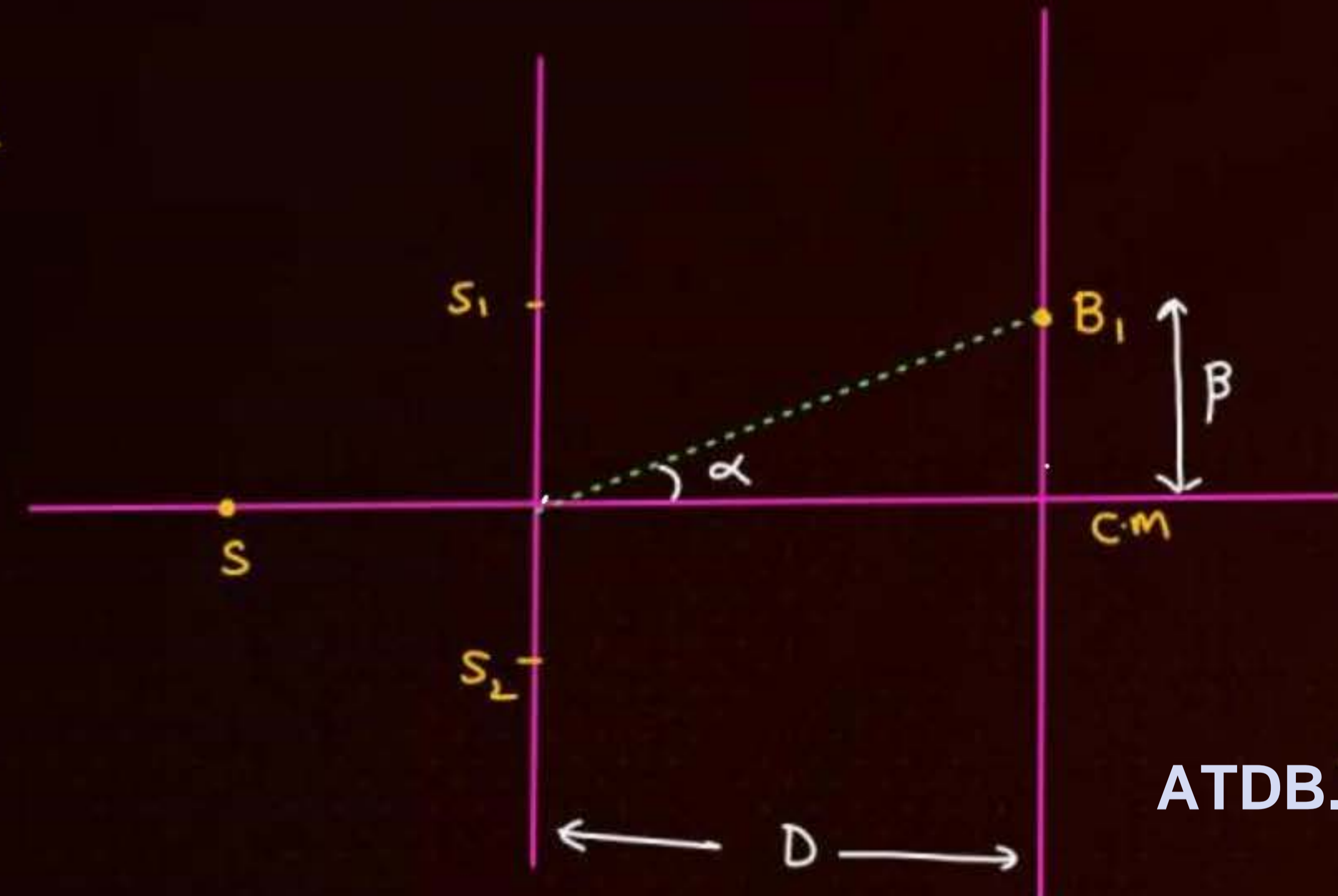
$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$$

$$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$$

$$I_1 = I_2 = I_0 \text{ Best}$$



#



$$\tan \alpha = \frac{\beta}{D} = \frac{\lambda D}{d \cdot D} = \left(\frac{\lambda}{d} \right)$$

$$\tan \alpha = \frac{\beta}{D} = \frac{\lambda D/d}{D} = \frac{\lambda}{d}$$

Angular width

ATDB.uno $\tan \alpha = \frac{\lambda}{d}$

$$\beta = \frac{\lambda D}{d}$$

Q If screen is moving away from slit

$$\beta = \frac{\lambda D}{d} \Rightarrow (\text{increase})$$

$$\alpha = \frac{\lambda}{d} \rightarrow \text{Same} \leftarrow$$

Angular width



YDSE Results

two λ coinciding maxima condition
 \Downarrow
 $n_1 \lambda_1 = n_2 \lambda_2$

$I \propto w$ (slit width)
 $I \propto A^2$ \rightarrow Amplitude

- $\Delta x = d \sin \theta = S_2P - S_1P$

- $\tan \theta = y/D$

- $\frac{\Delta x}{\lambda} = \frac{\Delta \phi}{2\pi}$

- $I = 4I_0 \cos^2(\phi/2)$

* If θ is very small

* $\beta = \frac{\lambda D}{d}$

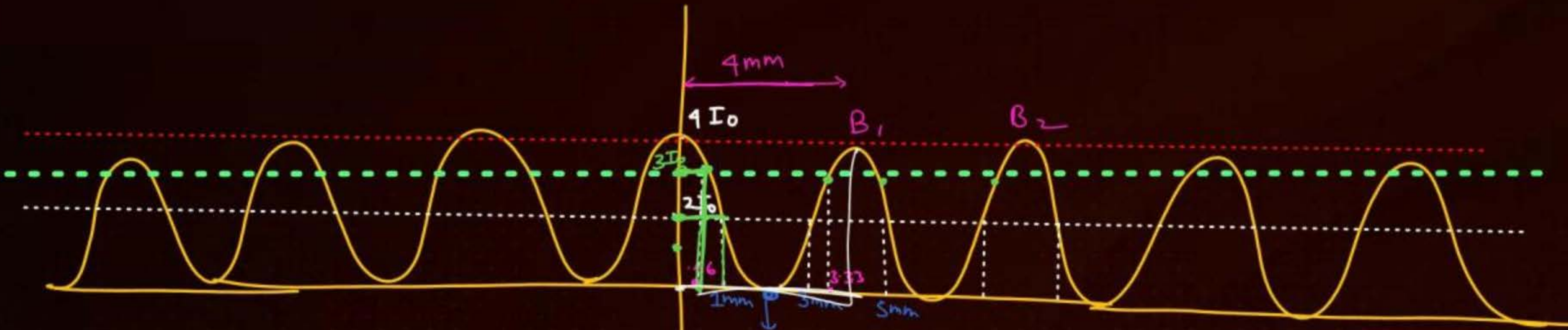
* $\tan \alpha = \frac{\lambda}{d}$

$\Delta x = \frac{dy}{D}$

$y = \Delta x \cdot \frac{D}{d}$

$\Delta x = n\lambda$ (for maxima)
 $\Delta x = \text{odd} \left(\frac{\lambda}{2} \right)$ for minimum

* All maxima point intensity = $4I_0$
 IF $I_1 = I_2 = I_0$



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D_1

$$\frac{2}{3}\text{mm} = -66$$

3.33



THANK YOU

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