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PRAYAS

JEE 2025

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Lecture - 02

Physics

wave optics - 02

By- Saleem Ahmed Sir

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Topics *to be covered*

1. Interference
2. YDSE
3.
4.

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

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

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

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

If

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

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

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

If source are incoherent

$$I = I_1 + I_2$$

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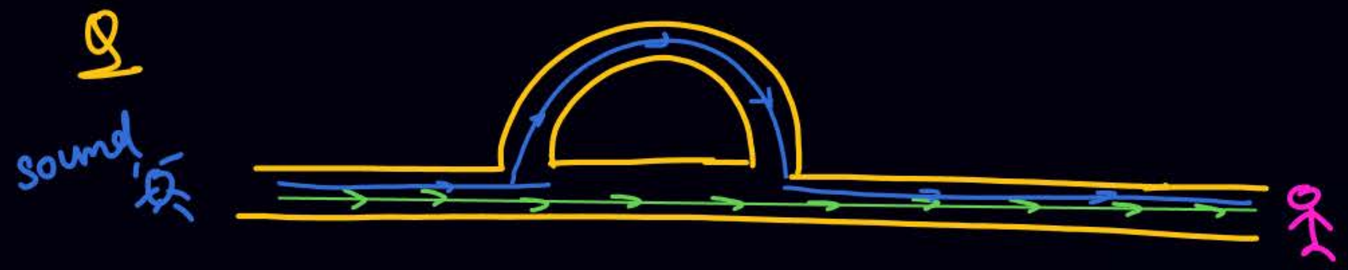

find λ so that man observe (D.I) (minima)

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

$$= n\lambda \text{ (maxima)}$$

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

max

$= 1$

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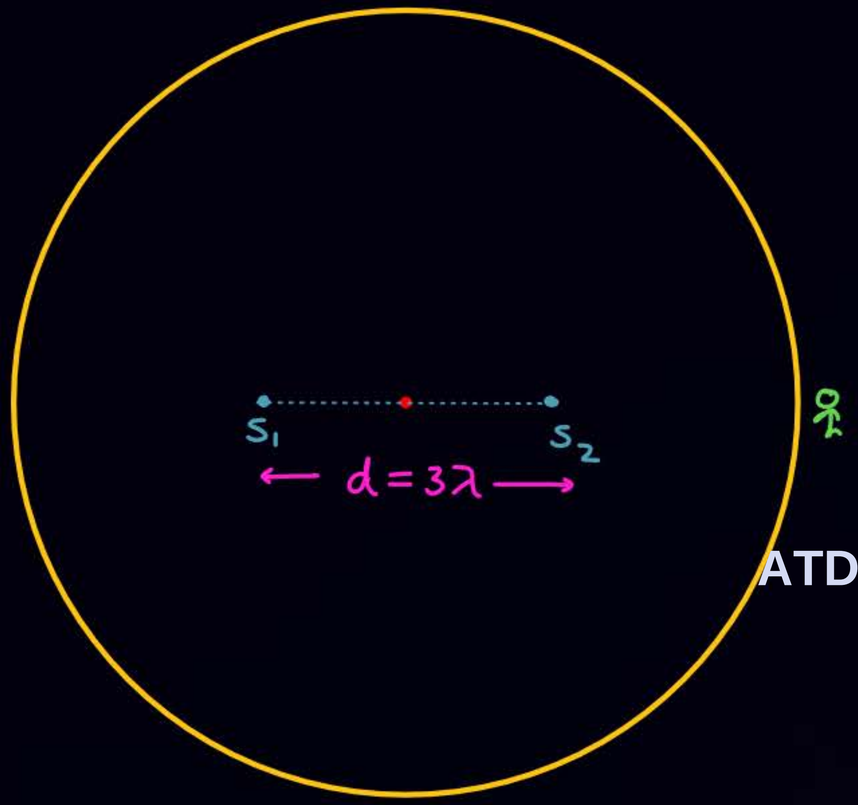
Coherent sound source/ light source

Q



find no. of max & minima formed on circular track

Soln

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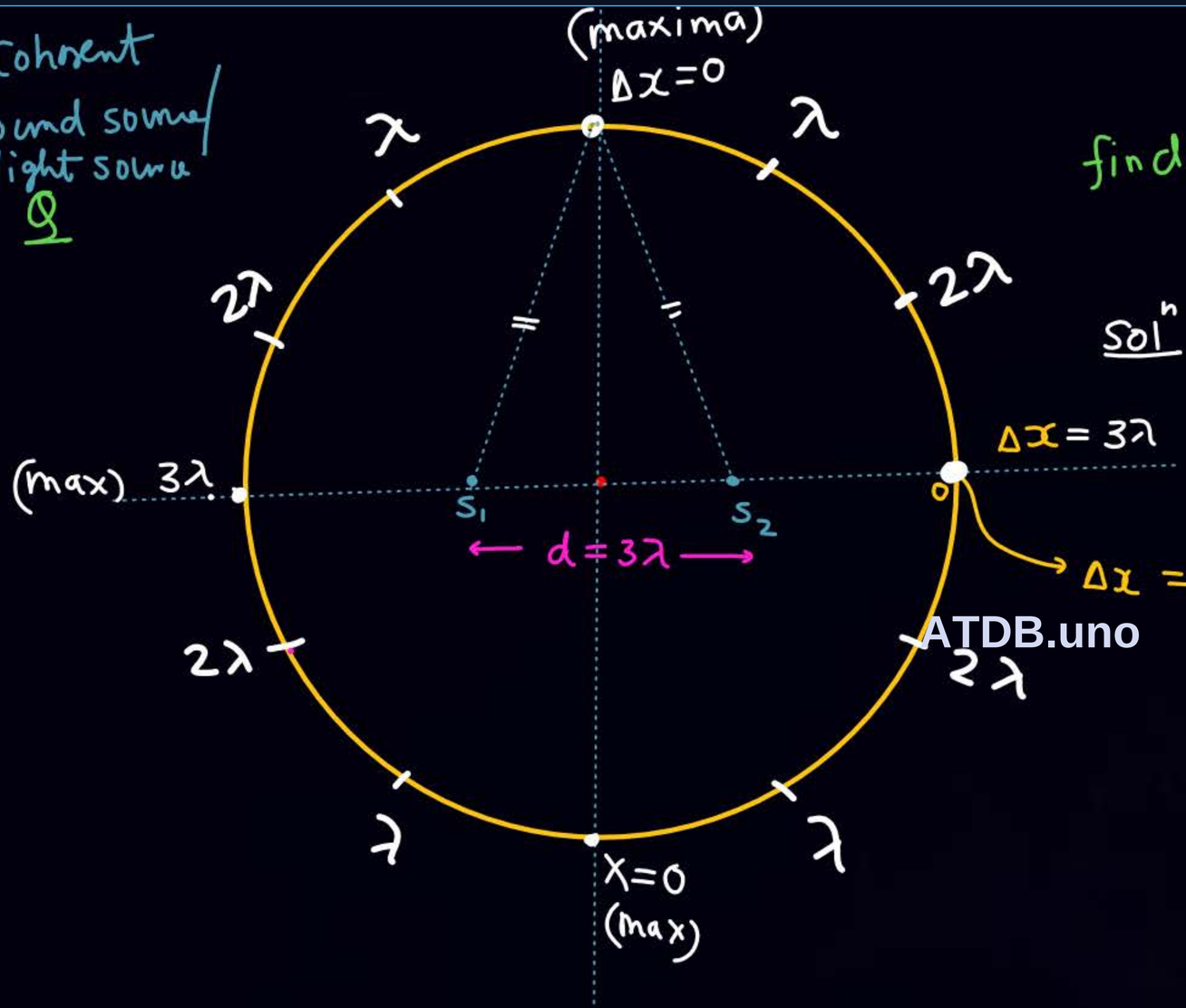
Coherent sound source/ light source

Q



find no. of max & minima formed on circular track

Sol^n

No. of maxima = 12

$\Delta x = S_1O - S_2O = 3\lambda$

$= n\lambda$ (maxima)

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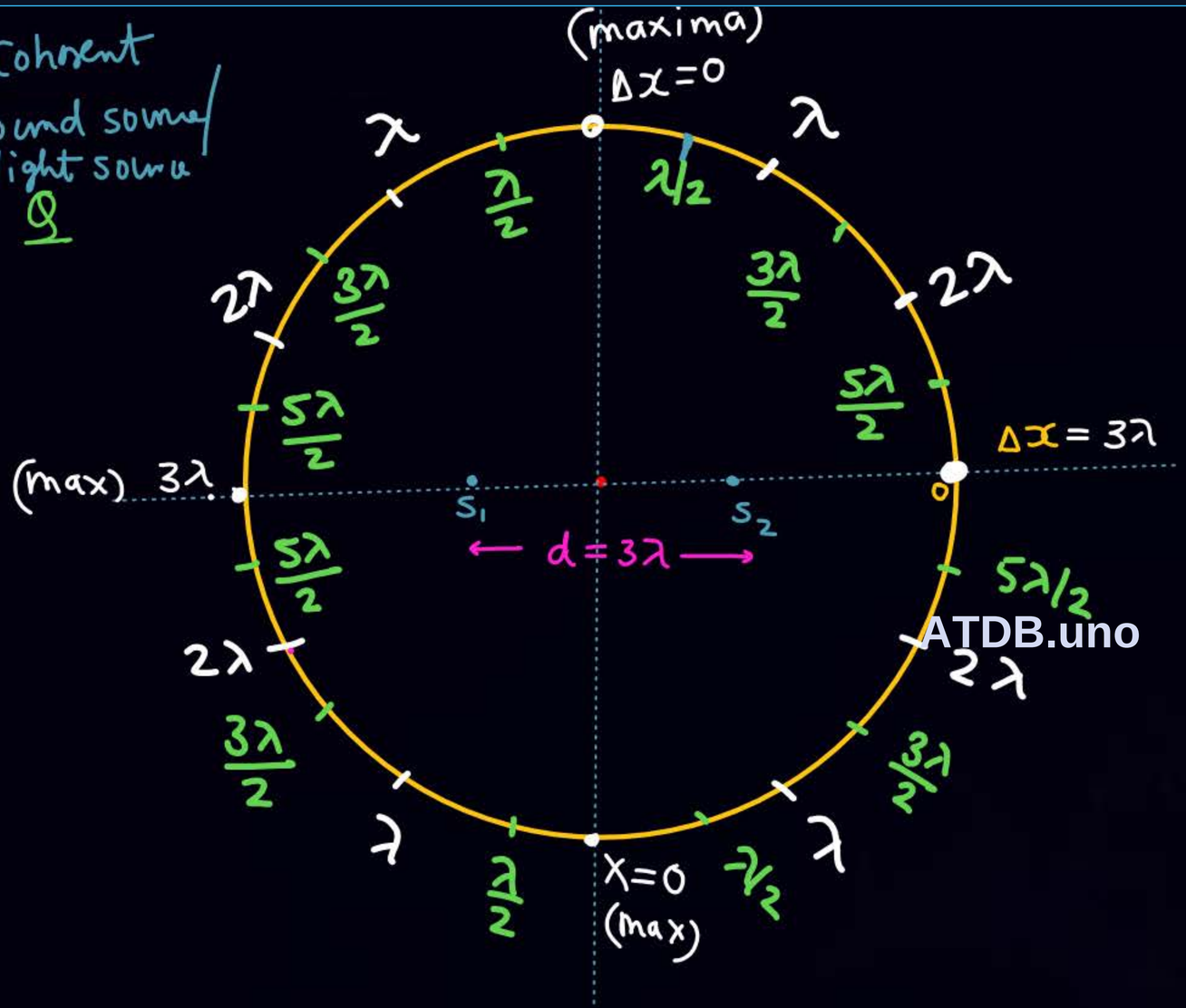
Coherent

Sound source/ light source

Q



No. of maxima = 12

No. of minima = 12

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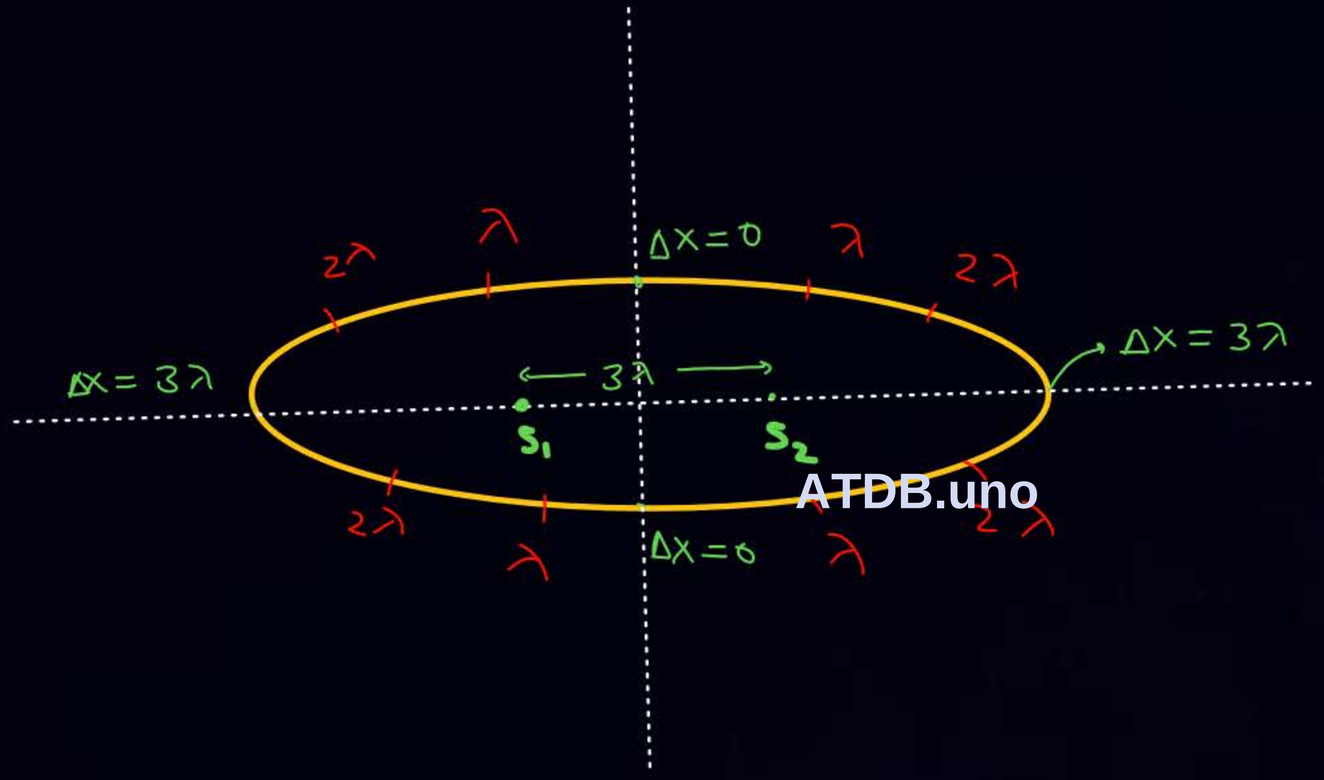

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Q

No. of max = 14

No. of min = 14

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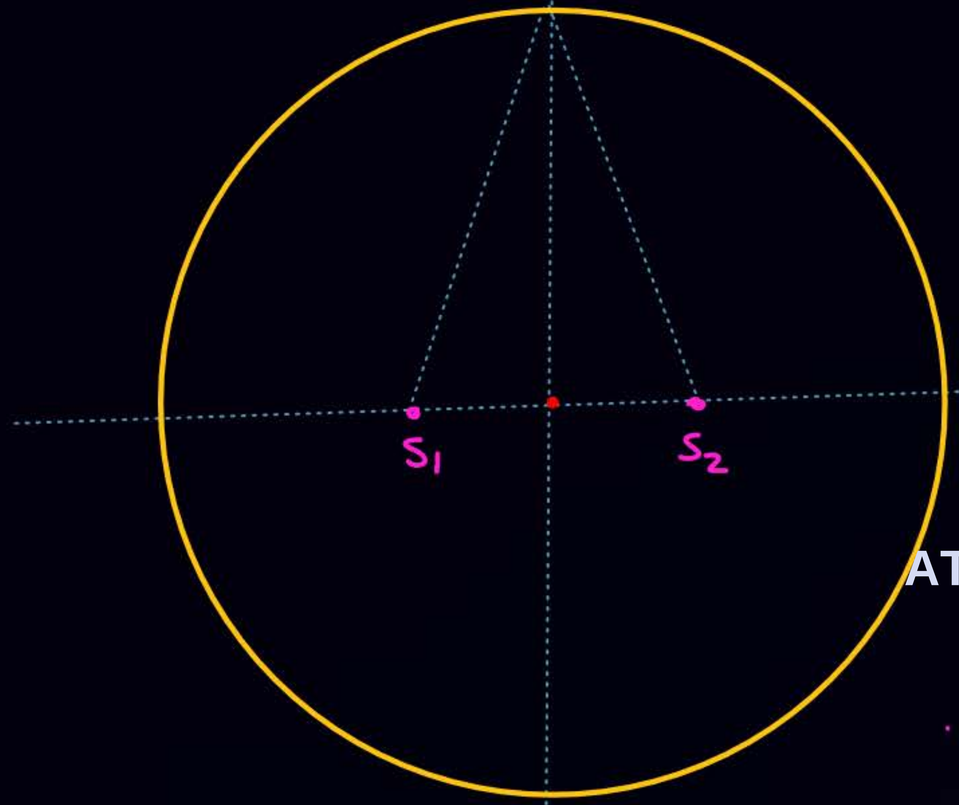
Q



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	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

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Q

(1) No. of maxima & minima formed on screen
⟶ (Large)

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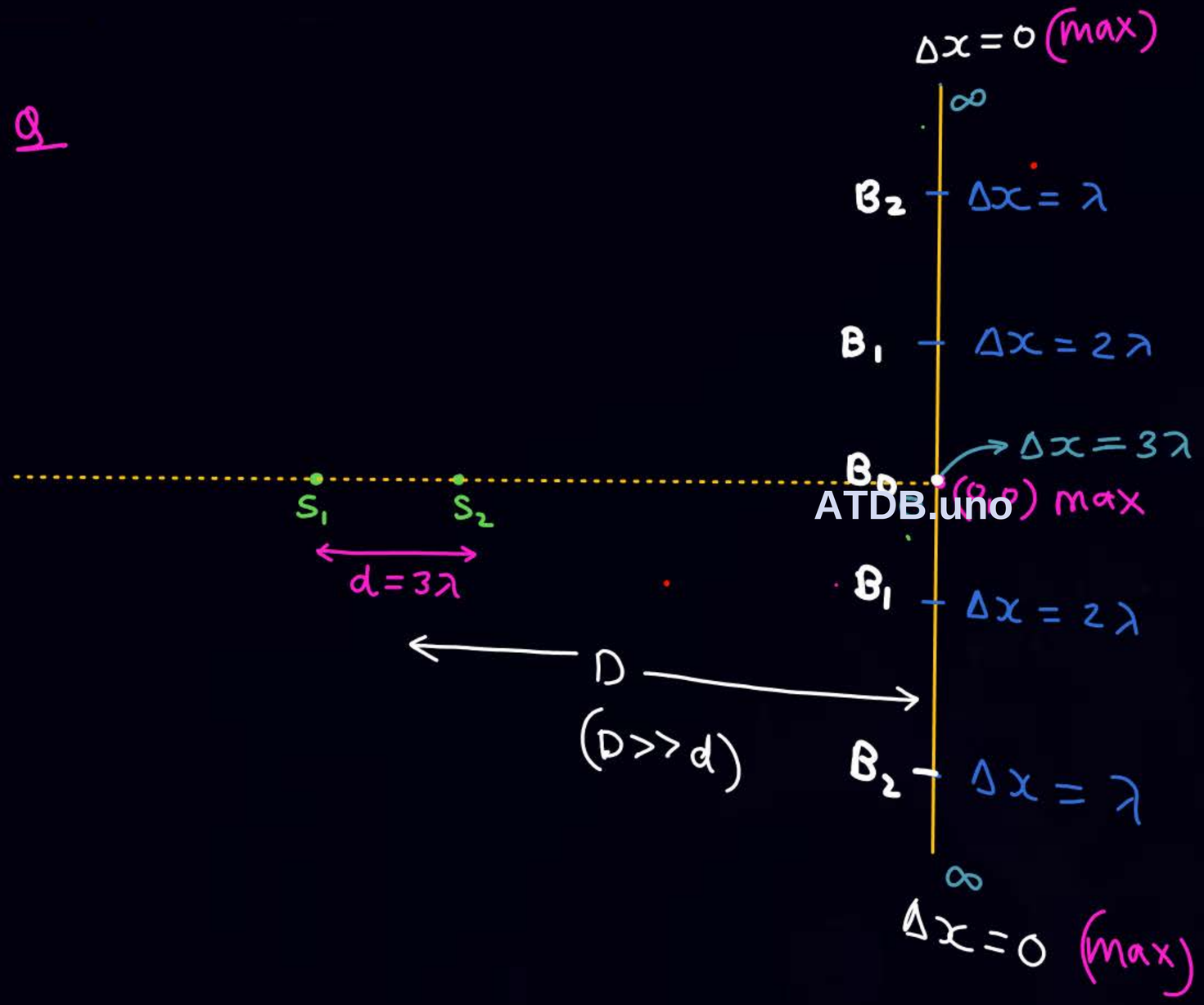

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(1) No. of maxima & minima formed on screen
→ (Large enough)

maxima = 5

minima = 6

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(y_{min})

Q find location of a point whose intensity is 75% of max intensity

So $I_{max} = 4I_0$

$75\%.\ I_{max} = 3I_0$

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

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

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

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

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

$\phi = 60^\circ, 300$

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

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

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

$\Delta x = d\cos\theta$

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

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

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

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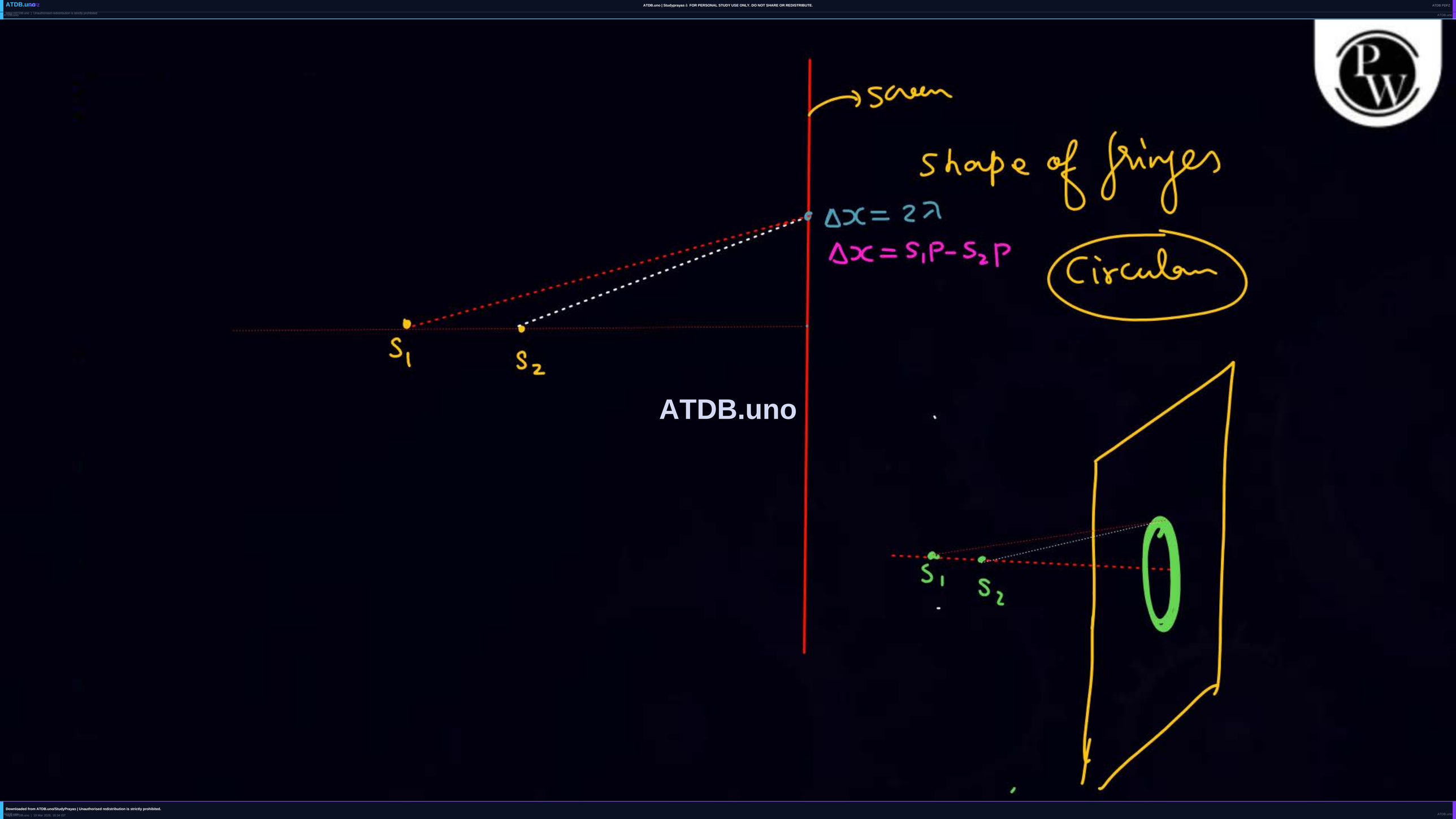

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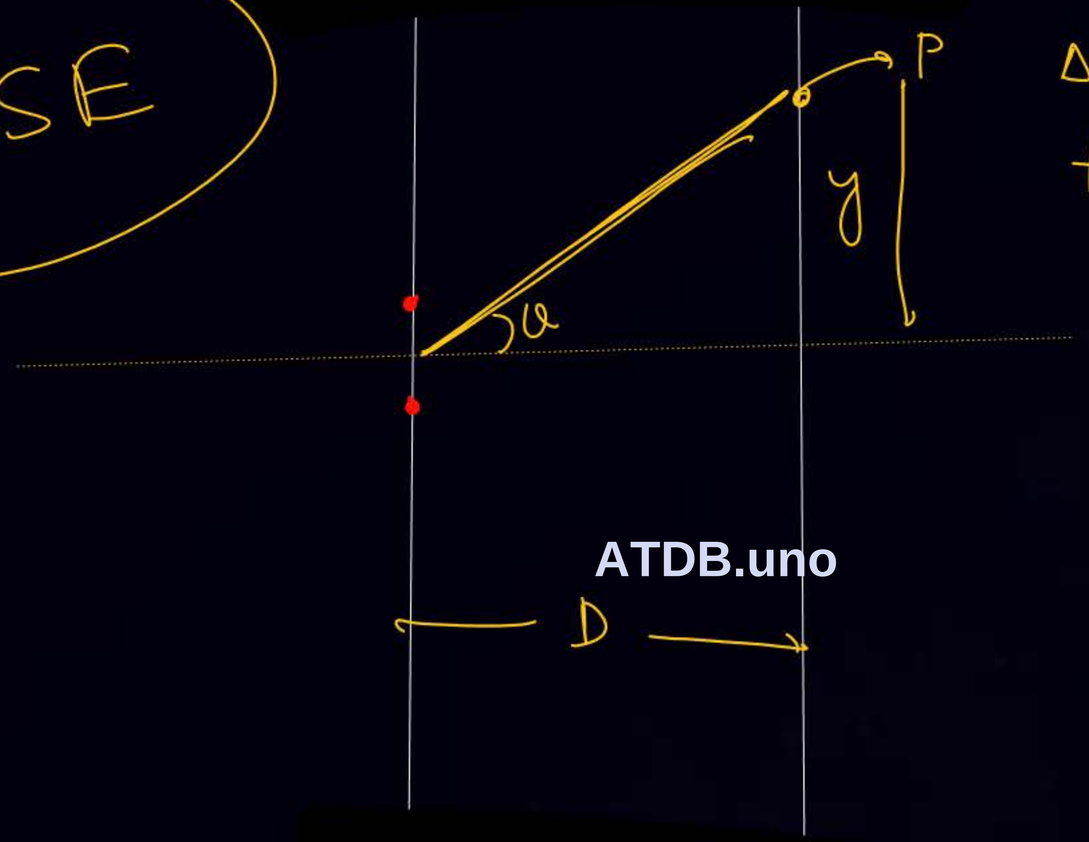
YDSE



$\Delta x =$

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

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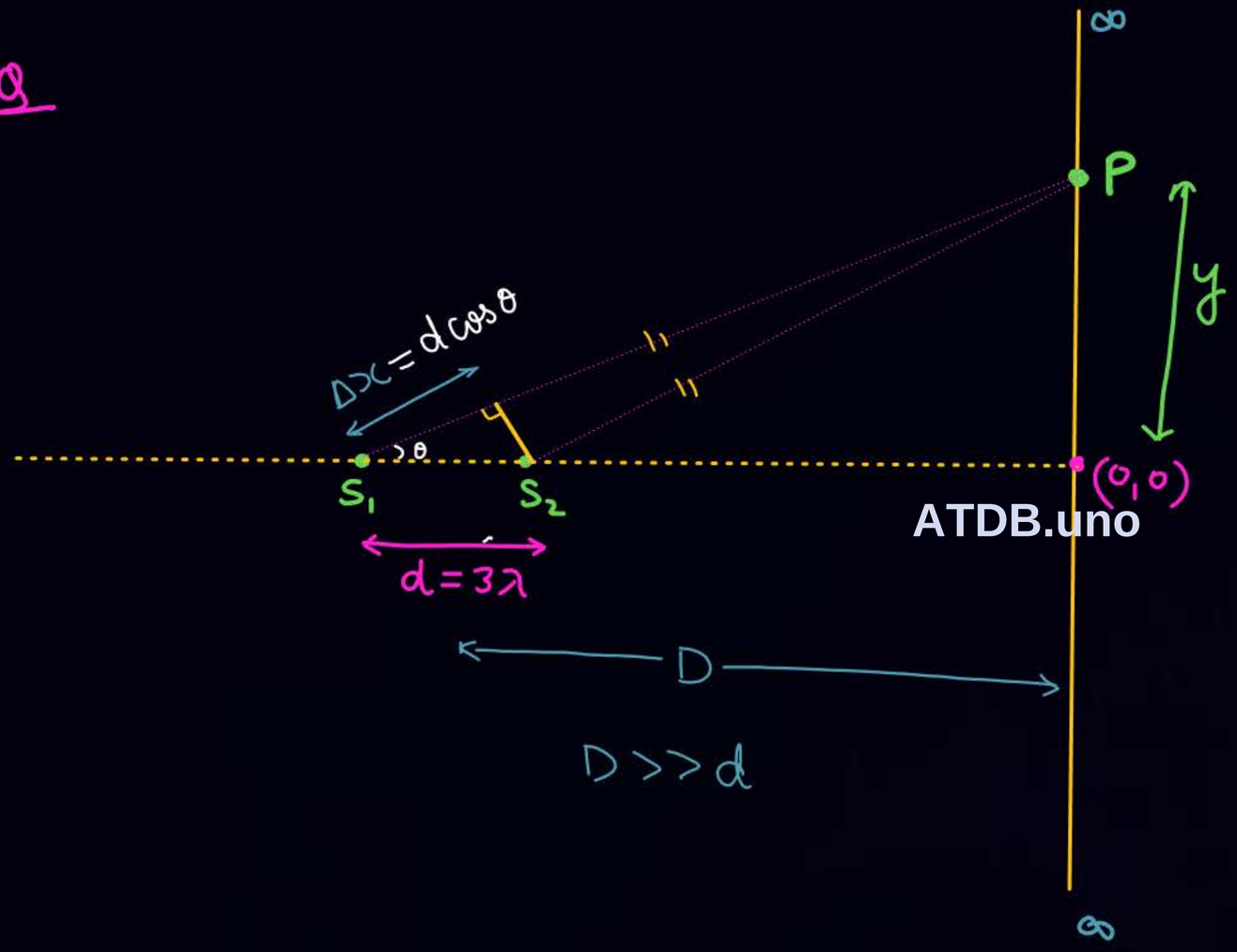
Q



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

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

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

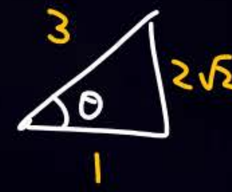
location of 2nd Bright above origin

$$\Delta x = \lambda$$

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

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

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



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

$\left(D = \frac{1\,m}{let}\right)$

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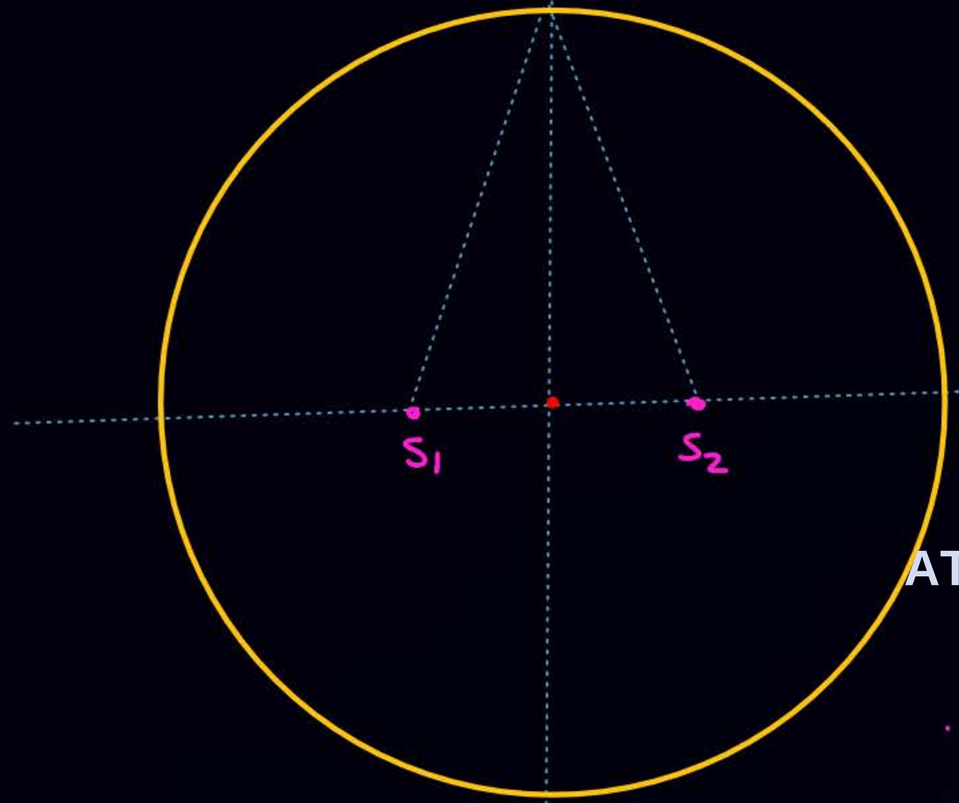
Q



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	No. of max	No. of min
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$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

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If

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

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

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

If source are incoherent

$$I = I_1 + I_2$$

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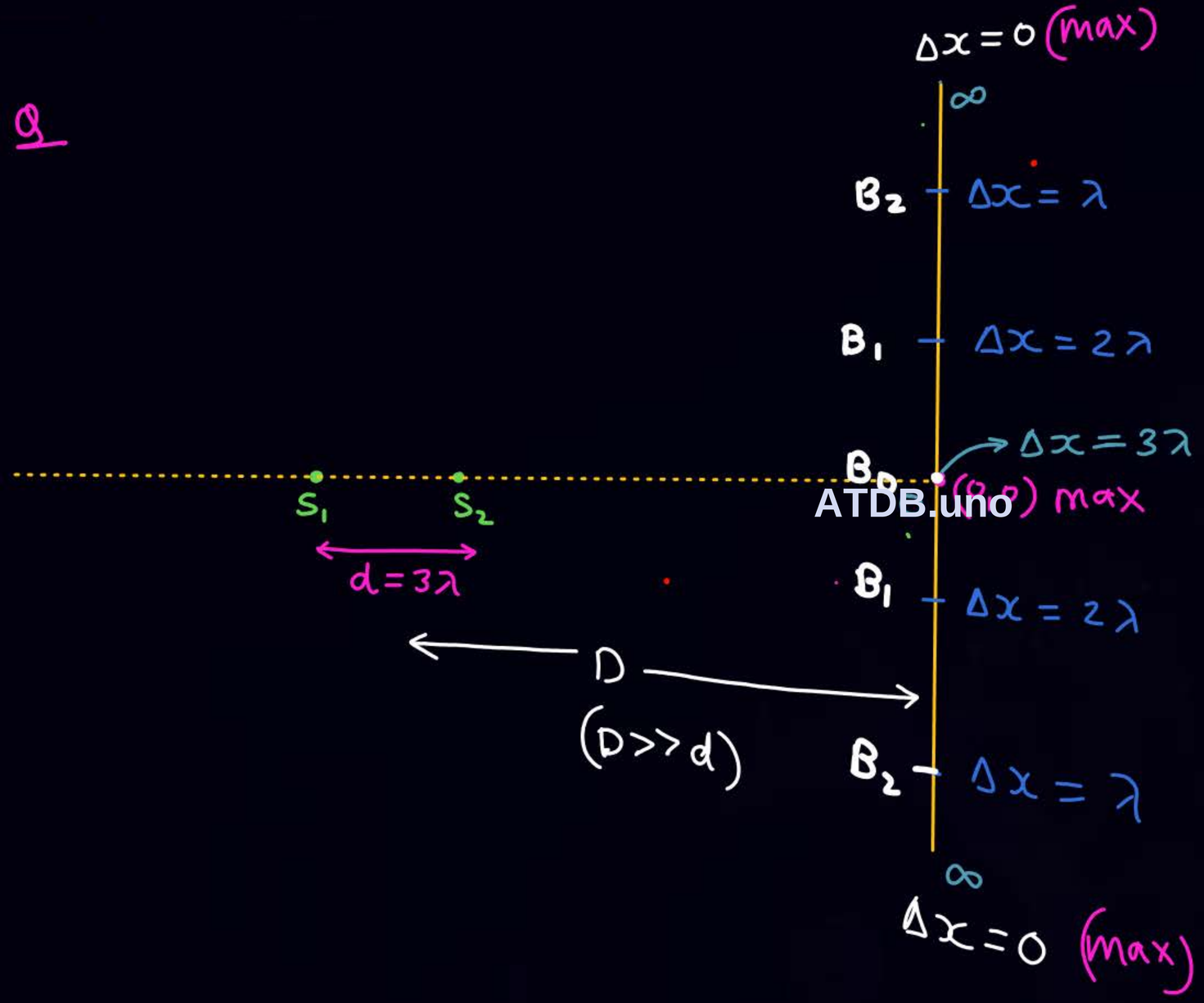
Q



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(1) No. of maxima & minima formed on screen → (Large enough)

maxima = 5

minima = 6

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(y_{min})

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$\phi = 60^\circ, 300$

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

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

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

$\Delta x = d\cos\theta$

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

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

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

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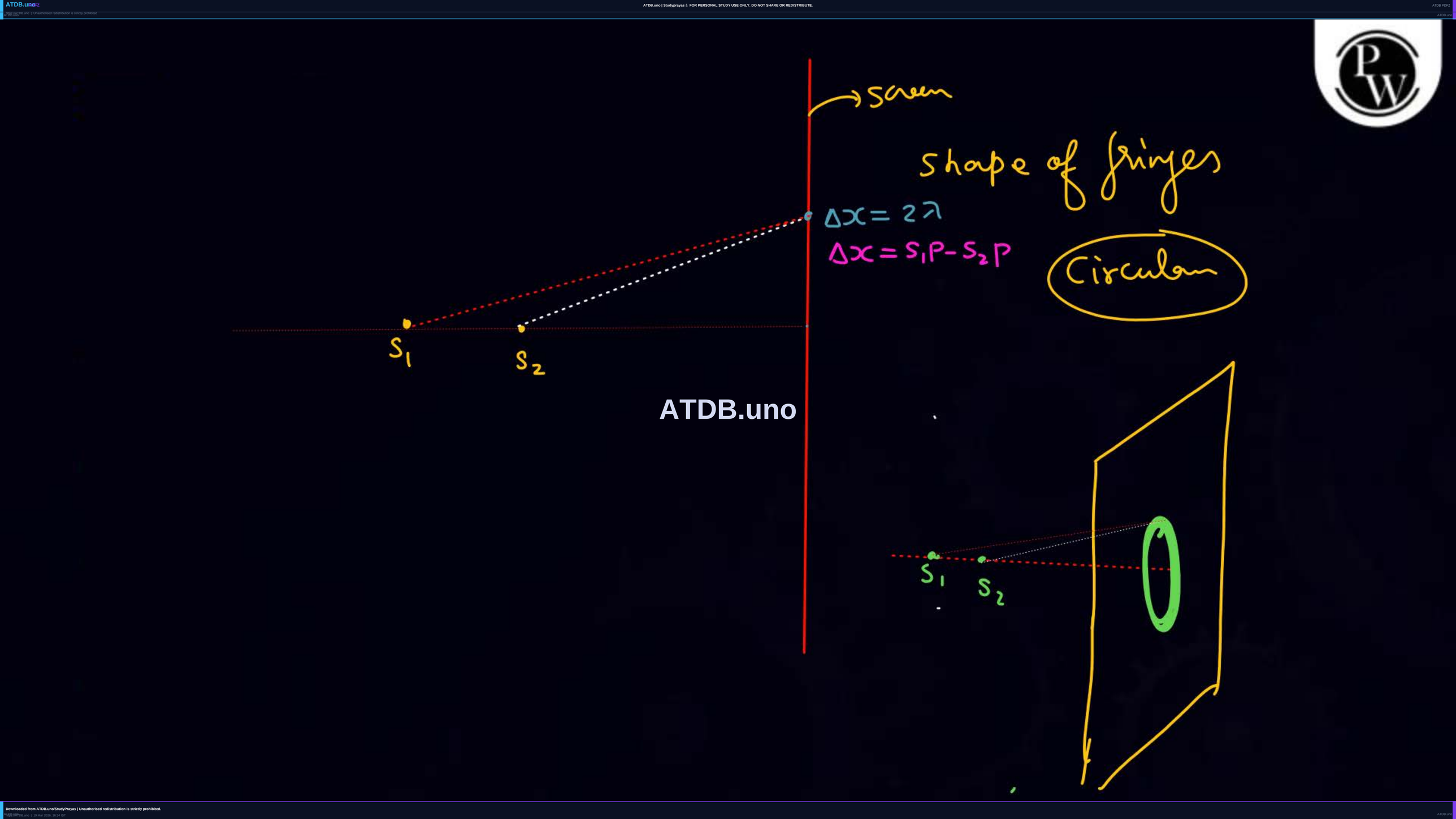

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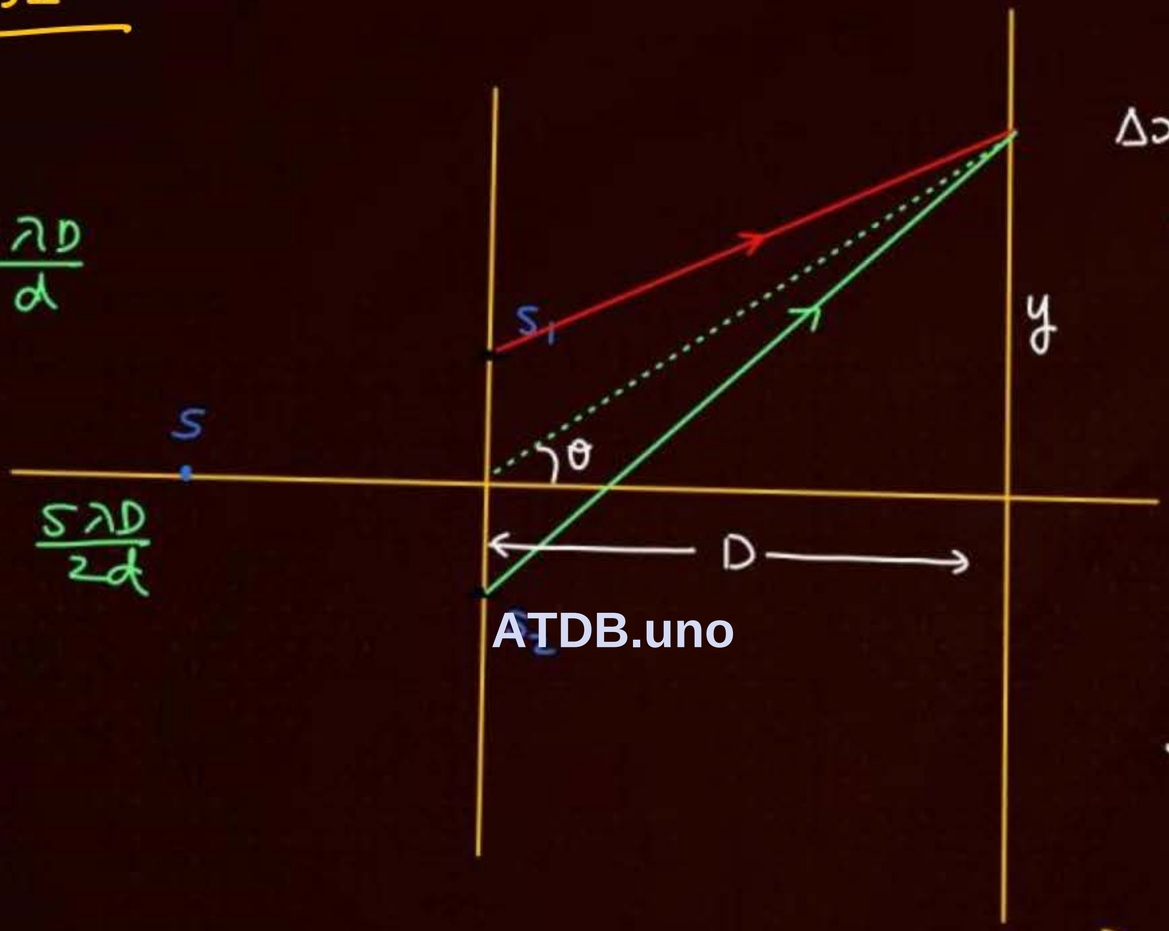
YDSE

Location of maxima

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

Location of minima

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



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

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

$\theta \rightarrow$ very small

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

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

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

$$\boxed{I_{net} = 4I_0 \cos^2\left[(\Delta\phi)/2\right]}$$

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

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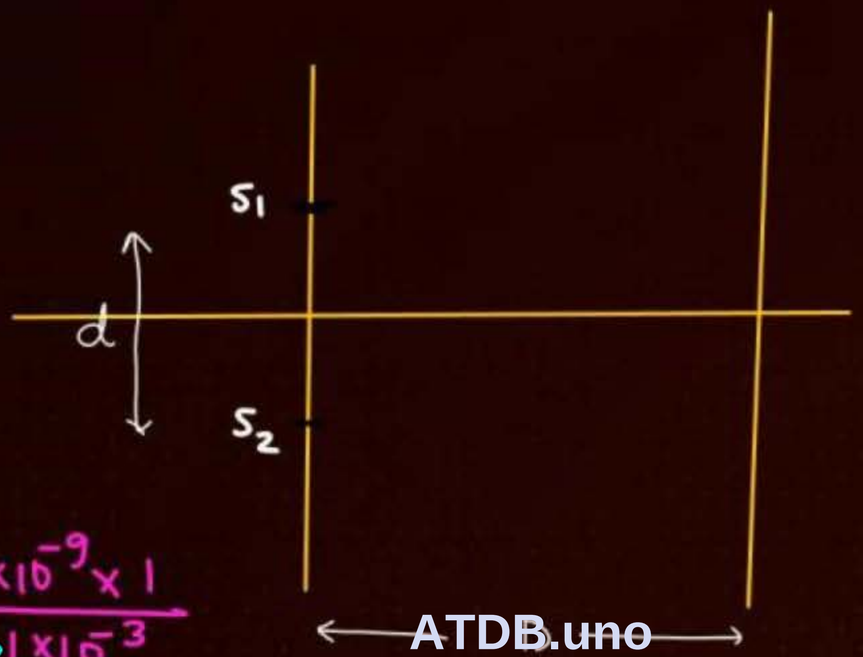
Q $d = \cdot 1mm$

$D = 1m$

$\lambda = 400nm$

find



① fringe width

$$\beta = \frac{\lambda D}{d} = \frac{400\times10^{-9}\times 1}{\cdot 1\times10^{-3}}$$

$$= 4mm$$

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

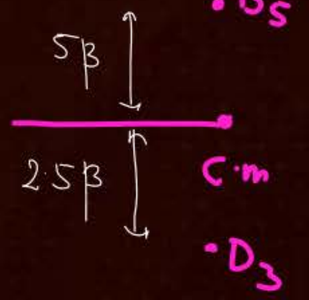
" " 7^{th} Dark " C.m $\equiv$ $D_7 \equiv 6.5\frac{\lambda D}{d} = 6.5\times4 = 26mm$

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

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

$= 7.5\times4mm$

$= \underline{30mm}$



⑤⑥ Angular width $= \alpha \approx \frac{\lambda}{d} = \frac{400\times10^{-9}}{1\times10^{-4}}$

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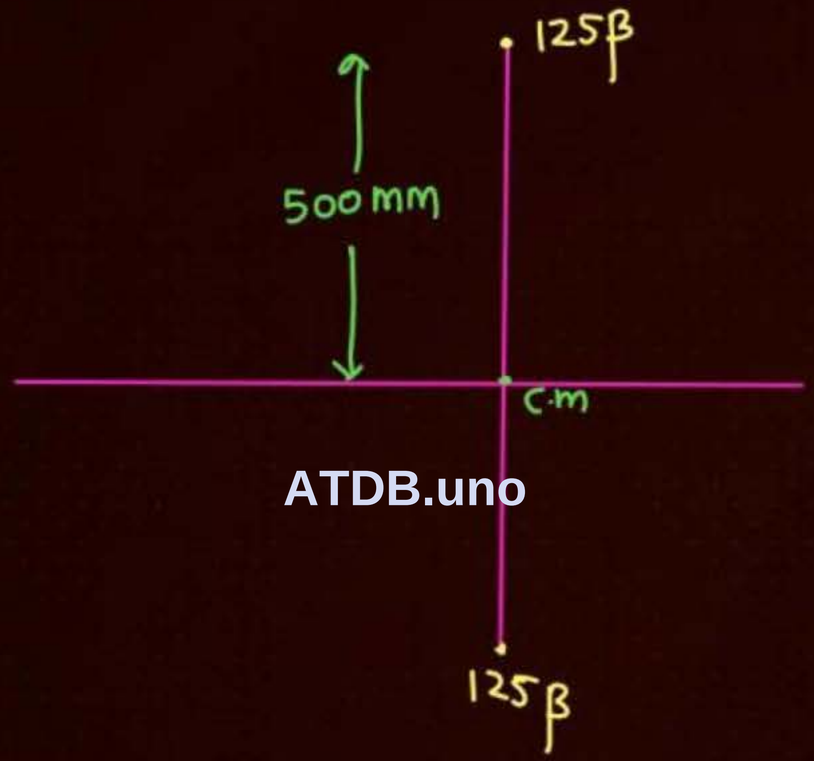
④ find no. of max & min if screen length is 1m. ⇛ 125 + 125 + 1 = 251

$\beta = 4mm$



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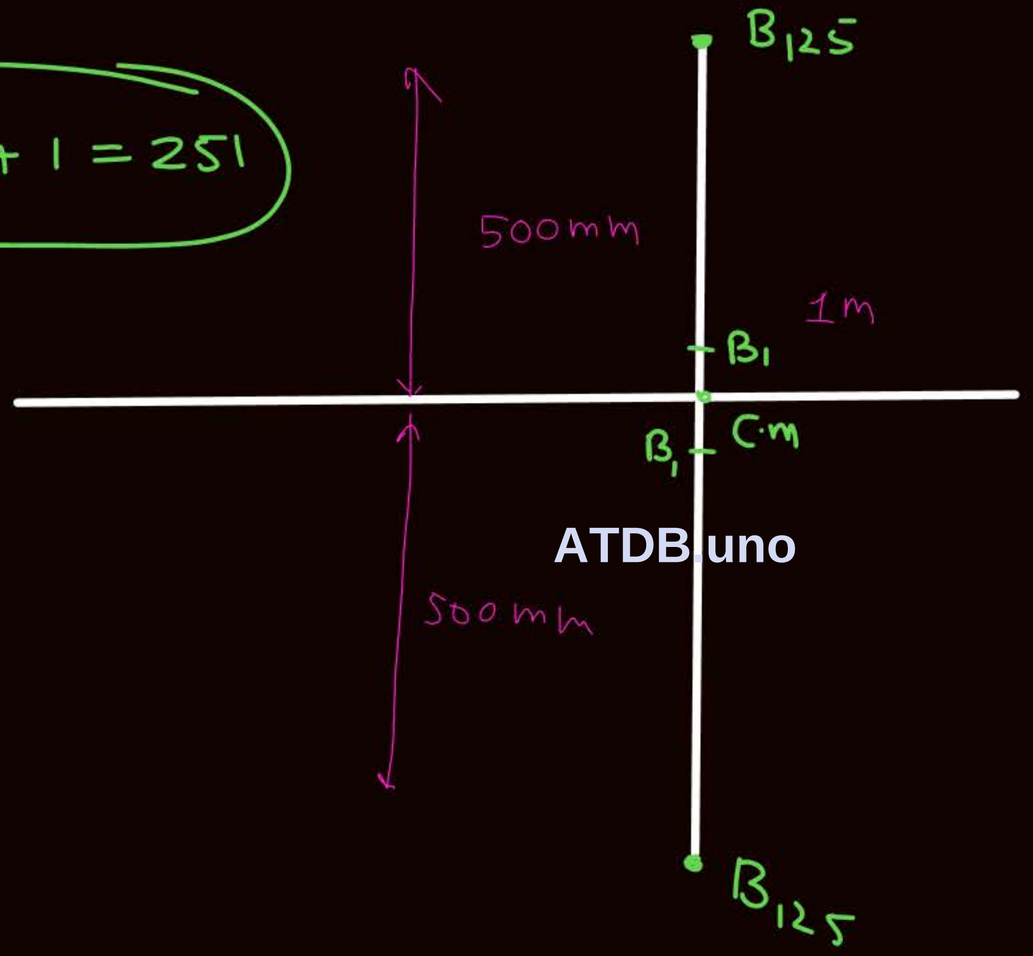
$125 + 125 + 1 = 251$



$\beta = 4mm$

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

$\beta = 4mm$

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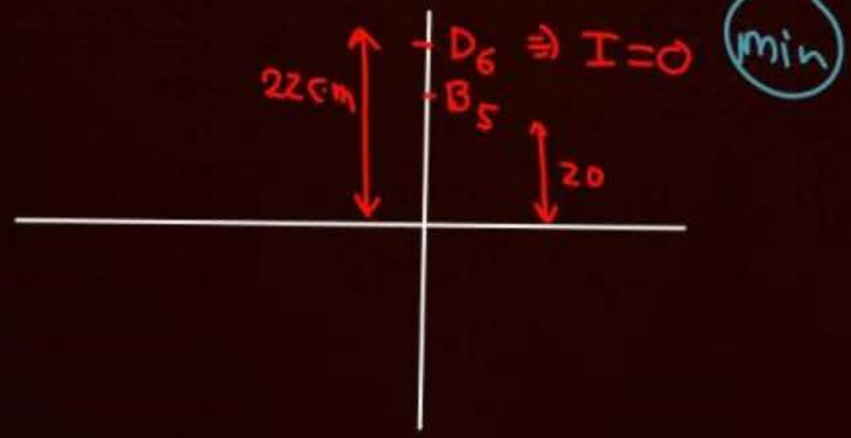
⑤ find Intensity at a point 22mm above C·m.



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

$2I_0$

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

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

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

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

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

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

$\Delta x =$ ✓

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

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

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

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

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

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

$$y_2 = 3mm$$

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

$2I_0$

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

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

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

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

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

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

$\Delta x =$ ✓

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

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

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

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

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

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

$$y_2 = 3mm$$

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

$I_{max} = 4I_0$

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

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

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

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

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

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

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

$\Delta\phi/2 = 30, 150, 210, \ldots$

$\Delta\phi = 60, 300, 420 \ldots$

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

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

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

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

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

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

$3I_0$

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

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

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

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

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

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

$\frac{\phi}{2} = 45^\circ, 135^\circ, \ldots$

$\phi = 90^\circ, 270^\circ \ldots$

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

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

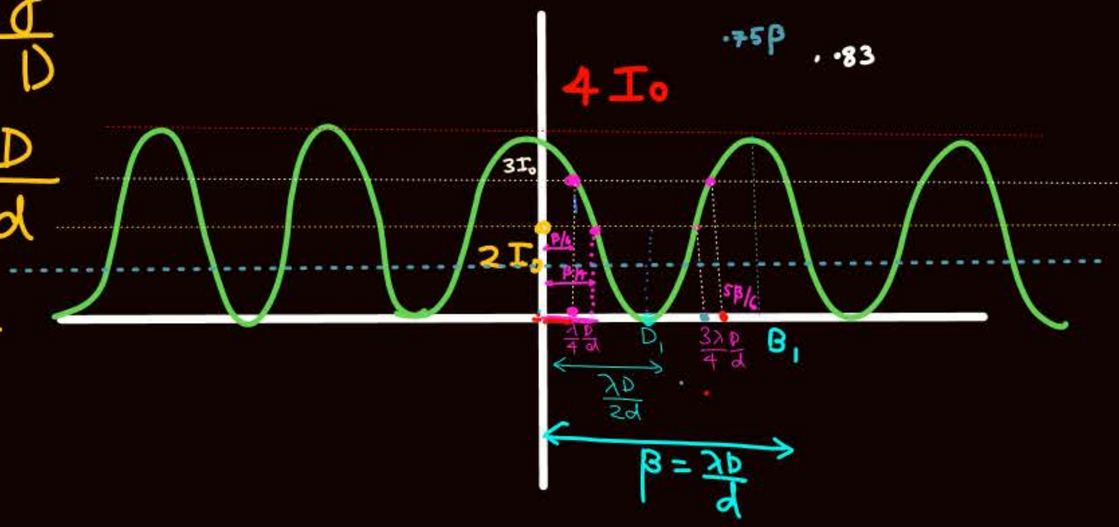
$\Delta x_2 = \frac{3\lambda}{4}$

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

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

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

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



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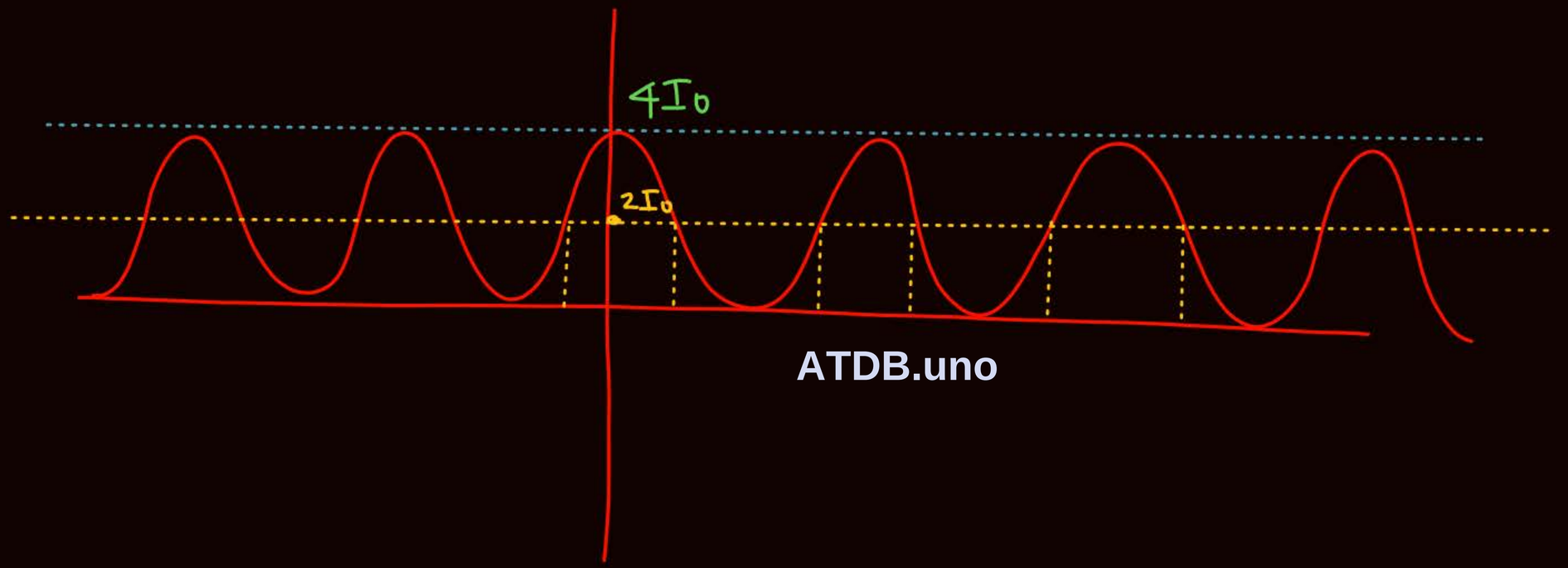

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Q If white light is used $\equiv$ (CM $\equiv$ White)

Colourfull fringes.

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

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

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

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

$v = f\lambda$

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$f \longrightarrow$ same

$v \longrightarrow v/\mu$

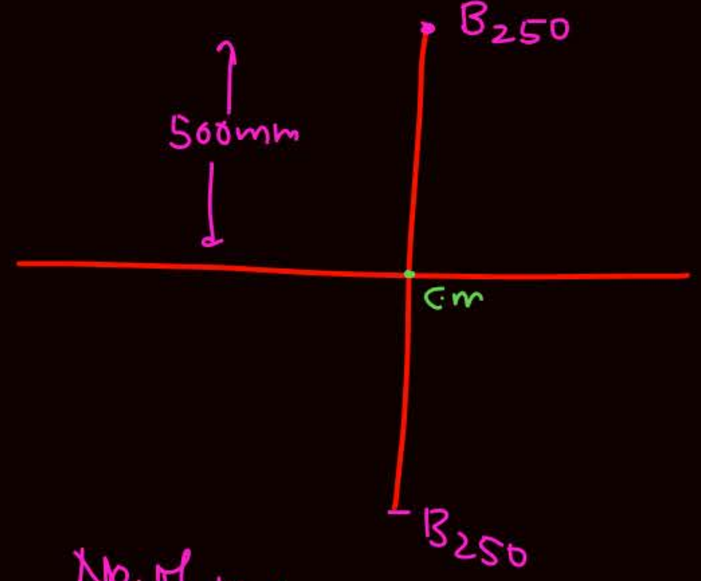
$c \longrightarrow c/\mu$

$\lambda \longrightarrow \lambda/\mu$

$\beta \longrightarrow \beta/\mu$

$\beta_{water} = 2mm$

Q $\mu_w = 2$ No. of maxima on screen 1 m



No. of max = 250 + 250 + 1

= 501

No. of min = 250 + 250

= 500

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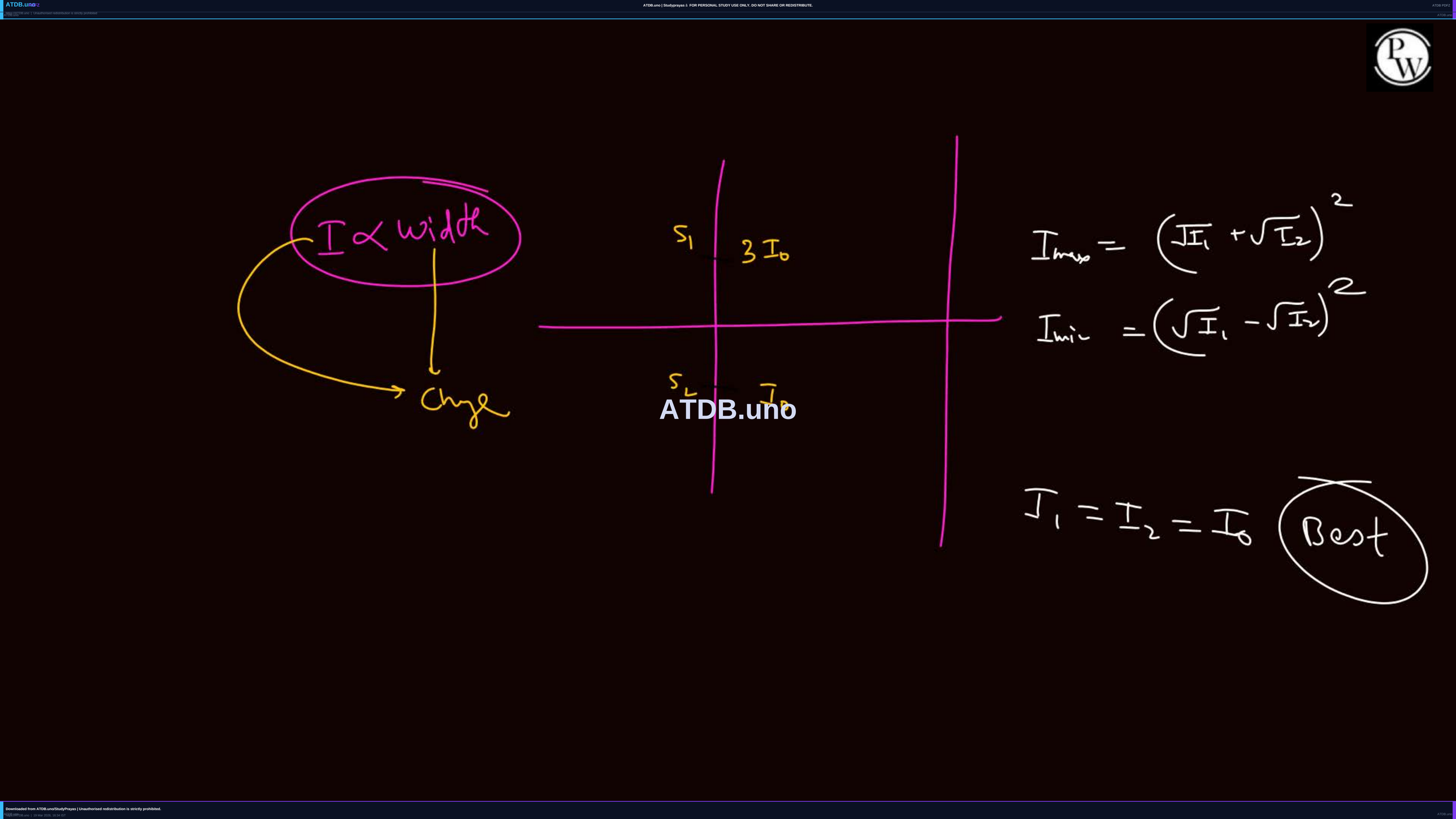

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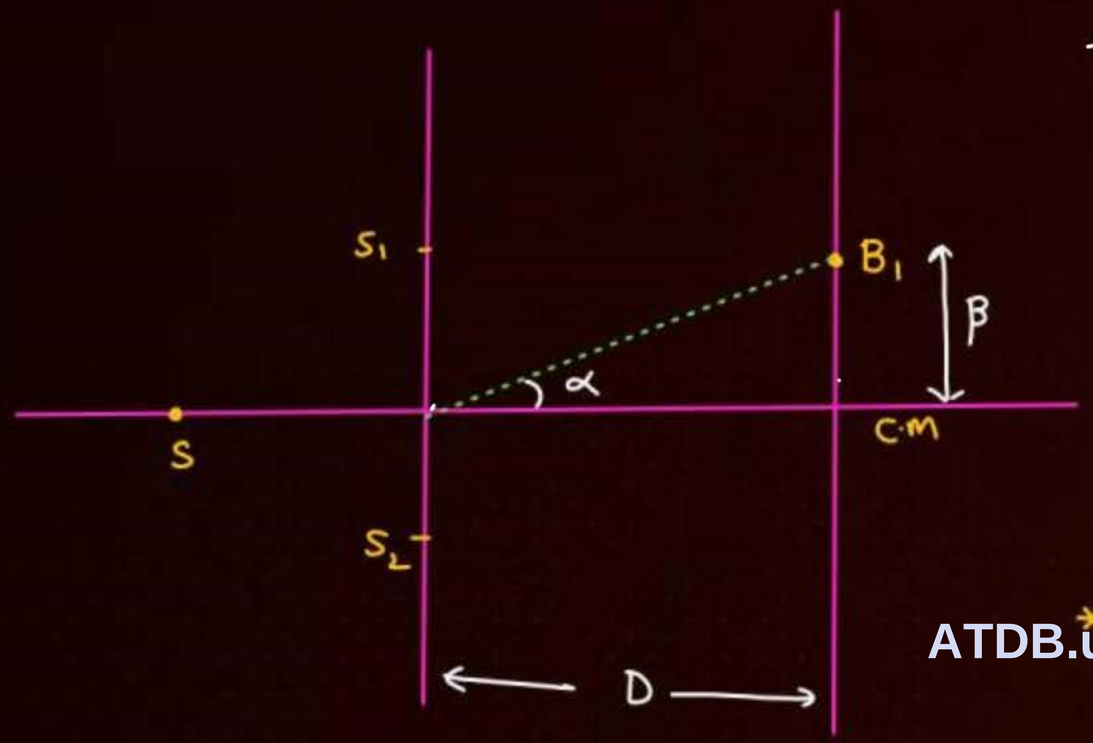

$$\beta = \frac{\lambda D}{d}$$

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

$\tan\alpha$ ↓ Angular width

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

Q If screen is moving away from slit

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

$$\alpha = \frac{\lambda}{d} \longrightarrow \text{Same}$$

↳ Angular width

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YDSE Results

- $\Delta x = d \sin\theta = S_2P - S_1P$
- $\tan\theta = y/D$
- $\frac{\Delta x}{\lambda} = \frac{\Delta\phi}{2\pi}$
- $I = 4I_0 \cos^2(\phi/2)$

$I \propto w$ (slit width)

$I \propto A^2$ → Amplitude

two λ coinciding maxima condition

$\Downarrow$

$n_1\lambda_1 = n_2\lambda_2$

* If θ is very small $\Delta x = \frac{dy}{D}$

$\Delta x = n\lambda$ (for maxima)

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

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

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

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

* All maxima point intensity $= 4I_0$

If $I_1 = I_2 = I_0$

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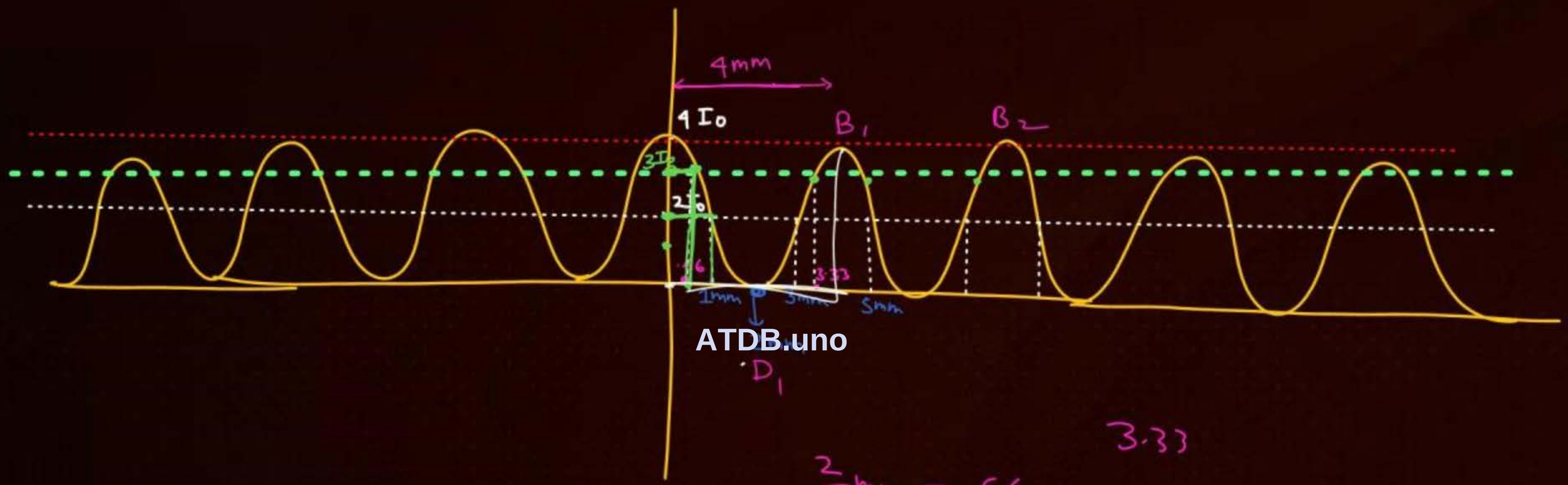

3.33

$\frac{2}{3}$ mm = .6(

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