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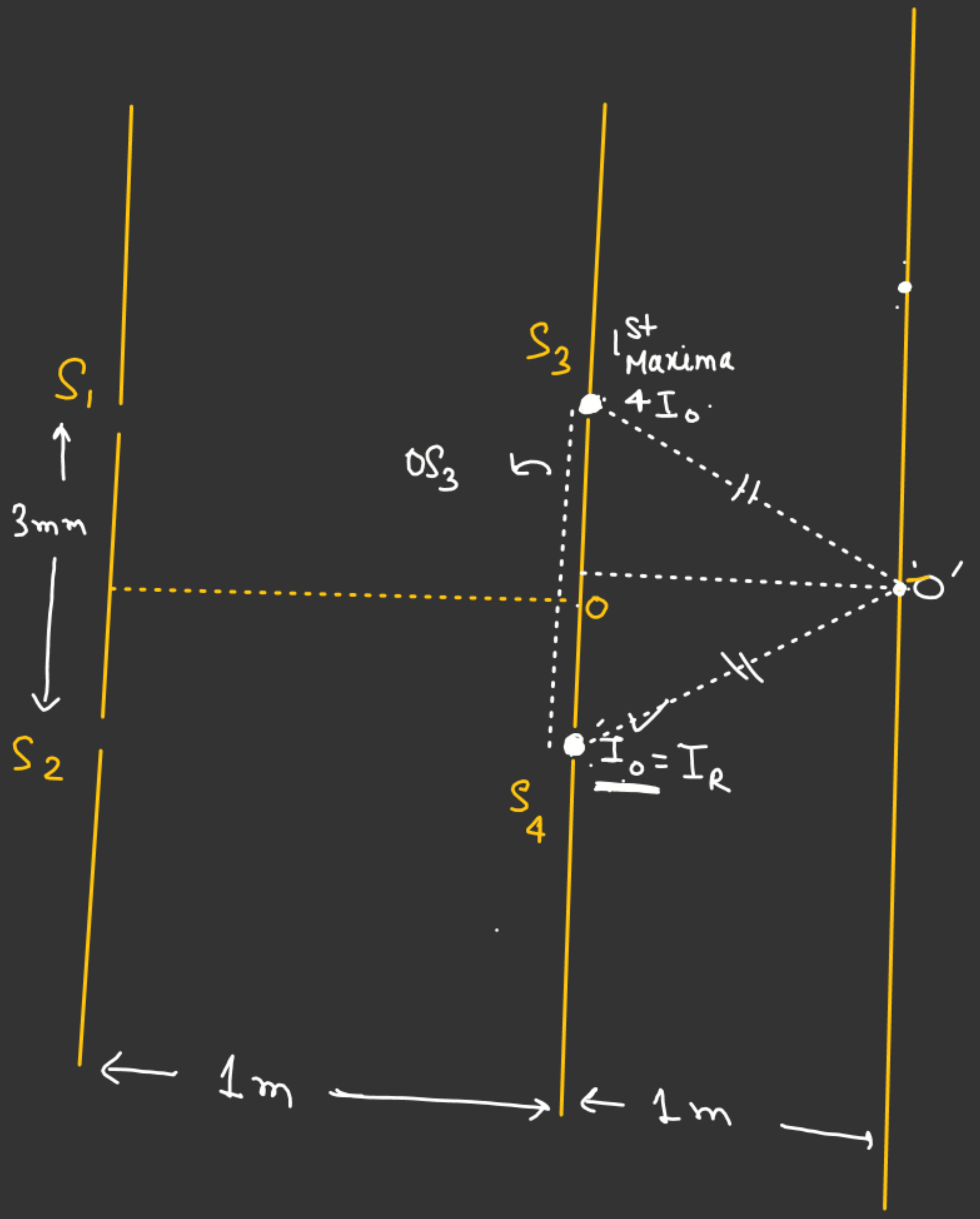
S_1 & S_2 Equidistance from o
S_3 & S_4 Equaidistance from o'
O → Mid point of distance b/w S_3 & S_4
O' → Center of Screen
$\lambda = 6000\,\text{Å}$

① Find the Intensity at o'.
② Find the Intensity of bright fringe.

S3 is the position of 1st Maxima
At S_4 Intensity is Same as of light source.



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For 1st Maxima at S_3.

$$\frac{dy}{D} = n\lambda \quad (n \to 1)$$

$$y = \left(\frac{D\lambda}{d}\right) = \frac{1 \times 6000\times10^{-10}}{3\times10^{-3}}$$

$$OS_3 = y = (2\times10^{-4})\,m \checkmark$$

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

$$\Delta\phi_1 = 2\pi \checkmark$$

$$I_R = 4I_0\cos^2\left(\frac{\Delta\phi}{2}\right)$$

$$I_R = (4I_0) \checkmark$$

(At 4). $I_R = I_0$.

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

$$\frac{1}{4} = \cos^2(\phi/2)$$

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

$$\frac{\phi}{2} = \frac{\pi}{3}$$

$$\phi = \left(\frac{2\pi}{3}\right) \checkmark \Rightarrow \frac{2\pi}{\lambda}\cdot\Delta x = \frac{2\pi}{3}$$

$$\Delta x = \left(\frac{\lambda}{3}\right) \checkmark$$

$$\frac{(OS_4)\,d}{D} = \left(\frac{\lambda}{3}\right)$$

$$OS_4 = \left(\frac{D\lambda}{3d}\right) = \frac{1\times6000\times10^{-10}}{3\times3\times10^{-3}}$$

$$= \frac{2}{3}\times10^{-4}$$

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Slit Seperation b/w S_3 and S_4.

$$= OS_3 + OS_4$$

$$= 2\times10^{-4} + \frac{2}{3}\times10^{-4}$$

$$= \frac{8}{3}\times10^{-3}$$

$\Rightarrow$ Due to path difference no phase difference at O' as $[S_3O' = S_4O']$

So, phase difference at O'.

$$= 2\pi - \frac{2\pi}{3}$$

$$= \left(\frac{4\pi}{3}\right)$$

$$(I_R)_{O'} = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$$

$$= 4I_0 + I_0 + 2\sqrt{(4I_0)I_0}\cos\frac{4\pi}{3}$$

$$= 5I_0 + 4I_0\cos\left(\pi+\frac{\pi}{3}\right)$$

$$= 5I_0 - 4I_0\cos\frac{\pi}{3}$$

$$= 5I_0 - 2I_0$$

$$= (3I_0)$$

Ans.

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I_0 = Intensity of light at S_1 and S_2

$O \to$ Center of Slit $S_1 S_2$

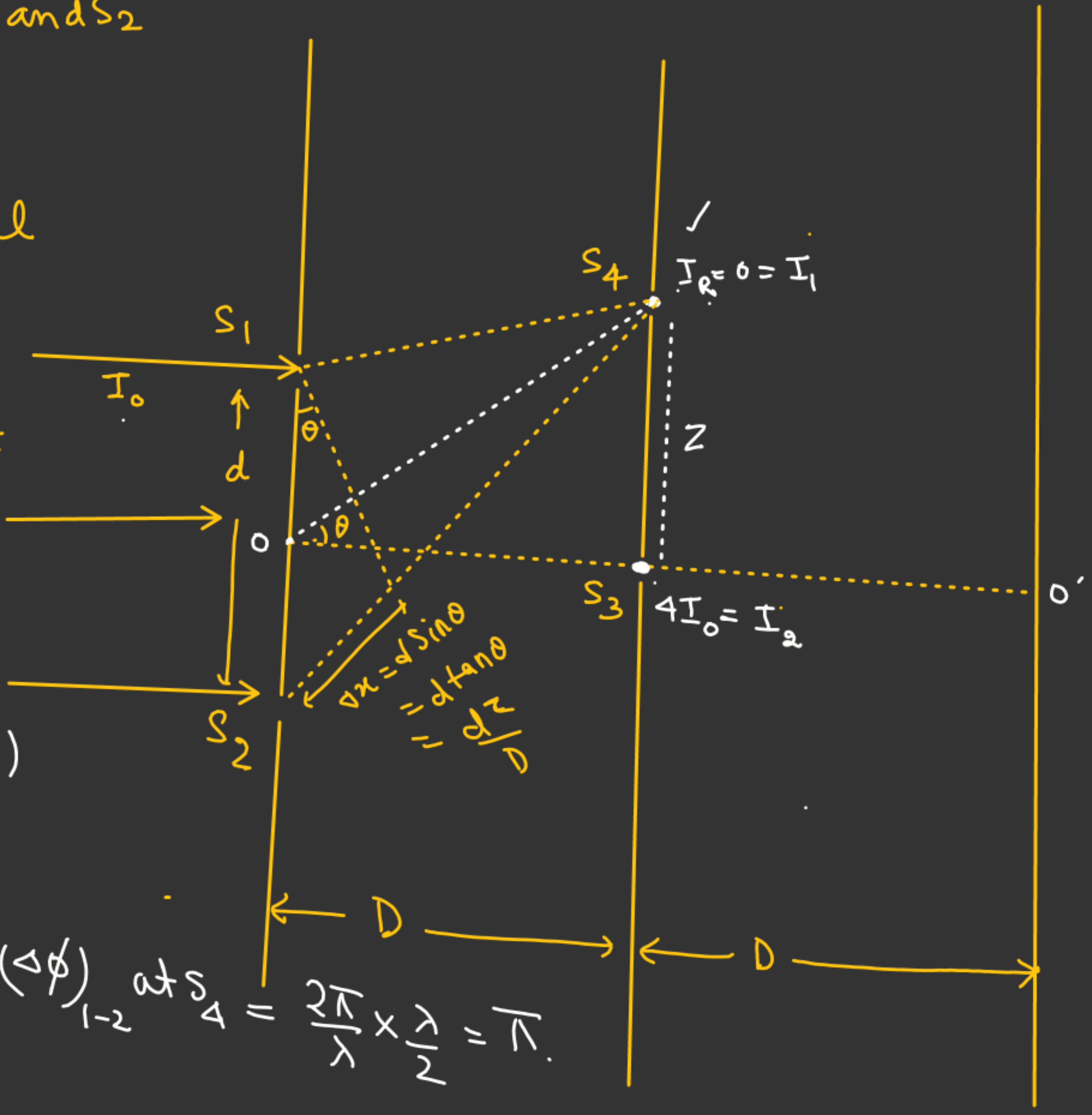
$O' \to$ Center of Screen

$S_3 \to$ just on the central line.

$S_4 \to$ Can vary.

Find ratio of I_{max}/I_{min} at the screen.

a) $\dfrac{D\lambda}{2d}$ b) $\dfrac{\lambda D}{4d}$ ✓



a) At S_3

$\delta = 0.$

$I_R = 4I_0$

$I_R = 4I_0\cos^2\left(\frac{\delta}{2}\right)$

At S_4

$\Delta x = d\sin\theta \simeq d\tan\theta = \left(\frac{dz}{D}\right)$

$\Delta x = \frac{d}{D} \times \frac{D\lambda}{2d} = \frac{\lambda}{2}$

$(\Delta\phi)_{1-2}$ at $S_4 = \frac{2\pi}{\lambda} \times \frac{\lambda}{2} = \pi.$

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a) $(I_R)_{max} = \left(\sqrt{I_1} + \underset{\downarrow\ 0}{\sqrt{I_2}}\right)^2$

$I_1 = 4I_0$

$\Rightarrow (I_R)_{max} = 4I_0.$

$(I_R)_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

$= 4I_0.$

$$\frac{(I_R)_{max}}{(I_R)_{min}} = \frac{1}{1}.$$

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b) $\dfrac{\lambda D}{4d}$ ✓

$$\underline{I_R} = 4I_0 \cos^2\left(\frac{\delta}{2}\right)$$

At S_3

$$\delta = 0$$

$$I_R = 4I_0$$

At the screen

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{4I_0} + \sqrt{2I_0}\right)^2}{\left(\sqrt{4I_0} - \sqrt{2I_0}\right)^2}$$

$$= \left(\frac{2+\sqrt{2}}{2-\sqrt{2}}\right)^2$$

$$= \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2 \ \underline{\underline{\text{Ans}}}$$ ✓

At S_4

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

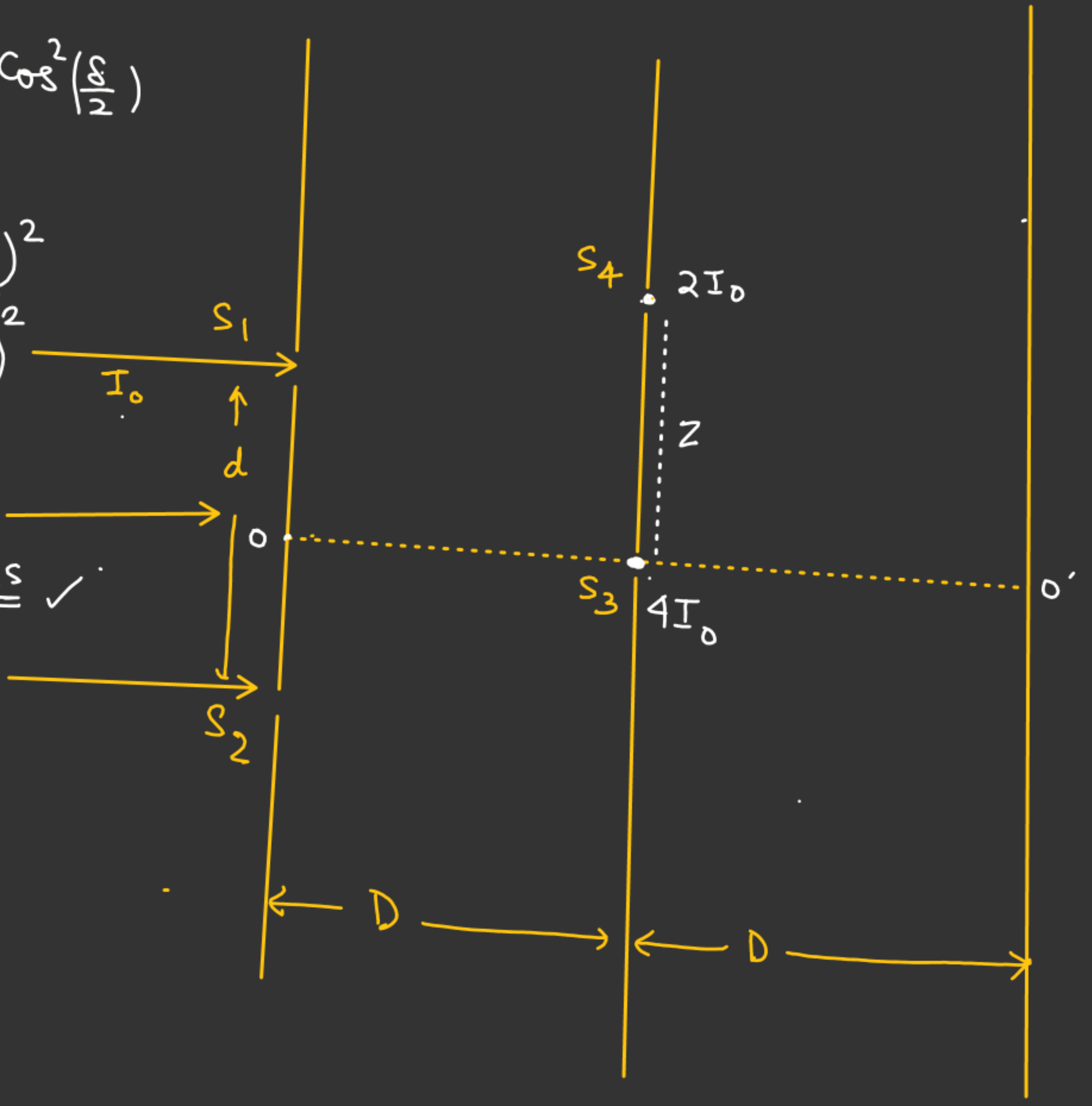
$$\Delta x = \frac{d}{D} \times \frac{D\lambda}{4d} = \left(\frac{\lambda}{4}\right)$$

$$\delta \Rightarrow \Delta\phi_{1-2} \text{ at } S_4 = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \left(\frac{\pi}{2}\right)$$

$$I_R \text{ at } S_4 = 4I_0 \cos^2\frac{\delta}{2}$$

$$= 4I_0 \cos^2\frac{\pi}{4}$$

$$= \underline{2I_0}$$



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Source at finite distance & not symmetrical w.r.t S_1 and S_2

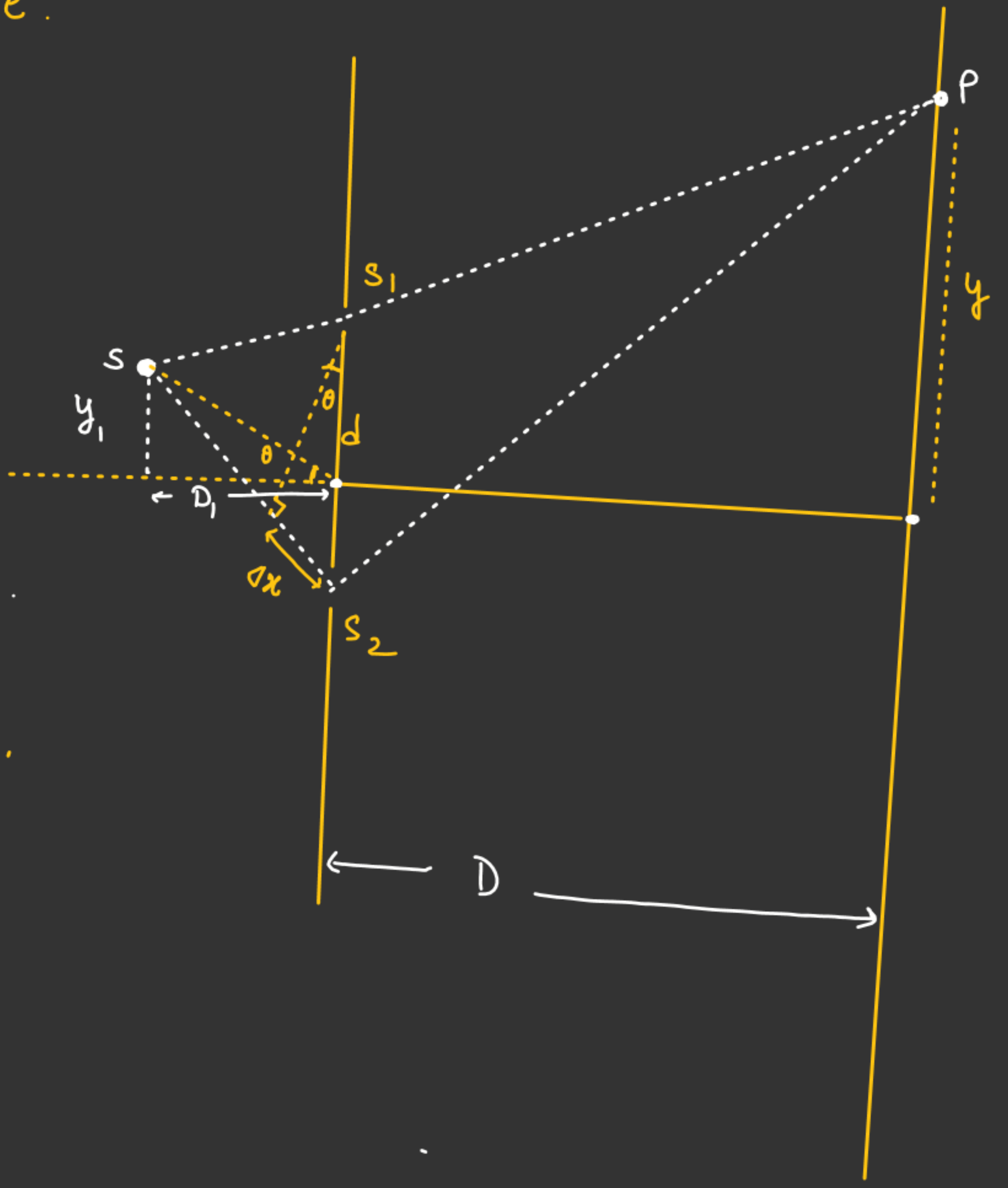
$(D_1 \text{ or } D) >> d$

$$\Delta x = (SS_2 + S_2P) - (SS_1 + S_1P)$$

$$\Delta x = (SS_2 - SS_1) + (S_2P - S_1P)$$

$$\Downarrow$$

$$\Delta x = \left(\frac{d\,y_1}{D_1}\right) + \left(\frac{d\,y}{D}\right)$$



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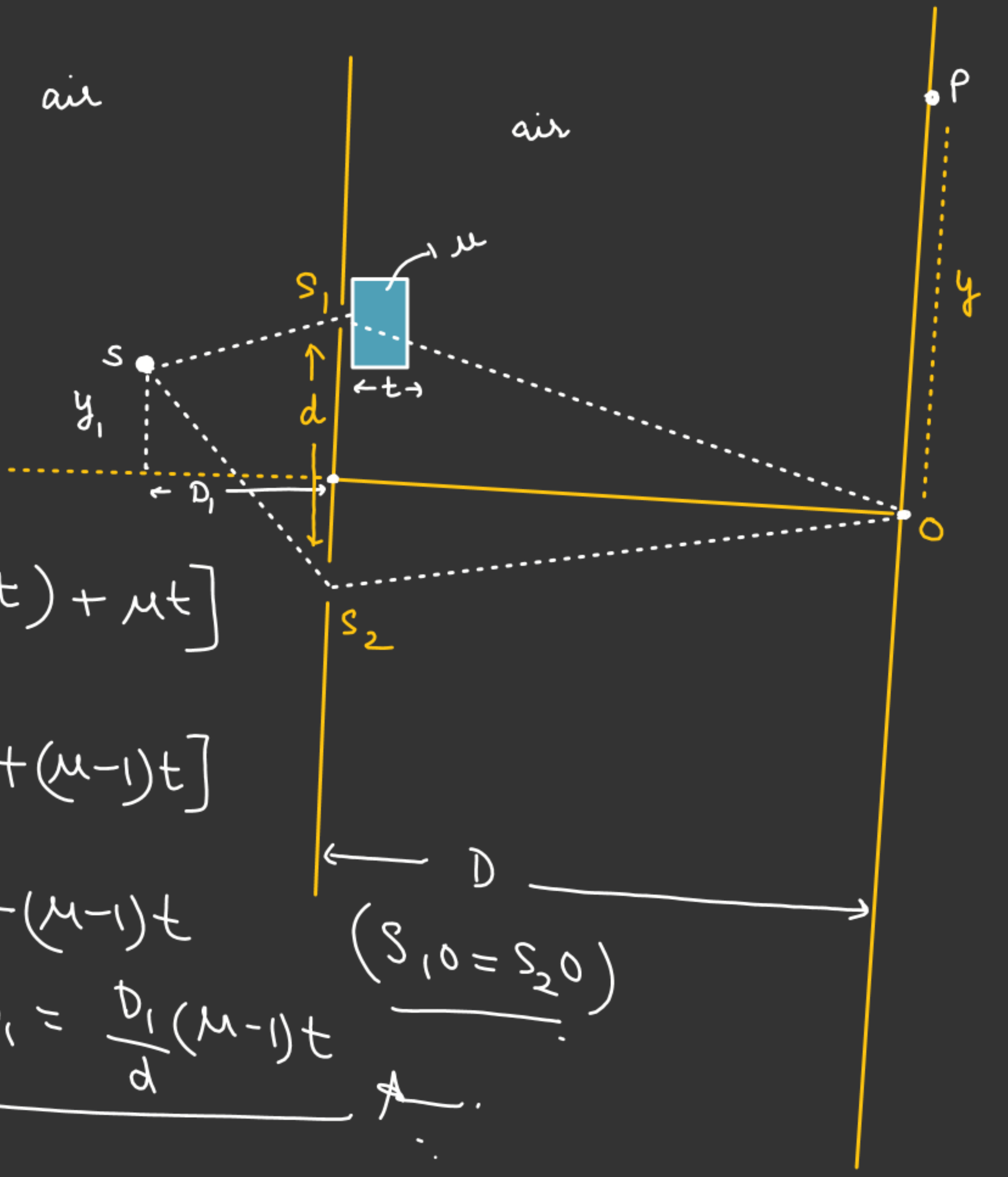
Q: Sorce S_1 is shifted to y_1 distance so that Central Maxima at the center of Screen O. Find the Value of $y_1 = ??$

λ = Wave length of Light.



For Central Maxima path difference zero.

$$0 = (SS_2 + S_2O) - [SS_1 + (S_1O - t) + \mu t]$$

$$0 = (SS_2 + S_2O) - [SS_1 + S_1O + (\mu - 1)t]$$

$$0 = \underbrace{(SS_2 - SS_1)}_{\Downarrow} + \underbrace{(S_2O - S_1O)}_{\Downarrow\, 0} - (\mu - 1)t$$

$(S_1O = S_2O)$

$$0 = \frac{dy_1}{D_1} - (\mu - 1)t \Rightarrow \underline{y_1 = \frac{D_1}{d}(\mu - 1)t} \quad \text{A.}$$

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$\Delta\theta$ //

$\Delta x' = (d\sin\phi)$

$\Delta x = d\sin\theta \approx d\tan\theta \approx \frac{dy}{D}$

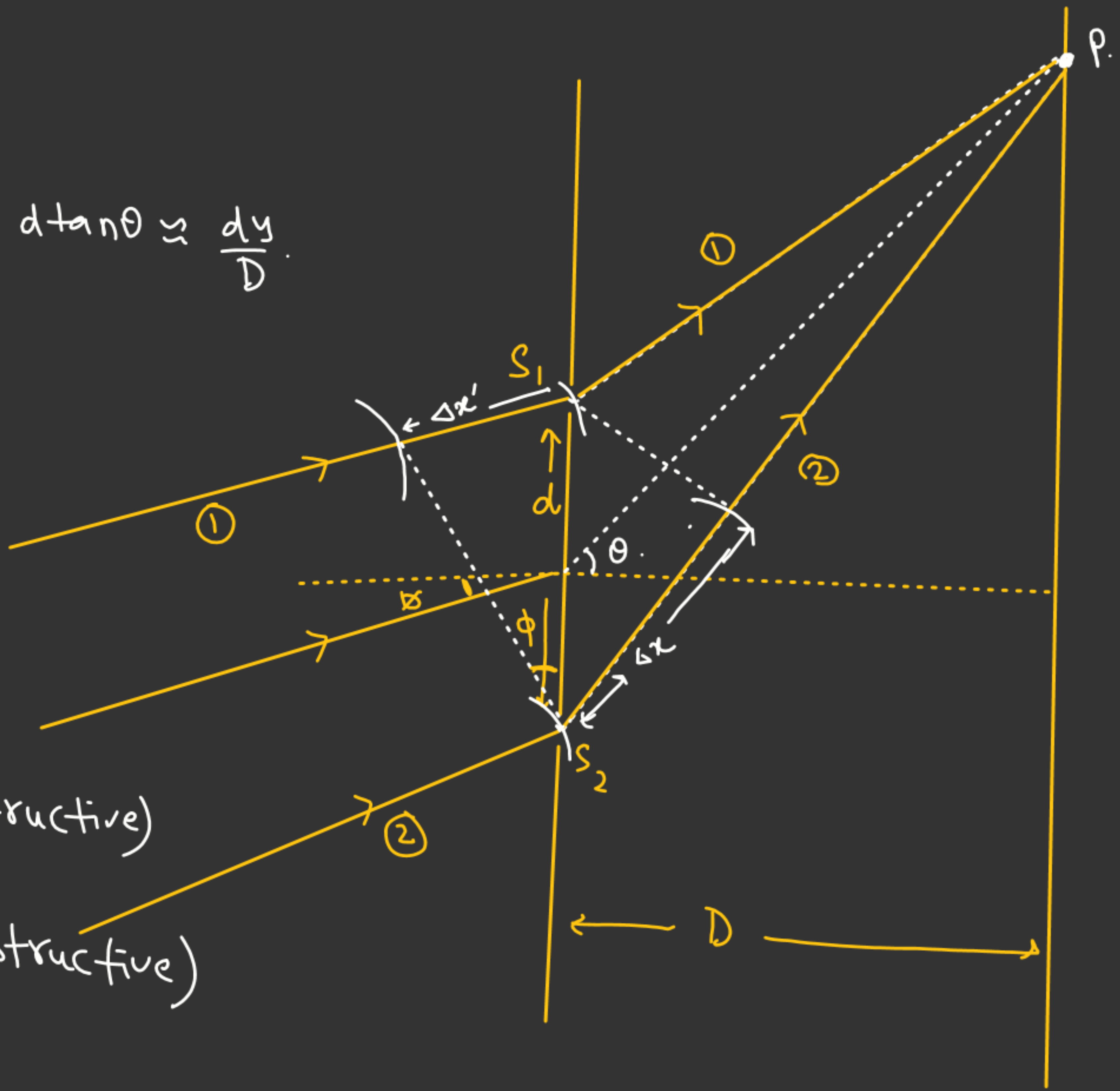
$\Delta x_{net} = |\Delta x - \Delta x'|$

$= |d\sin\theta - d\sin\phi|$

$= \left|\frac{dy}{D} - d\sin\phi\right|$

$\Delta x_{net} = n\lambda$ (Constructive)

$\Delta x_{net} = (2n+1)\frac{\lambda}{2}$ (Destructive)



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Case when Screen is perpendicular to Slits.

$D >> d$

In $\Delta\, S_1S_2A$.

$$\cos\theta = \frac{S_1A}{d}$$

$$S_1A = d\cos\theta.$$

For Maxima

$$\Delta x = n\lambda$$

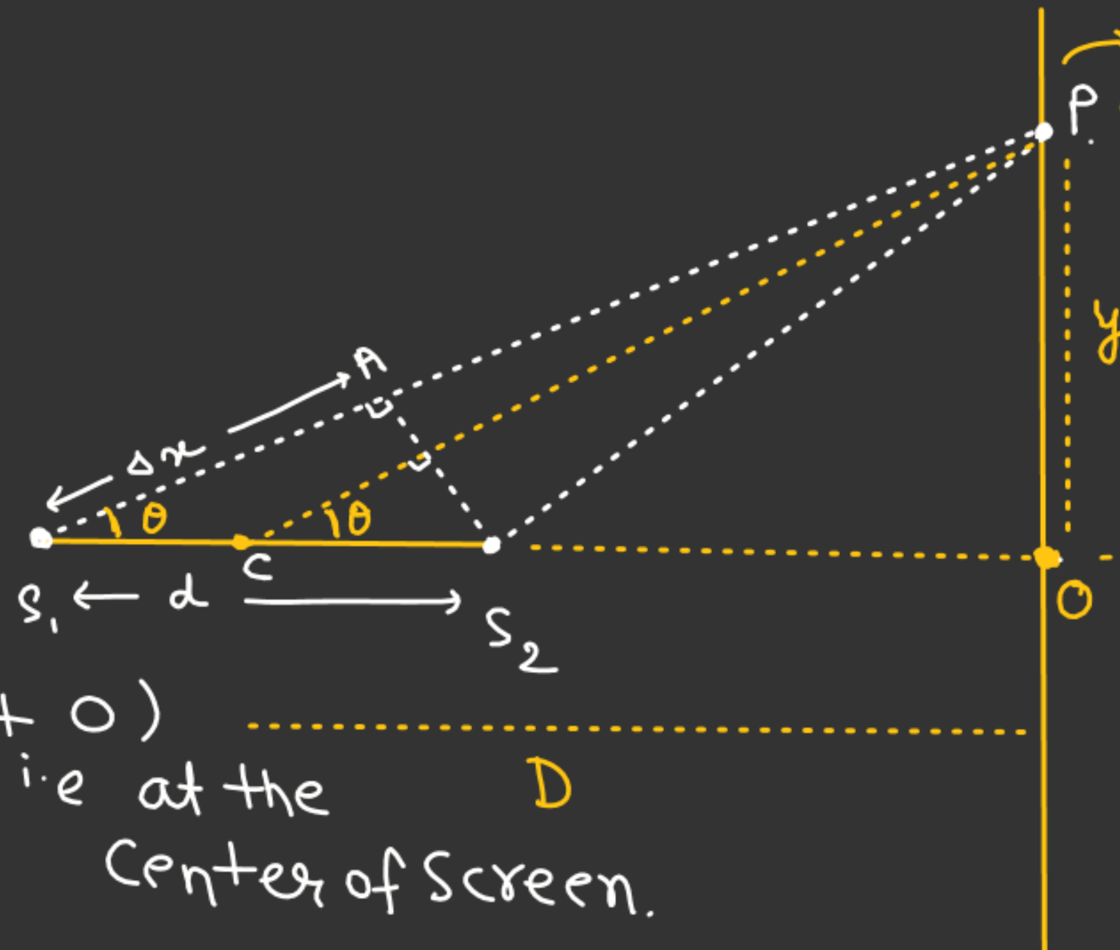
$$d\cos\theta = n\lambda$$

$$\boxed{n = \frac{d}{\lambda}\cos\theta}$$

For n_{max}

$\theta = 0° \Rightarrow$ (At O) i.e at the Center of Screen.

$$\left[n_{max} = \frac{d}{\lambda}\right].$$

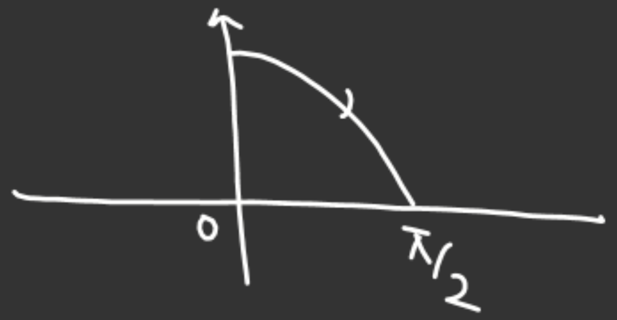


Ex→ If $d = 4\lambda$

$n_{max} = 4^{th}$ order maxima at O.

For Central Maxima.

$\Delta x = 0, \quad \cos\theta = 0 \Rightarrow \theta = \pi/2.$



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$\underline{d = 4\lambda}$ ✓

When θ increases.

we have 3rd order, 2nd order, & 1st Order maxima on the Screen above O.

Same pattern as below O.

$$\Delta x = d\cos\theta = \left(\frac{dD}{\sqrt{D^2+y^2}}\right)$$

$$\Delta x = \frac{d\cancel{D}}{\cancel{D}\left(1+\frac{y^2}{D^2}\right)^{1/2}}$$

$$\Delta x = d\left(1+\frac{y^2}{D^2}\right)^{-1/2}$$

$$\Delta x \simeq d\left(1-\frac{y^2}{2D^2}\right)$$

For 3rd Maxima

$$\Delta x = 3\lambda.$$

$$d\left(1-\frac{y^2}{2D^2}\right) = 3\lambda$$

$$1-\frac{y^2}{2D^2} = \frac{3\lambda}{d} = \frac{3}{4}$$

$$1-\frac{3}{4} = \frac{y^2}{2D^2}$$

$$\frac{1}{4} = \frac{y^2}{2D^2} \Rightarrow y^2 = \frac{D^2}{2}$$

$$y = \pm\frac{D}{\sqrt{2}}$$

Position of 3rd Maxima

H.W: Position of 2nd & 1st Maxima ??