Q. 8: In young's double slit experiment, when the slit plane is illuminated with light of wavelength λ_1, it was observed that point P is closest point from central maximum O, where intensity was 75% the intensity at O. When the light of wavelength λ_2 is used, point P happens to be the nearest point from O where intensity is 50% of that at O. Find the ratio $\frac{\lambda_1}{\lambda_2}$.

$$I = I_0 \cos^2 \frac{\Delta\phi}{2}$$

$$\frac{3I_0}{4} = I_0 \cos^2 \frac{\Delta\phi}{2} \Rightarrow \frac{\Delta\phi}{2} = \frac{\pi}{6} \Rightarrow \Delta\phi = \frac{\pi}{3}$$

$$\Delta\phi = \frac{2\pi}{\lambda_1}\Delta x = \frac{\pi}{3} \quad -(1)$$

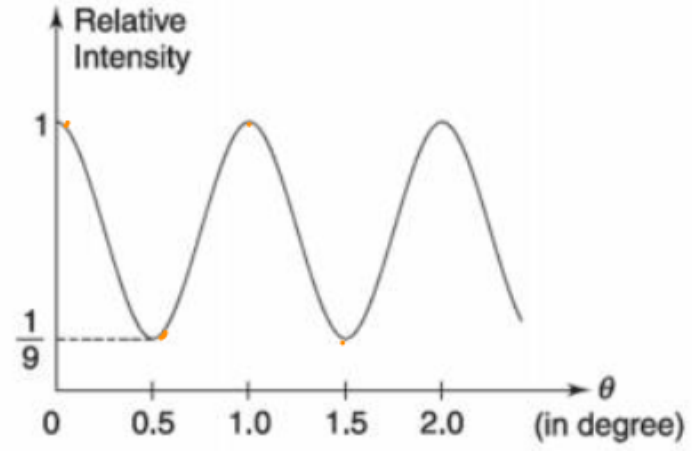
$$\frac{I_0}{2} = I_0 \cos^2 \frac{\Delta\phi}{2} \Rightarrow \frac{\Delta\phi}{2} = \frac{\pi}{4} \Rightarrow \Delta\phi = \frac{\pi}{2}$$

$$\Delta\phi = \frac{2\pi}{\lambda_2}\Delta x = \frac{\pi}{2} \quad -(2)$$

$$\boxed{\frac{(1)}{(2)} \Rightarrow \frac{\lambda_2}{\lambda_1} = \frac{2}{3}}$$

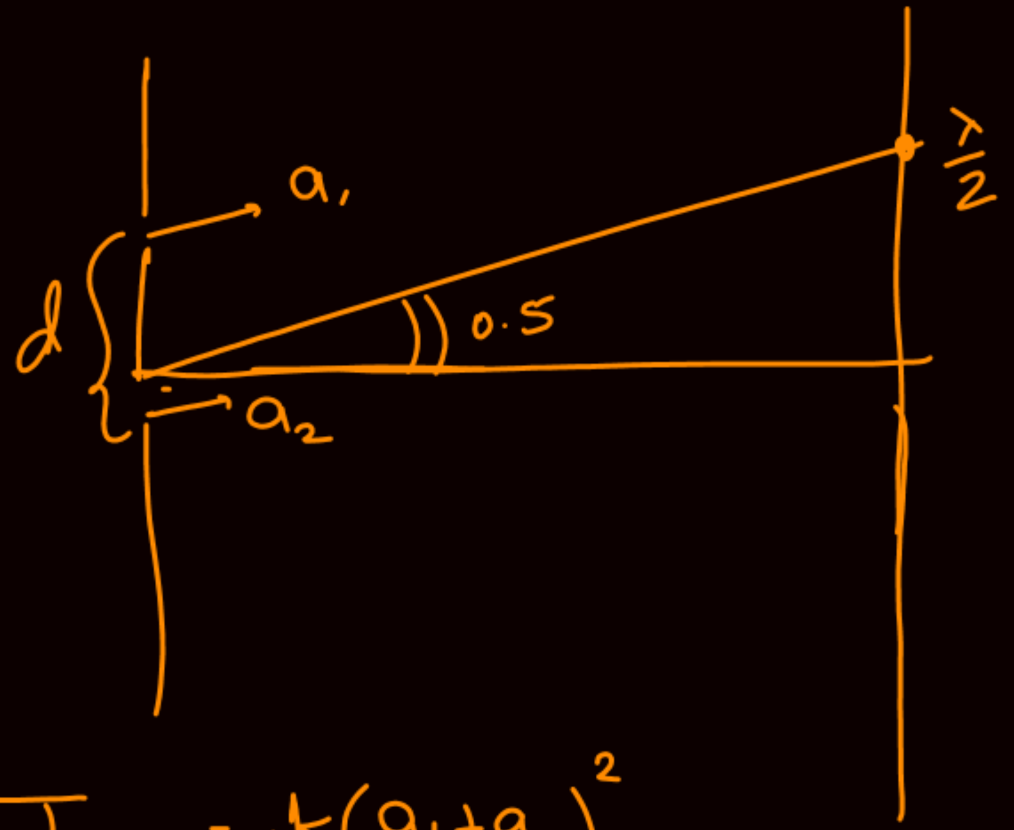
$$\frac{\lambda_1}{\lambda_2} = 3/2$$

Q. 9: In young's double slit experiment relative intensity at a point on the screen may be defined as ratio of intensity at that point to the maximum intensity on the screen. Light of wavelength 7500 Å passing through a double slit, produces interference pattern of relative intensity variation as shown in Fig. θ on horizontal axis represents the angular position of a point on the screen.



(a) Find separation d between the slits.

(b) Find the ratio of amplitudes of the two waves producing interference pattern on the screen.



$$d \sin\theta = \frac{\lambda}{2}$$

$$d\theta = \frac{\lambda}{2}$$

$$d = \frac{\lambda}{2\theta}$$

$$= \frac{7500\times10^{-10}}{2\times\frac{0.5}{180}\times 3.14}$$

$$= 0.04\times10^{-3}\,m$$

$$d = 0.04\,mm$$

$$I_{max} = k(a_1+a_2)^2$$

$$I_{min} = k(a_1-a_2)^2$$

$$\frac{I_{min}}{I_{max}} = \frac{1}{9} = \left(\frac{a_1-a_2}{a_1+a_2}\right)^2$$

$$\frac{a_1-a_2}{a_1+a_2} = \frac{1}{3} \Rightarrow \frac{a_1}{a_2} = \frac{2}{1}$$

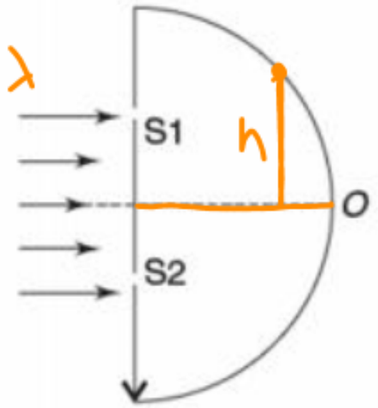
$d = 5\,\mu m$

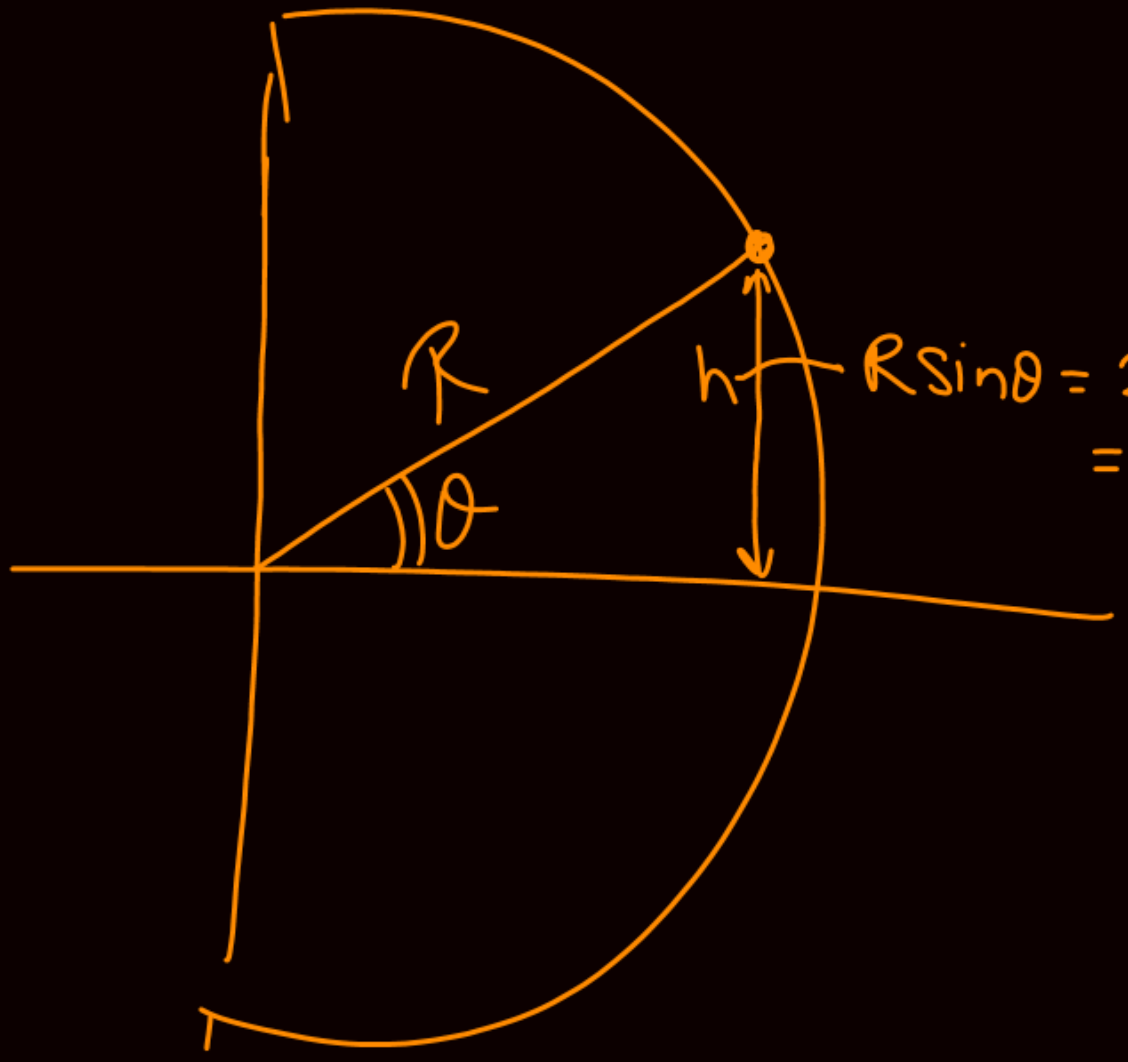
$\lambda = 500\,nm$

$d\sin\theta = 2\lambda$

$\sin\theta = \frac{2\lambda}{d} = \frac{2\times \cancel{500}^{100}\times 10^{\cancel{-9}}}{\cancel{5}\times 10^{\cancel{-6}}}\; 10^{\cancel{-7}} / 10^{-1} = 0.2$

Q. 13: Coherent light of wavelength λ = 500 nm is sent through two narrow parallel slits in a large vertical wall. The two slits are 5 μm apart. In front of the wall there is a semi cylindrical screen with its horizontal axis at the line running on the wall parallel to the slits and midway between them. Radius of the cylindrical screen is R = 2.0 m. Find the vertical height of the second order interference maxima from the centre (O) of the screen.





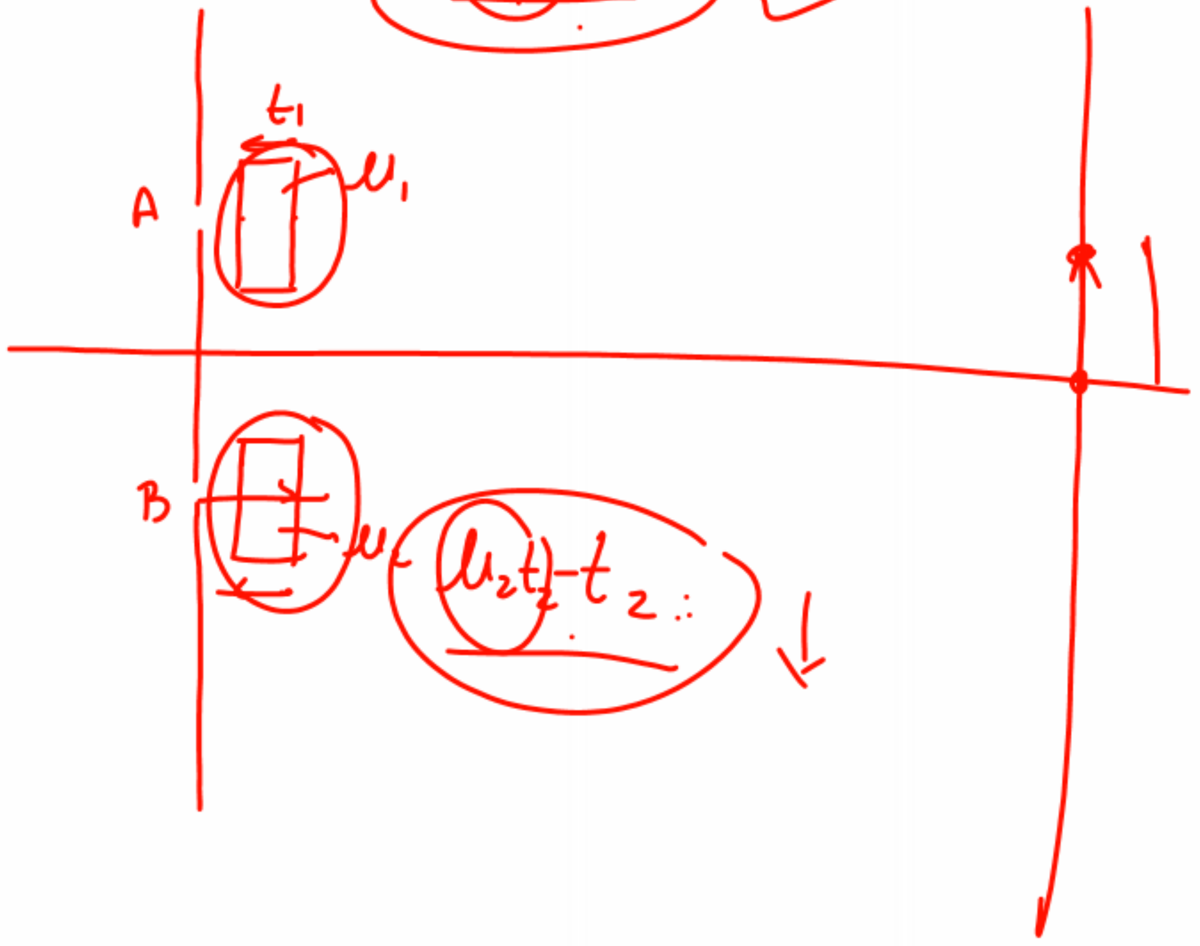
$R\sin\theta = 2\times 0.2$

$= 0.4\,m = 40\,cm$

Q. 14: In a Young double slit experiment, the two slits are named as A and B. Two transparent films of thickness t_1 and t_2 having refractive indices μ_1 and μ_2 placed in front of the slits A and B respectively. It is given that $\mu_1 t_1 = \mu_2 t_2$ and $t_1 < t_2$

In which direction will the central maximum shift after the two films are placed?

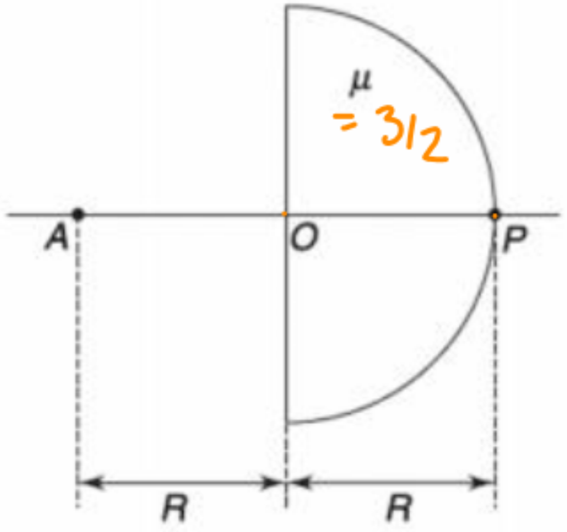
$\mu_1 t_1 - t_1$:

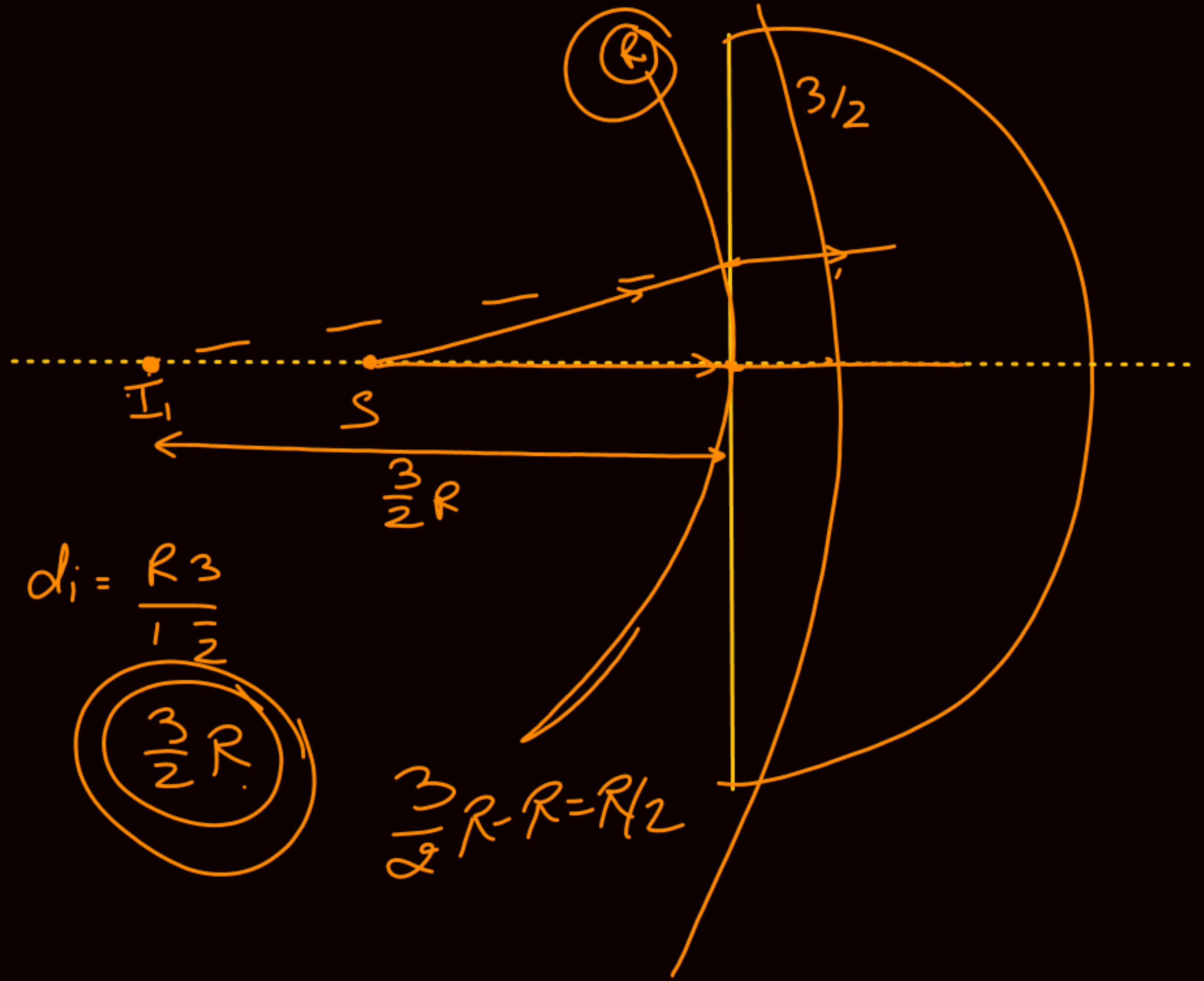


Q. 15: A point source (A) is kept on the axis of a hemispherical paperweight made of glass of refractive index $\mu = \frac{3}{2}$. The distance of the point source from the centre (O) of the sphere is R where R is radius of the hemisphere. Use paraxial approximations for answering following questions

(a) Find the change in radius of curvature of the wavefronts just after they enter the glass at O.

(b) Find the radius of curvature of the wavefronts at point P just outside the glass.

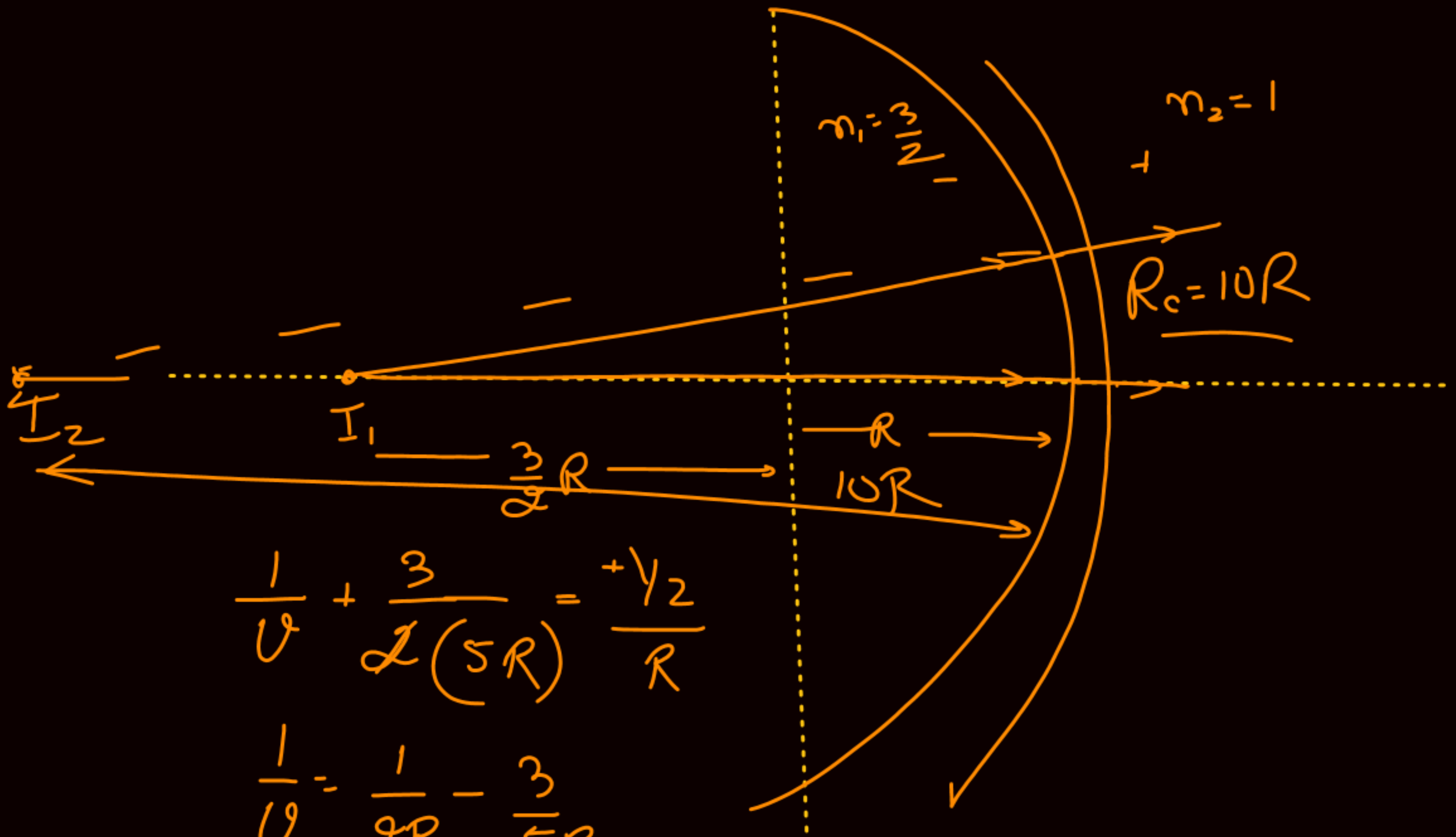




$d_i = \frac{R\,3}{1\ \overline{2}}$

$\frac{3}{2}R$

$\frac{3}{2}R - R = R/2$



$$\frac{1}{v} + \frac{3}{2(5R)} = \frac{+1/2}{R}$$

$$\frac{1}{v} = \frac{1}{2R} - \frac{3}{5R}$$

$$= \frac{5-6}{10R} \qquad v = -10R$$

$\lambda = 500\,nm$

$= 500 \times 10^{-9} m = 500 \times 10^{-6} mm$

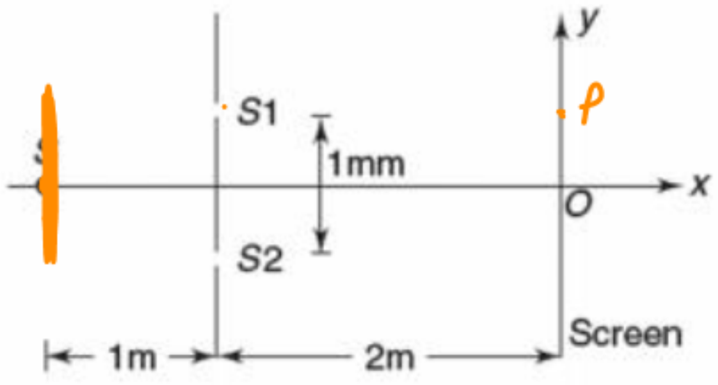
$d = 1mm.$

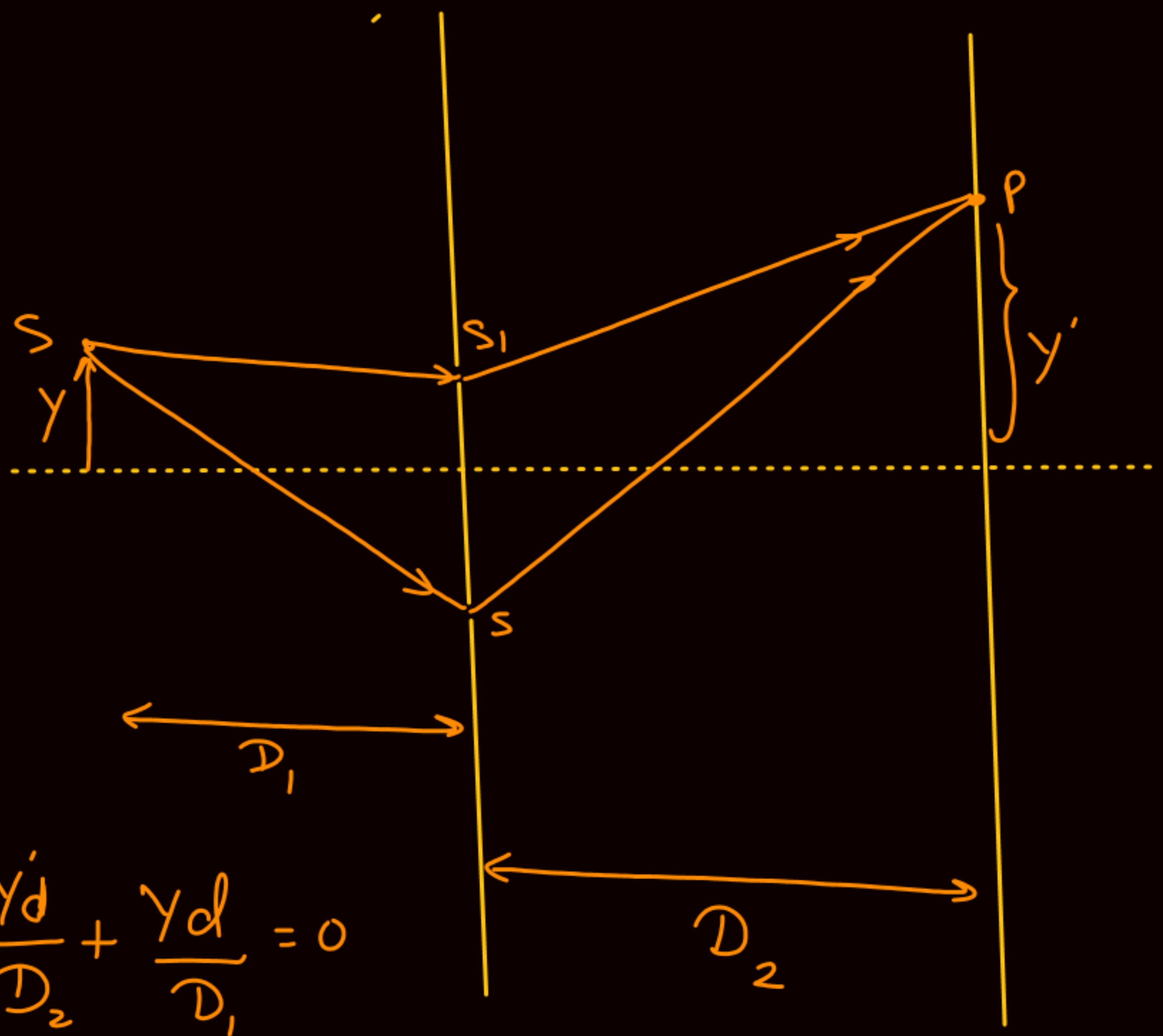
Q. 21: In a Young's double slit experiment set up source S of wavelength λ = 500 nm illuminates two symmetrically located slits $S1$ and $S2$. The source S oscillates about its shown position parallel to the screen according to the equation $y = (0.5\text{ mm})\sin(\pi t)$.

Where t is time in second. Distances are as marked in the figure.

(a) Write the y co-ordinate (y') of central maximum as a function of time

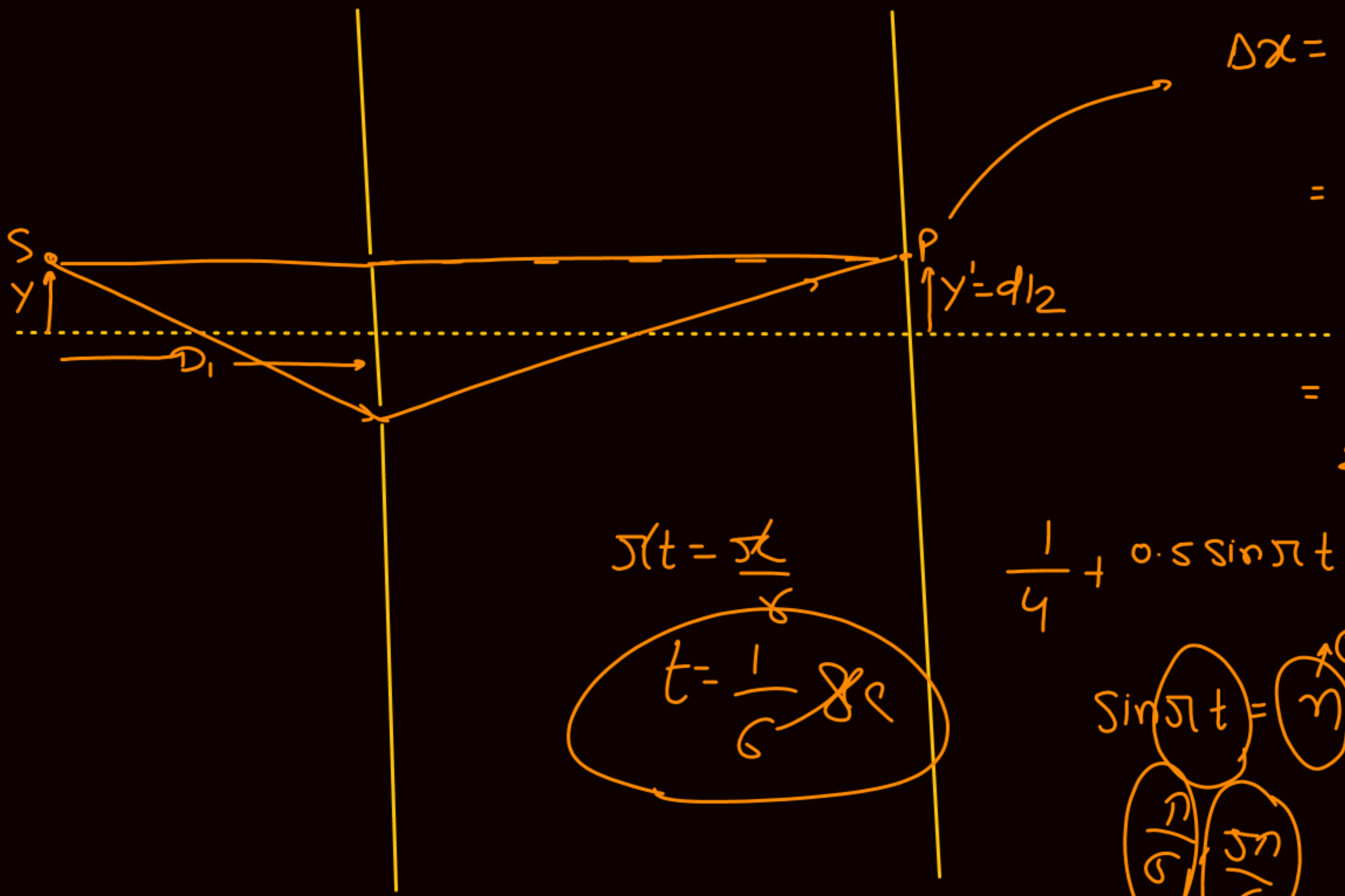
(b) Find least value of time (t) at which the intensity becomes maximum at a point on the screen that is exactly in front of slit $S1$.





$$\Delta x = \frac{y'd}{D_2} + \frac{yd}{D_1} = 0$$

$$y' = -\frac{yD_2}{D_1} = -(0.5mm\sin\pi t)2 = -1mm\sin\pi t$$



$$\Delta x = \frac{dy'}{D_2} + \frac{yd}{D_1}$$

$$= \frac{d^2}{2D_2} + \frac{dy}{D_1} = n\lambda$$

$$= \frac{1}{2\times 2\times 10^3} + \frac{1\times 0.5\sin\pi t}{10^3} = n\times 500\times 10^{-6}$$

$$\frac{1}{4} + 0.5\sin\pi t = \frac{n}{2}$$

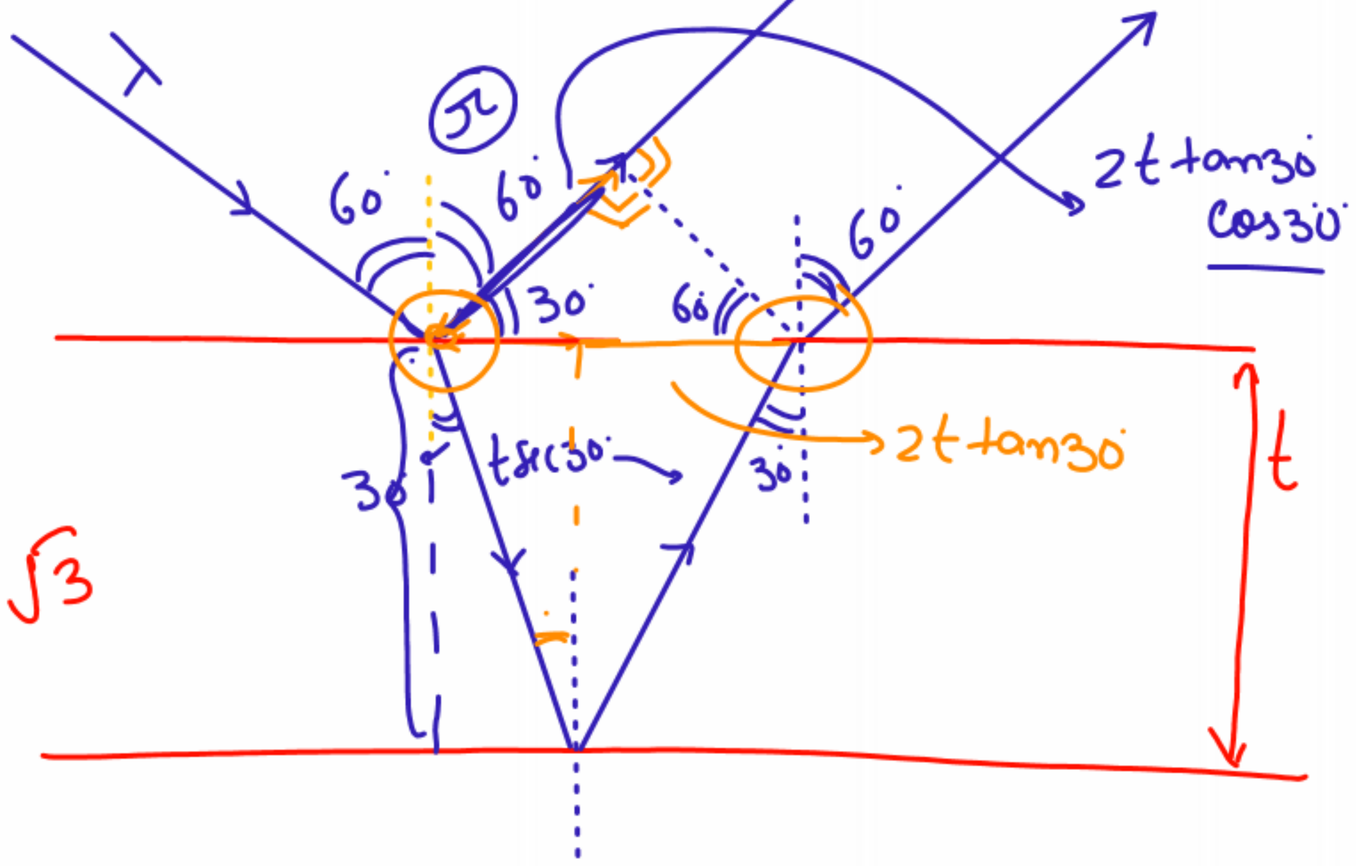
$$\sin\pi t = \overset{1}{n} - \frac{1}{2}$$

$$\frac{\pi}{6}, \quad \frac{5\pi}{6}$$

$$\pi t = \frac{\pi}{6}$$

$$t = \frac{1}{6}\ \text{sec}$$

Q. 24: A parallel beam of white light falls from air on a thin film whose refractive index is $\sqrt{3}$. The medium on both sides of the film is air. The angle of incdidence is 60°. Find the minimum film thickness if reflected light is most intense for λ = 600 nm.



$t = \frac{\lambda}{6}$

$t = 100\,nm$

$1 \times \frac{\sqrt{3}}{2} = \sqrt{3} \times \sin r \quad r = 30°$

$\Delta x = \left(\sqrt{3} \times 2t\sec 30°\right) - 2t\tan 30° \cos 30°$

$\Delta x = \sqrt{3} \times 2t \times \frac{2}{\sqrt{3}} - 2t \times \frac{1}{\sqrt{3}} \times \frac{\sqrt{3}}{2}$

$= \underline{\underline{3t}}$

$\Delta\phi = \frac{2\pi}{\lambda}(3t) + \pi = 2n\pi$

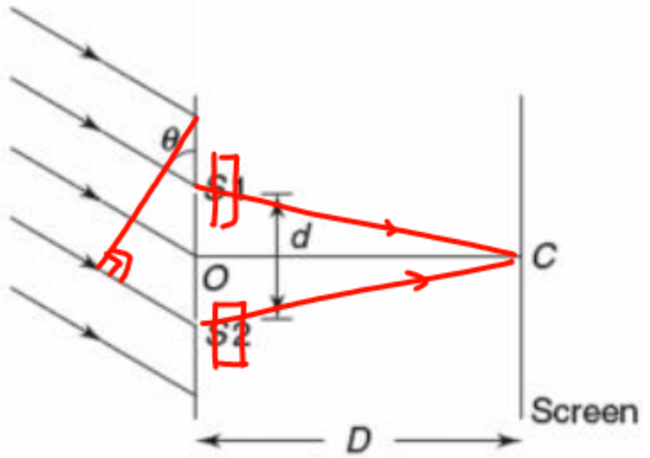
$\frac{2\pi}{\lambda} 3t = (2n-1)\pi$

$3t = (2n-1)\frac{\lambda}{2} = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$

Q. 26: In a double slit experiment a parallel beam of light strikes the slit plane at an angle θ as shown in the figure. The two slits are covered with transparent plastic sheets of equal thickness t but of different refractive indices 1.2 and 1.5. The central maxima is formed at the centre of the screen at C.

(a) Which sheet was used to cover the slit $S1$?

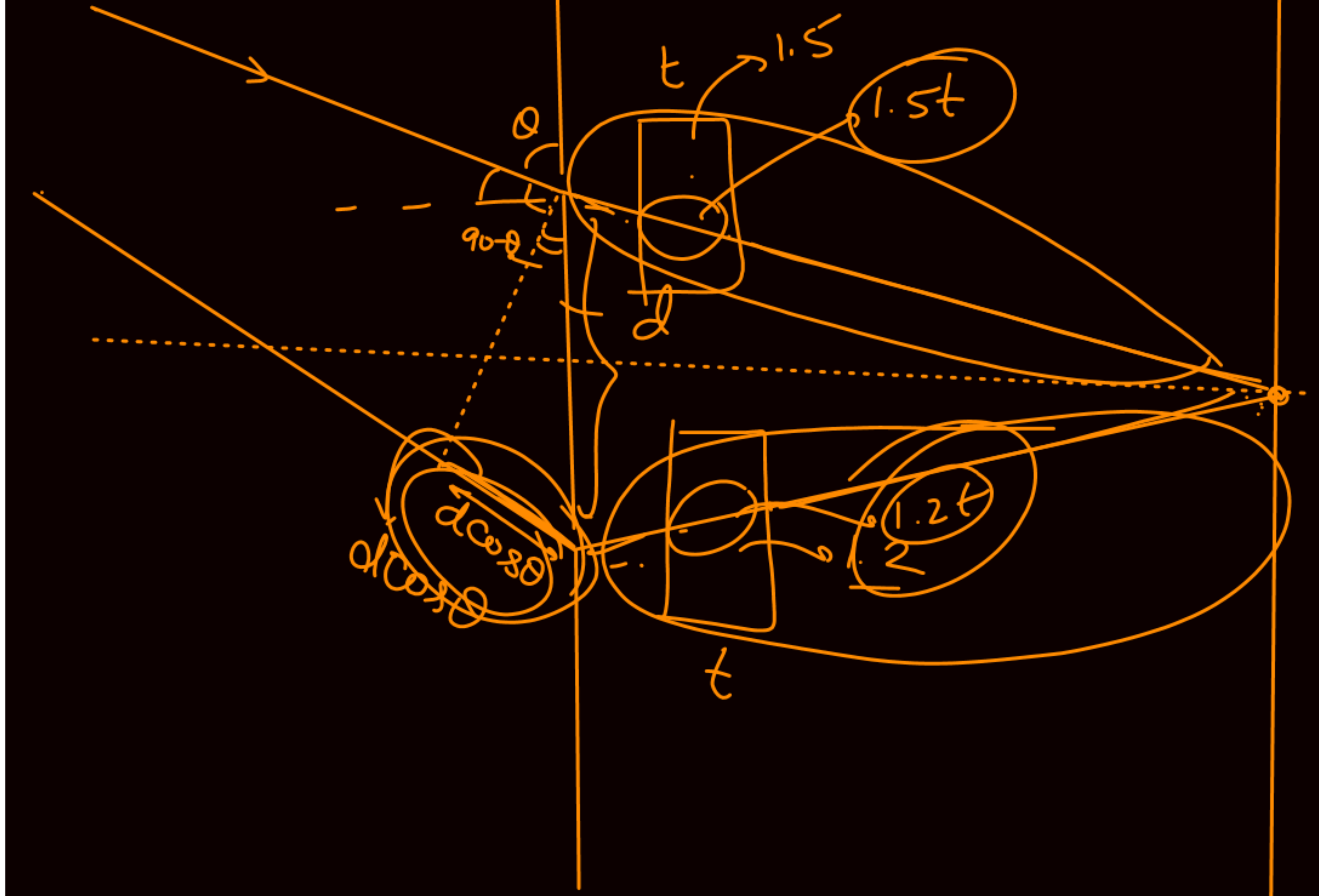
(b) Find θ.



$$0.3t = d\cos\theta$$

$$\cos\theta = \frac{0.3t}{d}$$

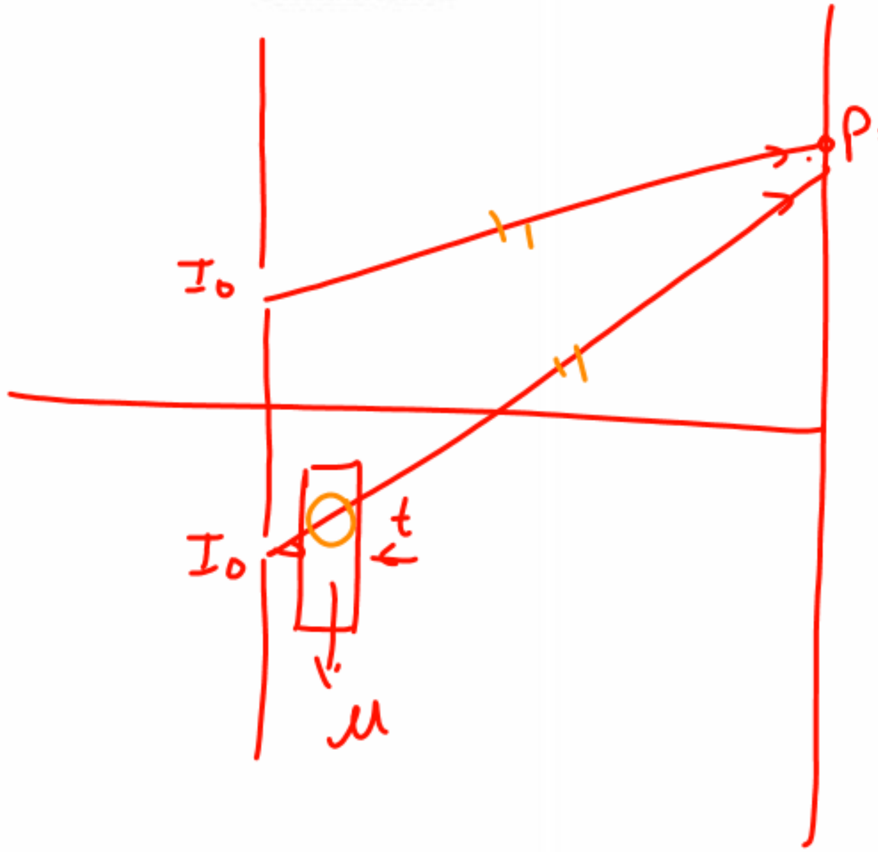
$$\boxed{\theta = \cos^{-1}\left(\frac{0.3t}{d}\right)}$$



Q. 29: In Young's double slit experiment a monochromatic light of wavelength λ from a distant point source is incident upon the two identical slits. The interference pattern is viewed on a distant screen. Intensity at a point P is equal to the intensity due to individual slits (equal to I_0). A thin piece of glass of thickness t and refractive index μ is placed in front of the slit which is at larger distance from point P; perpendicular to the light path. Assume no absorption of light energy by the glass.

(a) Write intensity at point P as a function of t.

(b) Write all values of t for which the intensity at P is minimum.



$\Rightarrow I = 4I_0 \cos^2 \frac{\Delta\phi}{2}$

$I_0 = 4I_0 \cos^2 \frac{\Delta\phi}{2}$

$\cos\frac{\Delta\phi}{2} = \frac{1}{2}$ $\quad \Delta\phi = 120^\circ = \frac{2\pi}{3}$

$I = 4I_0 \cos^2 \frac{\Delta\phi'}{2}$

$\Delta\phi' = \frac{2\pi}{3} + (\mu-1)t\,\frac{2\pi}{\lambda}$

$I = 4I_0 \cos^2\left(\frac{\pi}{3} + \frac{\pi}{\lambda}(\mu-1)t\right)$

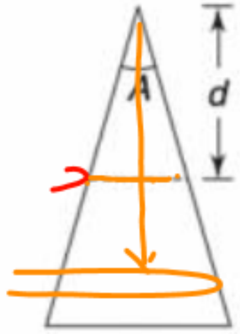
$\frac{\pi}{3} + \frac{\pi}{\lambda}(\mu-1)t = (2n+1)\frac{\pi}{2}$

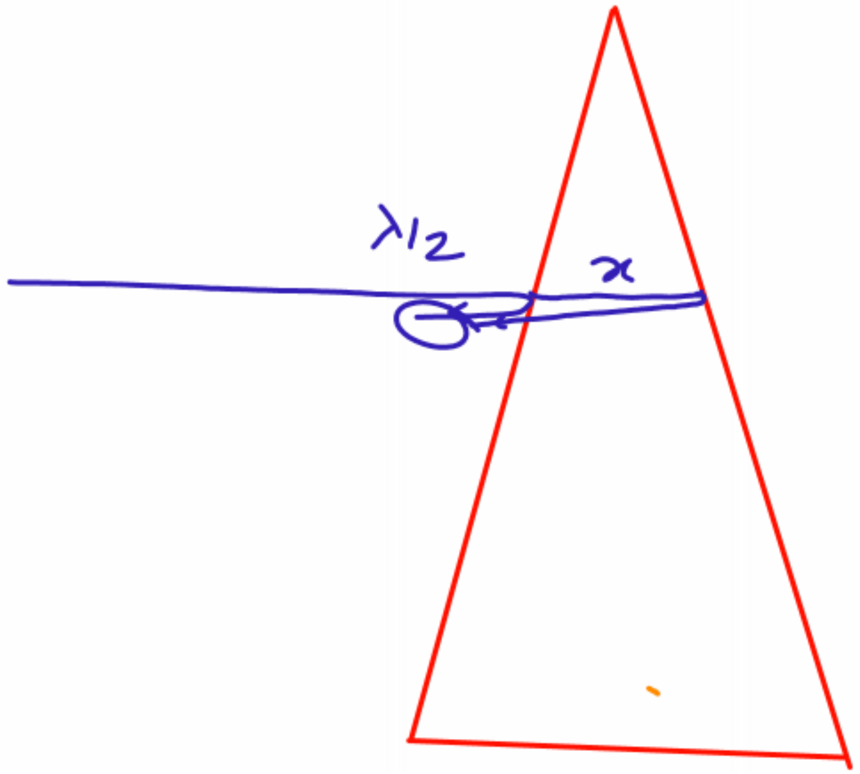
$t = (\quad\quad)$

Q. 33: A very thin prism has an apex angle A and its material has refractive index $\mu = 1.48$. Light is made to fall on one of the refracting faces at near normal incidence. Interference results from light reflected from the outer surface and that emerging after reflection at the inner surface. When violet light of wavelength $\lambda = 400$ nm is used, the first constructive interference band is observed at a distance $d = 3.0$ cm from the apex of the prism.

(a) Find the apex angle A.

(b) If red light ($\lambda = 800$ nm) is used, at what distance from the apex will we observe the first constructive interference band.





$$2\mu x - \frac{\lambda}{2} = n\lambda$$

$$2\mu x = (2n+1)\frac{\lambda}{2}$$

$$2\mu x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}$$

$$x = \frac{\lambda}{4\mu} = dA$$

$$A = \frac{\lambda}{4\mu d} = \frac{400\times10^{-9}}{4\times1.48\times3\times10^{-2}}$$

$$2\mu x = \frac{\lambda}{2}$$

$$\boxed{2\mu d A = \lambda/2}$$