DPP – 2 (Wave Optics)

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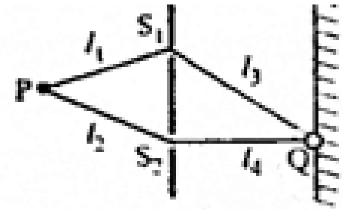
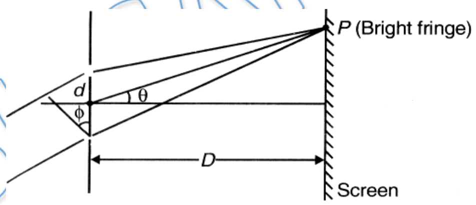
Q 1. Two identical narrow slits S_1 and S_2 are illuminated by light of wavelength λ from a point source P. If, as shown in the diagram above the light is then allowed to fall on a screen, and if n is a positive integer the condition for destructive interference at Q is that



(a) $(l_1 - l_2) = (2n + 1)\lambda/2$
(b) $(l_3 - l_4) - (2n + 1)\lambda/2$
(c) $(l_1 + l_2) - (l_2 + l_4) = n\lambda$
(d) $(l_1 + l_3) - (l_2 + l_4) = (2n + 1)\lambda/2$

Q 2. For maxima (bright fringe) at point P, relation between given quantities is (angles shown in figure are not small)



(a) $|d \sin\phi - d \sin\theta| = (2n-1)\lambda/2$
(b) $|d \sin\phi - d \sin\theta| = n\lambda$
(c) $|d \sin\phi - d \sin\theta| = (2n-1)\lambda/4$
(d) None of these

Q 3. Two coherent point sources s_1 and s_2 vibrating in phase emit light of wavelength λ. The separation between the sources is 2λ. The smallest distance from s_2 on a line passing through s_2 and perpendicular to s_1s_2 where a minimum of intensity occurs is:

(a) $\frac{7\lambda}{12}$ (b) $\frac{15\lambda}{4}$ (c) $\frac{\lambda}{2}$ (d) $\frac{3\lambda}{4}$

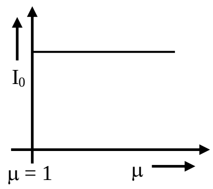
Q 4. White light is used to illuminate the two slits in Young's double slit experiment. The separation between the slits is b and the screen is at a distance d (>> b) from the slits. At a point on the screen directly in front of one of the slits, certain wavelengths are missing. Some of these missing wavelengths are:

(a) $X = b^2/d$ (b) $\lambda = 2b^2/d$ (c) $\lambda = b^2/3d$ (d) $\lambda = 2b^2/3d$

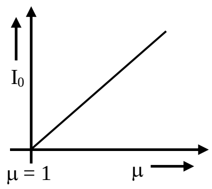
Q 5. In a Biprism experiment, if the wavelength of red light used is 6.5×10^{-7} m and that of green is 5.2×10^{-7}m, the value of n for which (n + 1)th green bright band coincides with the nth red bright band for the same setting is given by -

(a) 2 (b) 3 (c) 4 (d) 1

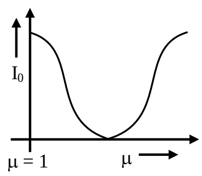
Q 6. In a YDSE experiment if a slab whose refractive index can be varied is placed in front of one of the slits then the variation of resultant intensity at mid-point of screen with 'μ' will be best represented by ($\mu \geq 1$). [Assume slits of equal width and there is no absorption by slab]



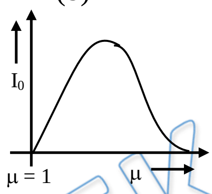
(a)



(b)



(c)



(d)

Q 7. If white light is used in a Young's double-slit experiment -

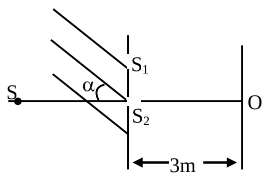
(a) bright white fringe is formed at the centre of the screen

(b) fringes of different colours are observed clearly only in the first order

(c) the first-order violet fringes are closer to the centre of the screen than the first order red fringes

(d) the first-order red fringes are closer to the centre of the screen than the first order violet fringes

Q 8. A parallel beam of light (λ = 5000 Å) is incident at an angle $\alpha = 30°$ with the normal to the slit plane in a young's double slit experiment. Assume that the intensity due to each slit at any point on the screen is I_0. Point O is equidistant from S_1 & S_2. The distance between slits is 1mm.



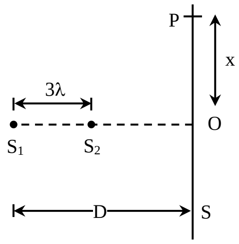
(a) the intensity at O is $4I_0$

(b) the intensity at O is zero

(c) the intensity at a point on the screen 4m from O is $4I_0$

(d) the intensity at a point on the screen 4m from O is zero

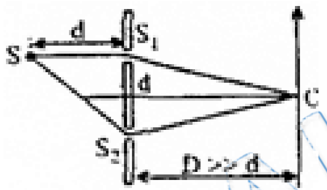
Q 9. Two coherent narrow slits S_1 and S_2 emitting light of wavelength λ in the same phase are placed parallel to each other at a small separation of 3λ. The light is collected on a screen S which is placed at a distance D (>> λ) from the slit S_1 and shown in figure. Find the distance x such that the intensity at point P is equal to the intensity at O.



(a) $\frac{D\sqrt{5}}{2}$ (b) $\frac{D\sqrt{5}}{4}$

(c) $\frac{D\sqrt{3}}{2}$ (d) $\frac{D\sqrt{7}}{2}$

Q 10. To make the central fringe at the centre O, a mica sheet of refractive index 1.5 is introduced. Choose the correct statements (s).

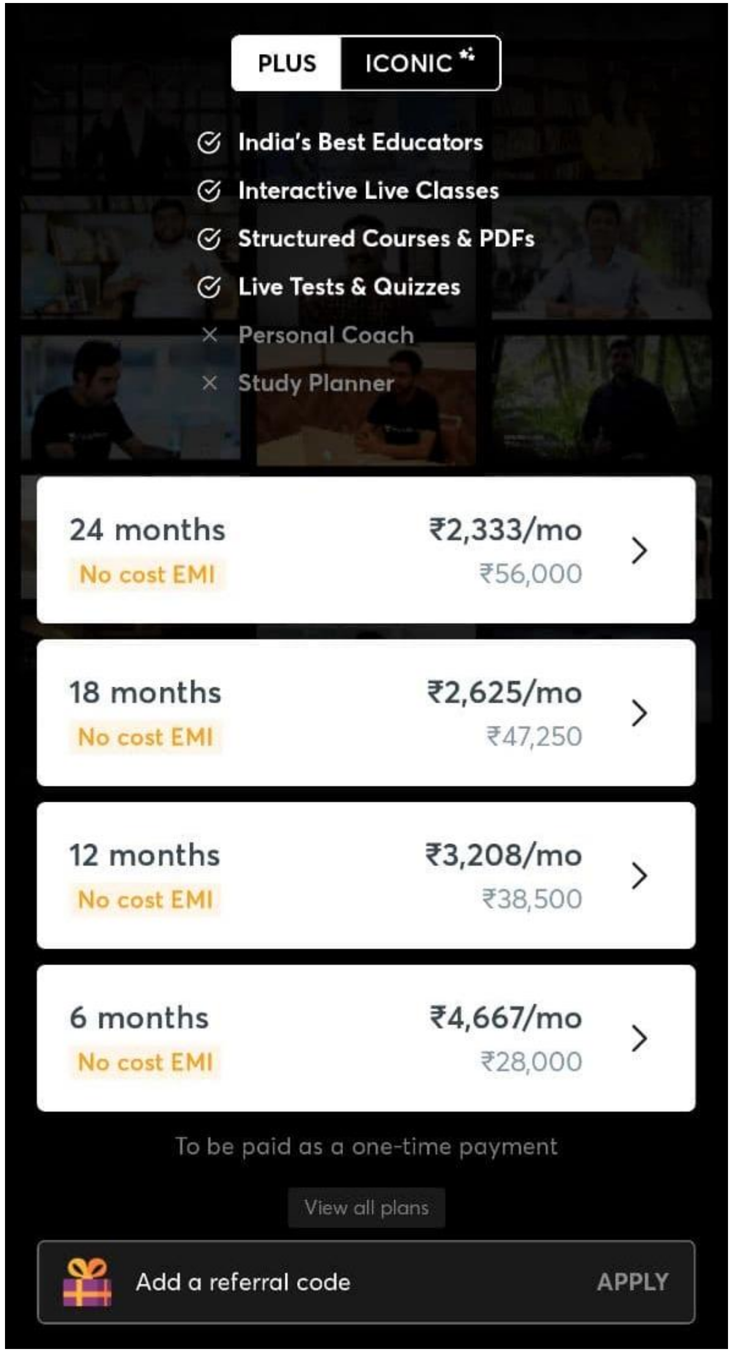


(a) The thickness of sheet is $2(\sqrt{2}$ - 1)d infront of S_1.
(b) The thickness of sheet is $(\sqrt{2}$ - 1)d infront of S_2.
(c) The thickness of sheet is 2 $\sqrt{2}$ d infront of S_1 .
(d) The thickness of sheet is (2 $\sqrt{2}$ - 1)d infront of S_1

Q 11. If one of the slits of a standard YDSE apparatus is covered by a thin parallel sided glass slab so that it transmit only one half of the light intensity of the other, then:
(a) the fringe pattern will get shifted towards the covered slit.
(b) the fringe pattern will get shifted away from the covered slit.
(c) the bright fringes will be less bright and the dark ones will be more bright.
(d) the fringe width will remain unchanged

Answer Key

Q.1 d	**Q.2 b**	**Q.3 a**	**Q.4 a,c**	**Q.5 c**
Q.6 c	**Q.7 a,b,c**	**Q.8 a, c**	**Q.9 a**	**Q.10 a**
Q.11 a,c,d				



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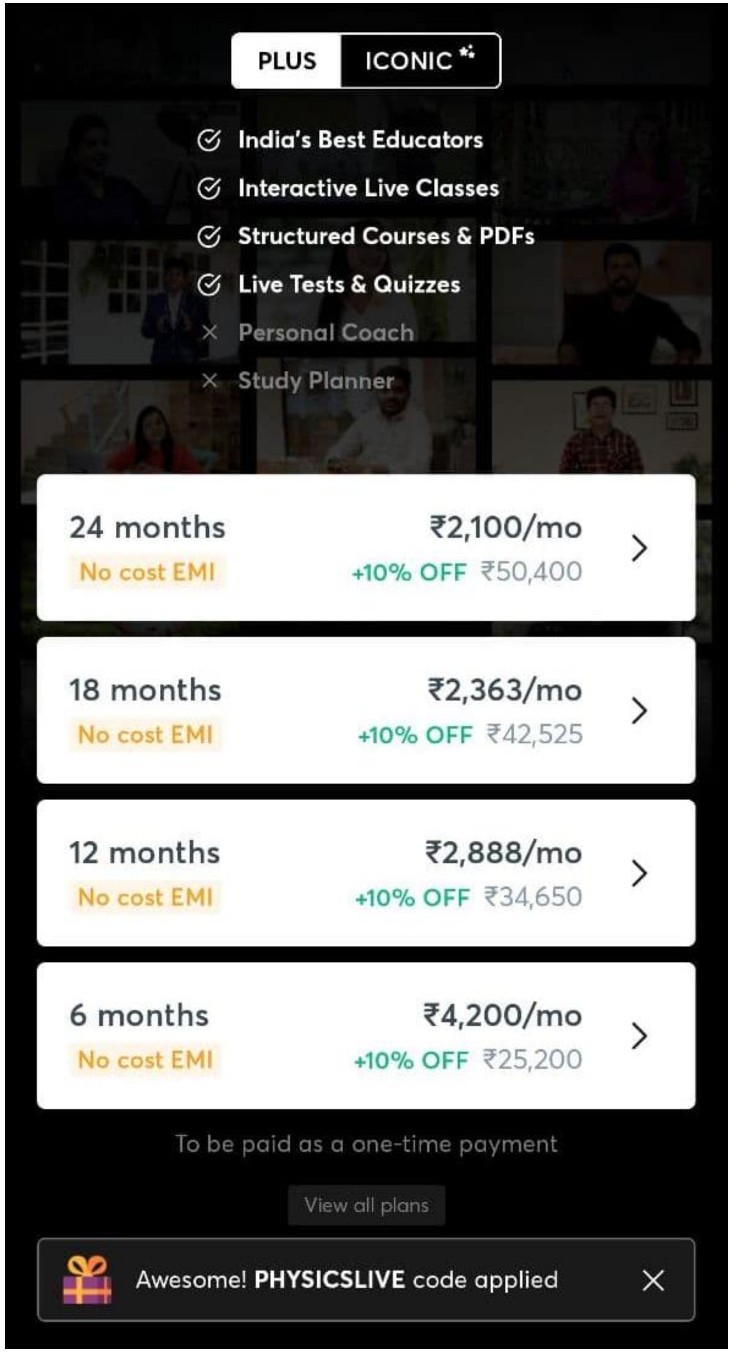

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Written Solution

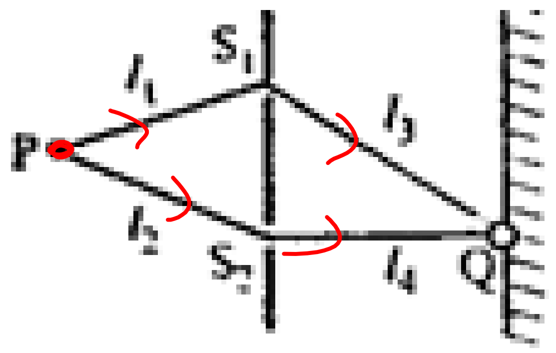
DPP-2 Wave Optics: Effect of medium on YDSE & Interference in different orientation of source

By Physicsaholics Team

Q 1) Two identical narrow slits S_1 and S_2 are illuminated by light of wavelength λ from a point source P. If, as shown in the diagram above the light is then allowed to fall on a screen, and if n is a positive integer the condition for destructive interference at Q is that

for distructive interference $\Delta x = (l_2 + l_4) - (l_1 + l_3) = (2n+1)\lambda/2$

(a) $(l_1 - l_2) = (2n + 1)\lambda/2$
(b) $(l_3 - l_4) - (2n + 1)\lambda/2$
(c) $(l_1 + l_2) - (l_2 + l_4) = n\lambda$
(d) $(l_1 + l_3) - (l_2 + l_4) = (2n + 1)\lambda/2$

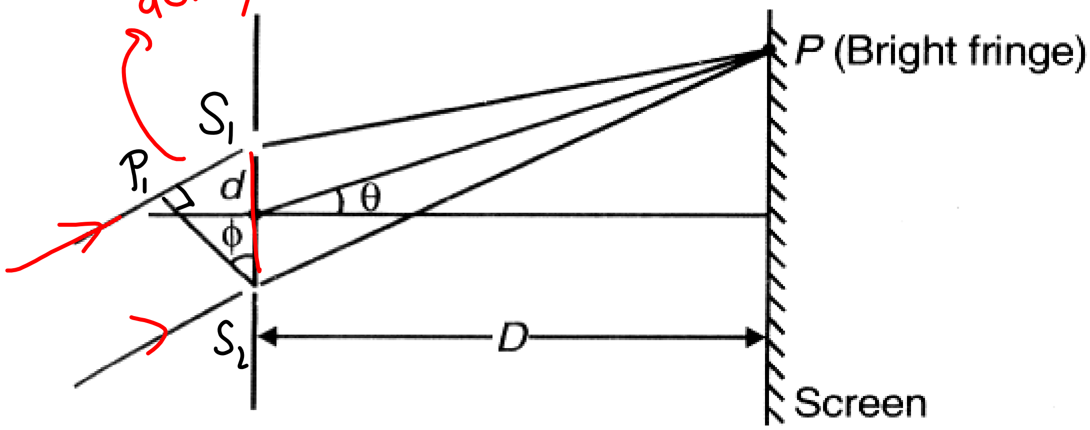


Q 2) For maxima (bright fringe) at point P, relation between given quantities is (angles shown in figure are not small)

$\Delta x = |(P_1S_1 + S_1P) - S_2P|$

$= |P_1S_1 - (-S_1P + S_2P)|$

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



(a) $|d\,Sin\,\phi - d\,Sin\,\theta| = (2n\text{-}1)\,\lambda/2$

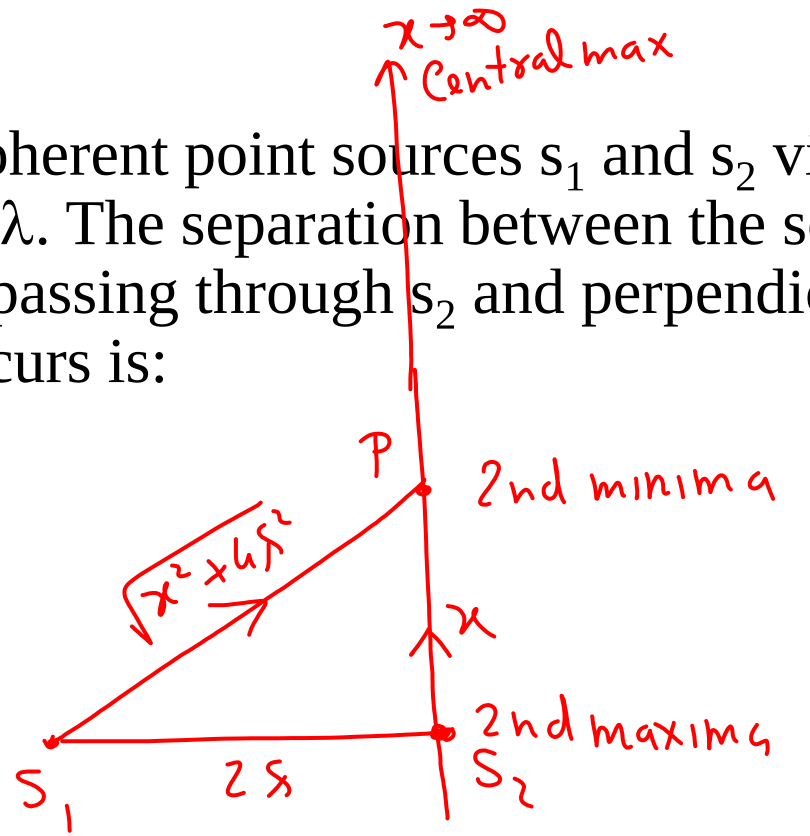
(b) $|d\,Sin\,\phi - d\,Sin\,\theta| = n\lambda$

(c) $|d\,Sin\,\phi - d\,Sin\,\theta| = (2n\text{-}1)\,\lambda/4$

(d) None of these

$\Delta x = |d \sin\phi - d \sin\theta| = n\lambda$

Q 3) Two coherent point sources s_1 and s_2 vibrating in phase emit light of wavelength λ. The separation between the sources is 2λ. The smallest distance from s_2 on a line passing through s_2 and perpendicular to s_1s_2 where a minimum of intensity occurs is:



At S_2: $\Delta x = 2\lambda$ $\Rightarrow$ 2nd maxima

at ∞: $\Delta x = 0$ $\Rightarrow$ Central maxima

(a) $\frac{7\lambda}{12}$ ✓ (b) $\frac{15\lambda}{4}$ (c) $\frac{\lambda}{2}$ (d) $\frac{3\lambda}{4}$

At P → $\Delta x = \sqrt{x^2+4\lambda^2} - x = 1.5\lambda$

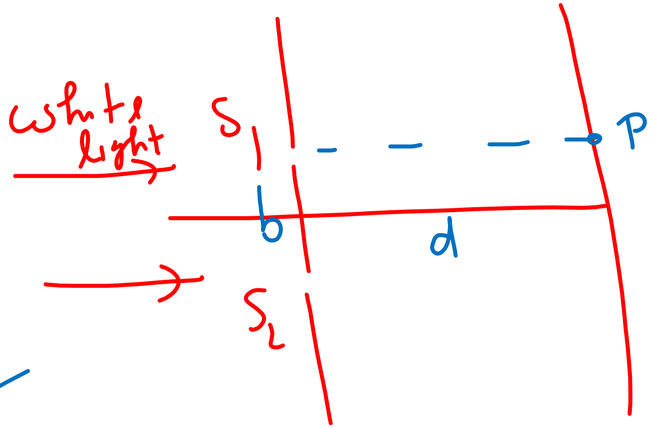
$\sqrt{x^2+4\lambda^2} = 1.5\lambda + x$

$x^2 + 4\lambda^2 = 2.25\lambda^2 + x^2 + 3\lambda x$

$1.75\lambda^2 = 3\lambda x$

$x = \frac{1.75\lambda}{3} = \frac{175}{300}\lambda = \frac{7\lambda}{12}$

Q 4) White light is used to illuminate the two slits in Young's double slit experiment. The separation between the slits is b and the screen is at a distance d (>> b) from the slits. At a point on the screen directly in front of one of the slits, certain wavelengths are missing. Some of these missing wavelengths are:



at P → $\Delta x = \frac{x d}{D} = \frac{(b/2)\, b}{d} = \frac{b^2}{2d}$

for minima at P → $\Delta x = \frac{b^2}{2d} = (2n-1)\frac{\lambda}{2}$

$$\lambda = \frac{b^2}{(2n-1)d} = \frac{b^2}{d}, \frac{b^2}{3d}, \frac{b^2}{5d}, \ldots$$

(a) $\lambda = b^2/d$ ✓ (b) $\lambda = 2b^2/d$ (c) $\lambda = b^2/3d$ ✓ (d) $\lambda = 2b^2/3d$

Q 5) In a Biprism experiment, if the wavelength of red light used is 6.5×10^{-7} m and that of green is 5.2×10^{-7}m, the value of n for which (n + 1)th green bright band coincides with the nth red bright band for the same setting is given by -

$$(n+1)\lambda_{green}\frac{D}{d} = n\lambda_{Red}\frac{D}{d}$$

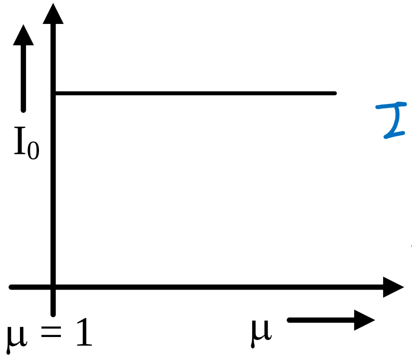
$$\left(\frac{n+1}{n}\right) = \frac{\lambda_{Red}}{\lambda_{green}} = \frac{6.5\times10^{-7}}{5.2\times10^{-7}} = \frac{5}{4}$$

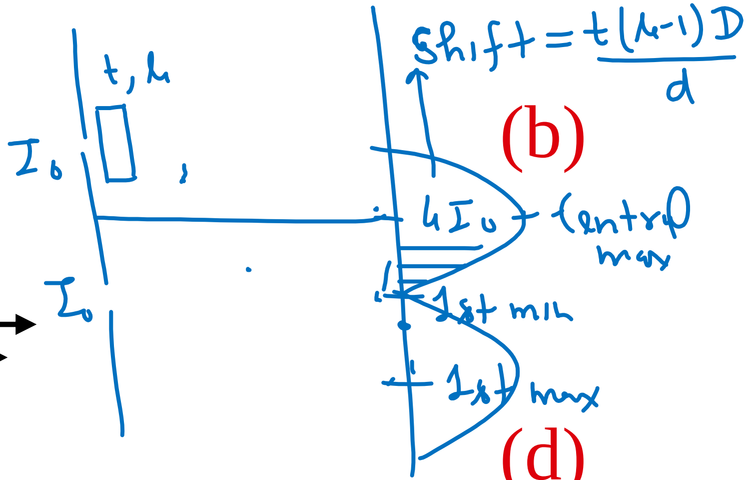
$n = 4$

(a) 2 (b) 3 (c) 4 ✓ (d) 1

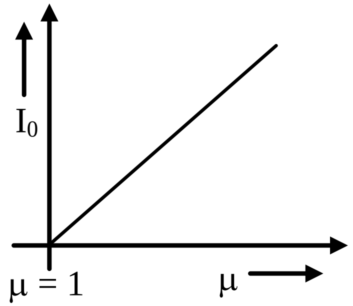
Q 6) In a YDSE experiment if a slab whose refractive index can be varied is placed in front of one of the slits then the variation of resultant intensity at mid-point of screen with ‘μ’ will be best represented by (μ ≥1). [Assume slits of equal width and there is no absorption by slab]

(a)

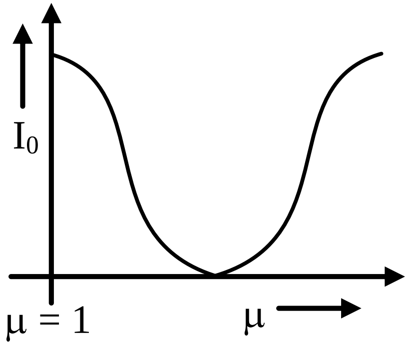




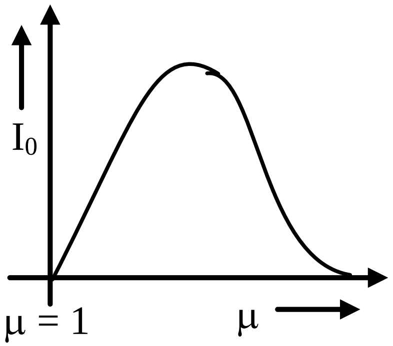
(b)



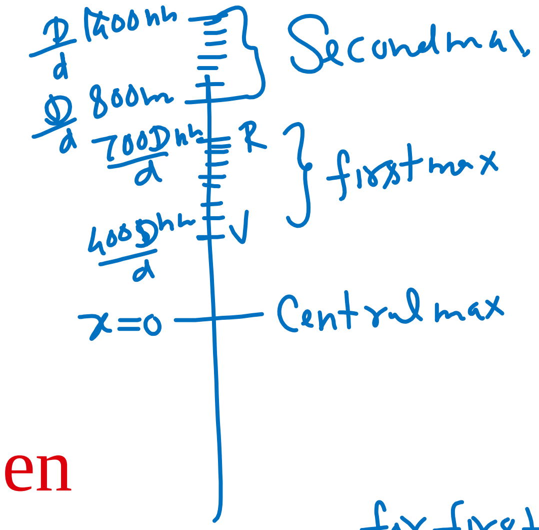
(c)



(d)



Q 7) If white light is used in a Young's double-slit experiment -



(a) bright white fringe is formed at the centre of the screen

(b) fringes of different colours are observed clearly only in the first order

(c) the first-order violet fringes are closer to the centre of the screen than the first order red fringes

(d) the first-order red fringes are closer to the centre of the screen than the first order violet fringes

for first max

$$x = \frac{\delta D}{d}$$

Q 8) A parallel beam of light (λ = 5000 Å) is incident at an angle α = 30° with the normal to the slit plane in a young's double slit experiment. Assume that the intensity due to each slit at any point on the screen is I_0. Point O is equidistant from S_1 & S_2. The distance between slits is 1mm.

for O → $\Delta x = P_2S_2 = d\sin\alpha = 10^{-3} \times \frac{1}{2} = \frac{1}{2} \times 10^{-3}\,m = 5 \times 10^{-4}\,m$

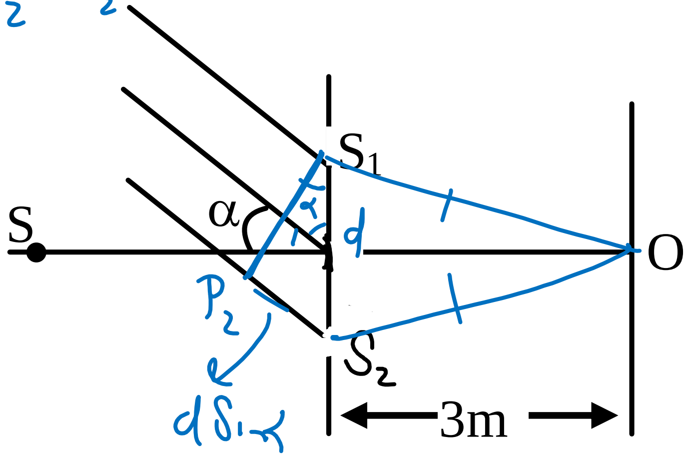
$\phi = \frac{2\pi}{\lambda}\Delta x$

$= \frac{2\pi}{5 \times 10^{-7}} \times 5 \times 10^{-4}$

$= 2000\pi$

$\Rightarrow \cos\phi = 1$

$\Rightarrow$ maxima

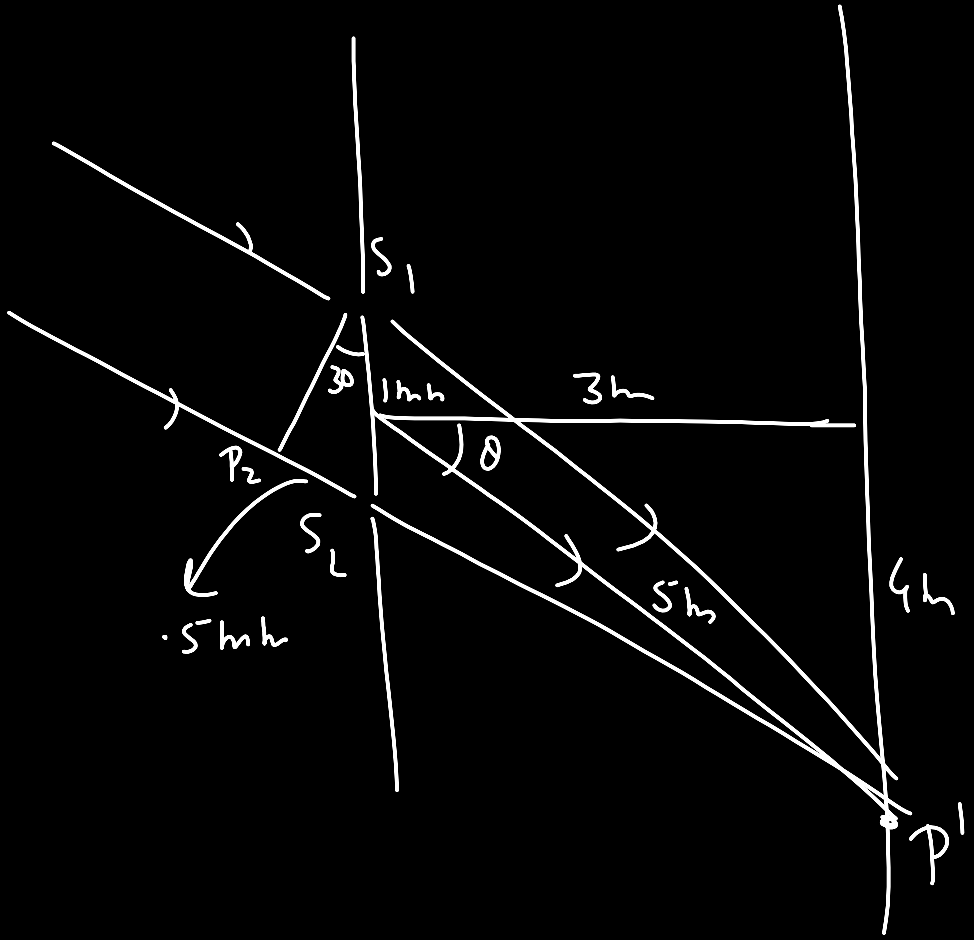


(a) the intensity at O is $4I_0$ ✓

(b) the intensity at O is zero

(c) the intensity at a point on the screen 4m from O is $4I_0$ ✓

(d) the intensity at a point on the screen 4m from O is zero



At P'

$$\Delta x = \left|\left(P_2S_2 + S_2P'\right) - \left(S_1P'\right)\right|$$

$$= \left|\left(P_2S_2\right) - \left(S_1P' - S_2P'\right)\right|$$

$$= \left|5\times10^{-4} - d\sin\theta\right|$$

$$= \left|5\times10^{-4} - 10^{-3}\times\frac{4}{5}\right|$$

$$= \left|5\times10^{-4} - 8\times10^{-4}\right|$$

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

phase difference

$$\phi = \frac{2\pi}{5\times10^{-7}}\times 3\times10^{-4} = 1200\pi$$

$\Rightarrow$ maxima

Ans. a,c

Q 9) Two coherent narrow slits S_1 and S_2 emitting light of wavelength λ in the same phase are placed parallel to each other at a small separation of 3λ. The light is collected on a screen S which is placed at a distance D (>> λ) from the slit S_1 and shown in figure. Find the distance x such that the intensity at point P is equal to the intensity at O.

at O
$\Delta x = 3\lambda$
⇒ 3rd maxima

at ∞
$\Delta x = 0$
⇒ Central max

(a) $\frac{D\sqrt{5}}{2}$

(b) $\frac{D\sqrt{5}}{4}$

(c) $\frac{D\sqrt{3}}{2}$

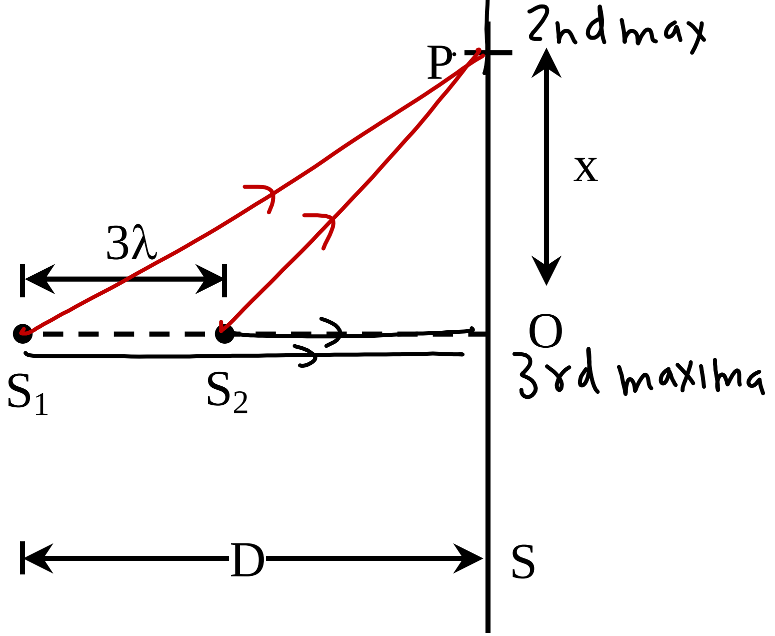
(d) $\frac{D\sqrt{7}}{2}$

At P
$\Delta x = S_1P - S_2P = 2\lambda$

$\Rightarrow \sqrt{D^2 + x^2} - \sqrt{(D-3\lambda)^2 + x^2} = 2\lambda$

$\Rightarrow \sqrt{D^2+x^2} - 2\lambda = \sqrt{(D-3\lambda)^2 + x^2}$

$\Rightarrow D^2 + x^2 + 4\lambda^2 - 4\lambda\sqrt{D^2+x^2} = D^2 + 9\lambda^2 - 6D\lambda + x^2$



$$6D\lambda - 5\lambda^2 = 4\lambda\sqrt{D^2 + x^2}$$

$$(6D - 5\lambda)^2 = 16(D^2 + x^2)$$

$$36D^2 + 25\lambda^2 - 60D\lambda = 16D^2 + 16x^2$$

$$20D^2 + \underbrace{25\lambda^2 - 60D\lambda}_{\text{tending to } 0} = 16x^2$$

$$20D^2 = 16x^2$$

$$x = D\sqrt{\frac{20}{16}}$$

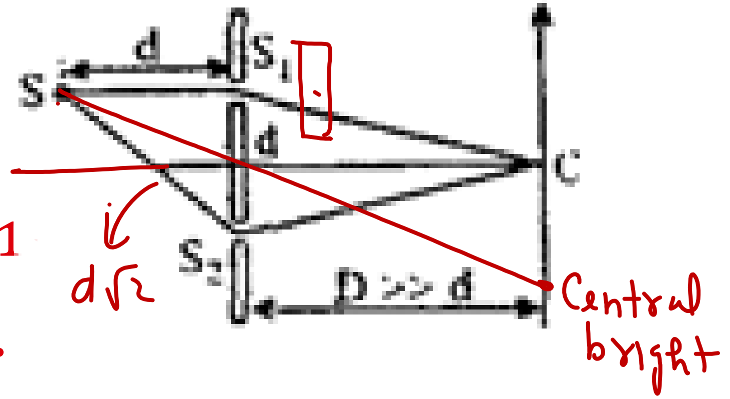
$$= D\sqrt{5/4}$$

Ans. a

Q 10) To make the central fringe at the centre O, a mica sheet of refractive index 1.5 is introduced. Choose the correct statements (s).

After introducing mica sheet Δx at C = 0

$\Delta x = (SS_2 + S_2C) - (SS_1 + S_1C - t + \mu t)$



(a) The thickness of sheet is $2(\sqrt{2} - 1)d$ infront of S_1

(b) The thickness of sheet is $(\sqrt{2} - 1)d$ infront of S_2.

(c) The thickness of sheet is $2\sqrt{2}\,d$ infront of S_1 .

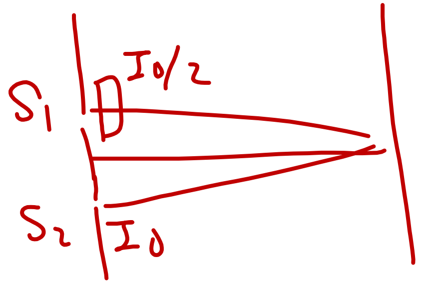
(d) The thickness of sheet is $(2\sqrt{2} - 1)d$ infront of S_1

$\Delta x = (SS_2 - SS_1) + t - \mu t = 0$

$\Rightarrow \quad d\sqrt{2} - d + t - 1.5t = 0$

$.5t = d(\sqrt{2} - 1) \Rightarrow t = 2d(\sqrt{2} - 1)$

Q 11) If one of the slits of a standard YDSE apparatus is covered by a thin parallel sided glass slab so that it transmit only one half of the light intensity of the other, then:



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

$$I_1 \longrightarrow \frac{I_1}{2} \Rightarrow I\downarrow$$

(a) the fringe pattern will get shifted towards the covered slit.

(b) the fringe pattern will get shifted away from the covered slit.

(c) the bright fringes will be less bright and the dark ones will be more bright.

(d) the fringe width will remain unchanged

from zero intensity to nonzero intensity.

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