Physicsaholics

DPP – 3 (Wave Optics)

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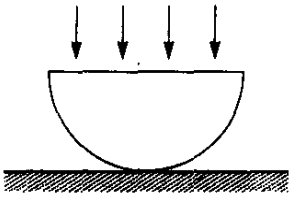
Q 1. The minimum thickness of film which will strongly reflect the light of λ= 300 nm, the R.I of material of film is 1.25
(a) 120 nm (b)100 nm (c) 110 nm (d) 60 nm

Q 2. A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat plate as shown. The observed interference fringes from this combination shall be:



(a) straight
(b) circular
(c) equally spaced
(d) having fringe spacing which increases as we go outwards

Q 3. A thin film of index 1.6 is placed in air and white light reflected from it is viewed. The wavelengths 432 nm, 540 nm and 120 nm are missing. Then -
(a) Minimum possible thickness of film is 675 nm
(b) if the order of 432 nm is 5, the order of 540 nm is 4
(c) order cannot be found from the given information
(d) None of these

Q 4. A thin film with index of refraction 1.50 coats a glass lens with index of refraction 1.80. What is the minimum thickness of the thin film that will strongly reflect light with wavelength 600 nm ?
(a) 150 nm (b) 200 nm
(c) 300 nm (d) 450 nm

Q 5. A thin film with index of refraction 1.33 coats a glass lens with index of refraction 1.50. Which of the following choices is the smallest film thicknesses that will not reflect light with wavelength 640 nm ?
(a) 160 nm
(b) 240 nm
(c) 360 nm
(d) 480 nm

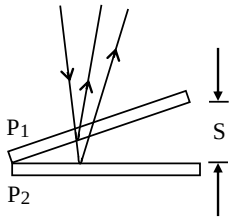
Q 6. A thick film of liquid polymer n = 1.25 coats a slab of Pyrex, n =1.50. White light is incident perpendicularly to the film. In the reflections, full destructive interference occurs for λ = 600

nm and full constructive interference occurs for λ = 700 nm. What is the thickness of the polymer film ?

(a) 120 nm (b) 280 nm
(c) 460 nm (d) 840 nm

COMPREHENSION(Q.7 to Q.9)

Figure shows two flat glass plates P_1 and P_2 placed nearly (but not exactly) parallel forming an air wedge. The plates are illuminated normally by monochromatic light and viewed from above. Light waves reflected from the upper and lower surfaces of the air wedge give rise to an interference pattern.



Q 7. Separation between successive bright fringes is

(a) $\frac{\lambda \ell}{4S}$ (b) $\frac{\lambda \ell}{3S}$ (c) $\frac{\lambda \ell}{S}$ (d) $\frac{\lambda \ell}{2S}$

Q 8. At line joining two plates, there is

(a) maxima
(b) minima
(c) neither maxima nor minima
(d) None of these

Q 9. What will be the answer of last question if space between plates is filled by water

(a) maxima
(b) minima
(c) neither maxima nor minima
(d) None of these

Q 10. A Fraunhoffer's single slit diffraction is observed in the focal plane of a lens of focal length one metre. Slit width is 0.3 mm. The 2nd minima is observed at a distance of 4mm from the central maxima. Then the wave length of the light used is

(a) 5000A° (b) 6000A°
(c) 6500A° (d) 5400A°

Q 11. Fraunhoffer diffraction pattern of a single slit is obtained in the focal plane of lens of focal length 1m. If third maximum is formed at a distance of 5mm from the central maximum and wavelength of light used is 5000Å, then width of the slit will be –

(a) 0.02 cm (b) 0.03 cm
(c) 0.04 cm (d) 1 cm

Q 12. If I_o is the intensity of the principle maximum in the single slit diffraction pattern, then what will be its intensity when the slit width is doubled ?

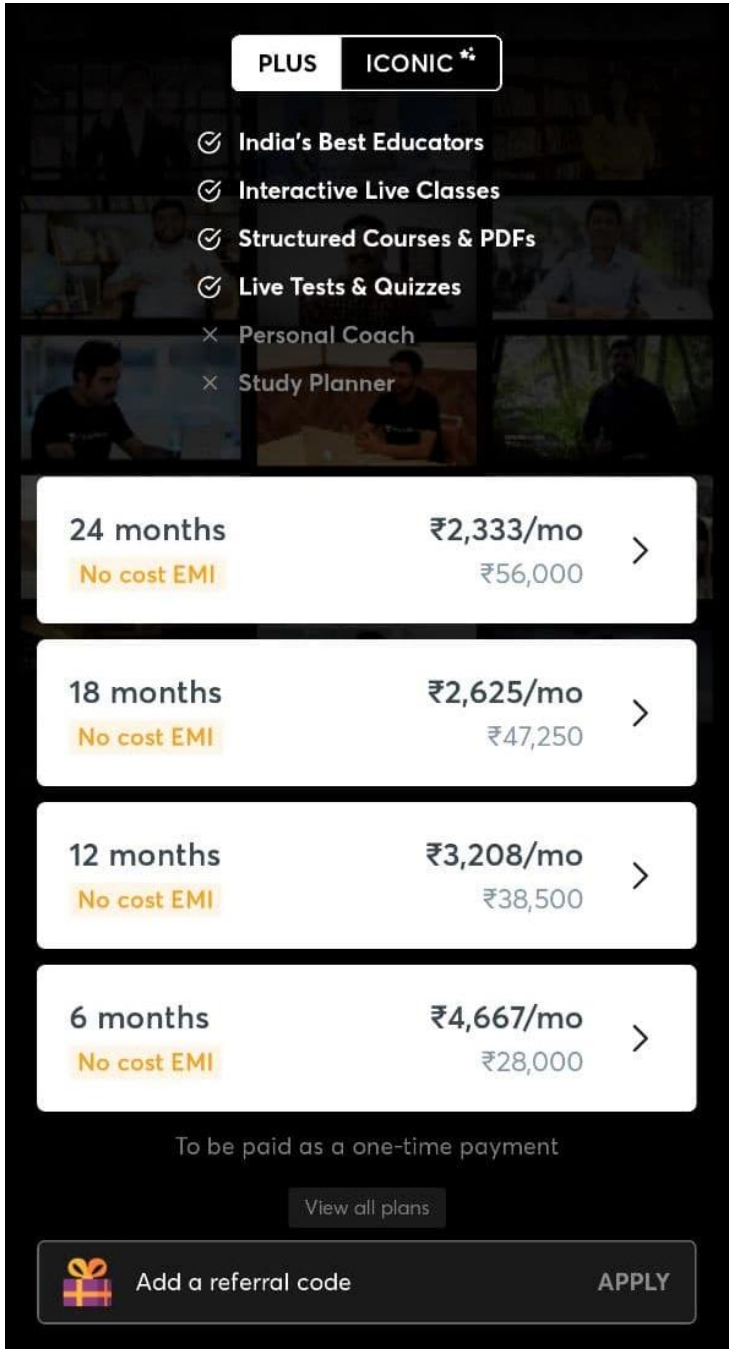
(a) $2I_o$ (b) $4I_o$ (c) I_o (d) $I_o/2$

Q 13. A slit of width d is placed in front of a lens of focal length 0.5 m and is illuminated normally with light of wavelength 5.89×10^{-7} m. The first diffraction minima on either side of the central diffraction maximum are separated by 2×10^{-3} m. The width d of the slit is

(a) 2.94×10^{-4}m
(b) 4.94×10^{-4} m
(c) 5.94×10^{-4} m
(d) 6.94×10^{-4} m

Answer Key

Q.1 d	**Q.2 a**	**Q.3 a,b,c**	**Q.4 b**	**Q.5 c**
Q.6 d	**Q.7 d**	**Q.8 b**	**Q.9 b**	**Q.10 b**
Q.11 c	**Q.12 b**	**Q.13 a**		



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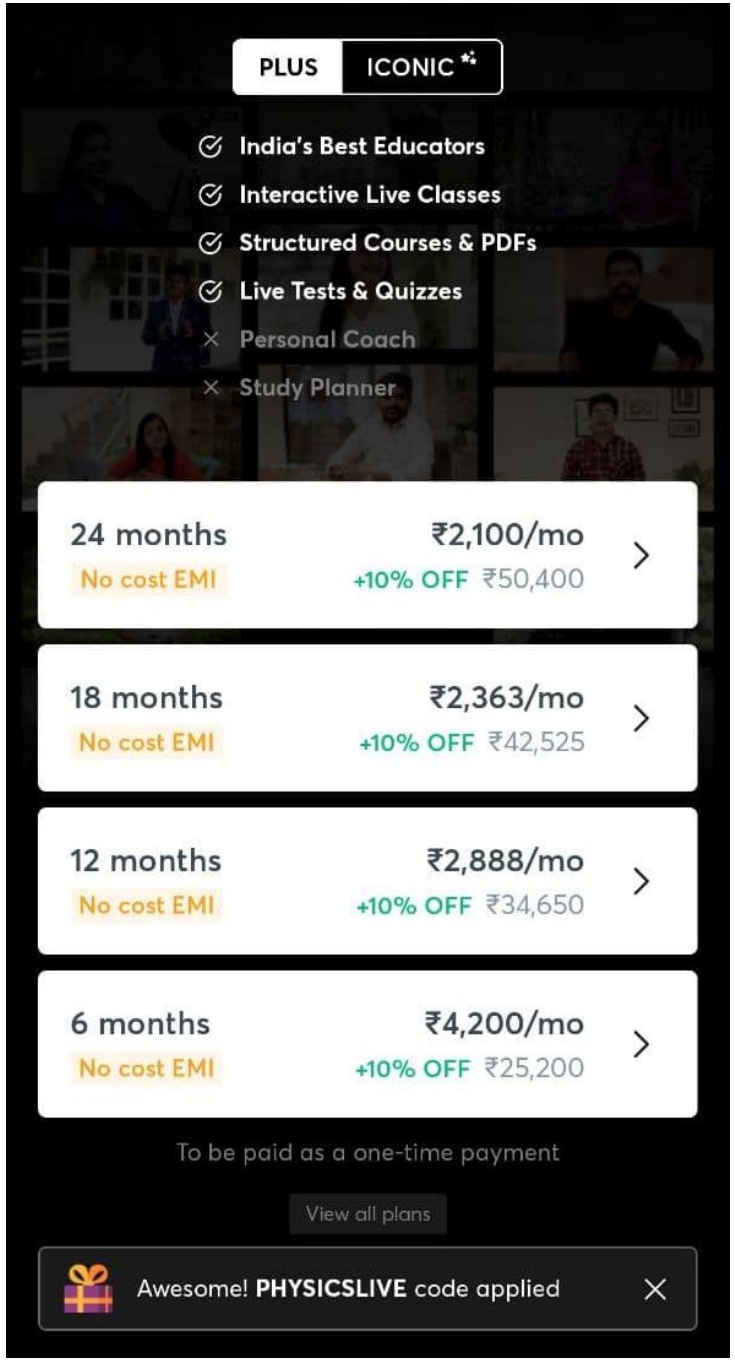
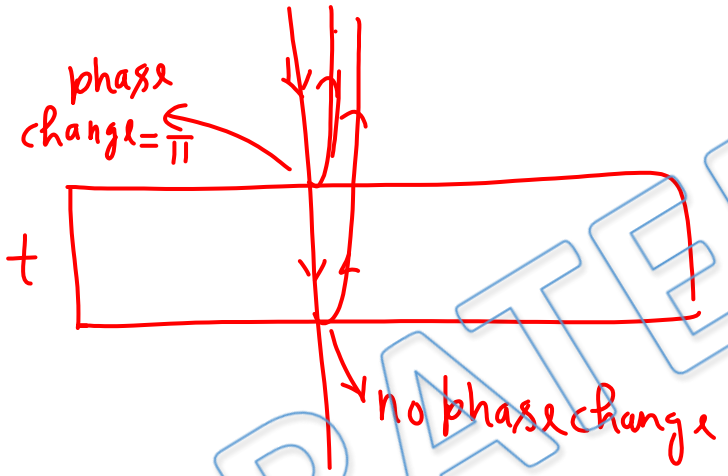


Written Solution

DPP-3 Wave Optics- Thin film interference & Diffraction

By Physicsaholics Team

Q 1) The minimum thickness of film which will strongly reflect the light of λ= 300 nm, the R.I of material of film is 1.25



maxima

for reflected Rays

$\Delta x = 2\mu t - \lambda/2 = n\lambda$ for maxima

$2\mu t = (2n+1)\lambda/2$

$t = (2n+1)\lambda/4\mu$

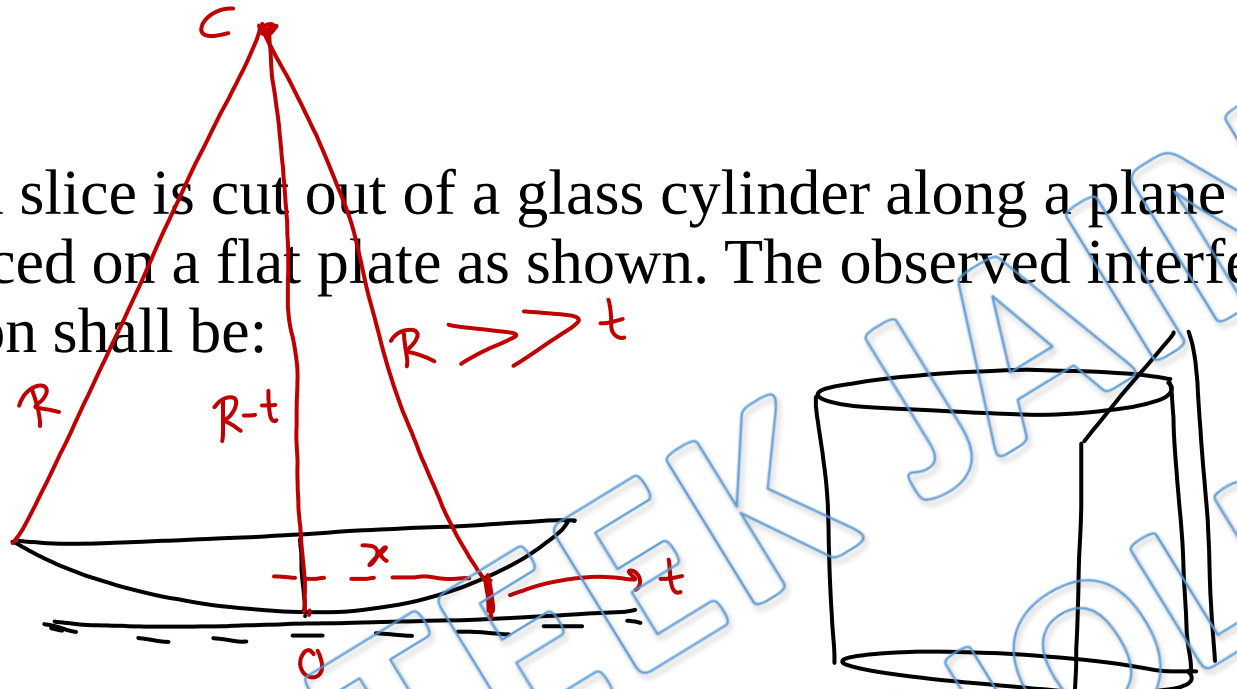
$t_{min} = \lambda/4\mu$

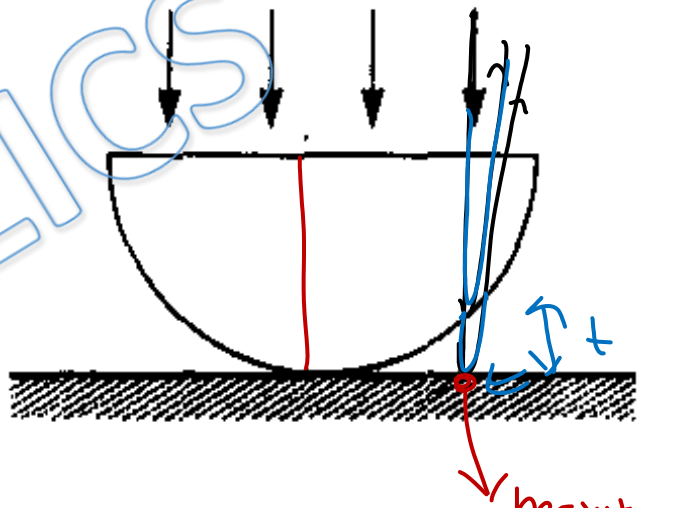
$= \frac{300\,nm}{4 \times 5/4}$

$= 60\,nm$

(a) 120 nm (b)100 nm (c) 110 nm ~~(d) 60 nm~~

Q 2) A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat plate as shown. The observed interference fringes from this combination shall be:





(a) straight

(b) circular

(c) equally spaced

(d) having fringe spacing which increases as we go outwards

$x^2 = R^2 - (R-t)^2$

$= R^2 - R^2 - t^2 + 2Rt$

$x^2 \simeq 2Rt$

path difference $\Delta x = 2t + \lambda/2$

for maxima $\Delta x = 2t + \lambda/2 = n\lambda \Rightarrow$ $2t = (2n-1)\lambda/2$

$t = (2n-1)\lambda/4$

$$\sqrt{5} = 2.24$$
$$\sqrt{3} = 1.73$$
$$\frac{}{.51}$$

$$\frac{x^2}{2R} = (2n-1)\frac{\lambda}{4}$$

$$x = \sqrt{(2n-1)\frac{\lambda R}{2}}$$

$$x = \sqrt{\frac{\lambda R}{2}}, \sqrt{\frac{3\lambda R}{2}}, \sqrt{\frac{5\lambda R}{2}}, \ldots$$

Ratio of spacing b/w successive maxima $= (\sqrt{3}-1) : (\sqrt{5}-\sqrt{3}) : (\sqrt{7}-\sqrt{5})$

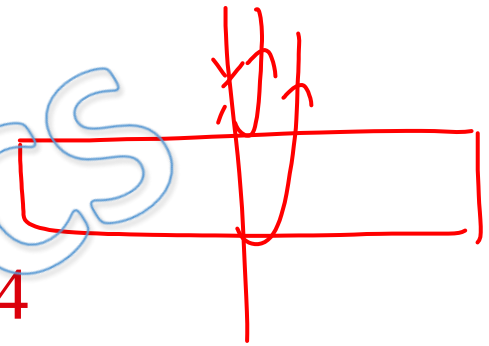
$\simeq .73 : .51 : \ldots$

distance b/w succ maxima is decreasing.

Ans. a

Q 3) A thin film of index 1.6 is placed in air and white light reflected from it is viewed. The wavelengths 432 nm, 540 nm and 120 nm are missing. Then -

for reflected light $\Delta x = 2\mu t - \lambda/2$



(a) Minimum possible thickness of film is 675 nm

(b) if the order of 432 nm is 5, the order of 540 nm is 4

(c) order cannot be found from the given information

(d) None of these

for minima $\Delta x = 2\mu t - \lambda/2 = (2n-1)\lambda/2$

$$\lambda = \frac{2\mu t}{n}$$

Ratio of missing λ : 120nm : 432nm : 540nm

$= 20 : 72 : 90 = 10 : 36 : 45$

$$\frac{10}{90}\ \frac{\overset{2}{\cancel{36}}}{\underset{5}{\cancel{90}}}\cdot\frac{\cancel{45}}{\underset{2}{\cancel{90}}} = \frac{1}{18}:\frac{1}{5}:\frac{1}{4} = \frac{1}{36}:\frac{1}{10}:\frac{1}{8}$$

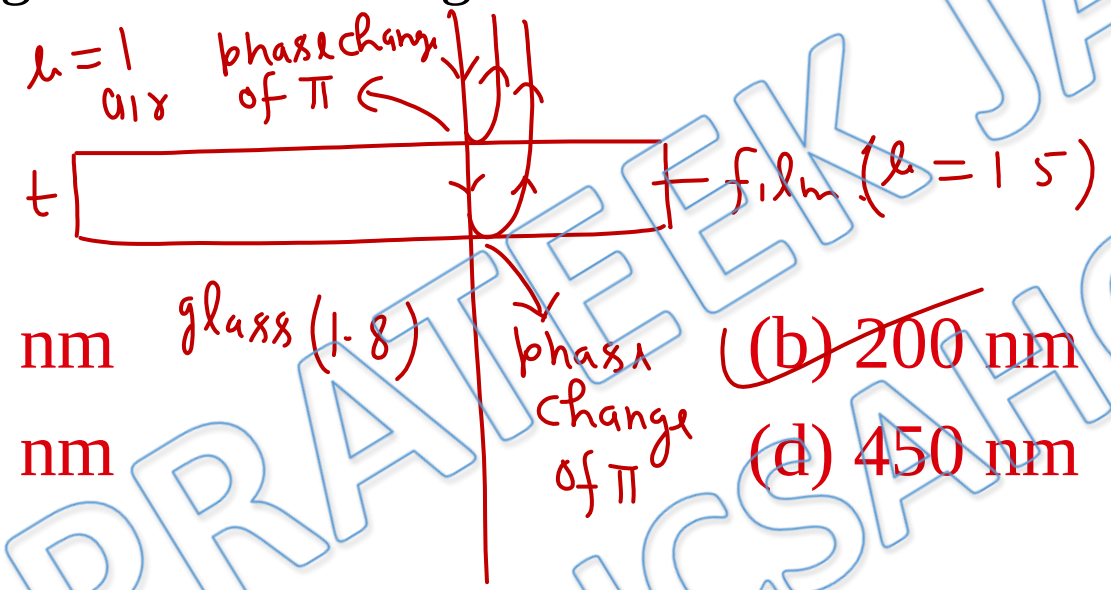
If 120 nm is 18th minima (minimum possible order)

$$t = \frac{n\lambda}{2\mu} \Rightarrow t_{min} = \frac{n_{min}\lambda}{2\mu} = \frac{\overset{90}{\cancel{180}}\times 120\,nm}{\cancel{2}\times 16}$$

$$t_{min} = 675\ nm$$

Ans. a,b,c

Q 4) A thin film with index of refraction 1.50 coats a glass lens with index of refraction 1.80. What is the minimum thickness of the thin film that will strongly reflect light with wavelength 600 nm ?



(a) 150 nm (b) ~~200 nm~~

(c) 300 nm (d) 450 nm

for reflected Ray

$\Delta x = (2\mu t + \lambda/2) - (\lambda/2)$

$\Delta x = 2\mu t$

for maxima

$\Delta x = n\lambda = 2\mu t$

$t = \frac{n\lambda}{2\mu}$

$t_{min} = \frac{\lambda}{2\mu} = \frac{600nm}{2 \times 1.5}$

$= 200nm$

Q 5) A thin film with index of refraction 1.33 coats a glass lens with index of refraction 1.50. Which of the following choices is the smallest film thicknesses that will not reflect light with wavelength 640 nm ?

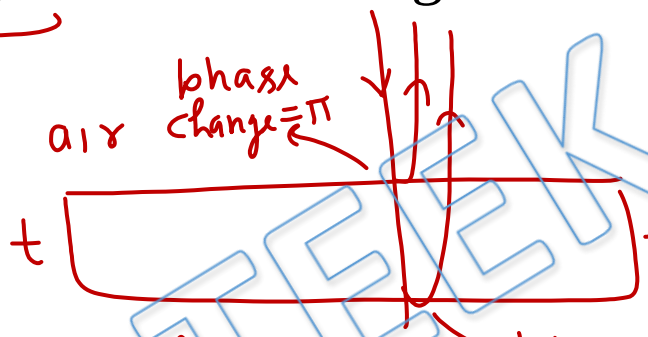
minima

(a) 160 nm

(b) 240 nm

(c) ~~360 nm~~

(d) 480 nm



for reflected

$\Delta x = (2\mu t + \lambda/2) - \lambda/2$

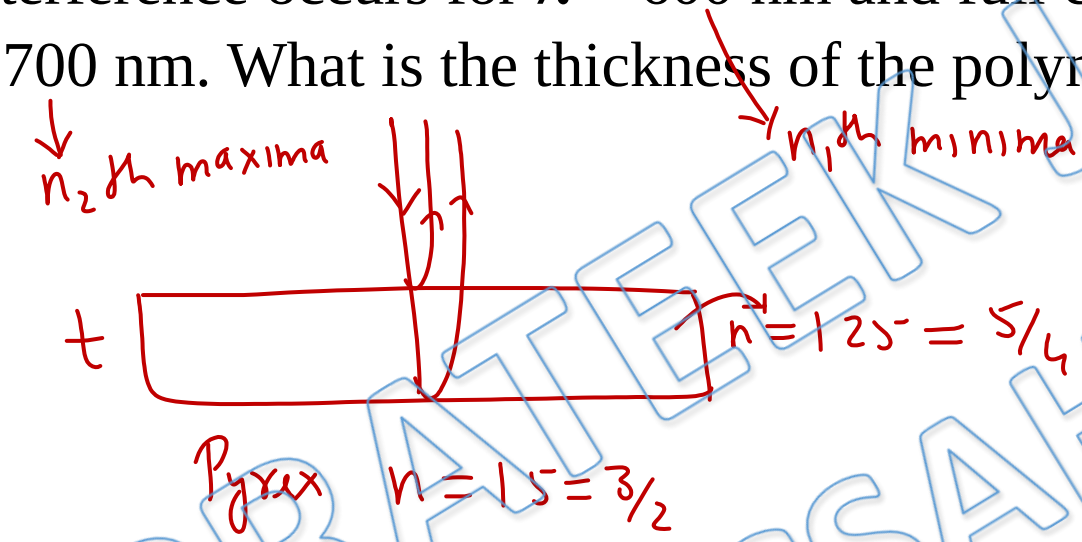
$= 2\mu t$

for minima $\Delta x = 2\mu t = (2n-1)\lambda/2$

$t = (2n-1)\frac{\lambda}{4\mu} = (2n-1)\frac{640\,nm \times 3}{4 \times 4} = 120\,nm\,(2n-1)$

40

Q 6) A thick film of liquid polymer n = 1.25 coats a slab of pyrex, n =1.50. White light is incident perpendicularly to the film. In the reflections, full destructive interference occurs for λ = 600 nm and full constructive interference occurs for λ = 700 nm. What is the thickness of the polymer film ?



(a) 120 nm (b) 280 nm

(c) 460 nm (d) 840 nm

$2\mu t = 3 \times 700\,nm$

$t = \frac{2100\,nm \times 4}{2 \times 5} = 840\,nm$

$\Delta x = (2\mu t + \lambda/2) - (\lambda/2)$

$\Delta x = 2\mu t$

$2\mu t = (2n_1 - 1)\frac{300}{600\,nm}$

$2\mu t = n_2 \times 700\,nm$

$(2n_1 - 1) \times 300 = n_2 \times 700$

$\frac{2n_1 - 1}{n_2} = \frac{7}{3} = \frac{21}{9} = -$

$n_2 = 3$

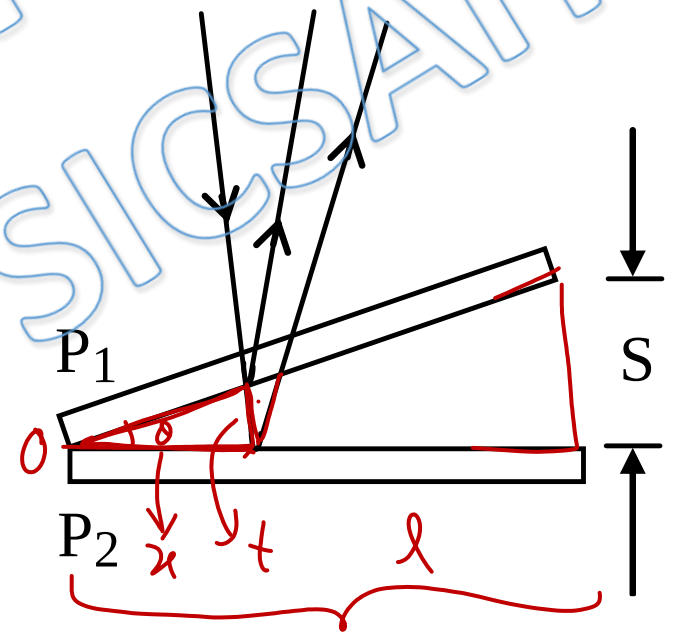
COMPREHENSION

Figure shows two flat glass plates P_1 and P_2 placed nearly (but not exactly) parallel forming an air wedge. The plates are illuminated normally by monochromatic light and viewed from above. Light waves reflected from the upper and lower surfaces of the air wedge give rise to an interference pattern.

$\Delta x = 2t + \lambda/2$

$\tan\theta = \frac{t}{x} = \frac{S}{l}$

$t = \frac{Sx}{l}$



Q 7) Seperation between successive bright fringes is

for maxima $\Delta x = 2t + \lambda/2 = n\lambda$

$2t = (2n-1)\lambda/2$

$\frac{Sx}{\ell} = (2n-1)\frac{\lambda}{4}$

$x = (2n-1)\frac{\lambda\ell}{4S}$

(a) $\frac{\lambda\ell}{4S}$ (b) $\frac{\lambda\ell}{3S}$ (c) $\frac{\lambda\ell}{S}$ (d) $\frac{\lambda\ell}{2S}$ ✓

$x = \frac{\lambda\ell}{4S}, \frac{3\lambda\ell}{4S}, \frac{5\lambda\ell}{4S}, \ldots$

Seperation $= \frac{\lambda\ell}{2S}$ (equidistant)

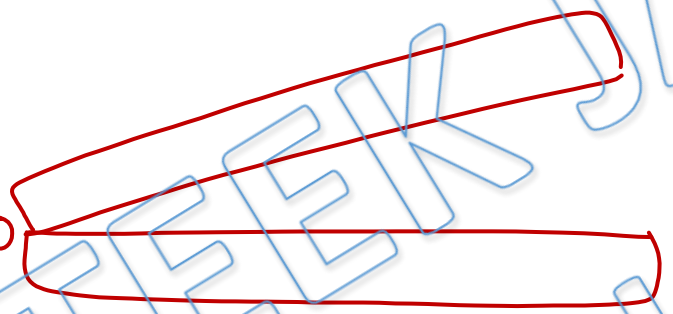
Q 8) At line joining two plates, there is

(a) maxima

(b) minima

(c) neither maxima nor minima

(d) None of these



$\Delta t = 0$, $t = 0$

$\Delta x = \lambda/2 \rightarrow$ first minima

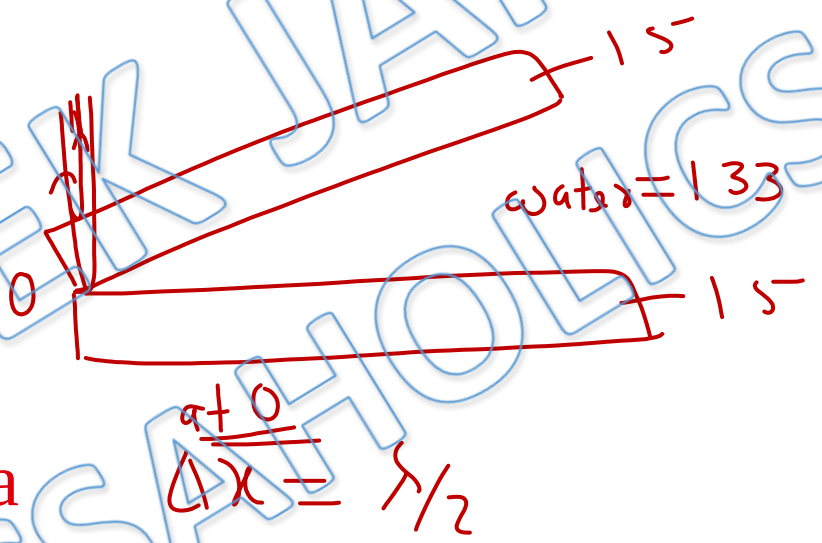
Q 9) What will be the answer of last question if space between plates is filled by water

(a) maxima

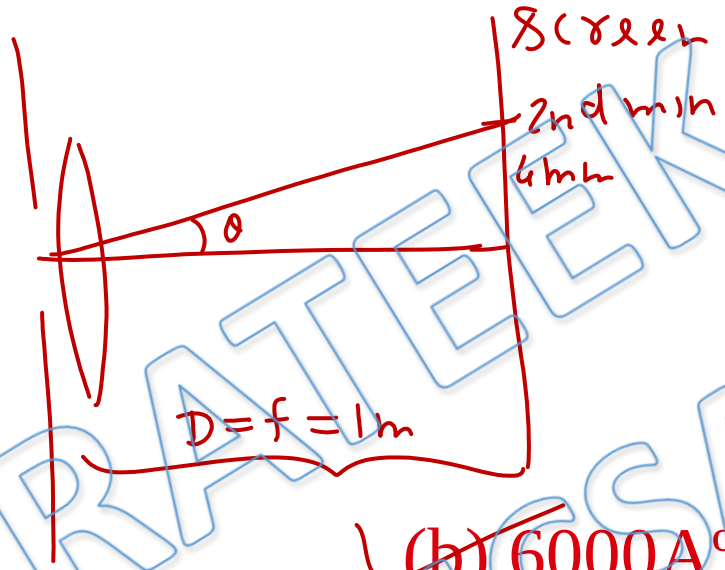
(b) minima

(c) neither maxima nor minima

(d) None of these



Q 10) A Fraunhoffer's single slit diffraction is observed in the focal plane of a lens of focal length one metre. Slit width is 0.3 mm. The 2nd minima is observed at a distance of 4mm from the central maxima. Then the wave length of the light used is



$$\sin\theta = \frac{2\lambda}{b} = \tan\theta$$

$$\Rightarrow \frac{4\times10^{-3}}{1} = \frac{2\times\lambda}{3\times10^{-4}}$$

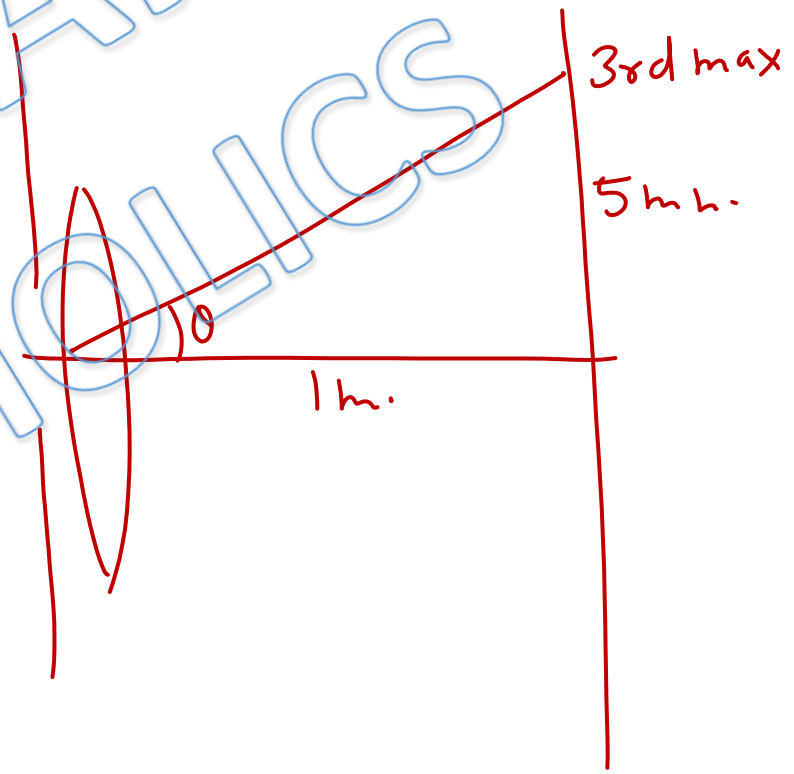
$$\lambda = 6\times10^{-7}\ m$$

(a) 5000A°
(b) 6000A°
(c) 6500A°
(d) 5400A°

Q 11) Fraunhoffer diffraction pattern of a single slit is obtained in the focal plane of lens of focal length 1m. If third maximum is formed at a distance of 5mm from the central maximum and wavelength of light used is 5000Å, then width of the slit will be –

(a) 0.02 cm (b) 0.03 cm

(c) 0.04 cm (d) 1 cm



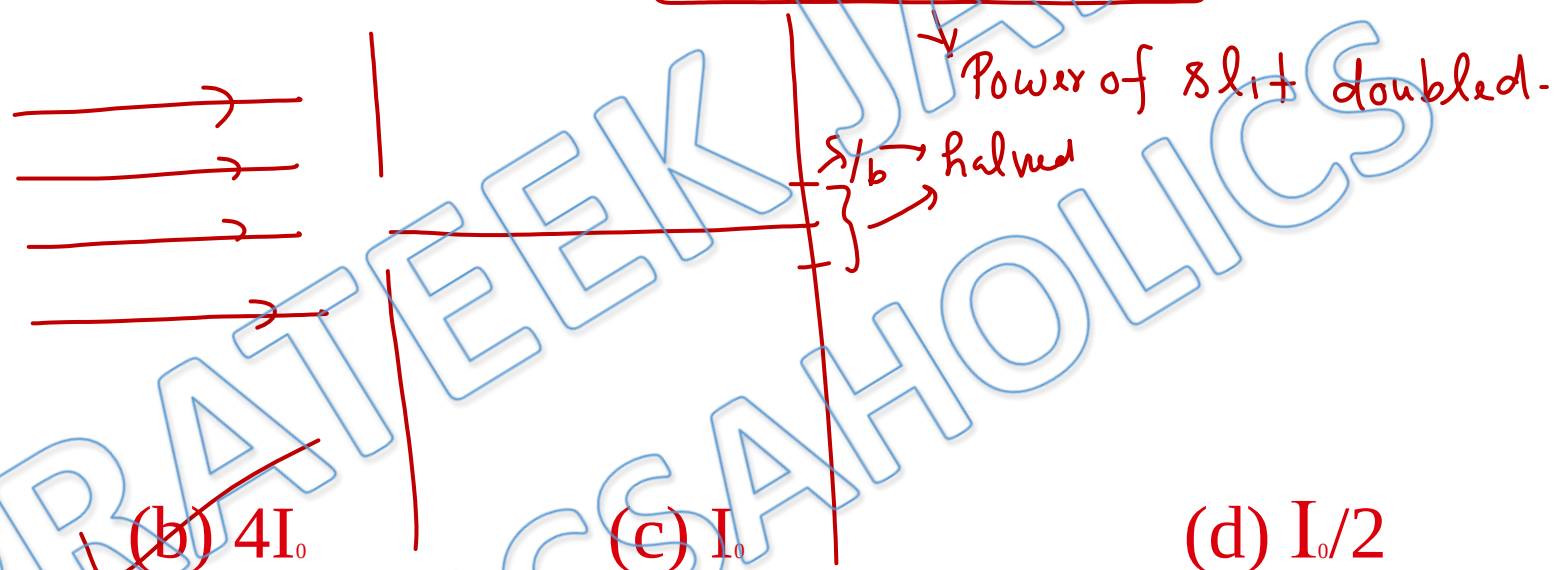
$$\sin\theta = \tan\theta = \frac{(3.5)\lambda}{b} = \frac{5\times10^{-3}}{1}$$

$$b = \frac{3.5\times5\times10^{-7}}{5\times10^{-3}}$$

$$= 3.5\times10^{-4}\ m = .35\ mm$$

$$= .035\ cm = .04\ cm$$

Q 12) If I_0 is the intensity of the principle maximum in the single slit diffraction pattern, then what will be its intensity when the slit width is doubled ?



(a) $2I_0$ (b) $4I_0$ (c) I_0 (d) $I_0/2$

Q 13) A slit of width d is placed in front of a lens of focal length 0.5 m and is illuminated normally with light of wavelength 5.89×10^{-7} m. The first diffraction minima on either side of the central diffraction maximum are separated by 2×10^{-3} m. The width d of the slit is

(a) 2.94×10^{-4} m

(b) 4.94×10^{-4} m

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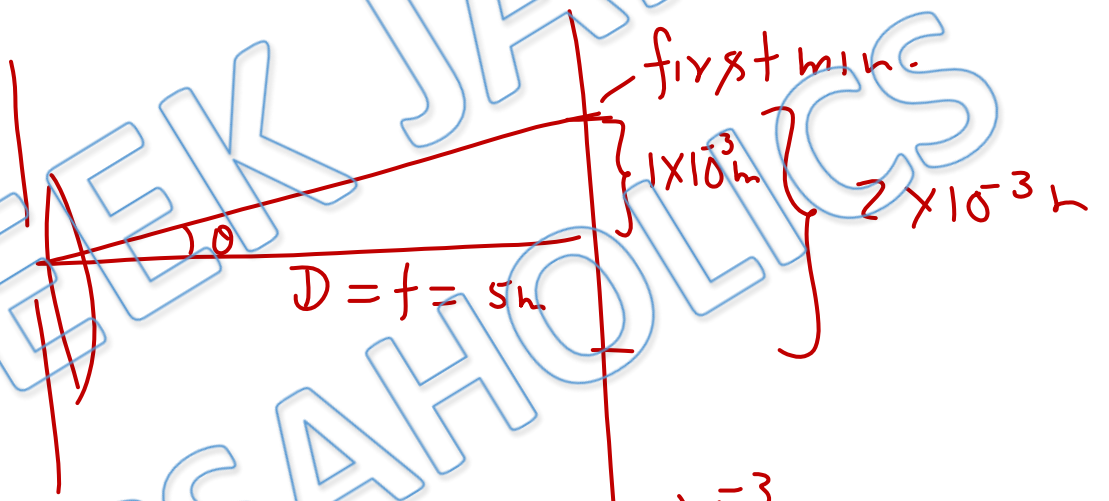

$\sin\theta = \lambda/b = \tan\theta = \frac{10^{-3}}{0.5}$

$b = \frac{0.5 \times 5.89 \times 10^{-7}}{10^{-3}}$

$= 2.94 \times 10^{-4}$ m

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