DPP – 3 (Wave Optics)

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Q 1. The first diffraction minima due to a single slit diffraction is at θ = 30° for a light of wavelength 5000Å. The width of the slit is

(a) 5×10^{-5} cm (b) 10×10^{-5} cm
(c) 2.5×10^{-5} cm (d) 1.25×10^{-5} cm

Q 2. A slit of width a is illuminated by white light. The first minimum for red light (λ = 6500 Å) will fall at θ = 30° when a will be

(a) 3250 Å (b) 6.5×10^{-4} cm
(c) 1.3 micron (d) 2.6×10^{-4} cm

Q 3. What will be the wavelength of the X-rays which give a diffraction angle 2θ equal to 16.80° for a crystal, if the inter planner distance in the crystal is 0.200 nm and only first order diffraction is observed (sin8.40° = 0.146).

(a) 5.84×10^{-9} cm (b) 2.84×10^{-11} cm
(c) 3.64×10^{-9} cm (d) 1.54×10^{-11} cm

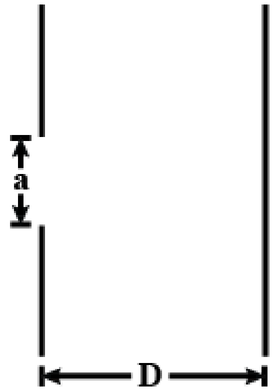
Q 4. Light waves of wave length λ propagate in a medium. If M and N are two points on the same wave front and they are separated by a distance λ/4, the phase difference between them will be (in radian)

(a) $\frac{\pi}{2}$ (b) $\frac{\pi}{8}$
(c) $\frac{\pi}{45}$ (d) zero

Q 5. A beam of light of wavelength 600 nm from a distance source falls on a single slit 1 mm wide and a resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringes on either side of central bright fringe is

(a) 0.2 mm (b) 1.7 cm
(c) 1.2 mm (d) 2.4 cm

Q 6. Consider the shown arrangement to obtain diffraction pattern when a monochromatic radiation of wavelength λ is incident on the narrow aperture. If a=3λ, in the diffraction pattern obtained on screen, the number of intensity minima seen on screen would be



(a) 3 (b) 4
(c) 5 (d) 6

Q 7. When white light is incidence on a diffraction grating, then the zero order maximum will be

(a) spectrum of colours (b) white
(c) one of the component colours (d) absent

Q 8. A linear aperture whose width is 0.02 cm is placed immediately in front of a lens of focal length 60 cm. The aperture is illuminated normally by a parallel beam of wavelength 5×10^{-5} cm. The distance of the first dark band of the diffraction pattern from the center of the screen is:
(a) 0.15 cm (b) 0.10 cm
(c) 0.25 cm (d) 0.20 cm

Q 9. A single slit of width 0.1mm is illuminated by parallel light of wavelength 6000Å, and diffraction bands are observed on a screen 40cm from the slit. The distance of third dark band from the central bright band is:
(a) 7.2 mm (b) 3.6 mm
(c) 2.4 mm (d) 0.6 mm

Q 10. Light of wavelength 6000Å is incident on a slit of width 0.30 mm. The screen is placed 2 m from the slit. Find (a) the position of the first dark fringe and (b). The width of the central bright fringe.
(a) 3mm, 6mm (b) 2mm, 4mm
(c) 2mm, 6mm (d) 4mm, 8mm

Q 11. A diffraction is obtained by using a beam of red light. What will happen if the red light is replaced by the blue light
(a) Bands will narrower and crowded together
(b) Bands become broader and further apart
(c) No change will take place
(d) Bands disappear

Q 12. What will be the angle of diffracting for the first minimum due to Fraunhofer diffraction with sources of light of wave length 550 nm and slit of width 0.55 mm

(a) 0.001 rad (b) 0.01 rad
(c) 1 rad (d) 0.1 rad

Q 13. If wavelength 4500Å and 6000Å are found to be missing in the reflected spectrum in thin air film interference, the thickness of the film for normal incidence is nearly
(a) 9000 Å (b) 10500 Å
(c) 5250 Å (d) 4240 Å

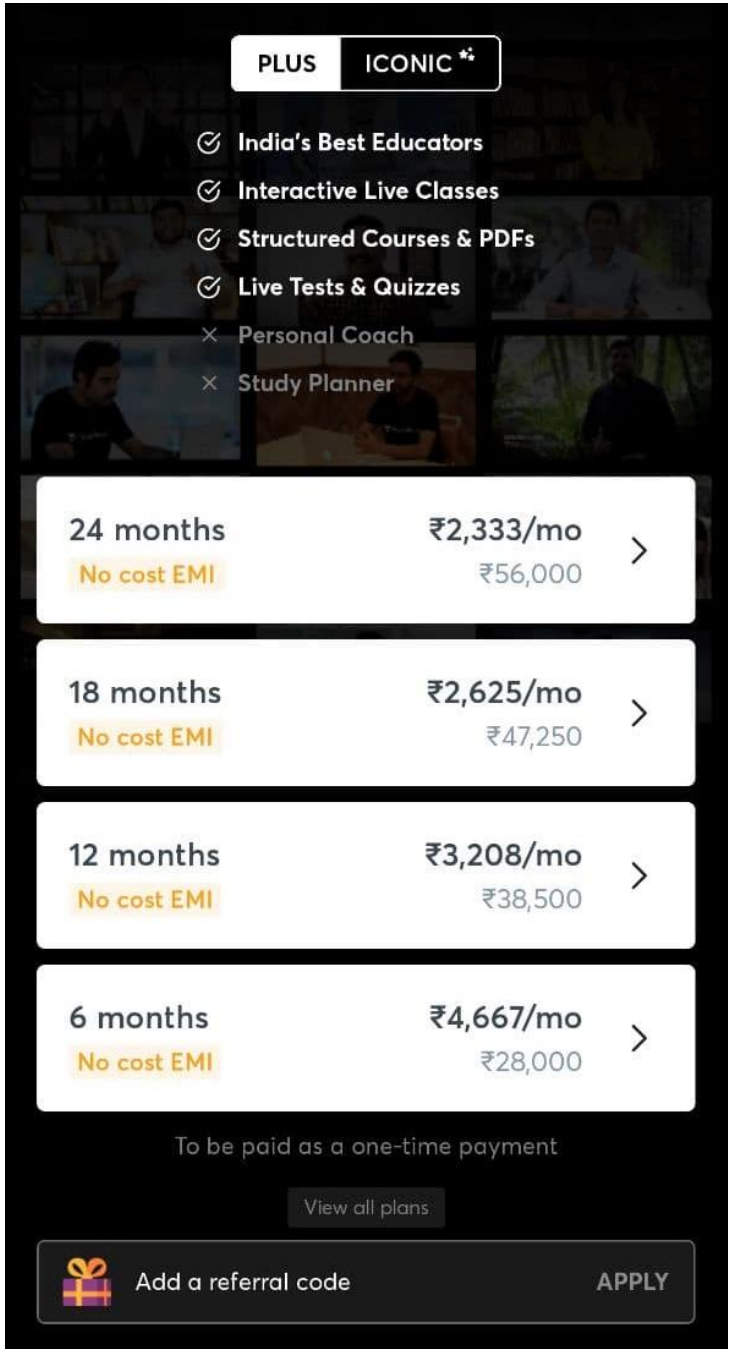
Q 14. A parallel beam of white light is incident on a thin film of air of uniform thickness. Wavelengths 7200 A° and 5400 A° are observed to be missing from the spectrum of reflected light viewed normally. The other wavelength in the visible region missing in the reflected spectrum is
(a) 6000 Å (b) 4320 Å
(c) 5500 Å (d) 6500 Å

Q 15. A glass of refractive index 1.5 is coated with a thin layer of thickness of t of refractive index 1.8. Light of wavelength 648 nm travelling in air is incident normally on the layer. It is partly reflected at upper and lower surfaces of the layer and the rays interfere constructively. Minimum thickness of layer is?
(a) 2 (b) 15
(c) 9 (d) 60

Q 16. A light of wavelength 5890Å falls normally on a thin air film. The minimum thickness of the film such that the film appears dark in reflected light is
(a) 2.945×10^{-7}m (b) 3.945×10^{-7}m
(c) 4.95×10^{-7}m (d) 1.945×10^{-7}m

Answer Key

Q.1 b	**Q.2 c**	**Q.3 a**	**Q.4 d**	**Q.5 d**
Q.6 b	**Q.7 b**	**Q.8 a**	**Q.9 a**	**Q.10 d**
Q.11 a	**Q.12 a**	**Q.13 a**	**Q.14 b**	**Q.15 c**
Q.16 a				



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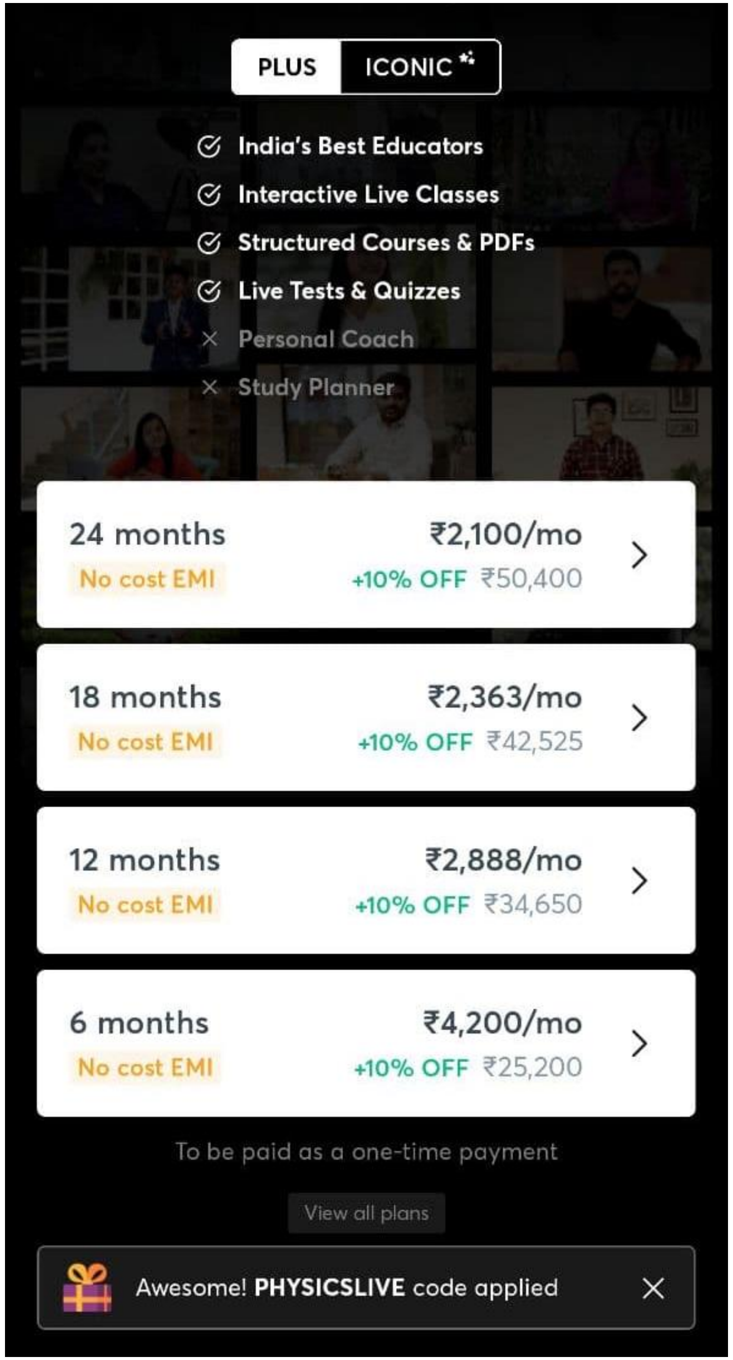


Written Solution

DPP-3 Wave Optics: Thin film interference & Diffraction

By Physicsaholics Team

Solution: 1

In diffraction:

for minima

$\Delta x = n\lambda$

$d \sin\theta = n\lambda$

for first minima

$n = 1$

$d \sin 30^\circ = 1 \times 5000 \times 10^{-10}$

$d = 2 \times 5000 \times 10^{-10}$

$d = 10 \times 10^{-7}$ m

$d = 10 \times 10^{-5}$ cm Ans.

Ans. b

Solution: 2

for minima in diffraction

$$a \sin\theta = n\lambda$$

$$a \sin 30^\circ = 1 \times 6500 \times 10^{-10}$$

$$a \times \frac{1}{2} = 6500 \times 10^{-10}$$

$$a = 13{,}000 \times 10^{-10}$$

$$a = 1.3 \times 10^{-6}\, m$$

$$\boxed{a = 1.3\ \mu m}$$ Ans

Ans. c

Solution: 3

Using Bragg's Law

$2d\sin\theta = n\lambda$

$\theta = \frac{16.80^\circ}{2} = 8.40^\circ$

$2d\sin 8.40^\circ = n\lambda$

$2 \times 0.2 \times 10^{-9} \times 0.146 = 1 \times \lambda$

$\because$ for first order ; $n = 1$

so; $\lambda = 0.4 \times 10^{-9} \times 0.146$

$\lambda = 0.0584 \times 10^{-9}$ m

$\lambda = 5.84 \times 10^{-11}$ m Ans

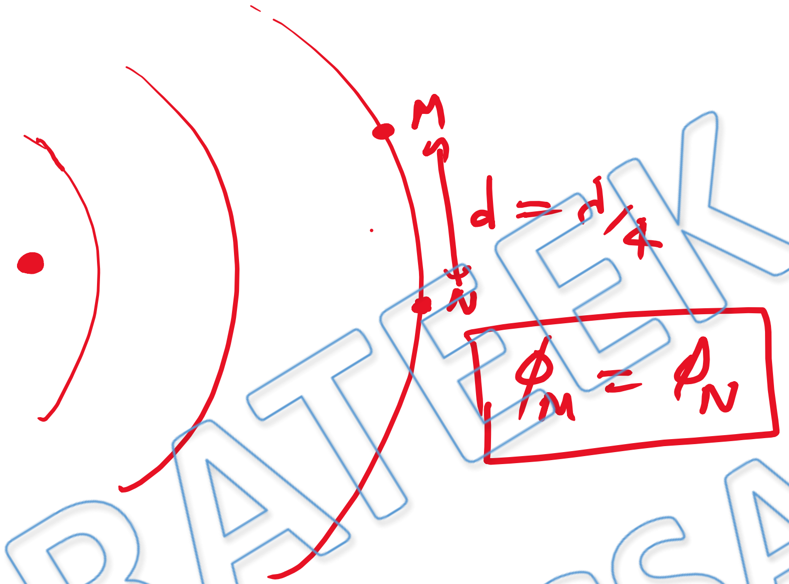
or

$\lambda = 5.84 \times 10^{-9}$ cm

Ans. a

Solution: 4

Phase difference between any two points on a wavefront is zero.



Ans. d

Solution: 5

distance between first dark fringes on either side of central bright = width of central bright fringe

So;

$$y = \frac{2\lambda D}{d}$$

$$y = \frac{2 \times 600 \times 10^{-9} \times 2}{1 \times 10^{-3}}$$

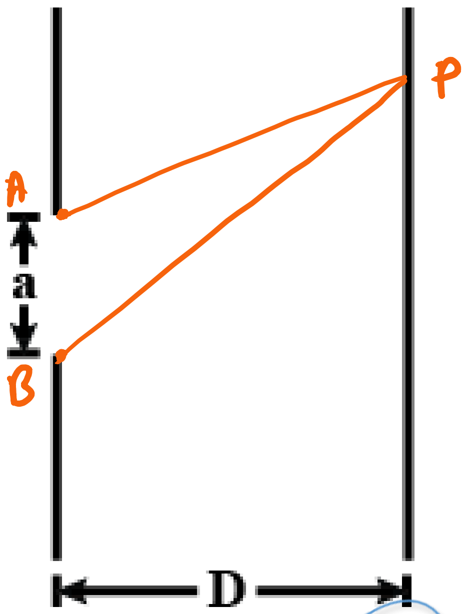
$$= 2 \times 600 \times 10^{-6} \times 2$$

$$y = 24 \times 10^{-4}$$

$$\boxed{y = 2.4\ mm}$$ Ans

Ans. d

Solution: 6



$\Delta x = BP - AP$

$(\Delta x)_{max} = a = 3\lambda$ so; $\Delta x \le 3\lambda$

for minima

$a \sin\theta = n\lambda$

$\sin\theta = \frac{n\lambda}{a} = \frac{n\lambda}{3\lambda}$

$\sin\theta = \frac{n}{3}$

so; $\sin\theta = \frac{1}{3}, \frac{2}{3}, \frac{3}{3}, \frac{4}{3}$ ✓ ✓ ✓ ✗ [$\because \sin\theta \le 1$]

same pattern will be formed below the central bright fringe.

so; Total minima formed = 6

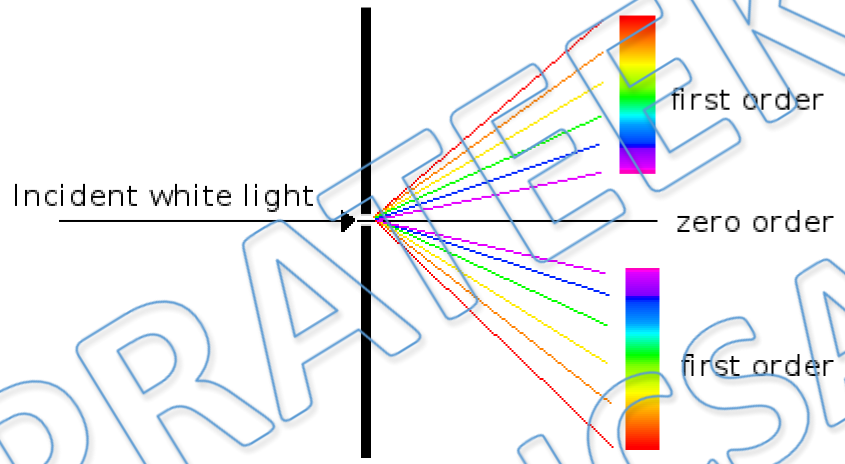
Two minima will be at ∞ when $\sin\theta = 1$; $\theta = 90°$

so; Total minima observed on screen = 4 Ans

Ans. b

Solution: 7

When white light is incident on a diffraction grating, then zero order principal maximum will have only white colour.At centre all colours form their central maxima due to which it appears White.



Ans. b

Solution: 8

focal length of lens = 60 cm

so; pattern of parallel beam will form at D = 60 cm.

$d = 5 \times 10^{-5}$ cm

$a = 0.02$ cm.

so; distance of first minimum from center of screen

$$y = \frac{dD}{a}$$

$$y = \frac{5 \times 10^{-5} \times 10^{-2} \times 60 \times 10^{-2}}{0.02 \times 10^{-2}} = \frac{300 \times 10^{-5} \times 10^{-4}}{2 \times 10^{-4}}$$

$y = 150 \times 10^{-5}$ m

$y = 1.5$ mm Ans

or

$y = 0.15$ cm Ans.

Ans. a

Solution: 9

for dark band

$a \sin\theta = n\lambda$

for third dark

$n = 3$

$a \sin\theta = 3\lambda$

$\sin\theta = \frac{3\lambda}{a} = \frac{3 \times 6000 \times 10^{-10}}{0.1 \times 10^{-3}}$

$\sin\theta = \frac{3 \times 6 \times 10^{-7}}{1 \times 10^{-4}}$

$\sin\theta = 18 \times 10^{-3}$

when θ is small

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

$\Rightarrow \frac{y}{D} = 18 \times 10^{-3}$

$y = 18 \times 10^{-3} \times D$

$y = 18 \times 10^{-3} \times 40 \times 10^{-2}\, m$

$y = 720 \times 10^{-2} \times 10^{-3}\, m$

$y = 7.2 \times 10^{-3}\, m$

$\boxed{y = 7.2\, mm}$ Ans

Ans. a

Solution: 10

(a) $y_1 = \frac{\lambda D}{a}$

$y_1 = \frac{6000 \times 10^{-10} \times 2}{0.3 \times 10^{-3}}$

$y_1 = \frac{12 \times 10^{-7}}{3 \times 10^{-4}}$

$y_1 = 4 \times 10^{-3}$

$\boxed{y_1 = 4\,mm}$ Ans

(b) $\beta = \frac{2\lambda D}{a}$

$\beta = 2y_1$

$\beta = 2 \times 4\,mm$

$\boxed{\beta = 8\,mm}$ Ans

Ans. d

Solution: 11

$y = \frac{n\lambda D}{d}$ & $\beta = \frac{2\lambda D}{d}$

$y \propto \lambda$ $\beta \propto \lambda$

$\because \lambda_R > \lambda_B$

so; if red light is replaced by blue light

$\lambda \downarrow \Rightarrow y \downarrow \beta \downarrow$

so; Band will be narrow & crowd together.

Ans. a

Solution: 12

$a \sin\theta = n\lambda$

$\sin\theta = \frac{\lambda}{a}$; $n = 1$

$\sin\theta = \frac{550 \times 10^{-9}}{0.55 \times 10^{-3}}$

$\sin\theta = \frac{55 \times 10^{-8}}{55 \times 10^{-5}}$

$\sin\theta = 10^{-3}$

when θ is small

$\sin\theta \approx \theta$

so, $\theta \approx 10^{-3}$ rad

$\boxed{\theta \approx 0.001 \text{ rad}}$ Ans.

Ans. a

Solution: 13

for distructive interference of reflected rays —

$2\mu t = n\lambda$ but for air $\mu = 1$

$\Rightarrow 2t = n_1\lambda_1 = n_2\lambda_2$ where $\lambda_1 = 4000\,Å$, $\lambda_2 = 6000\,Å$

$\Rightarrow \dfrac{n_1}{n_2} = \dfrac{\lambda_2}{\lambda_1} = \dfrac{6000}{4000} = \dfrac{3}{2}$

$\Rightarrow n_1 = 3, 6, 9, 12$ - - - -

$\Rightarrow t = \dfrac{n_1\lambda_1}{2} = 6000\,Å, 12000\,Å, 18000\,Å$ - - - -

Ans (a) Ans. a

Solution: 14

for minima in reflected light $2\mu t = n\lambda$

$\Rightarrow 2\mu t = n \times 7200\,\text{Å} = (n+1)\,5400\,\text{Å}$

$\Rightarrow 4n = 3n + 3 \Rightarrow n = 3$

$\Rightarrow 2\mu t = 3 \times 7200\,\text{Å} = 21600\,\text{Å}$

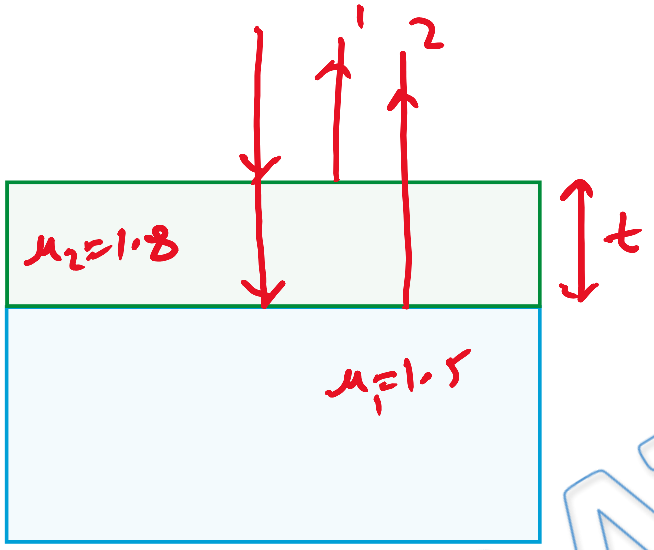
Other missing λ are

$\frac{2\mu t}{5}, \frac{2\mu t}{6}, \frac{2\mu t}{7}$ ----- .

$= 4320\,\text{Å}, 3600\,\text{Å}, 3085\,\text{Å}$ - -

Ans. b

Solution: 15



for constructive interference

$$2\mu_2 t = (2n+1)\frac{\lambda}{2}$$

$$t = (2n+1)\frac{\lambda}{4\mu_2}$$

for t_{min}, $n = 0$

$$t_{min} = \frac{\lambda}{4\mu_2}$$

$$t_{min} = \frac{648 \times 10^{-9}}{4 \times 1.8}$$

$$t_{min} = 90 \times 10^{-9}\, m$$

$$\boxed{t_{min} = 9 \times 10^{-8}\, m}$$ Ans

Ans. c

Solution: 16

for dark fringe / distructive interference of film

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

$$t = \frac{n\lambda}{2\mu} \quad (\mu_{air} = 1)$$

for minimum thickness ; $n = 1$

$$t_{min} = \frac{\lambda}{2\mu}$$

$$t_{min} = \frac{5890 \times 10^{-10}}{2 \times 1}$$

$$t_{min} = 2945 \times 10^{-10} \text{ m}$$

$$\boxed{t_{min} = 2.945 \times 10^{-7} \text{ m}}$$ Ans

Ans. a

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