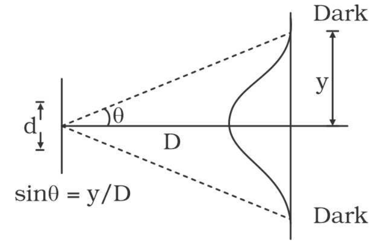
Solution : DTS

1.(D) For first dark fringe on either side. $d \sin\theta = \lambda$

Or $\frac{dy}{D} = \lambda$

$\therefore \quad y = \frac{\lambda D}{d}$



Therefore, distance two dark fringes on either side

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

Substituting the vales, we have

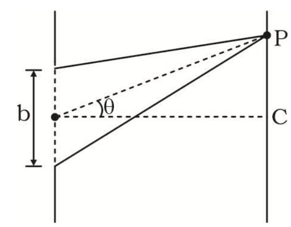
Distance $= \frac{2(600 \times 10^{-6} mm)(2 \times 10^{3} mm)}{(1.00\ mm)} = 2.4\ mm$

2.(D)

3.(D) If we increase the slit width, the envelope of the fringe pattern changes so that its central peak is sharper. The fringe spacing which depends on slit separation does not change. Hence, less interference maxima fall within the central diffraction maximum.

4.(A) **(i)** If $\lambda << b, \sin\theta = \theta \to 0$

So, spreading of light will take place. Hence, no diffraction pattern is observed on screen. But a sharp image of slit is found on screen.



(ii) If $\lambda < b,\ 0 < \theta < \frac{\pi}{2}$

So, diffraction pattern is found on screen.

(iii) If $\lambda = b, \theta \to \frac{\pi}{2}$, so central maximum will extend from $-\frac{\pi}{2}\ to \frac{\pi}{2}$.

(iv) If $\lambda = b, \sin\theta = \frac{\lambda}{b} > 1$, which is not realistic.

Hence, (i) $\to$ (Q, R) (ii) $\to$ (P) (iii) $\to$ (Q, S) (iv) $\to$ (Q)

5.(B) The angular limit of resolution is equal to the angular separation between the centre of central maximum and first minimum.

6.(B) $\because$ b sin $= \pm\lambda$ (for central maxima), when the b decreases, θ increases. So central maxima becomes wider.

7.(D) Polarisation takes place in transverse wave, but not in sound wave.

8.(B) $I = I_0 \cos^2 45°$

$kA'^2 = kA^2 \cos^2 45°$

$A'^2 = \frac{A^2}{2} \quad \therefore \quad A' = \frac{A}{\sqrt{2}}$

9.(B) $B_0 = E_0 / c, E_0$ and B_0 should be mutually perpendicular.

10.(B) Here, $\tan\theta = \frac{E_2}{E_1}$ = constant. Thus, wave is plane polarised.

11.(A) All the vibrations of unpolarised light at a given instant can be resolved in two mutually perpendicular direction.

12.(A) If incident light is unpolarised, then as vibrations are equally probable in all directions.

$\therefore \quad < I > = < I_0 \cos^1 \theta >$

$= I_0 < \cos^2 \theta > = \frac{I_0}{2}$

13.(C) $x_n = \frac{nf\lambda}{a} \Rightarrow \lambda = \frac{ax_n}{fn} = \frac{3\times10^{-4}\times5\times10^{-3}}{3\times1} = 5000\,\mathring{A} \quad [\because n=3]$

14.(C)

15.(D) Longitudinal wave never be polarised.

Solution : JEE Main (Archive)

1.(D) The angle of incidence at which reflected light gets totally polarized is called Brewster's angle $i = \tan^{-1}(n)$

2.(A) When an unpolarized light of intensity I_0 is incident on a polarizing sheet, the intensity of transmitted light, $I = I_0 / 2$

$\therefore$ Intensity of the light which does not get transmitted is

$I_1 = I_0 - I = I_0 - I_0/2 = I_0/2$

3.(B) When the slit width is doubled the energy failing per sec on the screen is doubled but angular width of central maxima $\left(\Delta\theta = \frac{2\lambda}{b}\right)$ is halved. Hence intensity of the central maxima will be $4I_0$

4.(A) Fact

5.(B) If a beam of unpolarized light of intensity I_0 is passed through the two polaroids. The intensity of the emergent light is

$I = \frac{I_0}{2}\cos^2\theta \quad ; \quad I = \frac{I_0}{2}\cos^2 45° = \frac{I_0}{4}$

6.(B) i = Brews ter's angle

$= \tan^{-1}(\mu)$

$= \tan^{-1}\left(\frac{4}{3}\right)$

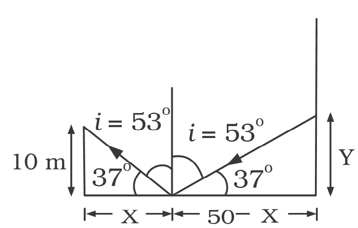
$i = 53° \quad \therefore \quad \tan 37° = 10/X$

$\frac{3}{4} = \frac{10}{X} \quad \Rightarrow \quad \frac{40}{3} = 13.3\ m$

Again, $\tan 37° = \frac{Y}{50 - X}$

$\frac{3}{4} = \frac{Y}{50 - X} \quad \Rightarrow \quad 3\left(50 - \frac{40}{3}\right) = 4Y$

$\Rightarrow \quad 110 = 4Y \quad \therefore \quad Y = 27.5\ m$



7.(C) The angular width of central maximum of the single slit diffraction pattern is, $\Delta\theta = \frac{2\lambda}{b}$

In the young's double slit experiment, the angular width of a fringe is $\beta = \frac{\lambda}{d}$

$\therefore$ no. of intensity maxima observed within the central maximum of the single slit diffraction pattern is

$$n = \frac{\Delta\theta}{\beta} = \frac{2\lambda / b}{\lambda / d} = \frac{2d}{b} = 2 \times 6.1 = 12.2 \qquad \therefore \qquad n = 12 \ (n \text{ is an integer})$$

8.(B) $I_A \cos^2 30 = I_B \cos^2 60$; $\frac{I_A}{I_B} = \frac{1}{3}$

9.(B) $\frac{\lambda_{red}}{a} = \frac{3\lambda}{2a}$ $\quad\therefore\quad$ $\lambda = 4400\text{Å}$

10.(C) $\sin\theta_{1C} = \frac{1}{\mu}$

$\tan\theta_{1B} = \frac{1}{\mu}$

$\therefore$ $\frac{\sin\theta_{1C}}{\sin\theta_{1B}} \cos\theta_{1B} = 1 \quad \Rightarrow \quad \cos\theta_{1B} = \frac{1}{\eta}$

$\tan\theta_{1B} = \sqrt{\eta^2 - 1}$

11.(A) $d\sin\theta = \lambda$

$\sin\theta = \frac{\lambda}{d} < 1 \quad \therefore \quad \lambda < d$

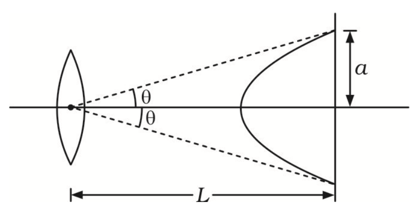
$\lambda = \frac{h}{|p_y|} \qquad \frac{h}{|p_y|} < d \quad \Rightarrow \quad h < |p_y| d$

12.(C) $a\sin\theta = \lambda$

$a\left(\frac{a}{L}\right) = \lambda$

$\Rightarrow \quad a = \sqrt{\lambda L}$

Spread $= 2a = \sqrt{4\lambda L}$



13.(B) $\sin 30° = \frac{\lambda}{b} \Rightarrow \lambda = \frac{b}{2} = \frac{1 \times 10^{-6}}{2} = 5 \times 10^{-7} m$

Fringe width, $\omega = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{\omega} = \frac{5 \times 10^{-7} \times 0.5}{1 \times 10^{-2}}$

$d = 25\ \mu m$

14.(D) $I / 2\cos^4\theta = \frac{I}{8} \quad \Rightarrow \quad \cos\theta = \frac{1}{\sqrt{2}} \quad \Rightarrow \quad \theta = 45°$

15.(D) de-Broglie wavelength, $\lambda = \frac{h}{P}$

$\therefore$ Angular width of centra maxima $= \frac{2\lambda}{d}$

$\therefore$ width of central maxima $= \frac{2\lambda D}{d}$

16.(D) Let width of each slit be $a = 4.05\ \mu m$.

Separation between slits $d = 19.44\ \mu m$

Width of each Interference fringe: $W = \frac{\lambda D}{d}$

No. of fringes between Ist and IInd Minima of diffraction:

$$N = \frac{\lambda D / a}{\lambda D / d} = \frac{d}{a} = 4.8, \quad N \simeq 5.$$

17.(D) At air-liquid interface

$$\frac{\sin i}{\sin\theta} = \mu \qquad \text{... (i)}$$

At liquid-glass interface, for reflected ray to be completely polarised

$$\tan\theta = \frac{1\cdot 5}{\mu} \qquad \text{... (ii)}$$

For μ to min, θ max

So from (i)

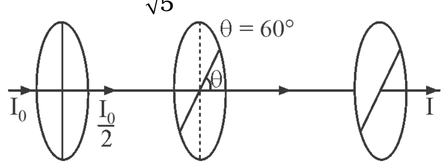
$$(\sin\theta)_{max} = \frac{1}{\mu}$$

$$\Rightarrow \quad (\tan\theta)_{max} = \frac{1}{\sqrt{\mu^2 - 1}} \quad \Rightarrow \quad \frac{1}{\sqrt{\mu^2 - 1}} = \frac{3}{2\mu}$$

$$9\mu^2 - 9 = 4\mu^2, \qquad 5\mu^2 = 9$$

$$\mu = \frac{3}{\sqrt{5}} \qquad \text{Option (D)}$$

18.(A)



$$\frac{I_0}{2}\cos^2\theta \cdot \cos^2 30° = I$$

$$\frac{I_0}{I} = \frac{2}{\frac{1}{4}\times\frac{3}{4}} = \frac{32}{3} = 10.67$$

19.(D) $\lambda = 6000 \times 10^{-8}\ cm$

For 2nd minimum $d\sin\theta_2 = 2\lambda \quad \Rightarrow \quad \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$

So, for 1st minimum, $d\sin\theta_1 = \lambda \quad \Rightarrow \quad \sin\theta_1 = \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$

$\therefore \quad \theta_1 = 25.65°$ (*from sin table*), $\quad \theta_1 \approx 25°$

20.(A) $I = I_0 \cos^2\theta$, $\quad \dfrac{I_0}{10} = I_0 \cos^2\theta$; $\quad \cos\theta = \dfrac{1}{\sqrt{10}} = 0.31 < 0.707$

$\therefore \quad \theta > 45°$ & $90° - \theta < 45°$; $\theta = 71.6°$ $\quad \therefore$ Angle rotated $= 90° - 71.6° = 18.4°$

21.(D) $\omega = 31.4\ rad/s = 10\pi rad/s$

$I = 3.3 Wm^{-2}$; $\quad A = 3 \times 10^{-4} m^2$

Energy $= \langle I \rangle AT \quad = \dfrac{I}{2}.A.\dfrac{2\pi}{\omega}$

$= \dfrac{\pi IA}{\omega} \quad = \dfrac{\pi(3.3)(3 \times 10^{-4})}{10\pi}$

$= 0.99 \times 10^{-4} J \quad \simeq 1.0 \times 10^{-4} J$

22.(200) Angular width $(\sin\theta) = \dfrac{\lambda}{a}$

$= \dfrac{6000 \times 10^{-10}}{0.6 \times 10^{-4}} = \dfrac{6 \times 10^{-7}}{6 \times 10^{-5}} = 10^{-2}$

Number of minima produced will be equal to $2 \times \dfrac{1}{10^{-2}}$