WAVE OPTICS

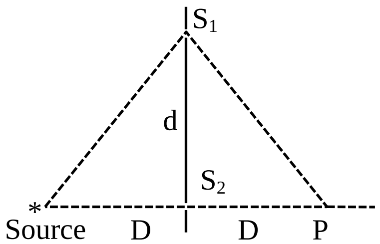
1. A parallel beam of monochromatic light of wavelength 5000 Å is incident normally on a single narrow slit of width 0.001 mm. The light is focused by convex lens on screen, placed on its focal plane. The first minima will be formed for the angle of diffraction of ________ (degree).

2. When a polaroid sheet is rotated between two crossed polaroids then the transmitted light intensity will be maximum for a rotation of :

(1) 60° (2) 30°

(3) 90° (4) 45°

3. In a double slit experiment shown in figure, when light of wavelength 400 nm is used, dark fringe is observed at P. If D = 0.2 m. the minimum distance between the slits S_1 and S_2 is ______ mm.



4. In Young's double slit experiment, light from two identical sources are superimposing on a screen. The path difference between the two lights reaching at a point on the screen is $\frac{7\lambda}{4}$. The ratio of intensity of fringe at this point with respect to the maximum intensity of the fringe is :

(1) 1/2 (2) 3/4

(3) 1/3 (4) 1/4

5. In a single slit diffraction pattern, a light of wavelength 6000 Å is used. The distance between the first and third minima in the diffraction pattern is found to be 3 mm when the screen in placed 50 cm away from slits. The width of the slit is ______ × 10^{-4} m.

6. The diffraction pattern of a light of wavelength 400 nm diffracting from a slit of width 0.2 mm is focused on the focal plane of a convex lens of focal length 100 cm. The width of the 1^{st} secondary maxima will be :

(1) 2 mm (2) 2 cm

(3) 0.02 mm (4) 0.2 mm

7. A beam of unpolarised light of intensity I_0 is passed through a polaroid A and then through another polaroid B which is oriented so that its principal plane makes an angle of 45° relative to that of A. The intensity of emergent light is :

(1) $I_0/4$ (2) I_0

(3) $I_0/2$ (4) $I_0/8$

8. Two waves of intensity ratio 1 : 9 cross each other at a point. The resultant intensities at the point, when (a) Waves are incoherent is I_1 (b) Waves are coherent is I_2 and differ in phase by 60°. If $\frac{I_1}{I_2} = \frac{10}{x}$ then x = _____.

9. When unpolarized light is incident at an angle of 60° on a transparent medium from air. The reflected ray is completely polarized. The angle of refraction in the medium is

(1) 30^0 (2) 60^0

(3) 90^0 (4) 45^0

10. A monochromatic light of wavelength 6000Å is incident on the single slit of width 0.01 mm. If the diffraction pattern is formed at the focus of the convex lens of focal length 20 cm, the linear width of the central maximum is :

(1) 60 mm (2) 24 mm

(3) 120 mm (4) 12 mm

11. A microwave of wavelength 2.0 cm falls normally on a slit of width 4.0 cm. The angular spread of the central maxima of the diffraction pattern obtained on a screen 1.5 m away from the slit, will be:

(1) 30° (2) 15°

(3) 60° (4) 45°

12. In Young's double slit experiment, monochromatic light of wavelength 5000 Å is used. The slits are 1.0 mm apart and screen is placed at 1.0 m away from slits. The distance from the centre of the screen where intensity becomes half of the maximum intensity for the first time is _____$\times 10^{-6}$ m.

13. Two wavelengths λ_1 and λ_2 are used in Young's double slit experiment λ_1 = 450 nm and λ_2 = 650 nm. The minimum order of fringe produced by λ_2 which overlaps with the fringe produced by λ_1 is n. The value of n is _______.

14. The width of one of the two slits in a Young's double slit experiment is 4 times that of the other slit. The ratio of the maximum of the minimum intensity in the interference pattern is :

(1) 9 :1 (2) 16 : 1

(3) 1 : 1 (4) 4 : 1

15. Light emerges out of a convex lens when a source of light kept at its focus. The shape of wavefront of the light is:

(1) Both spherical and cylindrical

(2) Cylindrical

(3) Spherical

(4) Plane

16. In Young's double slit experiment, carried out with light of wavelength 5000Å, the distance between the slits is 0.3 mm and the screen is at 200 cm from the slits. The central maximum is at x = 0 cm. The value of x for third maxima is .... mm.

17. In a single slit experiment, a parallel beam of green light of wavelength 550 nm passes through a slit of width 0.20 mm. The transmitted light is collected on a screen 100 cm away. The distance of first order minima from the central maximum will be $x \times 10^{-5}$ m. The value of x is :

18. Which of the following phenomena does not explain by wave nature of light.

(A) reflection (B) diffraction

(C) photoelectric effect (D) interference

(E) polarization

Choose the **most appropriate** answer from the options given below :

(1) E only (2) C only

(3) B, D only (4) A, C only

19. Two coherent monochromatic light beams of intensities I and 4I are superimposed. The difference between maximum and minimum possible intensities in the resulting beam is x I. The value of x is______.

20. A parallel beam of monochromatic light of wavelength 600 nm passes through single slit of 0.4 mm width. Angular divergence corresponding to second order minima would be____$\times 10^{-3}$ rad.

21. Two slits are 1 mm apart and the screen is located 1 m away from the slits. A light wavelength 500 nm is used. The width of each slit to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern is ……….. $\times 10^{-4}$ m.

22. In a Young's double slit experiment, the intensity at a point is $\left(\frac{1}{4}\right)^{th}$ of the maximum intensity, the minimum distance of the point from the central maximum is ________∝m.
(Given : λ = 600 nm, d = 1.0 mm, D = 1.0 m)

23. Monochromatic light of wavelength 500 nm is used in Young's double slit experiment. An interference pattern is obtained on a screen When one of the slits is covered with a very thin glass plate (refractive index = 1.5), the central maximum is shifted to a position previously occupied by the 4^{th} bright fringe. The thickness of the glass-plate is ……………….µm.

SOLUTIONS

1. Ans. (30)

Sol. For first minima

$a \sin\theta = \lambda$

$$\Rightarrow \sin\theta = \frac{\lambda}{a} = \frac{5000 \cdot 10^{-10}}{1 \cdot 10^{-6}} = \frac{1}{2}$$

$\Rightarrow \theta = 30°$

2. Ans. (4)

Sol. Let I_0 be intensity of unpolarised light incident on first polaroid.

I_1 = Intensity of light transmitted from 1st polaroid

$$= \frac{I_0}{2}$$

θ be the angle between 1st and 2nd polaroid

φ be the angle between 2nd and 3rd polaroid

$\theta + \varphi = 90^0$ (as 1st and 3rd polaroid are crossed)

$\varphi = 90^0 - \theta$

I_2 = Intensity from 2nd polaroid

$$I_2 = I_1 \cos^2\theta = \frac{I_0}{2}\cos^2\theta$$

I_3 = Intensity from 3rd polaroid

$$I_3 = I_2 \cos^2\varphi$$

$$I_3 = I_1 \cos^2\theta \cos^2\varphi$$

$$I_3 = \frac{I_0}{2}\cos^2\theta\cos^2\varphi$$

$\varphi = 90 - \theta$

$$I_3 = \frac{I_0}{2}\cos^2\theta \sin^2\theta$$

$$I_3 = \frac{I_0}{2}\left[\frac{2\sin\theta\cos\theta}{2}\right]^2$$

$$I_3 = \frac{I_0}{8}\sin^2 2\theta$$

I_3 will be maximum when $\sin 2\theta = 1$

$2\theta = 90°$

$\theta = 45°$

3. Ans. (0.20)

Sol. Path difference for minima at P

$$2\sqrt{D^2 + d^2} - 2D = \frac{\lambda}{2}$$

$$\therefore \sqrt{D^2 + d^2} - D = \frac{\lambda}{4}$$

$$\therefore \sqrt{D^2 + d^2} = \frac{\lambda}{4} + D$$

$$\Rightarrow D^2 + d^2 = D^2 + \frac{\lambda^2}{16} + \frac{D\lambda}{2}$$

$$\Rightarrow d^2 = \frac{D\lambda}{2} + \frac{\lambda^2}{16}$$

$$\Rightarrow d^2 = \frac{0.2 \cdot 400 \cdot 10^{-9}}{2} + \frac{4 \cdot 10^{-14}}{4}$$

$$\Rightarrow d^2 \approx 400 \cdot 10^{-10}$$

$$\therefore d = 20 \cdot 10^{-5}$$

$$\Rightarrow d \approx 0.20 \text{ mm}$$

4. Ans. (1)

Sol. $\Delta x = \dfrac{7\lambda}{4}$

$$\varphi = \frac{2\pi}{\lambda}\Delta x = \frac{2\pi}{\lambda}\cdot\frac{7\lambda}{4} = \frac{7\pi}{2}$$

$$I = I_{max}\cos^2\left(\frac{\varphi}{2}\right)$$

$$\frac{I}{I_{max}} = \cos^2\left(\frac{\varphi}{2}\right) = \cos^2\left(\frac{7\pi}{2\cdot 2}\right) = \cos^2\left(\frac{7\pi}{4}\right)$$

$$= \cos^2\left(2\pi - \frac{\pi}{4}\right)$$

$$= \cos^2\frac{\pi}{4} = \frac{1}{2}$$

5. Ans. (2)

Sol. For nth minima

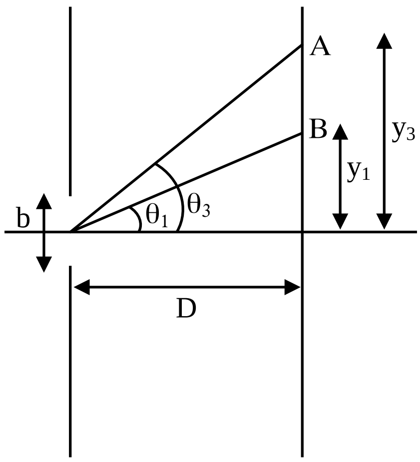
$b\sin\theta = n\lambda$

(λ is small so $\sin\theta$ is small, hence $\sin\theta$ $\tan\theta$)

$b\tan\theta = n\lambda$

$$b\frac{y}{D} = n\lambda$$

$$\Rightarrow y_n = \frac{n\lambda D}{b}$$ (Position of nth minima)



B → 1st minima, A → 3rd minima

$$y_3 = \frac{3\lambda D}{b}, \quad y_1 = \frac{\lambda D}{b}$$

$$\Delta y = y_3 - y_1 = \frac{2\lambda D}{b}$$

$$3\times 10^{-3} = \frac{2\times 6000\times 10^{-10}\times 0.5}{b}$$

$$b = \frac{2\times 6000\times 10^{-10}\times 0.5}{3\times 10^{-3}}$$

$b = 2 \times 10^{-4}$ m

$x = 2$

6. **Ans. (1)**

Sol. Width of 1st secondary maxima = $\frac{\lambda}{a}.D$

Here

$a = 0.2\times 10^{-3}$ m

$\lambda = 400\times 10^{-9}$ m

$D = 100\times 10^{-2}$

Width of 1st secondary maxima

$$= \frac{400\times 10^{-9}}{0.2\times 10^{-3}}\times 100\times 10^{-2}$$

$= 2$ mm

7. **Ans. (1)**

Sol. Intensity of emergent light

$$= \frac{I_0}{2}\cos^2 45° = \frac{I_0}{4}$$

8. **Ans. (13)**

Sol. For incoherent wave $I_1 = I_A + I_B \Rightarrow I_1 = I_0 + 9I_0$

$I_1 = 10I_0$

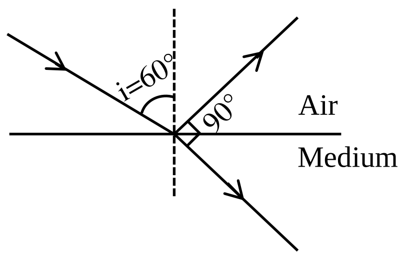
For coherent wave $I_2 = I_A + I_B + 2\sqrt{I_A I_B}\cos 60°$

$$I_2 = I_0 + 9I_0 + 2\sqrt{9I_0^2}.\frac{1}{2} = 13\, I_0$$

$$\frac{I_1}{I_2} = \frac{10}{13}$$

9. **Ans. (1)**

Sol. By Brewster's law



At complete reflection refracted ray and reflected ray are perpendicular.

10. **Ans. (2)**

Sol. Linear width

$$W = \frac{2\lambda d}{a} = \frac{2\times 6\times 10^{-7}\times 0.2}{1\times 10^{-5}}$$

$= 2.4 \times 10^{-2} = 24$ mm

11. **Ans. (3)**

Sol. For first minima $a\sin\theta = \lambda$

$$\sin\theta = \frac{\lambda}{a} = \frac{1}{2}$$

$\theta = 30°$

Angular spread = 60°

12. **Ans. (125)**

Sol. Let intensity of light on screen due to each slit is I_0

So intensity at centre of screen is $4I_0$

Intensity at distance y from centre-

$I = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\varphi$

$I_{max} = 4I_0$

$$\frac{I_{max}}{2} = 2I_0 = 2I_0 + 2I_0\cos\varphi$$

$\cos\varphi = 0$

$$\varphi = \frac{\pi}{2}$$

$$K\Delta x = \frac{\pi}{2}$$

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

$$\frac{2}{\lambda} d\cdot\frac{y}{D} = \frac{1}{2}$$

$$y = \frac{\lambda D}{4d} = \frac{5\times 10^{-7}\times 1}{4\times 10^{-3}}$$

$= 125 \times 10^{-6} = 125$

13. **Ans. (9)**

Sol. $n_2\lambda_2 = n_1\lambda_1$

$$\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2} = \frac{450}{650} = \frac{9}{13}$$

$n_2 = 9$

14. **Ans. (1)**

Sol. Since, Intensity $\propto$ width of slit (ω)

so, $I_1 = I$, $I_2 = 4I$

$$I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = I$$

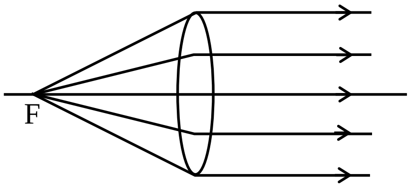
$$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = 9I$$

$$\frac{I_{max}}{I_{min}} = \frac{9I}{I} = \frac{9}{1}$$

15. **Ans. (4)**

Sol. Light emerges parallel

$\therefore$ planor wavefront



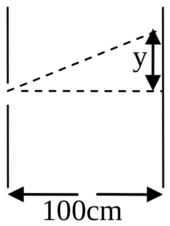
16. **Ans. (10)**

Sol. $\beta = \frac{\lambda D}{d} = \frac{5\cdot 10^{-7}\cdot 2}{3\cdot 10^{-4}} = \frac{10\cdot 10^{-3}}{3}$ m

For 3rd maxima $y_3 = 3\beta = 10 \times 10^{-3}$ m = 10 mm

17. **Ans. (275)**

Sol.



λ = 550 nm
d = 0.2 mm

$y = \frac{\lambda D}{d} = \frac{550\cdot 10^{-9}\cdot 100\cdot 10^{-2}}{0.2\cdot 10^{-3}} = 275$

18. **Ans. (2)**

Sol. (Theory)

Photoelectric effect prove particle nature of light.

19. **Ans. (8)**

Sol. $I_{max} = \left(\sqrt{I} + \sqrt{4I}\right)^2 = 9I$

$I_{min} = \left(\sqrt{4I} - \sqrt{I}\right)^2 = I$

$\therefore I_{max} - I_{min} = 8I$

20. **Ans. (6)**

Sol. $\sin\theta \quad \theta \quad \frac{2\lambda}{b}$

$= \frac{2\cdot 600\cdot 10^{-9}}{4\cdot 10^{-4}} = 3 \times 10^{-3}$ rad

Total divergence = $(3 + 3) \times 10^{-3} = 6 \times 10^{-3}$ rad

21. **Ans. (2)**

Sol. d = 1 mm, D = 1m, λ = 500 nm

$10\left(\frac{\lambda D}{d}\right) = \frac{2\lambda D}{a}$

a = $\frac{d}{5}$

$= \frac{10\cdot 10^{-4}\,m}{5}$

$= 2 \times 10^{-4}$

22. **Ans. (200)**

Sol. $I = I_0 \cos^2\left(\frac{\Delta\varphi}{2}\right)$

$\frac{I_0}{4} = \cos^2\left(\frac{\Delta\varphi}{2}\right)$

$\Delta\varphi = \frac{2\pi}{3}$

$\frac{2\pi}{\lambda}\left(\frac{yd}{D}\right) = \frac{2\pi}{3}$

$y = \frac{\lambda D}{3d} = \frac{600\cdot 10^{-9}\cdot 1}{3\cdot 10^{-3}} = 2 \times 10^{-4}$ m

23. **Ans. (4)**

Sol. $(\propto - 1)\, t = n\lambda$

$(1.5 - 1)\, t = 4 \times 500 \times 10^{-9}$ m

$t = 4000 \times 10^{-9}$ m

t = 4∝m