WAVE OPTICS

1. Visible light of wavelength 6000×10^{-8} cm falls normally on a single slit and produces a diffraction pattern. It is found that the second diffraction minimum is at 60° from the central maximum. If the first minimum is produced at θ_1, then θ_1 is close to :

(1) 20° (2) 45° (3) 30° (4) 25°

2. A polarizer - analyser set is adjusted such that the intensity of light coming out of the analyser is just 10% of the original intensity. Assuming that the polarizer - analyser set does not absorb any light, the angle by which the analyser need to be rotated further to reduce the output intensity to be zero, is :

(1) 18.4° (2) 71.6° (3) 90° (4) 45°

3. In a Young's double slit experiment, the separation between the slits is 0.15 mm. In the experiment, a source of light of wavelength 589 nm is used and the interference pattern is observed on a screen kept 1.5 m away. The separation between the successive bright fringes on the screen is :

(1) 6.9 mm (2) 5.9 mm (3) 4.9 mm (4) 3.9 mm

4. In a double slit experiment, at a certain point on the screen the path difference between the two interfering waves is $\frac{1}{8}$th of a wavelength. The ratio of the intensity of light at that point to that at the centre of a bright fringe is :

(1) 0.568 (2) 0.672 (3) 0.760 (4) 0.853

5. The aperture diameter of a telescope is 5m. The separation between the moon and the earth is 4×10^5 km. With light of wavelength of 5500 Å, the minimum separation between objects on the surface of moon, so that they are just resolved, is close to :

(1) 20 m (2) 600 m (3) 60 m (4) 200 m

6. A plane electromagnetic wave is propagating along the direction $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$, with its polarization along the direction $\hat{k}$. The correct form of the magnetic field of the wave would be (here B_0 is an appropriate constant) :

(1) $B_0 \frac{\hat{i}-\hat{j}}{\sqrt{2}} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(2) $B_0 \frac{\hat{i}+\hat{j}}{\sqrt{2}} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(3) $B_0 \hat{k} \cos\left(\omega t - k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

(4) $B_0 \frac{\hat{j}-\hat{i}}{\sqrt{2}} \cos\left(\omega t + k\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$

7. Interference fringes are observed on a screen by illuminating two thin slits 1 mm apart with a light source (λ = 632.8 nm). The distance between the screen and the slits is 100 cm. If a bright fringe is observed on a screen at a distance of 1.27 mm from the central bright fringe, then the path difference between the waves, which are reaching this point from the slits is close to :

(1) 1.27 μm (2) 2 nm
(3) 2.87 nm (4) 2.05 μm

8. In a Young's double slit experiment, 16 fringes are observed in a certain segment of the screen when light of wavelength 700 nm is used. If the wavelength of light is changed to 400 nm, the number of fringes observed in the same segment of the screen would be :

(1) 28 (2) 24 (3) 18 (4) 30

9. In a Young's double slit experiment, light of 500 nm is used to produce an interference pattern. When the distance between the slits is 0.05 mm, the angular width (in degree) of the fringes formed on the distance screen is close to :

(1) 0.07° (2) 0.17° (3) 1.7° (4) 0.57°

10. Two light waves having the same wavelength λ in vacuum are in phase initially. Then the first wave travels a path L_1 through a medium of refractive index n_1 while the second wave travels a path of length L_2 through a medium of refractive index n_2. After this the phase difference between the two waves is:

(1) $\frac{2\pi}{\lambda}(n_1L_1 - n_2L_2)$ (2) $\frac{2\pi}{\lambda}\left(\frac{L_2}{n_1} - \frac{L_1}{n_2}\right)$

(3) $\frac{2\pi}{\lambda}\left(\frac{L_1}{n_1} - \frac{L_2}{n_2}\right)$ (4) $\frac{2\pi}{\lambda}(n_2L_1 - n_1L_2)$

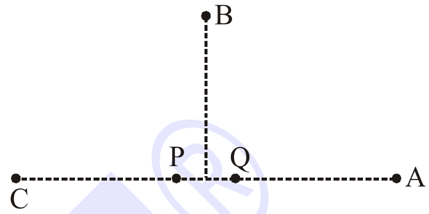
11. A beam of plane polarised light of large cross sectional area and uniform intensity of 3.3 Wm^{-2} falls normally on a polariser (cross sectional area 3×10^{-4} m^2) which rotates about its axis with an angular speed of 31.4 rad/s. The energy of light passing through the polariser per revolution, is close to :

(1) 1.0×10^{-5} J (2) 5.0×10^{-4} J
(3) 1.0×10^{-4} J (4) 1.5×10^{-4} J

12. Orange light of wavelength 6000×10^{-10} m in illuminates a single slit of width 0.6×10^{-4} m. The maximum possible number of diffraction minima produced on both sides of the central maximum is ______.

13. A beam of electrons of energy E scatters from a target having atomic spacing of 1Å. The first maximum intensity occurs at $\theta = 60°$. Then E (in eV) is ______.
(Planck constant $h = 6.64 \times 10^{-34}$ Js, $1eV = 1.6 \times 10^{-19}$ J, electron mass $m = 9.1 \times 10^{-31}$ kg)

14. In the figure below, P and Q are two equally intense coherent sources emitting radiation of wavelength 20 m. The separation between P and Q is 5 m and the phase of P is ahead of that of Q by 90°. A, B and C are three distinct points of observation, each equidistant from the midpoint of PQ. The intensities of radiation at A, B, C will be in the ratio:



(1) 0 : 1 : 2 (2) 4 : 1 : 0
(3) 0 : 1 : 4 (4) 2 : 1 : 0

15. A Young's doublc-slit experiment is performed using monochromatic light of wavelength λ. The intensity of light at a point on the screen, where the path difference is λ, is K units. The intensity of light at a point where the path difference is A $\frac{\lambda}{6}$ is given by $\frac{nK}{12}$, where n is an integer. The value of n is ________ .

SOLUTION

1. NTA Ans. (4)

Sol. $\sin\theta = \dfrac{2\lambda}{\omega}$

$\sin 60° = \dfrac{2\lambda}{\omega}$

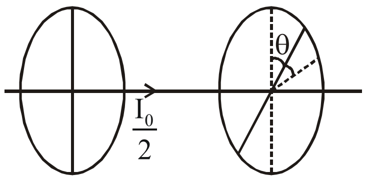
$\sin\theta_1 = \dfrac{\lambda}{\omega} = \dfrac{\sqrt{3}}{4}$

$\theta_1 = 25°$

2. NTA Ans. (1)

Sol. $\dfrac{I_0}{10} = I = \dfrac{I_0}{2} \times \cos^2\theta$

$\cos\theta = \dfrac{1}{\sqrt{5}}$



$\theta = 63.44°$

angle rotated = 90 – 63.44° = 26.56°

Closest is 1.

3. NTA Ans. (2)

Sol. Finge width, $\beta = \dfrac{D\lambda}{d} = \dfrac{1.5 \times 589 \times 10^{-9}}{0.15 \times 10^{-3}}$

$= 5.9 \times 10^{-3}$ m

= 5.9 mm

4. NTA Ans. (4)

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

$\dfrac{I}{I_0} = \cos^2\left(\dfrac{\Delta\phi}{2}\right)$

$\dfrac{I}{I_0} = \cos^2\left(\dfrac{\frac{2\pi}{\lambda} \times \frac{\lambda}{8}}{2}\right)$

$\dfrac{I}{I_0} = \cos^2\left(\dfrac{\pi}{8}\right) \quad \Rightarrow \dfrac{I}{I_0} = 0.853$

5. NTA Ans. (3)

Sol. Let distance is x then

$d\theta = \dfrac{1.22\lambda}{D}$ (D = diameter)

$\dfrac{x}{d} = \dfrac{1.22\lambda}{D}$ (d = distance between earth & moon)

$x = \dfrac{1.22 \times (5500 \times 10^{-10}) \times (4 \times 10^8)}{5} = 53.68\,\text{m}$

most appropriate is 60m.

6. NTA Ans. (1)

Sol. Direction of polarisation $= \hat{E} = \hat{k}$

Direction of propagation $= \hat{E} \times \hat{B} = \dfrac{\hat{i} + \hat{j}}{\sqrt{2}}$

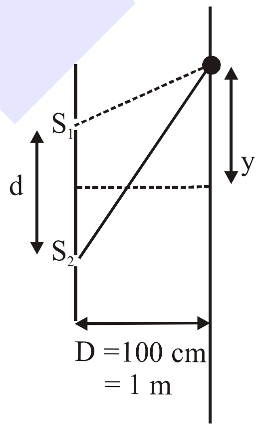
$\therefore \hat{E} \times \hat{B} = \dfrac{\hat{i} + \hat{j}}{\sqrt{2}}$

$\hat{B} = \dfrac{\hat{i} - \hat{j}}{\sqrt{2}}$

Correct answer (1)

7. Official Ans. by NTA (1)

Sol.



$y = \dfrac{nD\lambda}{d}$

$n = \dfrac{yd}{D\lambda} = \dfrac{1.27 \times 10^{-3} \times 10^{-3}}{1 \times 632.8 \times 10^{-9}} = 2$

Path difference $\Delta x = n\lambda$

= 2 × 632.8 nm

= 1265.6 nm

= 1.27 μm

8. Official Ans. by NTA (1)

Sol. Let the length of segment is "ℓ"

Let N is the no. of fringes in "ℓ"

and w is fringe width.

→ We can write

$N w = \ell$

$$N\left(\frac{\lambda D}{d}\right) = \ell$$

$$\frac{N_1\lambda_1 D}{d} = \ell$$

$$\frac{N_2\lambda_2 D}{d} = \ell$$

$N_1\lambda_1 = N_2\lambda_2$

$16 \times 700 = N_2 \times 400$

$N_2 = 28$

9. Official Ans. by NTA (4)

Sol. $$\Delta\theta_0 = \left(\frac{\lambda}{d} \times \frac{180}{\pi}\right)^0$$

$= 0.57°$

10. Official Ans. by NTA (1)

Sol. $\Delta p = n_1 L_1 - n_2 L_2$

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

11. Official Ans. by NTA (3)

Sol. Intensity, $I = 3.3\ Wm^{-2}$

Area, A = 3 × 10–4 m^2

Angular speed, ω = 31.4 rad/s

$\because \langle\cos^2\theta\rangle = \frac{1}{2}$, in one time period

$\therefore$ Average energy $= I_0 A \times \frac{1}{2}$

$$= \frac{(3.3)(3\times10^{-4})}{2}$$

$\simeq 5\times10^{-4}\,J$

12. Official Ans. by NTA (200)

Official Ans. by ALLEN (198)

Sol. Condition for minimum,

$d\sin\theta = n\lambda$

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

$$n < \frac{d}{\lambda} = \frac{6\times10^{-5}}{6\times10^{-7}} = 100$$

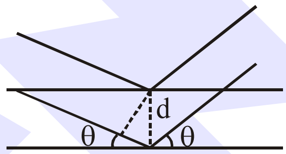
$\therefore$ Total number of minima on one side = 99

Total number of minima = 198

Correct Answer is 198

13. Official Ans. by NTA (50.00)

Sol.



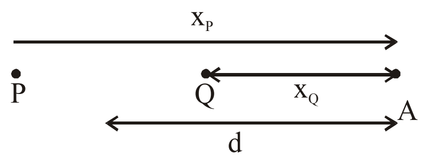
$$2d\sin\theta = \lambda = \frac{h}{\sqrt{2mE}}$$

$$2\times10^{-10}\times\frac{\sqrt{3}}{2} = \frac{6.6\times10^{-34}}{\sqrt{2mE}}$$

$$E = \frac{1}{2}\times\frac{6.64^2\times10^{-48}}{9.1\times10^{-31}\times3\times1.6\times10^{-19}} = 50.47$$

14. Official Ans. by NTA (4)

Sol. For (A)



$x_P - x_Q = (d + 2.5) - (d - 2.5)$

$= 5m$

$\Delta\phi$ due to path difference $= \frac{2\pi}{\lambda}(\Delta x) = \frac{2\pi}{20}(5)$

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

At A, Q is ahead of P by path, as wave emitted by Q reaches before wave emitted by P.

Total phase difference at A

$= \frac{\pi}{2} - \frac{\pi}{2}$ (due to P being ahead of Q by 90°)

$= 0$

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

$= I + I + 2\sqrt{I}\sqrt{I}\cos(0)$

$= 4I$

For C

$x_Q - x_P = 5$ m

$\Delta\phi$ due to path difference $= \frac{2\pi}{\lambda}(\Delta x)$

$= \frac{2\pi}{20}(5) = \frac{\pi}{2}$

Total phase difference at C $= \frac{\pi}{2} + \frac{\pi}{2} = \pi$

$I_{net} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos(\Delta\phi)$

$= I + I + 2\sqrt{I}\sqrt{I}\cos(\pi) = 0$

For B

$x_P - x_Q = 0$,

$\Delta\phi = \frac{\pi}{2}$ (Due to P being ahead of Q by 90°)

$I_B = I + I + 2\sqrt{I}\sqrt{I}\cos\frac{\pi}{2} = 2I$

$I_A : I_B : I_C = 4I : 2I : 0$

$= 2 : 1 : 0$

$\therefore$ correct option is (4)

15. Official Ans. by NTA (9.00)

Sol. $I_{max} = k$

$I_1 = I_2 = K/4$

$\Delta x = \lambda/6 \Rightarrow \Delta\phi = \pi/3$

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

$I = \frac{K}{4} + \frac{K}{4} + 2\times\frac{K}{4}\frac{1}{2}$

$= \frac{K}{2} + \frac{K}{4} = \frac{3K}{4} = \frac{9K}{12}$

n = 9