CBSE Test Paper-03

Class - 12 Physics (Wave Optics)

1. Two sources of light are coherent if they have
   a. different frequency and with a constant phase relationship
   b. same frequency and change phase randomly
   c. different frequency and random phases
   d. same frequency and with a constant phase relationship
2. For what distance is ray optics a good approximation when the aperture is 3 mm wide and the wavelength is 500 nm?
   a. 15 m
   b. 16 m
   c. 17 m
   d. 18 m
3. In the single slit diffraction the screen is at a large distance compared to slit width and θ is the angle by which light has bent.If the size of slit is a (given that n is not zero). The condition for maxima is given by
   a. $(n + \frac{1}{2})\frac{\lambda}{a}$
   b. $(n + \frac{1}{2})\frac{2\lambda}{a}$
   c. $(n + \frac{1}{2})\frac{\lambda}{2}$
   d. $(n + \frac{1}{3})\frac{\lambda}{a}$
4. Light traveling in air is incident on the surface of a block of plastic at an angle of 62.7° to the normal and is bent so that it makes a 48.1° angle with the normal in the plastic. Find the speed of light in the plastic
   a. $2.61 \times 10^{8} ms^{-1}$
   b. $2.71 \times 10^{8} ms^{-1}$
   c. $2.51 \times 10^{8} ms^{-1}$
   d. $2.81 \times 10^{8} ms^{-1}$
5. In a young's double slit experiment, the central bright fringe can be identified by
   a. No fixed pattern of colours is followed after white fringe
   b. Closest fringe near the centre is red
   c. Farthest fringe from centre is yellow

d. Using white light instead of monochromatic light

6. If I_0 is the intensity after the first Polaroid the intensity emerging from the second Polaroid kept at an angle θ to the first is given by
   a. $2I_0 \cos^2\theta$
   b. $I_0 \cos^2\theta$
   c. $I_0 \cos\theta$
   d. $I_0 \cos^2\theta/2$
7. If we have two coherent sources S_1 and S_2 vibrating in phase, then for an arbitrary point P destructive interference is observed whenever the path difference is
   a. $(n+\frac{1}{2})\lambda$ where n = 0,1,2,3 .....
   b. $(n+\frac{1}{2})\lambda$ where n = 0,1,2,3, ...
   c. $(n+\frac{1}{3})\lambda$ where n = 0,1,2,3, ...
   d. $n\lambda$ where n = 0,1,2,3, ...
8. Assume that light of wavelength 6000 $\overset{0}{A}$ is coming from a star. What is the limit of resolution of a telescope whose objective has a diameter of 100 inch?
   a. 2.9×10^{-7}rad
   b. 2.7×10^{-7}rad
   c. 2.6×10^{-7}rad
   d. 2.8×10^{-7}rad

9. In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band.

10. A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Find the width of the slit.

11. Unpolarised light is passed through a polaroid P_1. When this polarised beam passes through another polaroid P_2 and if the pass axis of P_2 makes an angle θ with the pass axis of P_1, then write the expression for the polarised beam passing through P_2. Draw a plot showing the variation of intensity, when θ varies from 0 to 2π.

12. How is resolving power of a microscope affected when

i. wavelength of illuminating radiations is decreased.
ii. the diameter of objective lens is decreased? Justify.

13. In a Young's double slit experiment, the two slits are kept 2 mm apart and the screen is positioned 140 cm away from the plane of the slits. The slits are illuminated with light of wavelength 600 nm. Find the distance of the third bright fringe, from the central maximum, in the interference pattern obtained on the screen.If the wavelength of the incident light were changed to 480 nm, find out the shift in the position of third bright fringe from the central maximum.

14. Define the term wavefront. State Huygen's principle. Consider a plane wavefront incident on a thin convex lens. Draw a proper diagram to show how the incident wavefront traverses through the lens and after refraction focusses on the focal point of the lens, giving the shape of the emergent wavefront.

15. i. Describe briefly how a diffraction pattern is obtained on a screen due to a single narrow slit illuminated by a monochromatic source of light. Hence, obtain the conditions for the angular width of secondary maxima and secondary minima.
    ii. Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture $2 \times 10^{-6} m$. The distance between the slit and the screen is 1.5m. Calculate the separation between the positions of first maxima of the diffraction pattern obtained in the two cases.

CBSE Test Paper-03

Class - 12 Physics (Wave Optics)

Answers

1. d. same frequency and with a constant phase relationship

   Explanation: If the two sources are coherent, then the phase difference ϕ at any point will not change with time.

2. d. 18 m

   Explanation: $Z_F = \frac{d^2}{\lambda}$
   $= \frac{90}{5}$
   = 18m

3. a. $\left(n + \frac{1}{2}\right)\frac{\lambda}{a}$

   Explanation: Experimental observation indicates that the intensity has a central maximum at θ = 0 and other secondary maxima at θ = (n+1/2) λ/a, and has minima (zero intensity) at θ =nλ/a, n = ±1, ±2, ±3, ...

4. c. $2.51 \times 10^8 \mathrm{ms}^{-1}$

   Explanation: use $\mu = \frac{\sin i}{\sin r}$ $\mu = \frac{c}{v}$

   $\mu = \frac{\sin(62.5)}{\sin(48.1)}$

   $\mu = 1.19$

   1.19 = 3 $\times$ 10^8

   v = 2.5 $\times$ 10^8

5. d. Using white light instead of monochromatic light

   Explanation: All the component colours of white light will meet in phase at centre to give white colour.

6. b. $\mathrm{I}_0 \cos^2\theta$

   Explanation: As per malus law when a beam of completely plane polarised light i passed through the analyser the intensity of transmitted light varies directly as the square of cosine of angle between the plane of polariser and analyser.

7. a. $(n + \frac{1}{2})\lambda$

   where n = 0,1,2,3 .....

Explanation: If the point P is such that the path difference, $S_2P \sim S_1P = (n + 1/2)\lambda$ (n = 0, 1, 2, 3, ...) we will have destructive interference and the resultant intensity will be zero.

8. a. 2.9×10^{-7}rad

Explanation: The limit of resolution is $d\theta = \frac{1.22\lambda}{d}$

$d\theta = \frac{1.22 \times 6 \times 10^{-7}}{2.5}$

2.9×10^{-7} radian

9. Width of central diffraction band $= 2D\frac{\lambda}{d}$, so on doubling the width of the slit, the size of the central diffraction band reduces to half value. But the light amplitude becomes double, which increases the intensity four fold.

10. Given, D = 1 m, n = 1

$x = 2.5$ mm $= 2.5 \times 10^{-3}$ m

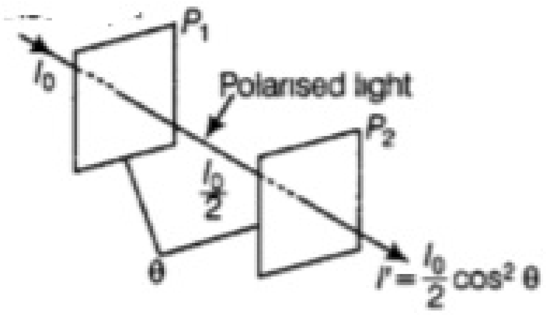
$\lambda = 500$nm $= 500 \times 10^{-9}$m $= 5 \times 10^{-7}$ m

Using formula, $x = n\frac{\lambda D}{d}$

$\Rightarrow d = \frac{n\lambda D}{x}$

or $d = \frac{1 \times 5 \times 10^{-7} \times 1}{2.5 \times 10^{-3}} = 2 \times 10^{-4} m$ = 0.2 mm

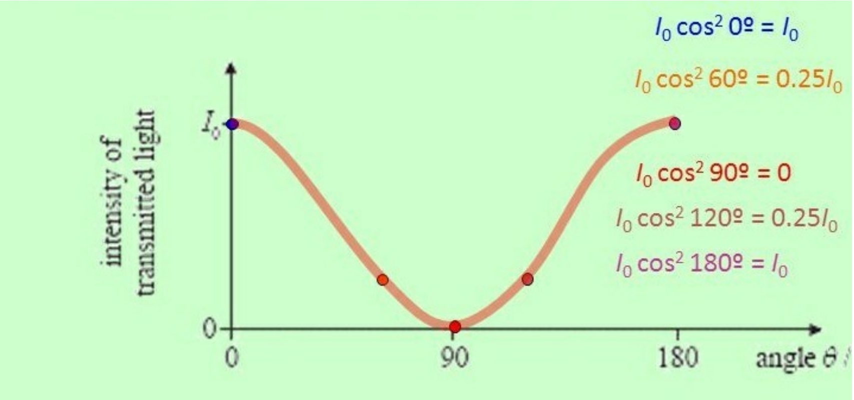
11. The figure when unpolarised light beam is passed through polaroid is shown below.



By the law of Malus,

intensity received after passing through the Polaroid, $P_2 = I' = \frac{I_0}{2}\cos^2\theta$.

Variation of intensity with rotation angle θ from 0 to π i.e. from 0° to 180°of the Polaroid is shown below.



12. For a microscope,

    Resolving power $= \frac{2\mu \sin\theta}{\lambda}$

    i. When λ is decreased, resolving power increases.
    ii. When diameter of objective lens is decreased, θ decreases, $\sin\theta$ decreases. Hence resolving power of microscope also decreases.

13. Given, d = 2 mm $= 2 \times 10^{-3} m$

    D = 140 cm = 1.40 m

    λ = 600 nm $= 600 \times 10^{-9} = 6 \times 10^{-7}$

    Position of bright fringes is given by

    $x_n = n\lambda \frac{D}{d}$

    Distance of the third bright fringe is

    $x_3 = 3\lambda \frac{D}{d}$

    $\Rightarrow x_3 = 3 \times 6 \times 10^{-7} \times \frac{1.40}{2 \times 10^{-3}}$

    $= 12.6 \times 10^{-4} = 1.26 \times 10^{-3} m$

    = 1.26 mm

    For λ = 480 nm $= 480 \times 10^{-9} = 4.8 \times 10^{-7} m$

    Distance of the third bright fringe is

    $x_3 = 3\lambda \frac{D}{d}$

    $= 3 \times 4.8 \times 10^{-7} \times \frac{1.40}{2 \times 10^{-3}}$

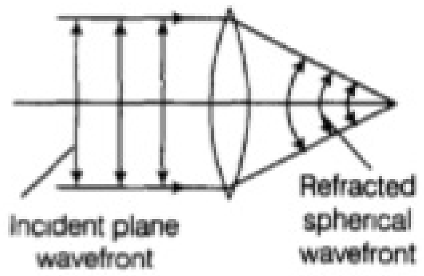
    $= 10.08 \times 10^{-4} = 1.008 \times 10^{-3} m$

    $= 1.01 \times 10^{-3} m$ = 1.01 mm

    $\therefore$ Shift in the position of third bright fringe

    = 1.26 - 1.01 = 0.25 mm.

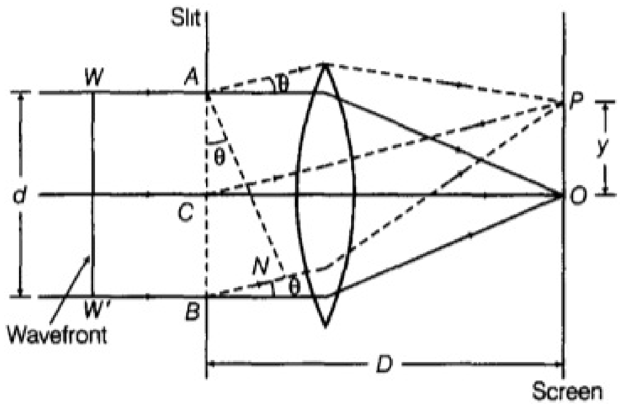
14. When light is emitted from a source, then the particles present around it begins to vibrate. The locus of all such particles which are vibrating in the same phase is termed as a wavefront.



Huygens' principle:*Every point on a wave-front may be considered a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wave-front is the tangential surface to all of these secondary wavelets.*

Now when a plane wavefront (parallel rays) is incident on a thin convex lens, the emergent rays are focused on the focal point of the lens. Thus the shape of emerging wavefront is spherical.

15. i. A single narrow slit is illuminated by a monochromatic source of light. The diffraction pattern is obtained on the screen placed in front of the slits. There is a central bright region called as central maximum. All the waves reaching this region are in phase hence the intensity is maximum. On both side of central maximum, there are alternate dark and bright regions, the intensity becoming weaker away from the center. The intensity at any point P on the screen depends on the path difference between the waves arising from different parts of the wave-front at the slit.
Diffraction of light at a single slit A parallel beam of light with a plane wavefront WW' is made to fall on a single slit AB. As width of the slit AB = dis of the order of wavelength of light, therefore, diffraction occurs on passing through the slit.



The wavelets from the single wavefront reach the centre O on the screen in same phase and hence, interfere constructively to give central maximum (bright fringe). The diffraction pattern obtained on the screen consists of a central bright band having alternate dark and weak bright band of decreasing intensity on both sides. Consider a point P on the screen at which wavelets travelling in a direction making an angle θ with CO are brought to focus by the lens. The wavelets from points A and B will have a path difference equal to BN.
From the right angled ΔANB, we have BN = AB sinθ or BN = d sinθ.
To establish the condition for secondary minima, the slit is divided into 2,4,6... equal parts such that corresponding wavelets from parts such that corresponding wavelets from successive regions interfere with path difference $\lambda/2$
or for nth secondary minlmum.the slit can be divided into 2n equal parts. Hence, for nth secondary minimum, path difference= $= d\sin\theta_n = n\lambda$.
or $\sin\theta_n = \frac{n\lambda}{d}(n = 1, 2, 3, \ldots)$
To establish the condition for secondary maxima, the slit is divided into 3,5,7... equal parts such that corresponding wavelets from alternate regions interfere with path difference of A./2 or for nth secondary maximum, the slit can be divided into (2n+ 1)equal parts.
Hence, for nth secondary maximum
$d\sin\theta_n = (2n+1)\frac{\lambda}{2}$ (n = 1, 2, 3,...)

ii. For $\lambda_1 = 590\text{mm}$
Location of 1 maxima $y_1 = (2n+1)\frac{D\lambda_1}{2d}$
If $n = 1 \Rightarrow y_1 = \frac{3D\lambda_1}{2d}$
For $\lambda_2 = 596\text{nm}$
Location of III maxima
$y_2 = (2n+1)\frac{D\lambda_2}{2d}$, if n = 1
$\Rightarrow y_2 = \frac{3D\lambda_2}{2d}$
$\therefore$ Path difference $= y_2 - y_1 = \frac{3D}{2d}(\lambda_2 - \lambda_1)$
$= \frac{3\times1.5}{2\times2\times10^{-6}}(596 - 590)\times10^{-9}$
$= 6.75\times10^{-3}\text{m}$