CBSE Test Paper-02

Class - 12 Physics (Wave Optics)

1. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment. Find the ratio of fringe widths in the two cases provided the geometry of set up in two cases is same.
   a. 1.47 mm
   b. 1.25 mm
   c. 1.37 mm
   d. 1.27 mm
2. If D and f are the objective diameter, and focal length, Minimum separation, d_{min}, in the object plane of a compound microscope that can be resolved is given by
   a. $\frac{1.52 f\lambda}{D}$
   b. $\frac{1.22 f\lambda}{D}$
   c. $\frac{1.32 f\lambda}{D}$
   d. $\frac{1.62 f\lambda}{D}$
3. Estimate the distance for which ray optics is good approximation for an aperture of 4 mm and wavelength 400 nm:
   a. 40 m
   b. 55 m
   c. 50 m
   d. 45 m
4. Shape of the wave front of light diverging from a point source is
   a. conical
   b. spherical
   c. hyperboloid
   d. plane
5. In the single slit diffraction, every point on the slit acts-
   a. to increase the intensity
   b. to reduce the intensity
   c. as a secondary source
   d. inclined

6. Differentiate between a ray and a wavefront.
7. How does the fringe width in Young's double slit experiment, change when the distance of separation between the slits and screen is doubled?
8. Define a wavefront.
9. How will the intensity of maxima and minima, in the Young's double experiment change, if one of the two slits is covered by a transparent paper which transmits only half of light intensity?
10. Is the speed of light in glass independent of the colour of light?
11.
    i. Write the conditions under which light sources can be said to be coherent.
    ii. Why is it necessary to have coherent sources in order to produce an interference pattern?
12. Find the maximum intensity in case of interference of n identical waves each of intensity I_0 if the interference is:(i) coherent (ii) incoherent
13. In deriving the single slit diffraction pattern, it was stated that the intensity is zero at angles of $n\lambda/a$. Justify this by suitably dividing the slit to bring out the cancellation.
14. In Young's double slit experiment, monochromatic light of wavelength 630 nm illuminates the pair of slits and produces an interference pattern in which two consecutive bright fringes are separated by 8.1 mm. Another source of monochromatic light produces the interference pattern in which the two consecutive bright fringes are separated by 7.2 mm. Find the wavelength of light from the second source. What is the effect on the interference fringes, when the monochromatic source is replaced by a source of white light?
15. A double slit is illuminated by light of wavelength $6000\overset{o}{A}$. The slits are 0.1 cm apart and the screen is placed 1 m away.
    Calculate:
    i. angular position of 10^{th} maximum in radian
    ii. separation of two adjacent minima.

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Answers

1. b. 1.25

   Explanation: ratio of fringe widths

   $\frac{w_1}{w_2} = \frac{\lambda_1}{\lambda_2} = \frac{650}{520} = 1.25$

2. b. $\frac{1.22 f\lambda}{D}$

   Explanation: Rayleigh criterion:

   $Sin\theta = \frac{1.22\lambda}{D}$

   approximately

   i.e,$Sin\theta = \frac{d_{min}}{f}$

   Therefore,$d_{min} = \frac{1.22\lambda f}{D}$

3. a. 40 m

   Explanation: use

   $z_f = \frac{d^2}{\lambda} = \frac{160}{4}$

   = 40 m

4. b. spherical

   Explanation: When light diverges from a point source it moves in the form of diverging spherical wavefront.

5. c. as a secondary source

   Explanation: Every part of the wavefront at the slit acts as secondary sources because the incoming wavefront is parallel to the plane of the slit, these sources are in phase.

6. **A wavefront** is a surface through the points, having the same phase of disturbances. While a ray of light is a path along which light travels. It is always perpendicular to the wavefront and in outward direction from the source.

7. Fringe width, $\beta = \frac{D\lambda}{d}$ to increase the intensity

   For given λ.and d, $\beta \propto D$ (D is the distance of separation between source and the screen)

Fringe width becomes double to that of original one($\beta' = 2\beta$), when D becomes doubled.

8. When light is emitted from a source, then the particles present around the source in all directions begins to vibrate. The locus of all such particles which are vibrating in the same phase is termed as wavefront. Example - Wavefront for a point source of light is spherical in nature.

9. if one of the slit transmits only half of the light intensity, then the intensity in the interference pattern will vary fro maximum to minimum to increase the intensityto increase the intensitybut not become zero. therefore contrast will be reduced & the interference pattern will become less sharp. So we can say that the to increase the intensityintensity of maxima decreases and the intensity of minima increases.

10. No, the speed of light is not independent of the colour (wavelength) of the light. The violet colour travels slower than the red light in a glass prism. The refractive index and hence the speed of light in a medium depend on the wavelength.

11. i. Coherent sources: Two sources are said to be coherent in nature if they emit light of same frequency and of a stable path difference. The essential condition, which must be satisfied for the sources to be coherent are:
    a. The two light waves should be of same wavelength.
    b. The two sources must be very close to each other.
    c. The two light waves should either be with same phase or should have a constant phase difference.
    d. The two sources should preferably have the same amplitude.
    e. The sources should emit light waves continuously.

    ii. Two sources of emitting light waves of same frequency or wavelength and of a stable phase difference are required to see interference pattern, and we can obtain such nature of light waves from coherent source.
    So, we require coherent sources to produce the interference of light.

12. i. In case of two coherent sources,
    $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$
    I_R will be maximum when
    $cos\phi = 1$ (maximum)

$\therefore (I_{\max})^{\infty} = I_1 + I_2 + 2\sqrt{I_1 I_2}$
$= \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$
So for n identical waves each of intensity I_0.
$(I_{\max})_{\infty} = \left(\sqrt{I_0} + \sqrt{I_0} \ldots \ldots\right)^2$
$= \left(n\sqrt{I_0}\right)^2 = n^2 I_0$

ii. In case of incoherent source,
$I_R = I_1 + I_2 + \ldots\ldots$
$= I_0 + I_0 + \ldots. = nI_0$

13. Let the slit width a be dividing into n equal parts of width a' so that
$a' = \frac{a}{n}$
or a = na'
Then angle $\theta = \frac{n\lambda}{a} = \frac{n\lambda}{na'}$
or $\theta = \frac{\lambda}{a'}$
At this angle each slit part will make first diffraction minimum. Hence, resultant intensity to all slits will be zero in that direction.

14. Here, we are given young's double slit experiment.
Wavelength of monochromatic light, $\lambda_1 = 630\text{nm} = 630 \times 10^{-9}\text{m}$
Fringe width, $\beta_1 = 8.1 \times 10^{-3}\text{m}$
Fringe width, $\beta_2 = 7.2 \times 10^{-3}\text{m}$
Let d be the slit width and D the distance between slit and screen, then we have

$\beta = D\lambda/d$
For given Young's double slit experiment, D and d are constants
$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$
Wavelength of light from the second source
$\Rightarrow \lambda_2 = \frac{\beta_2}{\beta_1} \times \lambda_1 = \frac{7.2 \times 10^{-3}}{8.1 \times 10^{-3}} \times 630 \times 10^{-9}$
$= \frac{8}{9} \times 630 \times 10^{-9} = 560 \times 10^{-9}\text{m}$
$\lambda_2 = 560\text{nm}$
The coloured fringe pattern would be obtained if monochromatic light is replaced by white light.
If the monochromatic source is replaced by white light, then we will not be able to see

the interference fringes because white light is not a coherent source of light. The condition for interference to take place is, the availability of coherent sources of light.

15. i. Angular position of nth maximum

$\theta_n = \frac{x_n}{D} = \frac{nD\lambda}{dD} = \frac{n\lambda}{d} \because \chi_n = \frac{nD\lambda}{d}$

Angular position of 10 th maximum,

$\theta_{10} = \frac{10 \times 6000 \times 10^{-10}}{0.1 \times 10^{-2}}$

$= 6 \times 10^{-3}$ radian

ii. Separation between two adjacent minima

i.e. fringe width, $\omega = \frac{D\lambda}{d}$

$\Rightarrow \omega = \frac{1 \times 6000 \times 10^{-10}}{10^{-3}}$

$= 6 \times 10^{-4} m$ = 0.6 mm

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