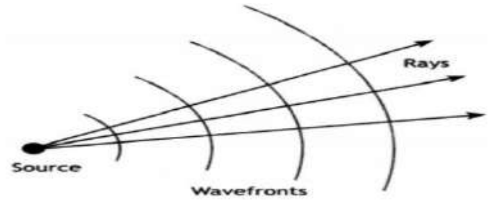
Assignment 3-ANSWERS

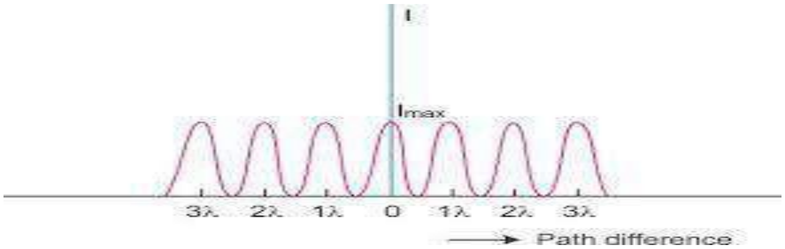
1 MARKS

1.

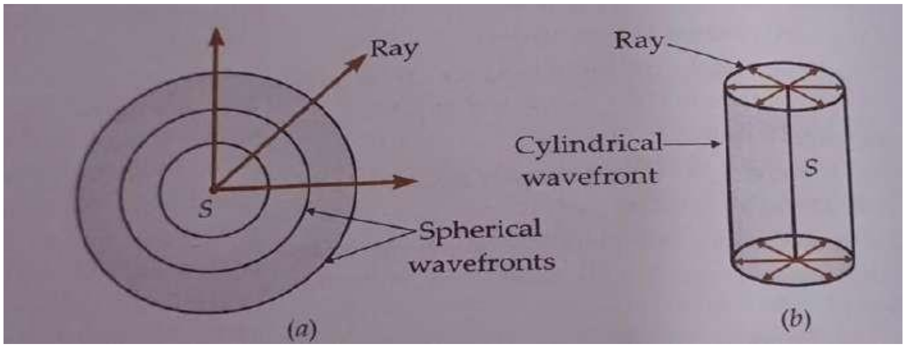


2. Both reflection and refractions occur due to interaction of light with the atoms at the surface of separation. These atoms may be regarded as the oscillators .Light incident on such atoms forces them to vibrate with the frequency of light, so both the reflected and refracted lights have same frequency as the frequency of incident light.

3.



4.



5. No, it does not imply a reduction in the energy carried by the light wave.. The energy carried by the wave depends on the amplitude of the wave but not on the speed of the wave propagation.

6. It is determined by the number of photons incident per unit area around that point.

7. Intensity of maxima decreases and that of minima increases

MCQ ANSWERS

8. C

9. C

10. B
11. C
12. B
13. B
14. B
15. B
16. B
17. B

2 MARKS

18. Diffraction of light is highly pronounced If the size of the obstacle is comparable to the wavelength of the light used

    The linear width of central maxima β_0 =2D λ /a

    (i) if slit with is half the width of the central maximum is doubled its area becomes 4 times and hence intensity becomes 1/4th of the initial intensity.

    (ii) if visible light of longer wavelength is used the width of Central maximum increases and hence intensity decreases.

19. (i) When the screen is moved away from the slits , the distance D increases . Fringe width increases but angular separation remains unchanged .

    (ii) The interference pattern becomes less and less sharp . When the source slit becomes so wide that the condition is not satisfied , the interference pattern disappears . But the angular width remains unchanged.

20. Following changes are observed

    (i) In each diffraction order, the diffracted image of the slit gets dispersed into component colours of white light . As fringe with higher wavelength is wider than the violet fringe with smaller wavelength .

    (ii) In higher order spectra , the dispersion is more and it causes overlapping of different colours .

21. Intensity at any point of an interference pattern is given by $I=2\,I_0\,(1+\cos\phi)$

    Where I_0 is the intensity of either wave.

    Therefore, $I_P / I_Q = [1+\cos\phi_P]/[1+\cos\phi_Q] = [1+\cos\pi/3\,]/\,[1+\cos\pi/2]$

    $=[1+1/2]\,/\,[1+0] = 3/2 = 3:2$

22. The directions of different minima in diffraction pattern is given by

$\theta_n = X_n / D$

Also $\theta_n = n\,\lambda / d$

Hence $X_n = n\,\lambda\, D / d$

Width of secondary maxima = $X_n - X_{n-1} = \lambda\, D / d$

Width of central maxima $\beta_0 = 2X_1 = 2\beta$

Thus the central maxima is twice as wide as any seconadary maximum.

Since the width of the seconadary maximum is inversly proportional to the slit width hence as the slit width increases the seconadary maximum becomes narrower.

3 MARKS

23. λ=600nm , D= 0.8m

The distance of second order maximum from the centre of the screen = 15mm = $15X10^{-3}$m

$$a = \frac{n\lambda}{\sin\theta} = \frac{n\lambda D}{x}$$

$$a = \frac{(2x600x10^{-9}x0.9)}{15x10^{-3}} = 6.4x10^{-5}m$$

24.

(a) y3 = n. Dλ/d

= 3 x 1.2m x 6500 x 10-10m / 2 x 10-3m

= 0.12cm

(b) Let nth maxima of light with wavelength 6500 Å coincides with that of mth maxima of 5200Å.

m x 6500Ao x D/d = n x 5200A° x D/d

m/n = 5200/6500 = 4/5

Least distance = y4= 4.D (6500Ao)/d

= 4 x 6500 x 10-10 x 1.2/ 2 x 10-3m

= 0.16cm.

25. (a)

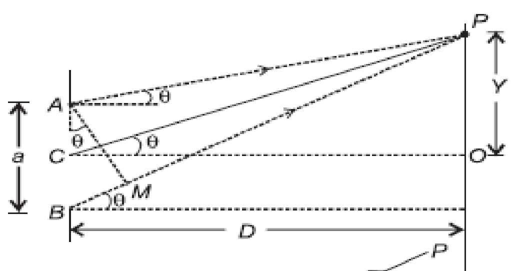
Interference	Diffraction
It is due to superposition of two Waves coming from coherent sources.	It is due to superposition of secondary wavelets originating from different parts of same wavefront.
Width of interference bands is equal	Width of diffraction bands is unequal
Intensity of all fringes is same	Central maxima is bright but intensity decreases with increase in order of maximum.

(b) given λ= 500 nm & a= 0.2 mm,

we have $\omega = 2\lambda/a$, ω= .005 rad

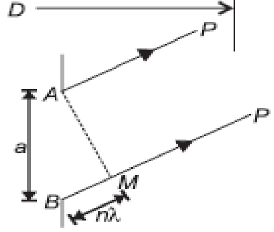
5 MARKS

26.



The wavelength of incident light should be comparable to the aperture of the slit/ opening or size of the obstacle.

We consider a single slit AB on which a plane wavefront is incident. The slit width is so small in comparison to the distance of the screen from the slit that the rays coming out of it, can be considered almost parallel.

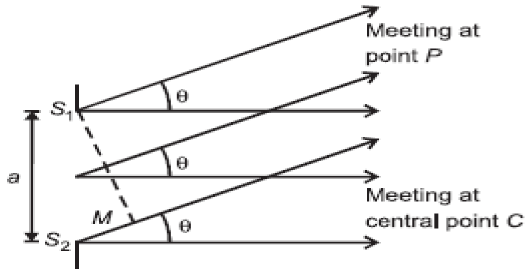


According to the Huygen's principle, each point on the slit will behave like a fresh source of secondary wavelets. The waves from the different parts of the same wavefront reach a point on the screen and superpose to form a diffraction pattern.

For n^{th} secondary minimum, $a \sin \theta_n = n\lambda$, where $n = 1, 2, 3$ ....

$a \sin \theta_n$ is the path difference between the waves reaching a point on the screen.

We treat each point on the wavefront at the slit, as secondary sources [Using Huygen's principle].



[We are taking parallel beam of light because angles are very small]

As the incoming wavefront is parallel to the plane of the slit, these sources are in phase [using Huygen's principle]. The path difference between the waves coming out from the two edges of the slits is $S_2P - S_1P = S_2M$.

$\therefore \quad S_2M = a \sin\theta \approx a\theta$

For any two point sources, S_1 and S_2 in the plane of the slit having a separation y, the path difference would be

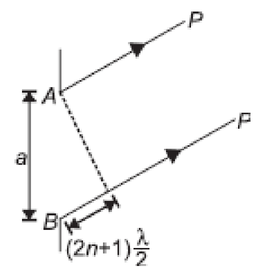
$$S_2P - S_1P \approx y\theta \quad \text{i.e. } \Delta P \approx y\theta$$

As the initial phase difference is zero, the phase difference between the waves is introduced only due to this path difference.

For the central point on the screen, $\theta = 0 \Rightarrow \Delta P = 0$

i.e. $\quad \Delta\phi = 0$

All the parts of the slit contribute in phase. So, the maximum intensity is obtained at C.



We can imagine as if the slit is divided into $2n$ parts.

The separation between two adjacent parts of the slit is $a/2n$. For a separation of a, the path difference is $n\lambda$. So, for a separation of $a/2n$, the path difference between the waves will be $\Delta P = \frac{n\lambda}{a} \times \frac{a}{2n} = \frac{\lambda}{2}$

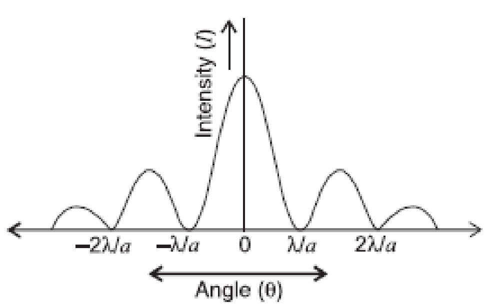
i.e. the phase difference, $\Delta\phi = \pi$ will be there and the waves will superpose destructively. We find the fringes of minimum intensity on the screen.

For n^{th} maximum, $a \sin\theta'_n = (2n + 1)\,\frac{\lambda}{2}$, where $n = 1, 2, 3, \ldots\ldots\ldots$

We can imagine as if the slit is divided into odd number of parts (e.g. 3, 5, 7, etc.).

In this case, only $(2n+1)^{th}$ part of the slit illuminates the screen. This is the reason why the intensity of secondary maxima falls rapidly.

The pattern given below shows the variation of intensity (I) with angle (θ).



27.

(a) According to the question,

$$X_n = \frac{1}{4}.\beta$$

$$X_n = \frac{1}{4}\ \frac{\lambda D}{d}$$

$\therefore$ Path difference $= \frac{\lambda}{4}$

Phase difference,

$$\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{4} = \frac{2\pi}{2}$$

$$\therefore \quad I = 4I_0 \cos^2 \frac{\phi}{2} = 4I_0 \cos^2 \frac{\pi}{4} = 2I_0$$

(b) If I_1 and I_2 be the intensities of waves from the sources, then the net intensity will be $I_{\text{net}} = I_1 + I_2$

(c) $\theta_{10} = 10\frac{\lambda}{d}$ $\quad \left[\because \theta_n = \frac{n\lambda}{d}\right]$

θ = angular fringe width of 10^{th} maxima

$\theta = \frac{\lambda}{d}$ (independent of n)

(d)
$$x_5^{max} - x_3^{min} = \frac{5\lambda D}{d}-(2\times3-1)\frac{\lambda}{2}\frac{D}{d}$$
$$= [10 - 5]\ \frac{\lambda d}{2d}$$
$$= 2.5\ \frac{\lambda D}{d}$$

(e) (i) $\theta = 5\pi$

$$\therefore \quad \text{I} = 4I_0\cos^2\frac{5\pi}{2} = 0$$

Therefore, dark fringe will be formed.

(ii) $\theta = 2\pi$

$$\therefore \quad I = 4I_0\cos^2 \frac{2\pi}{2} = 4I_0$$

Therefore, the colour of fringe will be bright red.