Chapter Ten

WAVE OPTICS

MCQ I

10.1 Consider a light beam incident from air to a glass slab at Brewster's angle as shown in Fig. 10.1.

A polaroid is placed in the path of the emergent ray at point P and rotated about an axis passing through the centre and perpendicular to the plane of the polaroid.

(a) For a particular orientation there shall be darkness as observed through the polaoid.

(b) The intensity of light as seen through the polaroid shall be independent of the rotation.

(c) The intensity of light as seen through the Polaroid shall go through a minimum but not zero for two orientations of the polaroid.

(d) The intensity of light as seen through the polaroid shall go through a minimum for four orientations of the polaroid.

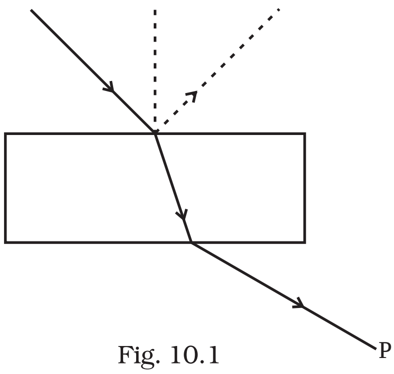

Fig. 10.1

10.2 Consider sunlight incident on a slit of width 10^4 A. The image seen through the slit shall

(a) be a fine sharp slit white in colour at the center.
(b) a bright slit white at the center diffusing to zero intensities at the edges.
(c) a bright slit white at the center diffusing to regions of different colours.
(d) only be a diffused slit white in colour.

10.3 Consider a ray of light incident from air onto a slab of glass (refractive index n) of width d, at an angle θ. The phase difference between the ray reflected by the top surface of the glass and the bottom surface is

(a) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+\pi$

(b) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}$

(c) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+\frac{\pi}{2}$

(d) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}\sin^2\theta\right)^{1/2}+2\pi$.

10.4 In a Young's double slit experiment, the source is white light. One of the holes is covered by a red filter and another by a blue filter. In this case

(a) there shall be alternate interference patterns of red and blue.
(b) there shall be an interference pattern for red distinct from that for blue.
(c) there shall be no interference fringes.
(d) there shall be an interference pattern for red mixing with one for blue.

10.5 Figure 10.2 shows a standard two slit arrangement with slits S_1, S_2. P_1, P_2 are the two minima points on either side of P (Fig. 10.2).

At P_2 on the screen, there is a hole and behind P_2 is a second 2- slit arrangement with slits S_3, S_4 and a second screen behind them.

(a) There would be no interference pattern on the second screen but it would be lighted.
(b) The second screen would be totally dark.

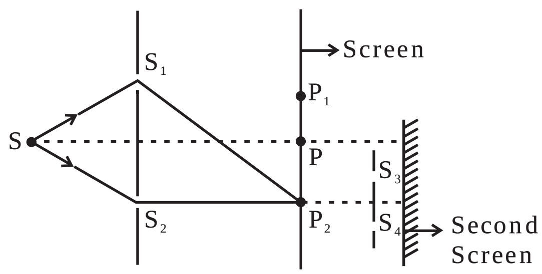

Fig. 10.2

(c) There would be a single bright point on the second screen.
(d) There would be a regular two slit pattern on the second screen.

MCQ II

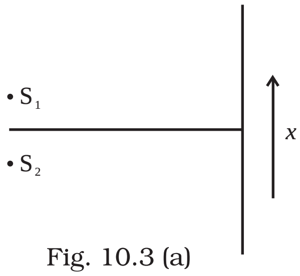

Fig. 10.3 (a)

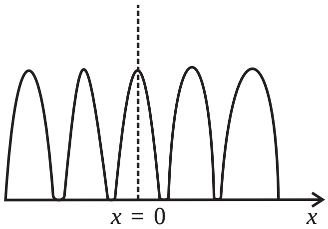

Fig. 10.3 (b)

10.6 Two source S_1 and S_2 of intensity I_1 and I_2 are placed in front of a screen [Fig. 10.3 (a)]. The patteren of intensity distribution seen in the central portion is given by Fig. 10.3 (b).

In this case which of the following statements are true.

(a) S_1 and S_2 have the same intensities.
(b) S_1 and S_2 have a constant phase difference.
(c) S_1 and S_2 have the same phase.
(d) S_1 and S_2 have the same wavelength.

10.7 Consider sunlight incident on a pinhole of width 10^3A. The image of the pinhole seen on a screen shall be

(a) a sharp white ring.
(b) different from a geometrical image.
(c) a diffused central spot, white in colour.
(d) diffused coloured region around a sharp central white spot.

10.8 Consider the diffraction patern for a small pinhole. As the size of the hole is increased

(a) the size decreases.
(b) the intensity increases.
(c) the size increases.
(d) the intensity decreases.

10.9 For light diverging from a point source

(a) the wavefront is spherical.
(b) the intensity decreases in proportion to the distance squared.
(c) the wavefront is parabolic.
(d) the intensity at the wavefront does not depend on the distance.

VSA

10.10 Is Huygen's principle valid for longitudunal sound waves?

10.11 Consider a point at the focal point of a convergent lens. Another convergent lens of short focal length is placed on the other side. What is the nature of the wavefronts emerging from the final image?

10.12 What is the shape of the wavefront on earth for sunlight?

10.13 Why is the diffraction of sound waves more evident in daily experience than that of light wave?

10.14 The human eye has an approximate angular resolution of $\phi = 5.8 \times 10^{-4}$ rad and a typical photoprinter prints a minimum of 300 dpi (dots per inch, 1 inch = 2.54 cm). At what minimal distance z should a printed page be held so that one does not see the individual dots.

10.15 A polariod (I) is placed in front of a monochromatic source. Another polatiod (II) is placed in front of this polaroid (I) and rotated till no light passes. A third polaroid (III) is now placed in between (I) and (II). In this case, will light emerge from (II). Explain.

SA

10.16 Can reflection result in plane polarised light if the light is incident on the interface from the side with higher refractive index?

10.17 For the same objective, find the ratio of the least separation between two points to be distinguished by a microscope for light of 5000 Å and electrons accelerated through 100V used as the illuminating substance.

10.18 Consider a two slit interference arrangements (Fig. 10.4) such that the distance of the screen from the slits is half the distance between the slits. Obtain the value of *D* in terms of λ such that the first minima on the screen falls at a distance *D* from the centre O.

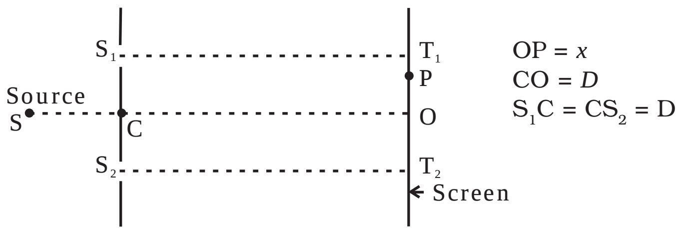

Fig. 10.4

LA

10.19 Figure 10.5 shown a two slit arrangement with a source which emits unpolarised light. P is a polariser with axis whose direction is not given. If I_0 is the intensity of the principal maxima when *no* polariser is present, calculate in the present case, the intensity of the principal maxima as well as of the first minima.

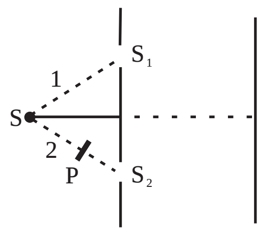

Fig. 10.5

10.20

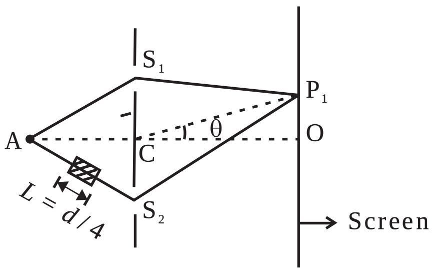

Fig. 10.6

$AC = CO = D$, $S_1C = S_2C = d << D$

A small transparent slab containing material of $\mu = 1.5$ is placed along AS_2 (Fig.10.6). What will be the distance from O of the principal maxima and of the first minima on either side of the principal maxima obtained in the absence of the glass slab. .

10.21 Four identical monochromatic sources A,B,C,D as shown in the (Fig.10.7) produce waves of the same wavelength λ and are coherent. Two receiver R_1 and R_2 are at great but equal distaces from B.

(i) Which of the two receivers picks up the larger signal?
(ii) Which of the two receivers picks up the larger signal when B is turned off?
(iii) Which of the two receivers picks up the larger signal when D is turned off?
(iv) Which of the two receivers can distinguish which of the sources B or D has been turned off?

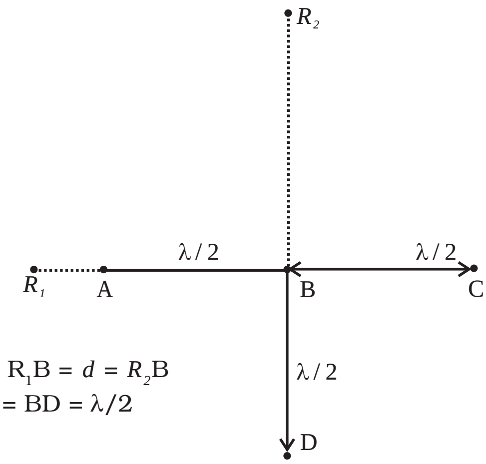

Fig. 10.7

10.22 The optical properties of a medium are governed by the relative permitivity (ε_r) and relative permeability (μ_r). The refractive index is defined as $\sqrt{\mu_r \varepsilon_r} = n$. For ordinary material $\varepsilon_r > 0$ and $\mu_r > 0$ and the positive sign is taken for the square root. In 1964, a Russian scientist V. Veselago postulated the existence of material with $\varepsilon_r < 0$ and $\mu_r < 0$. Since then such 'metamaterials' have been produced in the laboratories and their optical properties studied. For such materials $n = -\sqrt{\mu_r \varepsilon_r}$. As light enters a medium of such refractive index the phases travel away from the direction of propagation.

(i) According to the description above show that if rays of light enter such a medium from air (refractive index =1) at an angle θ in 2^{nd} quadrant, them the refracted beam is in the 3^{rd} quadrant.

(ii) Prove that Snell's law holds for such a medium.

10.23 To ensure almost 100 per cent transmittivity, photographic lenses are often coated with a thin layer of dielectric material. The refractive index of this material is intermediated between that of air and glass (which makes the optical element of the lens). A typically used dielectric film is MgF_2 (n = 1.38). What should the thickness of the film be so that at the center of the visible spectrum (5500 $\mathring{A}$) there is maximum transmission.