SHORT QUESTIONS

Write short answers of the following questions.

1. A soap bubble looks black when it bursts, why?

Ans. The colors of a bubble are dependent on the thickness " t " of the film. Since

$$2\,n\,t = m\,\lambda$$

A bubble becomes thinner and thinner as it dries out. As the surface film of the bubble becomes increasingly thinner, a change in overall color can be seen. Thick walls cancel out longer wavelengths in the red range. As the bubble film gets thinner, yellow wavelengths are cancelled out. As it gets even thinner, green light is lost. Beyond this point, even shorter wavelengths in the blue wavelength range disappear.

Eventually, the film becomes too thin to create interference of visible wavelengths, as all wavelengths are cancelled out. At this point the bubble appears black due to destructive interference of light in the thinnest film because the waves coming from air (rare medium) are reflected from the boundary of the film (denser medium) are 180° out of phase.

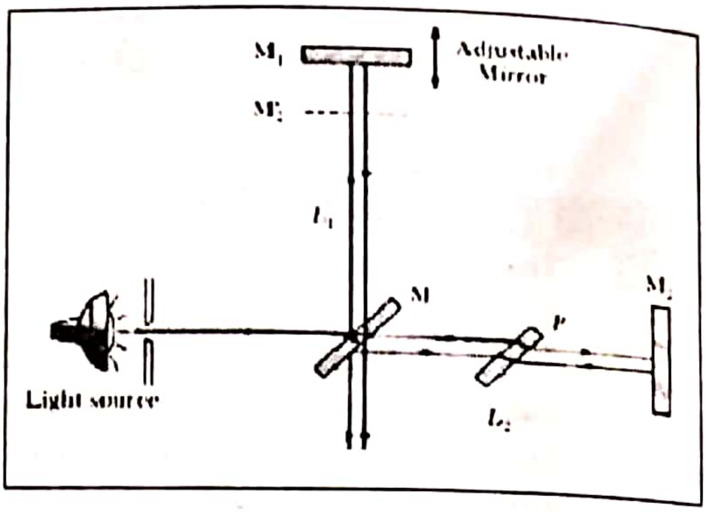
2. What is the difference between interference and diffraction?

Ans.

	Interference		Diffraction
1	Interference is the superposition of two waves.	1	Diffraction is the bending of waves around an obstacle.
2	Two separate wave fronts originating from two coherent sources produce interference.	2	Secondary wavelets originating from different parts of the same wave front cause diffraction.
3	The region of minimum intensity is perfectly dark in interference.	3	In diffraction they are not perfectly dark.
4	The width of the fringes is equal in interference.	4	In diffraction the width of the fringes is never equal.
5	The intensity of all positions of maxima are of the same intensity in interference.	5	In diffraction, only zeroth order maxima has maximum intensity while all other maxima are of lower intensity than the zeroth order maxima.

3. In a Michelson interferometer a second glass plate is also used, why?

Ans. Between glass plate M and mirror M_2, the wave travels twice through a second glass plate P, the compensator, which has the same orientation, the same thickness, and is made of the same quality of glass as used for plate G but without a metal coating. The compensator, as the name suggests, compensates for the difference in optical path length between the two beams of the interferometer because the beam reflected to mirror M_1 passes three times through the optically denser medium of the glass plate M, whereas the beam transmitted to mirror M_2 passes only once. The compensator plate equalizes the optical path length of the two rays. White light has only a very limited coherence length, when using a white light source, the two optical paths must be equal for all wavelengths.

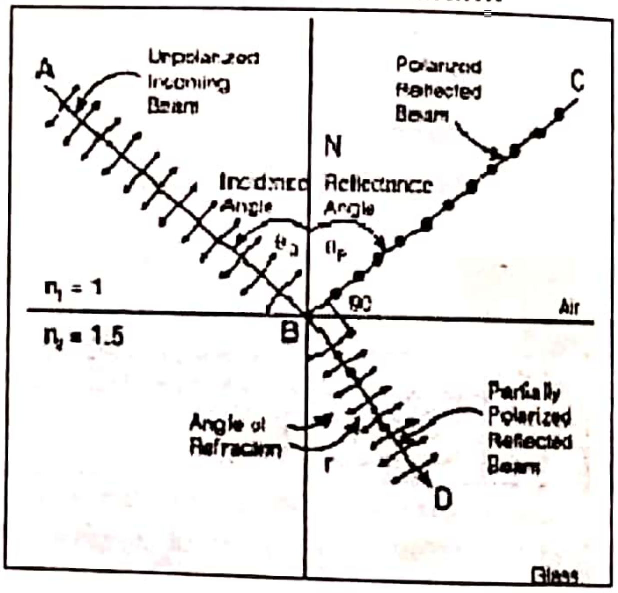


4. How you can explain Brewster's law of polarization?

Ans. Brewster's law is stated as "The tangent of the angle at which the polarization is obtained by reflection is equal to the refractive index of the medium."

i.e.

$$n = \tan \theta_p$$



If natural light is incident on a smooth surface at polarizing angle, it is reflected along BC and refracted along BD as shown in figure. From figure;

$$\theta_p + 90° + \theta_r = 180°$$

$$\theta_r = 180° - (\theta_p + 90°)$$

$$\theta_r = 90° - \theta_p \qquad (1)$$

From Snell's law;

$$n_1 \sin \theta_i = n_2 \sin \theta_r \qquad (2)$$

Putting value from Eq. 1 in Eq. 2, we get;

$$n_1 \sin \theta_p = n_2 \sin (90° - \theta_p)$$

$$n_1 \sin \theta_p = n_2 \cos \theta_p$$

$$\frac{n_2}{n_1} = \frac{\sin \theta_p}{\cos \theta_p}$$

$$\frac{n_2}{n_1} = \tan \theta_p \Rightarrow n = \tan \theta_p \qquad \text{(for air } n_1 = 1\text{)}$$

Which is Brewster's law.

5. What is meant by the path difference with reference to the interference of two wave motion?

Ans. The difference between the lengths of the path covered by two waves having the same initial and terminal points is called as path difference.

When two waves pass through a medium at a point, then the resultant displacement at that point is the vector sum of the displacements due to two component waves. This modification in displacement as a result of superposition of two waves is called INTERFERENCE.

The path difference of two waves determines the type of interference.

For constructive interference, the phase difference is;

$$\text{Phase difference} = \varphi = 0, 2\pi, 4\pi, 6\pi.......$$

Which correspond respectively to the path difference of;

$$\text{Path difference} = d = 0, \lambda, 2\lambda, 3\lambda....... = m\lambda$$

Where $m = 0, 1, 2, 3$ ....

For destructive interference, the phase difference is;

$$\text{Phase difference} = \varphi = \pi, 3\pi, 5\pi.......$$

Which correspond respectively to the path difference of;

$$\text{Path difference} = d = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, ... = \left(m + \frac{1}{2}\right)\lambda$$

Where $m = 0, 1, 2, 3$ ....

6. Why it is not possible to see the interference where the light beams from the head lamps of a car overlap?

Ans. You will not see an interference pattern from the automobile headlights for two reasons.

I. The headlights are not coherent sources and are therefore incapable of producing sustained interference.

II. Since

$$\Delta y = \frac{\lambda L}{d}$$

The headlights are so far apart (d is very large) in comparison to the wavelengths emitted that, even if they were made into coherent sources, the interference maxima and minima would be too closely spaced to be observable.

7. A telephone pole casts a clear shadow in the light from a distant head lamp of a car, but no such effect is noticed for the sound from the car horn. Why?

Ans. Sound and light both travel as waves. The properties of these waves differ quite considerably. Sound waves travel a million times slower than light waves and have wavelengths ranging from 1 cm to 10 m, and will easily diffract round corners. Light waves have much smaller wavelengths, and only diffract through very small holes. Since diffraction depends upon the wavelength of waves and the wavelength of light waves is very much shorter than those of sound waves, so light waves cannot diffract around the telephone pole, hence casts clear shadow, while sound waves diffract about the pole, therefore no such effect is observed.

8. Why it is not possible to obtain the diffraction of X-rays by Young's double slits experiment?

Ans. X-rays have very short wavelength of the order of 10 x 10 $^{-10}$ m. Therefore it is not possible to produce interference fringes of X-rays by Young's double slit experiment or by thin film method. The reason is that the fringe spacing is;

$$\Delta y = \frac{\lambda L}{d}$$

and unless the slits are separated by a distance of 10 x 10 $^{-10}$ m, the fringes so obtained will be closed together that they cannot be observed. However it is possible to obtain X-rays diffraction by making use of crystals such as rock salt in which the atoms are uniformly spaced in planes and separated by a distance of order of 2 A° to 5 A°. Therefore, the diffraction of X-rays takes place when they incident on the surface of crystals.

9. Can we apply Huygens's principle to radar waves?

Ans. The radar dish or antenna transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter.

Since radar waves are actually radio waves which is part of electromagnetic spectrum, therefore Huygens's principle is applicable to radar waves.

10. How would you justify that light waves are transverse?

Ans. To prove the polarization of light, we perform an experiment.

The ordinary un-polarized light falls on a tourmaline crystal from the source. The internal molecular structure of the crystal is such that it allows only those electric vibrations which are parallel to its crystallographic axis and absorbs all the remaining vibrations. Thus the light passed through this crystal has all the field's of vibrations in one plane and is known as the plane polarized light. When another tourmaline crystal is placed in the path of this polarized light in such a way that its crystallographic axis is parallel to the first one, then the polarized light will completely transmit through it. If it is rotated around the ray of light so that axis of the two crystals are inclined, the intensity of the transmitted light decreases, when the axis become at right angle to each other, then no light will pass through the second crystal. When the second crystal is further rotated, the emergent light will again appear. This shows that light is a transverse wave.

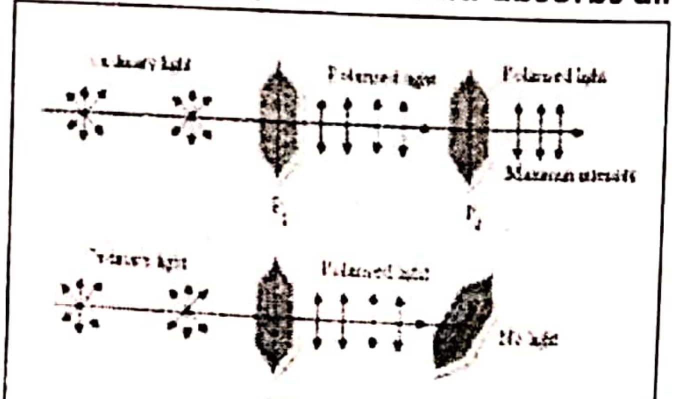


Figure 1