WAVE OPTICS

Electromagnetic waves

The disturbance produced in space due to variation in electric and magnetic field vectors at right angle to each other and also at right angle to the direction of propagation give rise to waves which are called electromagnetic waves. This waves are transverse in nature. The velocity of these waves in free space is given by

$$c = \frac{1}{\sqrt{\mu_o \in_o}} = 3 \times 10^8 \text{ ms}^{-1}$$

Conduction current : The current which flows through an electric circuit due to flow of electrons via connecting wires is called as conduction current.

Displacement current : The current which flows through some part of an electrical circuit due to change of electric flux with time is called as displacement current. Hence displacement current

$$I_D = \epsilon_o \frac{d\phi_E}{dt}$$

Wave front : Wave front is the locus of all those particles of the medium which are vibrating in the same phase at any instant. Depending upon the shape of the source of light, the wave front can be of any of the following three types :

(i) Plane wave front
(ii) Spherical wave front
(iii) Cylindrical wave front

A line drawn normal to the wave front represents a ray of light.

Huyghen's principle : Huyghen's principle is based on the following two assumptions :

(i) Every point of the given wave front, called as primary wave front, acts as a source of new disturbance, called as secondary wavelets. These secondary wavelets travel in all directions in the medium with the velocity of light.

(ii) The envelope of the secondary wavelets (i.e., a tangential surface touching the secondary wavelets) at any instant gives rise to secondary wave front at that instant.

Ether : It is a hypothetical medium, which was supposed by Huyghen. It pervades

everything. It is massless, has very high elasticity and very low density.

Interference of light : Interference of light is the phenomenon of redistribution of light energy in the medium due to superposition of light waves coming from two coherent sources.

At the point of the medium, where the resultant intensity of light is maximum, the interference is called as constructive interference and at other point of the medium, where the resultant intensity of light is minimum, the interference is called as destructive interference.

For constructive interference,

$$\phi = 2n\pi$$

or $$p = n\lambda$$

For destructive interference

$$\phi = (2n + 1)\pi$$

or $$p = (2n + 1)\frac{\lambda}{2}$$

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

ϕ = phase difference

p = path difference

λ = wavelength of light

Interference fringes : Alternate dark and bright bands of light in the interference pattern are called interference fringes.

Coherent sources : Two sources of light are said to be coherent if they emit light waves of same frequency or wavelength having constant phase difference.

Fringe width : The separation between two consecutive bright or dark fringes is called as fringe width. It is represented by β. Also,

$$\beta = \frac{D\lambda}{d}$$

where, d = distance between the two coherent sources of light.

D = distance of the plane of observation from the plane of the two sources.

λ = wavelength of light emitted by the sources.

Half angular width : The angular position of the first secondary minimum is called the half angular width of the central maximum. It is given by

$$\theta = \frac{\lambda}{a}$$

where, a = width of the slit.

Fresnel distance : The distance of the screen from the slit, beyond which the spreading of light due to diffraction becomes quite large as

compared to the size of the slit, is called as Fresnel's distance. It is given by

$$D_F = \frac{a^2}{\lambda}$$

where, a = width of the slit.

Polarisation of light : Polarisation of light is the phenomenon of restricting the vibration of light in a particular plane.

Plane polarised light : It is the light in which the vibrations of light (i.e., electric vector) are confined in a particular plane.

Plane of vibration : It is the plane in which the vibrations of plane polarised light are confined.

Plane of polarisation : It is the plane which is perpendicular to the plane of vibration.

Polarising angle : It is that angle of incidence at which the reflected light is completely plane polarised.

Brewster's law : Brewster's law states that when light is incident on a transparent medium at polarising angle, both reflected and refracted rays are perpendicular to each other.

If μ be the refractive index of the transparent medium and i_p be the polarising angle, then

$$\mu = \tan i_p.$$

Doppler's effect in light : The phenomenon of apparent change in frequency (or wavelength) of light due to relative motion between the source of light and the observer is called as Doppler's effect in light.

Apparent change in frequency is given by

$$\Delta\nu = \pm \frac{v}{c} \nu$$

And apparent change in wavelength is given by

$$\Delta\lambda = \pm \frac{v}{c} \lambda$$

where, v = relative velocity between the source of light and observer.

c = velocity of light in vacuum.

ν = frequency of light waves.

λ = wavelength of light waves.

$\Delta\nu$ or $\Delta\lambda$ is called as **Doppler's Shift**.

Law of Malus : Law of Malus states that when a beam of completely plane polarised light is incident on an analyser, the intensity of the emergent light varies directly as the square of the cosine of the angle between planes of transmission of the analyser and the polariser.

Mathematically,

$$I = I_o \cos^2 \theta$$

where, I = intensity of the emergent light

I_o = intensity of the incident plane polarised light

θ = angle between the planes of transmission of the analyser and the polariser.