9. Wave Theory of Light

Huygens principle

- Every point on a given wave front (called the primary wave front) acts as a fresh source of new disturbances, called secondary wavelets.
- The surface touching these secondary wavelets tangentially in the forward direction at any instant, gives the new wave front at that instant. This is called secondary wave front.
- Using Huygen's principle we can prove the laws of reflection and and laws of refraction.
- **Polarisation of light:** The phenomenon of restriction of the vibration of light (electric vector) in a direction perpendicular to the direction of wave motion, is called polarisation of light. A tourmaline crystal acts as a polariser.

- **Polarisation by reflection**
  - An ordinary beam of light, on reflection from a transparent medium, becomes partially polarised. The degree of polarisation increases as the angle of incidence is increased.
  - At a particular value of angle of incidence, the reflected beam becomes completely polarised. This angle of incidence is called the polarising angle (p).

- **Polaroid**
  - It is a large sheet of synthetic material packed with tiny crystals of a dichoric substance, oriented parallel to one another.
  - It is capable of blocking one of the two planes of vibration of an electromagnetic wave.
  - It absorbs the electric field vectors of an electromagnetic wave passing through it.
  - When light is passed through a polaroid, it becomes linearly polarised.

- **Uses of polaroid**
  - In three dimensional movie cameras
  - In production and analysis of plane polarised light
  - In the windows of aeroplanes to control the amount of light.
  - In polarising sunglasses to protect the eyes from sunlight.
  - In improving the colour contrast in old oil paintings
- **Brewster's Law**
  - When light is incident at the polarising angle at the interface of a refracting medium, the refractive index of the medium is equal to the tangent of the polarising angle, that is, $\mu = \tan p$.

Law of Malus

When a beam of completely plane polarised light is incident on the analyser, the resultant intensity of light varies directly as the square of the cosine of the angle between the plane of

transmission of the analyser and polariser.
That is, I α $\cos^2\theta$

Doppler's effect of Light

- Change in frequency of light when there is relative motion between the source of light and the observer.
- The fractional change in the frequency is found by Δνν= -vradc
  where v_{rad} is radial velocity that is relative velocity of source with respect to the observer along the line joining them.

Coherent and Incoherent addition of waves

- **Coherent sources:** Two sources of light emitting light waves of same frequency or wavelength and of a stable phase difference
- **Principle of superposition:** When two or more wave trains of light travelling in a medium superpose upon each other, the resultant displacement at any instant is equal to the vector sum of the displacements due to individual waves.
- **Interference of light:**
  Interference of light is the phenomenon of redistribution of light energy in a medium on account of the superposition of light waves from two coherent sources.
  - For constructive interference intensity should be maximum, for which
    cosϕ =1 = maximum or Φ=2nπ and $x = n\lambda$
    Where, n = 0, 1, 2
- **Destructive interference of light:**
  Intensity should be minimum
  cos ϕ = minimum= –1
  ϕ=(2n+1)π and $x= 2n+12\lambda$
  Where, n = 1, 2 … …and x is the path difference between the two waves, corresponding to phase difference is ϕ.