BRAIN MAP

CHRISTIAAN HUYGENS (1629-1695)

Christiaan Huygens, the first person to explain how wave theory can also account for the laws of geometric optics. He had a very important insight into nature of wave propagation which is known as Huygens' principle. He is known particularly as an astronomer, physicist. His work included early telescopic studies of rings of Saturn and the discovery of its Moon Titan. He also experimented in 1672 with double refraction (birefringence) in Iceland spar.

WAVE OPTICS

An encounter with wave nature of light

Propagation of light wave

Principle of superposition of light waves

Huygens Fresnel principle

Light as a transverse electromagnetic wave

Huygens' Wave Theory

- Every point on a wave-front may be considered as a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wave-front is the tangential surface to all of these secondary wavelets at a later time.
- Laws of reflection and refraction of light can be explained by Huygens wave theory.

Doppler's effect

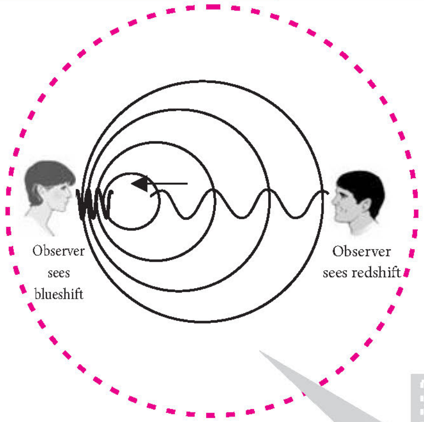
- The apparent frequency received by an observer during relative motion of source and observer is

$\upsilon' = \upsilon\left(1-\frac{v}{c}\right)$; source moving away from observer

$\upsilon' = \upsilon\left(1+\frac{v}{c}\right)$; source approaching the observer

Doppler shift : $\Delta\upsilon = \pm\frac{v}{c}\times\upsilon$

$\Delta\lambda = \pm\frac{v}{c}\times\lambda \Rightarrow \lambda' - \lambda = \pm\frac{v}{c}\lambda$



Interference of light

The superposition of two coherent waves resulting a pattern of alternating dark and bright fringes.

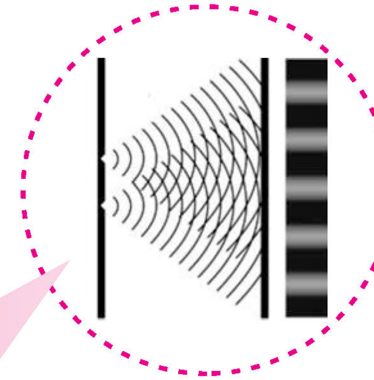
- Young's double slit experiment
  - ➢ Resultant intensity $I_R = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$

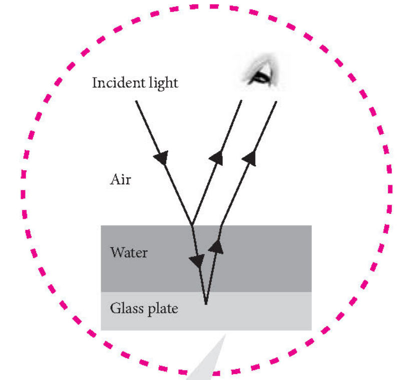
    for bright fringes, $I_{max} = (\sqrt{I_1}+\sqrt{I_2})^2$ at $\phi = 0°$ or $2n\pi$

    for dark fringes, $I_{min} = (\sqrt{I_1}-\sqrt{I_2})^2$ at $\phi = 180°$ or $(2n-1)\pi$

    for $I_1 = I_2 = I_0$; $I_R = 4I_0\cos^2\frac{\phi}{2}$
  - ➢ Position of bright fringes $x_n = \frac{n\lambda D}{d}$
  - ➢ Position of dark fringes $x_n' = \frac{(2n-1)\lambda D}{2d}$
  - ➢ Fringe width $\beta = \frac{\lambda D}{d}$
  - ➢ Ratio of slit width with intensity : $\frac{\omega_1}{\omega_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$
- If whole YDSE set up is taken in medium of refractive index μ, as λ changes β also changes

  $\lambda' = \frac{\lambda}{\mu}$ and $\beta' = \frac{\beta}{\mu}$





Interference in thin film

- For reflected Light

  Maxima $\rightarrow$ $2\mu t\cos r = (2n+1)\frac{\lambda}{2}$

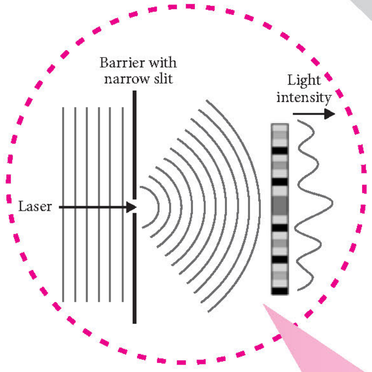
  Minima $\rightarrow$ $2\mu t\cos r = n\lambda$

  For transmitted light

  Maxima $\rightarrow$ $2\mu t\cos r = n\lambda$

  Minima $\rightarrow$ $2\mu t\cos r = (2n+1)\frac{\lambda}{2}$
- Shift in fringe pattern

  $\Delta x = \frac{\beta}{\lambda}(\mu-1)t = \frac{D}{d}(\mu-1)t$ (t = thickness of film, μ = R.I. of the film)



Diffraction

The spreading of light waves on passing through apertures or by sharp edges.

- Single slit experiment
  - ➢ Angular position of n^{th} minima, $\theta_n = \frac{n\lambda}{d}$
  - ➢ Angular position of n^{th} maxima $\theta_n' = \frac{(2n+1)\lambda}{2d}$
  - ➢ Width of central maximum $\beta_o = 2\beta = \frac{2D\lambda}{d}$
- Ray optics as a limiting case of wave optics
  - ➢ Fresnel's distance : distance at which diffraction spread is equal to the size of aperture
  - ➢ Size of Fresnel zone $D_F = \frac{d^2}{\lambda}$
- Diffraction at circular aperture $d_F = \sqrt{\lambda D}$
  - ➢ Linear spread, $x = D\theta$

    Areal spread, $x^2 = (D\theta)^2$ $\left\{\theta = \frac{1.22\lambda}{d}\right\}$

Resolving Power (R.P.)

The ability to resolve the images of two nearby point objects distinctly.

$\text{R.P.} = \frac{1}{\text{Limit of resolution}}$

- R.P. of a microscope = $\frac{1}{d} = \frac{2\mu\sin\theta}{\lambda}$

  θ = Semivertical angle subtended at objective.
- R.P. of a telescope = $\frac{1}{d\theta} = \frac{D}{1.22\lambda}$

  D = diameter of objective lense of telescope.

Polarisation of Light

- **Malus Law:** The intensity of transmitted light passed through an analyser is

  $I = I_0\cos^2\theta$

  (θ = angle between transmission directions of polariser and analyser)
- **Brewster's Law:** The tangent of polarising angle of incidence at which reflected light becomes completely plane polarised is numerically equal to refractive index of the medium

  $\mu = \tan i_p$ i_p = Brewster's angle.

  and $i_p + r_p = 90°$