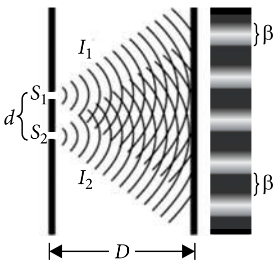
WAVE OPTICS

BRAIN MAP

CLASS XII

REFLECTION AND REFRACTION

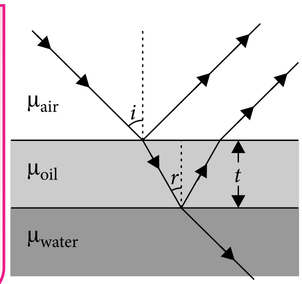
Law of reflection $\angle i = \angle r$ & law of refraction $\frac{\sin i}{\sin r} = \mu$ can be explained by Huygens wave theory.

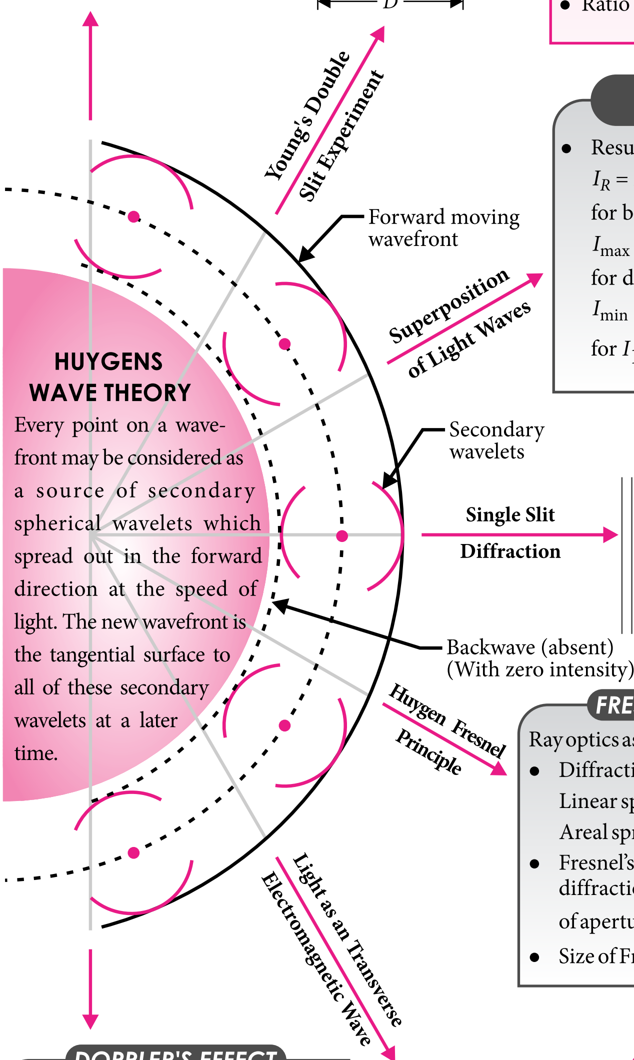


INTERFERENCE OF LIGHT

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

- 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 : $\frac{w_1}{w_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$





HUYGENS WAVE THEORY

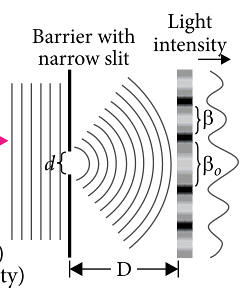
Every point on a wave-front may be considered as a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wavefront is the tangential surface to all of these secondary wavelets at a later time.

ADDITION OF COHERENT WAVE

- 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 $\phi = 0°, 2\pi, 4\pi...$
  for dark fringes,
  $I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$ at $\phi = \pi, 3\pi, 5\pi...$
  for $I_1 = I_2 = I_0$; $I_R = 4I_0\cos^2\frac{\phi}{2}$

INTERFERENCE IN THIN FILM

- For reflected Light
  Maxima → $2\mu t\cos r = (2n+1)\frac{\lambda}{2}$
  Minima → $2\mu t\cos r = n\lambda$
- For transmitted light
  Maxima → $2\mu t\cos r = n\lambda$
  Minima → $2\mu t\cos r = (2n+1)\frac{\lambda}{2}$
  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

- 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 $\beta_o = 2\beta = \frac{2D\lambda}{d}$

FRESNEL'S DISTANCE

Ray optics as a limiting case of wave optics

- Diffraction at circular aperture
  Linear spread, $x = D\theta$
  Areal spread, $x^2 = (D\theta)^2$
  $\left\{\theta = \frac{1.22\,\lambda}{d}\right\}$
- Fresnel's distance : Distance at which diffraction spread is equal to the size of aperture, $D_F = \frac{d^2}{\lambda}$
- Size of Fresnel zone, $d_F = \sqrt{\lambda D}$

RESOLVING POWER (R.P.)

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

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

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

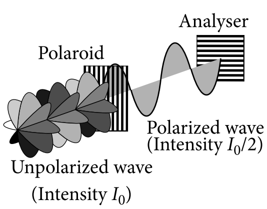
θ = Semi vertical angle subtended at objective.

R.P. of a telescope = $\frac{1}{d\theta} = \frac{D}{1.22\lambda}$

D = Diameter of objective lens of telescope.

DOPPLER'S EFFECT

- Apparent frequency received during relative motion of source and observer
  $\upsilon' = \upsilon\left(1 - \frac{v}{c}\right)$; (red shift)
  $\upsilon' = \upsilon\left(1 + \frac{v}{c}\right)$; (blue shift)
  Doppler shift : $\Delta\upsilon = \pm\frac{v}{c}\times\upsilon$
  $\Delta\lambda = \pm\frac{v}{c}\times\lambda \Rightarrow \lambda' - \lambda = \pm\frac{v}{c}\lambda$



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)

POLARISATION BY REFLECTION

- **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 $i_p + r_p = 90°$