Tutorial Session on Ray Optics & Wave Optics:

Note Title 8/3/2018

Example 1: Dispersion in a prism (thin)

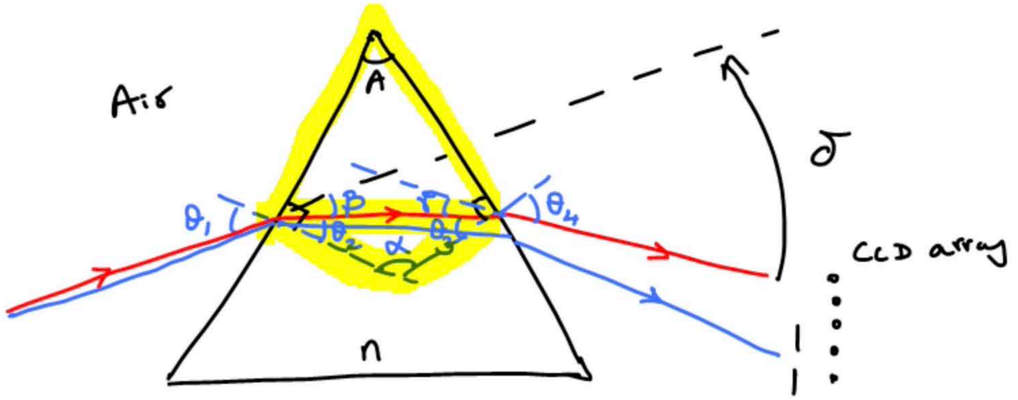
$\frac{c}{n(\lambda)}$ → velocity of light within a medium

$n_{blue} = 1.34$

$n_{red} = 1.33$

Paraxial approximation

$n_1 \theta_1 = n_2 \theta_2$



$\delta = (n-1)\,A$

$A = 10^\circ$

$\delta_{red} = (1.33 - 1)\,10^\circ = 3.3^\circ$

$\delta_{blue} = (1.34 - 1)\,10^\circ = 3.4^\circ$

$\Rightarrow 0.1$ deg

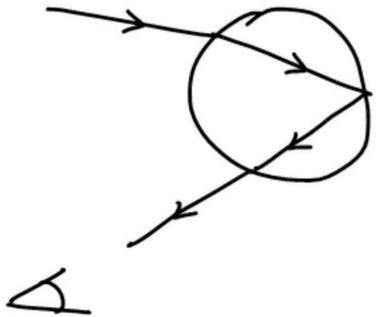
$\alpha + A = 180^\circ$

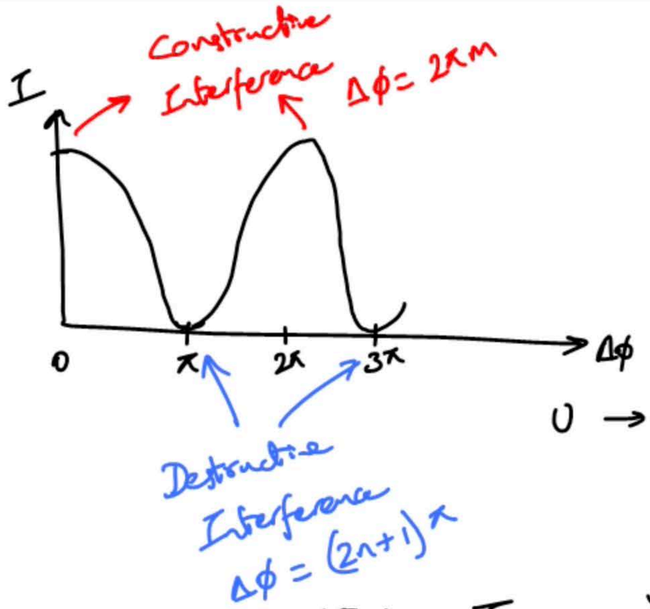
$\theta_2 + \theta_3 + \alpha = 180^\circ$

$\Rightarrow A = \theta_2 + \theta_3$

$\delta = \beta + \gamma = \theta_1 - \theta_2 + \theta_4 - \theta_3 = \theta_1 + \theta_4 - A$

$= n\theta_2 + n\theta_3 - A = (n-1)\,A$

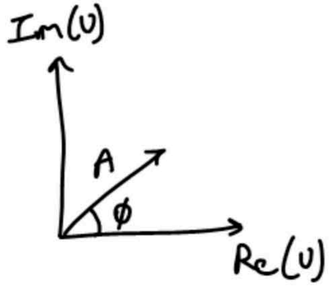


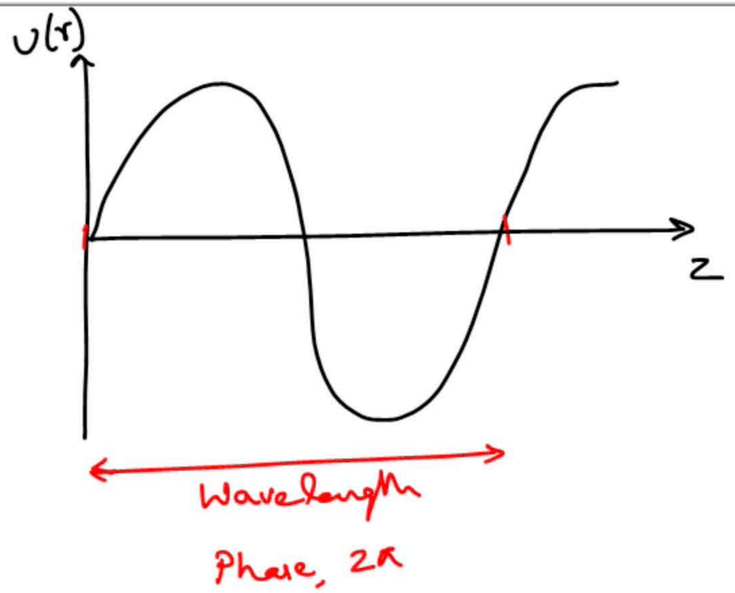


$$U(r) = A(r)\, e^{-jkz}\, e^{j\omega t}$$

Phase

$U \rightarrow$ Phasor $\rightarrow$ $A e^{j\phi}$



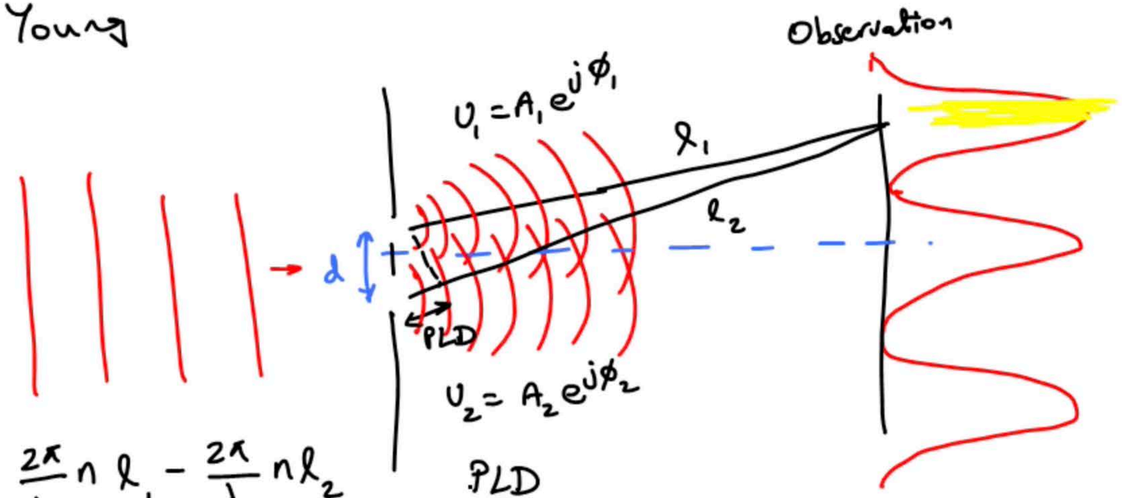


1801, Thomas Young

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\phi_1 - \phi_2)$$

If $I_1 = I_2 = I_0$

$$\boxed{I = 2I_0(1 + \cos\Delta\phi)}$$



$$\phi_1 - \phi_2 = \frac{2\pi}{\lambda} n r_1 - \frac{2\pi}{\lambda} n r_2$$

PLD

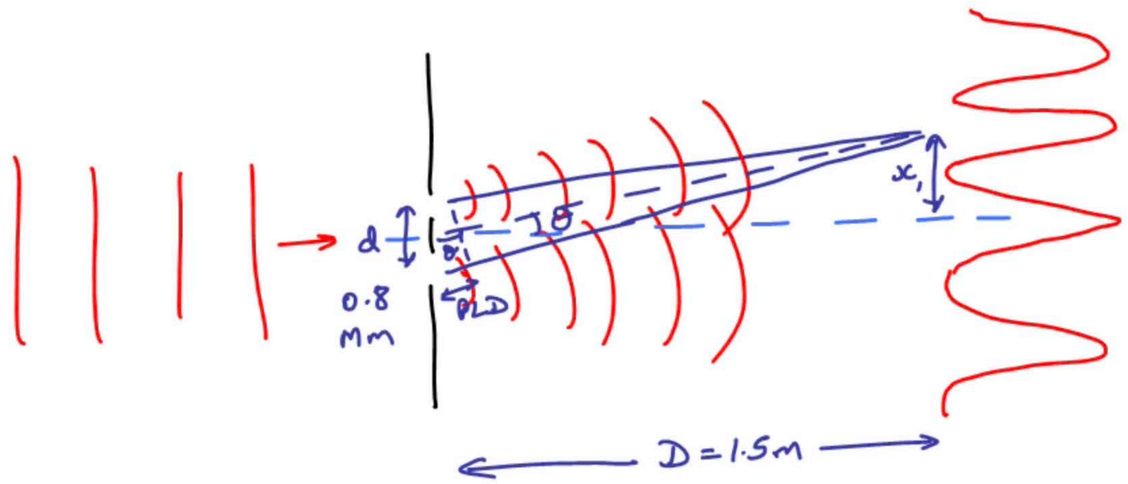
$$= \frac{2\pi}{\lambda} n (r_1 - r_2)$$

$$I = |U|^2 = |U_1 + U_2|^2$$

$$= |U_1|^2 + |U_2|^2 + U_1 U_2^* + U_1^* U_2$$

$$= I_1 + I_2 + \sqrt{I_1 I_2}\, e^{j(\phi_1 - \phi_2)} + \sqrt{I_1 I_2}\, e^{-j(\phi_1 - \phi_2)}$$

Example 2: Can you discriminate different colours using Young's double slit?



$\lambda_{red} = 650$ nm

$\lambda_{orange} = 600$ nm

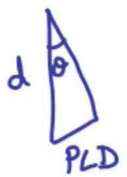
$x_1^r = D \tan(\theta_r)$

$= 1.218$ mm

$x_1^o = 1.125$ mm

$x_1^r - x_1^o = 93$ μm

Slit width $= \frac{x_1^r - x_1^o}{2} = 46.5$ μm



$\sin\theta = \frac{PLD}{d}$

$PLD = d \sin\theta$

$\phi_1 - \phi_2 = 2\pi m$

$\frac{2\pi}{\lambda} n d \sin\theta_m = 2\pi m$ (constructive interference)

For $m=1$ ($n=1$) $\quad \theta_1^r = \sin^{-1}\left(\frac{\lambda_r}{d}\right) = \sin^{-1}\left(\frac{0.65\times10^{-6}}{0.8\times10^{-3}}\right) = 0.8$ mrad