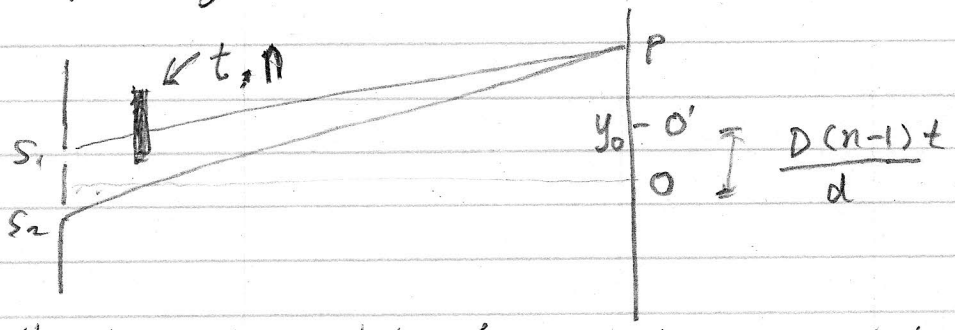
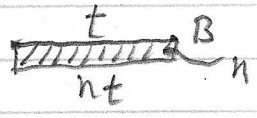
Lect. 14, March 23, 2010

Displacement of Fringes (Ch 14.10)



t: A thin transparent plate of width t is inserted.
The interference pattern is shifted by $\frac{D}{d}(n-1)t$.

Optical path $\tau = nt$.



true Geometric path t, n: refractive index.
The time a light takes from A to B is

$$\text{Time} = \frac{\tau}{c} = \frac{nt}{c} = \frac{t}{c/n} = \frac{t}{v}$$

* Fermat's principle: from A to B, travel time is minimal.
alternatively, optical path is minimal.

phase shift due to travel a distance x

$$\delta = (kx) = \frac{2\pi}{\lambda}x = \frac{2\pi}{\lambda_0/n}x = \frac{2\pi}{\lambda_0}\underbrace{(nx)}_{\text{optical path}}$$

Optical path $S_1 \to P$: $S_1P - t + nt = S_1P + (n-1)t$
optical path $S_2 \to P$: S_2P

$$\Delta = \underbrace{S_1P - S_2P}_{-y\frac{d}{D}} + (n-1)t$$

The new fringe center at O', $\Delta = 0 \Rightarrow y_0$

$$y_0 = \frac{D}{d}(n-1)t$$

This can be used to measure the thickness of a thin sheet.

Exp: shift of fringe $y_0 = 0.2$ cm, $d = 0.1$ cm, $D = 50$ cm, $n = 1.58$

$$t = y_0\frac{d}{D}(n-1) = 6.9 \times 10^{-4}\ \text{cm}$$