1-Problem 5.7 (K&F)

2- With regard to Young’s double slit experiment, derive a general expression for the shift in the vertical position of the $m$ the maximum as a result of placing a thin sheet of glass with index $n$ and thickness $d$ directly over one of the slits. Identify your assumptions.

3-Problem 5.22 (K&F)

4- White light falling on two long narrow slits emerges and is observed in a distant screen. If red light ($\lambda_0=780\text{ nm}$) in the first order fringe overlaps violet in the second order fringe, what is the latter’s wavelength?
#1 K&F 5.7

\[ \langle S \rangle = \langle S_1 \rangle + \langle S_2 \rangle + 2\sqrt{\langle S_1 \rangle \langle S_2 \rangle} \cos \delta \]

or

\[ I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \delta \quad \text{when} \quad \delta = \frac{2\pi a x'}{D} \]

Let \( I_2 = \frac{1}{3} I_1 \) (due to attenuation factor)

\[ I = 3I_2 + I_2 + 2\sqrt{3} I_2 \cos \delta = 4I_2 \left(1 + \frac{\sqrt{3}}{2} \cos \delta \right) \]

\[ I = \mathcal{A} (2+\sqrt{3}) I_2 \times \frac{\left(1 + \frac{\sqrt{3}}{2} \cos \delta \right)}{1 + \frac{\sqrt{3}}{2}} \]

\[ Y(\delta) \]

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Assumptions: ignore multiple reflection in the glass, small $\theta$

At $P'$:
\[ \Phi_2 = \frac{2\pi}{\lambda} R_2' \]
\[ \Phi_1 = \frac{2\pi}{\lambda} (R_1' - d) + \frac{2\pi d}{\lambda} \]

\[ \delta = \Phi_1 - \Phi_2 = \frac{2\pi}{\lambda} (R_1' - R_2') + \frac{2\pi d (n-1)}{\lambda} \]
\[ \delta = \frac{2\pi}{\lambda} \left[ a \frac{x'}{b'} + d (n-1) \right] \]

Since bright fringes correspond to $\delta = 2m\pi$

\[ \frac{ax'}{b'} + d (n-1) = m\lambda \Rightarrow x' = m\frac{\lambda b'}{a} + d\frac{b'(n-1)}{a} \]

Thus, all the fringes (regardless of order $m$) are shifted upward by:
\[ \Delta x' = d \frac{b' (n-1)}{a} \]
#3 K8F 5.22

\[ d = 2 \text{mm} \quad n = 1.6 \quad \lambda = 500 \text{ nm} \]

\[ \sigma_{\text{max}} = \frac{2nd}{\lambda} + \frac{1}{2} = \frac{2 \times 1.6 \times 0.2 \text{cm}}{500 \times 10^{-7} \text{cm}} + \frac{1}{2} = 12800.5 \]

\[ m = m_{\text{max}} \left(1 - \frac{1}{2} \frac{\theta^2}{n^2}\right) = m_{\text{max}} \left(1 - \frac{1}{2} \frac{\theta^2}{n^2}\right) \]

\[ P(\# \text{ of fringes}) = m_{\text{max}} - m = m_{\text{max}} \left(\frac{\Delta \theta^2}{2n^2}\right) \]

For \( \Delta \theta^2 = \frac{1}{36} \)

\[ P = \frac{12800 \times \frac{1}{36}}{900 \times 2(6)^2} \approx 2.77 \]

2 full fringes?

3 dark rings (including the central spot)

Note:

\[ \text{Since } m_{\text{max}} = \text{half intensity} \]

The central spot is dark
The nth order fringe associated with $\lambda$ is given by

$$\frac{n \alpha \gamma'}{\lambda} = m \pi$$

or

$$x_m(\alpha) = m \lambda \frac{b'}{a}$$

$$x_1(\lambda = 780) = x_2' \ (\lambda = ?)$$

$$\frac{780 \ b'}{a} = 2 \lambda \frac{b'}{a}$$

$$\lambda = \frac{780}{2} = 390 \text{ nm}$$