OPTICS 420 HOMEWORK

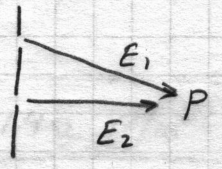
4/1/09

7-1

10-1

$$E_1 = 3\cos(KS_1 - \omega t + \pi/5) \quad kV/m$$

$$E_2 = 4\cos(KS_2 - \omega t + \pi/6) \quad kV/m$$



AT POINT P, $KS_1 - KS_2 = \pi/3$

a) IRRADIANCES OF EACH BEAM

$$I_1 = \tfrac{1}{2}\varepsilon_0 c E_{01}^2 \qquad \varepsilon_0 = 8.854\times10^{-12}\ C^2/N\text{-}m^2$$

$$c = 2.998\times10^{8}\ m/sec$$

$E_{01} = 3000\ V/m$

$$I_1 = \tfrac{1}{2}(8.854\times10^{-12})(2.998\times10^{8})(3000)^2 = \boxed{11945\ W/m^2 = I_1}$$

$$I_2 = \tfrac{1}{2}\varepsilon_0 c E_{02}^2 = \tfrac{1}{2}(8.854\times10^{-12})(2.998\times10^{8})(4000)^2$$

$$\boxed{I_2 = 21235\ W/m^2}$$

b) IRRADIANCE I_{12} DUE TO INTERFERENCE

PHASE DIFFERENCE AT P

$$\delta = KS_2 - KS_1 + \phi_2 - \phi_1$$

$KS_1 - KS_2 = \pi/3 \rightarrow KS_2 - KS_1 = -\pi/3 \qquad \phi_1 = \pi/5 \quad \phi_2 = \pi/6$

$\delta = -\pi/3 + \pi/6 - \pi/5 \qquad \delta = -1.152$ RADIANS

$= -66$ DEGREES

$$I_{12} = 2\sqrt{I_1 I_2}\,\langle\cos\delta\rangle$$

FOR MONOCHROMATIC LIGHT (BOTH E_1 & E_2 have ω)

$$\langle\cos\delta\rangle = \cos\delta$$

$$I_{12} = 2\sqrt{(11945)(21235)}\ \cos(-66^\circ) \qquad \boxed{I_{12} = 12956\ W/m^2}$$

SHOULD HAVE SAME RESULT IF $E_1 \leftrightarrow E_2$

$$\delta = KS_1 - KS_2 + \phi_1 - \phi_2 = \pi/3 + \pi/5 - \pi/6 = 1.152\ RAD$$

$\cos\delta = +0.4067 \rightarrow$ SAME RESULT FOR I_{12} ✓

c) NET IRRADIANCE

$$I = I_1 + I_2 + I_{12} = 11945 + 21235 + 12956$$

$$\boxed{I = 46,140 \ W/m^2}$$

ANSWER IN BACK OF BOOK IS 33,200 W/m^2.
NOT SURE HOW ?

d) FRINGE VISIBILITY

$$I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2} = 11945 + 21235 + 2\sqrt{11945(21235)}$$

$$I_{max} = 65033 \ W/m^2$$

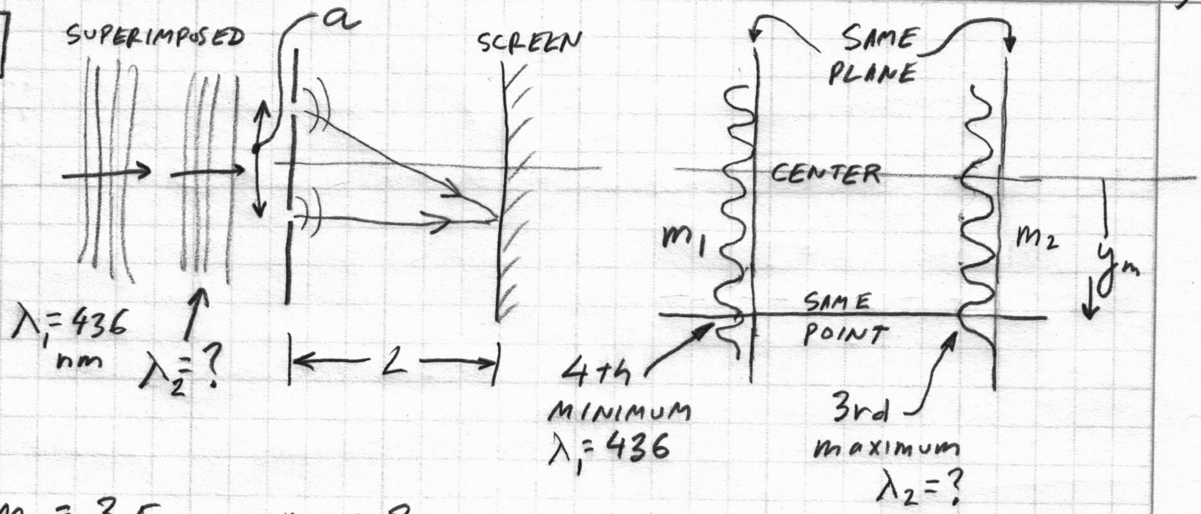
$$I_{min} = I_1 + I_2 - 2\sqrt{I_1 I_2} = 1327$$

$$\text{FRINGE VISIBILITY} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

$$= \frac{65033 - 1327}{65033 + 1327}$$

$$\boxed{\text{VISIBILITY} = 0.96}$$

10-6



$m_1 = 3.5 \qquad m_2 = 3$

DISTANCE FROM CENTER $(m=0)$

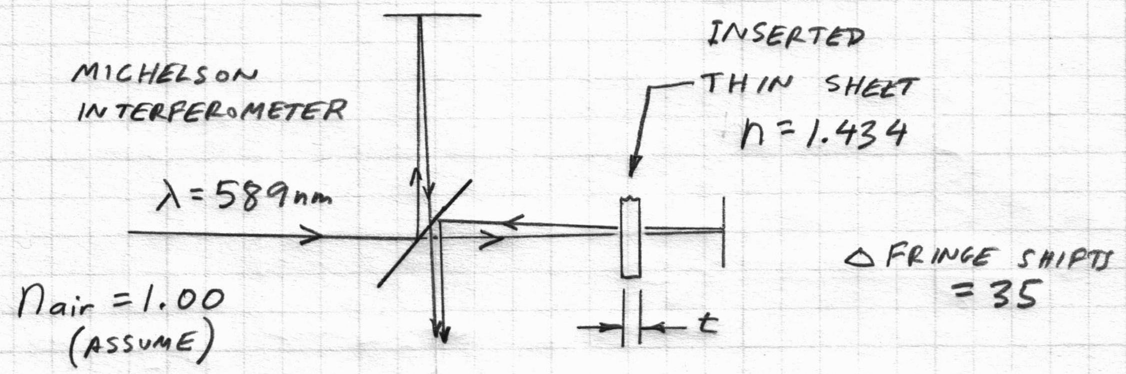
$$y_m = \frac{m \lambda L}{a}$$

AT 4th min for λ_1 AND 3rd max for λ_2:

$$y_{m_1} = y_{m_2} = \frac{m_1 \lambda_1 L}{a} = \frac{m_2 \lambda_2 L}{a} \qquad m_1 \lambda_1 = m_2 \lambda_2$$

$$3.5(436) = 3.0(\lambda_2) \qquad \boxed{\lambda_2 = 509 \text{ nm}}$$

8-3 **11-3**



OPTICAL PATH LENGTH: WITHOUT SHEET $OPL = 1.00(2t)$

WITH SHEET $OPL' = 1.434(2t)$

CHANGE IN OPL $\Delta OPL = 1.434(2t) - 1.000(2t)$

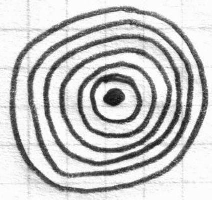
$= 0.868\,t$

EQUALS 35 FRINGES:

$35(589\text{nm}) = 0.868\,t$

$t = 23750$ nm
$t = 23.75\ \mu m$

8-4 **11-4**



MICHELSON INTERFEROMETER
$\lambda = 500$nm
ONE ARM 2 cm LONGER THAN THE OTHER

order $m_{max} = \dfrac{2d}{\lambda}$ $d = 2\text{cm} = 2\times10^7$ nm

a) ORDER OF CENTRAL SPOT – DARK

$m = \dfrac{2(2\times10^7)}{500}$

order = 80,000 @ center

b) SIXTH FRINGE FROM THE CENTER – numbers decrease outwards

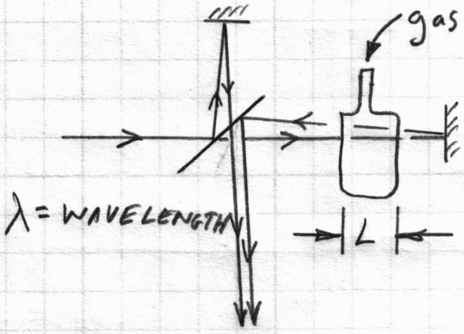
order of sixth dark ring

order = 80,000 – 6

order = 79,994

8-5

11-5



MICHELSON INTERFEROMETER

N = NUMBER OF FRINGE SHIFTS, VACUUM TO P_0
n = INDEX OF REFRACTION OF GAS AT STP
$n = 1.00$ = INDEX REFRACTION OF VACUUM

a) FIND FORMULA FOR n

CHANGE IN OPL $\Delta OPL = \underset{gas}{2nL} - \underset{vacuum}{2(1.00)L} = 2(n-1)L$

ΔOPL = CHANGE IN FRINGES $= N\lambda$

$$2(n-1)L = N\lambda \quad (1)$$

SOLVE FOR n: $2nL - 2L = N\lambda$ $\quad 2nL = N\lambda + 2L$

$$\boxed{n = 1 + \frac{N\lambda}{2L}}$$

b) $n = 1.00045$ $\quad L = 10\text{ cm}$ $\quad \lambda = 589\text{ nm} = 5.89 \times 10^{-5}\text{ cm}$

FROM (1) NUMBER OF FRINGES SHIFTED

$$N = \frac{2(n-1)L}{\lambda} = \frac{2(1.00045-1.00)(10)\text{ cm}}{5.89\times10^{-5}\text{ cm}}$$

$$\boxed{N = 152.8 \text{ FRINGES}}$$

≈ 153 FRINGES

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