Ch. 25 Fringe Shift Problems

42. 550nm light is used to calibrate an interferometer. If the moveable mirror is adjusted .180mm, how many fringes are counted? (1.3x10^3 fringes)

\[ N = \frac{4\Delta L}{\lambda} \]

43. An interferometer is used to measure the length of a bacterium with 650nm. As one arm is moved from one end of the cell to the other 310 shifts occur. How long is the bacterium? (What is the distance the mirror must be moved in \( \mu m \) to have 310 fringe shifts?) (50.4\( \mu m \))

\[ \Delta L = \frac{N\lambda}{4} \]

44. What would the length change be if 632.8nm causes 250 fringe shifts?

45. If a thin sheet of transparent film (15.0\( \mu m \)) with an index of refraction of 1.40 is inserted in the light path along one arm of an interferometer, how many fringe patterns occur if 600.0nm light is used?(40)

When the optical path length that light travels as it goes down one arm of the interferometer changes by one wavelength, four fringes occur (one shift for every quarter wavelength). The number of wavelengths(in a vacuum) that fit in a distance equal to a thickness \( t \) is \( N_{\text{vac}} = \frac{t}{\lambda} \). The number of wavelengths that fit in this thickness while traveling through the transparent material is \( N_n = \frac{t}{\lambda_n} = \frac{t(\lambda/\lambda_n)}{\lambda} = nt/\lambda \).

Thus: \[ \Delta N = N_n - N_{\text{vac}} = (n-1) \frac{t}{\lambda} \]
46. The interferometer can be used to measure the index of refraction of a gas by placing a tube of the gas in one arm. Assume that 600.0 nm light is used, that the tube is 5.00 cm long, and 160 fringe shifts, what is the index of refraction. (Wavelength changes as gas is added.) (1.0005)

A fringe shift will occur each time the effective length of the tube changes by a quarter wavelength (that is, for each additional wavelength fitted into the length of the tube, 4 fringes occur). If L is the length of the tube, the number of fringe shifts observed as the tube is filled with gas is:

\[ N_{\text{shifts}} = 4 \left( \frac{L}{\lambda} - \frac{L}{\lambda_n} \right) = 4 \left( \frac{L}{\lambda} - \frac{L}{\lambda_n} \right) = 4 \frac{L}{\lambda} (n_{\text{gas}} - 1) \]

Therefore:

\[ n_{\text{gas}} = 1 + \frac{\lambda}{4L} N_{\text{shifts}} \]

47. The light path in one arm of the interferometer includes a transparent cell that is 5.00 cm long. The wavelength of the light source is 590 nm and the refractive index of air is 1.00029. How many fringe shifts would be observed if all the air were evacuated from the cell? 

\[ n_{\text{gas}} = 1 + \frac{\lambda}{4L} N_{\text{shifts}} \]