Answer on Question #49228, Physics, Optics

What are the smallest thicknesses of a soap bubble that produce constructive interference visible light of 380 nm (violet) and 760 nm (red)?

And (b) the smallest thicknesses will give destructive interference?

The index of refraction of soap is 1.33.

Solution:

In the case of a soap bubble, light travels through air and strikes a soap film. The air has a refractive index of n=1 and the film has an index that is larger than 1 ($n_{film} > 1$). The reflection that occurs at the upper boundary of the film (the air-film boundary) will introduce a 180° phase shift in the reflected wave because the refractive index of the air is less than the index of the film. Light that is transmitted at the upper air-film interface will continue to the lower film-air interface where it can be reflected or transmitted.

(a) The general condition for constructive interference is simply that the difference in path-length Δ between the two waves be an integer number of wavelengths:

$$\Delta = 2nd = (m - \frac{1}{2})\lambda$$

where d is the film thickness, n is the refractive index of the film, m is an integer, and λ is the wavelength of light....

For $\lambda_v = 380\text{ nm}$

$$d_v = \frac{\frac{\lambda}{2}}{2n} = \frac{380 * 10^{-9}}{2 * 2 * 1.33} = 7.14 * 10^{-8}\text{m} = 71.4\text{ nm}$$

For $\lambda_r = 760\text{ nm}$

$$d_r = \frac{\lambda}{2n} = \frac{760 * 10^{-9}}{2 * 2 * 1.33} = 1.43 * 10^{-7}\text{m} = 143\text{ nm}$$

(b) The general condition for destructive interference on the screen is that the difference in path-length between the two waves be a half-integer number of wavelengths:

$$\Delta = 2nd = m\lambda$$

where m=1, 2, 3, ...

For $\lambda_v = 380\text{ nm}$

$$d_v = \frac{\lambda}{2n} = \frac{380 * 10^{-9}}{2 * 1.33} = 1.43 * 10^{-7}\text{m} = 143\text{ nm}$$

For $\lambda_r = 760\text{ nm}$

$$d_r = \frac{\lambda}{2n} = \frac{760 * 10^{-9}}{2 * 1.33} = 2.86 * 10^{-7}\text{m} = 286\text{ nm}$$