Answer on Question #43314, Physics, Optics

Light with wavelength 648 nm in air is incident perpendicularly from air on a film 8.76 μm thick and with refractive index 1.35. Part of the light is reflected from the first surface of the film, and part enters the film and is reflected back at the second surface, where the film is again in contact with air.

(a) How many waves are contained along the path of this second part of the light in its round trip through the film?

(b) What is the phase difference between these two parts of the light as they leave the film?

Solution:

a) The wavelength in film is

$$\lambda' = \frac{\lambda_0}{n} = \frac{648 \cdot 10^{-9}}{1.35} = 480 \cdot 10^{-9}\ \text{m}$$

Distance light travels through the film is (down and back up again)

$$d = 2t = 2 \cdot 8.76 \cdot 10^{-6} = 17.52 \cdot 10^{-6}\ \text{m}$$

Number of waves is

$$N = \frac{d}{\lambda'} = \frac{17.52 \cdot 10^{-6}}{480 \cdot 10^{-9}} = 36 + \frac{1}{2} = 36.5$$

2) A half-cycle phase shift occurs during reflection whenever the index of refraction in the second material is greater than that in the first. Thus, the reflection from the first surface has a π (½λ) phase change.

The phase difference is

$$\Delta\phi = k2t + \pi = \frac{2\pi n 2t}{\lambda_0} + \pi = 2\pi\left(36 + \frac{1}{2}\right) + \pi = 37 \cdot 2\pi = 74\pi$$

Answer: a) $N = 36.5$; b) $\Delta\phi = 74\pi$.