Ch 35: Interference of Electromagnetic Waves

•**8** In Fig. 35-33, two light pulses are sent through layers of plastic with thicknesses of either L or $2L$ as shown and indexes of refraction $n_1 = 1.55$, $n_2 = 1.70$, $n_3 = 1.60$, $n_4 = 1.45$, $n_5 = 1.59$, $n_6 = 1.65$, and $n_7 = 1.50$. (a) Which pulse travels through the plastic in less time? (b) What multiple of L/c gives the difference in the traversal times of the pulses?

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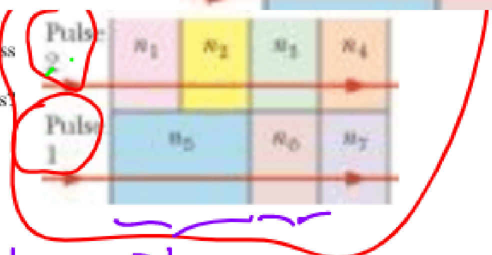

Pulse 1:

$$t_1 = \frac{2L}{c/n_5} + \frac{L}{c/n_6} + \frac{L}{c/n_7}$$

$$t_1 = \frac{L}{c}\left[2n_5 + n_6 + n_7\right]$$

$$= \frac{L}{c}(2 \times 1.59 + 1.65 + 1.5)$$

$$t_1 = 6.33\,\frac{L}{c}$$

ⓐ Pulse ②

ⓑ $\Delta t = t_2 - t_1 = 0.03\,\frac{L}{c}$

Pulse 2:

$$t_2 = \frac{L}{c/n_1} + \frac{L}{c/n_2} + \frac{L}{c/n_3} + \frac{L}{c/n_4}$$

$$t_2 = \frac{L}{c}\left[n_1 + n_2 + n_3 + n_4\right] = 6.3\,\frac{L}{c}$$

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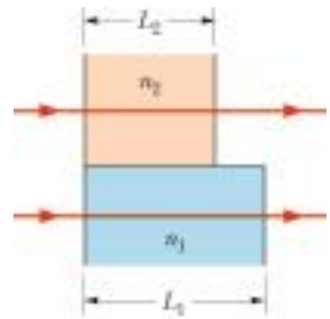
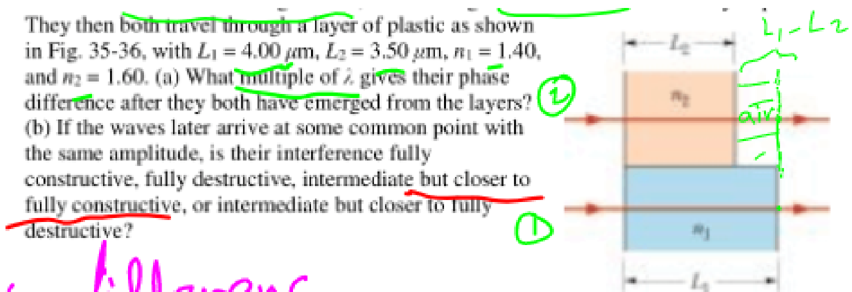
••13 GO ILW Two waves of light in air, of wavelength λ = 600.0 nm, are initially in phase. They then both travel through a layer of plastic as shown in Fig. 35-36, with L_1 = 4.00 μm, L_2 = 3.50 μm, n_1 = 1.40, and n_2 = 1.60. (a) What multiple of λ gives their phase difference after they both have emerged from the layers? (b) If the waves later arrive at some common point with the same amplitude, is their interference fully constructive, fully destructive, intermediate but closer to fully constructive, or intermediate but closer to fully destructive?





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(a) Phase difference

$$N_1 = \frac{L_1}{\lambda / n_1} = \frac{L_1 n_1}{\lambda} = \frac{4\times10^{-6}\times1.4}{600\times10^{-9}} = 9.333\lambda$$

$$N_2 = \frac{L_2}{\lambda / n_2} + \frac{(L_1 - L_2)}{\lambda / n_{air}}$$

$$N_2 = \frac{L_2 n_2}{\lambda} + \frac{(L_1 - L_2)}{\lambda} = 10.1667\lambda$$

Phase difference $= |N_1 - N_2| = 0.8333\lambda$

(b) Intermediate but closer to fully constructive

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•14 In a double-slit arrangement the slits are separated by a distance equal to 100 times the wavelength of the light passing through the slits. (a) What is the angular separation in radians between the central maximum and an adjacent maximum? (b) What is the distance between these maxima on a screen 50.0 cm from the slits?

$$d \sin\theta_m = m\lambda$$

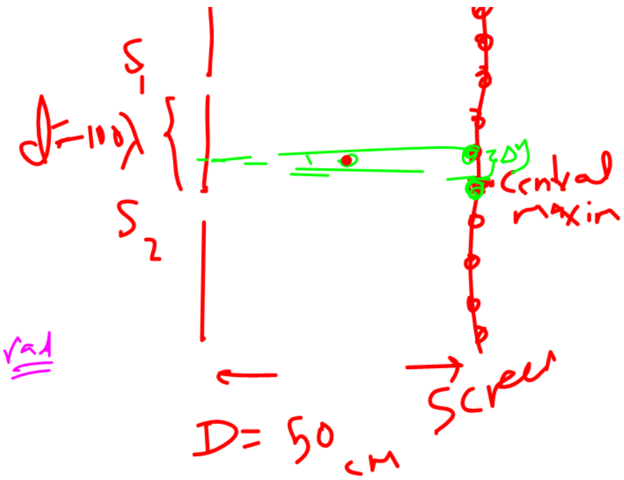
$$d \sin\theta_{m+1} = (m+1)\lambda$$

θ is small. $\sin\theta = \theta$, rad

$d\,\theta_m = m\lambda$

$d\,\theta_{m+1} = (m+1)\lambda$

$(\theta_{m+1} - \theta_m) = \frac{\lambda}{d}$



$(\theta_{m+1} - \theta_m) = \frac{\lambda}{d}$

$$\Delta\theta = \frac{\lambda}{d} = \frac{\lambda}{100\lambda} = \frac{1}{100} = 0.01 \text{ rad} \simeq 0.6^\circ$$

(b) sample problem.

$\tan\theta_m = \frac{y_m}{D} = \theta_m$

$\tan\theta_{m+1} = \frac{y_{m+1}}{D} = \theta_{m+1}$

$\Delta y = y_{m+1} - y_m$

$= D(\theta_{m+1} - \theta_m)$

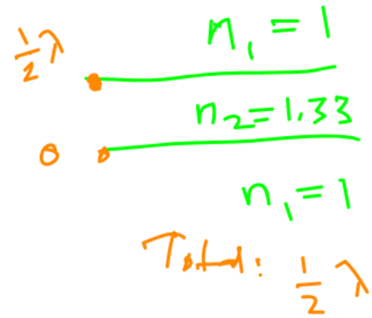
$= D\,\Delta\theta$

$= 50\text{ cm} \times 0.01\text{ rad} = 0.5\text{ cm}$

•39 ILW Light of wavelength 624 nm is incident perpendicularly on a soap film (n = 1.33) suspended in air. What are the (a) least and (b) second least thicknesses of the film for which the reflections from the film undergo fully constructive interference?

$2L = (m + \frac{1}{2})\frac{\lambda}{n_2}$ fully const.

$m = 0, 1, 2, \ldots$



$m = 0$

$2L = \frac{1}{2}\frac{\lambda}{n_2}$

$L = \frac{1}{4} \times \frac{624}{1.33}$ nm $= 117.3$ nm

$m = 1$ $\quad L = \frac{3}{4}\frac{\lambda}{n_2} = \frac{3}{4}\frac{624}{1.33} = 352$ nm.

11 Figure 35-28 shows four situations in which light reflects perpendicularly from a thin film of thickness L sandwiched between much thicker materials. The indexes of refraction are given. In which situations does Eq. 35-36 correspond to the reflections yielding maxima (that is, a bright film)?

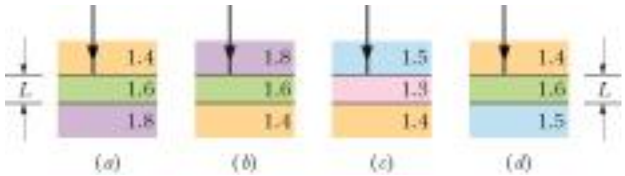


Figure 35-28 Question 11.

$$2L = \left(m + \tfrac{1}{2}\right)\frac{\lambda}{n_2}, \quad \text{for } m = 0, 1, 2, \ldots \quad \text{(maxima—bright film in air).} \quad (35\text{-}36)$$

Answer: c) and d) because there is half lambda difference from reflection