in air

$$0.95/\lambda_0 = 0.19 \times 10^7;$$

total 2,050,000 waves.

$$OPD = [(1.5)(0.05) + (1)(0.95)] - (1)(1),$$

$$OPD = 1.025 - 1.000 = 0.025 \text{ m},$$

$$\Lambda/\lambda_0 = 0.025/500 \text{ nm} = 5 \times 10^4 \text{ waves}.$$

7.6 $OPL_B = nx = (1.00)(100 \text{ cm}) = 100 \text{ cm} = 1.00 \text{ m}.$

$$OPL_A = \textstyle\sum_i n_i x_i = (1.00)(89 \text{ cm}) + 2(1.52)(0.5 \text{ cm}) + (1.33)(10 \text{ cm}) = 103.82 \text{ cm} = 1.0382 \text{ m}.$$

$$\Lambda = OPL_A - OPL_B = 1.0382 - 1.00 = .00382 \text{ m}.$$

(7.16) $\delta = k_0\Lambda = (2\pi/\lambda_0)\Lambda = 2\pi(3.82 \times 10^{-3} \text{ m})/5.00 \times 10^{-9} \text{ m} = 7.64 \times 10^6\pi.$

An integer multiple of 2π, so waves are in phase.

7.7 $E_1 = E_{01}\sin[\omega t - k(x + \Delta x)]$, so $\alpha_1 = -k(x + \Delta x)$. $E_2 = E_{01}\sin[\omega t - kx]$, so $\alpha_2 = -kx$.

(7.9)
$$\begin{aligned} E_0^2 &= E_{01}^2 + E_{02}^2 + 2E_{01}E_{02}\cos(\alpha_2 - \alpha_1) \\ &= E_{01}^2 + E_{01}^2 + 2E_{01}^2\cos(-kx - (-k(x + \Delta x))) = 2E_{01}^2(1 + \cos k\Delta x) \\ &= 2E_{01}^2(\cos(0) + \cos(k\Delta x)) = 4E_{01}^2\cos^2(k\Delta x/2), \end{aligned}$$

(see Problem 7.2),

$$E_0 = 2E_{01}\cos(k\Delta x/2).$$

(7.10)
$$\begin{aligned} \tan\alpha &= \frac{E_{01}\sin\alpha_1 + E_{02}\sin\alpha_2}{E_{01}\cos\alpha_1 + E_{02}\cos\alpha_2} \\ &= \frac{E_{01}\sin(-k(x + \Delta x) + E_{01}\sin(-kx))}{E_{01}\cos(-k(x + \Delta x)) + E_{01}\cos(-kx)} \end{aligned}$$

$$= \frac{2\sin\frac{1}{2}(-k(x+\Delta x)-kx)\cos\frac{1}{2}(-k(x+\Delta x)+kx)}{2\cos\frac{1}{2}(-k(x+\Delta x)-kx)\cos\frac{1}{2}(-k(x+\Delta x)+kx)}$$

$$= \tan(-kx-(k\Delta x/2)), \qquad \alpha = -k(x+(\Delta x/2)).$$

7.8 $E = E_1 + E_2 = E_{01}\{\sin[\omega t - k(x+\Delta x)] + \sin(\omega t - kx)\}$. Since

$$\sin\beta + \sin\gamma = 2\sin(1/2)(\beta+\gamma)\cos(1/2)(\beta-\gamma),$$

$$E = 2E_{01}\cos(k\Delta x/2)\sin[\omega t - k(x+\Delta x/2)].$$

7.9 $E = E_0\,\mathrm{Re}[e^{i(kx+\omega t)} - e^{i(kx-\omega t)}] = E_0\,\mathrm{Re}[e^{ikx}2i\sin\omega t]$

$= E_0\,\mathrm{Re}[2i\cos kx\sin\omega t - 2\sin kx\sin\omega t] = -2E_0\sin kx\sin\omega t.$

Standing wave with node at $x = 0$.

7.10 $E_i = 3\cos wt = 3\angle 0$, $(\alpha_1 = 0)$. $E_2 = 4\sin wt$, but $\sin\theta = \cos(\theta - \pi/2)$, so

$$E_2 = 4\cos(wt - \pi/2) = 4\angle - \pi/2. \qquad E_3 = E_1 + E_1.$$

$$E_{3o}^2 = E_{01}^2 + E_{02}^2 + 2E_{01}E_{02}\cos(\alpha_2 - \alpha_1)$$

$$= 9 + 16 + 2(3)(4)\cos(-\pi/2), E_{3o} = 5.$$

$$(7.10) \quad \tan\alpha = (E_{01}\sin\alpha_1 + E_{02}\sin\alpha_2)/(E_{01}\cos\alpha_1 + E_{02}\cos\alpha_2)$$

$$= (3(0) + 4(-1))/(3(1) + 4(0)) = -4/3; \qquad \alpha = -53^\circ,$$

so $\varphi = 53^\circ = 0.93$ rad. Note that $\alpha_1 < \varphi$, so E_1 leads E_3.

7.11 By Faraday's law, $\partial E/\partial x = -\partial B/\partial x$. Integrate to get

$$B(x,t) = -\int(\partial E/\partial x)\,dt = -2E_0k\cos kx\int\cos\omega t\,dt$$

$$= -2E_0(k/\omega)\cos kx\sin\omega t.$$

But $E_0k/\omega = E_0/c = B_0$; thus $B(x,t) = -2B_0\cos kx\sin\omega t$.

7.12 Fringes are spaces $\lambda/2$ vertically.

$$\sin\theta = \text{(fringes/cm) vertical/(fringes/cm) on film;}$$

7.38 By analogy with Eq. (7.61), $A(\omega) = (\Delta t/2)E_0 \operatorname{sinc}(\omega_p - \omega)\Delta t/2$. From Table 1, $\operatorname{sinc}(\pi/2) = 63.7\%$. Not quite 50% actually, $\operatorname{sinc}(\pi/1.65) = 49.8\%$. $|(\omega_p - \omega)\Delta t/2| < \pi/2$ or $-\pi/\Delta t < \omega_p - \omega < \pi/\Delta t$; thus appreciable values of $A(\omega)$ lie in a range $\Delta\omega \sim 2\pi/\Delta t$ and $\Delta\nu\Delta t \sim 1$. Irradiance is proportional to $A^2(\omega)$, and $[\operatorname{sinc}(\pi/2)]^2 = 40.6\%$.

7.39 $\Delta x_c = c\Delta t_c$, $\Delta x_c \sim c/\Delta\nu$. But $\Delta\omega/\Delta k_0 = \bar{\omega}/\bar{k}_0 = c$; thus $|\Delta\nu/\Delta\lambda_0| = \bar{\nu}/\bar{\lambda}_0$, $\Delta x_c \sim c\bar{\lambda}_0/\Delta\lambda_0\bar{\nu}$, $\Delta x_c \sim \bar{\lambda}_0^2/\Delta\lambda_0$. Or try using the uncertainty principle: $\Delta x \sim h/\Delta p$ where $p = h/\lambda$ and $\Delta\lambda_0 \ll \bar{\lambda}_0$.

7.40

$$\Delta x_c = c\Delta t_c = 3 \times 10^8 \text{ m/s} 10^{-8} \text{s} = 3 \text{ m}.$$

$$\Delta\lambda_0 \sim \lambda_0^2/\Delta x_c = (500 \times 10^{-9} \text{ m})^2/3 \text{ m},$$

$$\Delta\lambda_0 \sim 8.3 \times 10^{-14} \text{ m} = 8.3 \times 10^{-5} \text{ nm},$$

$$\Delta\lambda_0/\bar{\lambda}_0 = \Delta\nu/\bar{\nu} = 8.3 \times 10^{-5}/500 = 1.6 \times 10^{-7} \sim 1 \text{ part in } 10^7.$$

7.41 $\Delta\nu = 54 \times 10^3$ Hz; $\Delta\nu/\bar{\nu} = (54 \times 10^3)(10,600 \times 10^{-9} \text{ m})/(3 \times 10^8 \text{m/s})$ $= 1.91 \times 10^{-9}$. $\Delta x_c = c\Delta t_c \sim c/\Delta\nu, \Delta x_c \sim (3 \times 10^8)/(54 \times 10^3)$ $= 5.55 \times 10^3$ m.

7.42 $\Delta\nu/\nu = 2/10^{10}$; $c = \nu\lambda$, so

$$\nu = c/\lambda = 3 \times 10^8 \text{ m/s}/632.8 \times 10^{-9} \text{ m} = 4.74 \times 10^{14} \text{ Hz}.$$

$$(7.64) \quad \Delta\ell_c = c\Delta t_c.$$

Frequency range is $\pm 2(4.74 \times 10^4 \text{ Hz})$ or 9.48×10^4 Hz, so

$$\Delta t \simeq 1.05 \times 10^{-5} \text{ s}. \quad \Delta\ell_c = (3 \times 10^8 \text{ m/s})(1.05 \times 10^{-5} \text{ s}) = 3.15 \times 10^3 \text{ m}.$$

7.43 $\Delta x_c = c\Delta t_c = 3 \times 10^8 \times 10^{-10} = 3 \times 10^{-2}$ m, $\Delta\nu \sim 1/\Delta t_c = 10^{10}$ Hz, $\Delta\lambda_0 \sim \bar{\lambda}_0^2/\Delta x_c$ (see Problem 7.35),

7.38 By analogy with Eq. (7.61), $A(\omega) = (\Delta t/2)E_0 \operatorname{sinc}(\omega_p - \omega)\Delta t/2$. From Table 1, $\operatorname{sinc}(\pi/2) = 63.7\%$. Not quite 50% actually, $\operatorname{sinc}(\pi/1.65) = 49.8\%$. $|(\omega_p - \omega)\Delta t/2| < \pi/2$ or $-\pi/\Delta t < \omega_p - \omega < \pi/\Delta t$; thus appreciable values of $A(\omega)$ lie in a range $\Delta\omega \sim 2\pi/\Delta t$ and $\Delta\nu\Delta t \sim 1$. Irradiance is proportional to $A^2(\omega)$, and $[\operatorname{sinc}(\pi/2)]^2 = 40.6\%$.

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