$$= \frac{2\cos\theta_i \sin\theta_t}{\sin(\theta_t+\theta_i)\cos(\theta_i-\theta_t)}$$

$$\Gamma_\perp = \frac{\frac{1}{\sqrt{\varepsilon_{r2}}}\cos\theta_i - \frac{1}{\sqrt{\varepsilon_{r1}}}\cos\theta_t}{\frac{1}{\sqrt{\varepsilon_{r2}}}\cos\theta_i + \frac{1}{\sqrt{\varepsilon_{r1}}}\cos\theta_t} = \frac{\cos\theta_i - \frac{\sin\theta_t}{\sin\theta_i}\cos\theta_t}{\cos\theta_i + \frac{\sin\theta_t}{\sin\theta_i}\cos\theta_t} = \frac{\sin(\theta_t-\theta_i)}{\sin(\theta_t+\theta_i)}$$

$$\tau_\perp = \frac{\frac{2}{\sqrt{\varepsilon_{r2}}}\cos\theta_i}{\frac{1}{\sqrt{\varepsilon_{r2}}}\cos\theta_i + \frac{1}{\sqrt{\varepsilon_{r1}}}\cos\theta_t} = \frac{2\cos\theta_i}{\cos\theta_i + \frac{\sin\theta_t}{\sin\theta_i}\cos\theta_t} = \frac{2\cos\theta_i \sin\theta_t}{\sin(\theta_t+\theta_i)}$$

Prob. 10.72

(a) $n_1 = 1, \quad n_2 = c\sqrt{\mu_2\varepsilon_2} = c\sqrt{6.4\varepsilon_o \times \mu_o} = \sqrt{6.4} = 2.5298$

$$\sin\theta_t = \frac{n_1}{n_2}\sin\theta_i = \frac{1}{2.5298}\sin 12^o = 0.082185 \longrightarrow \theta_t = 4.714^o$$

$$\eta_1 = 120\pi, \qquad \eta_2 = 120\pi\sqrt{\frac{1}{6.4}} = 47.43\pi$$

$$\frac{E_{ro}}{E_{io}} = \Gamma = \frac{\eta_2\cos\theta_t - \eta_1\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i} = \frac{47.43\pi\cos 4.714^o - 120\pi\cos 12^o}{47.43\pi\cos 4.714^o + 120\pi\cos 12^o}$$

$$= \frac{47.27 - 117.38}{47.27 + 117.38} = \underline{\underline{-0.4258}}$$

$$\frac{E_{to}}{E_{io}} = \tau = \frac{2\eta_2\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i} = \frac{2x47.43\cos 12^o}{47.27 + 117.33} = \frac{92.787}{164.65} = \underline{\underline{0.5635}}$$

Prob. 10.73

(a) $k_i = 4a_y + 3a_z$

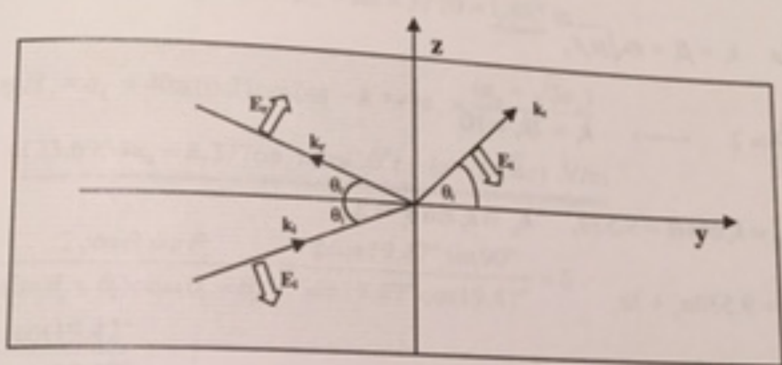
$k_i \bullet a_y = k_i \cos\theta_i \quad \longrightarrow \quad \cos\theta_i = 4/5 \quad \longrightarrow \quad \underline{\theta_i = 36.87^\circ}$

(b)

$$P_{ave} = \frac{1}{2}\text{Re}(E_s \times H_s^*) = \frac{E_o^2}{2\eta}a_k = \frac{(\sqrt{8^2+6^2})^2}{2\times 120\pi}\frac{(4a_y+3a_z)}{5} = \underline{106.1a_y + 79.58a_z \text{ mW/m}^2}$$

(c) $\theta_r = \theta_i = 36.87^\circ$. Let

$$E_r = (E_{ry}a_y + E_{rz}a_z)\sin(\omega t - k_r \bullet r)$$



From the figure, $k_r = k_{rz}a_z - k_{ry}a_y$. But $k_r = k_i = 5$

$$k_{rz} = k_r \sin\theta_r = 5(3/5) = 3, \quad k_{ry} = k_r \cos\theta_r = 5(4/5) = 4,$$

Hence, $k_r = -4a_y + 3a_z$

$$\sin\theta_t = \frac{n_1}{n_2}\sin\theta_i = \frac{c\sqrt{\mu_1\varepsilon_1}}{c\sqrt{\mu_2\varepsilon_2}}\sin\theta_i = \frac{3/5}{\sqrt{4}} = 0.3$$

$\theta_t = 17.46, \quad \cos\theta_t = 0.9539, \quad \eta_1 = \eta_o = 120\pi, \eta_2 = \eta_o/2 = 60\pi$

$$\Gamma_{//} = \frac{E_{ro}}{E_{io}} = \frac{\eta_2\cos\theta_t - \eta_1\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i} = \frac{\frac{\eta_o}{2}(0.9539) - \eta_o(0.8)}{\frac{\eta_o}{2}(0.9539) + \eta_o(0.8)} = -0.253$$

$$E_{ro} = \Gamma_{//}E_{io} = -0.253(10) = -2.53$$

But $(E_{ry}\boldsymbol{a}_y + E_{rz}\boldsymbol{a}_z) = E_{ro}(\sin\theta_r\boldsymbol{a}_y + \cos\theta_r\boldsymbol{a}_z) = -2.53(\frac{3}{5}\boldsymbol{a}_y + \frac{4}{5}\boldsymbol{a}_z)$

$$\underline{\boldsymbol{E}_r = -(1.518\boldsymbol{a}_y + 2.024\boldsymbol{a}_z)\sin(\omega t + 4y - 3z)}\ \text{V/m}$$

Similarly, let

$$\boldsymbol{E}_t = (E_{ty}\boldsymbol{a}_y + E_{tz}\boldsymbol{a}_z)\sin(\omega t - \boldsymbol{k}_t \bullet \boldsymbol{r})$$

$$k_t = \beta_2 = \omega\sqrt{\mu_2\varepsilon_2} = \omega\sqrt{4\mu_o\varepsilon_o}$$

But $k_i = \beta_1 = \omega\sqrt{\mu_o\varepsilon_o}$

$$\frac{k_t}{k_i} = 2 \quad \longrightarrow \quad k_t = 2k_i = 10$$

$$k_{ty} = k_t\cos\theta_t = 9.539, \qquad k_{tz} = k_t\sin\theta_t = 3,$$

$$k_t = 9.539a_y + 3a_z$$

Note that $k_{iz} = k_{rz} = k_{tz} = 3$

$$\tau_{\parallel} = \frac{E_{to}}{E_{io}} = \frac{2\eta_2\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i} = \frac{\eta_o(0.8)}{\frac{\eta_o}{2}(0.9539) + \eta_o(0.8)} = 0.6265$$

$$E_{to} = \tau_{\parallel}E_{io} = 6.265$$

But

$$(E_{ty}\boldsymbol{a}_y + E_{tz}\boldsymbol{a}_z) = E_{to}(\sin\theta_t\boldsymbol{a}_y - \cos\theta_t\boldsymbol{a}_z) = 6.256(0.3\boldsymbol{a}_y - 0.9539\boldsymbol{a}_z)$$

Hence,

$$\underline{\boldsymbol{E}_t = (1.879\boldsymbol{a}_y - 5.968\boldsymbol{a}_z)\sin(\omega t - 9.539y - 3z)}\ \text{V/m}$$

Prob. 10.74

(a)

$\tan\theta_i = \frac{k_{ix}}{k_{iz}} = \frac{1}{\sqrt{8}} \longrightarrow \underline{\theta_i = \theta_r = 19.47^\circ}$

$\sin\theta_t = \sin\theta_i\sqrt{\frac{\varepsilon_{r1}}{\varepsilon_{r2}}} = \frac{1}{3}(3) = 1 \longrightarrow \underline{\theta_t = 90^\circ}$

(b) $\beta_1 = \frac{\omega}{c}\sqrt{\varepsilon_{r1}} = \frac{10^9}{3\times10^8}\times3 = 10 = k\sqrt{1+8} = 3k \longrightarrow \underline{k = 3.333}$

(c) $\lambda = 2\pi/\beta, \quad \lambda_1 = 2\pi/\beta_1 = 2\pi/10 = \underline{0.6283}\,\text{m}$

$\beta_2 = \omega/c = 10/3, \quad \lambda_2 = 2\pi/\beta_2 = 2\pi\times3/10 = \underline{1.885}\,\text{m}$

(d)

$$E_i = \eta_1 H_x \times a_k = 40\pi(0.2)\cos(\omega t - k\bullet r)a_y \times \frac{(a_x + \sqrt{8}a_z)}{3}$$

$$= \underline{(23.6954a_x - 8.3776a_z)\cos(10^9 t - kx - k\sqrt{8}z)\ \text{V/m}}$$

(e) $\tau_{//} = \frac{2\cos\theta_i\sin\theta_t}{\sin(\theta_i+\theta_t)\cos(\theta_t-\theta_i)} = \frac{2\cos19.47^\circ\sin90^\circ}{\sin19.47^\circ\cos19.47^\circ} = 6$

$\Gamma_{//} = -\frac{\cot19.47^\circ}{\cot19.47^\circ} = -1$

Let $E_t = -E_{to}(\cos\theta_t a_x - \sin\theta_t a_z)\cos(10^9 t - \beta_2 x\sin\theta_t - \beta_2 z\cos\theta_t)$

where

$E_i = -E_{io}(\cos\theta_i a_x - \sin\theta_i a_z)\cos(10^9 t - \beta_1 x\sin\theta_i - \beta_1 z\cos\theta_i)$

$\sin\theta_t = 1, \quad \cos\theta_t = 0, \quad \beta_2\sin\theta_t = 10/3$

$E_{to}\sin\theta_t = \tau_{\backslash\backslash}E_{io} = 6(24\pi)(3)(1) = 1357.2$

Hence,

$E_t = 1357\cos(10^9 t - 3.333x)a_z$ V/m

Since $\Gamma = -1, \quad \theta_r = \theta_i$

$\underline{E_r = (213.3a_x + 75.4a_z)\cos(10^9 t - kx + k\sqrt{8}z)}$ V/m

(f) $\tan\theta_{B//} = \sqrt{\frac{\varepsilon_2}{\varepsilon_1}} = \sqrt{\frac{\varepsilon_o}{9\varepsilon_o}} = 1/3 \longrightarrow \underline{\underline{\theta_{B//} = 18.43^o}}$

Prob. 10.75

(a) From air to seawater,

$\varepsilon_{r1} = 1, \quad \varepsilon_{r2} = 81$

$\tan\theta_B = \sqrt{\frac{\varepsilon_2}{\varepsilon_1}} = \sqrt{\frac{81}{1}} = 9 \longrightarrow \underline{\underline{\theta_B = 83.66^o}}$

(b) From seawater to air,

$\varepsilon_{r1} = 81, \quad \varepsilon_{r2} = 1$

$\tan\theta_B = \sqrt{\frac{\varepsilon_2}{\varepsilon_1}} = \sqrt{\frac{1}{81}} = \frac{1}{9} \longrightarrow \underline{\underline{\theta_B = 6.34^o}}$

Prob. 10.76

(a) $n = \frac{c}{u} = \sqrt{\mu_r\varepsilon_r} = \sqrt{2.1\times 1} = \underline{\underline{1.45}}$

(b) $n = \sqrt{\mu_r\varepsilon_r} = \sqrt{1\times 81} = \underline{\underline{9}}$

(c) $n = \sqrt{\varepsilon_r} = \sqrt{2.7} = \underline{\underline{1.643}}$

Prob.10.77

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