Prob. 1

$$\underline{E} = -\hat{\underline{y}} E_0 e^{-jk_z z} \qquad k_z = k_1 = k_0\sqrt{\epsilon_r}$$

$$\boxed{\underline{H} = +\hat{\underline{x}} \frac{E_0}{\eta_1} e^{-jk_1 z}} \qquad \eta_1 = \frac{\eta_0}{\sqrt{\epsilon_r}}$$

$$\underline{J_s} = \hat{\underline{n}} \times \underline{H} = -\hat{\underline{y}} \times \underline{H} = \hat{\underline{z}} H_x$$

$$= \frac{E_0}{\eta_1} e^{-jk_1 z} \quad [A/m]$$

$$\boxed{I = \frac{E_0 W}{\eta_1} e^{-jk_1 z} \quad [A]}$$

$$V = -E_y h = E_0 h e^{-jk_1 z}$$

$$Z_0 = \frac{V}{I}$$

$$\boxed{Z_0 = \eta_1 \frac{h}{W} \quad [\Omega]}$$

$$\alpha_c = \frac{R_s}{2 Z_0 |I|^2} \oint_c |\underline{H}_t|^2 \, dl$$

$$= \frac{2 R_s}{2 Z_0 |I|^2} \oint_{c_+} |\underline{H}_t|^2 \, dl$$

$$= \frac{2 R_s}{2 Z_0 |I|^2} |H_x|^2 \, W$$

$$= \frac{\cancel{2} R_s}{\cancel{2} \left(\frac{\eta_1 h}{W}\right) \left(\frac{E_0 W}{\eta_1}\right)^2} \left(\frac{E_0}{\eta_1}\right)^2 W$$

$$\boxed{\alpha_c = \frac{R_s}{\eta_1 h} \quad [\text{nepers/m}]}$$

Prob. 2

$$\underline{E} = \hat{\underline{z}}\, E_0 \cos\left(\frac{\pi x}{L}\right)$$

$$\underline{H} = -\frac{1}{j\omega\mu}\,\nabla \times \underline{E}$$

$$= -\frac{1}{j\omega\mu}\left[\hat{\underline{x}}\,\cancel{\frac{\partial E_z}{\partial y}} - \hat{\underline{y}}\,\frac{\partial E_z}{\partial x}\right]$$

$$= \hat{\underline{y}}\left(\frac{1}{j\omega\mu}\right)\frac{\partial E_z}{\partial x}.$$

Hence

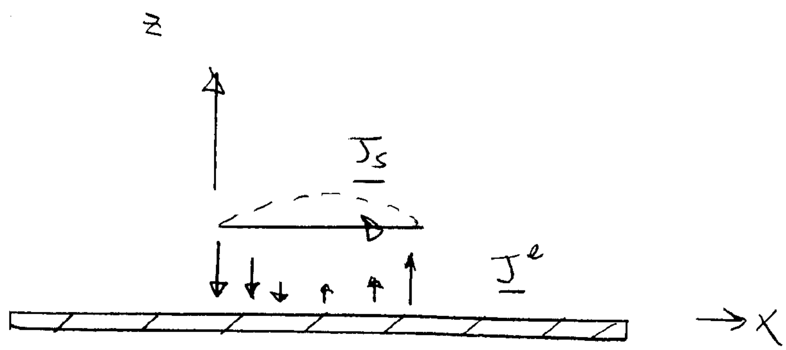
$$\underline{H} = -\hat{\underline{y}}\left(\frac{1}{j\omega\mu}\right)\left(\frac{\pi}{L}\right)E_0 \sin\left(\frac{\pi x}{L}\right)$$

$$\underline{J}_s = \hat{\underline{n}} \times \underline{H} = -\hat{\underline{z}} \times \underline{H} = \hat{\underline{x}}\, H_y$$

$$\boxed{\underline{J}_s = -\hat{\underline{x}}\left(\frac{\pi E_0}{j\omega\mu L}\right)\sin\left(\frac{\pi x}{L}\right)}$$

$\underline{J}^e = j\omega\epsilon_0(\epsilon_r^c - 1)\,\underline{E}$ inside substrate

$$\boxed{\underline{J}^e = \underline{\hat{z}}\,(j\omega\epsilon_0)\,(\epsilon_r^c - 1)\,E_0\cos\left(\frac{\pi x}{L}\right) \quad [A/m^2]}$$



Prob. 3

$$Z_0^A = \sqrt{\frac{L^A}{C^A}}$$

$$Z_0 = \sqrt{\frac{j\omega L}{G + j\omega C}} = \sqrt{\frac{j\omega L^A}{G + j\omega C}}$$

$$= \sqrt{\frac{j\omega L^A}{C\left(\frac{\omega \epsilon''}{\epsilon'}\right) + j\omega C}} = \sqrt{\frac{j\omega L^A}{C^A(\epsilon_r')\left[j\omega + \frac{\omega \epsilon''}{\epsilon'}\right]}}$$

$$Z_0 = \sqrt{\frac{L^A}{C^A}} \left[\frac{1}{\epsilon_r'\left[1 - j\frac{\epsilon''}{\epsilon'}\right]}\right]^{1/2}$$

Hence

$$\boxed{Z_0 = Z_0^A \frac{1}{\sqrt{\epsilon_r'}} \left(\frac{1}{\sqrt{1 - j\epsilon_r''/\epsilon_r'}}\right)}$$

Prob. 4

$$\gamma^2 = ZY = \left(\frac{1}{j\omega C_2}\frac{1}{\Delta L}\right)\left(j\omega C_1 \frac{1}{\Delta L}\right)$$

$$= \frac{C_1}{C_2}\left(\frac{1}{\Delta L}\right)^2$$

or

$$\gamma \Delta L = \sqrt{\frac{C_1}{C_2}} \, ,$$

Hence

$$\boxed{\begin{aligned} \beta &= 0 \\ \alpha &= \frac{1}{\Delta L}\sqrt{\frac{C_1}{C_2}} \end{aligned}}$$

$$20 \log_{10} e^{-\alpha (n\Delta L)} = -100$$

$$n\,(\alpha \Delta L) = 11.513$$

$$n\sqrt{\frac{C_1}{C_2}} = 11.513$$

$$\boxed{n \geq 12}$$