Prob. 10.2

(a) $\lambda = \frac{c}{f} = \frac{3\times10^8}{60} = \underline{\underline{5\times10^6 \text{ m}}}$

(b) $\lambda = \frac{3\times10^8}{2\times10^6} = \underline{\underline{150 \text{ m}}}$

(c) $\lambda = \frac{3\times10^8}{120\times10^6} = \underline{\underline{2.5 \text{ m}}}$

(d) $\lambda = \frac{3\times10^8}{2.4\times10^9} = \underline{\underline{0.125 \text{ m}}}$

Prob. 10.3

(a) $\omega = \underline{\underline{10^8 \text{ rad/s}}}$

(b) $\beta = \frac{\omega}{c} = \frac{10^8}{3\times10^8} = \underline{\underline{0.333 \text{ rad/m}}}$

(c) $\lambda = \frac{2\pi}{\beta} = 6\pi = \underline{\underline{18.85 \text{ m}}}$

(d) Along $-\mathbf{a}_y$

At y=1, t=10ms,

(e) $H = 0.5\cos(10^8 t\times10\times10^{-9} + \frac{1}{3}\times3) = 0.5\cos(1+1)$

$= \underline{\underline{-0.1665 \text{ A/m}}}$

$\eta = \dfrac{\quad}{\gamma}$

(c) From (b),

$$\eta = \frac{j\omega\mu}{\sqrt{j\omega\mu(\sigma + j\omega\varepsilon)}} = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}} = \frac{\sqrt{\mu / \varepsilon}}{\sqrt{1 - j\dfrac{\sigma}{\omega\varepsilon}}}$$

$$|\eta| = \frac{\sqrt{\mu / \varepsilon}}{\sqrt[4]{1 + \left(\dfrac{\sigma}{\omega\varepsilon}\right)^2}}, \tan 2\theta_\eta = \left(\frac{\omega\varepsilon}{\sigma}\right)^{-1} = \frac{\sigma}{\omega\varepsilon}$$

Prob. 10.6 (a)

$$\frac{\sigma}{\omega\varepsilon} = \frac{8 \times 10^{-2}}{2\pi \times 50 \times 10^6 \times 3.6 \times \dfrac{10^{-9}}{36\pi}} = 8$$

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} - 1\right]} = \frac{2\pi \times 50 \times 10^6}{3 \times 10^8}\sqrt{\frac{2.1 \times 3.6}{2}[\sqrt{65} - 1]} = 5.41$$

$$\beta = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1 + \left(\frac{\sigma}{\omega\varepsilon}\right)^2} + 1\right]} = 6.129$$

$$\gamma = \alpha + j\beta = \underline{\underline{5.41 + j6.129}} \text{ /m}$$

(b) $\lambda = \dfrac{2\pi}{\beta} = \dfrac{2\pi}{6.129} = \underline{\underline{1.025}}\text{ m}$

(c) $u = \dfrac{\omega}{\beta} = \dfrac{2\pi\times 50\times 10^6}{6.129} = \underline{\underline{5.125\times 10^7}}$ m/s

(d) $|\eta| = \dfrac{\sqrt{\dfrac{\mu}{\varepsilon}}}{\sqrt[4]{1+\left(\dfrac{\sigma}{\omega\varepsilon}\right)^2}} = \dfrac{120\pi\sqrt{\dfrac{2.1}{3.6}}}{\sqrt[4]{65}} = 101.4$

$$\tan 2\theta_\eta = \frac{\sigma}{\omega\varepsilon} = 8 \longrightarrow \theta_\eta = 41.44^\circ$$

$$\eta = \underline{\underline{101.41\angle 41.44^\circ\,\Omega}}$$

(e) $\boldsymbol{H}_s = \boldsymbol{a}_k \times \dfrac{\boldsymbol{E}_s}{\eta} = \boldsymbol{a}_x \times \dfrac{6}{\eta} e^{-\gamma z}\boldsymbol{a}_z = -\dfrac{6}{\eta} e^{-\gamma z}\boldsymbol{a}_y = \underline{\underline{-59.16 e^{-j41.44^\circ} e^{-\gamma z}\boldsymbol{a}_y}}$ mA/m

Prob. 10.7

(a) $\tan\theta = \dfrac{\sigma}{\omega\varepsilon} = \dfrac{10^{-2}}{2\pi\times 12\times 10^6\times 10\times\dfrac{10^{-9}}{36\pi}} = \underline{\underline{1.5}}$

(b) $\tan\theta = \dfrac{10^{-4}}{2\pi\times 12\times 10^6\times 4\times\dfrac{10^{-9}}{36\pi}} = \underline{\underline{3.75\times 10^{-2}}}$

(c) $\tan\theta = \dfrac{4}{2\pi\times 12\times 10^6\times 81\times\dfrac{10^{-9}}{36\pi}} = \underline{\underline{74.07}}$

Prob. 10.43

(a)

Let $H_s = \frac{H_o}{r}\sin\theta e^{-j3r}\boldsymbol{a}_H$

$$H_o = \frac{E_o}{\eta_o} = \frac{10}{120\pi} = \frac{1}{12\pi}$$

$$\boldsymbol{a}_H = \boldsymbol{a}_k \times \boldsymbol{a}_E = \boldsymbol{a}_r \times \boldsymbol{a}_\theta = \boldsymbol{a}_\phi$$

$$\underline{\underline{\boldsymbol{H}_s = \frac{1}{12\pi r}\sin\theta e^{-j3r}\boldsymbol{a}_\phi \text{ A/m}}}$$

(b)

$$\mathcal{P}_{ave} = \frac{1}{2}\mathrm{Re}(\boldsymbol{E}_s \times \boldsymbol{H}_s) = \frac{10}{2\times 12\pi r^2}\sin^2\theta \boldsymbol{a}_r$$

$$P_{ave} = \int_S \mathcal{P}_{ave} \bullet d\boldsymbol{S}, \qquad d\boldsymbol{S} = r^2\sin\theta d\theta d\phi \boldsymbol{a}_r$$

$$P_{ave} = \frac{10}{24\pi}\int_{\phi=0}^{\pi}\int_{\theta=0}^{\pi/6} r^2\sin^3\theta d\theta \Big|_{r=2} = \frac{5}{8} - \frac{5\sqrt{3}}{32} = 0.007145$$

$$= \underline{\underline{7.145 \text{ mW}}}$$

Prob. 10.44

(a) $P_{ave} = \frac{1}{2}\mathrm{Re}(E_s H_s^*) = \frac{1}{2}\mathrm{Re}\left(\frac{|E_s|}{|\eta|}\right) = \frac{8^2}{2|\eta|}e^{-0.2z}$

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left[\sqrt{1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2} - 1\right]}$$

$P_{ave} = \frac{1}{T}\int_0^T ... \underline{\underline{\frac{...}{2\eta r^2}\sin\theta \mathbf{a}_r}}$

Prob. 10.47

$$\beta = \frac{\omega}{c} \longrightarrow \omega = \beta c = 40(3\times10^8) = \underline{\underline{12\times10^9 \text{ rad/s}}}$$

$$E = \frac{1}{\varepsilon}\int \nabla\times H dt$$

$$\nabla\times H = \begin{vmatrix} \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & 10\sin(\omega t - 40x) & -20\sin(\omega t - 40x) \end{vmatrix}$$

$$= -800\cos(\omega t - 40x)\mathbf{a}_y - 400\cos(\omega t - 40x)\mathbf{a}_z$$

$$E = \frac{1}{\varepsilon}\int \nabla\times H dt = -\frac{800}{\omega\varepsilon}\sin(\omega t - 40x)\mathbf{a}_y - \frac{400}{\omega\varepsilon}\sin(\omega t - 40x)\mathbf{a}_z$$

$$= -\frac{800}{12\times10^9\times\frac{10^{-9}}{36\pi}}\sin(\omega t - 40x)\mathbf{a}_y - \frac{400}{12\times10^9\times\frac{10^{-9}}{36\pi}}\sin(\omega t - 40x)\mathbf{a}_z$$

$$\underline{\underline{= -7.539\sin(\omega t - 40x)\mathbf{a}_y - 3.77\sin(\omega t - 40x)\mathbf{a}_z \text{ kV/m}}}$$

$$P = E\times H = \begin{vmatrix} 0 & E_y & E_z \\ 0 & H_y & H_z \end{vmatrix} = (E_y H_z - E_z H_y)\mathbf{a}_x$$

$$= \left[20(7.537)\sin^2(\omega t - 40x) + 37.7\sin^2(\omega t - 40x)\right]\mathbf{a}_x 10^3$$

$$P_{ave} = \frac{1}{2}[20(7.537) + 37.7]\mathbf{a}_x 10^3 = \underline{\underline{94.23\mathbf{a}_x \text{ kW/m}^2}}$$

Prob. 10.48