Prob. 9.2

$$V_{emf} = -\frac{\partial \psi}{\partial t} = -\frac{\partial}{\partial t}\iint \boldsymbol{B} \bullet d\boldsymbol{S} = -\iint \frac{\partial \boldsymbol{B}}{\partial t} \bullet dxdy\boldsymbol{a}_z$$

$\vec{B} = 40\cos(30\pi t - 3y)\vec{a}_z \times 10^{-3}$

$$= \int_{y=0}^{0.1}\int_{x=0}^{0.8} 30\pi \times 40\sin(30\pi t - 3y)dxdy \text{ mV}$$

$$= 1200\pi \int_0^{0.8} dx \int_0^{0.1} \sin(30\pi t - 3y)dy$$

$$= 1200\pi(0.8)\left(-\frac{1}{-3}\cos(30\pi t - 3y)\Big|_0^{0.1}\right)$$

$$= 320\pi\left[\cos(30\pi t - 0.3) - \cos(30\pi t)\right] \text{ mV}$$

$\cos(A-B) - \cos(A+B)$
$= 2\sin A \sin B$

$$I = \frac{V_{emf}}{R} = \frac{V_{emf}}{10+4} = \frac{320\pi}{14}\left[-2\sin(30\pi t - 0.15)\sin(-0.15)\right]$$

$$= 143.62\sin(30\pi t - 0.15)\sin(0.15)$$

$$I = \underline{\underline{21.46\sin(30\pi t - 0.15) \text{ mA}}}$$

Prob. 9.6

$$\boldsymbol{B} = \frac{\mu_o I}{2\pi y}(-\boldsymbol{a}_x)$$

$$\psi = \int \boldsymbol{B} \bullet d\boldsymbol{S} = \frac{\mu_o I}{2\pi}\int_{z=0}^{a}\int_{y=\rho}^{\rho+a} \frac{dzdy}{y} = \frac{\mu_o Ia}{2\pi}\ln\frac{\rho+a}{\rho}$$

$$V_{emf} = -\frac{\partial \psi}{\partial t} = -\frac{\partial \psi}{\partial \rho} \bullet \frac{\partial \rho}{\partial t} = -\frac{\mu_o Ia}{2\pi} u_o \frac{d}{d\rho}[\ln(\rho+a) - \ln\rho]$$

$$= -\frac{\mu_o Ia}{2\pi}u_o\left[\frac{1}{\rho+a} - \frac{1}{\rho}\right] = \underline{\underline{\frac{\mu_o a^2 I u_o}{2\pi\rho(\rho+a)}}}$$

where $\rho = \rho_o + u_o t$

Prob. 9.16

$$J_c = \sigma E, \qquad J_d = \frac{\partial D}{\partial t} = \varepsilon\frac{\partial E}{\partial t}$$

$$|J_c| = \sigma|E|, \qquad |J_d| = \varepsilon\omega|E|$$

If $I_c = I_d$, then $|J_c| = |J_d| \longrightarrow \sigma = \varepsilon\omega$

$$\omega = 2\pi f = \frac{\sigma}{\varepsilon}$$

$$f = \frac{\sigma}{2\pi\varepsilon} = \frac{4}{2\pi \times 9 \times \frac{10^{-9}}{36\pi}} = \underline{\underline{8 \text{ GHz}}}$$

Prob. 9.26

$$\nabla\times\boldsymbol{H}=\boldsymbol{J}+\frac{\partial\boldsymbol{D}}{\partial t}=0+\varepsilon\frac{\partial\boldsymbol{E}}{\partial t}\quad\longrightarrow\quad\boldsymbol{E}=\frac{1}{\varepsilon}\int\nabla\times\boldsymbol{H}dt$$

$$\nabla\times\boldsymbol{H}=\begin{vmatrix}\frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z}\\ 0 & 0 & 10\cos(\omega t+\beta x)\end{vmatrix}=10\beta\sin(\omega t+\beta x)\boldsymbol{a}_y$$

$$\boldsymbol{E}=\frac{1}{\varepsilon}\int 10\beta\sin(\omega t+\beta x)dt\boldsymbol{a}_y=\frac{-10\beta}{\omega\varepsilon}\cos(\omega t+\beta x)\boldsymbol{a}_y$$

But $\nabla\times\boldsymbol{E}=-\mu\frac{\partial\boldsymbol{H}}{\partial t}\quad\longrightarrow\quad\boldsymbol{H}=-\frac{1}{\mu}\int\nabla\times\boldsymbol{E}dt$

$$\nabla\times\boldsymbol{E}=\begin{vmatrix}\frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z}\\ 0 & \frac{-10\beta}{\omega\varepsilon}\cos(\omega t+\beta x) & 0\end{vmatrix}=\frac{10\beta^2}{\omega\varepsilon}\sin(\omega t+\beta x)\boldsymbol{a}_z$$

$$\boldsymbol{H}=-\frac{1}{\mu}\int\frac{10\beta^2}{\omega\varepsilon}\sin(\omega t+\beta x)dt\boldsymbol{a}_z=\frac{10\beta^2}{\omega^2\mu\varepsilon}\cos(\omega t+\beta x)\boldsymbol{a}_z$$

Comparing this with the given **H**,

$$10=\frac{10\beta^2}{\omega^2\mu\varepsilon}\quad\longrightarrow\quad\beta=\omega\sqrt{\mu\varepsilon}=2\pi\times10^9\sqrt{4\pi\times10^{-7}\times\frac{10^{-9}}{36\pi}\times81}$$

$\beta=60\pi=\underline{\underline{188.5\text{ rad/m}}}$

$$E=\frac{-10\beta}{\omega\varepsilon}\cos(\omega t+\beta x)\boldsymbol{a}_y=\underline{\underline{-148\cos(\omega t+\beta x)\boldsymbol{a}_y\ \text{V}/m}}$$

Prob. 9.42

(a)

$$\boldsymbol{H}=\text{Re}\left[40e^{j(10^9t-\beta z)}\boldsymbol{a}_x\right],\quad\omega=10^9$$

$$=\text{Re}\left[40e^{-j\beta z}\boldsymbol{a}_x e^{j\omega t}\right]=\text{Re}\left[\boldsymbol{H}_s e^{j\omega t}\right]$$

$\boldsymbol{H}_s=\underline{\underline{40e^{-j\beta z}\boldsymbol{a}_x}}$

(b)

$$\boldsymbol{J}_d=\nabla\times\boldsymbol{H}=\begin{vmatrix}\frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z}\\ 40\cos(10^9t-\beta z) & 0 & 0\end{vmatrix}$$

$$=\underline{\underline{40\beta\sin(10^9t-\beta z)\boldsymbol{a}_y\ \text{A/m}^2}}$$