1 $\mu_r = 2, \quad \varepsilon_r = 10, \quad \sigma = 0$

$$\vec{J}_d(z,t) = 60 \sin(10^9 t - \beta z)\,\hat{x} \quad \text{mA/m}^2$$

$$\tilde{J}_d = 60\, e^{-j\beta z}\,\hat{x} \quad \text{mA/m}^2$$

$$\beta = \omega\sqrt{\mu\varepsilon} = (10^9)\sqrt{(2)(8.854\times10^{-12}) \times (10)(4\pi\times10^{-7})}$$

$$\beta \approx 14.9 \ \text{rad/m}$$

$$\tilde{J}_d = j\omega\tilde{D} \Rightarrow \tilde{D} = \frac{1}{j\omega}\tilde{J}_d$$

$$\tilde{D} = \frac{1}{j\omega} 60 e^{-j(14.9)z}\,\hat{x} \times 10^{-3}$$

$$= -j\,\frac{60\times10^{-3}}{10^9}\, e^{-j(14.9z)}\,\hat{x}$$

$$= (60\times10^{-12})\, e^{-j(14.9z)}\, e^{-j\pi/2}\,\hat{x}$$

$$\boxed{\vec{D}(z,t) = 60 \sin(10^9 t - 14.9z - \pi/2)\,\hat{x} \quad \text{pC/m}^2}$$

2

$$\vec{H} = \frac{1}{r}\cos(\omega t - 3z)\,\hat{\phi} \quad \frac{A}{m}$$

$$\frac{\omega}{\beta} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \quad ; \quad \beta = 3$$

$$\omega = 9 \times 10^8 \text{ rad/s}$$

$$\nabla \times \tilde{H} = j\omega(\varepsilon \tilde{E})$$

$$\tilde{E} = \frac{1}{j\omega\varepsilon} \nabla \times \tilde{H}$$

$$= \frac{1}{j\omega\varepsilon r} \begin{vmatrix} \hat{r} & r\hat{\phi} & \hat{z} \\ \partial/\partial r & \partial/\partial\phi & \partial/\partial z \\ 0 & e^{-j3z} & 0 \end{vmatrix}$$

$$= \frac{1}{j\omega\varepsilon r}\left[\frac{-\partial}{\partial z} e^{-j3z}\,\hat{r} \right]$$

$$= \frac{j}{\omega\varepsilon r}\left[-3j\, e^{-j3z}\,\hat{r} \right]$$

$$= \frac{3}{\omega\varepsilon r} e^{-j3z}\,\hat{r}$$

$$\boxed{\tilde{E}(z,t) = \frac{377}{r}\cos(9\times10^8 t - 3z)\,\hat{r} \quad V/m}$$

③ $\vec{E}(x,t) = 25\sin(2\pi\times10^6 t - 6x)\,\hat{z}$ V/m

$E_0 = 25$ V/m

$\omega = 2\pi\times10^6$ rad/s

$\beta = 6$ rad/m

(a) $T = 2\pi/\omega = 2\pi/(2\pi\times10^6)$

$= 10^{-6} = \boxed{1\ \mu s}$

(b) $\lambda = 2\pi/\beta = 2\pi/6 \approx \boxed{1.05\ m}$

(c) $u = \omega/\beta = \dfrac{2\pi\times10^6}{6} \approx 10^6$ m/s

$\vec{u} = \boxed{10^6\,\hat{x}\ m/s}$

4 $f = 50$ MHz

$\varepsilon_r = 3.6$

$\mu_r = 2.1$

$\sigma = 0.08$ S/m

$\tilde{E} = 6 e^{-\gamma x} \hat{z}$ V/m

(a) $$\eta = \frac{\omega\mu}{\beta - j\alpha}$$

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

α = (substitute values) = 5.41

β = (substitute values) = 6.13

$$\eta = \frac{(2\pi)(50)(10^6)(4\pi \times 10^{-7})}{6.13 - j\,5.41} \approx \boxed{101\angle 41^\circ\ \Omega}$$

(b) wave propagates in +x direction

$\therefore$ magnetic field points in $-y$ direction

$$\frac{E_0}{H_0} = \eta \Rightarrow H_0 = \frac{6}{101\angle 41^\circ} \approx 59\angle -41^\circ \text{ mA/m}$$

$$\tilde{H}(x) = -59 e^{-5.14x} e^{j6.13} e^{-j41^\circ}$$

$$\boxed{\tilde{H}(x) = -59 e^{-5.14x} e^{j5.41} \text{ mA/m}}$$

$\uparrow$ -50°