

**Problem 7.6** The electric field of a plane wave propagating in a lossless, nonmagnetic, dielectric material with  $\epsilon_r = 2.56$  is given by

$$\mathbf{E} = \hat{\mathbf{y}} 20 \cos(6\pi \times 10^9 t - kz) \quad (\text{V/m})$$

Determine:

- (a)  $f$ ,  $u_p$ ,  $\lambda$ ,  $k$ , and  $\eta$ .
- (b) The magnetic field  $\mathbf{H}$ .

**Solution:**

(a)

$$\begin{aligned}\omega &= 2\pi f = 6\pi \times 10^9 \text{ rad/s}, \\ f &= 3 \times 10^9 \text{ Hz} = 3 \text{ GHz}, \\ u_p &= \frac{c}{\sqrt{\epsilon_r}} = \frac{3 \times 10^8}{\sqrt{2.56}} = 1.875 \times 10^8 \text{ m/s}, \\ \lambda &= \frac{u_p}{f} = \frac{1.875 \times 10^8}{6 \times 10^9} = 3.12 \text{ cm}, \\ k &= \frac{2\pi}{\lambda} = \frac{2\pi}{3.12 \times 10^{-2}} = 201.4 \text{ rad/m}, \\ \eta &= \frac{\eta_0}{\sqrt{\epsilon_r}} = \frac{377}{\sqrt{2.56}} = \frac{377}{1.6} = 235.62 \Omega.\end{aligned}$$

(b)

$$\begin{aligned}\mathbf{H} &= -\hat{\mathbf{x}} \frac{20}{\eta} \cos(6\pi \times 10^9 t - kz) \\ &= -\hat{\mathbf{x}} \frac{20}{235.62} \cos(6\pi \times 10^9 t - 201.4z) \\ &= -\hat{\mathbf{x}} 8.49 \times 10^{-2} \cos(6\pi \times 10^9 t - 201.4z) \quad (\text{A/m}).\end{aligned}$$


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