A 93.5 MHz plane wave propagates through free space in the -z-direction. a) Find the phase velocity, wavelength, phase constant, and intrinsic impedance. b) If the electric field has an amplitude of 12 V/m at $z = 0$ and is oriented in the x-direction, write the equation for the phasor vector electric field. c) Find the corresponding phasor vector magnetic field.

Free space- $\varepsilon = \varepsilon_0 = 8.8541878 \times 10^{-12}$ F/m and $\mu = \mu_0 = 4\pi \times 10^{-7}$ H/m

a)

phase velocity (1.47) $v_p = \dfrac{\omega}{k} = \dfrac{1}{\sqrt{\mu\varepsilon}} = \dfrac{1}{\sqrt{4\pi \cdot 10^{-7}(8.8541878 \cdot 10^{-12})}}$

$\Rightarrow$ $\underline{\mathbf{v_p = 2.99792 \times 10^8\ m/s}}$

wavelength (1.48) $\lambda = \dfrac{2\pi}{k} = \dfrac{v_p}{f} = \dfrac{2.99792458 \cdot 10^8}{93.5 \cdot 10^6}$ $\Rightarrow$ $\underline{\mathbf{\lambda = 3.20634\ m}}$

phase/prop. constant (Table 1.1)

$k = \dfrac{2\pi}{\lambda} = \omega\sqrt{\mu\varepsilon} = 2\pi \cdot 93.5 \cdot 10^6 \sqrt{4\pi \cdot 10^{-7}(8.8541878 \cdot 10^{-12})}$ $\Rightarrow$ $\underline{\mathbf{k = 1.959615\ rad/m}}$

intrinsic impedance (Table 1.1) $\eta = \sqrt{\dfrac{\mu}{\varepsilon}} = \sqrt{\dfrac{4\pi \cdot 10^{-7}}{8.8541878 \cdot 10^{-12}}}$ $\Rightarrow$ $\underline{\mathbf{\eta = 376.7303\ \Omega}}$

b) Per (1.45), $E_x(z) = E^+ e^{-jkz} + E^- e^{jkz}$. As the wave only propagates in the -z-direction, we drop the first term. We are given $E_x(z=0) = 12\text{ V/m} = E^- e^0 \Rightarrow E^- = 12$ V/m. Therefore, we get

$\Rightarrow$ $\underline{\bar{E} = \hat{x}\, 12\, e^{j1.9596z}\ \text{(V/m)}}$

c) Using (1.76), $\bar{H} = \dfrac{1}{\eta_0}\left(\hat{n} \times \bar{E}\right) = \dfrac{1}{376.7303}\left(-\hat{z} \times \hat{x} 12 e^{j1.9596z}\right)$

$\Rightarrow$ $\underline{\bar{H} = -\hat{y}\, 0.031853\, e^{j1.9596z}\ \text{(A/m)}}$