A 103.5 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 8 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- $\varepsilon = \varepsilon_0 = 8.8541878\times10^{-12}$ F/m and $\mu = \mu_0 = 4\pi\times10^{-7}$ H/m

a)

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

$\Rightarrow$ **v_p = 2.99792×10^8 m/s**

wavelength (1.48) $\lambda = \dfrac{2\pi}{k} = \dfrac{v_p}{f} = \dfrac{2.99792458 \bullet 10^8}{103.5 \bullet 10^6}$ $\Rightarrow$ **λ = 2.8965455 m**

phase/prop. constant (Table 1.1)

$k = \dfrac{2\pi}{\lambda} = \omega\sqrt{\mu\varepsilon} = 2\pi \bullet 103.5 \bullet 10^6 \sqrt{4\pi \bullet 10^{-7}(8.8541878 \bullet 10^{-12})}$ $\Rightarrow$ **k = 2.1692 rad/m**

phase/prop. constant (Table 1.1) $\eta = \sqrt{\dfrac{\mu}{\varepsilon}} = \sqrt{\dfrac{4\pi \bullet 10^{-7}}{8.8541878 \bullet 10^{-12}}}$ $\Rightarrow$ **η = 376.7303 Ω**

b) Adapting (1.68), $\bar{E} = \hat{x} E_x = \hat{x} A e^{-j(k_x x + k_y y + k_z z)}$. As the wave only propagates in the +z-direction, $k_z = k$ and $k_x = k_y = 0$. We are given $A = 8$ V/m. Therefore, we get

$\Rightarrow$ $\bar{E} = \hat{x}\, 8\, e^{-j2.1692z}$ (V/m)

c) Using (1.76), $\bar{H} = \dfrac{1}{\eta_0} \hat{n} \times \bar{E} = \dfrac{1}{376.73} \hat{z} \times \hat{x} 8 e^{-j2.1692z}$

$\Rightarrow$ $\bar{H} = \hat{y}\, 0.021235\, e^{-j2.1692z}$ (A/m)