CMPE 330 Spring 2017 Problem Set #8

NOTE: You must show complete work for full credit. Report numerical solutions to two significant figures unless otherwise specified.

1. The electric field phasor of a uniform plane wave is given by $\widetilde{\mathbf{E}} = \hat{\mathbf{y}} 15 \exp(j0.25\, z)$ V/m. If the phase velocity of the wave is 2.0×10^8 m/s and the relative permeability of the medium is $\mu_\mathrm{r} = 2.7$, find the following: (a) the wavelength, (b) the frequency f of the wave, (c) the relative permittivity of the medium, and (d) the magnetic field $\mathbf{H}(z,t)$ [modified from Ulaby and Ravaioli 7.3, p. 348.]

2. The electric field of a plane wave propagating in a lossless, non-magnetic dielectric material with $\epsilon_\mathrm{r} = 2.75$ is given by $\mathbf{E} = \hat{\mathbf{y}}\, 25 \cos(8\pi \times 10^9\, t - kz)$ V/m. Determine: (a) f, u_p, λ, k, and η; (b) the magnetic field $\mathbf{H}$. [modified from Ulaby and Ravaioli 7.6, p. 348.]

3. For the wave characterized by the electric field

$$\mathbf{E}(z,t) = \hat{\mathbf{x}} a_x \cos(\omega t - kz) + \hat{\mathbf{y}} a_y \cos(\omega t - kz + \delta)$$

   identify the polarization state, determine the polarization angles, and sketch the locus (using a computer program) of $\mathbf{E}(0,t)$ for each of the following cases. Include a copy of your computer program with your solution. [modified from Ulaby, et al. 7.9, p. 346.]

   a. $a_x = 3$ V/m, $a_y = 4$ V/m, and $\delta = 0$

   b. $a_x = 3$ V/m, $a_y = 4$ V/m, and $\delta = 180°$

   c. $a_x = 3$ V/m, $a_y = 3$ V/m, and $\delta = 45°$

   d. $a_x = 3$ V/m, $a_y = 4$ V/m, and $\delta = -135°$

4. Based on wave attenuation and reflection measurements conducted at 1 MHz, it was determined that the intrinsic impedance of a certain medium is $35 \exp(j45°)\ \Omega$ and the skin depth is 2 m. Determine the following: [modified from Ulaby and Ravaioli 7.24, p. 347–348.]

   a. The conductivity of the material

   b. The wavelength in the medium

   c. The phase velocity

5. A rectangular copper block is 20 cm in height (along z). In response to a wave incident upon the block from above, a current is induced in the block in the positive x-direction. Determine the ratio of the a-c resistance of the block to its d-c resistance at 1 kHz. The relevant properties of copper are given in Ulaby's Appendix B. [modified from Ulaby and Ravaioli 7.29, p. 350.]

6. At microwave frequencies, the power density considered safe for human exposure is 1 mW/cm^2. A radar radiates a wave with an electric field amplitude E that decays

with distance as $E(R) = (3,000/R)$ V/m, where R is the distance in meters. What is the radius of the unsafe region? [Ulaby and Ravaioli 7.38, p. 350–351.]