Spring 2016 Prof. Andrew W. Poon

ELEC 3600 Electromagnetics: from wireless to photonic applications
Department of Electronics and Computer Engineering, HKUST

Problem Set 8 (due May 9th, Monday in class)

1. A manufacturer produces a ferrite material with $\mu = 750\ \mu_0$, $\varepsilon = 5\ \varepsilon_0$, and $\sigma = 10^{-6}$ S/m at 10 MHz.
   a. Would you classify the material as lossless, lossy, or conduction?
   b. Calculate β and λ.
   c. Determine the phase difference between two points separated by 2m.
   d. Find the intrinsic impedance.

2. A signal in air ($z \geq 0$) with the electric field component

$$\mathbf{E} = 10 \sin(\omega t + 3z)\ \mathbf{a}_x \text{ V/m}$$

   hits normally the ocean surface at z=0. Assuming that the ocean surface is smooth and that $\varepsilon = 80\ \varepsilon_0$, $\mu = \mu_0$, $\sigma = 4$ mhos/m in ocean, determine
   a. ω
   b. The wavelength of the signal in air
   c. The loss tangent and intrinsic impedance of the ocean

3. In a non-magnetic region ($\mu = \mu_0$), it has

$$\mathbf{E} = 10\cos(10^9 t - 8x)\mathbf{a}_y + 10\sin(10^9 t - 8x)\mathbf{a}_z \text{ V/m.}$$

   Find
   a. Dielectric constant ε_r
   b. Corresponding magnetic field **H**
   c. Poynting vector **S**
   d. Polarization of the wave.

4. A 20 MHz uniform plane wave with $\mathbf{E_i} = \sin(\omega t + \beta x)\,\mathbf{a_y} + \cos(\omega t + \beta x)\,\mathbf{a_z}$ V/m exist in the region $x \geq 0$ having $\sigma = 0$, $\mu = 3\mu_0$, and $\varepsilon = 6\varepsilon_0$. At x= 0 the wave encounters free space. Determine
   a. The phase constant in the region both $x < 0$ and $x \geq 0$.
   b. The reflected and transmitted magnetic field.

5. A DC voltage generator with V_g= 10V and Z_g= 50Ω is connected to a switch and a Z_0= 75 Ω transmission line. An oscilloscope with 50 Ω input impedance is connected to the other end of the line. At t= 0, the switch is turned on. It takes 30 ns for the signal to travel from the generator to the oscilloscope.
   a. Find the initial voltage V_0 at the sending end (near generator) of the line.
   b. Find the reflection coefficients at the sending end and receiving end (near oscilloscope) of the line.
   c. Sketch the voltage you would see the oscilloscope for $0 \leq t \leq 150$ns.
   d. Find the final voltage V_∞ at the sending end.