ELEN 3401 Electromagnetics
Problem Set #8

DUE: Friday April 18

Please include your name and UNI on the assignment

Problem 1: Uniform plane wave

Consider a uniform plane wave propagating in free space with the following electric field:

$$\boldsymbol{E}(y,z,t) = Re\left\{\hat{x}\, E_0\, e^{j\omega t}\, e^{-\frac{jk(y+z)}{\sqrt{2}}}\right\}$$

where $k = \omega/c$.

a. Obtain the direction of propagation and its unit vector $\hat{k}$
b. Find the magnetic field $\boldsymbol{H}(y,z,t)$ and its phasor.
c. Specify the polarization state of the electric field.

Problem 2: Electromagnetic wave polarization

The electric field complex phasor of a uniform propagating plane wave in free space is given by:

$$\widetilde{\boldsymbol{E}} = (\hat{x} + j\hat{y})30e^{-j\left(\frac{\pi}{6}z+\frac{\pi}{2}\right)}\ [\text{V/m}]$$

a. Obtain the complete expression for the electric field, $\vec{\boldsymbol{E}}(z,t)$, including solving for the angular frequency, ω, in terms of known values and physical constants.
b. Obtain the corresponding expression for the magnetic field, $\vec{\boldsymbol{H}}(z,t)$
c. Specify the magnitude and direction of the electric field at the *z=0* plane for times: *t = 0, 5,* and *10 nsec* (10^{-9}sec).
d. Obtain the polarization state of the electric field.

Problem 3: Wave propagation in lossy medium

The magnetic field of a linearly polarized uniform plane wave propagating in the +y direction in sea water, is given (at $y = 0$) by:

$$\vec{\boldsymbol{H}} = \hat{x}\ 0.1 \sin\left(10^{10}\pi t - \frac{\pi}{3}\right) \quad \text{[A/m]}$$

a. The sea water is specified by the following parameters: $\epsilon_r = 80$, $\mu_r = 1$, $\sigma = 4$ (S/m)
b. Determine whether this is a lossless medium, a low-loss medium, or a good conductor.
c. Determine the attenuation constant, α, the phase constant, β, and the complex intrinsic impedance, η_c.
d. Obtain the wavelength λ, and the phase velocity, u_p.
e. Obtain the skin depth, δ_s, and explain why we typically do not use radio frequency or optical communication undersea (e.g. between submarines).
f. Obtain an expression for $\vec{\boldsymbol{E}}(y, t)$.