MICROWAVE ENGINEERING

Read Chapter 1 in Pozar's Microwave Engineering. This should all be review material.

Problem #1: Wave Equation

a. Derive the frequency-domain wave equation in terms of the magnetic field for waves in a medium that is linear, inhomogeneous, and anisotropic.
b. Derive the frequency-domain wave equation in terms of the electric field for waves in a medium that is linear, homogeneous, and isotropic (LHI).

Problem #2: Plane Waves

A plane wave is propagating in a lossless LHI medium with $\varepsilon_r = 3.2$ and $\mu_r = 1.0$. The magnetic field is expressed as

$$\vec{H}(\vec{r},t) = \vec{H}_0 \cos\left(\omega t - \vec{k} \bullet \vec{r}\right)$$

Using Maxwell's equations, derive the expression for the corresponding electric field in this same medium. From this result: (1) derive how the electric and magnetic field amplitudes are related through impedance, and (2) derive an expression to find the polarization vector of the electric field $\vec{E}_0$ given the polarization vector of the magnetic field $\vec{H}_0$.

Problem #3: Scattering at an Interface

A wave propagates in an LHI medium 1 $\left(\varepsilon_{r1} = 3.0, \mu_{r1} = 1.0\right)$ where the electric field is expressed as

$$\vec{E}(\vec{r}) = \left(1.6196\hat{a}_x - 0.0821\hat{a}_y - 0.6747\hat{a}_z\right)\cos\left[\left(9.4248\times10^9\right)t - \left(9.3118\hat{a}_x + 51.1678\hat{a}_y + 16.1285\hat{a}_z\right)\bullet\left(x\hat{a}_x + y\hat{a}_y + z\hat{a}_z\right)\right] \ \frac{\text{V}}{\text{m}}$$

The wave is incident on an LHI medium 2 $\left(\varepsilon_{r2} = 6.0, \mu_{r2} = 2.5\right)$ where the interface lies in the *x*-*z* plane. Answer the following questions:

1. What polarization is the applied wave (i.e. LP, RCP, LCP, EP)? Why?
2. What is the frequency of this wave in Hertz?
3. What is the wavelength in the first medium?
4. Calculate the angle of incidence.
5. Calculate the angle of the transmitted wave.
6. Calculate the amplitude of the TE and TM polarizations of the applied wave.
7. Calculate the reflection and transmission coefficients.
8. Calculate the overall reflectance *R* and overall transmittance *T*. Note that *R* and *T* are single numbers that include power in both TE and TM polarizations.
9. Verify conservation of energy. That is $R + T = 1$.
10. How much power is carried by the applied wave (W/m^2)?