ECE 3065 Homework 4: Plane Waves

Due Date: 5 February 2009 (Thursday)

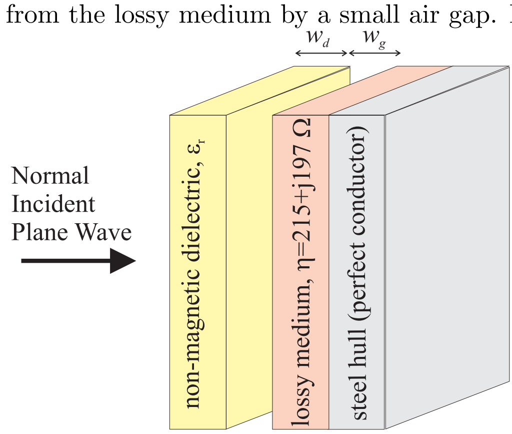
1. **Wave Equation:** Show that the E-field and H-field solutions for plane waves satisfy the Helmholtz wave equation for a simple medium. (5 points)

2. **Plane Wave Solutions:** Write the equation for the missing H-field component, the direction of *arrival* in spherical coordinates (ϕ, θ), and the wavelength for the following plane wave: (5 points)

$$\tilde{\vec{E}}(\vec{r}) = 10.0[\hat{x} + 2\hat{y} - \hat{z}] \exp\left(-j100\,[3\hat{x} - \hat{y} + \hat{z}] \cdot \vec{r}\right) \text{ mV/m} \quad \text{(in free space)}$$

3. **Reflection:** Derive the Fresnel reflection coefficient for a plane wave with parallel polarization upon a dielectric interface. (5 points)

4. **Stealth Boat:** You are designing a special coating for the hull of a naval warship that produces no reflected wave when its sides are illuminated by a 15-GHz enemy radar at normal incidence. You start by placing some special absorber material onto the metal hull that appears to be a lossy dielectric medium with $\eta = 215 + j197\Omega$ (lossy media have complex intrinsic impedances just like lossy transmission lines). This material should trap and absorb any power transmitted into it, although the drawback is that there will be strong reflections at normal incidence. To remove these reflections, you propose to put another layer of lossless dielectric on the outside of the hull, separated from the lossy medium by a small air gap. Refer to the diagram below:



Calculate values for the width of the dielectric (w_d), the width of the air gap (w_g), and the relative permittivity of the dielectric (ϵ_r). Hint: Treat the lossy medium as a complex load on a transmission line and use what you have learned about Smith Charts and matching techniques to perform your design. (10 points)