CMPE 330 **Spring 2017** **Problem Set #9**

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

1. A 200 MHz left-circularly polarized plane wave with an electric field modulus of 5 V/m is normally incident in air upon a dielectric medium with $\epsilon_r = 2.25$, $\mu_r = 1$, and $\sigma = 10^{-4}$ S/m that occupies the region defined by $z \geq 0$. [Ulaby and Ravaioli 8.5.]

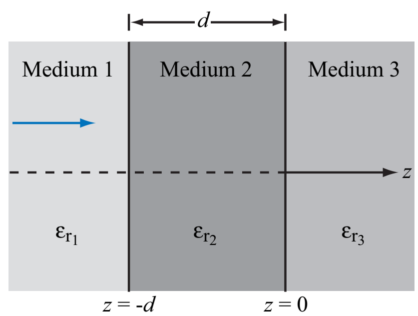
   a. Write an expression for the electric field phasor of the incident wave, given that the x-polarization amplitude of the field is a positive maximum at $z = 0$ and $t = 0$.

   b. Calculate the reflection and transmission coefficients.

   c. Write expressions for the electric field phasors of the reflected wave, the transmitted wave, and the total field in the region $z \leq 0$.

   d. Determine the percentages of the incident average power reflected by the boundary and transmitted into the second medium.

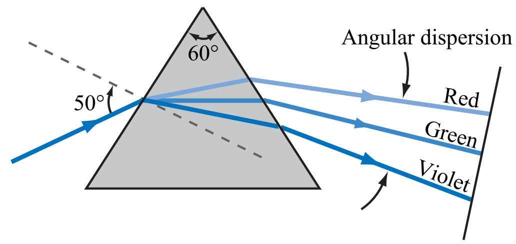
2. The three regions shown in the figure to the right [Ulaby and Ravaioli Fig. P8.9] contain perfect dielectrics. For a wave in medium 1, incident normally upon the boundary at $z = -d$, what combination of ϵ_{r2} and d produce no reflection? Express your answer in terms of ϵ_{r1}, ϵ_{r3}, and the oscillation frequency f. Discuss the analogy to quarter-wave impedance matching in transmission lines. [modified from Ulaby and Ravaioli 8.9, p. 395.]



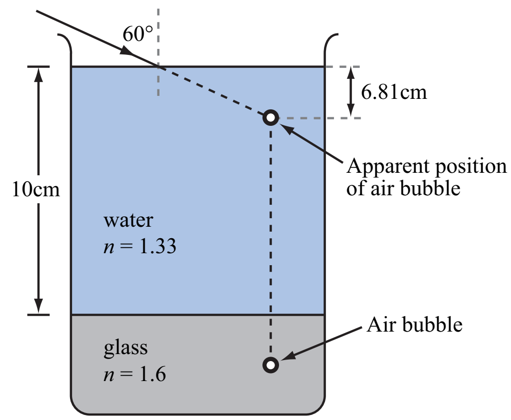
3. A 0.5 MHz antenna carried by an airplane flying over the ocean surface generates a wave that approaches the water surface in the form of a normally incident plane wave with an electric-field amplitude of 5,000 V/m. Seawater is characterized by $\epsilon_r = 72$, $\mu_r = 1$, and $\sigma = 4$ S/m. The plane is trying to communicate a message to a submarine submerged at a depth d below the water surface. If the submarine's receiver requires a minimum signal of 0.005 μV/m, what is the maximum depth d to which successful communication is still possible? [modified from Ulaby and Ravaioli 8.16, p. 396.]

4. For some types of glass, the index of refraction varies with wavelength. A prism made of material with $n = 1.71 - (4/30)\lambda_0$, where λ_0 is measured in micrometers and is the wavelength in the vacuum, was used to disperse white light as shown in the figure to the right [Ulaby and Ravaiol Fig. P8.18]. The white light is incident at an angle of 50°, the wavelength λ_0 of red light is 0.7 μm, and that of violet light is 0.4 μm.

Determine the angular dispersion in degrees. Note that you will have to keep approximately five figures in the calculation to obtain a result that is correct to two significant figures at the end. Why? [modified from Ulaby and Ravaioli 8.18, p. 396.]



5. The figure to the right [Ulaby and Ravaioli Fig. P8.22] depicts a beaker containing a block of glass at the bottom and water over it. The glass block contains a small air bubble at an unknown depth below the water surface. When viewed from above at an angle of 60°, the air bubble appears at a depth of 6.81 cm. What is the true depth of the air bubble to three significant figures? [Ulaby and Ravaioli 8.22, p. 397.]



6. A perpendicularly polarized wave in air is obliquely incident upon a planar glass-air interface at an incidence angle of 45°. The wave frequency is 450 THz (1 THz = 10^{12} Hz), which corresponds to red light, and the index of refraction of the glass is 1.55. If the electric field amplitude of the incident wave is 50 V/m, determine the following: [modified from Ulaby and Ravaioli 8.32, p. 399.]

   a. The reflection and transmission coefficients.

   b. The instantaneous expressions for **E** and **H** in the glass medium.