ECE 222b, Homework 2

Problem 1

A parallel polarized uniform plane wave is incident from the free space (from the right) obliquely on a lossless dielectric slab with ε and μ. The slab is bounded (from the left) by the PEC (perfect electric conductor) material. Derive the expression for the reflection coefficient in terms of the medium parameters and the thickness of the slab. What is the absolute value of the reflection coefficient?

Problem 2

Repeat Problem 1 for the perpendicular polarization.

Problem 3

A plane wave is incident (from the free space) upon a semi-infinite medium made of N=100 different lossless dielectric slabs with permittivity and permeability ε_n and μ_n. The layered region is ended with a half space with permittivity and permeability ε_{N+1} and μ_{N+1}. The incident angle is θ_i from the normal of the surface. Find the propagation direction θ_{tn} in the 10^{th}, 99^{th} slabs and also in the exit half space.

Problem 4

What is the condition leading to the total reflection in the free space in Problem 3.
Hint: consider the time averaged power of the incident plane wave and the transmitted plane wave in the exit half space.

Problem 5

In order to reduce the reflection of a normally incident plane wave from a conducting wall, a very thin sheet ($|\beta| d << 1$) of conductive material $\sigma, \varepsilon_0, \mu_0$, is placed on the distance $\lambda / 4$ from the wall.

a) What should the thickness of the conducting sheet be to have no reflected wave to the left of the conducting sheet?
b) Suppose the frequency is increased by 10 percent. What will be the standing wave ratio to the left of the conducting sheet?
c) (Optional) If you can cover your car with such a sheet, can you beat police's radar gun? Why?

Problem 6

Consider an interface between two half spaces as depicted in Fugure a. The half spaces are filled with lossless media having the free space permeability μ_0 and the permittivity ε_1 and ε_2, respectively, such that $\varepsilon_1 > \varepsilon_2$. A plane wave is incident from the medium 1 with an incidence angle θ_i which is larger than the critical angle ($\theta_i > \theta_c$). Consider the box in Figure a, which crosses the interface as depicted in Figure a. The width (x direction) and length (y direction) of the box are a and the height (z direction) is δ such that $\delta \to 0$ (i.e. the volume of the box tends to zero). Verify that the power conservation law is satisfied (both the real and imaginary parts) for the perpendicular as well as parallel incident wave polarization.

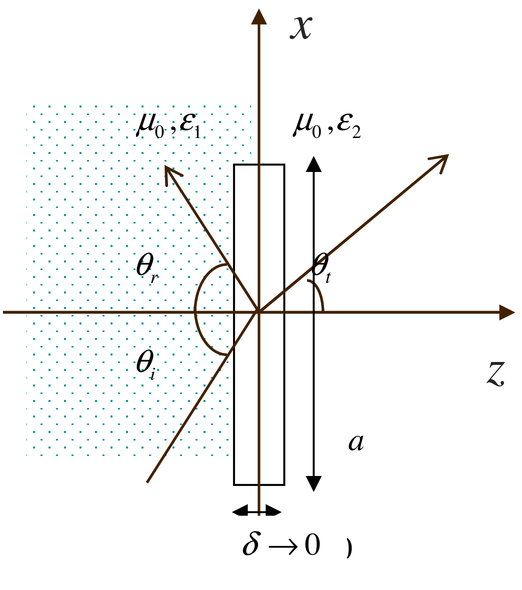

Figure a

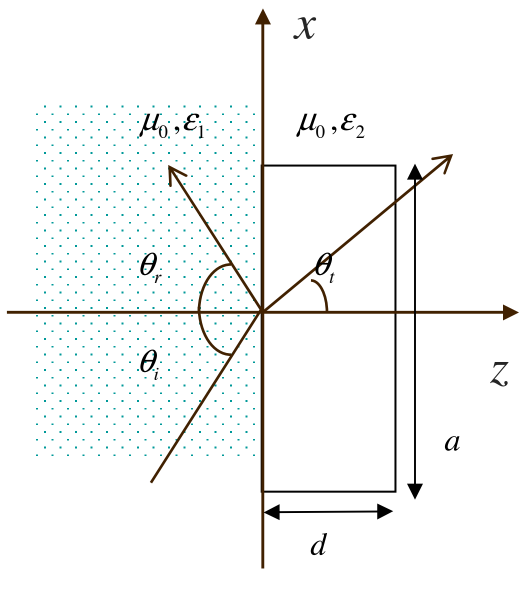

Figure b

Problem 7

Refer to the configuration similar to that in Problem 6. Now consider the box in the Figure b. It has the same width and length but nonzero thickness *d*. In addition the box entirely resides in the second medium (i.e. it does not cross the interface). Calculate the difference between the magnetic and electric energy within the volume for the perpendicular as well as parallel incident wave polarization. Conclude, in what case the energy within the volume of the box is mostly magnetic and for what case it is mostly electric.