VE230 Homework 7

2021 Summer

P.8-22 A uniform sinusoidal plane wave in air with the following phasor expression for electric intensity

$$\mathbf{E}_i(x, z) = \mathbf{a}_y 10e^{-j(6x+8z)} \qquad (V/m)$$

is incident on a perfectly conducting plane at $z = 0$.

a) Find the frequency and wavelength of the wave.

b) Write the instantaneous expressions for $\mathbf{E}_i(x, z; t)$ and $\mathbf{H}_i(x, z; t)$, using a cosine reference.

c) Determine the angle of incidence.

d) Find $\mathbf{E}_r(x, z)$ and $\mathbf{H}_r(x, z)$ of the reflected wave.

e) Find $\mathbf{E}_r(x, z)$ and $\mathbf{H}_r(x, z)$ of the total field.

P.8-29 Consider the situation of normal incidence at a lossless dielectric slab of thickness d in air as shown in Fig. 1 with

$$\epsilon_1 = \epsilon_3 = \epsilon_0 \qquad \text{and} \qquad \mu_1 = \mu_3 = \mu_0.$$

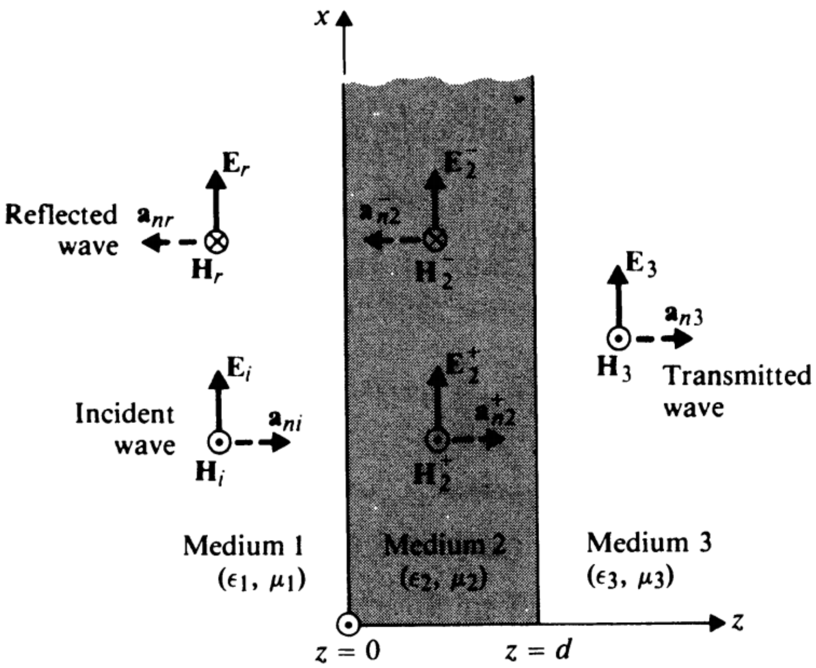

Figure 1: Normal incidence at multiple dielectric interfaces

Problems:

1. Find $\mathbf{E}_{r0}$,$\mathbf{E}_2^+$ and $\mathbf{E}_2^-$, and $\mathbf{E}_{r0}$ in terms of $\mathbf{E}_{i0}$, d, ϵ_2, and μ_2.
2. Will there be reflection at interface $z = 0$ if $d = \lambda_2/4$? If $d = \lambda_2/2$? Explain.

P.8-33 A uniform plane wave with $\mathbf{E}_i(z) = \mathbf{a}_x E_{i0} e^{-j\beta_0 z}$ in air propagates normally through a thin copper sheet of thickness d, as shown in Fig. 2. Neglecting multiple reflections within the copper sheets, find:

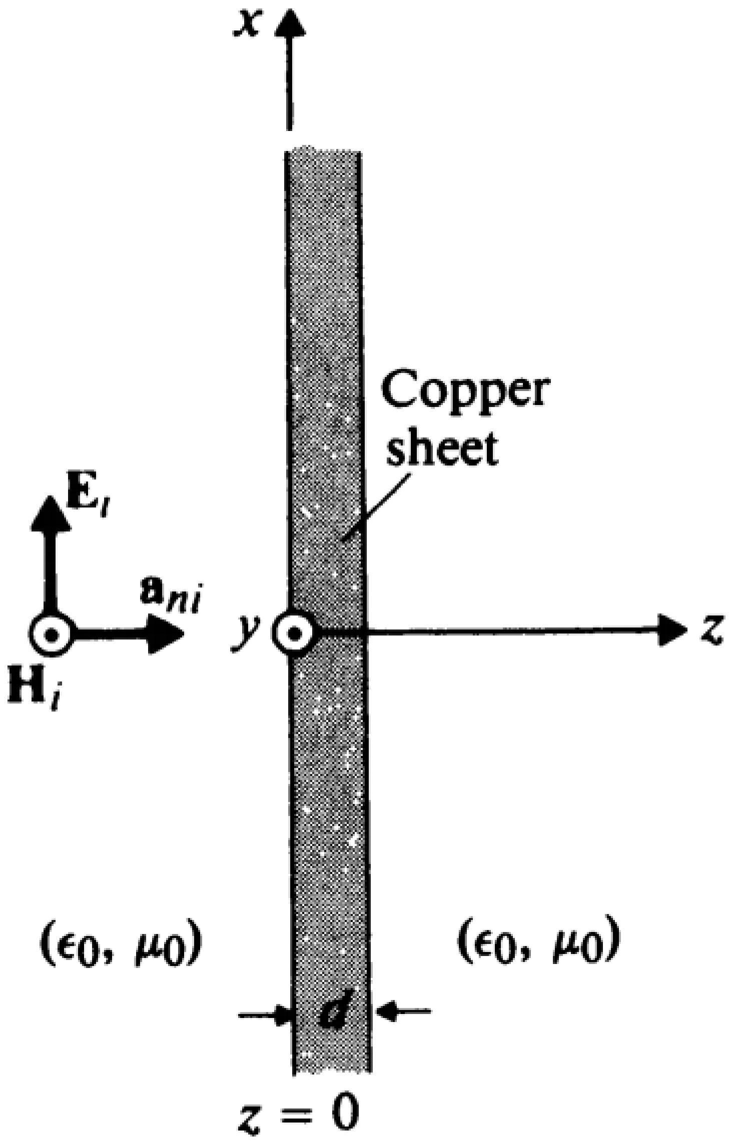

Figure 2: Plane wave propagating through a thin copper sheet

a) E_2^+, H_2^+

b) E_2^-, H_2^-

c) E_{30}, H_{30}

d) $(\mathscr{P}_{av})_3/(\mathscr{P}_{av})_i$

Calculate $(\mathscr{P}_{av})_3/(\mathscr{P}_{av})_i$ for a thickness d that equals one skin depth at 10 (MHz). (Note that this pertains to the shielding effectiveness of the thin copper sheet.)

P.8-37 A uniform plane wave with perpendicular polarization presented by Eqs. (8-196) and (8-197) is incident on a plane interface at $z = 0$, as shown in Fig. 3. Assuming $\epsilon_2 < \epsilon_1$ and $\theta_i > \theta_c$,

$$\mathbf{E}_i(x, z) = \mathbf{a}_y E_{i0} e^{-j\beta_1(x \sin\theta_i + z\cos\theta_i)} \tag{8-196}$$

$$\mathbf{H}_i(x, z) = \frac{E_{i0}}{\eta_1}(-\mathbf{a}_x \cos\theta_i + \mathbf{a}_z \sin\theta_i) e^{-j\beta_1(x \sin\theta_i + z\cos\theta_i)}. \tag{8-197}$$

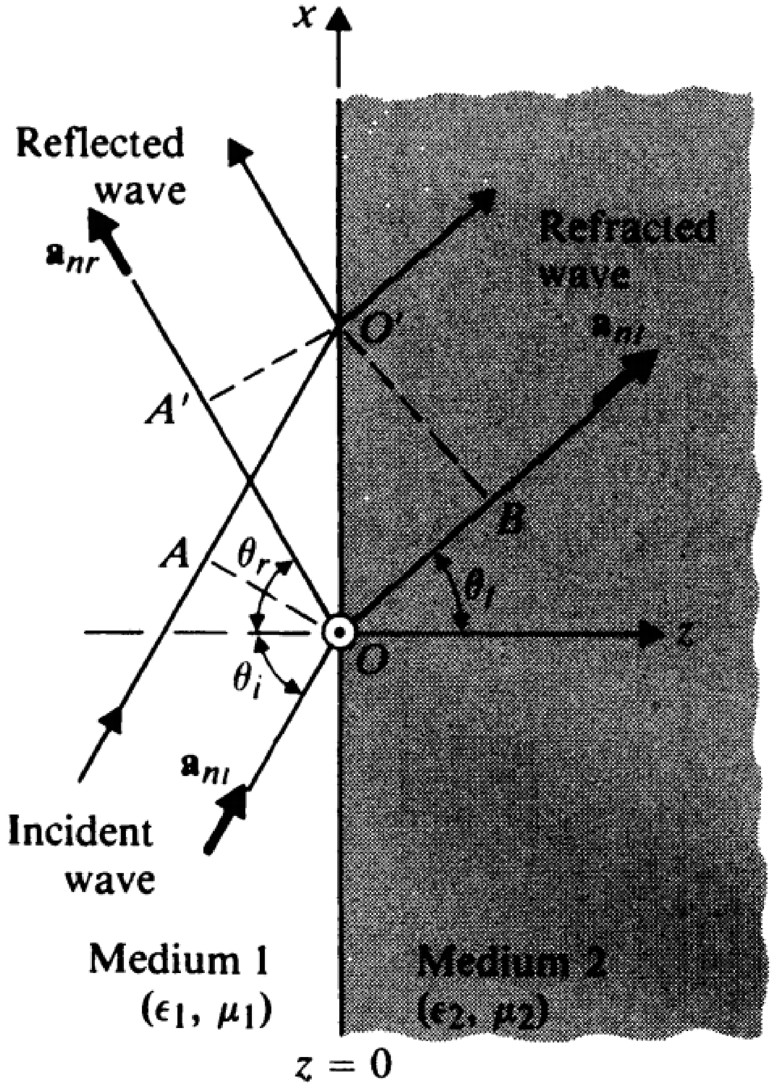

Figure 3: Uniform plane wave incident obliquely on a plane dielectric boundary

a) Obtain the phasor expressions for the transmitted field $(\mathbf{E}_t, \mathbf{H}_t)$

b) Verify that the average power transmitted into medium 2 vanishes.

P.8-40 Glass isosceles triangular prisms shown in Fig. 4 are used in optical instruments. Assuming $\epsilon_r = 4$ for glass, calculate the percentage of the incident light power reflected back by the prism.

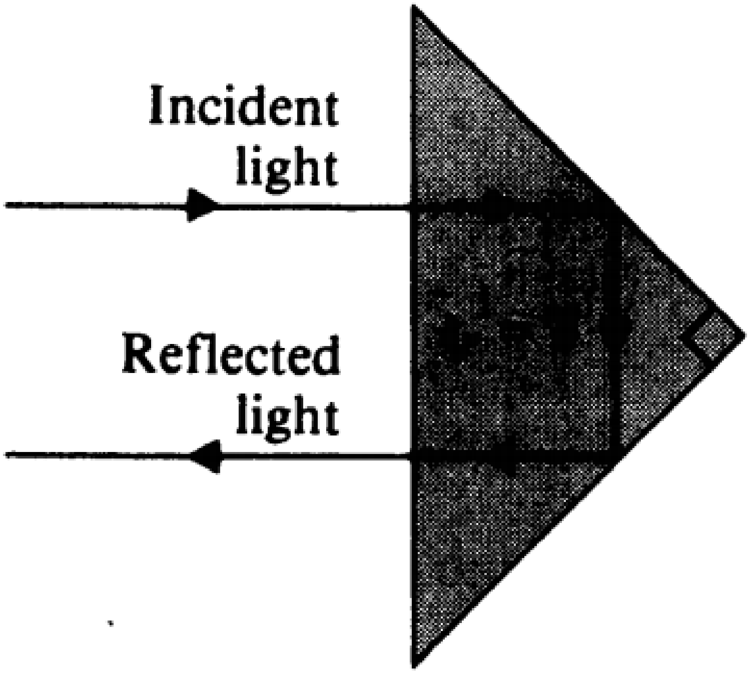

Figure 4: Light reflection by a right isosceles triangular prism

P.8-45 By using the Snell's law of reflection

a) Express Γ and τ in terms of ϵ_{r1}, ϵ_{r2} and θ_i

b) Plot Γ and τ versus θ_i for $\epsilon_{r1}/\epsilon_{r2} = 2.25$ for both perpendicular and parallel polarizations.