NAME: _____

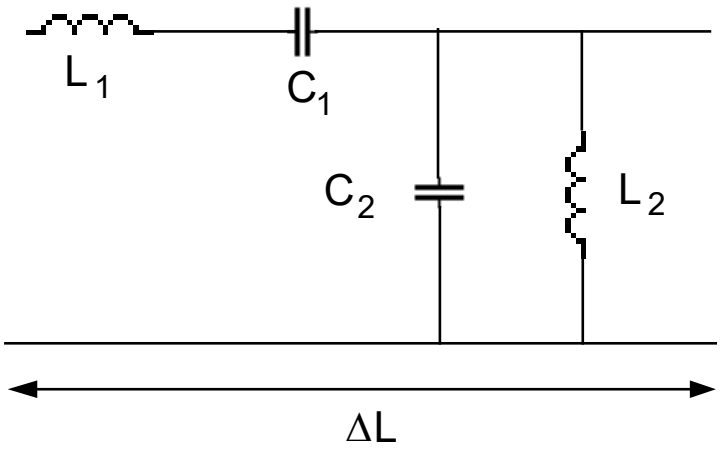
ELEE 6340
Fall 1997

INSTRUCTIONS:

This exam is open-book and open-notes. You may use any material or calculator that you wish. Please show all of your work and write neatly in order to receive credit. Put all of your answers in terms of the parameters given in the problems, unless otherwise noted. All problems are equal credit.

Prob. 1.

An artificial transmission line is made by cascading together many sections of the unit cell shown below.



a) Derive an expression for the propagation constant k_z and the characteristic impedance Z_0.

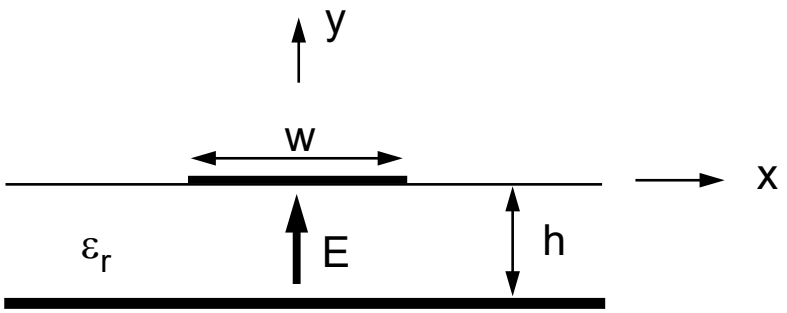
b) Make a qualitative sketch of what β and α should look like, as a function of frequency ω. The points $\omega_1 = \frac{1}{\sqrt{L_1 C_1}}$ and $\omega_2 = \frac{1}{\sqrt{L_2 C_2}}$ should be clearly labeled on your sketch. Assume that $\omega_1 < \omega_2$ in your sketch.

Prob. 2.

A microstrip transmission line is shown below (cross-section view). It consists of a conducting strip of width w on top of a grounded (nonmagnetic) substrate layer of thickness h. Assume that the strip is wide enough so that the electric field may be assumed to be that of a uniform plane wave between the strip and the ground plane ($-h < y < 0,\ -w/2 < x < w/2$). That is,

$$\mathbf{E} = \hat{\mathbf{y}} E_0 e^{-jk_1 z},$$

where k_1 is the wavenumber of the substrate. Outside of the region between the strip and the ground plane, the field is assumed to be zero.

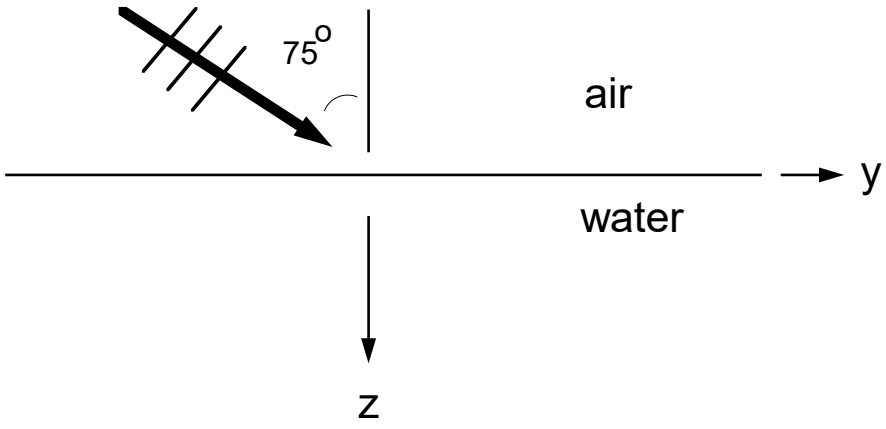


a) Derive an expression for the characteristic impedance of this transmission line.

b) Derive an expression for the attenuation constant α for this transmission line, assuming a conductivity σ for the strip and ground plane. (The metal may be assumed to be nonmagnetic).

Prob. 3.

A TM_z plane wave at a frequency of 3.0 GHz is incident on a lake as shown below. The water in the lake (nonmagnetic) has a relative permittivity of $\varepsilon_r = 81.0$ and a conductivity of $\sigma = 0.5$ S/m. The incident plane wave has a power density of 1.0 W/m^2 in the direction of the **k** vector, which likes in the *yz* plane.



a) What is the magnitude of the tangential electric field E_y at the surface of the lake? You do not need to compute a final number, but you must put your answer in a form where only numbers (real or complex) appear (no symbols).

b) What is the magnitude of the electric field E_y at a depth of 0.5 meters below the surface of the lake, relative to the magnitude at the surface? Give a final numerical answer.