NAME: ________________________________

ELEE 6340
Fall 2003

EXAM I

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. Include units with all answers in order to receive full credit.

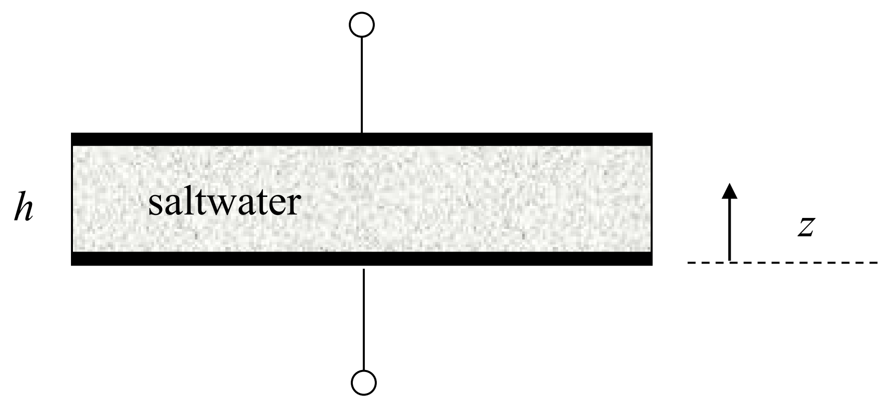
Please write all of your work on the sheets attached.

Problem 1 (30 pts)

A parallel-plate capacitor is filled with saltwater. The capacitor has a 1.0 [cm] separation between the plates. The area of each plate is 100 [cm^2]. At DC, the input resistance between the two plates is 0.5 [Ω]. At a frequency of 100 MHz, the input impedance is 0.475211-*j*(0.105455) [Ω]. Assume that the conductivity of the saltwater does not change with frequency.

Determine the following:

1. The complex effective relative permittivity ε_{rc} of the saltwater at 100 MHz.
2. The complex relative permittivity $\hat{\varepsilon}_r$ of the saltwater at 100 MHz.
3. The phasor charge Q on the top plate of the capacitor at 100 [MHz], assuming that the electric field inside the capacitor is $\mathbf{E} = \hat{\mathbf{z}}(10)$ [V/m].



ROOM FOR EXTRA WORK

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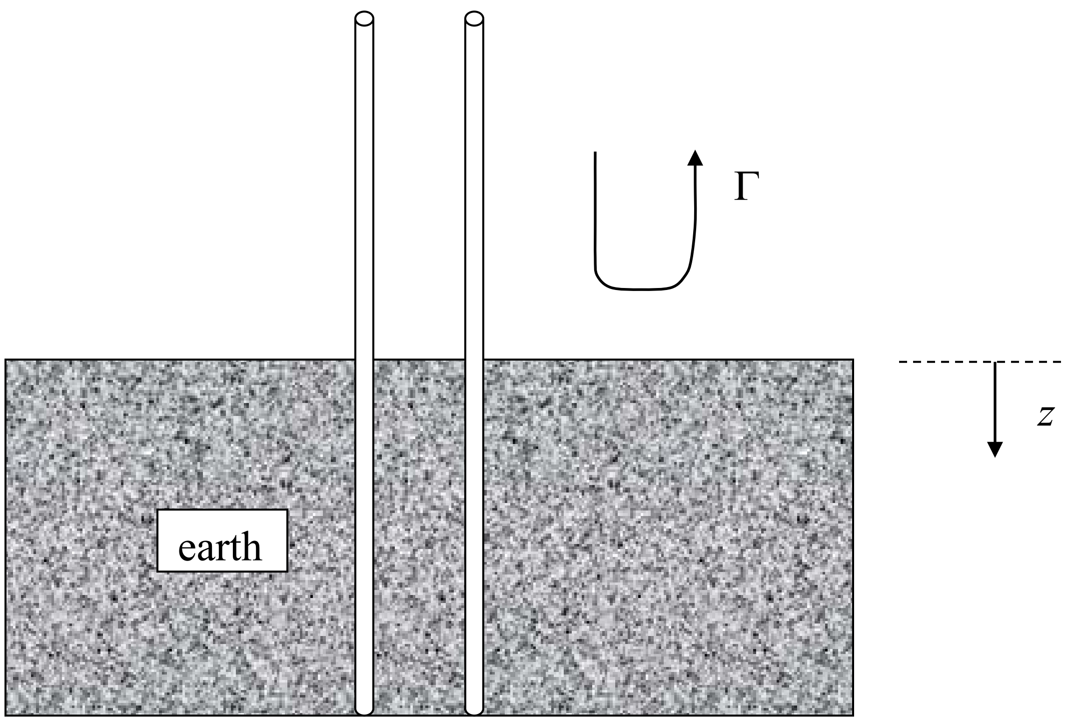
Problem 2 (30 pts)

A twin-line transmission line in air has a characteristic impedance of 300 [Ω]. The transmission line runs into the earth, which has a complex relative permittivity of $\varepsilon_{rc} = 4.0 - j1.0$. Assume that the wires are perfectly conducting, and that the earth (and the line inside of it) extends to $z = \infty$.

1. Determine the reflection coefficient Γ.

2. Determine the attenuation in dB of the signal 1 meter below the surface of the earth, relative to the signal just below the surface of the earth, at a frequency of 100 [MHz]



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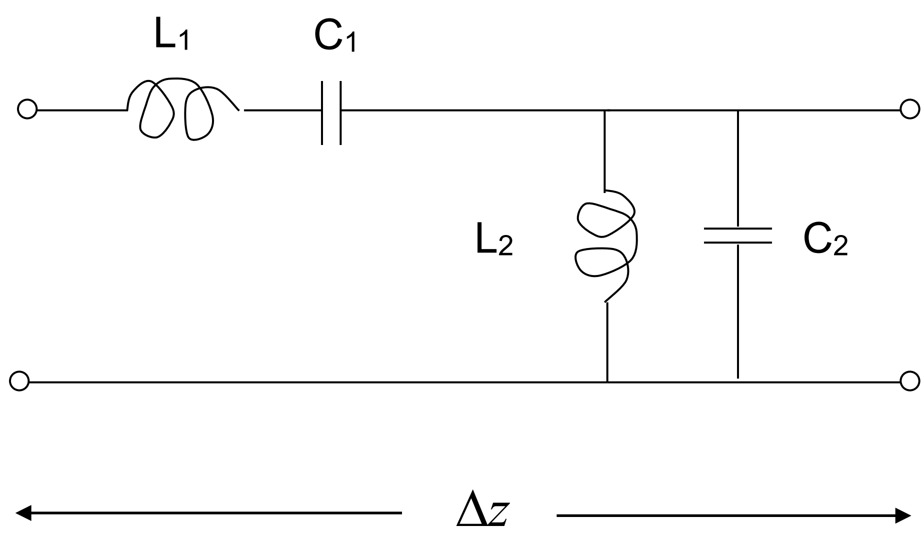
Problem 3 (40 pts)

An artificial transmission lines is made by cascading sections of the circuit shown below. The values L_1, C_1, L_2, C_2 are the actual element values in Henrys (for the inductors) or Farads (for the capacitors).

1. Find a formula for the propagation constant γ in terms of the element values and the unit-cell dimension Δz.
2. Find simple formulas for the phase constant β both at very low frequency and at very high frequency. To get the signs correct, assume that the group velocity is always a positive number at any frequency.
3. Explain why $\alpha = 0$ for both $\omega < \omega_1$ and $\omega > \omega_2$, where $\omega_1 = 1/\sqrt{L_1 C_1}$ and $\omega_2 = 1/\sqrt{L_2 C_2}$ (assume that $\omega_1 < \omega_2$). Explain why $\alpha > 0$ for $\omega_1 < \omega < \omega_2$.
4. Make a qualitative sketch of β and α versus frequency. Label the points ω_1 and ω_2 on your sketch.



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