NAME: ______________________________________

ELEE 6340
Fall 1999

EXAM I

INSTRUCTIONS:

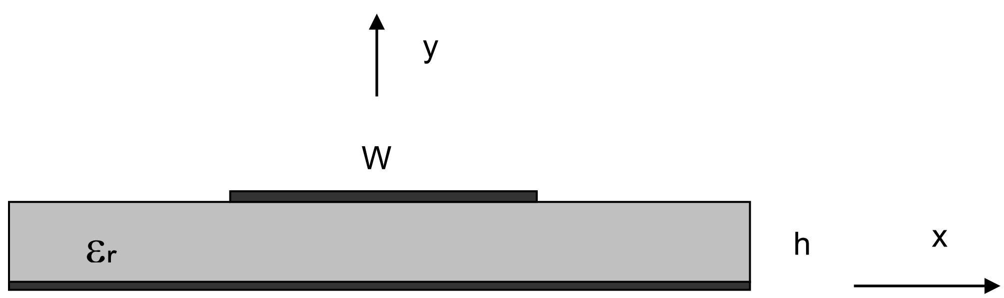
This exam is open-book and open-notes. You may use any material or calculator that you wish. Please show all of your work and write neatly in order to receive credit. Put all of your answers in terms of the parameters given in the problems, unless otherwise noted.

Prob. 1

A microstrip transmission line is shown below. Assume that the strip width W is large compared to the height of the substrate h , so that the electric field may be assumed to be constant under the line ($-w/2 < x < w/2$), and zero outside. Under the line, the electric field may be written as

$$\boldsymbol{E}(x,y,z) = -\hat{\boldsymbol{y}}\, E_0 e^{-jk_z z}$$

Under this assumption, the mode may be assumed to be a TEM transmission-line mode. (This determines k_z, and you should do so). The strip is one conductor of the transmission line, and the ground plane below the line is the other conductor.



1. Determine the magnetic field in the region under the strip, and the current I flowing in the z direction on the strip.

2. Solve for the characteristic impedance Z_0 of the transmission line mode.

3. Assume that the strip and ground plane are conductors with a surface resistance R_s. Derive a formula for the attenuation α_c on the line.

(space for work)

Prob. 2

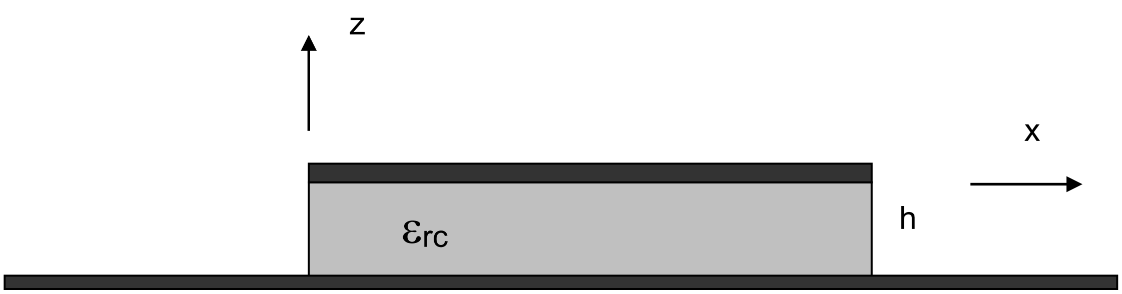
A rectangular microstrip patch antenna is shown below. The antenna consists of a rectangular patch of metal sitting on top of a substrate as shown below. The substrate is mounted on a ground plane. The substrate has a complex relative permittivity ε_{rc} .

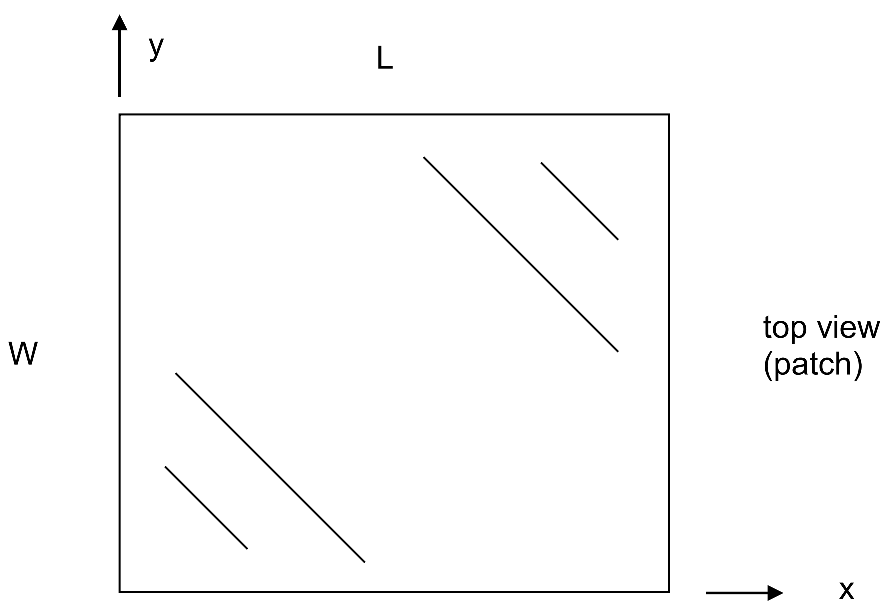
The electric field in the substrate region under the patch metal is written as

$$\boldsymbol{E}(x,y,z)=\hat{z}\,E_0\cos\left(\frac{\pi x}{L}\right).$$

A surface current $\boldsymbol{J}_s$ exists on the lower surface of the patch metal. The surface current on the top surface of the metal may be neglected.

Determine an equivalent current that, when placed over the ground plane (without the patch or the substrate), would replace the microstrip antenna in terms of producing the same radiation as the actual antenna. Your answer for the equivalent current should consist of two parts: the surface current $\boldsymbol{J}_s$ and an effective current due to the presence of the substrate. Determine these currents and draw a picture to show what they look like.





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Prob. 3

A TEM transmission line has a characteristic impedance of Z_0^A (a real number) when there is air between the conductors. The same transmission line is then filled with a lossy material having $\varepsilon_c = \varepsilon' - j\varepsilon''$.

Derive a formula for the complex characteristic impedance of the line, when filled with the lossy material. Your answer should be in terms of Z_0^A, ε_r', and ε_r''.

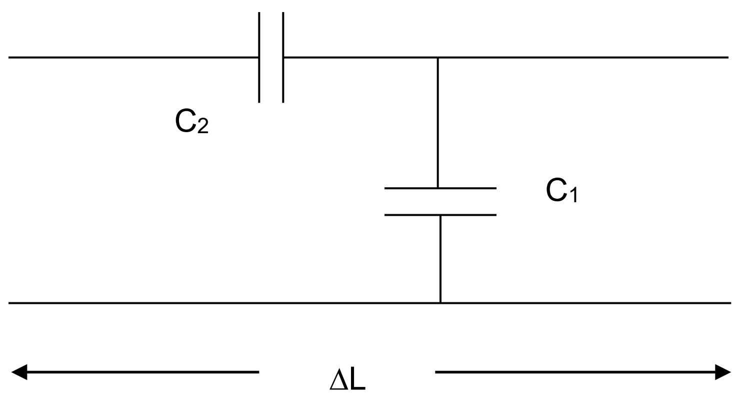
Hint: The capacitance per unit length of a transmission line is always proportional to ε'. Also, changing the permittivity of the material between the conductors does not change the inductance per unit length of the transmission line.

(space for work)

Prob. 4

An artificial transmission line is made by cascading sections of the circuit shown below.

1. Calculate the phase constant β and the attenuation constant α for this line.
2. How many sections have to be cascading together to attenuate all waves by at least 100 dB, assuming that $C_1 = C_2$?



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