NAME: ________________________________

# ECE 6340
# Fall 2010

# EXAM I

**INSTRUCTIONS:**

This exam is open-book and open-notes. You may use any material or calculator that you wish. Laptops or other devices that may be used to communicate are not allowed.

- 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 (if you need more room, you may write on the backs of the pages)

**Please show *all of your work* and *write neatly* in order to receive credit.**

**Problem 1 (40 pts)**

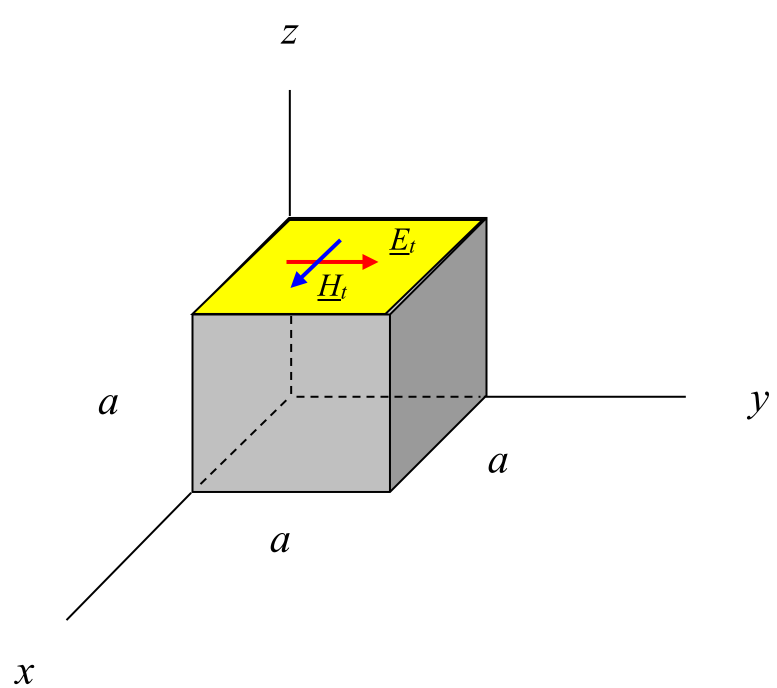
A cube consists of perfect conductor on all faces except the top face ($z = a$). On the top face the tangential electric and magnetic fields (the $x$ and $y$ components) at a frequency $\omega$ are given by

$$E_y = \sin\left(\frac{\pi x}{a}\right)$$
$$H_x = (A - jB)\sin\left(\frac{\pi x}{a}\right),$$

where $A$ and $B$ are positive real numbers. The cube is filled with a homogeneous lossy material having $\varepsilon_c = \varepsilon' - j\varepsilon''$.

a) Determine the time-average power being dissipated inside the cube due to material loses, in terms of the parameters given above.

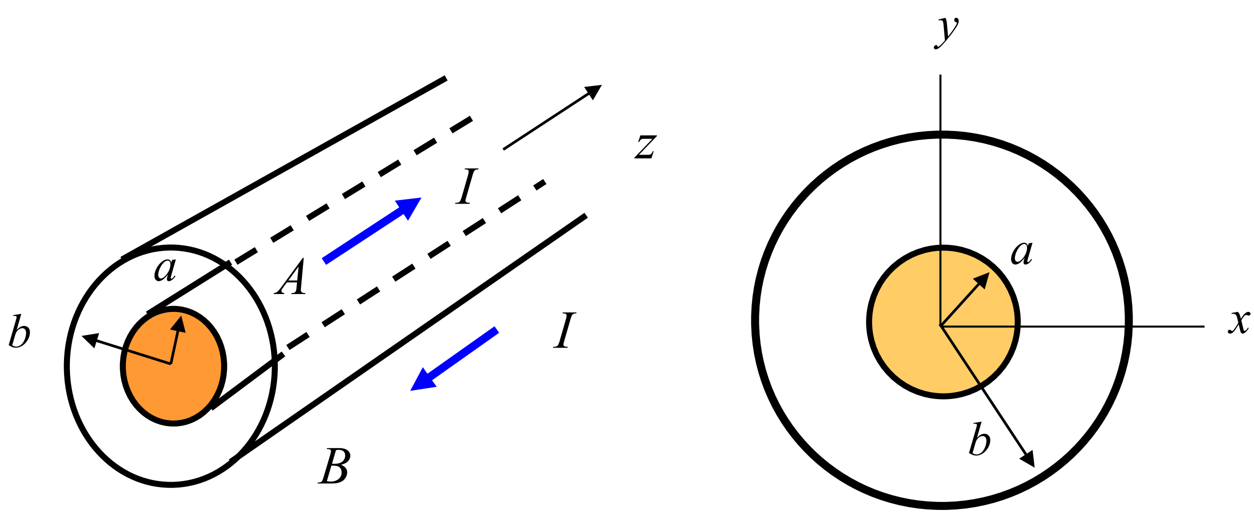
b) Assume that the electric field inside the cube has only a $y$ component and this component is a linear function of $z$, varying from zero at the bottom of the cube ($z = 0$) to the value that is given above at the top face ($z = a$). Determine the value of $\varepsilon''$ for the material, in terms of the parameters given above.



ROOM FOR WORK

**Problem 2 (30 pts)**

An air-filled coaxial cable is shown below.




Assume that the electric field of a TEM mode propagating in the *z* direction is described in the cross-sectional $z = 0$ plane by the function

$$\underline{E}(\rho) = \underline{\hat{\rho}} E_0 \left( \frac{1}{\rho} \right),$$

for some constant $E_0$.

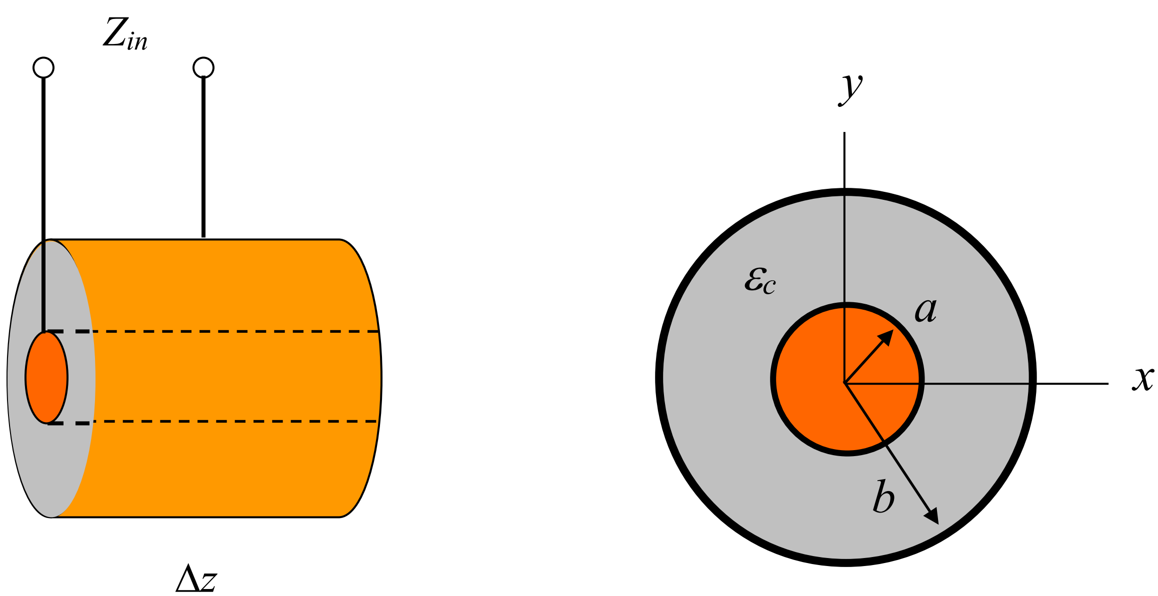
Determine the time-average pressure (force per unit area) on the outer shield of the coax for this mode. For convenience, you may determine the pressure at $\phi = 0$ (i.e., $x = b$, $y = 0$), since the pressure is independent of the angle $\phi$.

ROOM FOR WORK

**Problem 3 (30 pts)**

A coaxial cable is filled with a lossy dielectric material having $\varepsilon_c = \varepsilon' - j\varepsilon''$. An engineer takes a small length $\Delta z$ of the cable and measures the input impedance $Z_{in}$ seen between the inner and outer conductors at a frequency $\omega$. For this small length of line it may be assumed that there is no $z$ variation of the fields and that the structure is simply acting as a lossy capacitor.

Derive a formula for the propagation constant $\gamma$ at the frequency $\omega$ in terms of $Z_{in}$, $\Delta z$, and the dimensions of a coax. It maybe assumed that the lossy dielectric material filing the coax is nonmagnetic. Assume that $R$ (the resistance per unit length of the line) is small enough to be neglected.



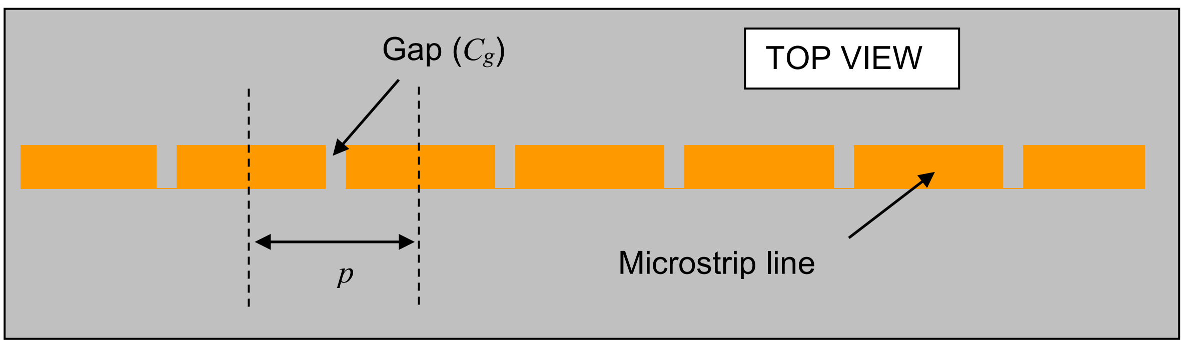
ROOM FOR WORK

**Problem 4 (30 pts)**

A lossless microstrip line has a characteristic impedance of $Z_0^M$ and a wavenumber of $k_z^M$. A periodic set of gaps is placed along the line as shown in the figure below, where the period $p$ is much smaller than a guided wavelength. Each gap has a capacitance of $C_g$.

(a) Derive a formula for the wavenumber $k_z$ of the structure. The result should be in terms of $Z_0^M$, $k_z^M$, $C_g$, and $p$.

(b) Make a sketch of what $\alpha$ and $\beta$ look like vs. frequency $\omega$. The sketch should label the values of any important frequencies such as where $\alpha$ or $\beta$ go to zero, and well as the value of $\alpha$ or $\beta$ at zero frequency. The slope of $\alpha$ or $\beta$ at high frequency should be indicated as well.



ROOM FOR WORK