NAME: ________________________________

ELEE 6340
Fall 2004

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 (25 pts)

A resistive bar with a resistance R rotates around a circular track at a constant angular velocity ω as shown below. The inside and outside parts of the track are connected to a battery with a voltage V_0. A magnetic field exists everywhere in space, which has the value

$\underline{B} = \hat{\underline{z}}\, B_0$

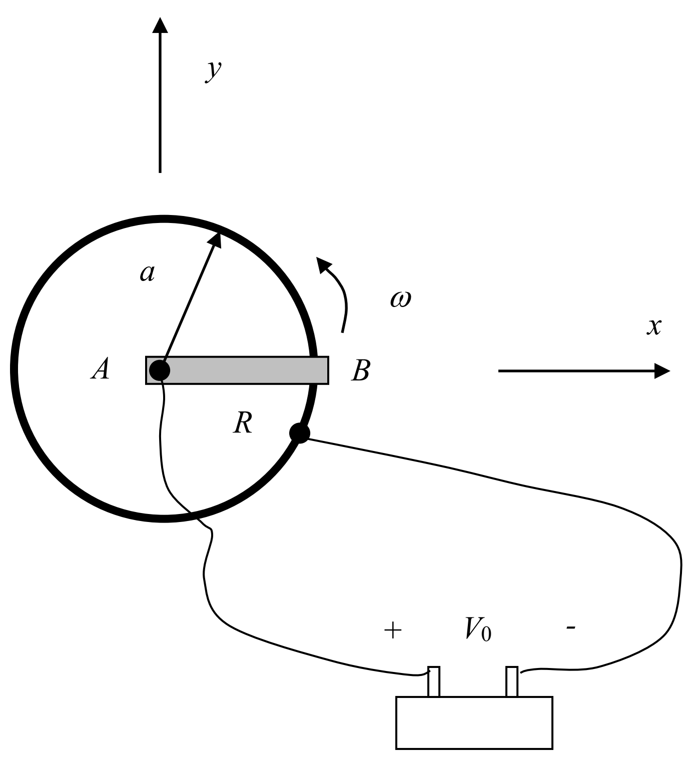
where B_0 is a constant.

a) Determine the voltage drop V_{AB} across the resistive bar, where A is the center point and B is the outside track.

b) Determine the change in EMF across the resistor, ΔEMF_{AB}. Do this by first calculating directly the term

$$I_m = \int_A^B \left(\underline{v} \times \underline{B}\right) \cdot d\underline{r}$$

c) Determine the current through the resistor.



Problem 2 (25 pts)

A rectangular waveguide section is filled with air, and short-circuited at $z = 0$. The length of the section is h. Inside the waveguide only the TE_{10} mode exists. The electric field inside the waveguide is given by

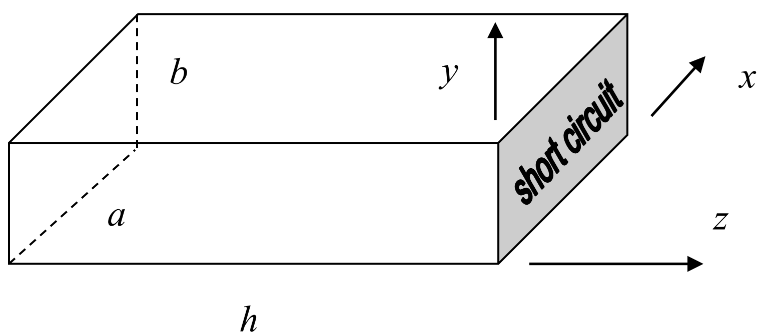
$$\underline{E} = \underline{\hat{y}} \sin\left(\frac{\pi x}{a}\right) \sin\left(k_z z\right).$$

a) Calculate the magnetic field component H_x inside the waveguide.

b) Calculate the complex power P_c flowing into the waveguide section through the cross-sectional plane $z = -h$.

c) Calculate the time-average energy stored in the electric field inside the waveguide section.

d) Use the complex Poynting theorem to determine the time-average energy stored in the magnetic field inside the waveguide section.



ROOM FOR EXTRA WORK

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Problem 3 (25 pts)

A certain waveguide is air filled. The cross-sectional shape of the waveguide is arbitrary. At a frequency of 10 GHz, a waveguide mode has a phase change of 1.5 radians per meter in the z direction.

a) What is the cutoff frequency of this waveguide mode?

b) What will the attenuation of this same waveguide mode be, in dB/cm, at a frequency of 5 GHz?

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Problem 3 (40 pts)

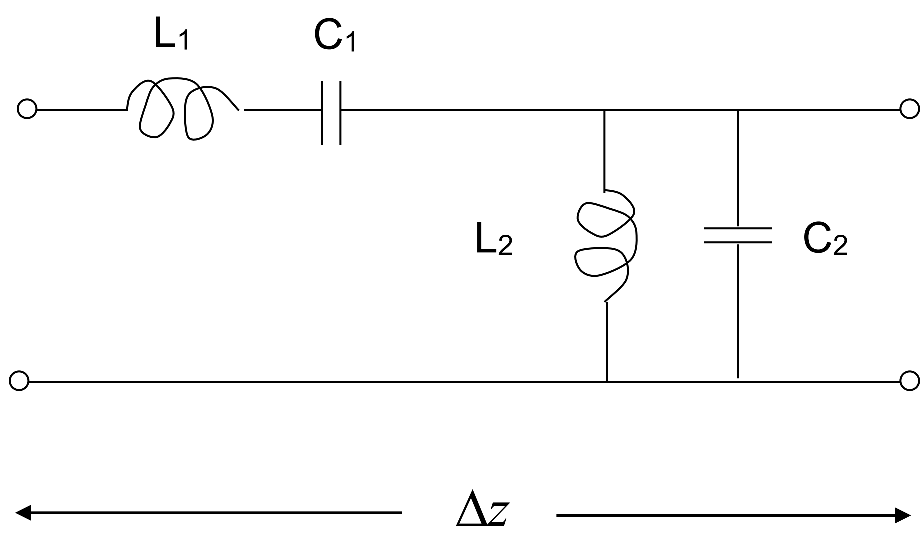
An artificial transmission lines is made by cascading sections of the circuit shown below. The values L_1, C_1, L_2, C_2 are the actual element values in Henrys (for the inductors) or Farads (for the capacitors).

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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