NAME: _____

ECE 6340
Fall 2008

EXAM I

INSTRUCTIONS:

This exam is open-book and open-notes. You may use any material or calculator that you wish.

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.

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

Useful identities:

$$\sin^2(x) = \frac{1-\cos(2x)}{2}$$

$$\cos^2(x) = \frac{1+\cos(2x)}{2}$$

Problem 1 (40 pts)

Ocean water has the following parameters:

$\sigma = 4$ [S/m]
$\varepsilon_r'(18\ \text{GHz}) = 43$
$\varepsilon_r''(18\ \text{GHz}) = 38$
$f_{\max} = 18$ GHz.

The frequency $f_{\max}$ is the frequency where the imaginary part of the permittivity is maximum.

Derive a formula for the complex permittivity ε_c of the ocean water as a function of frequency, using the Debye model to determine ε as a function of frequency. Make sure that all constants appearing in your expression have been determined.

EXTRA ROOM FOR WORK

Problem 2 (50 pts)

Consider the problem shown below, which has a top bar that slides upward at a constant velocity v_0. The magnetic field is given by

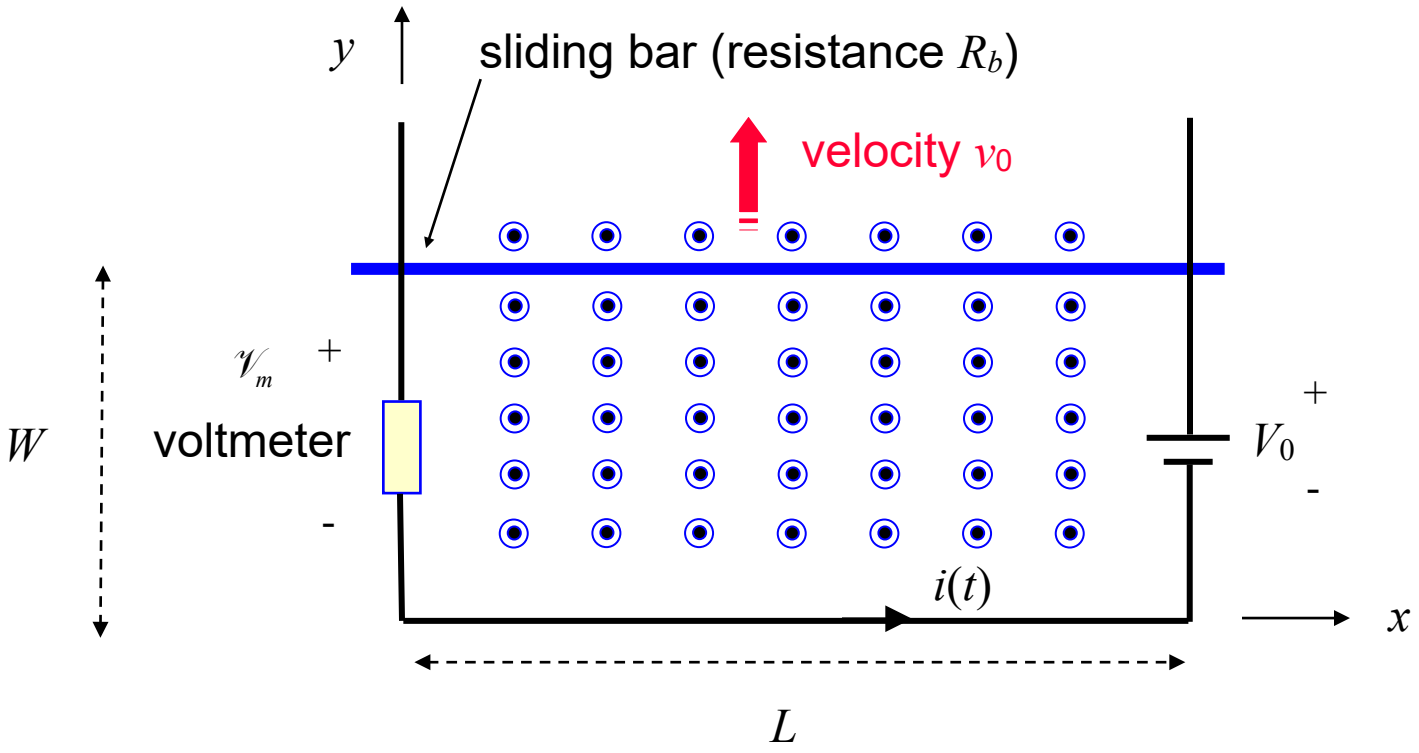
$$\underline{\mathscr{B}} = \underline{\hat{z}}\, e^{-t} .$$

The sliding bar has a resistance R_b. The other rails are perfectly conducting. A voltmeter is in the circuit, as shown below. Assume that this voltmeter has an internal resistance R_m. The circuit has an unknown current $i(t)$ flowing counterclockwise through it.

a) Determine the current $i(t)$.

b) Determine the voltage reading $\mathscr{V}_m$ on the voltmeter.

c) Determine the voltage drop $\mathscr{V}_{AB}$ across the sliding bar, where $\underline{A}$ is the left end of the bar and $\underline{B}$ is the right end.



EXTRA ROOM FOR WORK

Problem 3 (40 pts)

Consider a hollow rectangular waveguide resonator as shown below. It consists of a hollow rectangular waveguide of length L with metal plates at the two ends ($z = 0$ and $z = L$). The electric field inside of the waveguide resonator at a resonant frequency ω is given by

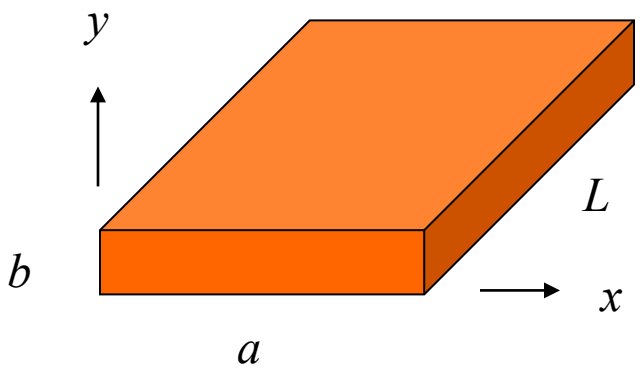
$$\underline{E} = \underline{\hat{y}} \sin\left(\frac{\pi x}{a}\right)\sin\left(\frac{\pi z}{L}\right).$$

a) Determine the magnetic field inside of the resonator.

b) Determine the time-average electric energy stored inside the resonator.

c) Determine the total complex power flowing down the waveguide in the z direction through the cross-sectional plane $z = L / 4$.

c) Determine the total time-average force on the plate at the left end of the resonator ($z = 0$).



EXTRA ROOM FOR WORK