6.013 Electromagnetics and Applications

| Quiz 2	Closed book, no calculators	November 14, 2002

Please note the two pages of formulas provided on a separate sheet. There are 3 problems on two pages. Please simplify all expressions, circle and dimension your answers, and present numerical answers to the extent practical without a calculator or tedious computation. You may leave natural constants in symbolic form (π, ε_o, h, e, etc.).

Problem 1. (36/100 points)

The illustrated generic device has an inductance of L Henries and the two plates have areas A and are separated by d meters. The medium between the plates is characterized by conductivity σ, permittivity ε, and permeability μ. Depending on frequency f, the impedance $\underline{Z}$ of this device is dominated either by resistive, inductive, or capacitive effects.

a) What is the capacitance C [Farads] of this device?

b) What is the resistance R [ohms] of this device?

c) As $f \rightarrow \infty$, is this device primarily resistive, inductive, or capacitive? That is, which effect dominates the device impedance $|\underline{Z}|$? Explain briefly.

Area A

ε, σ, μ_o

d
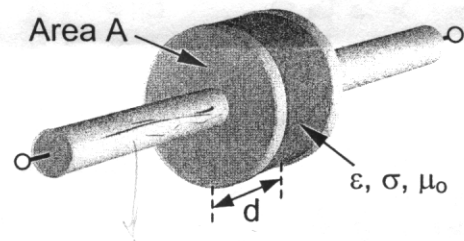
Problem 2. (28/100 points)

Two motionless conducting plates of area A and separation d are in vacuum. Ignore fringing fields.

Charge +Q

Area A

$\overline{v}$

z

d

Charge −Q

$\overline{v}$

y

$\overline{H}$

x

a) What is the magnitude of the force f [N] attracting the two plates?
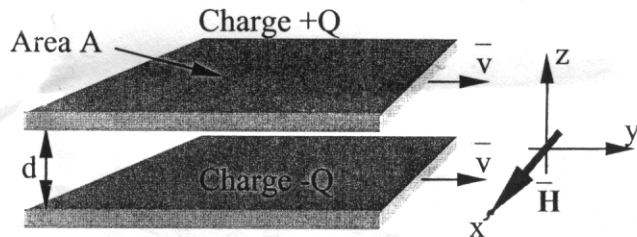
b) Both plates now move in the +y direction with velocity vector $\overline{v}$ perpendicular to the illustrated magnetic field vector $\overline{H}$. What is the additional force f between the plates of magnetic origin? Is it attractive or repulsive?

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Problem 3. (36/100 points)

A unit-step voltage source $u(t)$ directly excites an air-filled TEM line with impedance Z_o and length D. The TEM line is terminated with an inductor and resistor in series, as illustrated.
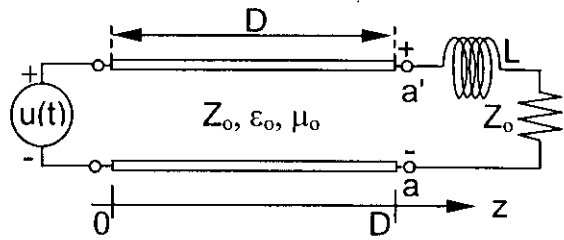
a) Sketch the current $i(z)$ on the line at $t = D/3c$ and dimension your answer.

b) Sketch the voltage $v(t)$ at the terminals a' a at the right-hand end for $0 < t < 3D/c$, and fully dimension your answer.

c) What is the voltage v_∞ across the terminals a'a in the limit where $t \rightarrow \infty$?