6.642 Continuum Electromechanics

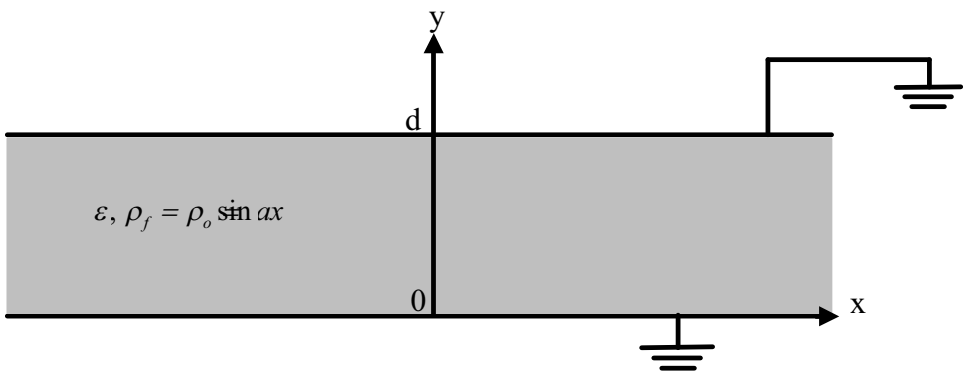
Fall 2008

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.642 Continuum Electromechanics

Problem Set #1 — Issued: 9/03/08
Fall Term 2008 — Due: 9/12/08

Reading: Continuum Electromechanics (Melcher) – Sections 2.16, 2.18

Problem 1



A slab of volume charge of thickness d and permittivity ε has free volume charge density

$$\rho_f \quad \rho_o \sin ax$$

and is confined between two perfectly conducting ground planes at $y \quad 0$ and $y \quad d$ that are of infinite extent in the x and z directions.

a) Find a particular solution $\Phi_p(x, y)$ to Poisson's equation for the electric scalar potential.

b) If your solution to (a) does not satisfy the zero potential boundary conditions at $y \quad 0$ and $y \quad d$, add a homogeneous Laplacian solution, $\Phi_h(x, y)$, which does.

c) What is the electric field distribution for $0 < y < d$ and what is the free surface charge distribution on the $y \quad 0$ and $y \quad d$ planes?

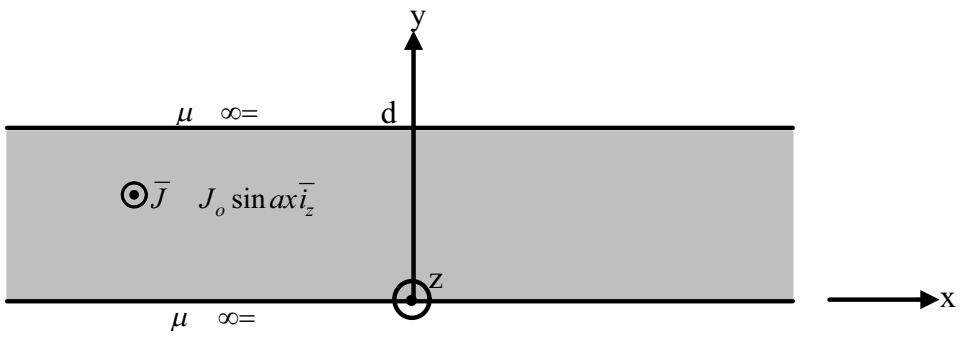
d) What is the equation of the electric field lines, defined as

$$\frac{dy}{dx} \quad \frac{E_y}{E_x}$$

that goes through the point (x_o, y_o)?

e) Using your favorite graphics program, plot the electric field lines over the interval $0 < x < \frac{2\pi}{a}$ and $0 < y < d$.

Problem Set 2



A slab of volume current of thickness d and magnetic permeability μ has free volume current density

$$\bar{J} \quad J_o \sin ax \bar{i}_z$$

and is confined between two perfectly conducting planes at $y \quad 0$ and $y \quad d$. The regions for $y > d$ and $y < 0$ is filled with material of infinite magnetic permeability.

a) What is the magnetic field $\bar{H}$ in the regions $y > d$ and $y < 0$?
Hint: Use the vector potential and $\nabla^2 \bar{A} \quad -\mu \bar{J}$

b) What is the boundary condition on $\bar{H}$ at $y \quad d_-$ and $y \quad 0_+$ inside the slab of volume current?

c) What is the magnetic field distribution for $0 < y < d$ and what is the free surface current distribution on the $y \quad 0$ and $y \quad d$ perfectly conducting planes?

d) What is the equation of the magnetic field lines?

e) Using your favorite graphics program, plot the magnetic field lines over the interval $0 < x < 2\frac{\pi}{a}$ and $0 < y < d$.

f) How are the field lines of part $2e$ different than the field lines of problem 1e?