6.641 Electromagnetic Fields, Forces, and Motion, Spring 2005

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.641 Electromagnetic Fields, Forces, and Motion
Quiz 1
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You are allowed to prepare a one page (both sides) formula sheet that you can use during Quiz 1.

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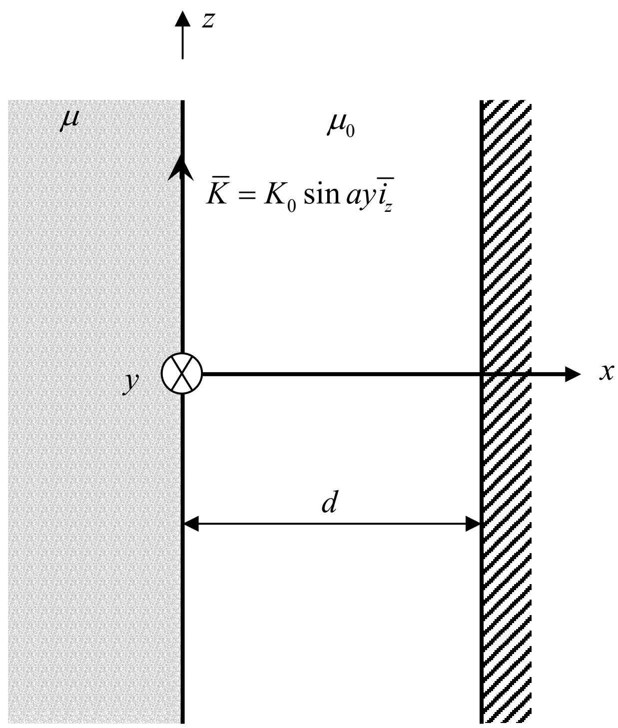
Problem 1



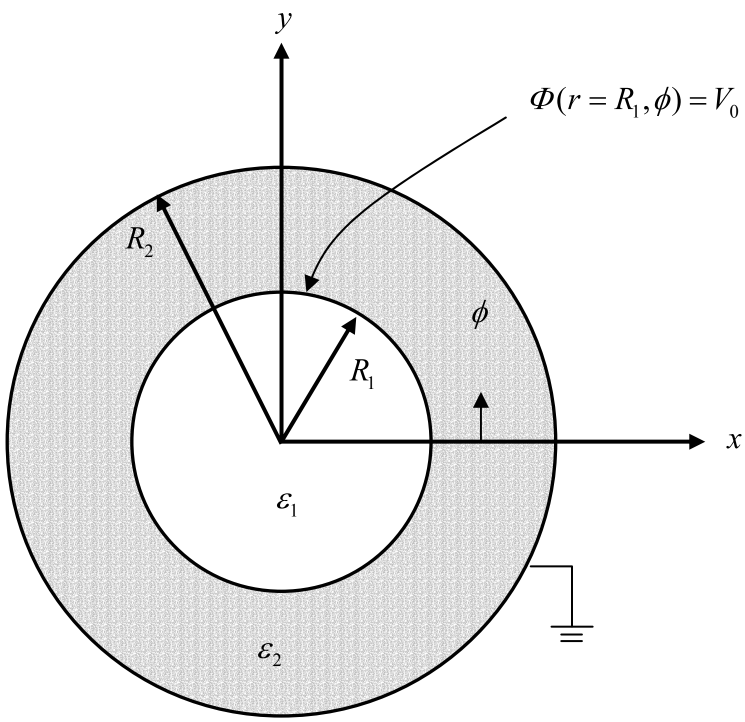

A current sheet $\overline{K} = K_0 \sin ay \overline{i}_z$ is placed at $x=0$ between magnetic material with permeability $\mu$ and free space with magnetic permeability $\mu_0$ where $a > 0$. A perfectly conducting plane of infinite extent in the $y$ and $z$ directions is placed at $x=d$. Because there are no volume currents for $x < 0$ and $0 < x < d$, in these regions a scalar potential can be defined such that $\overline{H} = -\nabla \chi$. Assume that there are no field dependencies on the z coordinate.

a) What is the general form of the solution for $\chi(x, y)$ in the regions $x < 0$ and $0 < x < d$.
b) What boundary conditions must be satisfied?
c) Solve for $\chi(x, y)$ for $x < 0$ and $0 < x < d$.

   Hint: To minimize algebraic complexity, think about the best way to write the general form of the solution for $\chi(x, y)$ to automatically satisfy one of the boundary conditions for part (b).

d) What is the surface current that flows on the $x=d$ interface?
e) What is the force per unit $y$-$z$ area on the $x=d$ interface?

Problem 2




An infinitely long cylinder of radius $R_1$ has the electroquasistatic potential at $r = R_1$ constrained to be $\Phi(r = R_1, \phi) = V_0 \sin 2\phi$. This cylinder is surrounded by a perfectly conducting cylinder of radius $R_2$ that is grounded. The dielectric permittivity for $r < R_1$ is $\varepsilon_1$ and is $\varepsilon_2$ for $R_1 < r < R_2$.

a) What is the general form of solution for the electric scalar potential $\Phi(r, \phi)$ for $r < R_1$ and $R_1 < r < R_2$?
b) What boundary conditions must be satisfied?
c) What is the potential distribution for $r < R_1$ and $R_1 < r < R_2$?
d) What are the surface charge distributions at $r = R_1$, and $r = R_2$?