AUB	Electrodynamics I	Feb. 6, 1998
Physics Dept.	Physics 303	Time 3 hours

Problem 1.

a) Using Maxwell's Equations and Ohm's law show that in a conductor of conductivity σ and no net charge density ($\rho = 0$),

$$\nabla^2 \vec{E} = \frac{4\pi\sigma}{c^2} \frac{\partial \vec{E}}{\partial t} \frac{1}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2}$$

b) Suppose that the conductor carries an alternating current $\vec{J} = \vec{J}_O \, e^{-i\omega t}$

Show that if it's a good conductor ($\sigma >> \omega$), then $\nabla^2 \vec{J} + \frac{4\pi\sigma i\omega}{C^2} \vec{J} = 0.$

c) Suppose that the conductor is a metal slab filling the space $-d < x < d$ and that the current flows in the y-direction.

Find the current distribution $\vec{J}$ (x, t) and plot it against x, given that on the surface of the metal slab ($x = \pm d$), the electric field is $\vec{E} = E_O \, e^{-i\omega t} . \hat{y}$.

Problem 2

Show that the self inductance of a toroidal solenoid of N turns can be given by:

$$L = \mu N^2 [R - (R^2 - r^2)^{1/2}]$$

in which r is the radius of the circular cross section of the solenoid, and R is the radius of the toroid.

You may need the integral:
(a > b > 0)

$$I = \int_0^{2\pi} \frac{\sin^2\theta \, d\theta}{a + b\cos\theta} = \frac{2\pi}{b^2} [a - (a^2 - b^2)^{1/2}]$$

Problem 3

A very long dielectric cylinder of radius R and dielectric constant k is placed in a uniform electric field $\vec{E}_O$. The axis of the cylinder is oriented at right angles to the direction of the uniform electric field. The cylinder contains no free charges. Determine the electric field at points inside and outside the cylinder.