Electromagnetics II
Makeup Exam
March 2, 1999

Solve the following four problems. Each carries equal weight. If you find it necessary to assume anything, you must state your assumptions clearly. Reasonable assumptions will be accepted but not if they modify the problem or if the assumptions are not necessary to solve the problem.

1. A magnetic flux density, $\mathbf{B}=\hat{y}0.1(\cos 100t)\cos 5z$ [T] exists in a linear, isotropic, homogeneous material characterized by ε and μ, but with zero conductivity. Find the displacement current density.

2. During lightning, a plasma channel is created (that's what we see as the lightning flash). The plasma channel has the following properties: radius of the channel is 6 [mm], the current in the channel is 50,000 [A], its conductivity is $\sigma=10^3$ [S/m] and its permittivity is ε_0.. Calculate:
a. The total displacement current in the channel if it is known that the frequency is 100 [kHz] aqnd the current is sinusoidal (typical).
b. The frequency at which displacement current would equal conducting current in the channel.

3. A plane wave propagates in a dielectric with properties: $\mu=\mu_0$ [H/m], $\varepsilon=4\varepsilon_0$ [F/m] and $\sigma=10^{-4}$ [S/m]. The electric field has an amplitude of 100 [V/m]. Frequency is 1,000 [MHz].
a. Calculate the propagation constant for the wave.
b. Write the electric and magnetic field intensity everywhere in space. Set up a convenient system of coordinates and write the fields in this system.
c. Calculate the phase velocity and the intrinsic impedance in the dielectric.
d. Calculate the distance required to attenuate the wave by 50 [db].

4. In a region in free space the magnetic field is:

$$\mathbf{H}=\hat{y}H_0 sin(\omega t-\beta z)$$

a. Calculate the time averaged potential energy stored in the magnetic field in a cube 2m on the side.
b. What is the total stored potential energy in the same cube as in (a)?