Name____ **SSN#**__________________________

EEL 4471 – Electromagnetics

Spring 2005

Test 3 – April 28, 2005

Open Book/Open Notes

1 hour and 15 minutes

1. The exam is open-book, open-notes.

2. A calculator may be used to assist with the test. No laptops or PDAs are allowed.

3. You must circle or box your answers to get full credit.

4. Partial credit may be given provided that the grader can clearly follow your work to the extent that an understanding of the problem is demonstrated.

5. No collaboration is allowed on this examination. Only Charles Baylis or the teaching assistant may be consulted for clarification.

6. You may attach extra sheets to the exam if necessary. Each page should contain your name, the problem number, and the page number for that problem.

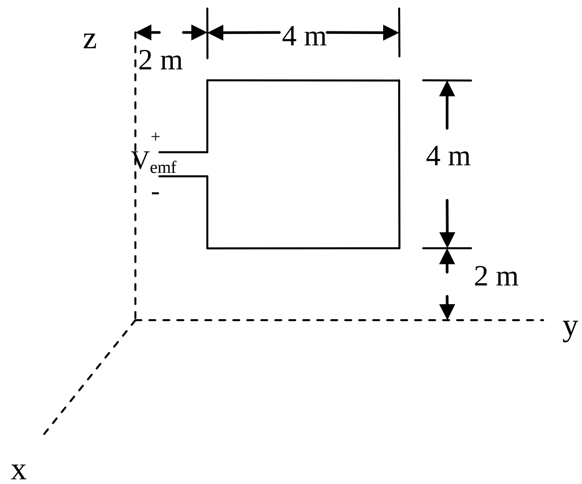
Please sign the statement below. YOU MUST SIGN THE STATEMENT OR YOU WILL GET A ZERO FOR THIS EXAMINATION!!!

I hereby testify that I have neither provided or received information during the test and that this test is the sole product of my effort.

Signed ____ Date______________________

PROBLEM 1: A square loop with sides of length 5 m (shown below) exists in a magnetic flux density that is given by the vector

$B = \hat{x}(7\times10^{-9})yz\cos(2\pi\times10^{6}t)$ (T)



(a) Determine the emf induced across a small gap created in the loop as described above by V_{emf} (10 points).

(Problem 1 continued on next page)

(b) Determine the current that would flow through a 2 Ω resistor connected across the gap. The loop has an internal resistance of 0.5 Ω (5 points).

(c) Give the direction (clockwise or counterclockwise as viewed in the above drawing) of this current flow in the loop at $t = 0$ s (5 points).

PROBLEM 2: A right-hand circularly polarized wave with an electric-field modulus of 5 V/m is traveling in free space ($\varepsilon = \varepsilon_0 = 8.85 \times 10^{-12}$ F/m) in the positive x direction. The wavelength is 2 m. The intrinsic impedance of free space is $\acute{\eta}_0 = 120\pi$ ohms.

(a) Write a valid time-domain vector expression for the wave's electric field vector $\vec{E}(x,t)$. (15 points)

(b) Write a valid time-domain vector expression for the wave's magnetic field vector $\vec{H}(x,t)$. (5 points)

PROBLEM 3: Silicon has a conductivity of 4.4 x 10^{-4} S/m and a relative permittivity of ε_r = 11.8. Use ε_0 = 8.85 x 10^{-12} F/m. Assume that $\mu = \mu_0 = 4\pi \times 10^{-7}$ H/m for silicon.

(a) Using the rule-of-thumb criteria given in the textbook, is silicon a good conductor, quasi-conductor or low-loss dielectric at 1 GHz? Show necessary calculations for full credit. (5 points)

(b) Calculate the attenuation constant at 1 GHz (you may use approximate expressions as provided by the textbook if applicable based on your answer to part (a)). (5 points)

(c) What is the skin depth at 1 GHz? (5 points)

(d) If a 1 GHz propagating wave is incident upon a semi-infinite block of silicon, at what depth is the electric field magnitude 10% of its value on the surface? (5 points)

PROBLEM 4: A plane wave traveling in free space is normally incident upon a nonmagnetic, nonconducting material with $\varepsilon_r = 16$. The electric field of the incident wave is given by

$$\bar{E}^i = \hat{x}3\cos(2\pi \times 10^9 t - 20.94z)$$

Obtain an expression for the transmitted electric field intensity (notice this field exists in the material with $\varepsilon_r = 4$). (20 points)

PROBLEM 5: A plane wave in free space with

$$\tilde{\bar{E}}^i = \hat{y}16e^{-j(4x+2z)} \qquad \text{(V/m)}$$

is incident upon the planar surface of a dielectric material which has $\varepsilon_r = 2$. The surface is the plane described by z = 0, and the dielectric material with $\varepsilon_r = 2$ occupies the half-space $z \geq 0$. Both media are nonmagnetic.

(a) Is the polarization perpendicular or parallel? (5 points)

(b) Determine the angle of incidence (5 points)

(c) Write the expression for the reflected electric field intensity phasor (notice this field exists in the free space region). (10 points)