Name_____ **SSN#**_____

EEL 4471 – Electromagnetics

Spring 2005

Test 2 – March 24, 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.

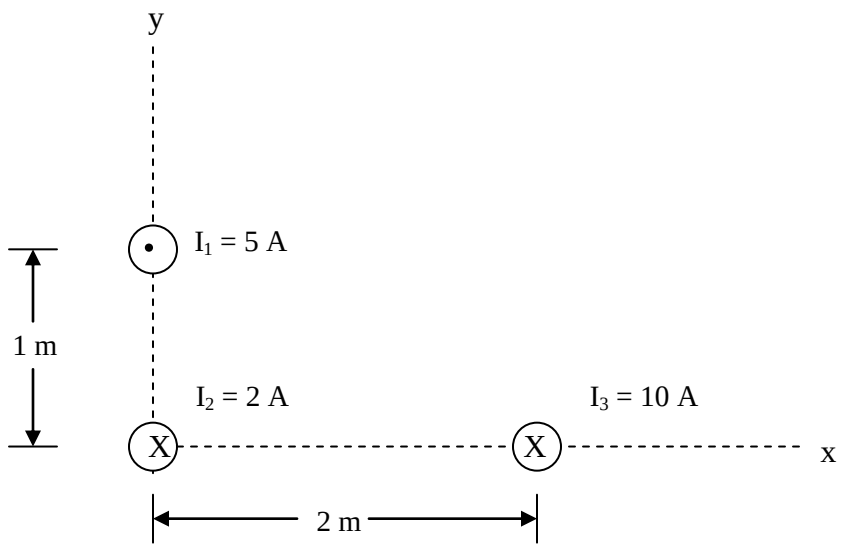
Please sign the statement below. YOU MUST SIGN THE STATEMENT OR YOU WILL GET A ZERO FOR THIS EXAMINATION!!!

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: Charge q_1 =5 μC is located at (x = 0.02 m, y = 0 m, z = 0) and charge q_2 is located at (x = 0.01 m, y = 0.03 m, z = 0). Assume the medium is free space ($\varepsilon = \varepsilon_0 = 8.85 \times 10^{-12}$ F/m). Using Coulomb's Law, find the charge q_2 such that the x component of the electric field is zero at the origin. (20 points).

PROBLEM 2: Three long, parallel wires are arranged as shown below such that the length of the wire extends out of the page. A dot refers to a current flowing out of the page and an "x" refers to current flowing into the page. Use the coordinate system given in your analysis. The wires can be considered as infinite in length for purposes of this problem.

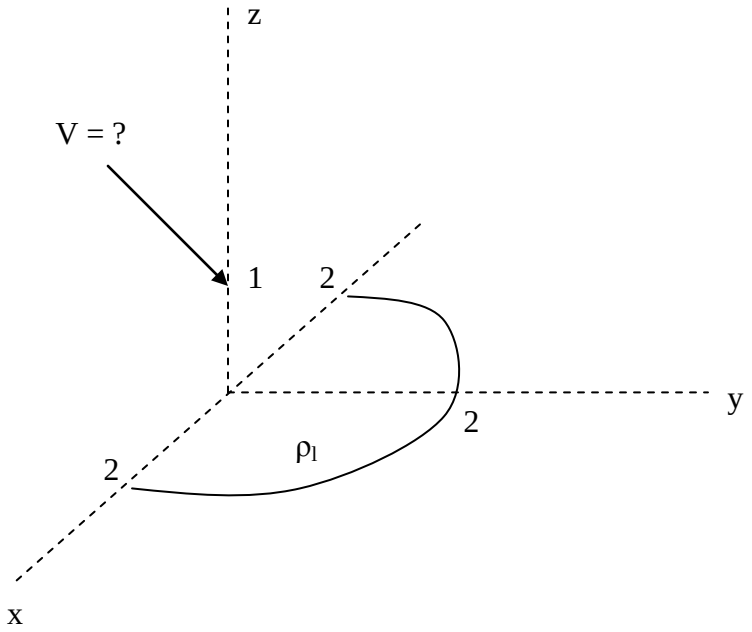


(a) Find the force per unit length vector acting on I_3 due to I_1 (8 points).

(b) Find the force per unit length vector acting on I_3 due to I_2. (8 points)

(c) From the results to parts (a) and (b), what is the total force per unit length vector acting on I_3 (4 points)

PROBLEM 3: In three-dimensional space, a semi-circle of charge density $\rho_l = 4 \times 10^{-11}$ C/m exists which has a radius of 2 m. The problem can be drawn such that the semi-circle sits in the x-y plane as shown. Assume the medium is free space ($\varepsilon = \varepsilon_0 = 8.85 \times 10^{-12}$ F/m). Find the electric potential (voltage) at (x = 0, y = 0, z = 1 m). Show all work in arriving at your solution.



PROBLEM 4: The plane boundary defined by z = 0 (the x-y plane) separates air (region 1) with $\varepsilon_1 = \varepsilon_0$ and $\mu_1 = \mu_0$ from a block of material (region 2) with $\varepsilon_2 = 5\varepsilon_0$ and $\mu_2 = 2\mu_0$, where $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m. The surface charge density on the boundary is $\rho_s = 2 \times 10^{-11}$ C/m^2 and it has been found that no current is flowing on the surface. The electric and magnetic fields in air (region 1) are given by

$$\overline{E}_1 = (-\hat{x}1 + y4 + \hat{z}2) \text{ V/m} \qquad \text{and} \qquad \overline{H}_1 = (\hat{y}10 - \hat{z}2) \text{ A/m.}$$

(a) Find the electric field $\overline{E}_2$ in region 2, assuming neither material is a perfect conductor. (10 points)

(b) Find the magnetic field $\overline{H}_2$ in region 2. (10 points)

PROBLEM 5: Consider a quarter circular section of conductor that lies in the x-y plane with radius 1 m conducting a current of 3 A. Use the Biot-Savart Law:

$$\overline{H} = \frac{I}{4\pi}\int \frac{d\bar{l} \times \hat{R}}{R^2}$$

to solve for the magnetic field at the origin.