UNIVERSITY OF TORONTO

Faculty of Applied Science and Engineering

Final Examinations, April 1992

Second Year - Program 7

ELE 221S - Electric and Magnetic Fields

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All questions are of equal value and any five constitute a complete paper.

Aids: $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m.

1. A capacitor consists of two 3 m long, circular, thin metallic co-axial tubes of 2 mm and 4 mm radii. The inner cylinder is coated by a 1 mm thick layer of dielectric of relative permittivity 5. The breakdown field of air is 10^6 V/m, that of the dielectric 3×10^6 V/m. Calculate the maximum voltage that can be applied to the capacitor.

2. Two infinitely long straight, thin parallel wires, 20 m apart run 10 m above a horizontal conducting ground plane. The linear charge density on one wire is 10^{-8} C/m and -10^{-8} C/m on the other. Calculate the surface charge densities on the ground plane:

   (i) directly below each of the lines and,

   (ii) on the line half-way between the positions specified in (i) above.

3. An electric field $\vec{E} = [E_x(x),\ 0,\ 0]$ in a medium of relative permittivity 5 is specified by means of a diagram in Fig. 1.

   (i) Draw a graph of the charge density producing the field, specifying relevant numerical values,

   (ii) determine the potential of point A with respect to point B and,

   (iii) draw a qualitative sketch of the potential of the field as a function of x.

4. The magnetic field $\vec{H} = [H_x(y),\ 0,\ 0]$ is specified below:

$$H_x = \begin{cases} H_o[(y/a)^2 - 1] & \text{for } -a \le x \le a \\ 0 & \text{elsewhere.} \end{cases}$$

For $H_0 = 5$ A/m and $a = 1$ cm calculate the magnitude and direction of the electric current flowing through a rectangle the corners of which in the (x, y, z) coordinate system are (1, 0, 0) cm, (1, 2, 0) cm, (4, 2, 0) cm and (4, 0, 0) cm.

5. A magneto-electric circuit is shown in Fig. 2. The relative permeability of magnetic material is 1000. Calculate the number of ampere turns NI required to produce a torque of 0.02 Newton meter exerted on the loop of circulating current $I_0 = 30$ Ampere.

6. A current loop has a radius of 20 cm and consists of 5 turns of wire, each carrying a current of I A rms at a frequency of 3,000 Hz. The loop lies in the x - y plane of a rectangular coordinate system, with the axis of the loop being coincident with the z - axis of the coordinate system.

A compact coil, having a mean radius of 10 mm, has 200 turns of fine, insulated wire and is located at the origin of the coordinate system. The center axis of the coil is at an angle of 30^o with respect to the axis of the larger loop.

A voltage of 0.25 V peak is measured at the terminals of the 200 turn coil.

Clearly stating all assumptions, determine the rms current that is flowing in the 5 turn current loop.

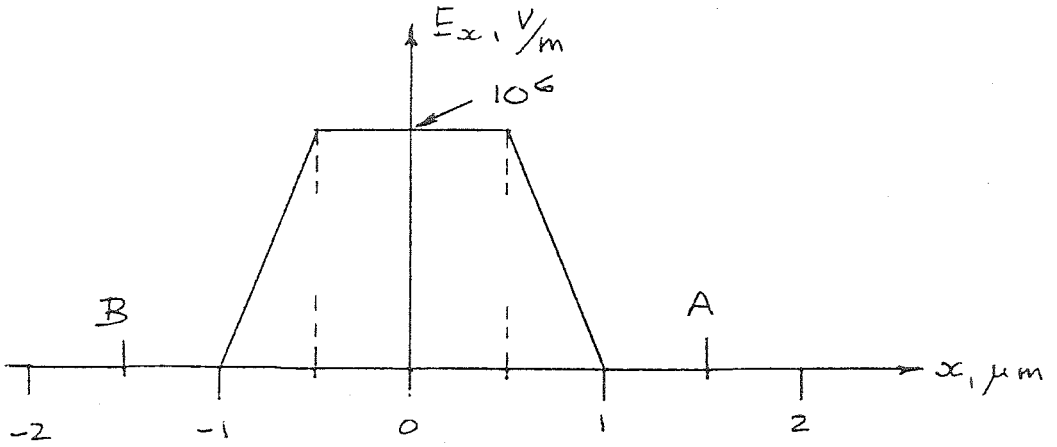

Figure 1 - Question 3

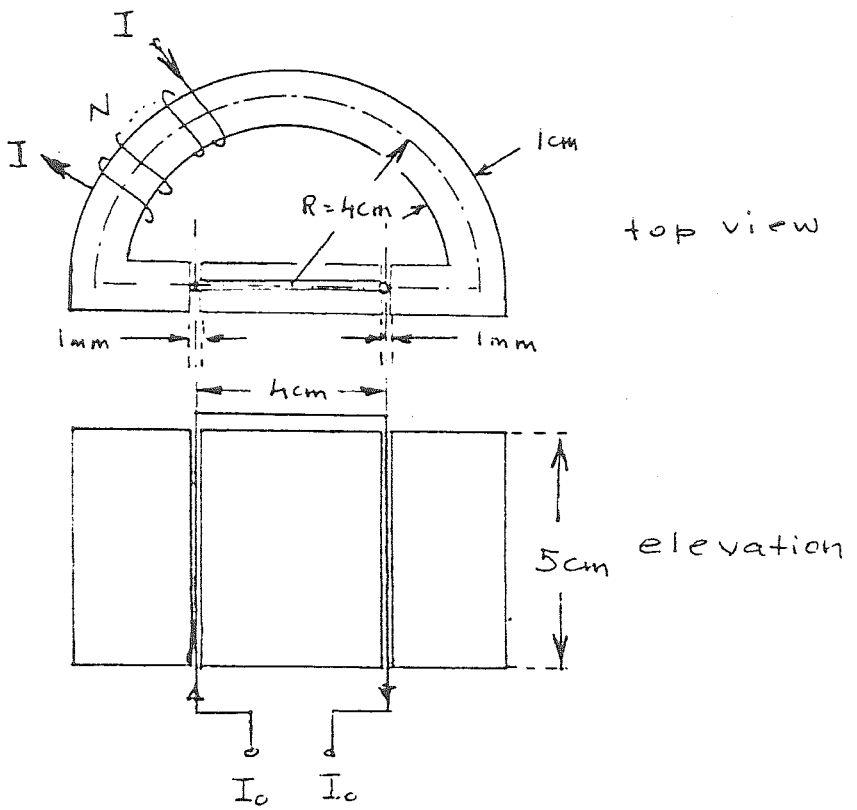

Figure 2 - Question 5