UNIVERSITY OF TORONTO

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Final Examinations, April 1993

First Year - Program 05

ELE 150S - Electricity and Magnetism

Examiners: S. Dmitrevsky, V.M. Ristic

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

Aids: $\varepsilon_o = 8.85 \times 10^{-12}$ Farad/meter,
$\mu_o = 4\,\pi \times 10^{-7}$ Henry/meter.

Write in ink!

1. A charge Q is uniformly distributed inside a spherical shell of inner radius R and outer radius 2R. Obtain the expression for electric field at distances 1.5R and 3R from the centre of the shell.

2. The charge distribution in two adjacent infinite layer of charge is specified in terms of charge densities ρ given below:

$$\rho = \begin{Bmatrix} 8.85\ C/m^3 \\ \\ -17.7\ C/m^3 \end{Bmatrix} \quad \text{for} \quad \begin{Bmatrix} -2 \times 10^{-6} m < x < 0 \\ \\ 0 < x < 10^{-6} m \end{Bmatrix} .$$

(i) Plot the electric field E produced and,

(ii) determine the potential of the point $x = 3 \times 10^{-6}$ m with respect to the point $x = -3 \times 10^{-6}$ m.

3. The plates of an air dielectric, parallel plate capacitor are circles of 8 cm radius with 1 mm separation. The energy stored in the capacitor is 88.5 micro Joule.
Calculate:

(i) the electric field inside and,

(ii) the voltage across the capacitor.

4. The currents in two identical circular current loops of 5 cm radius are 2 Ampere. The loops lie in two non-parallel faces of a cube of 20 cm side, with the loop centres in the centres of the faces.

(i) Determine the magnitude of the magnetic flux density vector at the centre of the cube and,

(ii) indicate by means of a suitable diagram the direction of the field and of the currents in the loops.

5. The frequency of a sinusoidal magnetic field is 10^6 Hertz. The maximum value of the energy density is 10^{-17} Joule/m^3.
Calculate the maximum value of the voltage induced by the field in a circular loop of 10^{-1} m radius, with the plane of the loop inclined at 30^o with respect to the direction of the field.

6. The voltage across a 10^{-6} Farad capacitor is 5 Volt. One terminal of the capacitor is connected through a 10^4 Ohm resistor to a terminal of 2×10^{-6} Farad capacitor carrying initially no charge. The other terminals of the two capacitors are connected directly to each other. The connecting process is carried out carefully so that no charge escapes from the system.
Determine:

(i) the final voltages on the two capacitors and

(ii) the time in which the voltage of the second capacitor will reach 63% of its final value.