University of Toronto

Faculty of Applied Science and Engineering

Final Examinations, April 1991.

First Year - Program 5

ELE 150S - Electricity and Magnetism

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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) Shown in Figure 1 are three capacitors of the same area and plate separation. The capacitance of the vacuum filled one is C_0. Each of the other is half-filled with dielectric of the same relative permittivity ε_r, but differently disposed as shown. Neglecting edge effects find the capacitance of each of these two capacitors.

(2) A coil of 5×10^{-4} Henry inductance in series with 10^{-2} Ohm resistance is connected through a switch across a 12 Volt battery of negligible internal resistance. How long after the switch is closed will the current reach 90 percent of its final value? At that time, how much energy, expressed in Joules, is stored in the magnetic field? How much energy has been withdrawn from the battery up to that time?

(3) Three long straight parallel wires are located as shown in Figure 2. One wire carries current 2I into the paper; each of the others carries current I in the opposite direction. What is the strength of the magnetic field at the points P_1 and P_2?

(4) The planes of two circular current loops of 5 cm radius and common centre are perpendicular to each other. Calculate the magnitude of the magnetic flux density vector $\vec{B}$ at the common centre and indicate by means of a simple sketch the direction of the vector.

(5) The electric charge density in an electron beam of circular cross-section of 10^{-3} m radius is zero at the axis and rises linearly to its maximum value of -10^{-7} Coulomb/m^3 at the surface. Calculate the potential of the beam axis with respect to surface of the beam, and the value of electric field 2 mm away from the axis.

(6) Three electrons (e = -1.6×10^{-19} Coulomb) are located at the vertices of an equilateral triangle of 10^{-10} m side. A nucleus of three protons (p = $+1.6 \times 10^{-19}$ Coulomb) occupies the centre of the triangle.

Determine:

(i) the magnitude and the direction of the force exerted on each of the electrons and,

(ii) the total electrostatic energy stored in the system.

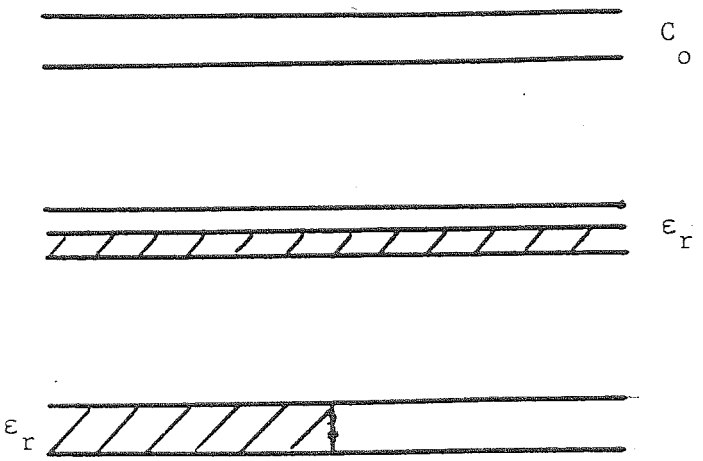

Figure 1.

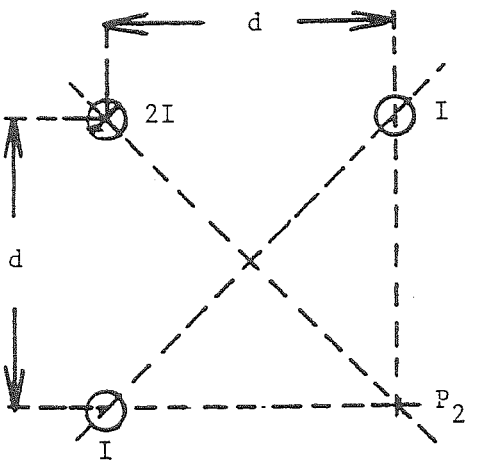

Figure 2.