UNIVERSITY OF TORONTO

DEPARTMENT OF ELECTRICAL ENGINEERING

Final Examinations, April 1992

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, $|e| = 1.6 \times 10^{-19}$ C.

1. Consider an infinitely long circular cylinder of uniform change density $\rho > 0$ and radius 2a as shown in Fig. 1a.

   (i) Find the magnitude of the electric flux density vector $\vec{D}$ at distance $r <$ 2a from the axis of the cylinder.

   (ii) Consider the same cylinder but now an infinitely long parallel cylinder of radius a as shown in Fig. 1b contains no charge. Find the magnitudes of the vector $\vec{D}$ at points A, B and C.

   Hint: Combine superposition and negative charge density.

2. A capacitor consists of two very thin coaxial metallic tubes 2 m long and 2 mm and 4 mm radii. The inner tube is coated by a 1 mm thick layer of dielectric of relative permittivity 5. A potential of 12 Volt is applied between the tubes, the outer one being positive. Calculate:

   (i) the charge on the inner tube and,

   (ii) the maximum electric field in the system.

3. The diameter of a 10 Ampere horizontal, circular current loop is 10 cm. An electron moving with 2×10^7 m/sec velocity passes due east through the vertical axis of the loop, 5 cm above it. Determine:

   (i) the magnitude of the force exerted on the electron and,

(ii) the direction of the electron deflection if the loop current circulates clockwise looking down on it.

4. An infinitely long straight wire carrying a current $I_1 = 5 \times 10^3$ Ampere is parallel to the plane containing a current loop of radius $R = 1m$ and carrying a loop current $I_2 = 1.59 \times 10^3$ Ampere as shown in Fig.2. A normal to the plane of the loop, passing through the centre intersects the wire at distance $d = 1m$. At point 0 find:

(i) the value of vector $\vec{B}_2$ due to the current I_2,

(ii) the value of vector $\vec{B}_1$ due to the current I_1 and,

(iii) the value and direction of the vector $\vec{B}$ due to both currents I_1 and I_2, indicating the direction by a simple sketch.

5. A square loop of 10 cm^2 area rotates about its symmetry axis parallel to one of its sides in a horizontal magnetic field of 10^{-5} Tesla pointing north.

(i) what should be the orientation of the rotation axis if the maximum induced voltage in the loop is to be achieved? Sketch the optimum configuration.

(ii) For the optimum configuration determined above, calculate the revolutions per minute required to produce 1.05×10^{-6} Volt peak induced voltage.

6. A 5 Volt, zero internal resistance DC source is employed to charge a 10^{-9} Farad capacitor through a 1000 Ohm resistor. Calculate the total energy extracted from the source in the process of charging the capacitor to 5 Volt.

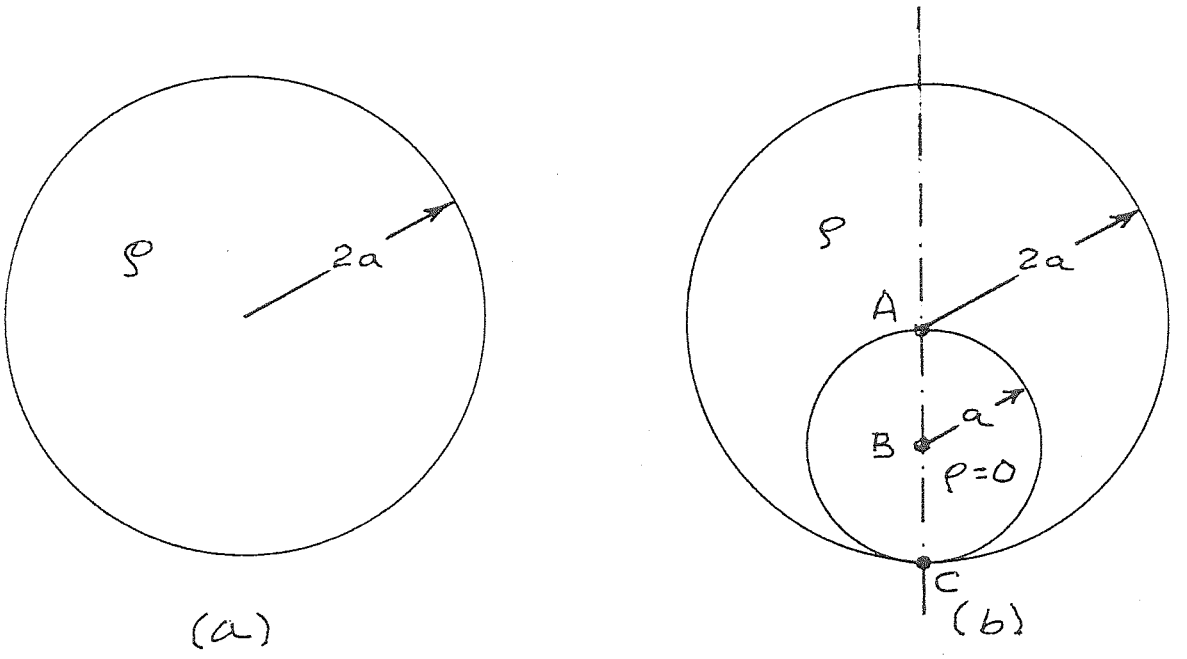

Figure 1 - Question 1

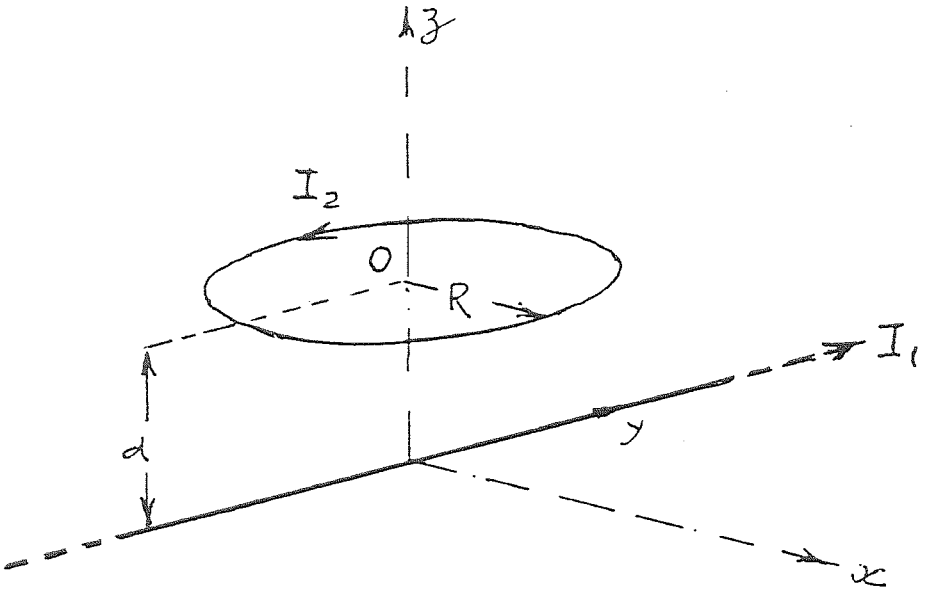

Figure 2 - Question 4