UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

Final Examinations, April 1994

First Year - Program 05

ECE 150S - Electricity and Magnetism

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

Aids: $\varepsilon_0 = 8.85 \times 10^{-12}$ Farad/meter,
$\mu_0 = 4 \pi \times 10^{-7}$ Henry/meter.

Write in ink!

1. A current i(t) plotted in Figure 1 is driven by a voltage source of negligible internal resistance through a solenoid of negligible resistance, the solenoid parameters being $N = 200$, $A = 2 \times 10^{-4}$ m^2, $l = 0.2$ m. Plot the source voltage as a function of time, indicating the relationship between the voltage polarity and the direction of current flow.

Figure 1.

2. Two concentric, connected current carrying quadrants of 0.25 m radius are shown in Figure 2. If the local terrestrial magnetic field is 10^{-5} Tesla pointing horizontally north, by how much and in what direction will the needle of a compass located at the centre of the quadrants be deflected by a 2 Ampere current circulating in the quadrants as shown in the drawing.
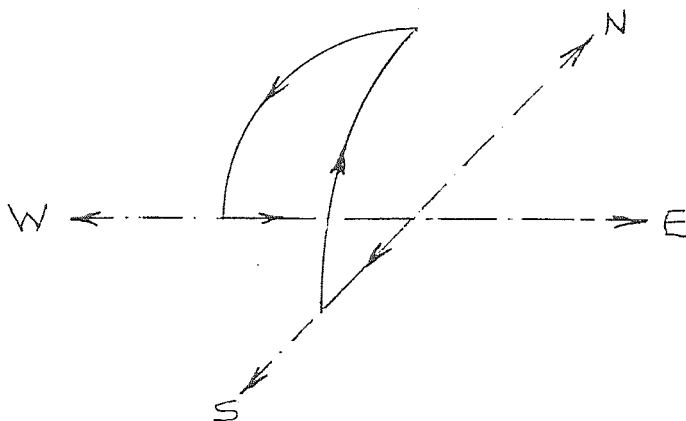
Figure 2.

3. A capacitor consists of 0.5 m long, thin coaxial metallic cylindrical shells of 10^{-3} m and 3×10^{-3} m radii. The inner of cylinder is coated by a 10^{-3} m thick layer of dielectric of relative permittivity 2.25. Employing suitable approximation determine:

   (i)   the capacitance of the device,

   (ii)   the voltage required to store 10^{-6} Joule of energy and,

   (iii) the maximum value of the field in the capacitor.

4. A charge Q is uniformely distributed on a straight section of line of length L. Calculate the electric field at a distance h from the line at the middle of the section

   (i)   using the infinite line approximation and,

   (ii)   exactly, using the superposition principle.

   (iii) Determine at what value of h the error of the approximate result will be 10% of the exact value.

$$\text{Aid:} \quad \int \frac{du}{(1+u^2)^{3/2}} = \frac{u}{(1+u^2)^{1/2}}$$

5.   A 2×10^{-6} Farad capacitor charged initially to 10 Volt is discharged through a 10^4 Ohm resistor.   Calculate:

   (i)   the time it takes the capacitor voltage to drop to 10% of its original value,

   (ii)   the total energy dissipated in the resistor and the energy extracted from the capacitor in the time interval calculated in (i) above.

6.   A 0.15 m x 0.1 m rectangular metallic loop rotates about vertical axis in a horizontal magnetic field of 0.1 Tesla with angular velocity 377 rad/sec. The long sides of rectangle are vertical and at an instant the plane of the rectangle is parallel to the field. Determine:

   (i)   the current flowing in 0.2 Ohm resistor bridging a small gap in the loop and,

   (ii)   the torque exerted on the loop, indicating by means of a suitable diagram the relationship between the direction of the current flow, magnetic field, sense of notation and the torque.