University of Toronto

Faculty of Applied Science and Engineering

Second Year - Program: Engineering Science

ECE150H1 Electricity and Magnetism

Final Examination, April 2001

Examination Type: A

Examiner: S. Dmitrevsky

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

Write in ink!

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

1. Three infinite parallel layers of charge 10^{-6} m thick are separated by neutral layers 0.5×10^{-6} m thick. The positive charge density of the middle layer is 5 C/m^3; the charge densities of the outer layers are -2.5 C/m^3. The relative permittivity of the medium is 10.

   (i) Plot the electric field produced and,

   (ii) determine the potential of the outside surface of an outside layer with respect to the middle of the central layer.

2. A current loop consists of a semicircle of 25 cm radius laying in a vertical north-south plane with its two ends located in a horizontal plane. The current to the loop is supplied by two infinitely long straight lines lying in the horizontal plane and pointing due west from each of the two terminals of the semicircle. The peak of the semicircle lies above the horizontal plane, with the loop current there flowing due north. The current flowing in the system is 2A.

   What are the magnitude and the direction of the magnetic field at the centre of the semicircle? Express the result in units of Tesla.

3. Square wire loop of 20 cm side with two of its sides horizontal and two vertical rotates at 300 Hz frequency about its vertical symmetry axis in a horizontal uniform magnetic field of 0.5 Tesla. A small gap exists in one of the horizontal sides of the loop near the axis of rotation. A load resistance of 10^{-1} Ohm is connected across the gap.

   Determine:

   (i) the average power delivered to the load resistor and,

(ii) the magnitude and direction of the maximum torque exerted by the magnetic field on loop.

4. A capacitor consists of two thin spherical, concentric metallic shells of 2 cm and 1 cm radii. The inner shell is covered by a 0.5 cm thick layer of dielectric of relative permittivity 2.5. A 1000 Volt potential is applied to the capacitor with outer shell at higher potential.

Determine:

(i) the value and location of the strongest field in the capacitor and,

(ii) the capacitance of the capacitor.

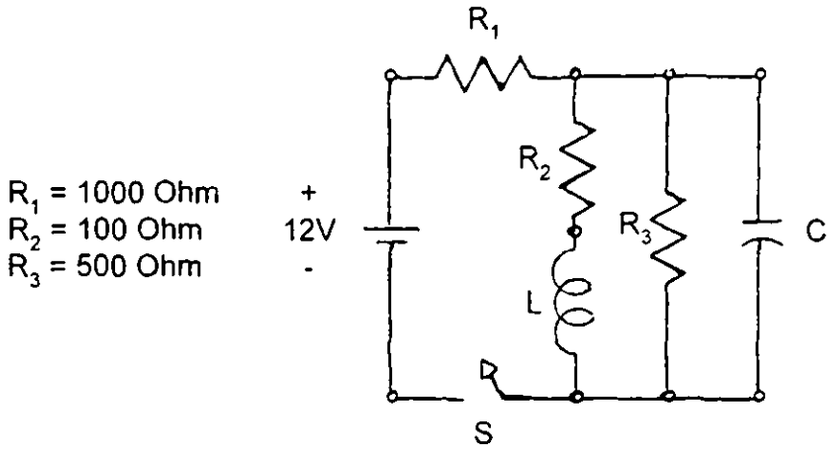
5. In the circuit shown below the switch S is open until time T_1 when it is closed. It remains closed for a long time interval T_2 when it is opened again. Determine the power delivered to resistor R_3,

(i) immediately after closing of the switch at time T_1,

(ii) at the end of time interval T_2, while the switch is closed and,

(iii) immediately following the opening of the switch following the end of the time interval T_2.

The words "long time interval" are included to simplify the problem. Explain their meaning in terms of circuit parameters.



6. Infinitely long straight cylindrically symmetric current distribution with uniform magnitude of current densities $|j|$ produces circular magnetic fields the values of which at specified distances from the axis of symmetry are listed below:

distance:	3 mm	3.5 mm	4 mm	5 mm
H, A/m:	$10^3/6\pi$	$10^3/7\pi$	$10^3/8\pi$	0

Above data provide complete information about the current distribution.

Describe the current distribution specifying relevant numerical values and supplement your answer by a sketch.