University of Toronto

Faculty of Applied Science and Engineering

Second Year -Program: Engineering Science

ECE150H1 Electricity and Magnetism

Final Examination, April 2000

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. The thickness of an infinite charge layer is 2×10^{-6} m, the charge density therein is $+3\,C/m^3$. The layer is located between two parallel surface charge layers. The gaps between the layers are 10^{-6} m wide. The charge density of one of the surface charge layers is $+2\,\mu C/m^2$, while the total charge of the system is zero. The relative permittivity of the medium is 10.

(i) Plot the electric field produced by the charge system and,

(ii) calculate the potential of the negative layer with respect to the positive surface charge layer.

2. The dimensions of a rectangular current loop are 0.2m×0.3 m. The loop consists of 30 turns and rotates at 3600 RPM about one of its symmetry axes lying in the plane of the loop, in a magnetic field of 0.375 Tesla, perpendicular to the axis. Terminals of the loop are connected to a load resistance of 9.6 Ohm.

Determine:

(i) the RMS voltage at the loop terminals,

(ii) the average power delivered to the load and,

(iii) the peak value of the torque exerted by the magnetic field on the loop.

(3.) A current loop consists of three orthogonal quarter circles of 30 cm radii and common centre as shown in Figure 1. The magnitude of the local terrestrial magnetic field is 10^{-5} Tesla pointing 10° west of north and 10° down.

Determine:

(i) the loop current for which the total magnetic field will lie in the vertical north-south plane and,

(ii) the angle of the total field with respect to the horizontal plane.

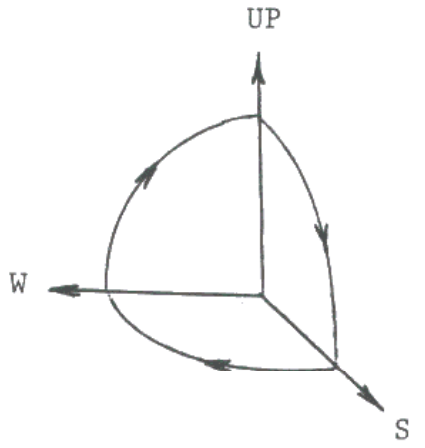

Figure 1

(4) The current in a north-south power line is 20 A. The horizontal separation and the height above ground of the two conductors are 2 m and 6 m respectively. The current in the western conductor flows north.

Determine the direction and the magnitude of the magnetic field on the ground directly below the western conductor. Express your results in units of Tesla.

5. A parallel plate capacitor consists of two parallel coaxial circular metallic plates of 50 mm radius. The separation between the plates is 1 mm. A 0.5 mm thick layer of relative permittivity ε_r=2.25 is glued to one of the plates on the surface facing the other plate. The maximum electric field permitted in air is 10^6 V/m and 10^7 V/m in the dielectric.

Determine:

(i) the maximum value of energy that can be stored in the capacitor and,

(ii) the associated voltage across the capacitor.

6. A 6 Volt D.C. battery is connected through an open switch to a series combination of a 2 Ohm resistor and an inductor.

What are the initial and ultimate values of the inductor and resistor voltages and currents following closing of the switch?