NATIONAL EXAMS, MAY 2013

04-BS-9, Basic Electromagnetics

3 Hours Duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a closed book exam.

3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.

4. All questions are of equal value.

5. 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. A capacitor consists of two concentric spherical metallic shells. The outer radius of the inner shell is 10 mm, the inner radius of the outer shell is 15 mm. A 2 mm thick layer of dielectric of relative permittivity 2.25 covers the outside of the inner shell. The electric breakdown field of the dielectric is $10^7$ V/m, that of the air is $10^6$ V/m. What is the lowest upper bound of charge that can be stored in the capacitor in coulombs?

2. A current of 2A circulates in a horizontal circular loop of 5 cm radius. Viewed from above the current circulates clockwise.
   (i) What is the direction and value of the magnetic flux density vector at the centre of the loop?
   (ii) Where on the vertical axis of the loop is the value of the field reduced to one half of that at the centre of the loop?

3. A circular loop of 100 cm$^2$ area and 10 turns is located in a vertical plane. A DC uniform magnetic field of 0.2 teslas pointing 45° up rotates at 3600 RPM about the vertical axis of the loop. What is the RMS value of the electromotive force induced in the loop?

4. A square current loop of 100 cm$^2$ area, 10 turns and 3A current circulating in it lies in a vertical east-west plane. The sides of the square are vertical and horizontal. Viewed due north the current circulates clockwise. A uniform magnetic field of 0.2 teslas pointing due north and 45° up passes through the loop. What is the magnitude and sense of the torque exerted by the field on the loop?

5. A circular parallel air dielectric capacitor of 5 cm radius and 0.1 mm air gap is driven by a current generator of 1A intensity and $10^6$ Hz frequency.
   (i) What is the RMS value of the charge stored in the capacitor, and
   (ii) What is the RMS value of magnetic field intensity vector induced along the rim of the air gap?
6. Two electric charges of $\pm 1.6 \times 10^{-19}$ C are located on the x-axis of an x-y-z coordinate system. The negative charge is located at $x = -0.5 \times 10^{-10}$ m, the positive at $x = 0.5 \times 10^{-10}$ m. What is the magnitude and direction of electric field at a point $(0, 0.707, 0.707) \times 10^{-10}$ m?

7. Two DC generators of zero internal impedance, one of 1000 V EMF, the other of 2000 V EMF drive their loads either:
   (A) directly, or
   (B) through a transmission line of 0.1 ohm resistance.
   The load of the 1000 V generator is 1 ohm, that of the 2000 V is 4 ohms. Compare the efficiencies of the two systems and comment.

8. A metallic object is positioned 300 m above the surface of a body of water, located directly below is a transmitter-receiver unit sending up pulses of electromagnetic energy and receiving their reflections from the object. The unit may be situated on the surface of the water or 10 m below it. The relative permittivity of water is 81. Calculate the delays between transmission and reception of the pulses for the two situations specified above.