

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:  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$ ,  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$ ,  $e = 1.6 \times 10^{-19} \text{ C}$

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  $100 \text{ cm}^2$  area and 10 turns is located in a vertical plane. A DC uniform magnetic field of 0.2 teslas pointing  $45^\circ$  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  $100 \text{ cm}^2$  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  $45^\circ$  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.