NATIONAL EXAMS, May 2010

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 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

1. Electric field on the surface of a spherical metallic shell is 10^6 V/m pointing outward. What are:
   i. the total charge on the shell and,
   ii. total electrostatic energy of the electric field produced by the charge?

2. An infinitely long beam of electrons carries a current of 10^{-6} A. The cross-section of the beam is a circle of 1 mm^2 area with electric charge spread uniformly across the cross-section. Electron velocity in the beam is 10^7 m/s. What are the magnitude and direction of electric field intensity on the surface of the beam?

3. A 10^6 Hz horizontal magnetic field of 2×10^{-5} T RMS amplitude points in the NW-SE direction. The field is monitored by a loop of 10 turns and 1 m^2 area located in the N-S vertical plane. What is the peak value of the EMF amplitude induced in the loop?

4. The radii of inner and outer conductors of a coaxial line are 2 mm and 3 mm respectively. The space between the conductors is filled with dielectric of relative permittivity 2.5.
   i. Calculate the capacitance of an one meter long section of the line.
   ii. If the potential difference between the two conductors is 2 V with outer conductor positive, what is the magnitude and sign of the charge on the inner conductor?

5. What are the magnitude and direction of magnetic flux density vector at a point 10^{-10} m above the center of a horizontal, circular current loop of 10^{-10}

m radius and 10^{-4} A current? Viewed from above the current circulates clockwise.

6. Gaps between three parallel infinite surface charge layers are 2×10^{-6} m. Surface charge densities of the two outer layers are 2.5×10^{-5} C/m^2 and 5×10^{-5} C/m^2 and that of the inside layer is -7.5×10^{-5} C/m^2. What is the potential of the 2.5×10^{-5} C/m^2 layer with respect to the 5×10^{-5} C/m^2 layer?

7. Two 1 cm wide, thin parallel metallic strips are separated by a 0.5 mm thick layer of dielectric of relative permittivity 2. A 1 m long section of the pair is short-circuited at one end forming a one loop coil. Using Ampere's law and neglecting fringe fields calculate the self-inductance of the coil.

8. An electromagnetic wave of 27 cm wavelength propagates vertically downward through a 27 m thick layer of air. At the bottom of the layer it enters a 30 cm thick layer of water at the bottom of which it is absorbed. Relative permittivities of air and water are 1 and 81 respectively. Calculate:

   i. the travel times of the wave in air and water layers,

   ii. the wavelength in water and,

   iii. the frequencies in air and water.