

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: $\epsilon_0 = 8.85 \times 10^{-12}$ 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/m² and 5×10^{-5} C/m² and that of the inside layer is -7.5×10^{-5} C/m². What is the potential of the 2.5×10^{-5} C/m² layer with respect to the 5×10^{-5} C/m² 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.