NATIONAL EXAMS, MAY 2015

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. Four electrons each of charge $-e$ are located in four corners of a square of 10^{-10} m side. At the centre of the square are located four protons of charge $+e$.

   Determine the magnitude and direction of electric field acting on one of the electrons.

2. The radius of an infinitely long, straight electron beam is 10^{-6} m. The current carried by the beam is 10^{-6} amperes, the velocity of the electrons is 6×10^{7} m/s.

   What are the magnitude and direction of electric field on the surface of the beam?

3. What are the magnitude and direction of magnetic flux density vector $\vec{B}$ produced by one ampere current circulating in a horizontal circular loop of 1 m radius at a point 1 m above the centre of the loop? Viewed from above the current circulates clockwise.

4. Currents flow in two infinite, flat, horizontal sheets of 1 mm thickness and 1 mm apart. The current in the upper sheet flows north, that in the lower sheet flows south. Current density in both sheets is 2A/mm^2.

   What are the direction and magnitude of the flux density vector $\vec{B}$ in the empty space between the sheets?

5. A horizontal circular wire loop is located in a uniform, vertical magnetic field of 0.1 teslas. The initial circumference of the loop is 30 cm and is being reduced (wound down) from 30 cm to zero at the rate of 1 cm/s.

   What are the maximum and minimum values of EMF induced in the loop?

6. Electric energy of 1 joule is stored in an air-dielectric circular, parallel plate capacitor of 10 cm^2 area and 1 mm separation between the plates.

   What is the value of electric field intensity vector $\vec{E}$ between the plates?

7. What is the mutual inductance of two coaxial circular loops located in two parallel planes 5 cm apart? The radius of one of loop is 5 cm, that of the other is 2 mm.

8. A pulse of light is generated at a point 10 m above a horizontal ground plane and detected at a point 30 m above the ground plane and 40 m horizontally away from the source point. The detected signal consists of a pulse travelling directly from the source to the detector and a pulse reflected from a horizontal mirror on the ground plane.

   Determine:

   (i) the location of the reflecting mirror on the ground plan and,

   (ii) time delay between the arrivals of the pulses at the detector.

   Assistance: $c = 3 \times 10^8$ m/s.