NATIONAL EXAMS, DECEMBER 2014

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: $\varepsilon_0 = 8.85 \times 10^{-12} F/m, \quad \mu_0 = 4\pi \times 10^{-7} H/m, \quad e = 1.6 \times 10^{-19} C$

1. A current loop consists of two semicircles with a common centre and 5 cm radii. One of the semicircles lies in a horizontal plane, the other in the vertical one. Viewed from above a 2 ampere loop current flows clockwise.

   What are the magnitude and direction of the magnetic intensity vector $\vec{H}$ at the center of the loop?

2. An electric charge distribution consists of a positive point charge +e surrounded by a sphere of charge of 10^{-10} m radius, uniform charge density and total charge –e.

   What are the magnitude and direction of the electric field intensity $\vec{E}$ at a point 0.5×10^{-10} m away from the centre of the system?

3. The radii of two infinitely long coaxial metallic cylinders (a transmission line) are 1 mm and 2 mm. The space between the two cylinders is filled with dielectric the relative permittivity of which is 2.25.

   What is the capacitance of a 2 m long section of the line?

4. A circular loop of wire of 1 mm radius is located at the centre of circular loop of wire of 3 cm radius. The angle between the planes of the two loops is 30°.

   Employing suitable approximations calculate the mutual inductance of the two loops.

5. A DC magnetic field of 0.2 teslas points horizontally west. A circular wire loop of 100 turns and 5 cm radius is located in the magnetic field. The orientation of the loop is such that one of its diameters is horizontal with 30° angle between it and the direction of the magnetic field. The loop rotates at 3600 RPM about the horizontal diameter.

   What is the RMS value of EMF induced in the loop?

6. Electric field $\vec{E}(x, y, z, t)$ in empty space is given by the expression $\vec{E} = (0,0,E)\cos(\omega t - kx)$, with $\omega = 2\pi f$, $f = 10^{10}$ Hz, $k = \omega/c$ with $c = 3 \times 10^8$ m/s and the value of E at 10^{-6} V/m peak.

   Calculate the RMS amplitude of the associated magnetic field intensity $\vec{H}$.

   Aid: curl $(X, Y, Z) = \left(\frac{\partial Z}{\partial y} - \frac{\partial Y}{\partial z}, \frac{\partial X}{\partial z} - \frac{\partial Z}{\partial x}, \frac{\partial Y}{\partial x} - \frac{\partial X}{\partial y}\right)$

7. Charge e is uniformly spread on the surface of a sphere of radius 10^{-10} m.

   What is the total electrostatic energy of the system?

8. A square current loop of 10 cm sides (vertical and horizontal) and 20 turns is located in a vertical plane rotating at 3600 RPM about vertical axis of the loop. A 2 ampere RMS 60 Hz current circulates in the loop which is imbedded in a uniform DC magnetic field of 0.2 teslas pointing horizontally. The phases of rotation and current are adjusted so that the current is zero when the plane of the loop is perpendicular to the magnetic field.

   Calculate the time average of the torque exerted by the field on the loop.

   Aid: $\vec{T} = \vec{m} \times \vec{B}$, m = area × current.