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

1. Electric field is produced by a charge distribution described below: positive point charge $2e$ ($e = 1.6\times10^{-19}$ C) surrounded by a spherical surface charge layer of radius 0.5×10^{-10} m centered on the positive charge and carrying a total charge $-e$.

   What is the electric potential with respect to infinity of a point separated from the positive charge by distance of 0.25×10^{-10} m ?

2. Magnetic field is produced by a cylindrical surface layer current of 0.5 cm radius and 2 cm length. Total current in the layer is 1 mA.

   What is the magnetic flux density B (in vacuum) on the axis of the cylinder in the middle thereof.

   Aid: $\int du(1+u^2)^{-\frac{3}{2}} = u(1+u^2)^{-\frac{1}{2}}$.

3. Two horizontal infinite current sheet each 1 mm thick are separated by a 1 mm wide gap. The current in the upper sheet flows north, that in the lower one flows south. Current densities in the two sheets are 10^{-3}A/m^2 .

   Using Ampere's law and principle of superposition determine the value and direction of magnetic field intensity vector $\vec{H}$ between the two sheets.

4. A uniform magnetic field of 10^{-5} teslas points in a horizontal direction. A circular wire loop of 10 turns and 10 cm^2 area located in vertical planes rotates at 3600 RPM about its vertical diameter.

   What is RMS voltage induced in the loop?

5. Plate separation of a circular parallel plate capacitor of 5 cm radius is 1 mm. The space between the plates is filled with dielectric of 2.5 relative permittivity. Breakdown field of the dielectric is 10^7 V/m.

   Determine:

   (i) the capacitance of the capacitor and,

   (ii) the lowest upper bound of energy that can be stored in the capacitor.

6. A 3 cm long solenoid of 50 turns is tightly wound on 10 cm long core of circular cross-section of 5 mm diameter. The relative permittivity of the core material is 100.

   What is the inductance of the system?

7. Magnetic field intensity $\vec{H}$ of a 10 MHz electromagnetic wave propagating in vacuum is $(H, 0,0)\cos(\omega t - kz)$, with RMS value of $H = 50\mu A/m$. Using Maxwell's equations determine the RMS value of the electric field of the wave.

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

8. Two 1 km long transmission lines connected in parallel are delivering power from a 115 volt, zero impedance generator to a 10 ohm resistive load. The cross-sections of the conductors of the two transmission lines are circular of 1 mm^2 area. The resistivity of the conductor material of one of the lines is 1.7×10^{-8} ohm meters (copper), that of the other is 20×20^{-8} ohm meters (steel).

   Calculate:

   (i) power delivered to the load and,

   (ii) power lost in the steel line.