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: \( \varepsilon_0 = 8.85 \times 10^{-12} \, \text{F/m}, \quad \mu_0 = 4\pi \times 10^{-7} \, \text{H/m}, \quad e = 1.6 \times 10^{-19} \, \text{C} \)
1. Electric field is produced by a charge distribution described below: positive point charge $2e$ ($e = 1.6 \times 10^{-19}$ C) surrounded by a spherical surface charge layer of radius $0.5 \times 10^{-10}$ 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 $0.25 \times 10^{-10}$ 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 $1.7 \times 10^{-8}$ ohm meters (copper), that of the other is $20 \times 10^{-8}$ ohm meters (steel).

Calculate:

(i) power delivered to the load and,

(ii) power lost in the steel line.