NATIONAL EXAMS, DECEMBER 2012

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 ampere forward and return currents flow in three coaxial thin tubes of 1 mm, 2 mm, and 3 mm radii. The forward current flows in the 2 mm radius tube. The return currents are split into a 1 ampere portion flowing in the 1 mm radius line and the 3 ampere portion flowing in the 3 mm radius line. Sketch a plot of magnetic flux density B as a function of radius, specifying key numerical values.

2. A five ampere current flows in a loop consisting of a 10 cm radius circle lying in a vertical plane. Determine the magnitude and direction of magnetic flux density vector at a point on the horizontal line perpendicular to the plane of the circle through the center thereof and 10 meters away from it. Viewed from the point the current circles clockwise.

3. The length of a solenoid of circular cross-section of a 2 mm radius is 5 cm. The 100 turns of the solenoid winding are tightly wound on a 10 cm long, circular cross-section of 2 mm radius rod. The relative permittivity of the rod material is 25. Calculate the self-inductance of the solenoid and magnetic energy stored in it if a 2 ampere current flows in it.

4. Calculate the value of resistance of a 2 m long metallic rod of 1 mm cross-section area. Density of electrons in the metal is $10^{28}/m^3$ and the velocity of electrons is proportional to applied electric field with the constant of proportionality at 0.625 m^2/Vs.

5. A uniform magnetic field of 0.2 teslas points horizontally due west. A circular loop of three turns of 10 cm^2 area rotates about its horizontal diameter at 3600 RPM. The diameter points in the north-east, south-west direction. What is the RMS value of EMF induced in the loop?

6. An electric field $\vec{E} = (0,0,E)$ produced by an infinite layer of charge of thickness 2a and parallel to $x - y$ plane is specified below:

$$E = \begin{cases} 1.88 \times 10^{19}(V/m^3)z^2 \\ 0 \end{cases} \quad \text{for} \quad \begin{cases} -a < z < a \\ |z| > a \end{cases}$$

at $a = 3 \times 10^{-6}$ m.

The relative permittivity of the medium is 16. Determine and describe verbally the charge distribution in the layer using the divergence form of the Gauss' law.

7. Three negative point charges of -1.6×10^{-19} C each are located in the corners of a horizontal triangle of 10^{-10} m side. A positive charge of $+4.8 \times 10^{-19}$ C is located 0.33×10^{-10} m above the centre of the triangle. What is the value of electrostatic energy of the system?

8. The speed in air of an electromagnetic wave is 3×10^8 m/s. The speed in water is 3×10^7 m/s. If a wave propagating in air impinges on water surface at 60° angle of incidence (angle between direction of propagation and normal to the surface of water) at what angle of transmission will the wave propagate in water?