NATIONAL EXAMS, DECEMBER 2011

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. A positive point charge $+2e$ is surrounded by a concentric spherical uniform surface charge layer of 2×10^{-11} m radius and carrying a total charge $-e$.

   What is the electric potential with respect to infinity of a point 10^{-11} m away from the positive charge?

   Aid: $e = 1.6 \times 10^{-19}\, C$

2. A 2 ampere current circulates in a horizontal square loop of 10 cm sides. Viewed from above the current circulates clockwise.

   What is the direction and magnitude of the magnetic flux density vector at a point 5 cm above the centre of the square?

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

3. Two horizontal, parallel infinite lines 5m apart horizontally, aligned north-south carry ± 50 ampere D.C. currents. The current in the east line flows north, the current in the other line flows south.

   What is the magnitude and direction of the magnetic flux density vector at a point 15m below the centre line of the transmission system?

4. The plate areas of a circular parallel plate capacitor are 20 cm^2 each. The separation between the plates is 1 mm. The space between the plates is filled by dielectric of relative permittivity 2.5. The breakdown field of the dielectric is 10^7 V/m.

   What is the lowest upper bound on the capacitor voltage and the electric energy stored?

5. A magnetic field of 0.5 teslas points north and 30° up. A vertical square loop of 10 cm sides and10 turns rotates at 3600 RPM about its vertical axis.

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

6. A 2 ampere current circulates in a square loop of 10 cm sides and 10 turns located in a vertical east-west plane is being acted on by a magnetic field of 0.5 teslas pointing horizontally west.

   What is the magnitude and sense of the torque exerted by the field on the current loop?

7. The parameters of a solenoid are: circular cross-section of 5 mm diameter, 5 cm length and 100 turns. The core of the solenoid is a magnetic material of relative permeability 20.

   What are the selfinductances of the solenoid if:

   (i) the magnetic core is 5 cm long or,

   (ii) 1 cm long?

   Note: in your calculations disregard the effects of fringing fields.

8. Break-down strength of air is 10^6 V/m at microwave frequencies.

   What is the lowest upper bound for E and the power density of a 10 GHz (10^{10} Hz) linearly polarized plane wave propagating in air?