NATIONAL EXAMS, December 2010

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 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: \( \varepsilon_0 = 8.85 \times 10^{-12} \text{F/m}, \quad \mu_0 = 4\pi \times 10^{-7} \text{H/m} \)
1. Radii of inner and outer conductors of an infinite coaxial line are 2.5 mm and 5 mm respectively. The inner conductor is coated by a 1 mm thick layer of dielectric of relative permittivity 5, while the remainder of the inter-conductor space is filled with dielectric of relative permittivity 2.5. Calculate the capacitance of a 1 m long section of the line.

2. A semicircle of 5 cm radius lies in the $x$-$y$ plane of an $x$-$y$-$z$ cartesian coordinate system. The diameter of the semicircle lines in the $x$-axis and its center is in the origin of the coordinate system. Another semicircle of 5 cm radius lies in the $x$-$z$ plane, with its center in the origin of the coordinate system and its diameter in the $x$-axis. The curved parts of the two semicircles form a closed, folded current loop. A 2 ampere current circulates in the loop. Viewed from a point on the positive $y$-axis the current circulates clockwise. What is the magnitude and the direction of magnetic flux density vector $B$ at the common centre of the two semicircles?

3. In a square loop of 10 cm sides two of the sides are vertical, while the other two sides are horizontal. The loop lies in a vertical east-west plane. A 3 ampere current circulates in the loop. Viewed from south the current circulates clockwise. A separate magnetic field of 0.1 teslas points northwest. What’s the magnitude and direction (sense) of the torque exerted by this magnetic field on the loop?
4. An infinite straight transmission line consists of two 1 cm wide, thin metallic ribbons located horizontally one above the other with a 1 mm gap between them. Calculate self-inductance of a 1 m long section of the line, neglecting the effects of fringing fields at the edges.

5. A metallic sphere of 2 cm radius carries an electric charge which produces on its surface a field of $10^6$ V/m pointing inward. What is the magnitude and sign of the charge?

6. A square loop of 10 cm$^2$ area lies in a vertical north-east, south-west plane. An AC magnetic field of 10 MHz frequency, $10^{-3}$ teslas RMS amplitude points in the north-south direction. What is the peak amplitude of the EMF induced in the loop?

7. A negative point charge of $1.6 \times 10^{-19}$ coulombs moves horizontally east at $3 \times 10^5$ m/s velocity in a $10^5$ V/m vertical electric field pointing down. Determine the magnitude and direction of the weakest magnetic field that would cancel the force exerted by the electric field on the charge.

8. A beam of light traverses at normal incidence a layer of air and a layer of water. Index of refraction of water is 1.3. What are the relative thicknesses of the two layers if travel times through them are same?