

NATIONAL EXAMS, MAY 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: $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$, $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$, $e = 1.6 \times 10^{-19} \text{ C}$

1. A stack of three parallel, thin metal plates of 3cm radius and arranged on common axis are separated by 1mm wide gaps and form a capacitor when the two outer plates are connected by a metallic jumper. One of the gaps is filled by a dielectric of relative permittivity 2.5. Determine the capacitance of the capacitor. Neglect the effects of fringing fields.

2. Radius r of a metallic wire varies with the distance s in meters as given by the expression below:

$$r = r_0 e^{s/a}, \text{ where } a = 100\text{m and } r_0 = 3\text{mm}.$$

The resistivity of the metal is 1.6×10^{-7} ohm meters.

What length of wire of the same metal and 3 mm radius would have the same resistance as a 100m long section of the variable radius wire as specified above?

3. A square loop of 1m^2 area rotates about its axis at 2400 RPM in a uniform magnetic field of 0.25 teslas. The direction of the field is perpendicular to the axis. What is the RMS EMF of the induced voltage in the loop?
4. Two concentric circular loops of 25cm and 5mm radii lie in a common east-west vertical plane. Using appropriate approximation determine:
- (i) the mutual inductance of the two loops, and
 - (ii) the mutual inductance of the two loops if one of them is rotated by 45° about north-south axis passing through the common centre of the loops.
5. A positive point charge $+3e$ is located at the centre of a triangle of 3×10^{-10} m sides. Negative charges $-e$ are located in the corners of the triangles. What is the magnitude and direction of the electric field acting on one of the negative charges?

6. A 4 ampere current circulates in a square loop of 500cm^2 area. The loop lies in an north-south vertical plane and its sides are horizontal and vertical. Viewing due west the current circulates clockwise. A horizontal magnetic field 0.5 teslas pointing north acts on the loop. What are the magnitude and the direction of the torque exerted by the field on the loop?

7. A 2 microampere current carried by electron beam flows horizontally due west. The circular cross-section area of the beam is 2mm^2 , the uniform charge density is $3 \times 10^{-8} \text{ C/m}^3$.

What are:

- (i) the uniform electron velocities in the beam, and
- (ii) the magnitude and direction of magnetic field (expressed in units of tesla) at the surface of the beam?

8. A plane wave of 10 GHz frequency propagates horizontally due west in free space. Magnetic field of the wave is polarized in horizontal direction. Power density of the wave is 0.1 W/m^2 . What is the RMS magnitude and direction of the electric field of the wave?