

December 2007

NATIONAL EXAMS

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: $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$, $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$

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

$$r = r_0 e^{s/a}, \text{ where } a = 100\text{m and } r_0 = 2\text{mm.}$$

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

What length of wire of the same metal and 2mm radius would have the same resistance as a 100m long section of the variable radius wire as specified above?

2. The plate area and plate separation of a parallel plate capacitor are 10cm^2 and 1mm respectively.

The medium between the plates is teflon. The maximum allowed field in Teflon is 10^7 V/m , the relative permittivity thereof is 2.5.

What is the maximum energy that can be stored in the capacitor?

3. The earth's magnetic field at a point is 5×10^{-6} teslas and points horizontally north-west. The field is to be neutralized at the centre of a circular current loop of 25cm radius.

What are:

- (i) the orientation of the plane of the loop and,
 - (ii) the magnitude and sense of circulation of the loop current.
4. A 2 microampere current carried by electron beam flows horizontally due north. The circular cross-section area of the beam is 1mm^2 , the uniform charge density is $5 \times 10^{-8} \text{ C/m}^3$.

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 top of the beam?
5. A DC current circulating in a 10cm long solenoid of 100 turns and 1cm^2 circular cross-section area stores 30 microjoules of magnetic energy in the solenoid.

What is the magnitude of the current?

6. A vertical square loop of 5cm^2 area and 10 turns rotates at 3000 RPM about its vertical axis in a uniform DC horizontal magnetic field of unknown direction. The peak EMF induced in the loop is 15.7 microvolts. The instantaneous value of the EMF peaks when the plane of the loop lies in the northwest-southeast plane.

What are the magnitude and possible directions of the magnetic field?

7. A 1000 MHz linearly polarized plane wave propagates in a medium with a relative permittivity 2.25. The RMS amplitudes of electric and magnetic fields are 0.1V/m and $2.7 \times 10^{-1}\text{A/m}$ respectively.

What is the value of total electromagnetic energy stored in a cube the edges of which are one wavelength long?

8. The electric field $\vec{E} = [0, 0, E(z)]$ in a boundless medium of relative permittivity $\epsilon_r = 10$, due to distributed charges is plotted below.

What are:

- (i) the charge densities producing the field and,
- (ii) the potential of point $z = 5\mu\text{m}$ with respect to point $z = -1\mu\text{m}$?

