

NATIONAL EXAMS, MAY 2009
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. Four positive charges $+1.6 \times 10^{-19} \text{ C}$ are located one each in four corners of a horizontal square of 10^{-10} m sides.
What is the magnitude and direction of force exerted on an electron of charge $-1.6 \times 10^{-19} \text{ C}$ located $0.5 \times 10^{-10} \text{ m}$ above the center of the square?

2. A negative charge -0.5 C is uniformly distributed inside a sphere of 100 m radius.
What are the magnitudes and directions of electric field
 - (i) *at the surface of the sphere and,*
 - (ii) *50 m away from the center?*

3. The capacitance of a parallel plate capacitor is $5 \times 10^{-10} \text{ F}$. The plates are separated by a 1 mm thick layer of dielectric of relative permittivity 2.5. The energy stored in the capacitor is $8 \times 10^{-8} \text{ J}$.
What are
 - (i) *the voltage between the plates,*
 - (ii) *the electric charges on the plates and,*
 - (iii) *electric field between the plates?*

4. The magnitude and direction of terrestrial magnetic field are $5 \times 10^{-6} \text{ T}$ and north respectively. The field is to be suppressed at the center of a circular current loop of 25 cm radius.
What are
 - (i) *the spatial orientation of the loop and,*
 - (ii) *the magnitude and sense of circulation of the loop current?*

5. Electric charge density ρ in an infinite plate of charge parallel to coordinate $x - y$ plane is a function of coordinate z only, with specific values given below.
 For $z > 10^{-6} \text{ m}$ and $z < -10^{-6} \text{ m}$ $\rho = 0$.
 For $-10^{-6} \leq z \leq 10^{-6} \text{ m}$ $\rho = \rho_0 z$, with $\rho_0 = 10 \frac{\text{C}}{\text{m}^4}$.

Determine

- (i) the location of the maximum electric field,
- (ii) the value and direction of the maximum and,
- (iii) the potential of a point with coordinate $z = 10^{-6} \text{ m}$ with respect to a point with coordinate $z = -10^{-6} \text{ m}$.

6. An infinitely long coaxial line consists of two thin metallic cylinders of 2 mm and 4 mm radii. One of the cylinders carries a current of 2A in one direction, the other cylinder carries the return current.

What is the magnetic energy stored in a 1 m long section of the line?

7. Metallic blades of a wind generator are 15 m long and rotate at 25 RPM in a north-east, south-west vertical plane. Viewed in the north-west directions they rotate clockwise. The magnitude and direction of earth magnetic field are 10^{-5} T and north respectively.

Determine

- (i) the magnitude and polarity of the EMF induced between hub and tip and,
- (ii) whether there would be induced if the blade material was non-conductive.

8. Electric field in a plane wave propagating in free space is linearly polarized in z-direction. The expression for the field, $e(x, y, t)$ is given below:

$$e(x, y, t) = E_0 \cos \left[\frac{2\pi}{a} \left(\frac{1}{2}x + \frac{3\frac{1}{2}}{2}y \right) + \omega t \right]$$

$$\text{with } E_0 = 5 \frac{\text{V}}{\text{m}} \text{ peak, and } a = 3 \text{ cm}$$

Determine

- (i) the RMS magnitude and direction of the magnetic field intensity vector,
- (ii) the frequency of the wave and,
- (iii) time averaged values of electric and magnetic energy densities.