NATIONAL EXAMS, DECEMBER 2017

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: $\varepsilon_0 = 8.85 \times 10^{-12}\, F/m, \quad \mu_0 = 4\pi \times 10^{-7}\, H/m, \quad e = 1.6 \times 10^{-19}\, C$

1. Three electrons (electron charge $-e = -1.6 \times 10^{-19}$ C) are located in vertices of a triangle of 5×10^{-11} m sides. Three protons (proton charge + e) are located in the centre of the triangle.

   What is the magnitude and direction of the electric field acting on an electron?

2. In a collimated electron beam of 1 mm diameter the uniform density of electrons is 1.33×10^{12} /m^3 .

   What is the magnitude and direction of the electric field on the surface of the beam?

3. Radii of the inner and outer conductor of an infinitely long coaxial line are 2 mm and 4 mm respectively. Space between the conductors is completely filled with dielectric of relative permittivity 2.25. Maximum allowed field in the dielectric is 10^7 V/m.

   What is the value of maximum allowed energy stored in 1 m length of the line?

4. An infinitely long current loop of two very thin, parallel 0.5A currents lies in the horizontal plane. One current flows east, the other flows west. The west flowing current is located 1 cm north of the east lowing current.

   Calculate magnitude and direction of force acting on a 1 cm long segment of the east flowing current.

5. A horizontal loop of 4 m^2 area and 10 turns moves with 50 m/s velocity in horizontal northerly direction. A spatially varying vertical magnetic field B(x) is present in the space. Spatial variation of the magnetic field B(x) is give below:

   $B(x) = B_0 \exp(-x/a)$ with $B_0 = 10^{-6}$ T,

a = 50 m and x is the horizontal Cartesian coordinate pointing north.

Calculate the voltage induced in the loop at x = 0.

6. Diameter of a circular, horizontal 1A current loop is 50 cm. Viewed from above the current circulates clockwise.

Determine magnitude and direction of magnetic field at a point 1 m above the center of the loop.

7. Electric field distribution is given below in terms of a Cartesian coordinate system

$\check{r} = (X, Y, Z)$

$\bar{E} = (Ex, Ey, Ez) = \check{r}\, \varrho / \varepsilon_0$, for $r \leq 10^{-3}$ m

$= 0$, for $r > 10^{-3}$ m

with $r = |\check{r}| = (X^2 + Y^2 + Z^2)^{1/2}$ and $\varrho = 10^{-6}$ C/m^3

Determine the charge distribution producing the electric field specified above.

8. A beam of light is flashed from the top of a 30 m high tower located above a body of water 2 m deep with a horizontal bottom. Some of the light is reflected from the water surface, some penetrates into the water, is reflected from the bottom and emerges into space above the water. Index of refraction of water is 1.33. The two beams are detected at the top of a 30 m high tower located 100 m away from the tower of the source.

What is the time interval between detection of the two beams?