NATIONAL EXAMS, DECEMBER 2016

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. A positive point charge +2e is surrounded by a sphere of uniformly distributed charge –e of radius 0.5 angstroms (= 5×10^{-11} m).

   Calculate the value of electric field intensity at a point separated by a distance of 0.25 angstroms from the positive charge.

2. A positive point charge +3e is located at the centre of a horizontal equilateral triangle of 1 angstrom (10^{-10} m) side. Negative point charges –e are located in the vertices of the triangle.

   What is the electric potential with respect to infinity of a point 1 angstrom above the centre of the triangle?

3. Plate separation of a parallel plate, air dielectric capacitor is 0.5 mm. Maximum allowable electric field in air is 10^6 V/m. The capacitor stores 1 joule of electrostatic energy.

   What is the minimum allowable area of the capacitor plates?

4. A horizontal, straight, infinitely long current of 1 A, circular cross-section of 1 mm radius and uniform current density flows north.

   Plot the values of magnetic flux density vector B produced by the current as a function of distance from the axis of the current in the range of r from 0 to 2 mm and specify the direction of vector $\vec{B}$ at points above the axis.

5. A horizontal circular current loop of 10 mA and 10^{-10} m radius produces magnetic flux density vector $\vec{B}$. Looking down from above the current circles clockwise.

   What is the direction and magnitude of $\vec{B}$ at a point 10^{-10} m above the centre of the loop?

6. A 1 m long horizontal metallic rod aligned in the north-south direction moves with 5 m/s velocity in horizontal westerly direction. The rod is immersed in a uniform magnetic field of 10^{-5} teslas pointing up at 45° angle.

   What is the value of induced electric potential of the norther tip of the rod with respect to the southern?

7. At a point in space with cartesian coordinates (x, y, z) the potential $V(x, y, z)$ of a charge distribution is $(x, y, z) = (1/4\pi\varepsilon_0)pz/r^3$, with $r = (x^2 + y^2 + z^2)^{1/2}$ and $p = 1.6\ 10^{-29}$ Cm.

   What are the components of the electric field at a point with coordinates $(x, y, z) = (a, 0,0)$, $a = 10^{-10}$ m ?

8. Light emitted from a 300 m high tower is reflected by a mirror located on the ground and observed on a 200 m high tower 600 m away. The mirror is located half-way between the two towers.

   What is the angle of the mirror with respect to the ground?