NATIONAL EXAMS, DECEMBER 2015

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

1. Negative charge $-e$ is uniformly distributed on the circumference of a horizontal circle of 0.5×10^{-10} m radius. A positive point charge e is located in the centre of the circle.

   Determine magnitude and direction of electric field at a point 0.5×10^{-10} m above the centre of the circle.

2. A negative charge $-e$ is uniformly distributed inside a sphere of 0.5×10^{-10} m radius. Another negative charge $-e$ is uniformly distributed inside a concentric sphere of 10^{-10} m radius. A positive point charge $1e$ is located at the common centre of the two spheres.

   What is the magnitude and direction of electric field at a point 0.75×10^{-10} m away from the centre of the spheres?

3. Plate separation of a circular parallel plate capacitor is 0.5mm. Medium between the plates is a dielectric of relative permittivity 2.5. Maximum allowed electric field in the dielectric is 5×10^6 V/m.

   What is the smallest possible radius of the plates if the capacitor is to contain 1 joule of electric energy?

4. An electron moving in easterly horizontal direction at 6×10^4 m/s velocity is acted on by vertical electric field of 10^4 V/m pointing down, and a magnetic field.

   What is the magnitude and direction of the magnetic field (expressed in units of tesla) if the magnetic force is to cancel the electric force acting on the electron?

5. A current loop consists of two joined semicircles of common centre and 10cm radius. One of the semicircles lies in a vertical east-west plane, the other in horizontal plane. The semicircle in the vertical plane lies in the upper half-space with respect to the horizontal plane. A 2A current circulates in the loop. Viewed from above the current circulates clockwise.

   What is the magnitude and direction of the magnetic flux density vector $\vec{B}$ at the common centre of the two semicircles?

6. A transmission line consists of three thin metallic coaxial cylinders of 5mm, 10mm, and 15mm radii. 2A DC current flows in the 5mm radius line. The return current is split evenly in the 10mm and 15mm radii lines.

   Calculate the magnetic fields in all of the three free spaces of the line specifying magnitudes and senses of circulation.

7. A 10cm diameter circular wire loop lies in the vertical east-west plane. A 1mm wide gap is located at the bottom of the loop. A horizontal, spatially uniform magnetic field of 0.2 teslas pointing north passes through the loop.

   Calculate the magnitude and polarity of the voltage occurring across the 1mm gap if the magnetic field is reduced at uniform rate from 0.2 teslas to zero in 0.1 seconds.

8. Two points A and B located on the surface of the earth are 500km apart. Point A communicates by wireless with point B. Signal from A can travel to B by skywave propagating upward with light velocity c (3×10^5 km/s) and reflected down by the ionosphere located 100km above ground, or by ground wave travelling along the ground surface with velocity which is 5% slower than c.

   What is the time interval between the arrivals of the two waves at point B? Assume in your calculation that earth is flat.