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06EE44

Fourth Semester B.E. Degree Examination, December 2010
Field Theory

Time: 3 hrs. Max. Marks:100

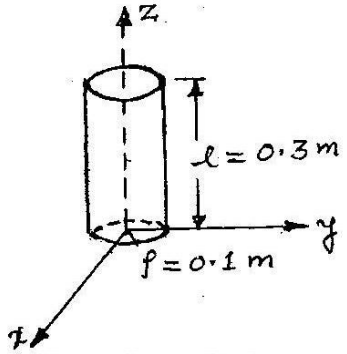
Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Define the following:
i) Electric field intensity.
ii) Electric scalar potential. **(05 Marks)**

b. A point charge Q_1=25 nC is located at $P_1(4, -2, 7)$ and a charge Q_2=60 nC be at $P_2(-3, 4, 2)$
i) If $\epsilon=\epsilon_0$ find 'E' at $P_3(1, 2, 3)$.
ii) At what point on the y-axis is $E_x = 0$? **(08 Marks)**

c. Determine the charge enclosed in a cylinder shown in fig.Q1 (c), when the volume charge density, $\rho_v = 2.0e^{-z}(x^2 + y^2)^{-\frac{1}{4}}$ c/m^3. **(07 Marks)**



Charge in a cylinder
Fig. Q1 (c)

2 a. Derive an expression for the electric field strength due to finite and infinite line of charge of linear charge density ρ_L c/m. **(07 Marks)**

b. A sphere of volume 0.1 m^3 has a charge density of 8.0 PC/m^3. Find the electric field at the point (2, 0, 0), if the centre of the sphere is at (0, 0, 0). **(05 Marks)**

c. Given $E = (10y\,\hat{a}_x + 10x\,\hat{a}_y - 2\,\hat{a}_z)$ V/m. Determine the work involved in carrying a charge of 3C from (0, -2, 8) to (5, 3, 23) along the path,
i) Direct straight line.
ii) $z_t = 2x^3 - y^3;\ y^2 = x + 4$ **(08 Marks)**

3 a. Derive an expression for the Poisson's and Laplace's equation and write down the equation in all the three co-ordinate systems. **(07 Marks)**

b. If a potential $V = x^2yz + Ay^3z$, i) Find 'A' so that Laplace's equation is satisfied. ii) With the value of 'A', determine electric field at (2, 1, -1). **(06 Marks)**

c. Given potential field $V = 2x^2y - 5z$ and a point P(-4, 3, 6) m. Find at P. i) the potential V, ii) Electric field intensity 'E', iii) the direction of 'E' iv) Electric flux density 'D', v) Volume charge density 'ρ_V' vi) ρ_v at P. Assume $\epsilon=\epsilon_0$. **(07 Marks)**

4 a. With usual notation, derive an expression for the energy stored in an electrostatic field and show that the energy density in an electrostatic field is, $W = \frac{1}{2}DE = \frac{1}{2}\epsilon E^2$. **(07 Marks)**

b. A parallel plate capacitor of $10cm \times 10cm$ and d = 1 cm is charged to a potential of 1 KV with air as dielectric.
   i) Find the energy stored.
   ii) The capacitance is now disconnected from the source and a dielectric slab is inserted into the capacitor ($\epsilon_r = 4$). Calculate the energy stored. **(05 Marks)**

c. Define divergence of electric flux density and derive an expression to show that $(\nabla \cdot D) = \rho$. Also represent the equation in all the three co-ordinate systems. **(08 Marks)**

PART – B

5 a. Derive an expression for the continuity equation. **(06 Marks)**

b. State and prove Biot-Savart law. **(06 Marks)**

c. Find the magnetic field intensity at the origin caused by a current element in free space Idl equal to,
   i) $3\pi\hat{a}_z \mu A.m$ located at (3, -4, 0).
   ii) $\pi(\hat{a}_x - 2\hat{a}_y + 2\hat{a}_z)$ mA.m located at (5, 0, 0) **(08 Marks)**

6 a. Find the vector magnetic potential 'A' at a point due to a straight current carrying conductor of length '2l' m. Hence find 'B'. **(07 Marks)**

b. Derive the Maxwell's equations for i) Free space ii) Harmonically varying field. **(07 Marks)**

c. A lossy dielectric has $\mu = 4\pi \times 10^{-9}$ H/m and $\epsilon = \frac{10^{-8}}{36\pi}$ F/m, $\sigma = 2 \times 10^{-8}$ S/m. The electric field, $E = 200\sin\omega t\ \hat{a}_z$ V/m exists at a certain point in the dielectric.
   i) At what frequency will the conduction current density and displacement current densities have equal magnitudes?
   ii) At this frequency calculate the instantaneous displacement current density. **(06 Marks)**

7 a. Deduce an expression for wave equation in the case of a lossless medium. **(07 Marks)**

b. State and prove Poynting's theorem and show that $S = E \times H$. **(05 Marks)**

c. Determine : i) attenuation constant - α ii) phase constant - β iii) phase velocity – V iv) wave length - λ v) Intrinsic impedance Z_c for Ferrite at 10 GHz, given $\epsilon_r = 9$, $\mu_r = 4$, conductivity = 10 m Ʊ/m. **(08 Marks)**

8 a. Derive an expression for the impedance of a conducting media. **(08 Marks)**

b. With an example, write a brief note on depth of penetration. **(05 Marks)**

c. A 200 MHz plane electromagnetic wave is incident normally on a good conductor which is having a constant conductivity = 58 M Ʊ/m. Find the following:
   i) $\frac{1}{e}$ depth of penetration.
   ii) 1% depth.
   iii) Wave length in the conductor - λ.
   iv) Velocity in the conductor – V_C. **(07 Marks)**

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