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06EE44

Fourth Semester B.E. Degree Examination, May/June 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 divergence of a vector. What do positive and negative divergences represent? **(04 Marks)**

b. Two uniform line charges of density 4nc/m and 6 nc/m lie in x = 0 plane at y = +5 m and – 6m respectively. Find $\overline{E}$ at (4, 0, 5)m. **(06 Marks)**

c. State and explain Gauss's law. Given that $\overline{D} = \frac{\rho^2 z^2}{3}\cos\phi\,\overline{a_\phi}$, determine the flux crossing $\phi = \pi/4$ half plane defined by $0 \le \rho \le 3$ and $2 \le z \le 4$. **(10 Marks)**

2 a. Show that the energy required to assemble 'n' number of point charges is $W_E = \frac{1}{2}\sum_{m=1}^{n} Q_m V_m$ and hence derive expression for energy in electric field in terms of field quantities $\overline{D}$ and $\overline{E}$. **(08 Marks)**

b. For a line charge $\rho_l = \frac{10^{-9}}{2}$ c/m on the z-axis, find V_{AB} where A is (2m, π/2, 0) and B is (4m, π, 5m). **(06 Marks)**

c. Find the workdone in assembling four qual point charges of 1 μc each on X and Y axis at ±3m and ±4m respectively. **(06 Marks)**

3 a. Starting from Gauss's law in integral form, derive Laplace's and Poisson's equations in Cartesian coordinates. **(07 Marks)**

b. Determine the expression for $\overline{E}$, in cylindrical coordinates, between two planes insulated along Z-axis, assuming a potential of 100 V for $\phi = \alpha$ and zero reference at $\phi = 0°$. **(06 Marks)**

c. Calculate the capacitance/unit length of two co-axial cylindrical conductors in free space. If the space between the cylinders were filled with dielectric, how would the dielectric constant of the dielectric have to depend on the distance 'r' from the axis, in order that the electric field intensity be independent of 'r'. **(07 Marks)**

4 a. State and explain Ampere's circuital law. **(04 Marks)**

b. Derive the Gauss's law for the magnetic field in point form. Hence show that scalar magnetic potential follows Laplace's equation. **(04 Marks)**

c. Given the field $\overline{H} = 6r\sin\phi\,\overline{a_r} + 18r\sin\theta\cos\phi\,\overline{a_\phi}$. Evaluate each side of Stoke's theorem for portion of a spherical surface specified by r = 4, $0 \le \theta \le 0.1\pi$, $0 \le \phi \le 0.3\pi$ and a closed path forming its perimeter. **(12 Marks)**

PART – B

5 a. Derive the boundary conditions to apply to B and H at the interface between two different magnetic materials. **(08 Marks)**

b. The point charge Q = 18 nc has a velocity of 5×10^6 m/s in the direction $\bar{a}_v = 0.60\bar{a}_x + 0.75\bar{a}_y + 0.3\bar{a}_z$. Calculate the magnitude of the force exerted on the charge by the field

i) $\bar{E} = -3\bar{a}_x + 4\bar{a}_y + 6\bar{a}_z$ kV/m ii) $\bar{B} = -3\bar{a}_x + 4\bar{a}_y + 6\bar{a}_z$ mT iii) $\bar{B}$ and $\bar{E}$ acting together. **(08 Marks)**

c. Find the force/mtr length between two long parallel wires separated by 10 cm in air and carrying a current of 100 A in opposite directions. State the nature of force between the wires. **(04 Marks)**

6 a. Derive the continuity equation from Maxwell's equation. **(04 Marks)**

b. For time varying field, show that $\bar{E} = -\nabla V - \frac{\partial \bar{A}}{\partial t}$, where $\bar{A}$ is vector magnetic potential. **(08 Marks)**

c. A rectangular loop is approaching a long straight current carrying conductor as shown in Fig.Q6(c). For the position shown, find the total induced emf in the loop. **(08 Marks)**

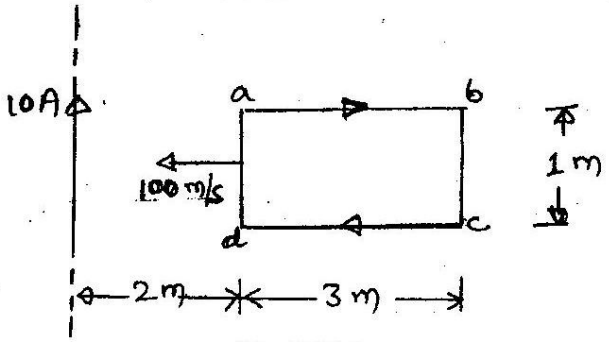

Fig.Q6(c)

7 a. Determine the relation between E and H of an EM wave traveling in free space along x direction. **(10 Marks)**

b. A 160 MHz plane wave penetrates through aluminium of conductivity 10^5 mhos/mtr, $\epsilon_r = \mu_r = 1$. Calculate the skin depth and also depth at which the wave amplitude decreases to 13.5% of its initial value. **(06 Marks)**

c. 8 Watts/m^2 is the Poynting vector of a plane wave traveling in free space. What is the average energy density? **(04 Marks)**

8 a. Discuss the reflection of uniform plane waves at normal incidence. Hence derive expressions for transmission and reflection coefficient. **(10 Marks)**

b. A conductor of circular cross-sectional area of radius 'a' is carrying a current of I amps. Show that the surface integral of the Poynting vector over the surface of the conductor gives the total power dissipated in the conductor. Given the conductivity of the material $\sigma = 1/\rho$. **(10 Marks)**

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