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06EE44

Fourth Semester B.E. Degree Examination, June / July 08

Field Theory

Time: 3 hrs. Max. Marks:100

Note : ***Answer any FIVE full questions, selecting atleast two questions from each part.***

PART - A

1 a. Derive the relation between vector E and scalar V. State Maxwell's equations applicable to electrostatic fields. **(05 Marks)**

b. Consider a uniform ring charge of radius a. Derive the general expression for electric field vector E at a height h (h < a), along the axis of the ring charge and normal to its plane. **(05 Marks)**

c. Point charges of 120 nano coulomb each are located at A(0, 0, 1) and B(0, 0, -1) in free space. Find vector E at P(0, 0.5, 0). What single charge at the origin would provide the identical field strength as calculated at P? **(10 Marks)**

2 a. State Gauss's Law. Derive an expression for the electric field vector due to an infinite line charge using Gauss's law. Assume the linear charge density of the charge distribution to be ρ_l C /m. **(05 Marks)**

b. Two 6 nano coulomb point charges are located at (1, 0, 0) and (-1, 0, 0) in free space. Find electric potential V at P(0, 0, z) and what is its maximum value? **(05 Marks)**

c. If a potential of $V = x^2yz + Ay^3z$ Volts, i) Find A so that the Laplace's equation is satisfied ii) With that value A, determine the electric field at a point P whose coordinates are (2, 1, -1). **(10 Marks)**

3 a. Let $\vec{G} = 4x\hat{a}_x + 2z\hat{a}_y + 2y\hat{a}_z$, given an initial point P(2, 1, 1) and a final point M(4, 3, 1), find $\int \vec{G}.d\vec{\ell}$ using the path along a straight line : y = x – 1, z = 1. **(05 Marks)**

b. State and prove Uniqueness theorem. **(05 Marks)**

c. Perform the analysis for the divergence of electric flux density vector D, with respect to differential cubical volume having a charge at its symmetric centre. Extend the analysis to work out the Maxwell's equation in the form $\nabla . \vec{D} = \rho_v$. **(10 Marks)**

4 a. State Biot –Savart's law. Derive the expression for magnetic flux density at a given point due to a current carrying element of finite length. **(05 Marks)**

b. Explain the concept of vector magnetic potential. **(05 Marks)**

c. Conducting spherical shells with radius a = 10 cm and b = 30 cm are maintained at a potential difference of 100 V such that $V_{(r=a)} = 0$ and $V_{(r=b)} = 100$ V. Determine V and vector E in the region between the shells. If $\varepsilon_r = 2.5$ in the region, determine the total charge induced on the shells and the capacitance thereon. **(10 Marks)**

PART - B

5 a. Derive the expression for the force between two current loops. **(05 Marks)**

b. Given the vector $E = 10 \sin(\omega t - \beta z)\ \hat{a}_y$ V /m, in free space, determine the vectors D, B and H. **(05 Marks)**

c. Workout the Lorentz force equation for the case of moving charge in the presence of electric and magnetic fields. **(10 Marks)**

6 a. State Maxwell's equations in point and integral forms for time varying fields. **(05 Marks)**

b. Two homogeneous, linear and isotropic media have an interface at $x = 0$. The region $x < 0$ describes medium 1 and $x > 0$ describes medium 2. $\mu_{r1} = 2$ and $\mu_{r2} = 5$. The magnetic field in medium 1 is $150\hat{a}_x - 400\hat{a}y + 250\hat{a}_z$ A /m. Determine i) Magnetic field in medium 2 ii) Magnetic flux density in medium 1. **(05 Marks)**

c. Derive the Maxwell's equation (based on Ampere's circuit law) $\nabla \times \hat{H} = J + J_d$ for time – varying field. The term $J_d = \partial\hat{D}/\partial t$ is known as displacement current density and J is the conduction current density. **(10 Marks)**

7 a. State and prove Poynting's theorem. **(10 Marks)**

b. If the electric field strength of a radio broadcast signal at a TV receiver is given by vector $E = 5.0 \cos(\omega t - \beta y)\ \hat{a}_z$, V /m, determine the displacement current density. If the same field exists in a medium whose conductivity is given by 2.0×10^3 (mho) /cm, find the conduction current density. **(10 Marks)**

8 a. Explain he phenomenon of Skin effect and its significance. **(05 Marks)**

b. Discuss the phenomenon of wave propagation in lossy dielectrics. **(05 Marks)**

c. Derive the wave equation for vector E and H fields in a conducting medium. **(10 Marks)**