CBCS SCHEME

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18EE45

Fourth Semester B.E. Degree Examination, July/August 2021
Electromagnetic Field Theory

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

1 a. Given three points in Cartesian co-ordinate system as A(3, -2, 1), B(-3, -3, 5) and C(2, 6, -4) Find:
i) The vector from A to C
ii) The unit vector from B to A
iii) The vector from 'A' to the mid point of the straight line joining B to C. **(06 Marks)**

b. Derive the relationship between rectangular and cylindrical co-ordinates. **(06 Marks)**

c. State and explain Gauss law. Find the electric field intensity at a distance 'r' from an infinite line charge using Gauss's law. **(08 Marks)**

2 a. State and explain Coulomb's law in vector form. **(06 Marks)**

b. A charge $Q_2 = 121 \times 10^{-9}$C is located in vaccum at P_2 (-0.03, 0.01, 0.04)m. Find the force on Q_2 due to $Q_1 = 110\mu$C at P_1(0.03, 0.08, -0.02)m. **(08 Marks)**

c. Find $\bar{H}$ in Cartesian coordinates of the vector field $\bar{H} = 20\bar{a}_r - 10\bar{a}_\phi + 3\bar{a}_z$ at point P(x = 5, y = 2, z = -1). **(06 Marks)**

3 a. Prove that $\bar{E} = -\nabla v$ in an electric field. **(06 Marks)**

b. Derive the expression for the capacitance of a parallel plate capacitor. **(06 Marks)**

c. Given the potential field $V = 50x^2yz + 20y^2$ V in free space. Find: i) V at P(1, 2, 3) ii) E_p iii) $\hat{a}_r$ at P. **(08 Marks)**

4 a. Derive the boundary conditions, the interface between a conductor and free space. **(06 Marks)**

b. With usual notations prove that $\nabla.\bar{J} = \frac{-\partial \rho v}{\partial t}$. **(06 Marks)**

c. Point charges Q_1 = 1nc, Q_2 = -2 nc, Q_3 = 3nc and Q_4 = -4nc are placed one by one in the same order at (0, 0, 0), (1, 0, 0), (0, 0, -1) and (0, 0, 1) respectively. Calculate the energy in the system when all charges are placed. **(08 Marks)**

5 a. State and prove uniqueness theorem. **(06 Marks)**

b. State and explain Biot-Savart's law and Ampere' circuital law. **(06 Marks)**

c. Let $V = \frac{\cos 2\phi}{r}$ in free space
i) Find the volume charge density at a point A(0.5, 60°, 1)
ii) Find $\bar{E}$ at B(2, 30°, 1). **(08 Marks)**

6 a. Derive Poisson's and Laplace equation. Write Laplace equation in all the coordinate systems. **(06 Marks)**

b. Discuss the concept of vector magnetic potential and arrive at expression for it. **(08 Marks)**

c. If the magnetic field intensity in a region is $\bar{H} = (3y - 2)\bar{a}_z + 2x\bar{a}_y$. Find the current density (J) at the origin. **(06 Marks)**

7 a. State and explain Lorentz force equation. **(06 Marks)**

b. Calculate the inductance of a solenoid of 200 turns wound tightly on a cylindrical tube of length 60cm and of a diameter 6cm given that medium is air. Derive the expression used. **(08 Marks)**

c. Derive an equation for the magnetic force between the two differential current elements. **(06 Marks)**

8 a. Derive the boundary conditions at the interface between two magnetic materials of different permeabilities. **(08 Marks)**

b. Find the force per meter length between two long parallel wires separated by 10cm in air and carrying a current of 10A in the same direction. **(06 Marks)**

c. A point charge of Q = -1.2C has a velocity $\bar{V} = \left(5\bar{a}_x + 2\bar{a}_y - 3\bar{a}_z\right) m/s$. Find the magnitude of the force exerted on a charge if

i) $\bar{E} = -18\bar{a}_x + 5\bar{a}_y - 10\bar{a}_z v/m$

ii) $\bar{B} = -4\bar{a}_x + 4\bar{a}_y - 3\bar{a}_z T$ **(06 Marks)**

9 a. Write Maxwell's equations in point form and in integral form for time varying fields. **(06 Marks)**

b. Find amplitude of displacement current density in a free space within a large power distribution transformer where $\bar{H} = 10^6 \cos(377t + 1.2566 \times 10^{-6} z)\bar{a}_y A/m$. **(06 Marks)**

c. State and prove Poynting theorem. **(08 Marks)**

10 a. State and explain Faraday's law. **(06 Marks)**

b. Derive the wave equations in $\bar{E}$ and $\bar{H}$ for a uniform plane wave travelling in free space. **(06 Marks)**

c. The magnetic field intensity of uniform plane wave in air is 20 (A/m) in $\bar{a}_y$ direction. The wave is propagating in the $\bar{a}_z$ direction at an angular frequency of 2×10^9 (rad/sec). Find:

i) Phase shift constant

ii) Wavelength

iii) Frequency

iv) Amplitude of electric field intensity. **(08 Marks)**

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