CBCS SCHEME

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15EE45

Fourth Semester B.E. Degree Examination, Feb./Mar. 2022
Electromagnetic Field Theory

Time: 3 hrs. Max. Marks: 80

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. Explain: i) Dot product ii) Cross product iii) Unit vector. **(05 Marks)**

b. Given: $\overline{A} = 2\overline{a}_x - \overline{a}_z$, $\overline{B} = 3\overline{a}_x + 4\overline{a}_y$ and $\overline{C} = -2\overline{a}_x + 6\overline{a}_y - 4\overline{a}_z$. Show that $\overline{C}$ is perpendicular to both $\overline{A}$ and $\overline{B}$. **(05 Marks)**

c. Given P(3, 4, 2)mt in rectangular coordinate system. Find its equivalent coordinate in spherical and cylindrical coordinate system. **(06 Marks)**

OR

2 a. State and explain Coulomb's law in vector form. Write the unit of each term in the expression. **(05 Marks)**

b. Determine the electric field intensity at P(2, 0, 2)mt due to three standard charge distributions. A uniform sheet charge at X = 1mt and $\rho_s = \frac{1}{3\pi}$ nc/m^2, another sheet charge at X = 4mt with $\rho_s = -\frac{1}{3\pi}$ nc/m^2. An infinite line charge at x = 6mt and y = 0 mt with ρ_s = 2nc/mt. take $\epsilon = \epsilon_0$. **(06 Marks)**

c. Derive an expression for electric field intensity due to infinite line charge using Gauss's law. **(05 Marks)**

Module-2

3 a. Show that the energy required to assemble 'n' number of charge is $w_\varepsilon = \frac{1}{2}\sum_{i=1}^{n} Qi\,Vi$. **(06 Marks)**

b. Given potential v = $3x^2 + 4y^2$ volts. Find the energy stored in a volume defined by $0 \le x \le 1$mt, $0 \le y \le 1$mt, $0 \le z \le 2$mt. **(05 Marks)**

c. Find work done in moving a point charge of Q = 20μc from origin to (4, 2, 0)mt in the field $\overline{E} = \left(\frac{x}{2} + 2y\right)\overline{a}_x + 2x\,\overline{a}_y$ V/M. **(05 Marks)**

OR

4 a. Find the total current passing through the surface at ϕ = constant, $0.1 \le r \le 0.2$mt, $0 \le z \le 1$mt. Given $\overline{J} = 5r^2\overline{a}_\phi$ A/m^2 **(05 Marks)**

b. Discuss the boundary conditions between two different dielectric materials. **(06 Marks)**

c. Find the capacitance of a capacitor consisting of two parallel plates 30cm × 30cm surface area separated by 5mm in air medium. What is the total energy stored if capacitor is charged to a potential of 500 volts. **(05 Marks)**

Module-3

5 a. State and explain Biot – Savart law. **(05 Marks)**

b. Calculate the magnetic field intensity at P(1.5, 2, 3)mt caused by current filament of 24Amps flowing in the $\bar{a}_z$ direction along 2 – axis extending from i) z = 6 to 2 = ∞ ii) 2 = –∞ to 2 = +∞. **(05 Marks)**

c. State and prove Ampere's Amperes circuital law. **(06 Marks)**

OR

6 a. Semi infinite conducting planes at $\phi = 0$ and $\phi = \pi/6$ are separated by an insulating gap. If V = 0 at $\phi = 0$ and V = 100volts at $\phi = \pi/6$. Find the electric potential and electric field intensity in the region between plates. **(07 Marks)**

b. Using Laplace equation develop an expression for capacitance of parallel plate capacitor. **(06 Marks)**

c. Find whether or not the potential $V = 2x^2 - 4y^2 + 2z^2$ satisfy the Laplace equation. **(03 Marks)**

Module-4

7 a. Derive an expression for force between two loop current circuits. **(08 Marks)**

b. A current element $I_1 \overline{d\ell}_1 = 10^{-5}\bar{a}_2 Am$ is located at P_1(1, 0, 0)mt. While another current element $I_2 \overline{d\ell}_2 = 10^{-5}(0.6\bar{a}_x - 2\bar{a}_y + 3\bar{a}_z)Am$ is at P_2 (–1, 0, 0,)mt both in free space. Find the vector force exerted on $I_2 \overline{d\ell}_2$ by $I_1 \overline{d\ell}_1$ **(08 Marks)**

OR

8 a. Determine the boundary conditions to apply B and H at the interface between two different magnetic materials. **(06 Marks)**

b. Find the inductance of a solenoid having 8cm length, 2cm in radius, wound with 900 turns and $\mu_r = 100$. **(04 Marks)**

c. Derive an expression for inductance of a toroid. **(06 Marks)**

Module-5

9 a. Explain transformer emf and motional induced emfs. **(08 Marks)**

b. The circular loop conductor at z = 0 plane has radius of 0.1mt and R = 5Ω. Given $\overline{B} = 0.2 \sin 10^3 t\ \bar{a}_z\ wb/m^2$. Find the current. **(08 Marks)**

OR

10 a. Prove that, the intrinsic impedance of a free space dialectic is 377Ω. **(08 Marks)**

b. Find the frequency at which the conduction current density and the displacement current density are equal in a medium with $\sigma = 2 \times 10^{-2}$ ℧/mt and $\epsilon_r = 81$. **(04 Marks)**

c. Define skin depth and derive an expression for it. **(04 Marks)**

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