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## 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:  $\vec{A} = 2\vec{a}_x - \vec{a}_z$ ,  $\vec{B} = 3\vec{a}_x + 4\vec{a}_y$  and  $\vec{C} = -2\vec{a}_x + 6\vec{a}_y - 4\vec{a}_z$ . Show that  $\vec{C}$  is perpendicular to both  $\vec{A}$  and  $\vec{B}$ . (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  $X = 1$ mt and  $\rho_s = \frac{1}{3\pi}$  nc/m<sup>2</sup>, another sheet charge at  $X = 4$ mt with  $\rho_s = -\frac{1}{3\pi}$  nc/m<sup>2</sup>. An infinite line charge at  $x = 6$ mt and  $y = 0$  mt with  $\rho_s = 2$ nc/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  $w_e = \frac{1}{2} \sum_{i=1}^n Q_i V_i$ . (06 Marks)
- b. Given potential  $v = 3x^2 + 4y^2$  volts. Find the energy stored in a volume defined by  $0 \leq x \leq 1$ mt,  $0 \leq y \leq 1$ mt,  $0 \leq z \leq 2$ mt. (05 Marks)
- c. Find work done in moving a point charge of  $Q = 20\mu\text{c}$  from origin to (4, 2, 0)mt in the field  $\vec{E} = \left(\frac{x}{2} + 2y\right)\vec{a}_x + 2x\vec{a}_y$  V/M. (05 Marks)

### OR

- 4 a. Find the total current passing through the surface at  $\phi = \text{constant}$ ,  $0.1 \leq r \leq 0.2$ mt,  $0 \leq z \leq 1$ mt. Given  $\vec{J} = 5r^2\vec{a}_\phi$  A/m<sup>2</sup> (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  $\times$  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 z – axis extending from i)  $z = 6$  to  $z = \infty$  (05 Marks)  
 ii)  $z = -\infty$  to  $z = +\infty$ . (06 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  $V = 100$ volts 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  $I_1 d\bar{l}_1 = 10^{-5} \bar{a}_z$  Am is located at  $P_1(1, 0, 0)$ mt. While another current element  $I_2 d\bar{l}_2 = 10^{-5} (0.6\bar{a}_x - 2\bar{a}_y + 3\bar{a}_z)$  Am is at  $P_2(-1, 0, 0)$ mt both in free space. Find the vector force exerted on  $I_2 d\bar{l}_2$  by  $I_1 d\bar{l}_1$  (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  $R = 5\Omega$ . Given  $\bar{B} = 0.2 \sin 10^3 t \bar{a}_z$  wb/m<sup>2</sup>. Find the current. (08 Marks)

**OR**

- 10 a. Prove that, the intrinsic impedance of a free space dialectic is  $377\Omega$ . (08 Marks)  
 b. Find the frequency at which the conduction current density and the displacement current density are equal in a medium with  $\sigma = 2 \times 10^{-2} \text{ } \bar{U}/\text{mt}$  and  $\epsilon_r = 81$ . (04 Marks)  
 c. Define skin depth and derive an expression for it. (04 Marks)

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