USN ☐☐☐☐☐☐☐☐☐☐   **18EE45**

Fourth Semester B.E. Degree Examination, June/July 2023
Electromagnetic Field Theory

Time: 3 hrs.   Max. Marks: 100

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

Module-1

1 a. Define the following:
   (i) Scalar and Vector   (ii) Dot product and cross product
   (iii) Divergence   (iv) Curl   **(08 Marks)**
   b. State and explain Coulomb's law of force between two point charges in vector form.
                                                                         (06 Marks)
   c. Explain electric field intensity at a point due to a point charge. **(06 Marks)**

OR

2 a. The flux density $\vec{D} = \dfrac{r}{3}\vec{a}_r$ nc/m^2 is in free space. Find:

   (i) $\vec{E}$ at r = 0.2 m
   (ii) Find the total electric flux leaving sphere of r = 0.2 m.
   (iii) Find the total charge within the sphere of r = 0.3 m   **(10 Marks)**

   b. Given $\vec{D} = 5r\,\vec{a}_r$ c/m^2, prove divergence theorem for a shell region enclosed by spherical surfaces at r = a and r = b (b > a) and centred at the origin.   **(10 Marks)**

Module-2

3 a. Obtain an expression for the workdone in moving a point charge 'Q' in an electric field $\vec{E}$.
                                                                         (08 Marks)
   b. Show that $\vec{E} = -\nabla V$ i.e. electric field intensity is negative gradient of potential.   **(06 Marks)**
   c. Obtain the equation of continuity in both integral and differential form.   **(06 Marks)**

OR

4 a. Explain and derive the boundary conditions for a conductor dielectric interface.   **(10 Marks)**
   b. The capacitance of the condenser formed by the two parallel metal sheets, each 100 cm^2 in area separated by a dielectric 2 mm thick is 2×10^{-4} μF. A potential of 20 KV is applied to it. Find:
   (i)   Electric flux
   (ii) Potential gradient in KV/m
   (iii) The relative permittivity of the material
   (iv) Electric flux density
                                                                         (10 Marks)

Module-3

5 a. From the Gauss's law, derive Poisson's and Laplace's equation and write Laplace's equation in Cartesian, cylindrical and spherical coordinate systems.   **(10 Marks)**
   b. State and prove Uniqueness theorem.   **(05 Marks)**
   c. There exists a potential of V = –2.5 Volts on a conductor at 0.02 m and V = 15 Volts at r = 0.35 m. Determine E and D by solving the Laplace's equation in spherical coordinates representing the potential system.   **(05 Marks)**

OR

6 a. State and explain Biot-Savart's law. (08 Marks)
  b. State and prove Ampere's circuital law. (08 Marks)
  c. Define magnetic field and state its properties. (04 Marks)

Module-4

7 a. Derive Lorent'z Force Equation. (08 Marks)
  b. A point charge of Q = –40 μC is moving with a velocity of $\vec{V} = (-3\vec{a}_x - 4\vec{a}_y + 4.5\vec{a}_z) \times 10^6$ m/sec. Find the magnitude of the vector force exerted on the moving particle by the field:
    (i) $\vec{B} = 2\vec{a}_x - 3\vec{a}_y + 5\vec{a}_z$ mT
    (ii) $\vec{E} = (2\vec{a}_x + 3\vec{a}_y - 4\vec{a}_z$ KV/m
    (iii) Both $\vec{B}$ and $\vec{E}$ active together. (06 Marks)
  c. Derive an expression for magnetic force due to magnetic field $\vec{B}$ on a conductor of length 'L' metre. (06 Marks)

OR

8 a. Find the force per meter length between two long parallel wires separated by 10 cm in air and carrying a current of 10 A in same direction. (06 Marks)
  b. Derive an equation for the magnetic force between two differential current elements. (08 Marks)
  c. A loop has a dimension of 1m × 2m and lies in the uniform magnetic field, $\vec{B}_0 = -0.6\vec{a}_y + 0.8\vec{a}_z$ T. The loop current is 4 mA. Calculate the torque on the loop. (06 Marks)

Module-5

9 a. List Maxwell's equations for steady and time varying fields in point form and integral form. Also mention the relevant laws. (10 Marks)
  b. Show that the ratio of the amplitudes of conduction current density and displacement current density is $\frac{\sigma}{\omega\varepsilon}$. (10 Marks)

OR

10 a. Starting from Maxwell's equations, obtain the general wave equations in electric and magnetic fields. (10 Marks)
   b. The magnetic field intensity of uniform plane wave in air is 20 A/m in $\vec{a}_y$ direction. The wave is propagating in $\vec{a}_z$ 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 (10 Marks)

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