USN ☐☐☐☐☐☐☐☐☐☐ **15EC36**

Third Semester B.E. Degree Examination, Dec.2017/Jan.2018
Engineering Electromagnetics

Time: 3 hrs.   Max. Marks: 80

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

Module-1

1   a.   State and explain Coulomb's law in vector form.   (05 Marks)
    b.   Find the electric field $\overline{E}$ at origin, if the following charge distributions are present in free space:
         i)   Point charge 12 nc at P(2, 0, 6).
         ii) Uniform line charge of linear charge density 3 nc/m at x = 2, y = 3.
         iii) Uniform surface charge of density P_s = 0.2 nc/m^2 at x = 2.   (06 Marks)
    c.   Define volume charge density. Also find the total charge within each of the indicated volumes.
         i) $0 \le \rho \le 0.1$, $0 \le \phi \le \pi$, $2 \le z \le 4$; $\rho_v = \rho^2 z^2 \sin(0.6\phi)$

         ii) Universe : $\rho_v = \dfrac{e^{-2r}}{r^2}$ (05 Marks)

OR

2   a.   Define Electric flux and flux density.   (04 Marks)
    b.   Given a 60 µC point charge located at the origin, find the total electric flux passing through:

         i)   That portion of the sphere γ = 26 cm bounded by $0 < \theta < \dfrac{\pi}{2}$ and $0 < \phi < \dfrac{\pi}{2}$.

         ii) The closed surface defined by ρ = 26 cm and z = ±26 cm.
         iii) The plane z = 26 cm.   (07 Marks)
    c.   Derive the expression for $\overline{E}$ due to infinite line charge of charge density $\rho_L (c/m)$.
                                                                                            (05 Marks)

Module-2

3   a.   State and prove Gauss law for point charge.   (05 Marks)
    b.   State and prove divergence theorem.   (05 Marks)
    c.   In each of the following parts, find value for $\operatorname{div} \overline{D}$ at the point specified:
         i) $\overline{D} = (2xyz - y^2)\overline{a}_x + (x^2 z - 2xy)\overline{a}y + x^2 y\overline{a}_z$ c/m^2 at P_A(2, 3, -1).
         ii) $\overline{D} = 2\rho z^2 \sin^2 \phi \overline{a}_\rho + \rho z^2 \sin 2\phi \overline{a}_\phi + 2\rho^2 z \sin^2 \phi \overline{a}_z$ c/m^2 at P_B(ρ = 2, ϕ = 110°, z = -1).
                                                                                            (06 Marks)

OR

4   a.   Define potential difference and absolute potential.   (04 Marks)
    b.   A point charge of 6 nc is located at origin in free space, find potential of point p, if p is located at (0.2, -0.4, 0.4) and
         i)   V = 0 at infinity
         ii) V = 0 at (1, 0, 0)
         iii) V = 20 V at (-0.5, 1, -1)   (06 Marks)
    c.   Derive point form of continuity equation for current.   (06 Marks)

Module-3

5   a.   Derive the expression for Poisson's and Laplace's equation.   (05 Marks)

    b.   Two plates of parallel plate capacitors are separated by distance 'd' and maintained at potential zero and V_0 respectively. Assuming negligible fringing effect, determine potential at any point between the plates.   (06 Marks)

    c.   State and prove uniqueness theorem.   (05 Marks)

OR

6   a.   State and explain Biot-Savart law.   (06 Marks)

    b.   Find the magnetic flux density at the centre '0' of a square of sides equal to 5m and carrying 10 amperes of current.   (06 Marks)

    c.   At a point p(x, y, z), the components of vector magnetic potential $\overline{A}$ are given as $A_x = 4x + 3y + 2z$, $A_y = 5x + 6y + 3z$ and $A_z = 2x + 3y + 5z$. Determine $\overline{B}$ at point P.   (04 Marks)

Module-4

7   a.   Derive Lorentz force equation.   (05 Marks)

    b.   Derive an expression for the force on a differential current element placed in a magnetic field.   (06 Marks)

    c.   A conductor 4m long lies along the y-axis with a current of 10 amps in the $\overline{a}_y$ direction. Find the force on the conductor if the field is $\overline{B} = 0.005\,\overline{a}_x$ Telsa.   (05 Marks)

OR

8   a.   Define: i) Magnetization,   ii) Permeability.   (04 Marks)

    b.   Find the magnetization in a magnetic material where
      i) $\mu = 1.8 \times 10^5$ (H/m) and 120 (A/m)
      ii) $\mu_r = 22$, there are 8.3×10^{28} atoms/m^3 and each atom has a dipole moment of 4.5×10^{-27} (A/m^2) and
      iii)   B = 300 µT and $\chi_m = 15$.   (06 Marks)

    c.   Discuss the boundary conditions at the interface between two media of different permeabilities.   (06 Marks)

Module-5

9   a.   State and explain Faraday's law of electromagnetic induction.   (04 Marks)

    b.   Find the frequency at which conduction current density and displacement current are equal in a medium with $\sigma = 2 \times 10^{-4}$ ℧/m and $\varepsilon_r = 81$.   (06 Marks)

    c.   List Maxwell's equations in point form and integral form.   (06 Marks)

OR

10   a.   Obtain solution of the wave equation for a uniform plane wave in free space.   (06 Marks)

    b.   State and prove Poynting theorem.   (06 Marks)

    c.   The depth of penetration in a certain conducting medium is 0.1 m and the frequency of the electromagnetic wave is 1.0 MHz. Find the conductivity of the conducting medium.   (04 Marks)

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