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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belgaum)

Fourth Semester, B.E. - Electrical and Electronics Engineering

Semester End Examination; June/July - 2015

Field Theory

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each **Unit**.*

UNIT - I

1. a. Define the following with basic expression and their unit:
   i) Electric field intensity ii) Absolute potential
   iii) Electric flux density iv) Capacitance. 7

   b. Derive an expression for electric field intensity due to infinite sheet charge using Coulomb's Law as basis. 7

   c. Two uniform charge distributions are as follows: A sheet of uniform charge density ρ_s = - 50 nC/m^2 at y = 2 m and a uniform line of ρ_l = 0.2 μC/m at Z = 2 m, y = -1 m. Find $\bar{E}$ at P (0, 0, 0). 6

2 a. State and explain Gauss's Law. Show that $Q = \oint_s \bar{D}.d\bar{s}$ for an arbitrary closed surface. 7

   b. Derive expression for electric field intensity everywhere due to uniform volume charge density using Gauss's law. 7

   c. A cylindrical volume $0 \le z \le 4\,m$ & $0 \le \rho \le 2\,m$, encloses certain charge. If $\bar{E} = \frac{Z\rho}{\epsilon_0}\hat{a}_z\ V/m$, determine the total charge enclosed by the cylinder. 6

UNIT - II

3 a. Show that energy expended in moving a point charge in an uniform electric field is independent of path and thus, prove that electric field as a negative gradient of potential. 10

   b. Calculate the work done in moving a 2 C charge from A (1, 0, 0) to B (0, 2, 0) along the path $y = 2 - 2x$; $z = 0$ in the field $\bar{E} = 5x\hat{a}_x + 5y\hat{a}_y\ V/m$. 4

   c. Given the potential $V = \frac{10}{r^2}\sin\theta\cos\phi$. Find the electric flux density $\bar{D}$ at $\left(2, \frac{\pi}{2}, 0\right)$ 6

4 a. Discuss the properties of conductor, when it is subjected to electric field. 6

   b. Define current density and obtain the expressions for convection and conduction current densities. 8

   c. In certain region $\bar{J} = 3r^2\cos\theta\hat{a}_r - r^2\sin\hat{a}_\theta A/m$ find the current crossing surface defined by $\theta = 30^o,\ 0 < \phi < 2\pi,\ 0 < r < 2\,m$ 6

Contd…2

UNIT- III

5 a. Derive the boundary conditions between the two perfect dielectric media. 8

b. Derive the expression for the capacitance of coaxial cable with inner radius 'a' and outer radius 'b'. 6

c. A parallel plate capacitor has plate area 200 cm^2 and plate separation 3 mm. The charge density is 1 $\mu C/m^2$ with air as dielectric. Find; i) Capacitance of the capacitor, ii) Voltage between the plates, and iii) Force with which the plates attract each other. 6

6 a. Two extensive homogenous isotropic dielectrics meet on the z = 0. For $z \geq 0$, $\in_{r1} = 5$ and $z \leq 0$, $\in_{r2} = 3$. An uniform electric field $\bar{E}_1 = 2\hat{a}_x + 2\hat{a}_y - 4\hat{a}_z$ kV/m exists for $z \geq 0$. Find; 8

i) $\bar{E}_2$ for $z \leq 0$ ii) the angles of E_1 and E_2 make with interface.

b. The potential distribution in the free space $V = 4x^2 - Ay^2 + 8$ satisfies Laplace's equation. Find, 6

i) the value of A ii) for the value of A determined in part (i) above determine $\bar{E}$ at P(1, 2, 0).

c. State and prove uniqueness theorem. 6

UNIT - IV

7 a. State and explain Biot-Savart's Law. 6

b. Derive the expression for the magnetic field intensity $\bar{H}$ at an height 'h' along z-axis due to a circular loop of radius 'a' carrying current of I located in z = 0 plane. 8

c. Derive the expression for the magnetic field intensity $\bar{H}$ everywhere due to solenoid of length L using Ampere's circuit law. 6

8 a. A square conducting loop of side '2a' lies in the z = 0 plane and carries a current I in the counter clockwise direction. Find $\bar{H}$ at the centre of loop. 6

b. Given $\bar{H} = 10\rho^2\hat{a}_\phi$ in free space. Find $\bar{J}$. 6

c. What is the importance of vector magnetic potential $\bar{A}$? Show that vector magnetic potential obeys Poisson's equation. 8

UNIT - V

9 a. Obtain the expression for transformer emf and motional emf. 8

b. The magnetic circuit of uniform cross section of 10^{-3} m^2 and radius of toroid 10 cm is energized by a current $i_i(t) = 3Sin(100\pi t)$ A in the coil of N_1 = 200, find the emf induced in the coil of N_2 = 100. Assume the $\mu = 500\mu_0$. 6

c. Obtain the expression for force between differential current elements. 6

10 a. Derive the expression for force between two straight current carrying parallel conductors. 6

b. A straight infinitely long conductor carries current of 10 A is located along x-axis. Find the vector force on a current carrying segment 'ab' of length 50 cm located at (0, 2, 0) cm and carrying current of 2 mA. 8

c. Obtain the expression for self inductance of a solenoid. 6

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