



10EE44

Fourth Semester B.E. Degree Examination, Dec.2019/Jan.2020  
**Field Theory**

Time: 3 hrs.

Max. Marks:100

Note: Answer FIVE full questions, selecting atleast TWO questions from each part.

**PART – A**

- 1 a. State and explain Coulomb's law in complete form. (05 Marks)  
b. It is required to hold four equal point charges each in equilibrium at the corners of a square. Determine the point charge which must be located at the centre of the square. (07 Marks)  
c. Evaluate both sides of divergence theorem for the volume enclosed by  $r = 2m$ ,  $z = 0$  and  $z = 10m$ . Given  $D = \frac{10r^3}{4} \text{ ar c/m}^2$ . (08 Marks)
- 2 a. With usual notations prove that  $E = -\nabla V$ . (06 Marks)  
b. Determine work-done in carrying a  $-2\mu\text{C}$  charge from  $P_1(2, 1, -1)$  to  $P_2(8, 2, -1)$  in a field  $E = y a_x + x a_y \text{ v/m}$  along the path i)  $x = 2y^2$  ii) joining  $P_1$  to  $P_2$ . (08 Marks)  
c. The potential field  $V = \frac{60 \sin \theta}{r^2}$  volts. Determine : i) electric flux density ii) volume charge density iii) electric potential at ( $r = 3m$ ,  $\theta = 60^\circ$ ,  $\phi = 25^\circ$ ). (06 Marks)
- 3 a. Derive Poisson's and Laplace equation. (06 Marks)  
b. A potential field  $V = x^2 y z + A y^3 z$  volts is required to satisfy Laplace equation. What should be value of 'A'? With this value of A determine : i) Potential ii) Electric field at  $(2, 1, -1)$ . (05 Marks)  
c. Derive an expression for capacitance of a spherical capacitor. (09 Marks)
- 4 a. Use Ampere Law to determine magnetic field intensity H at  $P(2, 3, 5)$  due to an infinitely long conductor placed at  $x = 0$ ,  $y = 0$  and carrying a current of 50A along positive  $a_z$  direction. (06 Marks)  
b. Evaluate the closed line integral of 'H' from  $P_1(5, 4, 1)$  to  $P_2(5, 6, 1)$  to  $P_3(0, 6, 1)$  to  $P_4(0, 4, 1)$  to  $P_1(5, 4, 1)$  using straight line segments,  $H = 0.1y^3 a_x + 0.4x a_y$ . Also determine :  
i) Quotient of closed line integral of 'H' to area enclosed by the path  
ii)  $\nabla \times H$  at the centre of path. (09 Marks)  
c. Compare scalar magnetic potential with sector magnetic potential. (05 Marks)

**PART – B**

- 5 a. Derive an expression for force between two infinitely long straight parallel conduction separated by distance of 'd' m between them. Assume that they are placed in air. (06 Marks)  
b. A current element  $10^{-4} a_z \text{ Am}$  is located at  $(2, 0, 0)$  and another current element  $10^{-6} (a_x - 2a_y + 3a_z) \text{ Am}$  is located at  $(-2, 0, 0)$  both in free space. Find force exerted on second element by the first element. (06 Marks)  
c. Determine inductance of a solenoid with 200 turns wound highly on a cylindrical core of length 60cm and diameter 6cm. derive the expression used. (08 Marks)

- 6 a. Starting from Faraday's law of electromagnetic induction derive the equation  $\nabla \times \mathbf{E} = \frac{-\partial \mathbf{B}}{\partial t}$ .  
(06 Marks)
- b. List Maxwell's equations for both steady and time varying fields in point form and integral form. Mention laws that each equation demonstrates.  
(08 Marks)
- c. Determine frequency at which conduction current density 'J' and displacement density are equal. Given conductivity  $\sigma = 2 \times 10^{-4}$  s/m and  $\epsilon_r = 81$ .  
(06 Marks)
- 7 a. For electromagnetic wave propagating in free space prove that  $\frac{|\bar{\mathbf{E}}|}{|\mathbf{H}|} = \eta$ .  
(08 Marks)
- b. A 50 GHz plane wave travelling in the medium has an amplitude  $E_0 = 20$  V/m. Determine :  
i) Phase velocity ii) Wavelength iii) Impedance. Given  $\epsilon_r = 2$  and  $\mu_r = 5$ .  
(06 Marks)
- c. State and prove pointing theorem.  
(06 Marks)
- 8 a. Define the terms : i) Reflection co-efficient and  
ii) Transmission coefficient.  
Also bring out the relation between.  
(08 Marks)
- b. Write a short note on SWR.  
(05 Marks)
- c. In free space ( $z \leq 0$ ), a plane wave with  $\mathbf{H} = 10 \cos(10^8 t - \beta z) \mathbf{a}_x$  mA/m is incident normally on a lossless medium ( $\epsilon = 2\epsilon_0$ ,  $\mu = 8\mu_0$ ) in region  $z \geq 0$ . Determine reflected wave  $H_r$ ,  $E_r$  and transmitted wave  $H_T$ ,  $E_T$ .  
(07 Marks)

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