FIELD THEORY
(ELEC 2103)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Vector magnetic potential is define as
(a) $\bar{B} = \nabla \times \bar{A}$ (b) $\bar{B} = \nabla . \bar{A}$ (c) $\nabla \times \bar{H} = \bar{J}$ (d) $\nabla \times \bar{A} = \bar{I}$.

(ii) The ε_0 for vacuum is given by
(a) $10^{-9}/36\pi$ (b) $10^{-19}/36\pi$ (c) 0 (d) 1.

(iii) Line integral of a magnetic field is
(a) depend upon the path taken (b) independent of the path
(c) constant (d) none of these.

(iv) The skin depth is given by
(a) $\delta = \sqrt{2/(\omega\mu\sigma)}$ (b) $\delta = \sqrt{\pi/(\omega\mu\sigma)}$
(c) $\delta = 2/\sqrt{(\omega\mu\sigma)}$ (d) $\delta = \pi/\sqrt{(\omega\mu\sigma)}$

(v) The direction of propagation of electromagnetic wave is given by
(a) E×H (b) E.H (c) E (d) H.

(vi) The electric potential within the hollow sphere carrying charge +Q is
(a) zero (b) constant (c) infinite (d) $Q/(4\pi\varepsilon 0R)$

(vii) For loss less line characteristic impedance is given by
(a) $\sqrt{\frac{C}{L}}$ (b) $\sqrt{\frac{L}{C}}$ (c) $2\pi\sqrt{\frac{C}{L}}$ (d) $2\pi\sqrt{\frac{L}{C}}$

(viii) For a loss-less transmission line
(a) $\frac{R}{C} = \frac{G}{L}$ (b) $R^2C = LG$ (c) R = 0 = G (d) $\frac{R}{L} = \frac{G}{C}$

(ix) A line of length l has characteristic impedance Z_0. The line is cut into half. The value of characteristic impedance becomes
(a) $Z_0/2$ (b) $Z_0/4$ (c) $2Z_0$ (d) Z_0

(x) The curl of a rotational vector function is
(a) zero (b) non zero
(c) can not determine (d) none of these.

Group – B

2. (a) Explain the physical significance of the term:
(i) Divergence of a vector field.
(ii) Curl of a vector field.

(b) Express the point P(1,-4,-3) in cylindrical and spherical coordinate.

(c) Determine the divergence of $\vec{A} = yz\hat{a}_x + xy\hat{a}_y + z\hat{a}_z$.

(3 + 3) + (2 + 2) + 2 = 12

3. (a) Given vector $\vec{A} = 2\hat{a}_\rho + 3\hat{a}_\phi + 4\hat{a}_z$, convert A into Cartesian coordinates at point (2,4,-1).

(b) Prove Divergence Theorem for the vector field
$\vec{A} = yz\hat{a}_x + xz\hat{a}_y + (xy)\,\hat{a}_z$
for a rectangular region defined by $0 \le x \le 3, 0 \le y \le 2, 0 \le z \le 5$.

6 + 6 = 12

Group – C

4. (a) Deduce the boundary condition on electric vector 'E' for dielectric-dielectric interface.

(b) A sphere of radius 'R' with a uniform charge density ρ C/m^3. Determine the electric flux density vector 'D' everywhere.

(c) Given $V = xy(2 + z)$, find 'E' at (3, 4, -6).

6 + 4 + 2 = 12

5. (a) Determine the expression of magnetic field intensity produced by a conductor carrying current 'I' at a distance 'R' from the conductor.

(b) A current of 15 A flows in each of two conducting wires parallel to each other in free space. The separation between the wires is 3 cm. Find the force per unit length on one of the wires.

(c) What is the physical significance of $\nabla.B = 0$.

4 + 4 + 4 = 12

Group – D

6. (a) State and proof the Poynting theorem.

   (b) In a nonmagnetic medium E = 4 $\cos(2\pi \times 10^6 t - x)\ \hat{a}_z$ V/m. Find intrinsic impedance (η), permittivity (ε_r) and the time average power carried by the wave.

6 + 6 = 12

7. (a) What is skin effect and skin depth?

   (b) Find the conduction and displacement current density in a material having conductivity of 10^{-3} S/m and $\varepsilon_r = 4$ if the electric field in the material is $E = 5.0 \times 10^{-6} \sin(7.0 \times 10^9)t$ V/m.

   (c) Write the Maxwell equations in differential and integral form.

4 + 4 + 4 = 12

Group – E

8. (a) What do you mean by distortionless line of a transmission line?

   (b) A telephone line has R = 15 Ω/km, L = 250 mH/km, G = 0, and C = 30 μF/km at f = 1.5 kHz, find characteristic impedance and propagation constant of the line.

   (c) What is propagation constant?

4 + 4 + 4 = 12

9. (a) Derive the general wave equation of transmission line.

   (b) For loss less two wire transmission line, show that phase velocity u = $\frac{1}{\sqrt{LC}}$

   (c) A transmission line with a characteristic impedance of 400 ohms is terminated with a purely resistive load. While making SVR measurement then maximum and minimum voltage is 8 μV and 5 μV. What should be the load resistance?

6 + 4 + 2 = 12