B.TECH/EE/3RD SEM/ELEC 2103/2016

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) $\overline{B} = \nabla x \overline{A}$ (b) $\overline{B} = \nabla . \overline{A}$
(c) $\nabla x \overline{H} = \overline{J}$ (d) None of above.

(ii) Line integral of a magnetic field
(a) depends upon the path taken (b) independent of the path
(c) constant (d) none of above.

(iii) Two parallel wires carry current along opposite directions. The resultant force experienced by two wire is
(a) zero (b) attractive
(c) repulsive (d) none of above.

(iv) 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) $2\pi\sqrt{\frac{L}{C}}$.

(v) The depth of penetration of a wave in lossy dielectric increases with increase in
(a) permeability (b) conductivity
(c) wavelength (d) permittivity

(vi) Point form of Ohm's Law is
(a) $\vec{J} = \sigma\vec{E}$ (b) $\sigma\vec{J} = \vec{E}$ (c) $\vec{J} = \vec{E}/\sigma$ (d) $\sigma = \vec{E}/\vec{J}$

(vii) Laplacian of a scalar is
(a) ∇V (b) $\nabla \times V$ (c) $\nabla^2 V$ (d) $\nabla \times \nabla \times V$.

(viii) The direction of propagation of electromagnetic wave is obtained from
(a) $\vec{E}.\vec{H}$ (b) $\vec{E} \times \vec{H}$ (c) $\vec{E} - \vec{H}$ (d) $\vec{E} / \vec{H}$.

(ix) Field $\vec{A}$ is solenoidal if
(a) $\nabla . \vec{A} = 0$ (b) $\nabla \times \vec{A} = 0$
(c) $\nabla . \vec{A} \neq 0$ (d) $\nabla \times \vec{A} \neq 0$.

(x) Laplace's equation is
(a) $\nabla^2 V = 0$ (b) $\nabla V = 0$ (c) $\nabla . \vec{V} = 0$ (d) $\nabla \times \vec{V} = 0$.

Group – B

2. (a) Express the vector from C (3, 2, -7) to D (-1, -4, 2) in cylindrical coordinates.

(b) Transform a cartesian vector $\overline{A} = 10\,\hat{a}_x - 8\,\hat{a}_y + 6\,\hat{a}_z$ to spherical coordinates at point
P (10, -8, 6)

6 + 6 = 12

3. (a) What is physical significance of divergence? State and explain divergence theorem.

(b) Given a vector function $\vec{A} = (x + C_1 z)\hat{a}_x + (C_2 x - 3z)\hat{a}_y + (x + C_3 y + C_4 z)\,\hat{a}_z$ then (i) Calculate the value of the constants C_1, C_2, and C_3 if $\vec{A}$ is irrotational. (ii) Calculate the value of constant C_4 if $\vec{A}$ is also solenoidal.

(2 + 6) + 4 = 12

Group – C

4. (a) If $\vec{D} = 2x\hat{a}_x + 10\hat{a}_y$ C / m^2, find the total charge enclosed by the cube centered at origin. The cube is defined by $-2 \leq x \leq 2$, $-2 \leq y \leq 2$, $-2 \leq z \leq 2$.

(b) Derive the relation $\vec{E} = -\nabla V$ **.** The symbols have usual meaning**.**

(c) Deduce boundary conditions of electric field for dielectric-dielectric boundary.

4 + 3 + 5 = 12

5. (a) Derive the energy density in an electrostatic field.

   (b) Show that the electric field is conservative.

   (c) Region $y \leq 0$ consists of a perfect conductor while $y > 0$ is a dielectric medium ($\mathcal{E}_r$=2). If there is a surface charge of 2 nC/m^2 on the conductor, determine $\vec{E}$ and $\vec{D}$ at (i) A (3, −5, 4) and (ii) B (−5, 1, 5).

6 + 3 + 3 = 12

Group – D

6. (a) Write the Maxwell's equations. Explain the physical significance of each equation.

   (b) A lossy dielectric has μ_r= 2 and ε_r =1.2, σ= 2.5x 10^{-8} S/m and $\overline{E}$ = 150 sin ωt $\hat{a}_z$ V/m. Find at what frequency the conduction and displacement current densities be equal.

   (c) Inside a typical metallic conductor where frequency f=1kHz, conductivity σ=2*10^8 ℧/m, ε_r =1.2 and conduction current density $\overline{J}_c$=10^{5}sin (6000t-200z) $\hat{a}_x$ A/m^2. Find the amplitude of displacement current density.

4 + 4 + 4 = 12

7. (a) State and proof 'Poynting's Theorem'.

   (b) An electric field is represented by $\overrightarrow{E_y} = 10\cos(6\pi 10^8 t - \beta x)\hat{a}_y$ is propagating through a lossless medium having $\mu_r = 1$ and $\mathcal{E}_r = 78$ at a frequency of 300 MHz. Find out the corresponding magnetic field $\vec{H}$.

   (c) Clarify 'skin depth' and 'skin effect'.

5 + 4 + 3 = 12

Group – E

8. (a) Develop the expression for input impedance (Z_{in}) of transmission line when the line is terminated by a load resistance Z_L. Then derive the value of Z_{in} for shorted line and open circuited line.

   (b) A telephone line has R=30Ω/km, L=100mH/km, G=0 and C=20μF/km. at f=1kHz, calculate (i) the characteristic impedance of line and (ii) propagation constant.

(6 + 3) + 3 = 12

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

   (b) Define the reflection coefficient and derive the expression for input impedance in terms of reflection coefficient.

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

4 + 4 + 4 = 12