B.TECH / EE /3RD SEM/ ELEC 2103/2017
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) Unit vector $\hat{a}_\theta$ is _____ to the plane $\theta = \theta_1$
(a) normal (b) parallel (c) above (d) tangent.

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

(iii) Two parallel wires carry current along same directions. The resultant force experienced by two wire is
(a) zero (b) attractive
(c) repulsive (d) can not be determined.

(iv) For a lossless line propagation constant (γ) is given by
(a) $j\omega\sqrt{LC}$ (b) $j\omega\sqrt{\frac{L}{C}}$ (c) $j\omega\sqrt{C}$ (d) $j\omega\sqrt{L}$.

(v) The divergence of $\vec{A} = yz\hat{a}_x + 7xy\hat{a}_y + y\hat{a}_z$ at (2,-2,3) is
(a) 7 (b) 3 (c) 14 (d) 21.

(vi) Which one of the following is called as 'continuity equation'?
(a) $\nabla . \vec{J} = \rho_v$ (b) $\nabla . \vec{J} = -\frac{\partial \rho_v}{\partial t}$
(c) $\rho_v = \nabla . \vec{D}$ (d) $\rho_v = -\nabla . \vec{D}$.

(vii) Point form of Gauss's Law is
(a) $\vec{J} = \sigma \vec{E}$ (b) $\nabla . \vec{J} = \rho_v$
(c) $\vec{J} = \vec{E}/\sigma$ (d) $\rho_v = \nabla . \vec{D}$.

(viii) 'Intrinsic Impedance' of free space is
(a) 377 Ω (b) 120 Ω (c) 50 Ω (d) 720 Ω.

(ix) Skin depth is denoted by
(a) $1/\sqrt{\pi f \mu \sigma}$ (b) $\sqrt{\pi f \mu \sigma}$ (c) $1/\beta$ (d) α/β.

(x) The ratio of the positively travelling voltage wave to the current wave at any point on the line is known as:
(a) Input impedance (b) Characteristic impedance
(c) Standing wave ratio (d) Voltage reflection coefficient.

Group - B

2. (a) Transfer the vector $\vec{A} = 5\hat{a}_x + 4\hat{a}_y - 6\,\hat{a}_z$ to spherical coordinate at a point p(x = –3, y = –4, z = 8).

(b) By using the differential length, calculate the length of the curves described by the edges of the surface r=12, $\pi/6 \le \theta \le \pi/2$, $\pi/4 \le \Phi \le \pi/2$.

8 + 4 = 12

3. (a) Explain the classification of vector fields characterised by its divergence and curl.

(b) Prove Divergence Theorem for the vector field :
$\vec{A} = (x^2 - y^2z^2)\hat{a}_x + (y^2 - x^2z^2)\hat{a}_y + (z^2 - y^2x^2)\,\hat{a}_z$
for a rectangular region defined by $0 \le x \le 2$, $0 \le y \le 3$, $0 \le z \le 4$.

6 + 6 = 12

Group - D

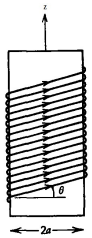
4. (a) Derive the electric flux density $\vec{D}$ with the help of Gauss's Law at any point due to infinite line charge distribution.

(b) Explain why a perfect conductor cannot contain electrostatic field within it?

(c) A homogeneous dielectric ($\varepsilon_r = 2.5$) fills region 1($x \le 0$) while region 2 ($x \ge 0$) is free space. (i) If $\overrightarrow{D_1} = 12\hat{a}_x - 10\hat{a}_y + 4\,\hat{a}_z$ nC/m² find $\overrightarrow{D_2}$. (ii) If E_2 = 12V/m and $\theta_2 = 60°$, find E_1 and θ_1. (Take $\theta_1$and θ_2 as the angles made by E_1 and E_2 respectively with the normal to the interface.)

3 + 3 + 6 = 12

5. (a) Closely spaced wires are wound about an infinitely long cylindrical core of diameter 2a at pitch angle θ. A current flowing in the wires approximated as surface current K as shown in figure 1. What is the magnetic field everywhere?



$K = K_0(\sin\theta\, \hat{a}_z + \cos\Phi\, \hat{a}_\Phi)$

figure 1

(b) Find the magnetic field at the point P for an n-sided regular equilateral polygon carrying current 'I' as shown in figure 2.

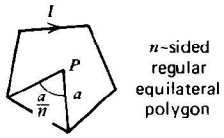


figure 2

(c) How is the path of the integration of $\oint \bar{B} \cdot \bar{dl}$ chosen when applying Ampere's law?

6 + 4 + 2 = 12

Group – D

6. (a) The magnetic flux density is given in cylindrical coordinates by

$$B = \begin{cases} B_0 sin\omega t \hat{a}_z & \text{for } r < a \\ 0 & \text{for } r > a \end{cases}$$

Where B_0 and ω are constants. Calculate the induced electric field for all the values of r.

(b) Explain the significance of displacement current.

(c) "A rectangular closed loop moves across a uniform magnetic field but the induced current is zero", -Justify.

6+ 4 + 2 = 12

7. (a) Derive the vector wave equations for a lossy dielectric medium.

(b) Find the skin depth δ at a frequency 1.6 MHz in aluminium, where σ = 38.2 Ms/m and μ_r=1. Also find the propagation constant and wave velocity.

(c) Define reflection coefficient, transmission coefficient and standing wave.

5 + 3 + (1 + 1 + 2)= 12

Group – E

8. (a) An air line has characteristic impedance of 70Ω and a phase constant of 4 rad/m at 150 MHz. Calculate the capacitance and inductance of the line per meter.

(b) Derive the expression of phase velocity for loss less two wire transmission lines.

(c) What do you mean by distortion less line in transmission line?

4 + 4 + 4 = 12

9. (a) In a lossless transmission line, the velocity of propagation is 2×10^8 m/s. Capacitance of the line is 30pF/m at a frequency of 1MHz. Find

(i) inductance of the line
(ii) phase constant of the line
(iii) characteristic impedance of the line

(b) At 1200Hz the characteristic impedance (Z_0) and propagation constant (γ) for an open wire transmission line are $Z_0 = 600 - j100$, $\gamma = 0.003 + j0.006$. Calculate the distributed parameter of the line.

(c) A transmission line with a characteristic impedance of 300 ohms is terminated with a purely resistive load. While making SVR measurement then maximum and minimum voltage is 7.5μV and 5μV. What should be the load resistance?

3 + 7 + 2 = 12