Roll No.:.....

National Institute of Technology, Delhi

Name of the Examination: B.Tech.

Branch	**: EEE**	**Semester**	**: 3rd**
Title of the Course	**: Electromagnetic Field Theory**	**Course Code**	**: EEL 203**

Time: 3 Hours **Maximum Marks: 50**

Note : **1.** This question paper has 3 sections. Section A consists of 10 parts of 1 mark each. Section B contains 5 questions of 5 marks each. Section C consists of 3 questions of 10 marks each.

2. All the symbols have their usual meaning. Make suitable assumptions wherever required.

Section A (All questions in this section are compulsory)

Q1. (i) Given the field $\vec{E} = 2x\hat{a}_x + \hat{a}_y + yz\hat{a}_z$ and $\vec{F} = xy\hat{a}_x - y^2\hat{a}_y + xyz\hat{a}_z$. Find a vector perpendicular to both $\vec{E}$ and $\vec{F}$ at (0, 1, -3) whose magnitude is unity.

(ii) How is the ratio of the magnitude of conduction current density to that of the displacement current density related to the loss tangent for the wave propagation in lossy medium?

(iii) Write the Poisson's equation for a nonhomogeneous medium.

(iv) Write the condition for a transmission line to be distortionless in terms of R, L, G and C.

(v) Determine the Laplacian of the scalar field $U = x^2y + xyz$.

(vi) For an electric dipole centered at $\vec{r_1}$ with dipole moment $\vec{p}$, the potential at $\vec{r}$ is given by _____.

(vii) What is an equipotential surface?

(viii) Given that $\vec{E} = xy\hat{a}_x + x^2\hat{a}_y$, find the electric flux density $\vec{D}$.

(ix) Write the continuity of current equation.

(x) The net magnetic flux through a closed surface is zero. True or False? Give reason in support of your answer.

Section B

(Answer any four (04) questions in this section)

Q2. An $\vec{H}$ field travels in the $-\hat{a}_z$ direction in free space with a phaseshift constant of 30 rad/m and an amplitude of $\frac{1}{3\pi}$ A/m. If the field has the direction $-\hat{a}_y$ when $t = 0, z = 0$, write the expressions for $\vec{E}$ and $\vec{H}$. Also, determine the frequency and wavelength.

Q3. Given that $\vec{J} = 4.5e^{-2r}\hat{a}_z$ A/m^2 in the region $0 < r < 0.5\ m$ and $\vec{J} = 0$ elsewhere. Use Ampere's law to find $\vec{H}$.

Q4. Region 1, described by $3x + 4y \geq 10$, is free space whereas region 2, described by $3x + 4y \leq 10$ is a magnetic material for which $\mu = 10\mu_0$. Assuming that the boundary between the material and free space is current free, find $\overrightarrow{B_2}$ if $\overrightarrow{B_1} = 0.1\hat{a}_x + 0.4\hat{a}_y + 0.2\hat{a}_z$ Wb/m^2.

Q5. Given that the plane $z = 0$ carries uniform current $\vec{K} = K_y\hat{a}_y$. Obtain $\vec{H}$ at points $(0, 0, h)$ and $(0, 0, -h)$ by using Biot-Savart's law.

Section C

(Answer any two (02) questions in this section)

Q7. The region between $x = 0$ and $x = d$ is free space and has the volume charge density $\rho_v = \frac{\rho_0(x-d)}{d}$. If $V(x = 0) = 0$ and $V(x = d) = V_0$, find **(a)** V and $\vec{E}$ **(b)** the surface charge densities at $x = 0$ and $x = d$.

Q8. A lossy material has $\mu = 5\mu_0$, $\varepsilon = 5\varepsilon_0$. If at 5 MHz, the phase constant is 10 rad/m, calculate:

a) the loss tangent **b)** the conductivity of the material **c)** the complex permittivity

d) the attenuation constant **e)** the intrinsic impedance

Q9. **(a)** State Ampere's circuit law.

(b) A hollow conducting cylinder has inner radius a and outer radius b and carries current I along the positive z-direction. Determine $\vec{H}$ everywhere.

Section B

Q6. A circular disc of radius a carries charge $\rho_s = \frac{1}{\rho}$ C/m^2. Calculate the potential at $(0, 0, h)$.