Roll No.:.....

National Institute of Technology, Delhi

Name of the Examination: B.Tech.

End Semester Examination (Autumn, 2019)

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

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

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

Section A

(All questions in this section are compulsory. Each question carry 1 mark.)

Q1. i) When is a vector field conservative?

ii) How is the current density $\vec{J}$ related to the volume charge density ρ_v?

iii) A current I flows in the inner conductor of a long coaxial cable and returns through the outer conductor. What is the magnetic field in the region outside the coaxial cable?

iv) The loss tangent is very small for a good dielectric. True/False?

v) In a good conductor, $\vec{E}$ and $\vec{H}$ are in time phase. True/False?

vi) State the Poynting's theorem.

vii) For a distortionless line, the condition $\frac{R}{C} = \frac{G}{L}$ holds. True/False?

viii) The electric flux density on a spherical surface $r = R$ is the same for a point charge Q located at the origin and for charge Q uniformly distributed on surface $r = a$ $(a < R)$. True/False?

ix) Write the continuity of current equation.

x) Just outside a conductor, $\vec{E}$ is tangential to the surface. True/False?

Section B

(Answer any four (04) questions in this section. Each question carry 5 marks.)

Q2. For the vector field $\vec{A} = \left(\frac{\cos\varphi}{r}\right)\hat{z}$, verify Stokes's theorem for a segment of a cylindrical surface defined by $r = 2$, $\frac{\pi}{3} \leq \varphi \leq \frac{\pi}{2}$, and $0 \leq z \leq 3$.

Q3. Consider an electric dipole residing in free space with d as the distance between the two charges. Determine V and $\vec{E}$ at a point P which is at a distance $R \gg d$ from the dipole centre.

Q4. Charge $q_1 = 6\ \mu C$ is located at (1, 1, 0) and charge q_2 is located at (0, 0, 4). What should q_2 be so that $\vec{E}$ at (0, 2, 0) has no y-component?

Q5. Explain how the tangential and normal components of $\vec{E}$ changes across the dielectric-dielectric boundary.

Q6 Suppose the potential is given by $V = 5x^3y^2z$. Find $\vec{E}$ and ρ_v at the point $(-3, 1, 2)$.

Section C

(Answer any two (02) questions in this section. Each question carry 10 marks.)

Q7. **a)** State the Biot-Savart's law. **(3M)**

b) In a cylindrical coordinate system, a $2m$ long straight wire carrying a current of 5 A in the positive z-direction is located at $r = 4\ cm$, $\varphi = \frac{\pi}{2}$, and $-1\ m \leq z \leq 1\ m$.

i) If $\vec{B} = 0.2\ \cos\varphi\ \hat{r}$ tesla, what is the magnetic force acting on the wire?

ii) How much work is required to rotate the wire once about the z −axis in the negative φ direction (while maintaining $r = 4\ cm$) ?

iii) At what angle φ is the force maximum? **(2+3+2 = 7M)**

Q8. Explain the following: **(4 ×2.5 = 10 M)**

a) Skin effect

b) Displacement current

c) Helmholtz's equations

d) Faraday's law

Q9. The magnetic field in a dielectric material with $\varepsilon = 4\varepsilon_0$, $\mu = \mu_0$ and $\sigma = 0$ is given by

$$\vec{H}(y,t) = 5\cos(2\pi \times 10^7 t + \beta y)\,\hat{x} \quad (A/m)$$

Find β and the associated electric field $\vec{E}$.