

ELECTRICITY AND MAGNETISM - I

Semester - I

Time Allowed : 3 Hours]

[Maximum Marks : 30

Note : Attempt *two* questions each from Section A and B carrying 5 marks each, and *five* questions from Section C consisting of 7 short answer type questions carrying 2 marks each.

Section - A

1. Derive an expression for divergence of a vector function in cartesian coordinates. Give its physical significance. 5
2. (a) What is a conservative field ? Show that electric field is conservative and $\text{curl } \vec{E} = 0$. 4
(b) Show that the vector field $\vec{A} = x^2\hat{i} + y^2\hat{j} + z^2\hat{k}$ is the irrotational field. 1
3. Derive an expression for electric field due to dipole from the expression for the potential. 5
4. Derive an expression for potential at a point due to a charge distribution. On the basis of results derived, explain the terms Monopole moment, Dipole moment and Quadrupole moment. 5

Section - B

5. (a) What is the vector form of Ohm's law ? Starting from the vector form of Ohm's law $\vec{J} = \sigma \vec{E}$, derive the conventional form of Ohm's law $V = IR$. 4
(b) Give the *two* limitations of Ohm's law. 1
6. Derive an expression for electric potential due to a point charge placed near an infinitely conducting sheet. 5
7. Show that the transformation laws for electric field from one inertial frame to another are given by
 $E_{\parallel}^I = E_{\parallel}$
 $E_{\perp}^I = E_{\perp}'$
where the symbols have their usual meaning. 5
8. (a) Derive and discuss the equation of continuity $\vec{\nabla} \cdot \vec{J} + \frac{\partial \rho}{\partial t} = 0$. 3½
(b) A current of 1 Amp. flows through a conductor of cross-section 1 mm². If the density of the charge carriers be 10²³ cm⁻³, calculate the drift velocity of electrons. Charge on electron is 1.6 × 10⁻¹⁹ C. 1½

Section - C

9. Attempt any *five* in short :
 - (a) Explain the term Electrical image.
 - (b) Give the significance of $\vec{E} = -\vec{\nabla} \cdot V$.
 - (c) What do you understand by a solenoidal vector field ?
 - (d) Establish the relation between Volt and Stat-volt.
 - (e) Calculate the energy gained by a α -particle when it is accelerated through a potential difference of 100 V.
 - (f) Define Ampere.
 - (g) Give Poisson and Laplace's equations. Explain their physical significance. (5×2=10)