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63 (FY)SEM-3/MAJ/PHYMAJ2014

2025

PHYSICS

Paper : PHYMAJ2014

(Electricity and Magnetism)

Full Marks : 50

Pass Marks : 20

Time : Two hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions **(all compulsory)** : 1×5=5

(a) The dielectric constant (ϵ_r) is related to susceptibility by

(i) $\epsilon_r = \chi_e$

(ii) $\epsilon_r = 1 + \chi_e$

(iii) $\epsilon_r = \chi_e - 1$

(iv) $\epsilon_r = \mu_0 \chi_e$

- (b) The magnetic dipole moment of a current-carrying loop is defined as
- (i) Current multiplied by the resistance of the loop
 - (ii) Product of current and the area vector of the loop
 - (iii) Magnetic field at the center of the loop
 - (iv) Torque on the loop in a magnetic field
- (c) The direction of an electric field line at a point gives
- (i) The direction of magnetic force
 - (ii) The direction of motion of a negative charge
 - (iii) The direction of electric force on a positive charge
 - (iv) The direction of potential gradient
- (d) In a region where charge density $\rho = 0$, the electrostatic potential satisfies
- (i) Poisson's equation
 - (ii) Laplace's equation
 - (iii) Maxwell's equation
 - (iv) Gauss's divergence law

- (e) The condition for resonance in a series LCR circuit is
- (i) $R = L = C$
 - (ii) $X_L = X_C$
 - (iii) $X_L > X_C$
 - (iv) $X_L < X_C$

2. Answer the following questions : **(any five)**
2×5=10

- (a) What is ionic and orientational polarization ?
- (b) State Ampere's circuital law and express its differential form.
- (c) Define magnetization vector and magnetic intensity.
- (d) Show that the curl of an electrostatic field is zero.
- (e) Explain why the electric field is zero inside a conductor in electrostatic equilibrium.
- (f) Define displacement current and write its mathematical expression.

(g) State the mutual inductions and mathematical expression of mutual inductances in a conducting wire of length L .

3. Answer the following questions : **(any five)**

5×5=25

(a) Derive the expression for the electronic polarizability of an atom under a uniform electric field.

(b) Define electric displacement vector and establish the relation between \vec{E} , \vec{P} and \vec{D} .

(c) Establish Gauss's law for an electric field in the presence of a dielectric medium.

(d) Obtain the magnetic field at a point at distance ' r ' from an infinitely long straight wire carrying current i .

(e) Show that the divergence of the magnetic field is zero ($\vec{\nabla} \cdot \vec{B} = 0$). Discuss its physical meaning.

(f) Explain why Gauss's Law is particularly useful for charge distributions with spherical or planar symmetry. Illustrate with an example.

(g) Derive an expression for the electric field due to a uniformly charged spherical shell at a point :

(i) outside the shell and

(ii) inside the shell.

(h) Derive the expression for displacement current and explain its physical significance.

4. Answer the following questions : **(any one)**

10×1=10

(a) (i) Explain the First Uniqueness Theorem in electrostatics and prove that the solution to Poisson's or Laplace's equation is unique when the boundary conditions are specified. 2+3=5

(ii) Define capacitance. Derive the capacitance of a parallel-plate capacitor with plate area A and separation d . 1+4=5

(b) Draw and explain the Series LCR circuit connected to an AC source. Derive the expression for the impedance of the circuit and obtain the condition for resonance. 3+5+2=10