2022

PHYSICS

Paper : CC–3

(Electricity and Magnetism)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×5=5

(a) Gauss's law in differential form is

(i) $\vec{\nabla}\times\vec{E}=\frac{\rho}{\varepsilon_0}$

(ii) $\vec{\nabla}\times\vec{E}=0$

(iii) $\vec{\nabla}\cdot\vec{E}=\frac{\rho}{\varepsilon_0}$

(iv) $\vec{E}=-\frac{\partial\vec{V}}{\partial\vec{r}}$

(b) The relation between electric field and electric potential is

(i) $\vec{E}=-\vec{\nabla}V$

(ii) $\vec{E}=\vec{\nabla}V$

(iii) $\vec{E}=-\nabla^2V$

(iv) $\vec{E}=\nabla^2V$

(c) The relation $\vec{D}=\varepsilon\vec{E}$ is true for

(i) homogeneous medium

(ii) isotropic medium

(iii) any medium

(iv) both isotropic and homogeneous media

(d) Curl of a magnetic field is

(i) 0

(ii) $\mu_0\vec{J}$

(iii) $-\mu_0\vec{J}$

(iv) $\vec{\nabla}\times\vec{A}$

(e) For a dipole, electric field varies as

(i) $\frac{1}{r}$

(ii) $\frac{1}{r^2}$

(iii) $\frac{1}{r^3}$

(iv) $\frac{1}{r^4}$

2. Answer the following questions : 2×5=10

(a) Write the difference between paramagnetic and diamagnetic substances.

(b) If the electric field is given by $\vec{E} = 8\hat{i} + 4\hat{j} - 3\hat{k}$, calculate the electric flux through the surface $\vec{S} = 50\hat{j}$.

(c) From differential form of Gauss's law, develop the Poisson's and Laplace's equations.

(d) Explain how a current loop can be considered as a magnetic dipole.

(e) Define current sensitivity and charge sensitivity of a ballistic galvanometer.

3. Answer the following questions (any *five*) : 5×5=25

(a) Derive an expression for force and torque acting on an electric dipole placed in a uniform electric field.

(b) State and prove maximum power transfer theorem.

(c) Applying Biot-Savart law, derive an expression for magnetic field at a point on the axis of a circular coil carrying current and hence find its value at the centre of the coil.

(d) Explain reciprocity theorem of mutual induction.

(e) Applying Ampere's circuital law, find the magnetic field due to a solenoid having n turns per unit length, carrying current I.

(f) The vector potential in a region is $\vec{A}(x, y, z) = -y\hat{i} + 2x\hat{j}$. Calculate the associated magnetic induction $\vec{B}$. Prove that $\vec{\nabla} \cdot \vec{B} = 0$.

(g) Derive an expression for electric field due to a uniformly distributed charged hollow sphere at a point *(i)* outside the sphere and *(ii)* inside the sphere using Gauss's law.

4. Answer the following questions (any *two*) : 10×2=20

(a) An alternating e.m.f. is applied to a circuit containing inductor L, capacitor C and resistor R in series. Derive an expression for *(i)* resonance frequency, *(ii)* bandwidth, *(iii)* quality factor of the series circuit and *(iv)* power dissipation in the circuit. 3+1+1+5=10

(b) Define coefficient of self-inductance and mutual inductance. Derive an expression for Faraday's law of electromagnetic induction in integral form. Calculate the energy stored in the magnetic field of a solenoid of inductance 30 mH when a current of 3 A flows through it. 2+5+3=10

(c) *(i)* Define the terms 'dielectric constant' and 'electric susceptibility'. Deduce the relation between dielectric constant and electric susceptibility. 2+3=5

(ii) Derive an expression for capacitance of a parallel-plate capacitor. 5

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