



বিদ্যাসাগর বিশ্ববিদ্যালয়
VIDYASAGAR UNIVERSITY
Question Paper

B.Sc. Honours Examinations 2021

(Under CBCS Pattern)

Semester - II

Subject : PHYSICS

Paper : C 3-T & P

Electricity and Magnetism

Full Marks : 60 (Theory - 40 + Practical - 20)

Time : 3 Hours

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

(Theory)

Group-A

Answer any *two* of the following questions :

2 × 15 = 30

- (a) In a region, the electric potential is expressed by
 $\phi(x, y, z) = 10(x^2 + y^2 + z^2)^{-1/2}$. Find the electric field at (2, 3, 4).

(b) Show that the vector $\vec{E} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$ represents electrostatic fields. Also find the corresponding electrostatic potential ϕ ; given $\phi = \phi_0$ at $x = y = z = 0$.

- (c) Consider a long cylinder with a charge density proportional to the distance from its axis. i.e. $\rho(r) = kr$, where k is a constant. Using Gauss's law find the electric field at any point inside the cylinder.
- (d) Write down Laplace's equation in electrostatics and show that the potential function $\phi = x^2 + y^2 - 2z^2$ satisfies the Laplace's equation.
- (e) An electric dipole is suspended in a uniform electric field, which is aligned parallel to the electric field. The dipole is slightly rotated about its center and released. Show that for small angular displacement, the motion is angular simple harmonic and find its time period. 3 + 3 + 3 + 3 + 3
2. (a) A parallel plate capacitor has plates of area 4 m^2 separated by a distance of 0.5 mm . The capacitor is connected across a battery of emf 100 Volts .
- (i) Find the capacitance, charge and energy stored in the capacitor.
- (ii) A dielectric slab of thickness 0.5 mm is inserted inside this capacitor after it has been disconnected from the cell. Find the answer to part (i) if $K = 3$.
- (b) A sphere of radius a carries a charge density $\rho(r) = kr$, where k is a constant. Show that total electrostatic energy of the system is $U = \frac{\pi k^2 a^7}{7 \epsilon_0}$.
- (c) A point charge q is placed in front of an infinite earthed conducting plane. By the method of electrical image find the surface density of induced charge on the conducting plane. 6 + 5 + 4
3. (a) Obtain the expression of $\text{curl } \vec{B}$ from the integral form of Ampere's circuital law.
- (b) From the definition of magnetic vector potential \vec{A} , show that, in free space $\nabla^2 \vec{A} = -\mu_0 \vec{J}$, where \vec{J} is the current density.
- (c) Find the dimension of \vec{A} ?
- (d) Consider an infinitely long solenoid of radius a , whose axis the Z axis. The solenoid has closely wound n turns per meter and carries a current i . From above the XY plane, the current appears anticlockwise. Obtain the expression of \vec{A} at a distance $\rho (< a)$ from the axis of the solenoid. 3 + 5 + 2 + 5

4. (a) Calculate the magnetic field at a position P(12 cm, 16 cm, 0 cm) due to a small, flat current carrying loop of area 1 cm² placed on the XY plane with centre at origin. The loop carries a current 1A which appears anticlockwise if viewed from above the XY plane. Consider the dimension of the loop to be small compared to the distance of P from it.
- (b) Define intensity of magnetisation \vec{M} in a material and give its dimension.
- (c) Name the types of magnetic materials in which \vec{M} depends linearly on the magnetic intensity.
- (d) Write down the expression of the magnetic field \vec{B} in a linear material in terms of magnetic susceptibility and magnetic intensity.
- (e) How is the permeability of a medium related with the magnetic susceptibility? 5 + 4 + 2 + 2 + 2

Group-B

Answer any *one* of the following questions : 1 × 10 = 10

5. (a) Show that the force experienced by the positive plate of a parallel plate capacitor when the voltage is kept constant is $\left(\frac{q^2}{2\epsilon_0 A}\right)$; where A is the plate area.
- (b) Define electric susceptibility and dielectric constant. How are they related?
- (c) A dielectric cube of side s, centered at the origin, carries a “frozen-in” polarization $P = kr$, where k is a constant. Find all the bound charges, and check that they add up to zero. 3 + 3 + 4
6. (a) Obtain Maxwell’s 3rd equation from Faraday’s law.
- (b) Obtain the dimension of inductance. On which factors do the self and mutual inductances depend?
- (c) A toroid has mean radius 10 cm and cross sectional radius 0.5 cm. It has 10 number of turns per cm closely wound on a nonmagnetic core ($\mu = \mu_0$). If it carries a current 10 mA, what will be the amount of energy stored in its core? 2 + 4 + 4

(Practical)

Answer any *one* question :

$1 \times 20 = 20$

1. Write down working theory, circuit diagram and procedure to determine an unknown low resistance using Carey Foster's bridge.
 2. Write down working theory, circuit diagram and procedure to determine (a) resonant frequency (b) Quality factor (c) Band width from response curve of a series LCR circuit.
 3. Write down working theory and procedure to study the characteristics of a series RC circuit.
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