UG/Sc./Core/Phy/TH/03/2022

BACHELOR OF SCIENCE EXAMINATION, 2022.

PHYSICS (Honours), 1st Year, 2nd Semester

Paper- Core-3 (Electricity and Magnetism)

Full Marks =40 Time = 2 hrs.

All parts of a question must be written in one place.

GROUP-A: Answer **ANY FOUR** questions(4×5=20 Marks).

1. (a) Using Green's first identity show that the general solution of the Poisson's equation takes the following form

$$\phi(\mathbf{x}) = \frac{1}{4\pi\epsilon_0}\int_V \frac{\rho(\mathbf{x}')d^3\mathbf{x}'}{|\mathbf{x}-\mathbf{x}'|} + \frac{1}{4\pi}\oint_S \left[\frac{1}{R}\frac{\partial\Phi}{\partial n'} - \Phi\frac{\partial}{\partial n'}(\frac{1}{R})\right] da'$$

where $R = |\mathbf{x}-\mathbf{x}'|$ and $\mathbf{x}'$ is a position vector of source point. Comment on the result. [5]

2. (a) A primitive model for an atom consists of a point nucleus $(+q)$ surrounded by a uniformly charged spherical cloud $(-q)$ of radius r. Calculate the atomic polarizability of such an atom.
(b) If a dipole $\vec{p_1}$ is fixed and second dipole $\vec{p_2}$ is free to rotate then find the equilibrium condition of two dipoles. [5]

3. A metal sphere of radius a carries a charge Q. It is surrounded, out to radius b, by linear dielectric material of permittivity ϵ. Find the potential at the center (relative to infinity). Also compute the polarization vector and the bound charge explicitly. [5]

4. Show that for an electrostatic field, the average potential over the sphere is equal to the net potential produced at the center. Discuss its consequences.
(b) A cubical box (sides of length a) consists of five metal plates, which are welded together and grounded. The top is made of a separate sheet of metal, insulated from the others, and held at a constant potential V. What should the potential at the center $(a/2, a/2, a/2)$ be? [5]

5. Two semi-infinite earthed conducting planes meet at right angles. In the region between them there is a point charge q, which is at a distance d from each plane. Set up the image charges. Hence calculate the force on q due to the planes. [5]

[Turn over

GROUP-B: Answer **ANY FOUR** questions(4×5=20 Marks).

1. State superposition theorem as applied to network analysis. Consider a two-port resistive T-network supplied with two ideal dc sources one at the input port and another at the output port. Using superposition theorem find the current through the resistor common to the input and output meshes in terms of the circuit parameters. [5]

2. Write down an expression for the magnetic field B near a long straight conductor carrying current I. Hence show by direct calculation that div B is zero. [5]

3. A battery of emf 10V and internal resistance 200 ohm is suddenly connected across the parallel combination of a resistor of 200 ohm and an inductor of L= 0.01 mH. Find the current through the inductor as a function of time. [5]

4. Suppose a square loop of side a is placed in the plane of a long straight wire carrying current I. The nearest side of the loop is at a distance d from the wire. Calculate the magnetic flux through the loop. If the loop is pulled directly away from the wire with a constant speed v what would be the emf generated in the loop? Will your answer be the same if the loop is pulled parallel to the wire with the same speed? [5]

5. What do you mean by hysteresis loss in a ferromagnetic substance? The core of a transformer is made of soft iron of total mass 10 kg and specific density 7.5. Calculate the hourly loss of energy when the transformer is used for operation in ac of frequency 50 Hz. Given that the area enclosed by the $B-H$ loop of soft iron is 250 $J.m^{-3}.cycle^{-1}$. [5]

6. What is a magnetic vector potential? Is it unique? Using the concept of magnetic vector potential establish Biot-Savart law. What is magnetic scalar potential? [5]