RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. THIRD SEMESTER EXAMINATION, MARCH 2022

SECOND YEAR [BATCH 2020-23]

Date : 05/03/2022

PHYSICS (HONOURS)

Time : 11 am – 1 pm

PAPER : VI [CC6]

Full Marks : 50

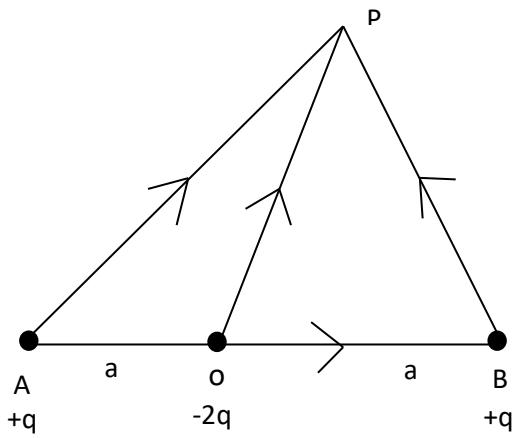
Answer **any five** questions of the following: [5×10]

1. a) Consider a point charge q is placed at the front of a conducting sphere of radius R at a distance d. Calculate the induced charge density on the surface of the sphere and show that the ratio of charge densities at two extreme ends $\left(\theta = 0^o \text{ and } \theta = 180^o\right)$ of the sphere is $\left(\frac{d+R}{d-R}\right)^3$. [4+1]

   b) Consider two dipoles one of which is held fixed. The distance between the coplanar dipole is r. If the fixed dipole makes 60^o angle and the other one makes angle θ with the line joining two dipoles at equilibrium condition, find the value of θ. [5]

2. a) Consider a grounded conducting sphere of radius R is placed in front of a point charge q. Calculate the potential and field at an external point P w.r.to the centre of the sphere. [5]

   b) Show that the potential at P due to charge distribution (shown in figure) is $V = \frac{qa^2}{8\pi \in 0 r^4} if\ r > a.$ [5]



3. a) Starting from the expression $\vec{B} = \frac{\mu_0 I}{4\pi}\int \frac{d\vec{l} \times \vec{r}}{r^3}$. Show that $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$ (symbols have their meaning). [5]

   b) Establish the boundary conditions satisfied by $\vec{H}$ at the interface of two media of different permeabilities. [5]

4. a) A thin disk of radius R carrying uniform surface charge density σ is rotating at constant angular velocity ω about its own axis. Find the magnetic field at an point on the axis. [5]

   b) Show that a non-uniform magnetisation $\vec{M}$ is equivalent to a bound current density $\vec{J} = \vec{\nabla} \times \vec{M}$ (symbols have usual meaning). [5]

5. a) Show that the potential of a polarized object can be expressed as the sum of potentials produced by volume charge density ρ_b and surface charge density σ_b. [4]

b) A small spherical cavity of radius α is cut in an infinite dielectric where there is an uniform field $\vec{E}$. If $\vec{P}$ be the uniform polarization in the dielectric them, find the electric field at the centre of the cavity. [6]

6. a) Show that the equivalent inductance of two coils of self-inductances L_1, L_2 and mutual inductances M connected in parallel is $L_{eq} = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 \pm 2M}$. Explain under what condition the positive and negative signs apply. [4]

b) The plane z = 0 separated by medium 1 of permeability $\mu_0 (z \le 0)$ from medium 2 of permeability $200\mu_0 (z \ge 0)$. Given that $\vec{H}_1 = 10\hat{x} + 15\hat{y} + 3\hat{z} A/m$. Find B_2, angle it makes

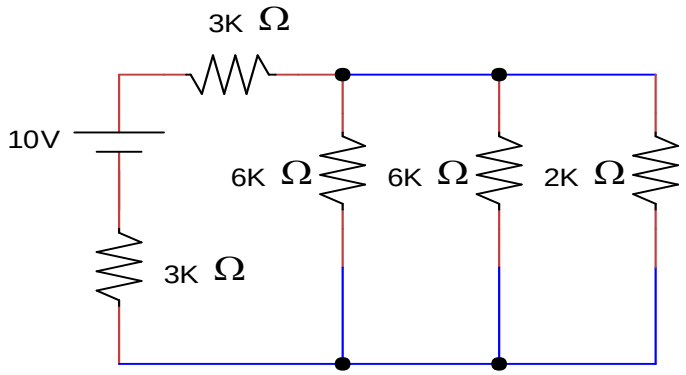
(i) with the normal of interface and (ii) with the interface. [6]

7. a) A series LCR circuit is driven by a sinusoidal voltage. Find out the instantaneous current and also the value of the current at resonance. Draw and explain the phasor diagram corresponding to resonance. [3+1+2]

b) A coil of resistance 10 ohm and inductance 0.1 H is connected in series with a capacitance of $150\mu F$ across a 200V, 50 Hz supply. Calculate the current and the power factor. What is the power consumed in the circuit? [4]

8. a) State Thevenin's theorem in electrical network. [2]

b) Using Thevenin's theorem to find the current through the 2KΩ resistor in the following circuit. [4]



c) A wire of length lm moves at right angles to its length at a speed of 100m/s in uniform magnetic field 1wb/m^2 which is also acting at right angles to the length of the wire. Calculate the emf induced in the wire when the direction of motion is

i) at right angles to the field.

ii) inclined at 300 to the direction of field. [2+2]

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