RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

SECOND YEAR

B.A./B.SC. THIRD SEMESTER (July – December) 2014

Mid-Semester Examination, September 2014

Date : 15/09/2014 **PHYSICS (Honours)**

Time : 2 pm – 4 pm Paper : III Full Marks : 50

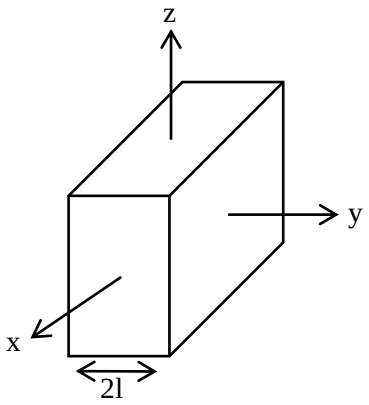
[Use a separate answer book for each group]

[*Answer **five questions** taking at least **one** from each group*]

Group – A

1. a) A long coaxial cable carries a uniform volume charge density ρ on the inner cylinder of radius a and a uniform surface charge density on the outer cylinderical shell of radius b. The surface charge is negative and of just right magnitude so that the cable as a whole in electrically neural. Find the electric field in each of the three regions (i) inside the inner cylinder (r<a), (ii) between the cylinders (a<r<b) (iii) outside the cable (r>b). [6]

   b) An infinite plane slab, of thickness 2d, carries a uniform volume charge density ρ. Find the electric field, as a function of y, the distance from the centre. Plot E versus y, calling E positive when it points in the +y direction and negative when it points in the –y direction. [4]



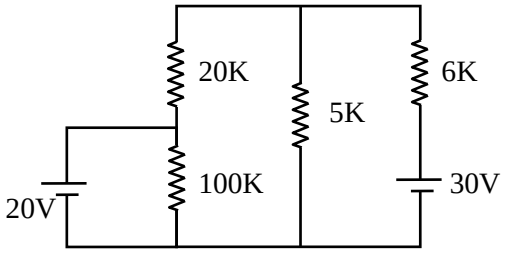
2. a) State and prove uniqueness theorem. [1+4]

   b) A sphere of radius carries a charge density $\rho(r) = Kr$ (K is a const) Find the energy of the configuration. [5]

Group – B

3. a) Establish the continuity equation relating the charge density and the current density at a point in a medium. Using this equation establish the law of charge conservation. [4+2]

   b) Use Kirchoff's laws to calculate the currents flowing through each resistor in the circuit shown in figure. [4]



4. a) Using Biot-Savart law, calculate the magnetic field B due to a circular current loop at any point on its axis. [4]

   b) Find the force between two magnetic dipoles $\vec{m}_1$ and $\vec{m}_2$ separated by a distance r. [4]

c) Calculate the force between two magnetic dipoles of magnetic moment m_1 and m_2 separated by a distance r. Assuming that m_1 and m_2 point in the direction of vector joining them. [2]

5. a) What do you mean by free current and bound current. [1]

b) Show that for non-uniform magnetization, $\vec{j}_m = \vec{\nabla} \times \vec{M}$, where $\vec{J}_m$ is the bound volume current density and $\vec{M}$ is the magnetization. [5]

c) The plane z = 0 separated air $(z \le 0; \mu = \mu_0)$ from iron $(z \le 0; \mu = 200\mu_0)$. Given that $\vec{H} = 10\hat{x} + 15\hat{y} - 3\hat{z}$ A/m in air, find $\vec{B}$ in iron and angle it makes with the interface. [4]

Group – C

6. a) For modelling intermolecular interaction, we generally use Lennard-Jones potential as given below : $V(r) = 4 \in \left[-\left(\frac{\sigma}{r}\right)^6 + \left(\frac{\sigma}{r}\right)^{12} \right]$ where $\in$ and σ are two constants associated with the molecule. Plot the above potential. Show that (i) equilibrium separation between two molecule is $1{\cdot}22\sigma$ and (ii) the dissociation energy is $\in$. [1+2+2]

b) State the law of equipartition of energy? Comment on its validity criterion. Find he total kinetic energy (KE) associated with the chaotic motion of one mole of an ideal monatomic gas at absolute temperature T. How does this K.E vary with temperature if pressure is maintained constant? [1+1+1+2]

7. Starting from the Maxwell speed distribution formula for one dimension, deduce the speed distribution formula for a two dimensional gas. Hence find the expression of (i) mean speed, (ii) mean square speed and (iii) the most probable speed. [4+2+2+2]

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