RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

SECOND YEAR [2014-17]

B.A./B.Sc. THIRD SEMESTER (July – December) 2015

Mid-Semester Examination, September 2015

Date : 14/09/2015 **PHYSICS (Honours)**

Time : 11 am – 1 pm Paper : III Full Marks : 50

[Use a separate answer book for each group]

[Answer <u>any five</u> questions taking atleast <u>one</u> from each group]

Group – A

1. a) Calculate the field and potential at an internal and external point of a solid sphere of radius R with uniform volume charge density ρ. [5]

   b) Determine the polar equation of equipotential surface for a dipole consisting of two charges of equal magnitude and opposite in sign and separated by a small distance. Also determine the locus of points at which the electric field is normal to the dipole moment of the given charge distribution. [5]

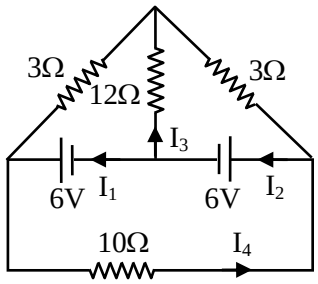
2. a) Show that the electrostatic potential due to an arbitrary charge distribution may be considered as the sum of potentials due to a monopole, a dipole, a quadrupole and higher order multipoles. [6]

   b) Four point charges +q, –q, +q, –q are placed respectively at the corners of a square ABCD of side 'a' cm in the xy plane, with +q at locations (a/2, a/2) and (–a/2, –a/2) and –q at (–a/2, +a/2) and (a/2, –a/2). Calculate the quadrupole moment of this charge distribution. [4]

Group – B

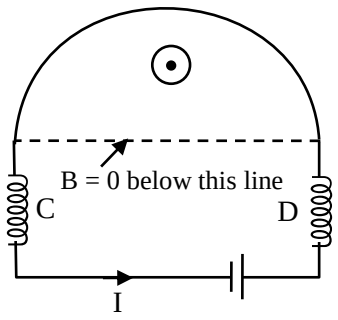
3. a) State and prove maximum power transfer theorem. [6]

   b) Find I_1, I_2, I_3 and I_4 in the given circuit. [4]



4. a) State and prove Ampere's circuital law. By using Ampere's circuital law find the magnetic induction at a distance r from the axis of a long straight wire carrying current I, in the following cases : (i) r>R (ii) r = R (iii) r<R and (iv) r = 0. [6]

   b) A wire in the form of a semicircle lies on the top of a smooth table. An upward directed uniform magnetic field of magnitude B is confined to the region above the dashed line in Fig. The ends of the semicircle are attached to springs C and D, whose other ends are fixed. The current I is introduced by a battery. Show that sum of the tension of the springs is 2BIr, where r is the radius of the semicircle. [4]



5. a) What do you mean by magnetic vector potential? Obtain an expression for magnetic vector potential due to a finite segment of a straight wire carrying current I and hence calculate the magnetic field B. [6]

   b) A rectangular coil of area $10cm^2$ carrying current of 50A lies on plane y – x = 2 such that the magnetic moment of the coil is directed away from the origin. Calculate the magnetic moment. [4]

Group – C

6. a) One end of a long insulated rod is periodically heated, find the phase velocity and group velocity of the temperature wave in the rod. The temperature of the hot end is $\theta = \theta_0 \sin \omega t$, where ω is the angular frequency of the periodic variation and t is the time. [5]

   b) Plot the following Gaussian distribution : $P_G(x, \mu, \sigma) = (1/\sqrt{2\pi} \cdot \sigma) \exp[-1/2\{(x-\mu)/\sigma\}^2]$ From the graph comment on the mean value. Show that it has two points of inflexion at $x = \mu \pm \sigma$. [5]

7. a) What is the justification behind the suitability of statistical method in macroscopic system consisting of large number of particles? List all the degrees of freedom for a molecule of water vapour and find its molar heat capacity. [3+2]

   b) For a gas of Helium at T = 200°C, what fraction of the particles have speeds greater than C = 2000 m/s? What is $\sqrt{\overline{v_x^2}}$ for an atom of Helium at T = 200°C, where v_x is the x-component of velocity of Helium atom. [2+3]

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