RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

SECOND YEAR [2015-18]

B.A./B.Sc. THIRD SEMESTER (July – December) 2016

Mid-Semester Examination, September 2016

Date : 10/09/2016 **PHYSICS (Honours)**

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

[Use a separate Answer Book for each group]

(Answer five questions taking atleast one from each group)

Group – A

1. a) What is Gauss's Law in electrostatics? Derive the integral form of the Law. Mention the important points on which the validity of the law depends. [1+3+2]

   b) A circle of radius *a* centred at the origin can have two different form of line charge density λ (i) $\lambda = \lambda_0 \cos\theta$ and (ii) $\lambda = \lambda_0$ where λ_0 is constant and θ is measured w.r. to the x-axis. Calculate the electric field at the origin for the two different line charge distributions. [2+2]

2. a) What are the important properties of a conductor relevant to electrostatics? [2]

   b) A thick metallic shell of inner radius *a* and outer radius *b* has charge Q on it. A point charge *q* is fixed at the centre of the shell. Calculate the charge on each surface of the shell and also the potential and field everywhere. [4]

   c) A cylindrical capacitor is formed by two hollow, cylindrical, metallic shells of length L fixed co-axially between two parallel planes which are a distance L apart. The outer diameter of the inner cylinder is 2*a* while the inner diameter of the outer shell is 2*b*. Show that the capacitance is given by $C = 2\pi \in_0 L / \ln(b/a)$ neglecting the edge effect. [4]

Group – B

3. a) State and prove Ampere's circuital law. [1+3]

   b) The current I flows down a wire of radius *a*. If volume current density is inversely proportional to the distance from the axis, find the magnetic field both inside and outside of the wire. [3]

   c) Starting from the expression $\vec{A} = \frac{\mu_0 I}{4\pi}\int \frac{d\vec{\ell}}{r}$ obtain the expression for $\vec{B}$. [3]

4. a) What do you mean by magnetic scalar potential? Show that for a current loop the magnetic scalar potential is $V_m = \frac{I}{4\pi}\Omega$. [1+5]

   b) Consider a uniformly magnetized disk of radius *a* and thickness t, $t << a$. It is magnetization $\vec{M} = M\hat{y}$. Assuming plane of the disc is xy plane and centre of the disk as origin, find the magnetization current densities. [4]

5. a) Establish the boundary condition satisfied by $\vec{H}$ at the interface of two media of different permeabilities. Assume no free surface current. [4]

   b) A sphere of radius R made of linear magnetic material of permeability μ is placed in an external uniform magnetic field $H_0\hat{z}$. Find the magnetic field $\vec{H}$ inside and outside of the sphere. [6]

Group – C

6. a) What do you mean by thermal equilibrium? State zeroth law of thermodynamics. [1+1]

   b) Write down the expression of partition function Z of a system in thermal equilibrium at a temperature T. What is its significance?

   Show that the mean energy of the system is $< E >= -\frac{\partial}{\partial \beta}(\ell nZ)$, where $\beta^{-1} = k_B T$.

   [k_B = Boltzmann constant] [1+1+2]

   c) A spherical hot water tank, fitted with a central electrical heater, has an internal radius of 0·25m and has a 0·05 m thick wall which is made of an insulating material of thermal conductivity 0·8 $Wm^{-1}K^{-1}$. If the temperature of the surrounding atmosphere is 15°C, calculate the power of the heater required to maintain the temperature of the water within the tank at 75°C. [4]

7. a) What are the basic differences between the thermodynamic approach and the kinetic theory (statistical) approach for studying thermal physics? [2]

   b) State and prove the principle of equipartition of energy for n particles in a system. Discuss the validity of the principle of equipartition of energy. [5]

   c) Calculate the value of velocity along x-direction of oxygen molecule for which the probability falls to $\frac{1}{10}$ times the maximum value at 200 K. [3]

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