RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

SECOND YEAR [2016-19]

B.A./B.Sc. THIRD SEMESTER (July – December) 2017

Mid-Semester Examination, September 2017

Date : 12/09/2017 **PHYSICS (Honours)**

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

(Answer any <u>five questions</u> taking at least <u>one from each group</u>) [5×10]

<u>Group – A</u>

1. a) Define Gauss's Law and discuss its validity in electrostatics. [1+2]
   b) Gauss's Law is true only because the Coulomb force depends exactly on the inverse square of the distance— justify the statement. [4]
   c) A uniform line charge density λ exists on the y-axis from y = 0 to $y = \infty$. Calculate the electric field due to this distribution at the point $P(a, 0)$ on the y-axis. [3]

2. a) Define dipole and quadruple in electrostatics. [2]
   b) Three point charges are located at the following points : $+2q$ at $(0, a, a)$; q at $(0, -a, a)$ and $-q$ at $(0, 0, -a)$. Calculate the potential at an arbitrary points $p(x, y, z)$ due to monopole, dipole and quadruple moment corresponding to the given charge distribution. [1+3+4]

<u>Group – B</u>

3. a) Establish the continuity equation relating the charge density and the current density at a point in a medium. [5]
   b) If $\vec{J} = 50\hat{r}\,A/m^2$. Find (i) the magnitude of the current density, (ii) the time rate of increase in volume charge density and (iii) the total current passing through surface defined r = lm, $0 < z < 2m$, $0 < \phi < 2\pi$. [1+2+2]

4. a) State Biot-Savart law in current electricity. Hence prove that $\vec{\nabla}.\vec{B} = 0$, where the symbols have the usual meanings. [1+3]
   b) Find an expression for the magnetic field (B) due to a straight conductor carrying a steady current. [3]
   c) A semi-infinitely long conducting filament (with respect to origin) carries 1A current in y-direction. Find B at (i) (3,4,0) cm (ii) (3,0,0) cm and (iii) (3,–4,0) cm. [3]

5. a) Determine vector potential at a large distance r due to a small circular current loop. Hence show that the magnetic field at large distance $(\vec{r})$ due to a small current loop having magnetic moment $\vec{m}$ is given by
   $$\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi}\left[-\frac{\vec{m}}{r^3} + 3\frac{(\vec{m}.\vec{r})\vec{r}}{r^5}\right]$$ [5+2]
   b) Current sheet at planes z = 0 and z = 6 carry current $\vec{K} = +50\hat{x}\,A/m$ and $\vec{K} = -50\hat{x}\,A/m$ respectively. Determine B at (i) (2,0,2) (ii) (2, 2,–2). [3]

<u>Group – C</u>

6. a) State zeroth law of thermodynamics. Discuss its importance for developing the concept of temperature. [1+4]
   b) Show that the probability of a gas molecule traversing a distance 'x' without collision is exp $(-x/\ell)$, where 'ℓ' is the mean free path of the gas. [3]

c) The mean free path in a certain gas at S.T.P is 60 nm. Consider 10000 free paths. How many are longer than 50 nm? [2]

7. a) State the limitations of the law of equipartion of energy. [2]

b) Explain from kinetic theory the concept of temperature. Derive an expression for the pressure of gas using solid angle concept. [2+3]

c) Calculate the fractional change in the number of Helium atoms in the velocity range of 999·5 to 1000·5 m/s, when a given mass of the gas is heated from 100K to 900K at constant volume. given Boltzmann constant $K = 1{\cdot}38 \times 10^{-16}$ c.g.s. unit, mass of Helium atom $= 6 \times 10^{-24}$ gms. [3]

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