MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : PH-301

PHYSICS-II

Time Allotted: 3 Hours

Full Marks: 70

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for *any ten* of the following: 1×10=10

(i) If $\text{Div}(\vec{F}) = 0$ and $\vec{A}$ is a vector quantity then

(a) $\vec{F} = \vec{\nabla} \times \vec{A}$ (b) $\vec{F} = \vec{\nabla} \cdot \vec{A}$

(c) $\vec{F} = \vec{\nabla}\vec{A}$ (d) $\vec{F} = \vec{\nabla}/\vec{A}$

(ii) In a conservative field

(a) work done is zero (b) line integral is independent of path

(c) curl is not equal to zero (d) divergence is zero

(iii) Line integral of an electrostatic field is the

(a) work done by the field per unit charge (b) electric field

(c) work done by magnetic field (d) total charge in the field

(iv) Polarisation is defined by

(a) dipole moment per unit length (b) dipole moment per unit volume

(c) dipole moment times volume (d) electric field per unit area

(v) The physical interpretation of $\vec{\nabla} \cdot \vec{B} = 0$ is

(a) magnetic monopole cannot exist (b) magnetic field is irrotational

(c) magnetic field is conservative (d) magnetic lines of force are open curves

Turn Over

Group – B
(Short Answer Type Questions)
Answer *any three* of the following questions. 5×3=15

2. (a) The potential field at any point in free space is given by $V = 5x^2y + 3yz^2 + 6xz$ Volt, where x, y, z, are in meters. Calculate the volume charge density at point (2, 5, 3)m.

   (b) Find out the relation between electric flux density (D), electric field (E) and polarization vector (P) in dielectric medium. 2+3

3. (a) Derive Poisson's equation and Laplace's equation from the differential form of Gauss' law.

   (b) Write down the force between two long parallel current carrying wires. 3+2

4. (a) Derive an expression of momentum operator.

   (b) Prove that $[x, p_x] = i\hbar$. 3+2

5. (a) Prove that Electric field $(\vec{E})$, Magnetic field $(\vec{H})$ and Propagation vector $(\vec{k})$ are mutually orthogonal.

   (b) Show that the potential function $V = V_0(x^2 - 2y^2 + z^2)$ satisfies Laplace's equation, where V_0 is a constant. 3+2

6. (a) Write down the difference between M–B, B–E and F–D statistics.

   (b) Write down F–D distribution function and define Fermi level at absolute zero and at a finite temperature. 3+2

Group – C
(Long Answer Type Questions)
Answer *any three* of the following questions. 15×3=45

7. (a) Using Gauss Law obtain Poisson's equation and Laplace's equation.

   (b) In a region of space, the electric field is given by $\vec{E} = 8\hat{i} + 4\hat{i} + 3\hat{k}$. Calculate the electric flux through a surface area of 100 units in X–Y plane.

   (c) Differentiate between polar and non-polar dielectrics and deduce the relation between dielectric constant k and (i) electric susceptibility χ (ii) Electric polarization $\vec{P}$. (2+2)+5+6

8. (a) Starting from Maxwell's equation obtain the wave equation for electric field E and magnetic field H in vacuum.

   (b) Obtain the expression of skin depth and indicate the factors on which it depends. Explain the reflection of electromagnetic waves by the ionosphere.

   (c) Elucidate the mathematical representation of Poynting's Theorem. 6+(3+2+2)+2

9. (a) Write down Lagrange's equation and apply it to obtain the equation of motion and hence the time period of a simple pendulum.

(b) Show that for a particle rotating in a plane (plane rotator) when θ is cyclic the angular momentum is conserved.

(c) A particle moving along the x-axis has the wave function

$\Psi(x) = \beta x^2$ between $x = 0$ and $x = 2$

$= 0$ elsewhere

Find the expectation value $\langle x \rangle$ of the particle's position. (2+3)+5+5

10. (a) State Ampere's law and obtain its differential form.

(b) Find the magnetic field at a point (1, 1, 1) if vector potential at that position is $\vec{A} = (10x^2 + y^2 - z^2)\hat{j}$.

(c) Obtain the magnetic field induction $\vec{B}$ at a point on the axis of a current circular conductor (loop) with n turns. 4+4+7

11. (a) Obtain the time-independent Schrodinger equation for a free particle of mass m.

(b) If a wave function $\Psi(x)$ of a quantum mechanical particle is given by:

$\Psi(x) = A \sin \pi x/L$ for $0 \leq x \leq L$

$= 0$ otherwise

Determine the value of A.

(c) Show that the function $\Psi(x) = A\, e^{ikx} + B\, e^{-ikx}$ is an eigen function of the kinetic energy operator $\hat{E}_k$. 6+5+4

12. (a) In how many ways 2 indistinguishable particles can be distributed in 3 distinct non-degenerate states, if the particles obey F–D statistics and B–E statistics.

(b) Derive the expression for the density of states for a system of particle of energy lying between ε and $\varepsilon + d\varepsilon$.

(c) Plot the electron distribution function governed by Fermi Dirac Statistics in metal at (i) $T = 0K$ (ii) $T > 0K$. Explain their physical significance. 5+5+(3+2)

(vi) In a conducting medium of permeability μ and conductivity σ. The skin depth for an e.m. wave of angular frequency ω is

(a) $\sqrt{\frac{1}{\mu\sigma\omega}}$ (b) $\sqrt{\frac{2}{\mu\sigma\omega}}$

(c) $\sqrt{\frac{\mu}{\sigma\omega}}$ (d) $\sqrt{\frac{2\mu}{\sigma\omega}}$

(vii) The induced magnetic field at the centre of a circular coil of radius r and total number of turns N, carrying current I is

(a) $\frac{\mu_0 NI}{r}$ (b) $\frac{\mu_0 N}{2\pi}$

(c) $\frac{\mu_0 NI}{2r}$ (d) 0

(viii) The expectation value $< x >$ of the particle of wave function $\Psi(x) = bx$ at $x = 0$ to $x = 1$:

(a) b^2 (b) $b^2/2$

(c) $b^2/3$ (d) $b^2/4$

(ix) The value of $[\hat{x}, \widehat{px}]$:

(a) $ih/2\pi$ (b) 0

(c) $-ih/2\pi$ (d) 1

(x) Energy of a particle in a one-dimensional potential box is proportional to:

(a) n^2 (b) n

(c) $1/n$ (d) $1/n^2$

(xi) Average energy of an electron in a metal at $T = 0$ is:

(a) E_F (b) $1/E_F$

(c) $3E_F/5$ (d) $5E_F/2$

(xii) For $T > 0K$, the probability occupancy of an electron at Fermi energy level is

(a) 0 (b) 1/2

(c) 1 (d) 2

(xiii) The Eigen value of the Eigen function cos x for the operator d^2/dx^2 is

(a) 0 (b) 1

(c) -1 (d) ½

(xiv) The degrees of freedom of a constraints system of N particles with constraints is

(a) 3N + K (b) 3N – K

(c) N + 3K (d) N + K

(xv) Which of the following is a Fermion?

(a) Proton (b) Electron

(c) Phonon (d) Alpha-particle