Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (N)-CSE/IT/APM/MRE/AUE/CE
/ME/PE/TT/SEM-3/PH-301/2012-13

2012

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 :

$10 \times 1 = 10$

i) The angle between the vectors $\hat{i} + \hat{j}$ and $\hat{i} - \hat{j}$ is

a) 90° b) 60°

c) 30° d) 0°.

ii) The value of $\oint_C \vec{r} \cdot d\vec{l}$ on any arbitrary closed curve C is

a) 3 b) 1

c) – 1 d) 0.

iii) In free space Poisson's equation reduces to

a) $\nabla^2 v = 0$ b) $\nabla^2 v = \frac{\rho}{\varepsilon_0}$

c) $\nabla^2 v = -\frac{\rho}{\varepsilon_0}$ d) $\nabla^2 v = \infty$.

iv) The continuity equation for steady current is

a) $\vec{\nabla} . \vec{j} + \frac{\partial \rho}{\partial t} = 0$ b) $\vec{\nabla} . \vec{j} = 0$

c) $\frac{\partial \rho}{\partial t} = 0$ d) $\vec{\nabla} \times \vec{j} = 0$.

v) The electrostatic potential energy of a system of two charges q_1 and q_2 separated by a distance r is

a) $\frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$ b) $\frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r}$

c) $\frac{1}{4\pi\varepsilon_0} \frac{q_1^2 q_2}{r^2}$ d) $\frac{\varepsilon_0}{4\pi} \frac{q_1 q_2}{r}$.

vi) If $\vec{B} = \vec{\nabla} \times \vec{A}$, $\vec{B}$ and $\vec{A}$ are any vectors then

a) $\vec{\nabla} . \vec{B} = 0$ b) $\vec{\nabla} . \vec{B} = 1$

c) $\vec{\nabla} . \vec{B} = -1$ d) $\vec{\nabla} . \vec{B} = |\vec{A}|$.

vii) The energy associated with a magnetic field $\vec{H}$ is

a) $\frac{1}{2} H^2$ b) $\mu_0 H^2$

c) $\frac{1}{2} \mu_0 H^2$ d) $\frac{1}{2\mu_0} H^2$.

viii) Skin depth for a conductor in reference to electromagnetic wave varies

a) inversely as frequency

b) directly as frequency

c) inversely as square root of frequency

d) directly as square root of frequency.

ix) Schroendinger time independent wave equation is

a) $\hat{H}\psi = E\psi^2$ b) $\hat{H}\psi^2 = E\psi^2$

c) $\hat{H}\frac{1}{\psi} = E\frac{1}{\psi}$ d) $\hat{H}\psi = E\psi$.

x) The ground state energy of a particle moving in a one dimensional potential box is given in terms of length L of the box by

a) $\frac{2\hbar^2}{8mL^2}$ b) $\frac{\hbar^2}{8mL^2}$

c) $\frac{h^2}{8mL^2}$ d) 0.

xi) The communication bracket $[\hat{p}_y, \hat{y}]$ is equal to

a) $i\hbar$ b) $-i\hbar$

c) $i\hbar^2$ d) $i/\hbar$.

xii) The electric dipole moment of a particle (atom or molecule) per unit polarizing electric field is termed as

a) polarization b) polarizability

c) net dipole moment d) susceptibility.

xiii) A system is called strongly degenerate if

a) $\frac{N_i}{g_i} = 1$ b) $\frac{N_i}{g_i} >> 1$

c) $\frac{N_i}{g_i} << 1$ d) $g_i = 1$.

xiv) A coin and a six faced disc are thrown simultaneously. The probability that the coin shows head and the disc shows 2 is

a) $\frac{1}{4}$ b) $\frac{1}{12}$

c) $\frac{1}{6}$ d) $\frac{1}{8}$.

xv) The average energy of an electron in a metal at 0 K is

a) E_F b) $\frac{E_F}{2}$

c) $\frac{3E_F}{5}$ d) $\frac{5E_F}{3}$,

where E_F is the Fermi energy.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following $3 \times 5 = 15$

2. a) Use Gauss' law to calculate the electric field between infinite extent parallel plate capacitor carrying charge density σ and mutual separation *d*.

b) Verify whether the potential function $V(x, y)$ satisfy Laplace's equation or not. Find also the charge density.

3. a) A superposed state of a quantum particle is given by, $\psi(x) = C_1\psi_1(x) + C_2\psi_2(x)$ where $\psi_1(x)$ and $\psi_2(x)$ are orthonormal states. Show that $C_1^2 + C_2^2 = 1$.

   b) Show that $\psi(x) = Ae^{2ix}$ & $\psi(x) = Ae^{-2ix}$ are degenerate wave functions. Find out the energy eigenvalue. 3 + 2

4. a) Define displacement current.

   b) Find the displacement current within a parallel plate capacitor in series with a resistor which carries current *I*. Area of the capacitor plates are *A* and the dielectric is vacuum. 2 + 3

5. a) A proton moves with a velocity 0·6 c parallel to a straight current 1A at a distance of 10 cm from the current. What is the magnetic force on the proton ?

   b) State the law you used in solving the above problem. 4 + 1

6. a) Construct the Hamiltonian and the Hamilton's equation of motion of a simple pendulum.

   b) Give a comparative study of BE and FD statistics. 3 + 2

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Define degree of freedom, generalized coordinates and Hamiltonian of a system.

   b) Derive the Lagrangian of a simple pendulum and obtain the equation of motion.

   c) Deduce the D'Alembert's principle from the principle of virtual work.

   d) Prove that for a conservative system, the Hamiltonian represents the total energy of the system. 3 + 4 + 4 + 4

8. a) What are the basic postulates of quantum mechanics ?

   b) Apply Schrödinger equation for one dimension to a particle in one dimensional box and find its total energy and normalized wave function. Plot the probability densities and explain.

   c) Find the energy difference between the ground state and first excited state of an electron moving in a one dimensional potential box of length 1Å. 3 + 8 + 4

9. a) A fluid motion is given by $V=(y+z)i+(z+x)j+(x+y)k$. Show that the motion is irrotational.

   b) Solve Laplace's equation to find the potential at a distance *r* from the axis of an infinitely long conducting cylinder of radius *a* charged with a surface charge density σ. Take the potential of the cylinder to be zero.

   c) The electrostatic potential in free space is given by $\Phi = \alpha - \beta(x^2+y^2) - \gamma \ln\sqrt{(x^2+y^2)}$ where α, β and γ are constants. Find the charge density in the region.

   5 + 5 + 5

10. a) The magnetic field in a region of free space is given by $B = B_0 \cos(\omega t - kz)\,\hat{y}$.

   i) What is the displacement current if there is no free charge ?

   ii) Obtain an equation for *E*, neglecting the integration constant.

   iii) Verify that the differential form of Faraday's Law of electromagnetic induction is satisfied by *E* and *B*.

   b) Find out Hamilton's equations of motion for a system comprising masses m_1 and m_2 connected by a massless string of length *L* through a frictionless pulley such that $m_1 > m_2$. (3 + 3 + 3) + 6

11. a) State Gauss's law of electrostatics.

    b) Derive an expression for the electric field between two infinite extent parallel plate capacitors carrying charge density σ and mutual separation d. Draw the necessary diagram.

    c) Stating from the definition of current density derive the equation of continuity in current electricity. What is the condition of steady current ?

    d) Two parallel wires carry equal current of 10A along with the same direction and are separated by a distance of 2·0 cm. Find the magnetic field at a point which is two cm away from any of these wires. 2 + 4 + (4 + 1) + 4

12. a) Deduce density of states of free electrons having energy between E and $E + \mathrm{d}E$ in the phase space.

    b) Write down the postulates of B-E statistics and write down the *B-E* distribution function explaining the symbols. At what condition BE-statistics will yield classical statistics ?

    c) A system has non-degenerate single particle states with 0, 1, 2, 3 energy units. Three particles are to be distributed in these states such that the total energy of the system is 3 units. Find the number of microstates if the particles obey

        i) MB statistics

        ii) BE statistics

        iii) FD statistics. 4 + (3 + 1 + 1) + (2 + 2 + 2)

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