



Name :

Roll No. :

Invigilator's Signature :

CS/B.Tech(ECE-NEW,PWE-NEW)/SEM-4/PH-401/2012

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 × 1 = 10

i) The dimension of $\mu_0 t_0$ is

a) $L^{-2} T^{-2}$

b) $L^{-2} T^2$

c) $L T^{-1}$

d) $L^{-1} T^{-1}$.

ii) The displacement current arises due to

a) positive charge only

b) negative charge only

c) time varying electric field

d) magnetic monopole.

- a) 9 eV b) 10 eV
- c) 15 eV d) 12 eV.

- a) $\psi c \log x$ b) ψcx^2
c) $\psi \frac{c}{x}$ d) ψce^{-mx}

v) BE statistics is applicable for

- a) ideal gas b) electron
- c) proton d) photon.

- a) $N - K$
- b) $N - 3K$
- c) $3N - K$
- d) $3(N - K)$.



vii) The number of ways in which 4 identical bosons can be distributed in 3 different energy states is

- a) 15 b) 6
c) 144 d) 24.

viii) The equation of continuity essentially represents

- a) conservation of mass
b) conservation of charge
c) conservation of potential
d) conservation of force.

ix) The ignorable co-ordinate corresponding to the motion of a particle under central force is given by

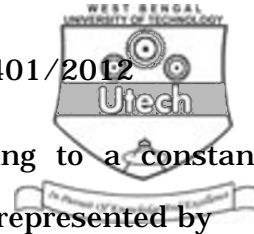
- a) r b) θ
c) \dot{r} d) $\dot{\theta}$.

x) An electric field in a certain region has the components $E_x = ax - bz$, $E_y = -ay + bz$ and $E_z = b(y - x)$.

Then which of the following statements is correct ?

(a, b are positive constants)

- a) \vec{E} is an electrostatic field
b) There is free charge in space
c) \vec{E} is irrotational
d) \vec{E} is solenoidal.



xi) The vector potential \vec{A} corresponding to a constant magnetic field \vec{B} along z-axis can be represented by

- a) $-Bz \hat{k}$
- b) $\frac{B}{2} (\hat{i}_x - \hat{j}_y)$
- c) $B (\hat{j}_x - \hat{i}_y)$
- d) $\frac{B}{2} (\hat{j}_x - \hat{i}_y) .$

xii) 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.

xiii) The expectation value of the position of a particle in a one-dimensional potential box of length

$$L (V(x) = 0; 0 < x < L, V(x) = \infty \text{ at } x = \neq L) \text{ is}$$

- a) L
- b) $\frac{L}{2}$
- c) $\frac{L}{3}$
- d) $\frac{L}{4} .$



xiv) The force experienced by a charged particle in a magnetic field is independent of

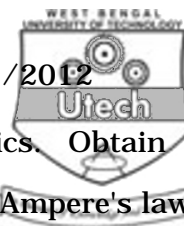
- a) velocity of the particle
 - b) strength of the field
 - c) charge of the particle
 - d) mass of the particle.
- xv) The electronic polarizability (α_e) of an atom is related to its radius (R) as
- a) $\alpha_e \propto R^3$
 - b) $\alpha_e \propto R^2$
 - c) $\alpha_e \propto R$
 - d) $\alpha_e \propto R^0$.

GROUP - B

(Short Answer Type Questions)

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

2. Write down the Maxwell's equations of an electromagnetic field. Hence, obtain the wave equation for electric field in free space. 3 + 2
3. State Stokes theorem in vector calculus. Find the unit vectors perpendicular to $x^2 + y^2 - z^2 = 100$ at the point (1, 2, 3). 2 + 3



4. State the Ampere's law of magnetostatics. Obtain its differential form from the integral one. Apply Ampere's law of magnetostatics to deduce an expression of magnetic field B due to a straight conductor of infinite length carrying current I . 1 + 2 + 2

5. a) Four distinguishable particles each of which can be in one of the energy states ϵ , 2ϵ , 4ϵ and 6ϵ having total energy 6ϵ . Find all possible number of distributions of all the particles in the energy states. Write the number of microstates possible and the number of microstates corresponding to each macrostate.

- b) Sketch the nature of Fermi-Dirac distribution function at $T = 0$ and $T > 0$ K in the same graph. 3 + 2

6. Show that if the Lagrangian does not depend on time, then the Hamiltonian is a constant of motion. Write down the Hamiltonian and obtain the equation of motion for a simple harmonic oscillator. 3 + 1 + 1

7. a) Find the value of $\left[\hat{L}_x, \hat{z} \right]$.

- b) Show that the eigenvalues of a Hermitian operation are real. Give an example of a Hermitian operator in quantum mechanics. 2 + 2 + 1



GROUP - C

(Long Answer Type Questions)

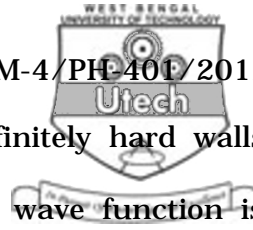
Answer any *three* of the following.

$3 \times 15 = 45$

8. a) Distinguish between holonomic and non-holonomic constraints. 2
- b) Write down the equation of constant, specify the nature of constant and calculate the degrees of freedom in each case :
- i) A particle constrained to move on the surface of a sphere
- ii) A simple pendulum with a fixed support. 3 + 3
- c) Show that if a generalized coordinate is cyclic in Lagrangian, then the corresponding generalized momentum will be conserved. 3
- d) Find the equation of motion using Hamilton's canonical equation for a system comprising masses m_1 and m_2 connected by a massless string of length L through a frictionless pulley such that $m_1 > m_2$. 4



9. a) What do you mean by μ and Γ -phase space ? Find the area in the phase space of a one-dimensional harmonic oscillator of mass m whose total energy is E . 2 + 2
- b) Derive Planck's radiation law from BE statistics. State clearly the assumptions made in the theory. 3 + 2
- c) What is Fermi energy ? Calculate the degeneracy function $g(E)$ as a function of energy E for an ideal Fermi gas. 1 + 3
- d) Evaluate the temperature at which there is one per cent probability that a state with energy of 0.6 eV above the Fermi energy will be occupied by an electron. 2
10. a) Give the physical interpretation of the wave of function $\psi(x)$. 2
- b) Show that for a stationary state given by the wave function $\psi(x, t) = \psi(x) e^{-\frac{i E t}{\hbar}}$, the expectation value of energy is equal to the energy eigenvalue. 3



- c) A particle is in a cubic box with infinitely hard walls whose edges are L units long. The wave function is given by

$$\psi(x, y, z) = A \sin\left(\frac{n\pi x}{L}\right) \sin\left(\frac{n\pi y}{L}\right) \sin\left(\frac{n\pi z}{L}\right).$$

Find the value of A . Find the ground state and first excited energy eigenvalues. Are they non-degenerate ?

Explain.

2 + 2 + 2

- d) Show that the function $\psi(x) = Cx e^{-\frac{x^2}{2}}$ is an eigenfunction of the operator $\left(x^2 - \frac{d^2}{dx^2}\right)$. Find the corresponding eigenvalue.

3 + 1

11. a) If \hat{a} and \hat{b} are unit vectors and θ is the angle between them, show that $2 \sin \frac{\theta}{2} = |\hat{a} - \hat{b}|$.

2

- b) Show that the electric field is always perpendicular to the equipotential surface.

3

- c) Show the

$$\vec{A} = (6xy + z^3) \hat{i} + (3x^2 - z) \hat{j} + (3xz^2 - y) \hat{k} \text{ is}$$

irrotational. Find ϕ such that $\vec{A} = \vec{\nabla} \phi$.

2 + 3



- d) Calculate the work done in moving a particle in a force field given by $\vec{F} = 3xy\hat{i} - 4z\hat{j} + 8y\hat{k}$ along the curve $x = t^2 + 1, y = t^2, z = t^3$ from $t = 0$ to $t = 1$. 3

- e) Show that $\int_S (ax\hat{i} + by\hat{j} + cz\hat{k}) \cdot d\vec{S} = \frac{4\pi}{3} (a + b + c)$

where S is the surface of the sphere

$$x^2 + y^2 + z^2 = 1. \quad 2$$

12. a) A spherically symmetric charge distribution is given by $\rho(r) = \rho_0 \left(1 - \frac{r^2}{a^2}\right)$ for $0 \leq r \leq a$, ρ_0 is a constant.

$$= 0 \quad \text{for } r > a$$

Calculate the

- i) total charge
- ii) the electric field intensity \vec{E} and potential V both inside ($r < a$) and outside ($r > a$) regimes.

$$1 + 2 + 2$$

- b) If ϕ is a scalar potential associated with the electric field \vec{E} and \vec{A} is the vector potential associated with the magnetic induction \vec{B} , show that they must satisfy the equation $\Delta^2 \phi + \frac{\partial}{\partial t} (\vec{\nabla} \cdot \vec{A}) = -\frac{\rho}{\epsilon_0}$. 5



- c) The intensity of sunlight reaching the earth's surface is about 1300 W/m^2 . Calculate the strength of the electric and magnetic fields of the incoming sunlight. 3
- d) N charged spherical water drops, each having a radius r and charge q , coalesce into a single big drop. What is the potential of the big spherical drop ? 2

