

Name :

Roll No. :

Invigilator's Signature :

CS/B.TECH/ECE/PWE/NEW/SEM-4/PH-401/2013

2013

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) If the constraint relations can be made independent of velocity, then the constraints are called
- a) Sclerenomic b) Bilateral
- c) Holonomic d) Conservative.
- ii) If a system had f degrees of freedom, then the number of Lagrange's equation for the system is
- a) 3 b) f
- c) $2f$ d) $f/2$.



- iii) The physical interpretation of $\vec{\nabla} \cdot \vec{B} = 0$ is
- a) magnetic monopole does not exist
 - b) magnetic field is irrotational
 - c) magnetic field is conservative
 - d) magnetic lines of force are open curves.
- iv) The velocity of electromagnetic wave in free space is
- a) equal to velocity of light
 - b) greater than the velocity of light
 - c) less than the velocity of light
 - d) zero.
- v) Dielectrics are substances which are
- a) semiconductor
 - b) conductor
 - c) insulator
 - d) none of these.
- vi) Ampere's circuital law is applicable when the current density is
- a) constant over space
 - b) time independent
 - c) solenoidal
 - d) irrotational.
- vii) The waves representing a free particle in three dimensions are
- a) standing waves
 - b) progressive waves
 - c) transverse waves
 - d) polarized waves.



- viii) In an electromagnetic wave in free space, the electric and magnetic fields are
- a) parallel to each other
 - b) perpendicular to each other
 - c) inclined at an angle
 - d) inclined at an obtuse angle.
- ix) A moving charge produces
- a) electric field only
 - b) magnetic field only
 - c) both of them
 - d) static electric field only.
- x) When the Hamiltonian operator operates on a wave function $\psi (r)$, then the corresponding eigenvalue is
- a) potential energy of the system
 - b) kinetic energy of the system
 - c) total energy of the system
 - d) none of these.
- xi) The value of probability of an event cannot be
- a) 1
 - b) negative
 - c) zero
 - d) positive.



xii) If a wave packet is described by

$\varphi(x) = A \exp\left(-\frac{x^2}{2\sigma^2}\right)$ then the normalization constant is

- a) 2σ
- b) σ
- c) $\frac{\pi\sigma}{2}$
- d) none of these.

xiii) He^3 and muon are

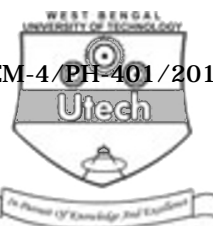
- a) Fermions
- b) Bosons
- c) Fermions & Bosons respectively
- d) classical particles.

xiv) The spin angular momentum of photon is

- a) h
- b) $h/8$
- c) 0
- d) $2h$.

xv) The maximum energy that can be occupied by an electron at $T = 0$ K is known as

- a) band gap energy
- b) Fermi energy
- c) radiation energy
- d) potential energy.



GROUP - B

(Short Answer Type Questions)

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

2. a) If the vectors A and B be irrotational, then show that the vector $A \times B$ is solenoidal.

- b) Prove that

$$i \times (j \times k) = j \times (k \times i) = k \times (i \times j) = 0.$$

$$2\frac{1}{2} + 2\frac{1}{2}$$

3. a) Write down Laplace's equation. Show that the potential function $x^2 - y^2 + z^2$ satisfies Laplace's equation.

$$1 + 2$$

- b) Show that when a dielectric is placed in an electric field, the field within the dielectric becomes weaker than the original field.

$$2$$

4. a) Calculate the magnetic field along the axis of the current carrying circular coil.

$$4$$

- b) What is the value of magnetic field at the centre of the coil ?

$$1$$

5. a) What do you mean by commutator ? Prove that

$$[x, P_x] = i\hbar.$$

$$1 + 2$$

- b) Write the basic postulates of wave mechanics.

$$2$$

6. a) Show that the average energy of an electron in a metal at 0 K is given by $\frac{3}{5} E_F$, where E_F is the Fermi energy.

$$3$$

- b) Show that both FD and BE statistics approach MB statistics at a certain limit. When does that happen ?

$$2$$



GROUP - C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) If in a region of space electric field is always in the x-direction then prove that
 - i) the potential is independent of y and z coordinates and
 - ii) if the field is constant, there is no free charge in that region. 2 + 1
- b) Write down the differential form of Gauss' law. Suppose that electric field in some region is found to be $\vec{E} = \alpha r^3 \hat{r}$ in spherical coordinates (α is a constant). Find the electric charge density. 1 + 3
- c) A very long cylindrical object carries charge distribution proportional to the distance from the axis (r). If the cylinder is of radius a , then find the electric field both at $r > a$ and $r < a$, by the application of Gauss' law in electrostatics. 4
- d) What is Electric Displacement vector ? Establish the relation $\vec{D} = \epsilon_0 \vec{E} + \vec{P}$ where symbols have their usual meanings. 1 + 3
8. a) State Biot-Savart's law and obtain the magnetic field induction due to a wire carrying current I at a point P situated at a distance R from it. 2 + 3
- b) Find the magnetic field at a point (1, 1, 1) if vector potential at that position is $\vec{A} = (10x^2 + y^2 - z^2) \hat{j}$. 3
- c) Obtain the magnetic field induction \vec{B} at a point on the axis of a current circular conductor (loop) with n turns. 7



9. a) State Poynting theorem. 2
- b) Prove that $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$. 3
- c) A conducting wire in the shape of an equilateral triangle of each side a carries a current I . Calculate the magnetic field at its centroid. 3
- d) 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 $\nabla^2 \phi + \frac{\partial}{\partial t} (\vec{\nabla} \cdot \vec{A}) = -\frac{\rho}{\epsilon_0}$. 5
- e) A long solenoid of 40 cm length has 300 turns. If the solenoid carries a current of 3.5 A, find the magnetic field at one end of the solenoid. 2
10. a) Calculate total number of particles in a Fermionic gas in terms of the Fermi level at absolute zero temperature. 4
- b) Apply $B-E$ statistics to a photon and deduce Planck's law of spectral energy density of black body radiation. 3
- c) Define Microstates and Macrostates with suitable examples. 3
- d) A box contains 5 red balls and 3 white balls. The balls except their colours, are identical. What is the probability that, on two independent draws, 1 ball is red and 1 ball is white? 3
- e) What do you mean by Macro-canonical and Micro-canonical ensemble? 2



11. a) If a system has two eigenstates ψ_1 and ψ_2 with eigenvalues E_1 and E_2 , under what condition will linear combination $(\psi = a \psi_1 + b \psi_2)$ be also an eigenstate ? 2

- b) If the wave function $\psi(x)$ of quantum mechanical particle is given by

$$\psi(x) = a \sin\left(\frac{\pi x}{L}\right) \text{ for } 0 \leq x \leq L$$

= 0, otherwise,

then determine the value of a . Also determine the value of x where probability of finding the particle is maximum. 5

- c) Write down Schrödinger equation for one-dimensional motion of a free particle in a one-dimensional potential box. Find its eigenfunction and eigenenergy. 5
- d) Prove that the first excited energy state of a free particle in a cubical box has three fold degeneracy. 3

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