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## 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 :

 $10 \times 1 = 10$ 

- 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

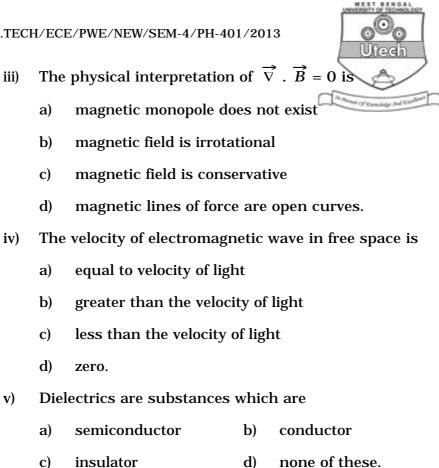
b) *f* 

c) 2f

d) f/2.

4105 Turn over

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- vi) Ampere's circuital law is applicable when the current density is
  - a) constant over space
  - time independent b)
  - solenoidal c)
  - irrotational. d)
- The waves representing a free particle in three dimensions are
  - standing waves a)
- 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)  $\frac{\pi c}{2}$ 

d) none of these.

xiii) He <sup>3</sup> 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) 2 h.

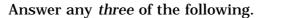
xv) The maximum energy that can be occupied by an electron at T = 0 K is known as

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



#### **GROUP - B**

#### (Short Answer Type Questions)



 $3 \times 5 = 15$ 

- 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  $x^2 - y^2 + z$  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.
- 4. a) Calculate the magnetic field along the axis of the current carrying circular coil.
  - b) What is the value of magnetic field at the centre of the coil?
- 5. a) What do you mean by commutator? Prove that

$$\left[\begin{array}{c} x, P_x \end{array}\right] = i\hbar . \qquad 1+2$$

- b) Write the basic postulates of wave mechanics.
- 6. a) Show that the average energy of an electron in a metal at 0 K is given by 3/5  $E_F$  , where  $E_F$  is the Fermi energy.
  - 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.  $3 \times 15 = 45$ 

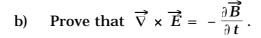
- 7. a) If in a region of space electric field is always in the *x*-direction then prove that
  - i) the potential is independent of y and z coordinates and
  - ii) if the field is constant, there is no free charge in that region. 2 + 1
  - b) Write down the differential form of Gauss' law. Suppose that electric field in some region is found to be  $\vec{E} = \alpha r^3 \hat{r}$  in spherical coordinates ( $\alpha$  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.
  - d) What is Electric Displacement vector? Establish the relation  $\overrightarrow{D} = \varepsilon_0 \overrightarrow{E} + \overrightarrow{P}$  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

$$\vec{A} = (10x^2 + y^2 - z^2) \hat{j}.$$

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



A Annual of Exercising and Exercision 2



- 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.
- d) If  $\phi$  is a scalar potential associated with the electric field  $\overrightarrow{E}$  and  $\overrightarrow{A}$  is the vector potential associated with the magnetic induction  $\overrightarrow{B}$ , show that they must satisfy the equation  $\nabla^2 \phi + \frac{\partial}{\partial t} (\overrightarrow{\nabla} \cdot \overrightarrow{A}) = -\frac{\rho}{\epsilon_0}$ .
- 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.
- 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.
  - 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?
  - e) What do you mean by Macro-canonical and Micro-canonical ensemble?

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- 11. a) If a system has two eigenstates  $\psi_1$  and  $\psi_2$  with eigenvalues  $E_1$  and  $E_2$ , under what condition will linear combination  $\left(\psi = a \psi_1 + b \psi_2\right)$  be also an eigenstate?
  - b) If the wave function  $\psi$  ( x ) of quantum mechanical particle is given by

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

= 0, otherwise,

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

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