



Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS / B.TECH(EE-NEW / EEE-NEW / EIE-NEW / ICE-NEW) /  
SEM-4 / PH(EE)-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)  $\text{He}^3$  and muon are
  - a) fermions
  - b) bosons
  - c) fermions & bosons respectively
  - d) bosons & fermions respectively.
- ii) The degrees of freedom for a system of  $N$  particles with  $K$  constraint relations is given by
  - a)  $N - K$
  - b)  $N - 3K$
  - c)  $3N - K$
  - d)  $3K - N$ .

- 2



- GROUP – B**

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

- 4



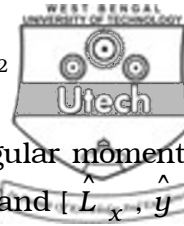
5. a) Derive Curie's law of paramagnetism in the framework of Langevin's theory.
- b) Are all orientations of the magnetic dipoles possible in quantum theory ? Explain. 4 + 1
6. a) Explain what you mean by degeneracy of an eigenstate with an example.
- b) The eigenvalue equation for the momentum operator is  $(\frac{\partial}{\partial x}) \Psi = \lambda \Psi$ .
- Solve the above equation and hence show that for  $\Psi$  to be a physically admissible eigenstate, the eigenvalue  $\lambda$  must be real. 2 + 3
7. Derive the Bragg's law of X-ray diffraction from Laue equation and deduce the vector form of Bragg's law of X-ray diffraction in reciprocal space. 2 + 3

### GROUP – C

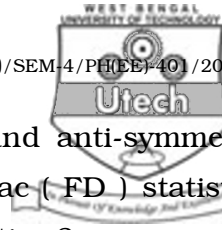
#### ( Long Answer Type Questions )

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

8. a) A free particle of mass  $m$  is confined within  $x = 0$  and  $x = L$ .
- i) Write down Schrödinger time-independent equation for such a system.
- ii) Solve the equation to find out the normalized eigenfunctions.
- iii) Show that the eigenfunctions corresponding to two different eigenvalues are orthogonal. 1 + 4 + 3



- b) If  $\hat{P}$  and  $\hat{L}$  be the momentum and angular momentum operators, find the values of  $[\hat{L}_x, \hat{x}]$  and  $[\hat{L}_x, \hat{y}]$ .  
2 + 2
- c) Find the expectation value of  $x$  for the wave function given by  $\Psi(x) = Ae^{-bx^2}$ .  
3
9. a) The energy wave vector dispersion relation for a one-dimensional crystal of lattice constant  $a$  is given by  $E(k) = E_0 - \alpha - 2\beta \cos ka$ , where  $E_0$ ,  $\alpha$ ,  $\beta$  are constants.
- Find the value of  $k$  at which the velocity of an electron is a maximum.
  - Find the difference between the top and the bottom of the energy band.  
2 + 2 + 2
  - Obtain the effective mass  $m^*$  of the electron at the bottom and at the top of the band.
- b) What do you mean by density of states? Show that the density of states of free electrons vary with energy ( $E$ ) as  $\sqrt{E}$ .  
1 + 4
- c) In sodium metals, the free electron density is  $2.5 \times 10^{28} \text{ m}^{-3}$ . Calculate the Fermi energy and the dermi temperature.  
2 + 2
10. a) Define Hamiltonian of a dynamical system. When does it represent the total energy of the system? Explain.  
2 + 3
- b) The Lagrangian of a particle of mass  $m$  in one dimension is given by
- $$L = \frac{1}{2} m (\dot{x}^2 - \omega^2 x^2) e^{bt}$$
- Obtain the canonical momentum and equation of motion. Is the Hamiltonian constant of motion? 3 + 3
- c) Deduce D'Alembert's principle from the principle of virtual work.  
4



11. a) What do you mean by symmetric and anti-symmetric wave function ? How does Fermi-Dirac ( FD ) statistics differ from Bose-Einstein ( BE ) statistics ? 2
- b) Explain graphically the Fermi distribution at zero and non-zero temperature. 3
- c) Derive Planck's radiation law from BE statistics. State clearly the assumptions made in the theory. 3 + 2
- d) Compute the specific heat of a free electron gas using classical statistics. Using FD statistics, argue that the specific heat of electrons should vary linearly with temperature (  $T$  ). 2 + 3
12. a) What is Larmor frequency ? 2
- b) With the help of Weiss molecular field theory of ferromagnetism, derive the Curie-Weiss law. 5
- c) Draw the B-H curve for a ferromagnetic material and identify the retentivity and the coercive field on the curve. What is the energy loss per cycle ? 3 + 1
- d) Explain the reason behind the negative susceptibility of diamagnetic material. 2
- e) Calculate the effective Bohr magneton for  $Gd^{+3}$ . The electronic configuration for  $Gd^{+3}$  is  $4f^7 5s^2 5p^6$ . 2

