

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.

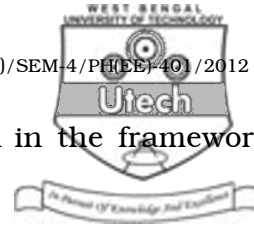
Candidates are required to give their answers in their own words as far as practicable.

**GROUP – A
(Multiple Choice Type Questions)**

1. Choose the correct alternatives for any *ten* of the following :

10 × 1 = 10

- i) 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) $3K - N$.



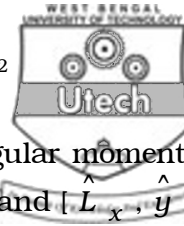
5. a) Derive Curie's law of paramagnetism in the framework of Langevin's theory.
- b) Are all orientations of the magnetic dipoles possible in quantum theory? Explain. 4 + 1
6. a) Explain what you mean by degeneracy of an eigenstate with an example.
- b) The eigenvalue equation for the momentum operator is $(\hat{p}) \left(\frac{\partial \Psi}{\partial x} \right) = \lambda \Psi$.
- Solve the above equation and hence show that for Ψ to be a physically admissible eigenstate, the eigenvalue λ 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

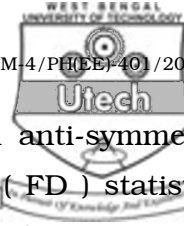
(Long Answer Type Questions)

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 , α , β are constants.
- i) Find the value of k at which the velocity of an electron is a maximum.
 - ii) Find the difference between the top and the bottom of the energy band.
 - iii) Obtain the effective mass m^* of the electron at the bottom and at the top of the band. 2 + 2 + 2
- 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

