Total No. of Questions : 7] **[Total No. of Pages : 2**

P740

[4024] - 101

M.Sc. (Sem. - I)

PHYSICS

PHY UTN - 501 : Classical Mechanics

(2008 Pattern) (New Course)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates:

1) ***Question No. 1 is compulsory and solve any Four questions from the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and electronic pocket calculator is allowed.***

Q1) Attempt any four of the following :

a) Apply the principle of virtual work to obtain lever equation. **[4]**

b) Show that the constraints acting in the case of a rigid body are conservative. **[4]**

c) A bead slides on a smooth rod which is rotating about one end in a vertical plane with uniform angular velocity W. Show that the equation of motion is $m\ddot{r} = mrw^2 - mg\sin(wt)$. **[4]**

d) Describe the Hamiltonian and Hamilton's equations for an ideal spring mass arrangement. **[4]**

e) Show that the transformation $Q = \frac{1}{P}$, $P = 9P^2$ is canonical. **[4]**

f) Use Hamilton's equation to prove that the areal velocity is constant in planetary motion. **[4]**

Q2) a) A disc of radius 'a' and mass 'm' rolls down an inclined plane making an angle θ with the horizontal. Set up the Lagrangian and find the equation of motion and acceleration of the disc. **[8]**

b) Prove viral theorem. **[4]**

c) Deduce Hamiltonian for a compound pendulum and Hamiltons equations of motion. Also calculate the period of its oscillation. **[4]**

P.T.O.

Q3) a) Obtain an expression for coriolis acceleration for rotating co-ordinate system. **[8]**

b) Derive Hamiltonian function and Hamilton's canonical equations of motion. What is the physical significance of Hamiltonian function. **[8]**

Q4) a) Derive Euler-Lagrange equation and using variational principle show that geodesics of a spherical surface are great circles. **[8]**

b) Deduce Hamilton's principle and use it to find the equation of one dimensional harmonic oscillator. **[4]**

c) Write note on artificial satellite. **[4]**

Q5) a) A bullet is fired horizontally in the north direction with a velocity of 500 m/sec. at 30°N latitude. Calculate the horizontal component of coriolis acceleration and the consequent deflection of the bullet as it hit a target 250 meters away. Also determine the vertical displacement of the bullet due to gravity. If the mass of the bullet is 10gm. Find coriolis force. **[8]**

b) The transformation equations between two sets of co-ordinates are **[8]**

$P = 2(1 + 9^{1/2} \cos p)\, 9^{1/2} \sin p$ and $Q = \log(1 + 9^{1/2} \cos p)$

Show that i) The transformation is canonical ii) The generating function of this transformation is $F_3 = -(e^Q - 1)^2 \tan p$.

Q6) a) Prove that **[8]**

$[J_y, J_z] = J_x$, $[J_z, J_x] = J_y$ and $[J_x, J_y] = J_z$ where J is angular momentum.

b) A pendulum of mass 'm' is attached to a block of mass 'M'. The block slides on a horizontal frictionless surface. Find the Lagrangian and equation of motion of the pendulum. For small amplitude oscillations, derive an expression for periodic time. **[8]**

Q7) a) A particle describes a circular orbit under the influence of an attractive central force directed towards a point on the circle. Show that the force varies as the inverse fifth power of the distance. **[8]**

b) Prove the distribution and multiplication law for poisson bracket. **[4]**

c) Show that the function $F = -\sum_i Q_i p_i$ generates the identity transformation. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 2**

P741

[4024] - 102
M.Sc. (Sem. - I)
PHYSICS
PHY UTN - 502 : Electronics
(2008 Pattern)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates:

1) ***Question No. 1 is compulsory. Attempt any Four questions from the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and calculator is allowed.***

Q1) Attempt <u>ANY FOUR</u> of the following :

a) What is foldback current limiting. How is it superior to simple current limiting. Draw circuit diagram of basic high voltage regulator with foldback current limiting using IC 723. **[4]**

b) Design second order Butterworth low pass filter for higher cutoff frequency of 5kHz. **[4]**

c) What is PLL? Draw its block diagram. Define it capture range and locking range. **[4]**

d) If logic '1' = 16V and logic '0' = 0V, determine the following for R–2R type DAC. **[4]**

   i) Analog output for digital input of 1111.

   ii) Resolution.

e) Draw circuit diagram of sample and hold circuit. Explain its working. Define aperture time and hold time. **[4]**

f) State and define any four parameters of OPAMP. State its ideal values and real values for IC 741. **[4]**

Q2) a) Draw circuit diagram of an asymmetric astable multivibrator. Explain its operation. Design it to generate a rectangular wave of 80% duty cycle and 1 kHz frequency at output. **[8]**

(Given : $+V_{CC} = +10V$ and $-V_{CC} = -10V$)

$\beta = 0.4$

b) With neat block diagram, explain the working of switching regulator. State its advantages and two applications. **[8]**

P.T.O.

Q3) a) Draw circuit diagram of full wave precision rectifier. Explain its action. Derive expression for its output voltage. **[8]**

b) What is PLA? How it can be used to implement a combinational logic circuit that generates square of 3-bit binary input data. **[8]**

Q4) a) Draw functional block diagram of IC 7495. State its various operating modes. State its four applications. **[8]**

b) Draw circuit diagram of an instrumentation amplifier using three OPAMPS. Derive expression for its output voltage. Prove that the CMRR of this circuit depends upon the tolerance of the resistances used. **[8]**

Q5) a) Sketch a block diagram of IC 8038. State the function of each component. Design it to generate a waveform of frequency 10 kHz. using single resistor R. **[8]**

b) Design a notch filter using twin-T network, for f_n = 50 Hz and Q = 5. Determine its f_h, f_l and bandwidth. Draw its frequency response curve. **[8]**

Q6) a) Draw a combinational logic circuit to implement following expression

$$Y = \sum_m (0, 2, 4, 5, 6, 8, 10, 12, 13, 14)$$

How it can implemented using multiplexer? **[8]**

b) Draw block diagram of 3-pin voltage regulator. Explain function of each block. Design adjustable voltage regulator using LM 317 to have an output voltage variable from 5 to 15 V. **[8]**

Q7) Write short notes on <u>ANY FOUR</u> of the following : **[16]**

a) Monostable multivibrator using IC 74123.

b) DC-to-DC converter.

c) Function generator using two OPAMPs.

d) Successive approximation ADC.

e) Optical fiber communication.

f) Voltage controlled oscillator using IC 566.

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Total No. of Questions : 7] **[Total No. of Pages : 2**

P742

[4024] - 103

M.Sc. (Sem. - I)

PHYSICS

PHY UTN - 503 : Mathematical Methods in Physics (New Course) (2008 Pattern)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates:

1) ***Question No. 1 is compulsory. Attempt any four of the remaining questions.***
2) ***Draw neat figures wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and pocket calculator is allowed.***

Q1) Attempt any four of the following :

a) Represent the following function graphically for the period = 10 **[4]**

$$f(x)\begin{cases} = 3 & 0 < x < 5 \\ = -3 & -5 < x < 0 \end{cases}.$$

b) A linear transformation T : $V_2 \rightarrow V_3$ is defined as $T(x_1, x_2) = (x_1 + x_2, 2x_1 - x_2, 7x_2)$. If $B_1 = (e_1, e_2)$ & $B_2 = (f_1, f_2, f_3)$ are the standard bases of V_2 and V_3 respectively, find the matrix of T, relative to B_1 and B_2. **[4]**

c) Prove that if function $f(z)$ is analytic, it is independent of z. **[4]**

d) Let u, v, w be independent vectors. Show that $(u + v)$, $(v + w)$ and $(u + w)$ are also independent. **[4]**

e) Prove the following recurrence relation $2n\, H_{n-1}(x) = H_n'(x)$. **[4]**

f) Using Rodrigue's formula, generate first two Legendre polynomials $P_0(x)$ & $P_1(x)$. **[4]**

Q2) a) For Legendre polynomials, prove the orthogonality condition **[8]**

$$\int_{-1}^{+1} P_n(x) P_m(x)\, dx = \frac{2}{2n+1}\ \delta mn.$$

b) State and prove Cauchy integral formula $\oint \frac{f(z)}{(z - z_0)}\, dz = 2\pi i\, f(z_0)$. **[8]**

P.T.O.

Q3) a) If the function $f(x)$ satisfies Dirichlet condition, then prove that **[8]**

$$\frac{1}{\pi}\int_{-\pi}^{\pi}[f(x)]^2\,dx = \frac{a_0^2}{2} + \sum_{n=1}^{\infty}(a_n^2 + b_n^2).$$

b) Write the general definition of the inner product in vector space and prove schwartz inequality $|u.v| \le \|u\|.\|v\|$. **[8]**

Q4) a) State and prove Laurent's theorem. **[8]**

b) Define eigenvalues and eigenvectors. Find the eigenvalues and normalized eigen vectors of the matrix $\begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix}$. **[8]**

Q5) a) Find $L^{-1}\left\{\frac{1}{(s^2+1)^2}\right\}$. **[8]**

Where $L^{-1}\left\{\frac{s^2}{(s^2+1)^2}\right\} = \frac{d}{dt}\left(\frac{1}{2}t\sin t\right)$.

b) State and prove Cauchy's theorem for closed contour. **[8]**

Q6) a) Let T be linear operator on R^3 defined by $T(x, y, z) = (2y + z, x - 4y, 3x)$. Find the matrix of T in the basis $\{f_1 = (1, 1, 1), f_2 = (1, 1, 0), f_3 = (1, 0, 0)\}$. **[8]**

b) What are spherical harmonics? State orthonormal condition satisfied by it. **[8]**

Q7) a) Define (i) Finite Fourier sine transform (ii) Finite Fourier cosine transform. **[4]**

b) Define Linear vector space and write the conditions to be satisfied by it. **[4]**

c) Generate first two Lagurre polynomials by using Rodrigue's formula. **[4]**

d) Prove $|z_1 + z| \le |z_1| + |z_2|$. **[4]**

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Total No. of Questions : 7] [Total No. of Pages : 3

P743

[4024] - 104
M.Sc. (Sem. - I)
PHYSICS
PHY UTN - 504 : Quantum Mechanics - I
(2008 Pattern) (New Course)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates:

1) *Question No. 1 is compulsory. Solve any four from the remaining.*
2) *Draw neat diagrams wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and calculator is allowed.*

Q1) Attempt <u>any four</u> of the following :

a) For a ground state of a linear harmonic oscillator, the wave-function is $\phi_0(x) = \left(\dfrac{mw}{\pi\hbar}\right)^{1/4} \exp\left[\dfrac{-mwx^2}{2\hbar}\right]$. For this state, show that the uncertainty product $(\Delta x \Delta P_x) = \dfrac{\hbar}{2}$ (Given : $< X > = < P_x > = 0$). **[4]**

b) In momentum space, show that $[x_{op}, p_{op}] = i\hbar$. **[4]**

c) The dynamical variable A is observable then show that $< A > = < A >^*$ and state positive property of operator A. **[4]**

d) In three dimensions, the ground state wave-function is $\Psi(r) = \sqrt{\dfrac{1}{\pi\, a_0^3}}\ \exp\left(\dfrac{-r}{a_0}\right)$ where a_0 = radius of first Bhor orbit. Show that probability amplitude is : $C(p) = \dfrac{1}{\pi}.\left(\dfrac{2a_0}{\hbar}\right)^{\frac{3}{2}}.\dfrac{1}{\left[\dfrac{p^2 a_0^2}{\hbar^2}+1\right]^2}$. **[4]**

e) Show that the operator $\hat{L}_z = -i\hbar\frac{\partial}{\partial\phi}$ is hermitian. **[4]**

f) For $j = \frac{1}{2}$, obtain matrices for J_x and J_y. **[4]**

Q2) a) Define adjoint and self adjoint operators. Show that (i) the eigen-values of a self-adjoint operator are real and (ii) any two eigen functions belonging to distinct (unequal) eigen values of a self adjoint operator are mutually orthogonal. **[8]**

b) Describe a square potential barrier of height V_0. For a particle with energy $E < V_0$, write down Schroedinger equation for three regions. Discuss qualitatively how this leads to tunneling effect. **[8]**

Q3) a) Using the abstract operator method; obtain the eigen value spectrum of H.for one dimensional hamonic oscillator. **[8]**

b) Evaluate the clebsh-Gorden coefficient matrix equation for a system having $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. **[8]**

Q4) a) A linear operator $\hat{F}$ takes a vector $|\Psi>$ into $|x>$ as $F|\Psi> = |\chi>$. Represent $\hat{F}$ as a matrix elements in A-representation. **[8]**

b) Obtain the eigen-value spectrum of J^2 and J_z by using operators

$J_\pm = J_x \pm iJ_y$. **[8]**

Q5) a) What is spin angular momentum? For spin: $\frac{1}{2}$, the spin angular momentum operator, operating on states $\alpha = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\beta = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$. Obtain the matrix representation for S_x, S_y and S_y. Hence define Pauli spin matrices. **[8]**

b) Describe Shroedinger and Heisenberg pictures for time evolution of system. **[8]**

Q6) a) Explain : **[8]**

i) State vector and Dirac notations.

ii) Norm and Scalar product.

iii) Hibert space and basis of it.

b) What is unitary transformation? By using it, explain the transformation of one complete orthonormal set of basis to other basis. **[8]**

Q7) a) Show that momentum eigen function $\phi_P(x)$ are orthogonal where ϕ_P is box normalized. **[4]**

b) Show that $\sum_a \phi_a(x)\phi_a^*(x) = \delta(x - x')$ by using completness theorem and δ-function. **[4]**

c) State expansion postulate for any arbitrary wave function Ψ and show that eigen functions belonging to discrete values are normalizable. **[4]**

d) State the four postulates of quantum mechanics. **[4]**

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Total No. of Questions : 7] [Total No. of Pages : 3

P744

[4024] - 201
M.Sc. (Sem. - II)
PHYSICS
PHY UTN - 601 : Electrodynamics
(New Course) (2008 Pattern)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates:

1) *Question No. 1 is compulsory, and solve any four questions from the remaining.*
2) *Draw neat labelled diagrams wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and pocket calculator is allowed.*

Q1) Attempt <u>any four</u> of the following :

a) The earth receives about 1300 Watt/m^2 radiant energy from the sun. Assuming the energy to be in the form of plane polarized monochromatic waves and assuming normal incidence, calculate the magnitude of electric field vector in the sun light. **[4]**

Given : $\in_0 = 8.85 \times 10^{-12} \dfrac{C^2}{N-m^2}$ and $\mu_0 = 4\pi \times 10^{-7} \dfrac{wb}{A-m}$.

b) Find the skin-depth in sea water with conductivity $\sigma = 5\ (\Omega m)^{-1}$ at frequency 10^{10} Hz. For sea water $\mu = \mu_0 = 4\pi \times 10^{-7} \dfrac{wb}{A-m}$. **[4]**

c) Two identical bodies move towards each other, the speed of each being 0.9C. What is their speed relative to each other? **[4]**

d) Show that the ratio of electrostatic and magnetic energy densities $\left(\dfrac{u_e}{u_m}\right)$ is equal to unity. **[4]**

e) Find the velocity at which the mass of the particle is double it's rest mass. **[4]**

Given : C = 3×10^8 m/sec.

f) Explain Minkowski's space-time diagram. **[4]**

Q2) a) Starting from Maxwell's equations, derive inhomogeneous wave equations in terms of scalar potential ϕ and vector potential $\vec{A}$. Hence explain Lorentz's and Coulomb's gauges. **[8]**

b) Show that the operator

$\Box^2 \equiv \nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$ is invariant under Lorentz transformations where as

$\nabla^2 \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$ is not Lorentz invariant. **[8]**

Q3) a) Obtain Faraday's law of induction in differential form for a stationary medium and show how it can be modified if the medium is moving with a velocity $\vec{u}$. **[8]**

b) Using the concept of e.m. energy, show that power transferred to the e.m. field through the motion of charge in volume V is given by : **[8]**

$$-\int_v \left(\vec{j}\cdot\vec{E}\right)dv = \frac{d}{dt}\int_v \frac{1}{2}\left(\vec{E}\cdot\vec{D}+\vec{B}\cdot\vec{H}\right)dv + \int_{c.s.}\left(\vec{E}\times\vec{H}\right)\cdot\vec{ds}$$

Explain the significance of each term.

Q4) a) Explain the term 'multipole moments'. Hence derive an expression for potential at a distant point using multipole expansion for a localized charge distribution in free-space. **[8]**

b) The magnetic field intensity $\vec{B}$ at a point is given by

$\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\int \frac{\vec{j}\times\vec{r}}{r^3}d\tau$. Show that $\left(\vec{\nabla}\times\vec{B}\right) = \mu_0\vec{j}$. **[8]**

Q5) a) Explain the term Hertz potential and show that it obeys inhomogeneous wave equation. Obtain the electric and magnetic fields in terms of Hertz potential $\vec{Z}$. **[8]**

b) Explain the term e.m. field tensor. Hence obtain an expression for e.m. field tensor $F\mu\nu$. **[8]**

Q6) a) Prove that the relativistic addition theorem for

velocities : $u_x = \dfrac{u'_x + v}{1 + \dfrac{u'_x v}{c^2}}$ where $u'_x = \dfrac{dx'}{dt'}$ and $u_x = \dfrac{dx}{dt}$.

Hence show that any velocity added relativistically to 'c' gives resultant velocity 'c', which is Lorentz invariant. **[8]**

b) Describe Michelson-Morley experiment with reference to the special theory of relativity. Derive the necessary formula for the fringe shift and comment on the result. **[8]**

Q7) a) Calculate the wave impedance of an e.m. wave travelling through free-space.

Given : for free-space $\mu = \mu_0 = 4\pi \times 10^{-7} \dfrac{\text{Wb}}{\text{A}-\text{m}}$

and $\in = \in_0 = 8.85 \times 10^{-12} \dfrac{\text{C}^2}{\text{N}-m^2}$. **[4]**

b) Calculate the rest mass energy of an electron in eV if it's rest mass is equal to 9.11×10^{-31} kg. **[4]**

c) Write a short note on electric dipole radiation and explain the term 'radiation resistance'. **[4]**

d) Explain the term 'momentum space'. **[4]**

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Total No. of Questions : 7] [Total No. of Pages : 2

P745

[4024] - 202
M.Sc. (Sem. - II)
PHYSICS
PHY UTN - 602 : Atoms, Molecules and Solids
(New Course) (2008 Pattern)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates:

1) ***Question No. 1 is compulsory. Solve any four questions of the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and electronic pocket calculators is allowed.***

Given

Rest mass of electron	= 9.109×10^{-31} kg
Charge on electron	= 1.6021×10^{-19} coulomb
Plank's constant	= 6.626×10^{-34}Js
Boltzmann constant	= 1.38054×10^{-23} JK^{-1}
Avogradro's number	= 6.02252×10^{26}(K mole)$^{-1}$
Bohr Magneton	= 9.27×10^{-24} amp-m^2
1eV	= 1.6021×10^{-19} J

Q1) Attempt any four of the following : **[16]**

a) Find Lande's g factor for the state, $^2f_{7/2}$.

b) The Zeeman components of 500 nm spectral line are 0.0106 nm apart when the magnetic field is 0.4T. Find $\frac{e}{m}$ by this data.

c) The band origin of a transition in C_2 is observed at 19.378 cm^{-1}. While the rotational fine structure indicates that the rotational constants in excited and ground state are respectively B' = 1.7527 cm^{-1} and B" = 1.6326 cm^{-1}. Estimate the position of band head.

d) Consider (2, 2, 2) (3, 3, 3) (1, 1, 1) and (3, 0, 3) planes. State the possibility of reflection for these planes in bcc and fcc, lattices. Explain your result.

e) Show that the maximum radius of the sphere that can just fit into the void at the body centre of the fcc structure coordinated by the facial atoms is 0.414 r where r is the radius of the atom sitting at fcc sites.

f) What would be the effect on specific heat of solids at room temp. if plank's constant h is increased 10 folds.

P.T.O.

Q2) a) State and explain Frank-Condon principle. **[8]**

b) Explain normal Zeeman effect. Derive the formula for change in wavelength $d\lambda$. **[8]**

Q3) a) Explain the principle of NMR. Calculate the difference in energies of protons oriented with and against magnetic field of 1.5 T. **[8]**

b) Explain with the help of suitable diagrams band head and band origin in case of rotational fine structure of electronic vibration spectra. **[8]**

Q4) a) What are the different types of couplings in atomic spectroscopy? Explain in details. **[8]**

b) On the basis of Laue diffraction theory obtain the condition for diffraction maxima. **[8]**

Q5) a) Explain Debye model of lattice heat capacity. **[8]**

b) What are normal & umlelapp processes. **[4]**

c) Explain what do you mean by configurational entropy. **[4]**

Q6) a) Derive the expression for concentration of vacancies in Frankel defect. **[8]**

b) Derive dispersion relation for vibrations in a linear diatomic lattice. Hence explain optical and acoustic modes. **[8]**

Q7) a) What are the drawbacks of Einstein model? Explain the reasons. **[4]**

b) Write a note on edge dislocation. **[4]**

c) Describe an experiment which can detect defects in the solid. **[4]**

d) Calculate the magnetic field if the resonance frequency of 9530 MHz is observed in some ESR experiment. Given g = 2.0023. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 3**

P746

[4024] - 203
M.Sc. (Sem. - II)
PHYSICS
PHY UTN - 603 : Statistical Mechanics in Physics
(New Course) (2008 Pattern)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates:

1) *Question No. 1 is compulsory, attempt any four questions from the remaining questions.*
2) *Draw neat diagrams wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and electronic pocket calculators is allowed.*

Q1) Attempt any four of the following :

a) Consider a system consisting of two particles each of which can be in any one of three quantum states of respective energies 0, $\in$ and $3\in$. The system is in contact with a heat reservoir at absolute temperature T. Write an expression for the partition function Z, if the particles obey classical M.B. Statistics and considered distinguishable. **[4]**

b) Show that the single particle partition function for quantum mechanical oscillator is given by $Z = \left[2\sin h\left(\frac{\hbar w}{2KT}\right)\right]^{-1}$. **[4]**

c) Calculate the average potential energy of a molecule of an ideal gas in thermal equilibrium at absolute temperature T, contained in a cubical box of side L. Consider that the gravitational field is the only external field acting on the gas. **[4]**

d) Show that mean square deviation for the number of particles distributed according to grand canonical distribution is given by **[4]**

$$\overline{(\Delta N)^2} = KT\frac{\partial \overline{N}}{\partial \mu}.$$

e) A system consists of N weakly interacting particles, each of which can be in either of two states with respective energies $\in_1$ and $\in_2$. Calculate explicitly the mean energy of the system. **[4]**

f) An electric current of 1.5 Amperes passes through a wire of resistance 4 Ohms. The temperature of wire is maintained constant at 27°C by running cold water. Calculate the change in entropy of the universe in 30 sec. **[4]**

P.T.O.

Q2) a) Compare the basic postulates of M.B., B.E. and F.D. statistics. Hence, comment about the probabilities of particles coming together according B.E. and F.D. statistics. **[8]**

b) On the basis of canonical distribution obtain the curie law of paramagnetism. **[8]**

Q3) a) Write the partition function for Bose-Einstein statistics and hence obtain Bose Einstein distribution in the form $\overline{n_s} = \frac{1}{e^{\beta(\epsilon_s - \mu)} - 1}$. **[8]**

b) Discuss the behaviour of sharpness of probability curve and show that the fractional width of the maximum in P(E) is given by **[8]**

$$\frac{\Delta^* E}{\overline{E}} = \frac{1}{\sqrt{f}}.$$

Q4) a) What is black body radiation? Show that radiation pressure is equal to one third of the energy density. **[8]**

b) Show that the specific heat of strongly degenerate fermions is given by $C_v = \frac{\pi^2}{2} R \frac{T}{T_F}$. **[8]**

Q5) a) Show that for classical monoatomic ideal gas having particles contained in volume V, the number of states $\Omega(E)$ for the system in the energy range E and E + δE is given by $\Omega(E) = BV^N E^{3N/2}$. **[8]**

b) Explain, what do you mean by Bose-Einstein condensation. **[8]**

Q6) a) Use equipartition theorem to discuss the behaviour of molar specific heat of solid as a function of temperature. **[8]**

b) For grand canonical ensemble, show that the probability of finding the system in particular microstate having energy E_r is given by **[8]**

$$P_r = \frac{e^{-\beta E_r - \alpha N_r}}{\sum_r e^{-\beta E_r - \alpha N_r}}.$$

Q7) a) Obtain Maxwell-Boltzmann velocity distribution and prove the following quantities **[8]**

i) Mean Speed $\overline{V} = \left(\frac{8kT}{\pi m}\right)^{1/2}$.

ii) Vr.m.s. = $\sqrt{\frac{3kT}{m}}$.

b) State and discuss the behaviour of Fermi function under the following conditions. **[8]**

i) $\varepsilon = 0$.

ii) $\varepsilon << \mu$.

iii) $\varepsilon >> \mu$.

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Total No. of Questions : 7] [Total No. of Pages : 3

P747

[4024] - 204
M.Sc. (Sem. - II)
PHYSICS
PHY UTN - 604 : Quantum Mechanics - II
(New Course) (2008 Pattern)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates:

1) *Question No. 1 is compulsory. Attempt any four from the remaining.*
2) *Figures to the right indicate full marks.*
3) *Draw neat figures wherever necessary.*
4) *Use of mathematical tables and calculator is allowed.*

Q1) Attempt any four of the following : **[16]**

a) Find energy levels of Hamiltonian $H = \begin{pmatrix} 1+\in & \in \\ \in & -1+\in \end{pmatrix}$ where $\in << 1$; corrected to first order in $\in$ using perturbation theory.

b) Explain the term :

i) Identical particles and

ii) Symmetric and antisymmetric wave functions.

c) A system in an unperturbed state n is suddenly subjected to a constant perturbation $H^{'}(r)$ which exists during time 0 to t. Find probability of transition from n to k state and show that it varies simple harmonically with angular frequency $(E_k - E_n)/2\hbar$ and amplitud = $4/H^{'}_{kn}/^2/(E_k - E_n)^2$.

d) What is Born approximation? Discuss the conditions for its validity.

e) Show that the variation method gives an upper bound to the ground state energy.

f) The screened coloumb potential is represented by $v(r) = \frac{-Ze^2}{r}$, $e^{-\alpha r}$, where $\frac{1}{\alpha}$ has the dimension of length. For an electron incident on the atom find Born approximation amplitude $f_B(\theta)$.

P.T.O.

Q2) a) Explain the terms : Differential and total cross-section in scattering. Hence obtain the relation $\frac{d\sigma(\theta,\theta)}{d\Omega} = |f(\theta,\theta)|^2$. **[8]**

b) What is stark effect? Discuss it for first excited level of hydrogen atom. **[8]**

Q3) a) Starting from perturbation equations, obtain the first order and second order energy corrections in case of stationary non-degenerate cases. **[8]**

b) Condiser the scattering by square-well attractive potential given by

$$V(r) = -V_0 \quad 0 < r < a$$
$$= 0 \quad r > a$$

obtain the expression for phase shift δ_0 for scattering by s-waves. **[8]**

Q4) a) Define exchange operator in case of a system of identical particles. 1 and 2. Find its eigen values. Hence **[8]**

i) explain symmetric and antisymmetric wave functions

ii) show that it commutes with hamiltonian operator $\hat{H}(1, 2)$.

b) Using variation method, obtain the ground state energy of hydrogen atom, where the trial wave function is $\psi(r) = e^{-\alpha r}$ where α is trial parameter for variation. **[8]**

Q5) a) Discuss WKB approximation and explain the conditions for its validity. **[6]**

b) Using the partial wave analysis, obtain the expression for scattering amplitude in terms of phase shift and total scattering cross-section. Hence discuss optical theorem. **[10]**

Q6) a) Explain in brief the time dependent perturbation theory and obtain expression for first order amplitude $a_n^{(1)}(t)$. **[10]**

b) Obtain slater determinent for a system of N-identical fermions. **[6]**

Q7) a) In case of scattering by rigid sphere of radius a, show that the scattering cross-section for s wave is $4\pi a^2$. **[4]**

b) Show that the symmetry of a quantum system implies the existance of constant of motion. **[4]**

c) Explain selection rules for electric dipole transitions. **[4]**

d) A simple harmonic oscillator of mass m_0 and angular frequency ω is perturbed by an additional potential bx^3. Evaluate the second order correction to the ground state energy of the oscillator. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 2**

P748

[4024] - 301
M.Sc. (Sem. - III)
PHYSICS
PHY UTN - 701 : Solid State of Physics
(New Course) (2008 Pattern)

Time : 3 Hours] ***[Max. Marks : 80***

Instructions to the candidates:

1) *Question No. 1 is compulsory, attempt any four questions from the remaining.*
2) *Draw neat labelled diagrams wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and pocket calculator is allowed.*

Given

Rest mass of electron	= 9.109×10^{-31} kg
Charge of electron	= 1.6021×10^{-19} C.
Planck's constant	= 6.626×10^{-34} J–s
Boltzmann constant	= 1.3805×10^{-23} JK^{-1}
Avogadro's number	= 6.0225×10^{26}(kilomole)$^{-1}$
Bohr Magneton	= 9.27×10^{-24} A–m^2
Permeability of free space	= $4\pi \times 10^{-7}$ Henry/m.
Permittivity of free space	= 8.85×10^{-12} C^2/N–m^2.

Q1) Attempt <u>any four</u> of the following : **[16]**

a) A copper wire of length 0.5 metre and diameter 0.3 mm has a resistance 0.12 Ω at 20°C. If the thermal conductivity of copper at 20°C is 390 Wm^{-1}K^{-1}, calculate Lorenz number.

b) A magnetic material has a magnetization of 3300 A/m and flux density of 0.0044 Wb/m^2 Calculate the magnetizing force and relative permeability of the material.

c) The relaxation time of conduction electron in copper is 2.5×10^{-14} sec. Find the thermal conductivity of copper at 0°C. Assume density of electrons to be 8.5×10^{28}/m^3.

d) Calculate the critical current which can flow through a long thin superconducting wire of Al of diameter 10^{-3}m. The critical magnetic field for Al is 7.9×10^3 A/m.

e) The London penetration depths for Pb at 3k and 7.1 k are respectively 39.6 nm and 173 nm. Calculate it's transition temperature as well as the depth at ok.

f) The relative permittivity of argon at 0°C and one atmosphere is 1.000435. Calculate the polarizability of the atom.

P.T.O.

Q2) a) Define dielectric function of the free electron gas and derive the expression for plasma frequency. **[8]**

b) Distinguish between reduced zone, extended zone and periodic zone scheme of representing energy bands. **[8]**

Q3) a) Draw neat diagrams showing construction of 2-D fermi surfaces in first, second and third Brillowin zones. Explain and interpret these diagrams. **[8]**

b) For an atom placed at general lattice site, derive an expression for local electric field Elocal. Explain each term in the expression. **[8]**

Q4) a) Derive London equation for superconducting state and obtain an expression for the penetration depth. **[8]**

b) Distinguish between ferromagnetism, antiferromagnetism and ferrimagnetism. **[8]**

Q5) a) Explain the origin of diamagnetism in a free atom. Derive Langevin's diamagnetism equation for the diamagnetic susceptibility. **[8]**

b) Explain Antiferromagnetism with reference to Neel temperature and susceptibility. Hence describe ferrimagnetism. **[8]**

Q6) a) What are the assumptions of BCS theory of superconductivity. **[8]**

b) State and explain Bloch theorem. **[4]**

c) What is cyclotron resonance? **[4]**

Q7) a) Explain Meissner effect in superconductivity. **[4]**

b) The atomic radius of sodium is 1.86Å. Calculate the fermi energy of sodium at absolute zero. **[4]**

c) Describe the term 'Bloch wall' with reference to magnetism. **[4]**

d) Determine the percentage of ionic polarizability in the sodium chloride crystal which has the optical index of refraction and static dielectric constant as 1.5 and 5.6 respectively. **[4]**

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Total No. of Questions : 7] **[Total No. of Pages : 2**

P749

[4024] - 401
M.Sc. (Sem. - IV)
PHYSICS
PHY UTN - 801 : Nuclear Physics
(New Course) (2008 Pattern)

Time : 3 Hours] *[Max. Marks : 80*

Instructions to the candidates:

1) *Question No. 1 is compulsory, attempt any four questions from the remaining.*
2) *Draw neat figures wherever necessary.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables and pocket calculator is allowed.*

Q1) Attempt any four of the following :

a) Show that the electrical quadrupole moment of a charge ze, over a ring of radius R can be expressed in terms of charge density ρ and electrostatic potential ϕ. **[4]**

b) Calculate the radiation loss for 1Mev 'β' particles in Pb. Calculate the β energy for which these losses are equal to Pb (z = 82). **[4]**

c) For energy filters in mass spectrometers, show that, $\frac{1}{2}mv^2 = \frac{neVRo}{2d}$, where the symbols have usual meanings. **[4]**

d) Calculate the half value thickness for β absorption in aluminium for the β spectrum with E_{max} = 1.17MeV, Density of Al = 2.7 gm/cm^3.**[4]**

e) Calculate the range of 9 MeV α particles in aluminium, if the relative stopping power of Aluminium is 1700. Also calculate the thickness of aluminium that is equivalent in stopping power to 1 meter air ρ_{Al} = 2700 kg/m^3. **[4]**

f) What is the distance of closest approach of a 2 MeV proton to a gold nucleus? How does this distance compare with those for a deuteron and an α-particle of the same energy.

Z for gold = 79, e = 1.6 × 10^{-19} Coulomb, $\frac{1}{4\pi\in_o} = 9\times10^9 \frac{N\text{ - }m^2}{c^2}$.**[4]**

P.T.O.

Q2) a) Explain the concept of nuclear magnetic moment and show that,

$$\mu = \mu_s + \mu_l = \frac{\mu_0 e}{2m}\,(g_s.s + g_l.l).$$ **[8]**

b) What is straggling? Derive the formula for straggling when a charged particle is moving through the matter. **[8]**

Q3) a) Calculate the electric Quadrupole moment of a charge of magnitude Ze, over a ring of radius R and with axis along z axis. **[8]**

b) Describe the electron scattering method to measure the radius of nucleus. **[8]**

Q4) a) Give important features of Gamow's theory of α-decay. **[8]**

b) With the help of suitable diagram describe the construction and working of Bainbridge and Jordan mass spectrometer. **[8]**

Q5) a) Derive Bethe's formula for stopping power of a charged nuclear particle when it moves through matter. Also show that stopping power doesnot depend on the mass of the particle but its only a function of its charge and velocity. **[8]**

b) What are quarks? Explain how quarks are treated as building blocks of hadrons and mesons. **[8]**

Q6) a) Discuss the effective range theory of low energy in np scattering. **[8]**

b) Discuss the principle, construction and working of a microtron. **[8]**

Q7) a) Write a note on mirror nuclei. **[4]**

b) Define and explain the term effective range. **[4]**

c) Define scattering length write the expression for it and interprete the same. **[4]**

d) Write down any two properties of π meson. **[4]**

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