Total No. of Questions : 7]

SEAT No. :

P594

[Total No. of Pages : 2

[4124] - 101

M.Sc. (Sem. - I)

PHYSICS

PHY UTN - 501 : Classical Mechanics

(2008 Pattern)

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

Instructions to the candidates:

1) ***Question No. 1 is compulsory and 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 calculator is allowed.***

Q1) Attempt any four of the following :

a) Obtain the equation of motion of a Atwood's machine by using Lagrangian method. **[4]**

b) Prove that $\frac{d}{dt}[F,G]=\left[\frac{dF}{dt},G\right]+\left[F,\frac{dG}{dt}\right]$. **[4]**

c) A bead moves on a circular wire. Specify the type of constraint. **[4]**

d) A particle of mass m moves under the action of central force whose potential is $V_{(r)} = kmr^3$ (K > 0), then for what kinetic energy and angular momentum will the orbit be a circle of radius R about the origin? **[4]**

e) Prove that generating function $F = \Sigma q_i p_i$ generates identity transformation. **[4]**

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

Q2) a) Explain variational principle. Show that the shortest distance between two points in a plane is a straight line. **[8]**

b) Show that $Q = \ln\frac{\sin p}{q}$, $P = q \cot p$ are canonical. Find corresponding F_1 and F_2. **[8]**

P.T.O

Q3) a) What is Focault's pendulum? Obtain an equation of motion for such a pendulum. **[8]**

b) Show that $Q = \sqrt{2q}\ e^{t} \cos p \ and\ P = \sqrt{2q}\ e^{-t} \sin p$ are canonical. **[8]**

Q4) a) Prove the Poisson's bracket. **[8]**

$[L_x, L_y] = L_z$.

b) State and prove viral theorem. **[8]**

Q5) a) Evaluate the poisson's bracket's **[8]**

i) $[L_x, x]$ ii) $[L_x, P_x]$

b) Obtain the Hamiltonian and equation of motion for a projectile near the surface of the earth. **[8]**

Q6) a) Deduce the Lagrangian function and Lagrange's equation of motion for a compound pendulum. Also calculate the period of its oscillation. **[8]**

b) Show that the transformation $P = \frac{1}{2}\left(p^2 + q^2\right)$ and $Q = \tan^{-1}\left(q/p \right)$ is canonical. **[8]**

Q7) a) What are configuration space and phase space. Draw phase space diagram for **[8]**

i) Damped and undamped harmonic oscillator.

ii) A stone thrown vertically up in the field of uniform gravity.

b) Explain artificial satellite. **[4]**

c) Explain the different types of constraints. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P595

[Total No. of Pages : 2

[4124] - 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 tables and non-programmable calculator is allowed.***

Q1) Attempt any four of the following :

a) An op-amp is used in following modes with $R_1 = 1k\Omega$ and $R_f = 100k\Omega$, $V_i = 120$ mV and $V_{cc} = \pm 12$ V. Find output V_o in each case. **[4]**

i) Inverting mode ii) Noninverting mode

b) Using 4-bit k-map, design a circuit for election vote counter system for 4 candidates. The output is valid if one key is depressed. Draw the necessary logic diagram. **[4]**

c) Design mode 27 operation using BCD counters. **[4]**

d) Explain the concept of CVCC and fold back current limiting power supply. **[4]**

e) How capacity 'C' charges in voltage controlled oscillator using IC 566? Find the output frequency with the following data. **[4]**

$V^+ = 10$ V, $V_c = 8$ V, $R_1 = 10$ kΩ and $C_1 = 0.1$ μF

f) For 10-bit DAC if $V_{ref} = 10.240$V, find the following **[4]**

i) The output voltage for an input of 0100010100.

ii) The digital input for output of 4.230V.

g) Design 1:8 demultiplexer using 1:4 demultiplexer. **[4]**

Q2) a) Design a function generator circuit using op-amps for an output frequency of 20kHz. Draw the necessary output waveforms. **[8]**

b) Draw a circuit diagram of shift register using IC-7495 to explain SISO, SIPO, PISO and PIPO operation. **[8]**

Q3) a) Derive the necessary output relation for Instrumentation Amplifier. How instrumentation amplifier is differ from ordinary op-amp **[8]**

b) Obtain the output for 3-bit DAC employing resistor of R-2R network. Explain the advantages over binary weighted resistor network. **[8]**

Q4) a) Design foldback current limit power supply for 20V, 1Amp. **[8]**

b) Explain in detail 3-bit simultanous A/D converter circuit with reference to logic equation logic table (comparator outputs for input voltage ranges and binary output). What is the conversion time for circuit? **[8]**

Q5) a) Explain the working of a PLL-IC 565 with the help of block diagram. Calculate the free running centre frequency f_O, lock range frequency f_L and capture range frequency f_C for the following data. **[8]**

$V_{cc} = \pm 10V$, $R_1 = 6k\Omega$. $C_1 = 0.01\ \mu F$, $C_2 = 10\ \mu F$.

b) Explain the working of a full wave precision rectifier circuit. Sketch input and output waveforms. **[6]**

c) How to obtain dual power supply of ± 15v from single power supply of 30V? **[2]**

Q6) a) Design the wide Band Pass Filter with $f_L = 100Hz$, $f_H = 1kHz$ and a pass band gain of 4. Calculate the value of Q for this filter. **[8]**

b) Obtain a pulse width of 1ms for monostable multivibrator using IC-555 timer and IC-74121. **[4]**

c) Implement the following using 4:1 multiplexer $F(A, B, C) = \Sigma m(1, 3, 5, 6)$. **[4]**

Q7) Write a short notes on any four of the following: **[16]**

a) Cellular phone

b) Sample and Hold circuit

c) DC to DC converter

d) Notch filter

e) Conversion time for Dual-slope, counter type, successive approximation type.

f) UPS and Inverters.

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Total No. of Questions : 7]

SEAT No. :

P596

[Total No. of Pages : 3

[4124] - 103

M.Sc. (Sem. - I)

PHYSICS

PHY UTN - 503 : Mathematical Methods in Physics

(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 tables and pocket calculator is allowed.***

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

a) Show that $f(z) = z^2$ is analytical function of z.

b) Determine whether the set of vectors:

$V_1 = (2, 1, 0, 3)$; $V_2 = (3, -1, 5, 2)$ and $V_3 = (-1, 0, 2, 1)$ is linearly independent.

c) Show that the Legendre polynomials satisfy the orthogonality conditions:

$$\int_{-1}^{+1} P_n(x)\, P_m(x)\, dx = 0 \quad \text{where } n \neq m.$$

d) Obtain Laplace transform of Dirac delta function.

e) Prove the convolution Theorem for fourier transform.

f) Find: $L \int_0^1 \frac{\sin x}{x} dx$.

Q2) a) Find a series of sines and cosines of multiples of x which will represent x^2 in the interval of $-\pi < x < \pi$. Hence deduce that : **[8]**

$$\frac{\pi^2}{6} = \sum_{n=0}^{\infty} \frac{1}{n^2} = 1 + \frac{1}{2^2} + \frac{1}{3^2} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

P.T.O

b) Find eigen values and eigen vectors of the matrix:

$$A = \begin{bmatrix} -1 & 4 & -2 \\ -3 & 4 & 0 \\ -3 & 1 & 3 \end{bmatrix}$$ **[8]**

Q3) a) Prove the Cauchy integral formulae : $\oint \frac{f(z)}{(z-z_0)} dz = 2\pi i\, f(z_0)$. **[8]**

b) Prove the following recurrence relations for Laguerre polynomials $L_n(x)$:

i) $L_{n+1}(x) + (x - 2n + 1)\, L_n(x) + n^2 L_{n-1}(x) = 0$.

ii) $L_n'(x) = n\, L_{n-1}'(x) - n\, L_{n-1}(x)$. **[8]**

Q4) a) Using convolution theorem for Laplace's transform, evaluate:

$$L^{-1}\left\{\frac{s^2}{(s^2+a^2)(s^2+b^2)}\right\} \text{ with } a \neq b.$$ **[8]**

b) Apply the calculus of residue to prove that : $\int_0^{2a} \frac{\cos 2\theta}{5+4\cos\theta} d\theta = \frac{\pi}{6}$. **[8]**

Q5) a) Using Gram - Schmidth orthogonal process; construct the lowest three Hermite polynomials:

Given : $U_n(x) = x^n$

$W_n(x) = e^{-x}$

where $n = 0, 1, 2, \ldots\ldots\ldots\ldots\ldots (-\infty < x < \infty)$. **[8]**

b) Show that by direct differentiation:

$$J_n(x) = \sum_{x=0}^{\infty} \frac{(-1)^s}{s!(n+s)!}\left(\frac{x}{2}\right)^{n+2s}$$ satisfy the recurrence relation

$$J_{n-1}(x) + J_{n+1}(x) = \frac{2n}{x} J_n(x)$$ **[8]**

Q6) a) State and prove Residue theorem. **[8]**

b) Solve the differential equation using Laplace transform: **[8]**

$Y'' - 3Y' + 2Y = 2e^{-t}$

$Y(0) = 2$ and $Y'(0) = -1$

Q7) a) i) State and prove Cauchy - Schwart identity and show that **[4]**

$|< u, v >| \leq \|u\| \cdot \|v\|$.

ii) Show that eigen values of Hermitian matrice are real numbers. **[4]**

b) Find the fourier integral of the function: **[8]**

$$F(x) = \begin{cases} 0 & \text{when } x < 0 \\ \frac{1}{2} & x = 0 \\ e^{-x} & x > 0 \end{cases}$$

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Total No. of Questions : 7]

SEAT No. :

P597

[Total No. of Pages : 2

[4124] - 104

M.Sc. (Sem. - I)

PHYSICS

PHY UTN - 504 : Quantum Mechanics - I

(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) ***Draw neat figures 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 : **[16]**

a) For an arbitrary operator A show that

i) $A^{+}A$ is hermitian   ii) $<A^{+}A> \geq 0$

b) Show that $(xp_x)^2 \neq x^2 p_x^2$ where x & p_x are operators.

c) For simple harmonic oscillator show that $(u_n, x^2 u_n) = \frac{(2n+1)\hbar}{2mw}$.

d) Prove $L^2 = L - L + \ + L_z^2 + \hbar L_z$ for the angular momentum operators.

e) Estimate the ground state energy of linear harmonic oscillator using uncertainty relation.

f) Let $\alpha = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\beta = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$. Show that α and β are eigen vectors of pauli spin matrix σ_z.

Q2) a) Write a note on Heisenberg picture of time evolution. Discuss its resemblance with Hamiltonian eq^n in classical mechanics. **[8]**

b) Consider two commutating operators A and B. Show that they share same set of eigen function denoted as Q_{ab}. Show how this is used for the removal of degeneracy. **[8]**

Q3) a) Write the statements of orthonormality, expansion postulate and closure property for a set $\{Q_a\}$. Prove the closure property. **[10]**

b) Define i) Adjoint of an operator ii) Hermitian operator. Prove that momentum operator is hermitian operator. **[6]**

Q4) a) Obtain the coefficients $C_{lm}^{\pm}$ in equation $L_{\pm}|l, m> = C_{lm}^{\pm}|l, m \pm 1>$ where $|l, m>$ are simultaneous eigen states of L^2 and L_z operators and L_+ & L_- are raising and lowering operators. **[8]**

b) Draw diagram for square well potential barrier of height V_o. Write potential energy conditions and boundary conditions. Write schrodinger equations for 3 regions for $E < V_o$. Draw diagram for wave functions and explain tunneling qualitatively. **[8]**

Q5) a) Obtain Clebsh-gorden coefficients for a system of two non-interacting particles with angular momentum $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. **[8]**

b) i) Prove that $(L_z/\hbar)$ generates infinitesimal rotation. **[4]**

ii) Write Pauli Spin Matrices σ_x, σ_y and σ_z. Show that they are unitary. **[4]**

Q6) a) Consider a linear operator $\hat{F}$ such that $F|\psi> = |\chi>$ where $|\psi>$ and $|\chi>$ are arbitrary vectors. Represent $\hat{F}$ as a matrix element in A representation. **[8]**

b) In case of abstract formulation define

i) State vectors

ii) Basis of Hilbert space

iii) Quantum condition and

iv) Projection operator $\hat{P}_a$.

Prove that $\sum_a \hat{P}_a |\psi> = |\psi>$. **[8]**

Q7) a) Show that the eigen values of a self-adjoint operator are real. **[4]**

b) Define operators a and a^+. Prove the relation $H = (a^+ a + \frac{1}{2})\hbar w$ for simple harmonic oscillator. **[4]**

c) State postulates 1 and 2 of Quantum Mechanics. **[4]**

d) For $j = \frac{1}{2}$, obtain matrix of J_x. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P598

[Total No. of Pages : 3

[4124] - 201

M.Sc. (Sem. - II)

PHYSICS

PHY UTN - 601 : Electrodynamics

(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 log-tables and calculator is allowed.***

Q1) Attempt any four of the following :

a) Determine skin-depth in sea water with conductivity $\sigma = 5\ (\Omega m)^{-1}$ at 10GHz. $\mu = \mu_0 = 4\pi \times 10^{-7}$ Wb/A-m. **[4]**

b) An electron is accelerated from rest to a speed of 0.9995C in a particle accelerator. Determine the electron's kinetic energy. **[4]**

c) Find from poynting flow the value of intensity of magnetic field at a distance of 100cm from a radiating source of power 10kW. Given $\sqrt{\frac{\mu_0}{\epsilon_0}} = 377\,\Omega$. **[4]**

d) A rocket travels directly away from earth with a velocity of 0.7C. A missile is launched from the rocket with a velocity of 0.8C relative to the rocket towards earth. Determine the velocity of the missile relative to earth. **[4]**

e) Prove that :

$$\vec{E}\cdot\frac{\partial\vec{D}}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2}\vec{E}\cdot\vec{D}\right) \textit{ and } \vec{H}\cdot\frac{\partial\vec{B}}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2}\vec{H}\cdot\vec{B}\right)$$ **[4]**

f) Describe magnetic interaction between two current loops. **[4]**

P.T.O.

Q2) a) 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 :

$$-\int_v (\vec{j}.\vec{E})\, dv = \frac{d}{dt}\int_v \tfrac{1}{2}(\vec{E}.\vec{D}+\vec{B}.\vec{H})\, dv + \int_{cs} (\vec{E}\times\vec{H})\, ds$$ **[8]**

b) Show that $C^2 B^2 - E^2$ and $\vec{E}\cdot\vec{B}$ are invarient under Lorentz transformations. **[8]**

Q3) a) Derive the Lorentz relativistic transformation equations. **[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 $\vec{\nabla}\times\vec{B} = \mu_0\, j$. **[8]**

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

b) Explain the term 'electromagnetic field tensor'. Hence obtain an expression for e.m. field tensor $F_{\mu\nu}$. **[8]**

Q5) 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 velocity $\vec{u}$. **[8]**

b) Prove that the space-interval $x^2 + y^2 + z^2$ is not invariant under Lorentz transformations, while the combined space-time interval $x^2 + y^2 + z^2 - c^2 t^2$ is Lorentz invariant. **[8]**

Q6) a) Explain concept of an oscillating electric dipole. Hence derive the expressions for electric and magnetic field radiations, when the length of the dipole is extremely small compared with the wavelength of radiation. Explain the term 'radiation resistance'. **[8]**

b) Write Maxwell's equations for a stationary medium. Show that in a charge-free region the Maxwell's equations lead to $\nabla^2 E - \mu \in \frac{\partial^2 \vec{E}}{\partial t^2} - \mu\, \sigma \frac{\partial \vec{E}}{\partial t} = 0$ which of the above term is predominant in metals. **[8]**

Q7) a) Explain the term 'Four Vector Potential'. **[4]**

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

c) Determine the velocity at which the mass of a particle is double its rest mass c = 3 $\times 10^8$ m/sec. **[4]**

d) A plane electromagnetic wave travels in an unbounded lossless dielectric medium having relative permeability $\mu_r = 1$ and relative permittivity $\in_r = 3$. Determine intrinsic impedance of the medium. Given $\sqrt{\frac{\mu_0}{\in_0}} = 377\Omega$. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P599

[Total No. of Pages : 2

[4124] - 202

M.Sc. (Sem. - II)

PHYSICS

PHY UTN - 602 : Atoms, Molecules and Solids

(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 diagram wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and electronic pocket calculator is allowed.***

Given

Rest mass of electron	= 9.109×10^{-31} kg
Charge on the electron	= 1.6021×10^{-19} coulomb
Plank's constant	= 6.626×10^{-34}Js
Boltzmann constant	= 1.38054×10^{-23} JK^{-1}
Avogadro'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 <u>any four</u> of the following : **[16]**

a) Find the minimum magnetic field needed for Zeeman effect to be observed in a spectral line of 400 nm wavelength, when a spectrometer whose resolution is 0.010 nm is used.

b) For Aluminium $C_l = 6.32 \times 10^3$ m/s and $C_t = 3.1 \times 10^3$ m/s. The density of Aluminium is 2.7×10^3 kg/m^3 and atomic weight is 26.97. Calculate the Debye frequency for Aluminium.

c) The concentration of Schotty defects in an ionic crystal is 1 in 10^{10} at temperature 300 K. Estimate the energy of the vacancy pair.

d) In NMR of ^{14}N with I = 1, how many spectral lines will be observed? Calculate the frequency required for NMR line at external field 1.4 Tesla (^{9}N = 0.403)

e) The Zeeman splitting of 500 nm spectral line when magnetic field of 0.4T is applied is observed as 0.016 nm find e/m.

f) Determine Lande's g factor for $^2f_{5/2}$.

P.T.O

Q2) a) Explain Paschen - Back effect for 2s–2p transition. **[8]**

b) Derive an expression for the specific heat of solid based on Einstein model. What are the drawbacks of this model. **[8]**

Q3) a) State the principle of ESR. Explain working of ESR spectrometer with the help of a block diagram. **[8]**

b) Define dissociation energy and calculate it in case of diatomic molecule. **[8]**

Q4) a) Write a note on vibrational course structure explaining and progression? Explain with the help of necessary diagrams. **[8]**

b) Explain the theory of geometric structure factor and derive an expression for fcc lattice. **[8]**

Q5) a) State and explain Frank - condon principle. **[8]**

b) Write notes on : **[8]**

i) Screw dislocation ii) Edge dislocation

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

b) Discuss the vibrational modes of one dimensional monoatomic lattice of identical atoms. Hence derive the dispersion relation. **[8]**

Q7) a) What are normal and Umklapp processes? **[4]**

b) Obtain an expression for configurational entropy **[4]**

c) Explain concept of photon and quantization of elastic waves. **[4]**

d) Calculate the highest possible frequency for silicon if the Debye temperature is 570 K. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P600

[Total No. of Pages : 4

[4124] - 203

M.Sc. (Sem. - II)

PHYSICS

PHY UTN - 603 : Statistical Mechanics in Physics

(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 calculator is allowed.***

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

a) Determine the phase trajectory of a bullet of unit mass fired straight upwards with an initial speed of 392 m/s. Acceleration due to gravity is 9.8 m/s^2. **[4]**

b) Show that entropy of the composite system is equal to the sum entropies of all sub-systems, $S = S_1 + S_2 + S_3 + \ldots\ldots\ldots\ldots\ldots\ldots$ **[4]**

c) Helmholtz energy $\overline{F} = \overline{E} - TS = -kT\,ln Z$ show that **[4]**

i) $$\overline{E} = \frac{\partial(\beta F)}{\partial \beta}$$

ii) $$C_V = -k\beta^2\left[\frac{\partial^2(\beta F)}{\partial \beta^2}\right]$$

P.T.O

d) The partition function for monoatomic ideal gas of N identical particles is

$$Z = V^N \left(\frac{2\pi m}{\beta h^2} \right)^{3/2 N}$$

Hence show that mean pressure $\overline{P} = \frac{NK\pi}{V}$. **[4]**

e) Determine whether the electron gas in copper at room temperature is degenerate or non-degenerate. **[4]**

Given : Concentration of electrons in copper is 8.5×10^{28} m^{-3}.

f) Derive an expression for the compressibility of a Fermi gas at absolute zero temperature. **[4]**

Q2) a) For canonical ensemble, show that probability of finding the system in a particular microstate 'r' having energy E_r is given by

$$P_r = \frac{\bar{e}^{\beta E_r}}{\sum_r \bar{e}^{\beta E_r}}$$ **[8]**

b) Show that the mean pressure of the photon gas is related to mean energy by the relation $\overline{P} = \frac{1}{3} \frac{\overline{E}}{V}$. **[8]**

Q3) a) Show that if energy $\in$ depends on generalised coordinates q and its conjugate momentum p in such way that $\in \to \infty$ as p or q tends to $\pm \infty$, the following generalization of equipartition theorem is valid.

$$< q \frac{\partial \in}{\partial q} > = < p \frac{\partial \in}{\partial p} > = kT$$ **[8]**

b) A single molecule of mass m in a spherical enclosure of volume V has energy that can vary from 0 to E. Show that the number of accessible microstates ϕ of the molecule is $\phi = \frac{4\pi V}{3h^3} (2mE)^{3/2}$. **[8]**

Q4) a) In case of Bose - Einstein condensation for $T < T_B$, Prove that **[8]**

$$N = N_o + N\left(\frac{T}{T_B}\right)^{3/2}$$

where N – total number of particles and

N_o – number of particles in ground state.

b) Using canonical distribution, obtain the law of atmosphere.

$P(z) = P(o)\ e^{-mgz/k\pi}$ **[8]**

Q5) a) Show that the specific heat of a strongly degenerate fermi gas is given by

$$C_v = \frac{\pi^2}{2} \cdot R\frac{T}{T_F}$$ **[8]**

b) State the partition function for M.B. Statistics and show that the quantum distribution function for M.B. distribution is $\bar{n}_r = \frac{N\ \bar{e}^{\beta\epsilon_r}}{\sum_r \bar{e}^{\beta\epsilon_r}}$. **[8]**

Q6) a) A simple harmonic 1–D oscillator has energy levels given by

$E_n = \left(n + \frac{1}{2}\right)\hbar w.$

Where w is angular frequency of the oscillator and the quantum number n can assume the possible integral values n = 1, 2, 3, ... etc. Suppose that such oscillator is in contact with a heat reservoir at temperature T low enough so that $kT << \hbar w$:

i) Find the ratio of probability of the oscillator being in the first excited state to the probability of its being in the ground state.

ii) Assuming that only the ground state and the first excited state are appreciable occupied, find the mean energy of the oscillator as a function of the temperature. **[8]**

b) Obtain maxwell velocity distribution and hence show that root mean square speed V_{rms} to the mean speed $\overline{V}$ to the most probable speed $\tilde{V}$ is given by

$$V_{rms} : \overline{V} : \tilde{V} = \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$$ **[8]**

Q7) a) Obtain stefan's law of radiation, $E = 6T^4$ in case of black body radiation. **[8]**

b) i) Consider the gas at room temperature and pressure, the values of which and constants are given below :

Mean pressure (P) = 10^6 dyne/cm^2

Temperature T = 300°K

Boltzmann constant K = 1.38×10^{-16} erg/degree

Planck's constant h = 6.625×10^{-27} erg-s

Find mean separation between the molecules of gas and de Broglie wavelength associated with it. **[4]**

ii) Prove the following relation : **[4]**

$$\left[\frac{\overline{(\Delta E)^2}}{(\bar{E})^2}\right]^{\frac{1}{2}} = \left(\frac{2}{3N}\right)^{\frac{1}{2}}$$

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Total No. of Questions : 7]

SEAT No. :

P601

[Total No. of Pages : 3

[4124] - 204
M.Sc. (Sem. - II)
PHYSICS
PHY UTN - 604 : Quantum Mechanics - II
(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 allowed.*

Q1) Attempt any four of the following.

a) The harmonic oscillator is perturbed by $H' = bx^4$. Obtain first order perturbation in energy in n[th] state.

$$\left(\text{Given}: < n | x^4 | n >= \frac{3}{4\alpha^2}(2n^2 + 2n + 1)\right)$$ **[4]**

b) Interpret the concept of Identical particles. What is difference between bosons and fermions? **[4]**

c) State the conditions for the validity of Born Approximation for scattering. **[4]**

d) Apply the WKB method to calculate the energy eigen values corresponding to harmonic oscillator potential, $v(x) = \frac{1}{2} m w^2 x^2$. **[4]**

e) Using trial wave function $\psi(x) = Ae^{-\alpha x^2}$, where α is variation parameter, obtain an upper bound for ground - state energy of linear harmonic oscillator. **[4]**

f) The transition probability for constant perturbation from time 0 to t is given by

$$\left|a_m^{(1)}(t)\right|^2 = \frac{|H'_{ml}|}{\hbar^2} \cdot \frac{4\sin^2\left(W_{ml}\frac{t}{2}\right)}{w_{ml}^2}$$

Interpret it graphically as a function of w_{ml} for fixed t. **[4]**

P.T.O.

Q2) a) What is harmonic perturbation? Calculate transition probability per unit radiation of intensity of a harmonic perturbation. **[8]**

b) State connection formulae for WKB approximation. Obtain the Bohr - Sommerfeld quantum condition for potential well. **[8]**

Q3) a) Deduce the expression for scattering amplitude using Born Approximation for a potential given as

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

Also find total scattering cross - section in the low energy limit. **[8]**

b) Discuss the time - independent perturbation theory for non - degenerate stationary state. Obtain first order corrected eigen functions and eigen values. **[8]**

Q4) a) Construct symmetric and antisymmetric wave - functions for two - electron atoms. **[8]**

b) The infinite square potential well is described by

$$V = 0 \quad -a < x < a$$
$$V = \infty \quad |x| > a$$

Using trial wave function $\psi(x) = (a^2 - x^2)(1 + \alpha x^2)$ estimate the ground state energy by variational method. α is variational parameter. **[8]**

Q5) a) Using WKB method obtain expression of transmission for a slowly varying potential barrier $V(x)$. **[8]**

b) Show that the Born scattering amplitude is proportional to the spatial Fourier transform of the scattering potential with respect to the momentum transfer. **[8]**

Q6) a) A one - dimensional harmonic oscillator with angular frequency w_0 and electric charge 'q' is perturbed by an electric field ε such that the perturbation is $H'(t) = -q\varepsilon x$ for $0 \leq t \leq t$. Using first order perturbation theory, calculate the probability of transition from ground state to first excited state. **[8]**

b) Using partial wave analysis show that the total scattering cross - section is given by

$$\sigma = \frac{4\pi}{k^2} \sum_{l=0}^{\infty} (2l+1) \sin^2 \delta_l$$ **[8]**

Q7) a) Show that exchange operator $\hat{p}$ for identical particles commute with Hamiltonian operator. **[4]**

b) Show that stark effect in ground state of hydrogen atom is zero. **[4]**

c) Obtain the relation between scattering angles in laboratory frame and centre of mass frame. **[4]**

d) State and explain Pauli's Exclusion principle for system of two identical particles. **[4]**

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Total No. of Questions : 7]

SEAT No. :

P602

[Total No. of Pages : 2

[4124] - 301
M.Sc. (Sem. - III)
PHYSICS
PHY UTN - 701 : Solid State of Physics
(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) ***Figures to the right indicate full marks.***
3) ***Draw neat labelled diagram wherever necessary.***
4) ***Use of logarithmic table 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 any four of the following : **[16]**

a) Electrical resistivity of Ni at R.T. is 14×10^{-8} Ωm. If Wiedemann–Franz law applies to this material, find the electronic contribution of the thermal conductivity of Ni at 27ºC.

b) For a simple square lattice, calculate K.E. of free electron at the corner and at the mid point of the side face of the 1st Brillouin zone. How are these two values related?

c) At what temperature we expert 10% probability of the electron in silver have energy 1% above Fermi level E_F = 5.5 eV.

d) Calculate the critical current which can flow through a long thin superconducting wire of Al of diameter 1mm. The critical magnetic field for Al is 8×10^3 A/m.

e) A paramagnetic material has 10^{28} atoms/m^3. The magnetic moment of each atom is 1.8×10^{-23} A–m^2. Calculate the paramagnetic susceptibility at 300 K.

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

P.T.O

Q2) a) For an atom placed at general lattice site, derive an expression for local electric field E_{local}. Explain each term in the expression. **[8]**

b) Define dielectric function $\in(w, k)$. For long wavelength region obtain an expression $\in(w) = 1 - \frac{wp^2}{w^2}$ where symbols carry usual meaning. Plot this equation graphically and thus explain attenuation of the wave. **[8]**

Q3) a) Discuss the nearly free electron model and explain how it leads to the formation of forbidden gap and band structure. **[8]**

b) With the help of diagrams explain the concept of reduced, extended and periodic zone schemes used for the representation of energy bands. **[8]**

Q4) a) Explain the quantum theory of paramagnetism and obtain curie law. Discuss the behaviour of rare earth ions. **[8]**

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

Q5) a) Distinguish between ferromagnetism, ferrimagnetism and antiferromagnetism. **[8]**

b) Discuss the origin of diamagnetism in a free atom. Obtain Langevin's diamagnetism equation for the diamagnetic susceptibility. **[8]**

Q6) a) Prove that the entropy of a superconductor is lesser than that of a normal metal. Interpreat the result. **[8]**

b) Draw a suitable diagram for the hysteresis loop for a magnetic material and explain the same. **[4]**

c) Discuss the term 'Anisotropy Energy' with reference to magnetization. **[4]**

Q7) a) Define Bloch function and write a note on it. **[4]**

b) Write a note on Fermi-Dirac statistics. Explain it's temperature dependance with the help of neat diagram. **[4]**

c) A superconducting material has a critical temperature of 3.7 K in zero magnetic field and a critical field of 0.0306 Tesla at zero K. Find the critical field. **[4]**

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

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Total No. of Questions : 7]

SEAT No. : ______

P603

[Total No. of Pages : 3

[4124] - 401
M.Sc. (Sem. - IV)
PHYSICS
PHY UTN - 801 : Nuclear Physics
(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 calculators is allowed.***

Q1) Attempt any four of the following :

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

b) Calculate the half value thickness for β absorption in aluminium for β spectrum with E_{max} = 1.17 MeV
Given: Density of aluminium = 2700 kg/m^3. **[4]**

c) In a Bainbridge and Jordan mass spectrometer singly ionised atoms of Ne - 20 pass into the deflection chamber with a velocity of 10^5 m/s. If they are deflected by a magnetic field of flux density 0.08 tesla, calculate the radius of their path and where neon-22 ions would fall if they had the same initial velocity. [Given : $m_p = 1.67 \times 10^{-27}$ kg]. **[4]**

d) Determine K_∞ for the homogeneous, natural uranium heavy water moderated assembly containing 50 molecules of moderator per molecule of uranium. Assume natural uranium to contain one part of U^{236} to 139 parts of U^{238}.
Given : $\sigma_a(U)$ = 7.68 barn, $\sigma_s(U)$ = 8.3 barn for D_2O, σ_a = 0.00092 barn, σ_s = 10.6 barn and ξ_t = 0.570. **[4]**

e) Estimate 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.

Given : Z for gold nucleus = 79, e = 1.6 × 10^{-19} C $\frac{1}{4\pi\epsilon_o} = 9\times10^9\ N\text{-}m^2/c^2$.

[4]

P.T.O.

f) Calculate the maximum energy of the compton recoil electrons resulting from the absorption in Aluminium of 2.19 MeV γ-rays.
Given : $m_0 = 9.109 \times 10^{-31}$ kg. **[4]**

Q2) a) Explain the concept of quadrupole moment and derive an expression for the same and show that it is zero for spherical distribution of charges. **[8]**

b) With the help of partial wave analysis for low energy n-p scatlering show that : $\sigma_0 = \frac{4\pi}{k^2} \sin^2 \delta_0$

Where symbols have usual meanings. **[8]**

Q3) a) Explain the working of proportional counter. State its advantages and applications. **[8]**

b) For p-p scattering at low energies, derive an expression for differential cross-section in laboratory system. **[8]**

Q4) a) Draw a diagram of the electron synchrotron accelrator. State its working principle and action. Explain how maximum energy of the electron depends on the radius of orbit. **[8]**

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

Q5) a) Describe the working of the Bainbridge and Jordon mass spectrograph. What are its advantages and limitations. **[8]**

b) Explain important features of Gamow's theory of α-decay. **[8]**

Q6) a) Derive Bethe's formula for 'stopping power' of charged particles moving through the matter. Write the expression for relativistic effects. **[8]**

b) Verify the following reaction and state whether it is allowed or for bidden on the basis of laws of conservation of strangeness, baryon number and charge : $\pi^+ + p \rightarrow \wedge^\circ + k^\circ$. **[4]**

c) Explain the concept of iso-spin associated with elementary particle. **[4]**

Q7) a) Write a note on : Graphite-Moderated Research Reactor. **[4]**

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

c) Explain weak and strong interactions with suitable examples with reference to elementary particles. **[4]**

d) Discuss in brief production and properties of pion. **[4]**

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