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

P1042

[3622]-101
M.Sc. PHYSICS
PHY UTN-501 : Classical Mechanics
(Sem. - I) (New Course)

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

Instructions :

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 pocket calculator is allowed.***

Q1) Attempt any four of the following :

a) Derive equation of motion for a particle moving under central force. What is the form of the equation, when the particle is moving under an attractive inverse square law force $\left(F=\frac{-k}{r^2}\right)$. **[4]**

b) Two heavy particles of weight W_1 and W_2 are connected by a light inextensible string and hang over a fixed smooth circular cylinder of radius R, the axis of which is horizontal. Find the condition of equilibrium of the system by applying the principle of virtual work. **[4]**

c) Prove that **[4]**

$$\frac{d}{dt}[F,G]=\left[\frac{dF}{dt},G\right]+\left[F,\frac{dG}{dt}\right]$$

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

f) Calculate the reduced mass of CO and HCl molecules. **[4]**

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

b) Compare Newtonian, Lagrangian and Hamiltonian formulation and discuss the advantages and disadvantages of each. **[8]**

P.T.O.

Q3) a) Prove that under canonical transformation (q, p) to (Q, P)

$$[F,G]_{q,p} = [\overline{F},\overline{G}]_{Q,P}.$$ **[8]**

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

Q4) a) Prove the Poisson's bracket

$$[L_x, L_y] = L_z.$$ **[8]**

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

Q5) a) Obtain Hamiltonian and Hamilton's equation for compound pendulum. **[8]**

b) Use Lagranges equation to find the equation of motion of a system of two masses connected by an inextensible string passing over a small smooth pulley. **[8]**

Q6) a) A bullet is fixed horizontally in the north direction with a velocity of 500 m/sec. at 30°N lattitude. 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 10 gm. Find the Coriolis force. **[8]**

b) A smooth table with a hole. Let the mass m_1 *be* resting on the table and is connected to mass m_2, ($m_2 > m_1$), by an inextensible string of lengths '*l*'. The mass m_2 hangs vertically down and the string passes through hole on the table. Find the equation of motion using D'Alembert's principle. **[8]**

Q7) a) State and prove viral theorem. **[8]**

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

c) What are configuration space and phase space. **[4]**

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

P1043

[3622]-102
M.Sc.
PHYSICS
PHY UTN - 502 : Electronics
(Sem. - I) (New Course)

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

Instructions :

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 maximum marks.***
4) ***Use of logarithmic tables and calculators is allowed.***

Q1) Attempt any four of the following :

a) What are shift registers? How are they used? State the different types of shift registers. **[4]**

b) Explain the working of a narrow bandpass filter. **[4]**

c) Design a second order high-pass filter with a cutoff frequency of 3 kHz and a passband gain of 2. Determine Q of the filter. **[4]**

d) Design a regulated supply using LM317 which is variable from +5V to +20V. Sketch the circuit diagram. **[4]**

e) Explain in brief DC-to-DC converters. **[4]**

f) Design a square wave oscillator for an output frequency of 5kHz. Sketch the circuit. **[4]**

Q2) a) Sketch a functional block diagram of an IC8038 and explain its working. Design a function generator using IC8038 with f_0 = 2kHz. **[8]**

b) Explain the working of an R-2R DAC. What are its advantages? **[8]**

Q3) a) Explain the working of a Dual-slope type ADC. **[8]**

b) Explain the working of IC566. Design a VCO using an IC566 for a nominal output frequency of 2 kHz. Given V_{CC} = 10 Volts. **[8]**

Q4) a) Explain the working of foldback current limiting using IC723 and external components. **[8]**

b) Explain the working of an Instrumentation amplifier. **[8]**

Q5) a) Explain the working of a PLL. Determine the free running frequency, capture range and lock range for an IC565. Given $V_{CC} = \pm 12V$, $R_1 = 10K\Omega$, $C_1 = 0.01\mu F$, $C_2 = 10\mu F$. **[8]**

b) Explain the working of a full wave precision rectifier. Why is it also known as an absolute value circuit? **[8]**

Q6) a) Explain the working of a boost switching regulator. **[8]**

b) Design a wide bandpass filter with $f_1 = 1$ kHz, $f_2 = 4$ kHz and a passband gain of 4. Determine the centre frequency and Q of the filter. Sketch a block diagram of the filter implementation.. **[6]**

c) What is a Karnaugh map? How is it useful in logic circuit designing? **[2]**

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

a) Optical fibre communication.

b) Satellite communication.

c) Multiplexers and Demultiplexers.

d) Opamp characteristics.

e) Sample and hold circuits.

f) UPS and inverters.

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

P1044

[3622]-103
M.Sc.
PHYSICS
PHY UTN 503 : Methods of Mathematical Physics
(Sem. - I) (New Course)

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

Instructions :

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

Q1) Attempt any four of the following :

a) Prove the convolution theorem for the Fourier transform. **[4]**

b) Define basis and dimension for vector space. **[4]**

c) Prove the following recurrence relation $H_{n+1}(x) = 2xH_n(x) - 2nH_{n-1}(x)$. **[4]**

d) Check wether the following set of vectors is linearly dependent or linearly independent {(1, 0, 1), (1, 1, 0), (1, -1, 1), (1, 2, -3)}. **[4]**

e) Show the graphical presentation of the following function for period=10

$$f(x) = \begin{cases} 3 & 0<x<5 \\ -3 & -5<x<0 \end{cases}$$ **[4]**

f) Show that $f(z) = z^2$ is analytic function. **[4]**

Q2) a) State Cauchy's integral formula and prove that

$$f(z_0) = \frac{1}{2\Pi i}\int \frac{f(z)}{(z-z_0)}dz$$ **[8]**

b) Find the Fourier integral of the function

$$f(x) = 0 \qquad x<0$$
$$= \frac{1}{2} \qquad x = 0$$
$$= e^{-x} \qquad x>0$$ **[8]**

Q3) a) Expand $ln\left(\frac{1+z}{1-z}\right)$ in Taylor series about $z = 0$. **[8]**

b) Find $L^{-1}\left\{\frac{3s+7}{s^2+2s-3}\right\}$ **[8]**

P.T.O.

Q4) a) What is analytic function? Obtain necessary and sufficient conditions for the function to be analytic. **[8]**

b) Find the eigen values and eigen vectors of the matrix. $A=\begin{pmatrix} 3 & 1 & 4 \\ 0 & 2 & 0 \\ 0 & 0 & 5 \end{pmatrix}$. **[8]**

Q5) a) State and prove Laurent'z theorem. **[8]**

b) Obtain orthogonal properties of Hermite polynomials.

$$\int_{\infty}^{+\infty} H_n(x)H_m(x)e^{-x^2}dx = 2^n n!\sqrt{\pi}\, S_{mn}$$ **[8]**

Q6) a) Develop Fourier Series representation for the function

$f(x) = 0, \quad -\pi < x < \pi$

$= \frac{\pi x}{4}, \quad 0 < x < \pi$ **[8]**

b) Obtain an expression for the integral representation of Bessel function.

$J_n(x) = \frac{1}{\pi}\int_0^{\pi} Cos(n\theta - xSin\theta)d\theta$, where $n = 0, 1, 2, \ldots\ldots\ldots$. **[8]**

Q7) a) Show that eigen values of Hermition matrices are real. **[4]**

b) Find Laplace transform of the function $f(t) = Cos\ at$. **[4]**

c) Define Dirac delta function and it's properties. **[4]**

d) Define Linear Vector space and give the conditions to be satisfied. **[4]**

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

P1045

[3622]-104
M.Sc. PHYSICS
PHY UTN - 504 : Quantum Mechanics -I
(Sem. - I) (2008 Pattern) (New Course)

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

Instructions :

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 calculators are allowed.*

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

a) The electron in hydrogen atom may be thought of as confined to a nucleus of radius 5×10^{-11}m. Calculate minimum uncertainty in momentum of electron. Also calculate minimum Kinetic energy of the electron.

b) If $H = \frac{P^2}{2m} + \frac{1}{2} m w^2 x^2$. Show that

i) $[x, H] = i\hbar \frac{P}{m}$

ii) $[x, [x, H]] = \frac{-\hbar^2}{m}$

c) What is the probability distribution of momentum of a particle with the Gaussian wave function $\psi(x) = \left(\sigma\sqrt{\pi}\right)^{-\frac{1}{2}} \exp\left[-\frac{x^2}{2\sigma^2}\right]$?

d) Define adjoint of an operator. Show that $\left(\hat{A}\hat{B}\right)^+ = \hat{B}^+ \hat{A}^+$.

e) Show that Pauli spin matrices σ_x, σ_y and σ_z are unitary.

f) Show that momentum operator is self adjoint.

Q2) a) Show that for Hermitian operator

i) eigen values are real and

ii) any two eigen functions belonging to distinct eigen values are mutually orthogonal. **[8]**

b) Obtain eigen values of L^2 and L_z using L_+ and L_- operators. **[8]**

P.T.O.

Q3) a) Obtain the matrix of Clebsch-Garden coefficients when $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. **[8]**

b) Discuss and compare the Schrodingers picture and Heisenbergs picture of time evaluation. **[8]**

Q4) a) Define the operators a and a^+ for a simple harmonic oscillator. Hence obtain the expressions for energy eigen value and eigen functions. **[8]**

b) Draw an infinitely potential well and describe it mathematically. Write the Schrodinger's equations for the same and state corrosponding boundary conditions. Write the solution and draw first three eigen functions and probability density functions. **[8]**

Q5) a) Describe change of basis by using unitary transformations. **[8]**

b) The normalized momentum eigen function of a particle within box of length L is given as $\psi_{P'}(x) = \frac{1}{\sqrt{L}} \exp\left(\frac{iP'x}{\hbar}\right)$ with $P' = \frac{2\pi n\hbar}{L}$ where $n = 0, \pm 1, \pm 2, \ldots\ldots\ldots$.

Show that they are mutually orthogonal and they obey closure property. **[8]**

Q6) a) Discuss matrix representation of J in terms of the $|jm\rangle$ basis. Hence for $j = \frac{1}{2}$. Calculate matrices for j_x, j_y, j_z and j^2. **[8]**

b) State the fourth postulate of quantum mechanics. Hence obtain the condition for an operator to be a conserved quantity. **[8]**

Q7) a) Explain the representation of state by vectors, Hilbert space and basis of Hilbert state. **[4]**

b) What is difference between Kronecker and Dirac delta function. Explain Dirac function and represent it graphically. **[4]**

c) Define projection operator. Show that $\sum_a P_a = \hat{1}$ where $\hat{P}_a$ is projection operator for $|a\rangle$. **[4]**

d) Evaluate expectation value of r, i.e. $\langle r\rangle$ when wave function in spherically polar coordinate is $\psi = \left(\frac{1}{\pi a^3}\right)^{\frac{1}{2}} e^{-r/a}$ where a is constant. **[4]**

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

P1037

[3622]-11
M.Sc.PHYSICS
PHY UT- 501 : Classical Mechanics
(Sem. - I) (Old Course)

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

Instructions :

1) ***Question No. 1 is compulsory and solve any four questions from remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicates 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 simple pendulum by using Lagrangian and hence deduce the formula for its time period for small amplitude oscillations. **[4]**

b) In Rutherford scattering experiment 10^5 particles are scattered at an angle of 2^o. Calculate the number of particles scattered at an angle of 20^o. **[4]**

c) The maximum and minimum velocities of satellite are V_{max} and V_{min} respectively. Prove that the eccentricity of the orbit of the satellite is $e=\frac{V_{max}-V_{min}}{V_{max}+V_{min}}$. **[4]**

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

e) If H is the Hamiltonian and f is any function depending on position momenta and time, show that $\frac{df}{dt}=\frac{\partial f}{\partial t}+[f,H]$. **[4]**

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

Q2) a) Two identical simple pendulum each of length 0.5 m are connected by a light spring. The force constant of the spring is $2Nm^{-1}$ and mass of each bob is 0.1 kg. If one pendulum is clamped, calculate the period of other pendulum. When the clamp is removed, determine the periods of two normal modes of the system. **[8]**

b) What are generalized co-ordinates? What are the advantage of using them? **[4]**

c) Two particles are connected by a rod of variable length $l = f(t)$. What is the nature of the constraints? **[4]**

Q3) a) What is meant by differential cross-section? Discuss the problem of scattering of charged particles by a Coulomb's field and obtain Rutherford's formula for the differential scattering cross-section. **[8]**

b) What are configuration space and phase space? Draw phase space diagram for

i) Damped and undamped harmonic oscillator.

ii) A stone thrown vertically up in the field of uniform gravity. **[8]**

Q4) a) A particle slides from rest at one point on a frictionless wire in a vertical plane to another point under the influence of the earth's gravitational field. If the particle travels this distance in the shortest time, show that the path followed by it is a cycloid. **[8]**

b) Show that for the transformation $Q=\sqrt{q}\cos 2p, P=\sqrt{q}\sin 2p$, the generating function is $\frac{1}{2}q\cos^{-1}\left(\frac{Q}{\sqrt{q}}\right)-\frac{1}{2}Q\sqrt{q-Q^2}$. **[8]**

Q5) a) Compare Newtonian, Lagrangian and Hamiltonian formulation and discuss the advantages and disadvantages of each. **[8]**

b) Starting with Newton's law of gravitation deduce Kepler's first law of planetary motion. **[8]**

Q6) a) Obtain expression for vertical and horizontal components of Coriolis force in case of particle of mass m, moving with horizontal velocity v, at any lattitude λ, when earth is rotating with angular velocity ω. **[8]**

b) A cylinder 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. **[8]**

Q7) a) Prove the Jacobi's Identity

$[x,[y,z]]-[y,[x,z]]+[z,[x,y]]=0$ **[8]**

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

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

P1038

[3622]-12
M.Sc.PHYSICS
PHY UT- 502 : Electronics
(Sem. - I) (Old Course)

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

Instructions :

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 maximum marks.*
4) *Use of logarithmic tables and calculators is allowed.*

Q1) Attempt any four of the following :

a) Explain the working of an active peak detector. **[4]**

b) Design a second order low-pass filter with a cutoff frequency of 2 kHz, and a passband gain of 2. Also determine Q of the filter. **[4]**

c) Sketch a functional block diagram of an IC8038. Design a function generator using IC8038 to provide an output frequency of 5kHz. **[4]**

d) Discuss the working of an ionization gauge. **[4]**

e) Discuss the working of a strain gauge. Sketch a circuit diagram for use of a strain gauge. **[4]**

f) Design a square wave oscillator for an output frequency of 10 kHz. Sketch the circuit diagram. **[4]**

Q2) a) Explain the working of a PLL. Determine the free running frequency, capture range and lock range for IC565. Given $V_{cc} = \pm 12$ V, $R_1 = 10$ $K\Omega$, $C_1 = 0.022\,\mu F$, $C_2 = 10\,\mu F$. **[8]**

b) Explain the working of a step-up switching regulator. **[8]**

Q3) a) Explain foldback current limiting in a power supply. How is this useful? **[8]**

b) State the different types of noise and explain any two in detail. **[8]**

Q4) a) Sketch a circuit diagram of a Notch filter and explain its working. Design a notch filter for a frequency of 1 kHz. **[6]**

b) Design a Bandpass filter with $f_1 = 1$ kHz and $f_2 = 4$ kHz and a passband gain of 5. Determine f_C and Q of the filter. **[6]**

c) Design a VCO using IC566 for a nominal output frequency of 10 kHz. Given $V_{cc} = 10$ V. **[4]**

P.T.O.

Q5) a) Explain the working of a full-wave precision rectifier. **[8]**

b) Sketch the circuit diagram for use of an LM317. Design a regulated supply using LM317 which is variable from +5 V to +15 V. **[4]**

c) Explain how an 8-input multiplexer can be expanded into a 16-input multiplexer. **[4]**

Q6) a) Discuss the working of an Instrumentation Amplifier. **[8]**

b) Explain the working of a spectrum Analyzer. **[6]**

c) Sketch a circuit diagram to generate square and triangular waveforms, using opamps. **[2]**

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

a) Lock-in detection.

b) DC-to-DC converters.

c) Karnaugh maps.

d) Monostable multivibrators.

e) Magnetic field measurements.

f) Demultiplexers and Decoders.

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

P1039

[3622]-13

M.Sc. PHYSICS

PHY UT-503 : Methods of Mathematical Physics

(Old Course)

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

Instructions :

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 pocket calculator is allowed.*

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

a) Find the Laplace transform of the function $f(t) = e^{at}$. **[4]**

b) Show that the following set of vectors which are in R^3 are linearly independent (i) $u = (6, 2, 3, 4)$, (ii) $v = (0, 5, -3, 1)$, (iii) $w = (0, 0, 7, -2)$. **[4]**

c) State and explain Fourier transform. **[4]**

d) Let a linear transformation $T: v_2 \rightarrow v_3$ be defined by $T(x_1, x_2) = (x_1 + x_2, 2x_1 - x_2, 7x_2)$ and if $B_1 = (e_1, e_2)$ and $B_2 = (f_1, f_2, f_3)$ are the standard bases of V_2 and V_3 respectively. Then find the matrix of T relative to B_1 and B_2. **[4]**

e) Prove that, if a function is analytic, it is independent of Z. **[4]**

f) Prove the recurrence relation $xP_n'(x) - P_{n-1}'(x) = nP_n(x)$. **[4]**

Q2) a) Explain Fourier series theorem and hence evaluate Fourier Coefficients a_0, a_n, and b_n. **[8]**

b) Show that Legendre polynomials satisfy the orthogonality condition $\int_{-1}^{+1} P_n(x) P_m(x) dx = 0$ for $n \neq m$. **[8]**

Q3) a) What is residue? Obtain the residue of analytic function $f(z)$ at the pole $z = a$. **[8]**

b) Obtain Rodrigue's formula $e^x \frac{d^n}{dx^n}\left(x^n e^{-x}\right) = L_n(x)$. **[8]**

P.T.O.

Q4) a) Prove the following recurrence relation for Hermite polynomials. **[8]**

i) $H_n''(x) - 2xH_n'(x) + 2nH_n(x) = 0$.

ii) $2xH_n(x) - H_{n+1}(x) = H_n'(x)$.

b) What is mapping? Discuss the various types of mappings. **[8]**

Q5) a) Find the eigen values and eigen vectors of the matrix. **[8]**

$$A = \begin{pmatrix} 1 & 4 \\ 2 & 3 \end{pmatrix}$$

b) State and prove the convolution theorem for Fourier transform. **[8]**

Q6) a) Develop Fourier series representation for the function, **[8]**

$$f(x) = 0, \quad -\Pi < x < 0$$

$$= \frac{\pi x}{4}, \quad 0 < x < \pi.$$

b) Define linear vector space and give conditions to be satisfied by it. **[8]**

Q7) a) Solve $L^{-1}\left\{\frac{3s+7}{s^2-2s-3}\right\}$. **[8]**

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

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

P1040

[3622]-14
M.Sc. PHYSICS
PHY UT-504 : Quantum Mechanics - I
(Sem. - I) (Old Course)

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

Instructions :

1) ***Question No. 1 is compulsory, attempt 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 calculators is allowed.***

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

a) Decide whether the functions e^{2x} and $\sin^2 x$ are the eigenfunctions of the operator $\left(\frac{d^2}{dx^2}\right)$?

b) Prove $[x, p^n] = ni\hbar\, p^{n-1}$.

c) Explain the statement : A^+A is a positive operator.

d) For Pauli spin matrices show that $\sigma_x \cdot \sigma_x^+ = 1$ and $\sigma_x \cdot \sigma_y = i\sigma_z$.

e) For a particle moving with non-relativistic velocity let ϑ_g be the group velocity and ϑ_p be the phase velocity show that $\vartheta_g = 2\vartheta_p$.

f) $[J^2, J_+] = 0$.

Q2) a) Draw deep potential well and write conditions of V. Write boundary conditions and Schrodinger eq^n. State the solution of schrodinger eq^n. Draw the wave functions $|\psi|$ & prob.$|\psi|^2$ for ψ_1 and ψ_2. **[8]**

b) Using Schrodinger time dependent equation obtain the condition for an operator to correspond to a conserved quantity. **[8]**

Q3) a) Prove the closure property, using δ –function normalization and expansion postulate. **[8]**

b) Define Hermitian operator and show that the eigenvalues of such an operator are real and the eigenfunctions of non-degenerate eigenvalues are orthogonal. **[8]**

Q4) a) For a system of two non-interacting electrons with $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. Obtain the Clebsch-Gorden coefficients. **[8]**

b) Define angular momentum operator. Show that the angular momentum operator is a generator of rotational motion. **[8]**

Q5) a) $\overline{S}$ is a spin angular momentum operator of two states $\chi_+ = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\chi_- = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$. Obtain S_x, S_y and S_z. Hence obtain Paulispin matrices. **[8]**

b) Discuss the Schrodinger and Heisenberg pictures of time evolution and compare them. **[8]**

Q6) a) Using abstract operator method, obtain the eigenvalues and the eigenfunctions of simple harmonic oscillator. **[8]**

b) Define norm and scalar product in Hilbert space for orbitrary vectors $|\psi\rangle$ and $|\chi\rangle$. Prove : i) $\langle a|\hat{A}|a'\rangle = a'\delta aa'$, (ii) If $\langle\psi|\psi\rangle = 1$ and U is unitary $\langle U\psi|U\psi\rangle = 1$. **[8]**

Q7) a) State postulates 2 and 3 of Quantum Mechanics. **[4]**

b) Define Dirac δ function. Represent it graphically and interpreat. **[4]**

c) Define projection operator and show that $\sum_a P_a = 1$. **[4]**

d) $[L_x, L_y] = i\hbar L_z$. **[4]**

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

P431

[3622] - 204

M.Sc.

PHYSICS

PHY UT - 604 : Quantum Mechanics - II

(New Course) (2008 Pattern) (Semester - II)

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

Instructions to the candidates :

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

Q1) Attempt any four of the following:

a) Use perturbation time independent theory to obtain the first order energy correction for n^{th} state of anharmonic oscillator with Hamiltonian $H = \frac{p^2}{2m} + \frac{1}{2}mw^2x^2 + \lambda x^4$ for small λ. **[4]**

b) Calculate differential cross section for Yukawa potential $v(r) = -g^2 \frac{e^{-\alpha r}}{r}$ by using Born approximation. (Given : imaginary part of integral $\int_0^\infty \exp(-\alpha r)\, e^{iqr}\, dr = \frac{q}{\alpha^2 + q^2}$). **[4]**

c) Show that there is no stark effect in the ground state of hydrogen atom. **[4]**

d) Determine the form of normalized antisymmetric total eigen-function for a system of three identical particles. **[4]**

e) Describe scattering event in Laboratory and centre of mass frames and show that scattering angles are related by expression:

$$\tan\theta_{lab} = \frac{\sin\theta_{cm}}{(m_1/m_2) + \cos\theta_{cm}}.$$ **[4]**

f) Using WKB approximation, obtain the Bohr - Sommerfeld quantization condition. **[4]**

P.T.O.

Q2) a) Discuss the time independent perturbation theory for non-degenerate case upto second order and obtain the first order correction of energy as well as wave-function. **[10]**

b) Using the partial wave analysis method, show that the total scattering cross-section for scattering from hard rigid sphere is $4\pi a^2$. Where a = radius of sphere. **[6]**

Q3) a) What is Green function? By using it, obtain the expression for scattering amplitude when potential is symmetric. **[8]**

b) Apply variation method to find grand state energy of hydrogen atom when trial wave-function is $\psi = \mathrm{A}e^{-\lambda\gamma}$ and λ is variational parameter. **[8]**

Q4) a) Describe the classical and quantum mechanical pictures of Collisions between identical particles.

For spin $\frac{1}{2}$ particles, when spin orientations are not specified then write down $\frac{d\sigma}{d\Omega}$. **[8]**

b) State and prove the Fermi-Golden rule for the rate of transitions induced by constant potential. **[8]**

Q5) a) What are identical particles? Define exchange operator P_{12} between particle 1 and 2. (i) show that it's eigen - values are $\pm$ 1 and discuss how it leads to symmetric and antisymmetric wave functions. **[8]**

b) Develope the time dependent perturbation theory to obtain transition amplitudes for 1st and 2nd order. **[8]**

Q6) a) Using partial wave analysis, obtain the expression for phase - shift, scattering amplitude and total cross-section. Use it to prove optical theorem. **[10]**

b) Obtain slater determinant for system of N-electrons. **[6]**

Q7) a) Discuss the conditions for validity of WKB approximation. **[4]**

b) Show that the variational method gives an upper bound to the ground state energy. **[4]**

c) Using Born approximation, show that the scattering amplitude is the fourier transform of potential. **[4]**

d) What is a dipole approximation? State the selection rules for electrical dipole transitions. **[4]**

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

P1046

[3622]-301
M.Sc. PHYSICS
PHY UTN-701 : Solid State Physics
(Sem. - III) (New Course)

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

Instructions :

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 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 = 4π × 10^{-7} Henry/m.

Permittivity of free space = 8.85 × 10^{-12} $C^2/N\text{-}m^2$.

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

a) Estimate the mean free path of the conduction electron in Silver at R.T. using following data :

$E_f = 5.5eV$, resistivity $\rho = 1.6\times10^{-8}\,\Omega m$, Electron density $n = 5.27\times10^{28}/m^3$.

b) At what temperature we expect 10% probability of the electron in silver have energy 1% above Fermi level $E_f = 5.5\ eV$.

c) Calculate the individual dipole moment of a molecule of carbon tetrachloride with the following data :

$\epsilon_r = 2.24$, density = 1.6 × 10^3 kg/m^3, Molecular weight = 156, E = 10^7V/m and $N_A = 6.02 \times 10^{26}$ electrons.

d) A paramagnetic system of electron spin magnetic dipole moment is placed in an external field of 10^5 A/m. Calculate the average magnetic moment per dipole at 300K.

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

f) For a superconducting material the critical fields are 1.4 × 10^5 A/m and 4.2 × 10^5 A/m for 14 K and 13 K respectively. Calculate the transition temperature at zero K.

Q2) a) Explain Kronig-Penny model in brief. Obtain the equation in P and plot the function for $P=\frac{3\pi}{2}$ and interpret it. **[8]**

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

Q3) a) Define dielectric function $\in(\omega,k)$. For long wavelength region obtain an expression $\in(\omega)=1-\frac{\omega p^2}{\omega^2}$ where symbols carry usual meaning. Plot this equation graphically and thus explain attenuation of the wave. **[8]**

b) Distinguish between metals, insulators and semiconductors using band structure of solids. **[8]**

Q4) a) Explain Langevin's classical theory of paramagnetism. Hence obtain an expression for paramagnetic susceptibility. **[8]**

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

Q5) a) Derive London equation for superconducting state and obtain an expression for the penetration depth. **[8]**

b) Derive the Weiss molecular field theory of ferromagnetism with reference to Curie point. Hence derive the relation for Curie-Weiss law. **[8]**

Q6) a) Explain thermodynamics of superconductivity with special reference to the stabilization energy. **[8]**

b) Define intensity of magnetization. How will it vary with temperature in a ferromagnetic solid? **[4]**

c) Explain Meissner effect in superconductivity. **[4]**

Q7) a) Write statement of Bloch function and discuss its properties. **[4]**

b) Explain the concept of ferroelectricity. Define Curie point temperature T_C for ferromagnetic crystals. **[4]**

c) A magnetic material has a magnetization of 3300 A/m and magnetic flux density of 4.4×10^{-3} T. Calculate the magnetizing force. **[4]**

d) Explain flux quantization in a superconducting ring. **[4]**

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

P1041

[3622]-31

M.Sc. Physics

PHY UT-701 : Solid State Physics

(Sem. - III) (Old Course)

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

Instructions :

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 indicates full marks.***
4) ***Use of logarithmic tables and calculators is allowed.***

Given :

Rest mass of the electron = 9.109×10^{-31} kg.

Charge on the electron = 1.6021×10^{-19} cou.

Planck's constant = 6.026×10^{-34} J-S.

Boltzmann constant = 1.3805×10^{-23} $J.K^{-1}$.

Avogadro's number = 6.0225×10^{26} $(Kmole)^{-1}$

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} $C^2/N\text{-}m^2$.

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

a) Find the lowest energy of an electron confined in a box of each side 1.0A.

b) Show that for a simple square lattice the kinetic energy of a free electron at a corner of the first zone is higher than that of an electron at mid-point of a side face of zone by a factor of 2.

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

d) Calculate the critical current density for 1 mm diameter wire of lead at 4.2 K.

Given : T_C for Lead is 7.18 K and H_O for Lead is 6.5×10^4 amp/m.

e) A magnetic material has a magnetisation of 3300 ampere/meter and flux density of .0044 Wb/m^2. Calculate the magnetising force.

f) What is meant by hystersis in magnetic materials?

P.T.O.

Q2) a) Distinguish between metals, insulators and semi conductors in terms of their band structures. **[8]**

b) Explain qualitatively Kronig-Penny model in brief. Plot the functions for $p = \frac{3\pi}{2}$ and explain. **[8]**

Q3) a) What do you mean by local electric field at an atom? Write the expression for local electric field E_{local} at an atom placed at general lattice site. Explain each term in it. **[8]**

b) Explain thermodynamics of superconductivity with reference to the stabilization energy. **[8]**

Q4) a) For a dielectric material derive Clausius-Mossetti relation. **[8]**

b) Describe the assumptions of BCS theory of superconductivity. **[8]**

Q5) a) Distinguish between ferromagnetism, ferrimagnetism and antiferromagne--tism. **[8]**

b) Give an account of Weiss theory of ferromagnetism and show from the plot of Langevin's function spontaneous magnetisation exists below the curie temperature and vanishes above the curie temperature. **[8]**

Q6) a) Explain antiferromagnetism with reference to Neel temperature and susceptibility. Hence describe ferrimagnetism. **[8]**

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

Q7) a) State and explain Bloch theorem. **[4]**

b) Explain why ferrites are used in high frequency transformer. **[4]**

c) Explain Josephson superconducting tunneling. **[4]**

d) Hole is a fictious particle. Comment. **[4]**

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

P424

[3622] - 22
M.Sc.
PHYSICS
PHY UT 602 : Atoms, Molecules and Solids
(Old Course) (2005 Pattern) (Sem. - II)

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 table and electronic pocket calculator is allowed.***

Given : Rest mass of the electron = 9.109×10^{-31} kg
Charge on the electron = 1.6021×10^{-19} coulomb
Planck's constant = 6.626×10^{-34} J.S.
Boltzmann constant = 1.38054×10^{-23} JK^{-1}
Avogadro's number = 6.02252×10^{26} $(\text{Kilomole})^{-1}$
Bohr magneton =9.27×10^{-24} amp. m^2
l eV = 1.6021×10^{-19} J

Q1) Attempt any Four of the following:

a) Iron is bcc below 910ºC and is fcc at 910ºC. The fractional change in density accompaning the transition is +1%. Calculate the ratio of the atomic radii in two phases. **[4]**

b) The diffusion rate of A in B was studied at 500ºC and 850ºC. It was found that for the same diffusion time the depths of penetration in the two experiments were 1 : 4. Calculate the activation energy for diffusion of A in B. **[4]**

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

d) Calculate Lande splitting factor for $2p_{3/2}$ state. **[4]**

e) The spin orbit effect splits the 3P $\rightarrow$ 3S transition into two lines 5890 A and 5896 A. Calculate the effective magnetic field experienced by outer electron in the atom as a result of its orbital motion. **[4]**

f) An NMR signal for a compound is found to be 180 Hz downward from TMS peak using a spectrometer operating at 60 MHz. Calculate its chemical shift in ppm. **[4]**

P.T.O.

Q2) a) Derive an expression for concentration of vacancies in a crystalline solid as a function of temperature. **[8]**

b) What are the limitations of classical theory of specific heat? Derive an expression for the specific heat of solids on the basis of Einstein's model. **[8]**

Q3) a) Explain the theory of geometrical structure factor and derive an expression for bcc structure. **[8]**

b) Derive the dispersion relation for a linear diatomic lattice and explain the origin of optical mode and acoustic mode. **[8]**

Q4) a) State and explain Franke - Condon principle. **[8]**

b) Define dissociation energy for a diatomic molecule. Hence calculate ν_{max} corresponding to the dissociation limit. **[8]**

Q5) a) Explain the principle and working of a ESR spectrometer. **[8]**

b) What is meant by Nuclear spin magnetic moment? Explain in brief principle and working of a NMR spectrometer. **[8]**

Q6) a) What is anomalous Zeeman effect? Derive an expression for shift in frequency in case of anomalous. Zeeman effect. **[8]**

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

c) With the help of neat diagram show that a base centered cubic structure of side a becomes a primitive tetragonal structure of side a | $\sqrt{2}$. **[4]**

Q7) a) What is a Phonon? **[4]**

b) Write short note on screw dislocation. **[4]**

c) What are the causes of broadning of the spectral line S? **[4]**

d) Point out essential difference between atomic spectra and molecular spectra. **[4]**

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

P423

[3622]- 21

M.Sc.

PHYSICS

PHY UT - 601 : Electrodynamics

(Sem. - II) (2005 Pattern) (Old Course)

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 calculator is allowed.***

Q1) Attempt any four of the following :

a) Prove that :

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

b) 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]**

c) A plane electromagnetic wave travels in an unbound lossless 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]**

d) Determine skin-depth in sea water with conductivity

$\sigma = 5\ (\Omega \text{m})^{-1}$ at 10GHz

$\mu = \mu_0 = 4\pi \times 10^{-7}$ Wb/A $- m$. **[4]**

e) Determine the velocity at which the mass of a particle is double its rest mass. **[4]**

f) A radiator approximates to an electric dipole of length 250m at a frequency of 60kHz. Assuming that the current is maintained over the length, evaluate the radiation resistance of the radiator. **[4]**

Q2) a) The magnetic field intensity $\vec{B}$ at a point is given by **[8]**

$$\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\int \frac{\vec{j} \times \vec{r}}{r^3}\, d\uparrow. \text{ Show that } \vec{\nabla} \times \vec{B} = \mu_0 \vec{j}.$$

b) Prove the relativistic addition theorem for velocities : **[8]**

$$u_x = \frac{u'_x + v}{1 + \frac{u'_x v}{c^2}} \quad \text{where } u'_x = \frac{dx'}{dt'} \; and \; u_x = \frac{dx}{dt}$$

Hence show that any velocity added relativistically to 'c' gives resultant velocity 'c' which is Lorentz invariant.

Q3) a) What is a linear quadrupole? Derive an expression for potential at a distant point due to a small linear quadrupole. **[8]**

b) Derive the Lorentz relativistic transformation equations. **[8]**

Q4) a) Explain the term electromagnetic field tensor. Hence obtain an expression for the e.m.field tensor $F_{\mu\nu}$. **[8]**

b) Describe the Michelson-Morley experiment. Derive the formula for fringe shift. Comment on the results obtained. **[8]**

Q5) a) State and prove Poynting's theorem. **[8]**

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

Q6) a) A plane electromagnetic wave is incident obliquely on an interface between two non-conducting dielectric media. Obtain Fresnel's equations if the electric field vectors are perpendicular to the plane of incidence. **[8]**

b) Explain the term Hertz potential and show that it obeys the in homogeneous wave-equation. Obtain electric and magnetic fields in terms of the Hertz potential $\vec{z}$. **[8]**

Q7) a) Explain the term 'Four vector potential' **[4]**

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

c) Find from Poynting flow the value of intensity of magnetic field in air at a distance of 100cm from a radiating source of power 10kW, Given

$$\sqrt{\frac{\mu_0}{\epsilon_0}} = 377\Omega.$$ **[4]**

d) An electron is accelerated from rest to a speed of 0,9995c in a particle accelerator. Determine the electrons rest energy and total energy in MeV. **[4]**

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

P425

[3622]-23
M.Sc.
PHYSICS
PHY UT - 603 : Statistical Mechanics in Physics
(2005 Pattern) (Old Course)

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

Constants :

1) Boltzmann constant $k_B = 1.38 \times 10^{-23}$J/K
2) Planck's constant $h = 6.623 \times 10^{-34}$Js
3) Avogadro's number $N = 6.023 \times 10^{23}$cgs units
4) Mass of electron $m_s = 9.1 \times 10^{-31}$kg
5) Velocity of light $c = 3 \times 10^8$ m/s
6) Gas constant R = 8.314J/mole/^{o}k

Q1) Attempt any four of the following :

a) The energy parameters and accessible states for two systems A and B are given below. **[4]**

System A	System B
$E_1 = 3, 4, 5$	$E_2 = 3, 4, 5$
$r_1 = 10, 30, 90$	$r_2 = 20, 50, 120$

If the systems are in thermal contact with each other, obtain the maximum number of accessible states for 8 units of energy in the equilibrium state.

b) The molar mass of Lithium is 0.00694 and its density is 0.53×10^3 kg/m^3. Calculate the Fermi energy and Fermi temperature of electrons. **[4]**

c) Prove the relation $\overline{(\Delta E)^2} = KT^2C_v$. **[4]**

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

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

e) Show that entropy in canonical distribution can be expressed as **[4]**

$$S = -K \sum_r P_r \ln P_r$$

f) Calculate r.m.s. speed and average kinetic energy of neutrons at 300°K. **[4]**

Given : Mass of neutron = 1.67×10^{-27}kg.

Q2) a) Write the partition function for Bose-Einstein statistics and hence obtain B-E distribution in the form $\bar{n}_S = \dfrac{1}{e^{\beta(\epsilon_s - \mu)} - 1}$ **[8]**

where μ = chemical potential.

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

Q3) a) Show that for classical monoatomic ideal gas having N particles contained in volume V, the number of states $\Omega(E)$ to the system in the energy range E and E + δE is given by $\Omega(E) = BV^N E^{3N/2}$

where B is constant independent of V and E. **[8]**

b) For canonical ensembles show that the probability of finding the system in a particular microstate 'r' having energy E_r is given by $P_r = \dfrac{e^{-\beta E_r}}{\sum e^{-\beta E_r}}$

[8]

Q4) a) Discuss Bose-Einstein condensation of bosons. **[8]**

b) Show that for photons, the mean pressure <p> is related to its total energy E by the relation $< p > = \dfrac{1}{3}\dfrac{< E >}{V}$ **[8]**

Q5) a) Show that for temperature smaller than Debye temperature $(T << \theta_D)$ the specific heat of solid is given by **[8]**

$$C_V = \frac{12}{5}\pi^4 \, Nk\left(\frac{T}{\theta_D}\right)^3$$

b) State and prove Liouville's theorem. **[8]**

Q6) a) Show that the electronic specific heat of a strongly degenerate fermi gas is given by $C_v = \frac{\pi^2}{2} R \frac{T}{T_f}$ where symbols have their usual meaning. **[8]**

b) Find out the average energy of linear harmonic oscillator in thermal equilibrium with a heat bath at temperature T. **[8]**

Q7) a) Using the relation for accessible state $\Omega = B(v-b)^N F(E)$ where F(E) is function of energy only. Obtain the equation of state P(v-b) = NKT. **[4]**

b) Show that the mean pressure $\overline{P}$ is given by $\overline{P} = \frac{1}{\beta}\frac{\partial lnz}{\partial v}$, where z is the partition function. **[4]**

c) Describe the thermal interaction. **[4]**

d) The Helmholtz energy $F = \overline{E} - TS = -KT lnz$ show that **[4]**

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

ii) $C_v = -K\beta^2 \left\{\frac{\partial^2(\beta F)}{\partial \beta^2}\right\}_v$

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P426

[3622]-24
M.Sc.
PHYSICS
PHY UT - 604 : Quantum Mechanics - II
(2005 Pattern) (Old Course) (Semester - II)

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

Instructions to the candidates:

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

Q1) Attempt any four of the following :

a) Show that estimation of energy by variational method is always the upper bound of ground state energy. **[4]**

b) Use time independent perturbation theory to obtain the first order correction to n^{th} level of anharmonic oscillator with Hamiltonian

$$H=\frac{p^2}{2m}+\frac{1}{2}mw^2x^2+\lambda x^4 \text{ for small } \lambda.$$ **[4]**

c) The screened coulomb potential is given by function $V(r)=\frac{-Ze^2}{r}e^{-\chi r}$ where $\left(\frac{1}{\chi}\right)$ is measure of radius of an atom. Obtain the Born approximation amplitude. **[4]**

d) Discuss the scattering event in laboratory and centre of mass frames and obtain the relation for scattering angle : $\tan\theta_{cm}=\frac{\sin\theta_{Lab}}{\left(\frac{m_1}{m_2}\right)+\cos\theta_{Lab}}$. **[4]**

e) Determine the form of the normalized antisymmetric total eigen-function for a system of three identical particles. **[4]**

f) What is dipole approximation? State the selection rules for electrical dipole transitions. **[4]**

Q2) a) What is WKB approximation? Obtain the asymptotic solution of Schrödinger equation when $u(x) = A(x)\, e^{is(x)th}$ and discuss validity of WKB approximation. **[10]**

b) Obtain the expression for ground state energy of harmonic oscillator by using variational principle. Use trial wave-function $\psi = A\, e^{-\lambda x^2}$ where λ is variational parameter. **[6]**

Q3) a) Explain :- differential cross-section, total cross-section and scattering amplitude. Show that $\frac{d\sigma(\theta,\phi)}{d\Omega} = |f(\theta,\phi)|^2$ **[8]**

b) State and prove fermi-Golden rule for the rate of transition induced by a constant perturbation. **[8]**

Q4) a) Describe partial analysis technique of scattering and obtain the expression for

i) Scattering amplitude and

ii) Total cross-section in terms of phase-shifts. **[8]**

b) Explain stark splitting for $n = 2$ level of hydrogen atom in presence of electric field using first order time independent theory for degenerate case. **[8]**

Q5) a) Develop non-degenerate time independent theory up to second order and obtain expression for first order energy correction and wave-function. **[10]**

b) For rigid sphere of radius 'a', show that scattering cross section is $\sigma = 4\pi a^2$. **[6]**

Q6) a) Define exchange operator P_{12} for identical particles 1 and 2. Find eigen values of operator P_{12}, hence define symmetric and antisymmetric wave-functions for identical particles. **[8]**

b) Develop the time dependent perturbation theory to obtain first order correction to transition amplitude $a_n^{(1)}(t)$. **[8]**

Q7) a) Discuss the validity of Born approximation. **[4]**

b) Obtain Einstein Coefficients A and B in case of spontaneous emission of radiations. **[4]**

c) Show that total energies in laboratory and centre of mass systems are related by $E_{cm} = \frac{\mu}{m_1} E_{lab}$ where μ is reduced mass. **[4]**

d) Explain terms : identical particles, intrinsic parity and pseudo-vector. **[4]**

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

P427

[3622]-41
M.Sc.
PHYSICS
PHY UT - 801 : Nuclear Physics
(2005 Pattern) (Semester - IV)

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

Instructions to the candidates:

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

Q1) Attempt any four of the following :

a) In a Bainbridge and Jorden mass spectrograph, singly ionized atom of Neon-20 pass into deflection chamber with a velocity of 10^7 cm/sec. If they are deflected by magnetic field of flux density 0.08 tesla, calculate the radius of their path. If the initial velocity of Neon-22 is same as Neon-20, find radius of Neon-22.
Given : Mass of proton = 1.67×10^{-27} kg. and e = 1.6×10^{-19}C. **[4]**

b) What are ortho and para hydrogen molecules? If neutron spin is assumed to be $\frac{3}{2}$; then show that $\frac{\sigma_{ortho}}{\sigma_{para}} \simeq 2$. **[4]**

c) The shell model terms for ${}_8O^{17}$ are : $({}^1s_{\frac{1}{2}})^2;({}^1p_{\frac{3}{2}})^4;({}^1p_{\frac{1}{2}})^2;({}^1d_{\frac{5}{2}})^1$. Find parity, magnetic moment due to odd neutrons and the quadrupole moment. **[4]**

d) Show that the Gamow-factor i.e. approximate barrier transparancy in case of Gamow's theory of alpha decay can be written as $G \simeq e^{-\pi bk}$, where k is wave number and '*b*' is collision diameter. (Given : Probability of transmission of S-wave is $T = e^{-\gamma}$ where $\gamma = \frac{2\sqrt{2m}}{\hbar} \int_R^{r_1} [V(r) - E]^{\frac{1}{2}} dr$. **[4]**

P.T.O.

e) Define atomic differential compton cross-section and calculate the maximum energy of the compton recoil electrons resulting from absorption in Al of 2.19 MeV = γ rays. (Given $m_0 = 9.109 \times 10^{-31}$ kg). **[4]**

f) By considering the conservation of strangeness, conservation of baryon number and conservation of charge, verify the following reaction and state whether reaction is allowed or forbidden $\pi^+ + n \rightarrow \wedge^\circ + K^+$. **[4]**

Q2) a) Describe the principle, construction and working of a proportional counter. **[8]**

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

Q3) a) Discuss the principle, construction and working of microton. State it's advantage over betatron. **[8]**

b) Explain the multipole radiation in case of γ decay. State the selection rules. **[8]**

Q4) a) Describe the violation of parity conservation in β-decay and explain how it is demonstrated by Wu's experiment. **[8]**

b) What is collective nuclear model? Obtain the expression of the energy for rotational states. **[8]**

Q5) a) Derive Bethe's formula for 'stopping power' of charged particles moving through matter. Write the expression for relativistic effects. **[8]**

b) Explain neutron-proton scattering at low energies and obtain the expression for the total elastic scattering cross-section. **[8]**

Q6) a) Explain the magnetic dipole moment. Show that, for the nucleus of mass number A the magnetic dipole moment is

$$\vec{\mu} = \frac{\mu_o e}{2m}\left[\sum_{k=1}^{A} g_s \vec{S}_k + \sum_{k=1}^{Z} g_l \vec{l}_k\right]$$ **[8]**

b) Describe the shape independent effective range scattering theory and obtain the expression for cross-section in terms of effective range. **[8]**

Q7) a) By drawing a suitable diagram, describe the construction and working of Bainbridge-Jorden mass spectrometer. **[8]**

b) Explain the terms :

i) isospin

ii) strangeness in case of elementary particles. **[4]**

c) Write a short note on : pair production. **[4]**

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

P428

[3622]- 201
M.Sc.
PHYSICS
PHY UT - 601 : Electrodynamics
(Sem. - II) (2008 Pattern) (New Course)

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 calculator is allowed.***

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

a) Find from Poynting flow the value of intensity of magnetic field at a distance of 100cm from a radiating source of power 10kW. Given $\sqrt{\frac{\mu_0}{\in_0}} = 377\Omega$. **[4]**

b) 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]**

c) 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]**

d) Prove that : $\vec{E}.\frac{\partial \vec{D}}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2}\vec{E},\vec{D}\right)$ and $\vec{H}.\frac{\partial \vec{B}}{\partial t} = \frac{\partial}{\partial t}\left(\frac{1}{2}\vec{H}.\vec{B}\right)$ **[4]**

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

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

P.T.O.

Q2) a) Describe the Michelson-Morley experiment and obtain the expression for fringe-shift. Comment on the results obtained. **[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 :

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

Explain significance of each term. **[8]**

Q3) a) Derive the Lorentz relativistic transformation equations. **[8]**

b) The magnetic field intensity $\vec{B}$ at a point is given by : **[8]**

$\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\int \frac{\vec{j}\times\vec{r}}{r^3}\, d\uparrow$ show that $\vec{\nabla}\times\vec{B} = \mu_0\,\vec{j}$.

Q4) a) Explain the term 'linear quadrupole'. Derive an expression for potential due to a small linear quadrupole. **[8]**

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

Q5) a) Obtain Faraday's law of induction in differential form for a stationary medium. 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 $x^2 + y^2 + z^2 - c^2t^2$ is Lorentz invariant. **[8]**

Q6) a) Explain the 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 as 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 :

$$\nabla^2\,\vec{E} - \mu\in\frac{\partial^2\vec{E}}{\partial t^2} - \mu\sigma\,\frac{\partial\vec{E}}{\partial t} = 0\,.$$

which of the above terms is predominant in metals. **[8]**

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

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

c) A radiator approximates to an electric dipole of length 250m at a frequency of 60KHz. Assuming that the current is maintained over the length, evaluate the radiation resistance of the radiator. **[4]**

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

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M.Sc.

PHYSICS

PHY UT - 602 : Atoms, Molecules and Solids

(Sem. - II) (2008 Pattern) (New Course)

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

Instructions to the candidates:

1) ***Question No. 1 is compulsory. 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.***

Given :

Rest mass of the electron = 9.109×10^{-31}kg.

Charge on the electron = 1.6021×10^{-19} coulomb.

Planck's constant = 6.626×10^{-34} J.S.

Boltzmann constant = 1.38054×10^{-23} JK^{-1}.

Avogadro's number = 6.022×10^{26} $(kilomole)^{-1}$.

Bohr magneton = 9.27×10^{-24} amp.m^2

1eV = 1.6021×10^{-19} J.

Q1) Attempt any four of the following :

a) When Hg vapour in a discharge tube is exposed to a magnetic field 4wb/m^2, the line of wavelength $\lambda = 4226.73$ A exhibits normal Zeeman splitting. Calculate wavelength of 3 components of normal Zeeman pattern. **[4]**

b) Determine Lande g factor for $^2D_{5/2}$ state. **[4]**

c) The spectroscopic bond dissociation energy of ^{35}Cl ^{16}O radical is 1.9eV. Calculate the equilibrium bond dissociation energy of clo if the fundamental vibrational frequency is 780cm^{-1}. **[4]**

d) Calculate the size of the largest atom that could fit interstatially in a fcc structure. **[4]**

e) The energy of formation of Schottky defects in a material is leV/atom. What is the equilibrium concentration of these defects at 1000K. **[4]**

f) The Debye temperature for diamond is 2230K. Calculate the highest possible lattice vibration frequency. **[4]**

P.T.O.

Q2) a) Derive an expression for concentration of Frankel defects in crystalline solids as a function of temperature. **[8]**

b) For an elastic continum prove that the number of modes of vibration in the frequency interval $d\nu$ is given by **[8]**

$$Z(\nu)\, d\nu = 4\pi V \nu^2 \left[\frac{2}{C_t^3} + \frac{1}{C_l^3}\right] d\nu$$

where the symbols have their usual significance.

Q3) a) Explain the theory of geometrical structure factor and derive an expression for the geometrical structure factor for a bcc structure. **[8]**

b) Derive dispersion relation for the vibrational modes of one dimensional monatomic lattice and discuss the origin of Brillouin zone. **[8]**

Q4) a) State and explain Franke-condon principle. **[8]**

b) Explain Band origin and band head in relation to rotational fine structure of electronic vibration spectra. **[8]**

Q5) a) Explain the principle of electron spin resonance. ESR is observed for atomic hydrogen with an instrument operating at 9.5 GHz. If g = 2.0026 calculate the magnetic field applied. **[8]**

b) What is meant by nuclear spin magnetic moment? Explain in brief principle and working of a NMR spectrometer. **[8]**

Q6) a) Explain normal Zeeman effect and derive an expression for Zeeman shift. **[8]**

b) Give reasons to explain the fact that coefficient of linear expansion approaches zero at low temperatures. **[4]**

c) Differentiate clearly between atomic spectra and molecular spectra. **[4]**

Q7) a) Write short note on edge dislocation. **[4]**

b) What are the limitations of Bragg's law. **[4]**

c) What are the causes for the broadning of the spectral lines. **[4]**

d) Anomalous Zeeman effect is the proof for the quantization of total angular momentum. Comment. **[4]**

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M.Sc.
PHYSICS
PHY UT - 603 : Statistical Mechanics In Physics
(Sem. - II) (2008 Pattern) (New Course)

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

<u>**Constants**</u> :

1) Boltzmann constant $K_B = 1.38 \times 10^{-23}$ J/K.
2) Plank's constant $h = 6.623 \times 10^{-34}$ Js.
3) Avogadro's number $N = 6.023 \times 10^{23}$ cgs units.
4) Mass of electron $m_e = 9.1 \times 10^{-31}$ kg.
5) Charge on electron $e = 1.6 \times 10^{-19}$ C.
6) Velocity of light $C = 3 \times 10^{8}$ m/s.

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

a) A simple harmonic one dimensional 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 quantum no. n can assume the possible integral values n = 0, 1, 2, ... etc. suppose that such an oscillator is in contact with a heat reservoir at temperature T, low enough so that $kT << \hbar w$.

Assuming that only ground state and first excited state are occupied, find the mean energy of the oscillator as a function of temperature. **[4]**

b) Calculate in terms of kT, the vibrational contribution of energy of one mole of hydrogen at a temperature at which $\frac{hv}{kT} = 2$. **[4]**

c) A particle of unit mass is executing simple harmonic motion. Determine its trajectory in phase space. **[4]**

d) Show that entropy in canonical distribution can be expressed as $S = -K \sum Pr \ln Pr$. **[4]**

e) An excited state of an atom is 1.38 eV above the ground state. Calculate number of atoms in this excited state relative to the ground state at 16000K. **[4]**

f) Calculate the pressure of black body radiation at 300K. **[4]**

Q2) a) For grand canonical ensemble, show that probability of finding the system in a particular microstate *r* having energy Er and number of particles Nr is given by : **[8]**

$$Pr = \frac{e^{-\beta E r - \alpha N r}}{\sum e^{-\beta E r - \alpha N r}}.$$

b) What is radiation density? Write Plank's radiation law and hence show that it leads to Rayleigh-Jean's law and Wien's law at high and low temperature respectively. **[8]**

Q3) a) State and prove Liouville's theorem. **[8]**

b) Using Fermi-Dirac distribution, obtain the temperature dependance of energy relation, $\in_F = \in_F (0)\left[1 - \frac{\pi^2}{12}\left(\frac{T}{T_F}\right)^2\right]$. **[8]**

Q4) a) State and prove equipartition theorem. **[8]**

b) Discuss the behaviour of sharpness of the probability curve and show that the functional width of maximum in P(E) is given by :

$$\frac{\Delta^* E}{E} = \frac{1}{\sqrt{f}}.$$ **[8]**

Q5) a) Show that for vibrational motion of a diatomic molecule, $C_v\,(\text{vib}) = NK\left(\frac{\theta v}{T}\right)^2 e^{-\theta v/T}$ when $\frac{\theta v}{T} >> 1$ and $C_v\,(\text{vib}) = NK$ when $\frac{\theta v}{T} << 1$ where θv is vibrational characteristic temperature. **[8]**

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

Q6) a) Obtain classical partition function of monoatomic ideal gas and use it to obtain the mean gas pressure p. **[8]**

b) Using quantum mechanical treatment, show that magnetic susceptibility is inversely proportional to temperature, when temperature is high enough. **[8]**

Q7) a) Show that mean square velocity **[4]**

$$\overline{E}^2 = \frac{1}{z}\frac{\partial^2 z}{\partial \beta^2}$$

for canonical ensemble, where *z* is partition function.

b) Find the temperature at which there is 1% probability that a state with an energy 0.5 eV above fermi energy will be occupied. **[4]**

c) The atomic weight of sodium is 23 amu and density 0.97 gm/cm^3. Calculate fermi energy. **[4]**

d) Using Maxwell velocity distribution show that most probable speed is $\sqrt{\frac{2KT}{m}}$. **[4]**

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