Total No. of Questions :8]

SEAT No. :

P2653

[Total No. of Pages :2

[5022] - 101

M.Sc.

PHYSICS

PHYUT 501: Classical Mechanics

(2013 Pattern) (Credit System) (Semester - I) (5 Credits)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Attempt any five questions out of eight questions.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicates full marks.***
4) ***Use of logarithmic table & electronic calculator is allowed.***

Q1) a) Draw the configuration space, phase space & state space for one dimensional harmonic oscillator. **[4]**

b) Prove that the total linear momentum of any closed system is conserved due to the homogeneity of space. **[3]**

c) Show that if lagrangian is cyclic in 9i, then Hamiltonian is also cyclic in 9i. **[3]**

Q2) a) State & prove virial theorem. **[4]**

b) Explain Geostationary & Geosynchronus orbits of an artificial satellites. **[3]**

c) Explain the effect of coriolis force on river flow & cyclones **[3]**

Q3) a) Evaluate the Poisson's Bracket $\left[\bar{a}.\bar{r}, \bar{b}.\bar{p}\right]$, where $\bar{a}$ & $\bar{b}$ are constant. **[4]**

b) Show that the function F = $\sum$ Qipi generate indentity transformation. **[3]**

c) Find the period of plane of oscillation of Foucault's pendulum at **[3]**

i) Equator

ii) Poles.

P.T.O.

Q4) a) Solve the problem of Atwood's machine by D' Alembert's principle. **[4]**

b) Show that for a charged particle moving in electromagnetic field canonical momentum is given by $\bar{P} = M\bar{v} + 9\bar{A}$. **[3]**

c) State & prove poisson's theorem. **[3]**

Q5) a) Prove that shortest distance between two points in a plane is a straight line. **[4]**

b) "Simple pendulum with variable length." State constraint equation & classify the constraint. **[3]**

c) Give the electromagnetic analogy of the inertial forces. **[3]**

Q6) a) Starting with Newton's law's of gravitation, deduce kepler's second law of planetary motion. **[4]**

b) State & prove law of conservation of angular momentum. **[3]**

c) Show that $[9i, Pj] = \delta ij$ **[3]**

Q7) a) Show that the following transformation is canonical. **[5]**

$Q = q \tan p, \quad P = \ln \sin p$

b) For a given Lagrangian, L $(x, \dot{x}) = \frac{1}{\alpha}x^2 - \frac{1}{\alpha}\omega^2 x^2 - \alpha x^3 + \beta x\dot{x}$ find corresponding Hamiltonian. **[5]**

Q8) a) What is Foucault's pendulum? Obtain an equation of motion for such a pendulum. **[5]**

b) Solve the problem of projectile by Hamilton's equation of motion. **[5]**

Total No. of Questions :8]

SEAT No. :

P2654

[Total No. of Pages :3

[5022] - 102

M.Sc. PHYSICS

PHYUT 502: ELECTRONICS

(2013 Pattern) (Semester - I) (5 Credit Based System)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Solve any FIVE questions out of the following EIGHT questions.***
2) ***Neat diagrams must be drawn wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of calculator is allowed.***

Q1) a) An op-amp is used in following modes with Rs = 1KΩ and Rp = 100 KΩ, Vi = 120 MV and Vcc = 12V. Find output Vo in inverting and Novinverting modes. **[4]**

b) Explain with internal block diagram of a 3- pin voltage regulator. **[3]**

c) Explain with a neat diagram the working of a 3 - bet up - down counter. Also give output waveforms. **[3]**

Q2) a) Explain the symmetrical square wavegenerator Astable multivibrator using IC 555. Also give it is output waveforms. Derive the formula for its duty cycle. **[4]**

b) Place the truth table and map the function **[3]**

$$R=\bar{A}\bar{B}\bar{C}D + A\bar{B}C\bar{D} + \bar{A}BC\bar{D}$$

c) What are the ideal parameters of ap-amp. **[3]**

P.T.O.

Q3) a) Give the circuit diagram of square wave generater using an op-amp and Explain it is working. **[4]**

b) Give the circuit diagram of R-2R Ladder type converter. Discuss the advantages and disadvantages of R - 2R type converter. **[3]**

c) Give the circuit diagram of DC-DC converter. Explain its operation. What are it is applications? **[3]**

Q4) a) Draw a circuit diagram of foldback current limiting power supply using IC 723 and explain it is working. **[4]**

b) What are different applications of counters? **[3]**

c) Discuss the working of a successive approximation type ADC. **[3]**

Q5) a) Explain with a neat diagram the working of a 4-bit decade counter. **[4]**

b) Draw a neat circuit diagram of complete regulated power supply using discrete components. Explain the role of each block. **[3]**

c) What are the advantages and disadvantages of SMPS? **[3]**

Q6) a) Design and explain first order high pass filter using op-amp for cut off frequency f_c= 10KHz. **[4]**

b) Minimize the following Boolean expression using K - map and realize it using the logic gate. $Y = \sum_m (1, 3, 5, 9, 11, 13)$. **[3]**

c) Design a monostable multivibrator using Ic 555 timer for Vcc = 12 V and pulse width of 1 msec. **[3]**

Q7) a) Calculate the output frequency f_o. Lock reange Δf_e and capture range Δf_c of PLL Ic 565. If R_T = 10 KΩ, C_T = 0.01 μF and C_f = 10 μF., Vcc = I10V. **[5]**

b) What is K - map? Write a truth table for four input variables has a high output for an input of 0000, low output for 0001 to 1001 and don't cares for 1010 to 1111. What is the simplest logic circuit with this truth table? **[5]**

Q8) a) How capacity 'C' charges in voltage controlled oscillator using IC 566? Find the output frequency with the following data. **[5]**

$V^+ = 10V$, $V_C = 8V$, $R_1 = 10\ K\Omega$ and $C_1 = 0.1\ \mu F$.

b) Design first order low pass filter using op-amp for the following specifications. Draw circuit diagram and show its frequency response characteristics. **[5]**

i) Passband voltage gain = 2

ii) Cut off frequency f_c = 10 KHz.

Total No. of Questions :8]

SEAT No. :

P2655

[Total No. of Pages :3

[5022] - 103

M.Sc.

PHYSICS

PHY UT 503: Mathematical Methods in Physics

(2013 Pattern) (5- Credits) (Credit System) (Semester - I)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Answer <u>ANY FIVE</u> questions out of eight questions.***
2) ***Neat diagrams must be drawn wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of calculator is allowed.***

Q1) a) Define Basis and Dimension of a Vector Space. Explain with one example. **[4]**

b) Evaluate $\oint_c \frac{e^z}{z(z+1)} dz$ where C is the circle $|z - 1| = 3$. **[3]**

c) Obtain the Associated Legendre function $P_2^3(x)$. **[3]**

Q2) a) State and prove a necessary condition (Cauchy - Riemann Equations) for a function $w = f(z) = u(x, y) + iv(x, y)$ to be analytic in a region R. **[4]**

b) Find the Fourier coefficients a_n and b_n in the interval (–L, +L) for odd function. **[3]**

c) Determine whether or not the following vectors in R^3 are linearly dependent: $\{(1, 0, 0), (0, 1, 0), (0, 0, 0)\}$. **[3]**

Q3) a) State and prove Cauchy-Schwarz inequality. **[4]**

b) For which value of K will the vector u = (1, –2, K) in R^3 be a linear combination of the vectors V = (3, 0, –2) and W = (2, –1, –5)? **[3]**

c) Determine the region in the z - plane represented by $1 < |z + 2i| \leq 2$. **[3]**

P.T.O.

Q4) a) Consider the following basis of Euclidean space R^3: **[4]**

$$\{V_1 = (1,1,1),\ V_2 = (0,1,1),\ V_3 = (0,0,1)\}$$

By using Gram schmidt orthogonalization process to transform $\{V_i\}$ into an orthonormal basis $\{u_i\}$

b) Let V = R^3. Show that W is a subspace of V, where W = $\{(a,b,c)/\ a+b+c=0\}$. **[3]**

c) Prove that: $J_n'(x) = \frac{1}{2}\left[J_{n-1}(x) - J_{n+1}(x)\right]$. **[3]**

Q5) a) Determine the first three Laguerre polynomials $L_0(x)$, $L_1(x)$ and $L_2(x)$. **[4]**

b) Prove that the Inverse Laplace transform operator L^{-1} is linear. **[3]**

c) Determine the residue of $\frac{z^2}{(z-2)(z^2+1)}$ at $z = i$. **[3]**

Q6) a) Prove that if $\mathcal{L}\{f(t)\}$ = F (S) then **[4]**

$$\mathcal{L}\{f(at)\} = \frac{1}{a} F\left(\frac{S}{a}\right)$$

b) Prove that: **[3]**

$$H_{n+1}(x) = 2x\, H_n(x) - 2n\, H_{n-1}(x).$$

c) Discuss whether or not R^2 is a subspace of R^3. **[3]**

Q7) a) Let T be the linear operator on R^3 defined by $T(x, y, z) = (2y + z, x - 4y, 3x)$. **[5]**

i) Find the matrix of T in the basis $\{f_1 = (1,1,1), f_2 = (1,1,0), f_3 = (1,0,0)\}$

ii) Verify that $[T]_f [V]_f = [T(V)]_f$ for any vector $V \in R^3$.

b) State and prove the orthogonality property of Legendre polynomials. **[5]**

Q8) a) Find $\mathcal{L}^{-1}\left\{\frac{3s+1}{(s-1)(s^2+1)}\right\}$ **[5]**

b) Let $A = \begin{pmatrix} 1 & -3 & 3 \\ 3 & -5 & 3 \\ 6 & -6 & 4 \end{pmatrix}$. **[5]**

Find a (real) orthogonal matrix P for which $P^{-1}AP$ is diagonal.

Total No. of Questions :8]

SEAT No. :

P2656

[Total No. of Pages :2

[5022] - 104

M.Sc.

PHYSICS

PHYUT - 504: Atoms, Molecules and Lasers

(2013 Pattern) (Semester - I) (Credit System) (5 Credits)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Solve any Five questions.***
2) ***Draw neat digrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of Lagorithmic table and electronic packet calculator is allowed.***

Given :- Rest mass of $\bar{e}$ $= 9.109 \times 10^{-31}$ kg.

Change on the $\bar{e}$ $= 1.6021 \times 10^{-19}$ coloumb

Plank's constant $= 6.626 \times 10^{-34}$ Js

Boltzman's constant $= 1.38054 \times 10^{-23}$ JK^{-1}

Avogadro's number $= 6.022 \times 10^{26}$ $(k\ mole)^{-1}$

Bohr mageton $= 9.27 \times 10^{-24}$ amp. m^2

1 ev $= 1.6021 \times 10^{-19}$J

Q1) a) Discuss constrution and working of He-Ne Laser. **[4]**

b) Write a short note on vibrational course structure. **[3]**

c) State Pauli's exclusion principle. What is Hund's rule of Maximum multiplicity. **[3]**

Q2) a) State and explain frank - condon principle. **[4]**

b) What is Zeeman effect? Discuss anamolous Zeeman effect. **[3]**

c) Discuss application of Laser in Medicine. **[3]**

P.T.O.

Q3) a) What is NMR? Derive the necessary formula for shift in wavelength $d\lambda$. **[4]**

b) Calculate magnetic field required to get a transition frequency 60 MHz for fluorine. **[3]**

[Given = $g_N = 5.255$, $\mu_N = 5.051 \times 10^{-27}$ JT^{-1}]

c) What are the properties of Laser? **[3]**

Q4) a) Derive an expression for specific heat from Einstein's model. **[4]**

b) Find the relative population of two states in a Ruby Laser that produces a light beam of wavelength 6943 A° at 300°K. ($K_B = 8.61 \times 10^{-5}$ ev/k). **[3]**

c) Discuss rotational fine structure of electronic vibrational transitions. **[3]**

Q5) a) The value of $x_e\, x_e^1$ for lower and upper states of C_2 are 0.00711 and 0.00919 respectively. Find the no. of levels in lower and upper states. **[4]**

b) Describe characteristics of Laser beam. **[3]**

c) What is holography? How it differ from photography. **[3]**

Q6) a) Differentiate between spontaneous emission and stimulate emission. **[4]**

b) A free e^- is placed in a magnetic field of strength 1.3T. Calculate the resonance frequency if g = 2.0023. **[3]**

c) Discuss the origin of spectral line. **[3]**

Q7) a) Explain Paschen - Back effect for 25-2P transition. **[5]**

b) Draw and explain black diagrams of ESR. **[5]**

Q8) a) Differentiate between spatial coherence and temperal coherence. **[5]**

b) What is metastable state? Explain its role in laser action. **[5]**

Total No. of Questions :8]

SEAT No. :

P2657

[Total No. of Pages :2

[5022] - 201

M.Sc.

PHYSICS

PHYUT 601: Electrodynamics

(2013 Pattern) (New Course) (5 - Credits) (Semester - II)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Attempt any five questions from the following.***
2) ***Draw neat labelled diagrams wherever necessary.***
3) ***Figures to the right indicates full marks.***
4) ***All questions carry equal marks.***
5) ***Use of lagorithmic tables and pocket calculator is allowed.***

Q1) a) Write Maxwell's equations for stationary medium and explain the significance of vacuum displacement current. **[4]**

b) Explain the term 'momentum space' with the help of suitable example. **[3]**

c) Show that $\left(\vec{E}\cdot\vec{B}\right)$ is invarient under Lorentz transformations. **[3]**

Q2) a) Derive an expression for potential at a point due to a small linear quadruple. **[4]**

b) Explain the term Hertz potential. Show that the magnetic field can be expressed as $\vec{B}=\frac{1}{C^2}\frac{\partial}{\partial t}\left(\vec{\nabla}\times\vec{Z}\right)$. **[3]**

c) Show that $(C^2 B^2 - E^2)$ is invarient under Lorentz transformations. **[3]**

Q3) a) Derive inhomogeneous wave equations in terms of scaler potential ϕ and vector potential $\vec{A}$. **[4]**

b) Given the electromagnetic wave: **[3]**

$\vec{E}=\hat{i}\,E_0\cos\omega\left(\sqrt{\in\mu}\;z-t\right)+\hat{j}\,E_0\sin\omega\left(\sqrt{\in\mu}\;z-t\right)$ where E_0 is constant. Find the corresponding magnetic field.

c) Explain the terms 'skin-effect' and 'skin -depth'. **[3]**

P.T.O.

Q4) a) Derive Faraday's law of induction for moving medium. **[4]**

b) Find the ratio of skin - depth in copper at 1kHz to 100 MHz. **[3]**

c) Explain the term 'Four vector Potential'. **[3]**

Q5) a) Draw a suitable diagram and explain the magnetic interaction between two current loops. **[4]**

b) Write the boundary conditions at the interface of a dielectric and explain them. **[3]**

c) Two identical bodies move towards each other, the speed of each being 0.9C. What is their speed relative to each other? **[3]**

Q6) a) Explain an oscillating electric dipole. Hence derive an expression for magnetic field radiation when $l << \lambda$. **[4]**

b) Find the wave impedance of an e.m. wave travelling through free space.

Given : $\mu_0 = 4\pi \times 10^{-7} \frac{\omega b}{A - m}$ and $\in_0 = 8.85 \times 10^{-12} \frac{C^2}{N - m^2}$. **[3]**

c) Write an expression for magnetic field intensity $\vec{B}$ at a point and show that its curl equals to $\mu_0 \vec{j}$. **[3]**

Q7) a) Derive the Lorentz relativistic transformation equations. **[5]**

b) State and prove Poynting's theorem. **[5]**

Q8) a) Describe Michelson-Morley experiment with a suitable diagram. Hence derive the formula for fringe shift. **[5]**

b) Explain the concept of dipole radiation and radiation resistance. **[5]**

Total No. of Questions :8]

SEAT No. :

P2658

[Total No. of Pages :3

[5022] - 202

M.Sc.

PHYSICS

PHY UT 602: Solid State Physics

(2013 Pattern) (5 Credits) (Semester - II)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Attempt any five questions.***
2) ***Draw neat and labelled diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic tables and calculators is allowed.***

Physical constants:-

Boltzmann constant = 1.38×10^{-23} J/K.

Planck's constant = 6.623×10^{-34} J – s.

Avogadro's number = 6.023×10^{26} per kg mole

Mass of electron = 9.1×10^{-31} kg.

Electronic charge = 1.6×10^{-19} C

Bohr Magneton = 9.27×10^{-24} A - m^2

Permeability of free space = $4\pi \times 10^{-7}$ H/m.

Permittivity of free space = 8.85×10^{-12} SI units.

Q1) a) Prove that for the Kronig - Penny potential with P << 1, the energy of the lowest energy band at k = 0 is, $E = \frac{h^2 P}{4\Pi m a^2}$ **[4]**

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

c) Explain Type I and Type II super - conductors. **[3]**

P.T.O.

Q2) a) Show that the flux coming from the hollow space of the super conducting ring is quantised. **[4]**

b) For Helium atom in ground state, the mean radius in the Langervin's formula is approximated by Bohr radius of 0.53 nm. Estimate the diamagnetic susceptibility of helium atom. Given :Density of helium = 0.178 kg/m^3. **[3]**

c) With neat diagrams, explain the reduced, extended and periodic zone schemes for the band theory of solids. **[3]**

Q3) a) Using equation, $m\left[\frac{dv}{dt}+\frac{v}{\tau}\right]=-e\mathrm{E}$ for the electron drift velocity v, Derive the relation for a.c. electrical conductivity. **[4]**

b) Describe the assumptions of the BCS theory of super conductivity. **[3]**

c) The saturation magnetic induction of Ni is 0.65 Wb/ m^2. Determine the magnetic moment of Niatom interms of Bohr magneton. **[3]**

Given: ρ for Ni = 8906 kg/m^3, M_A for Ni = 58.7.

Q4) a) Explain how energy gap is produced in solids on the basis of nearly free electron model. **[4]**

b) For a simple 2 - D square lattice, show that the Kinetic energy of a free electron at the corner of the 1st Brillouin zone is higher than the electron at the midpoint of a side face by a factor of two. **[3]**

c) A magnetic material has a magnetization of 3300 A/m and flux density of 0.0044 Wb/m^2. Calculate the magnetising force and relative permeability of the material. **[3]**

Q5) a) Explain the phenomenon of hysteresis and hysteresis curve on the basis of domain theory. **[4]**

b) The critical temperature (T_c) for mercury with isotopic mass 199.5 is 4.185 K. Determine its critical temperature when isotopic mass becomes 203.4 **[3]**

c) An atom contains 10 electrons revolving in a circular path of radius 10^{-11} m. Assuming homogeneous charge distribution, calculate the orbital diapole moment of the model in Bohr magneton. **[3]**

Q6) a) Derive London equation for super conducting state. Hence obtain an expression for penetration depth. **[4]**

b) For a specimen of V_3 Ga, the critical fields are 1.4×10^5 and 4.2×10^5 A/m respectively at 14 K and 13 K. Determine the transition temperature and the critical fields at 0 K and 4.2K. **[3]**

c) An electromagnet with iron core can be magnetised upto 1 Tesla. At room temperature, determine the magnetic interaction and thermal energies of the core. **[3]**

Q7) a) Explain antiferromagnetism with reference to Neel temperature and susceptibility. **[5]**

b) Explain classical theory paramagnetism. Hence derive Curie law. **[5]**

Q8) a) Describe the motion of electron in 1 - D periodic potential. Draw E - K, V - K and m* - K diagrams. **[5]**

b) Distinguish between Ferromagnetism, Ferrimagnetism and Anti Ferromagnetism. **[5]**

Total No. of Questions :8]

SEAT No. :

P2659

[Total No. of Pages :3

[5022] - 203

M.Sc.

PHYSICS

PHY UT 603: Experimental Techniques in Physics

(2013 Pattern) (5 Credit System) (Semester - II)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Attempt any five questions.***
2) ***Figures to right indicate full marks.***
3) ***Draw neat diagrams wherever necessary.***
4) ***Use of non-programmable electronic calculator and logarithmic table is allowed.***

Constants:

a) Boltzmann constant, K_B = 1.38×10^{-23} J/K.

b) Planck's constant, h = 6.63×10^{-34} J . S.

c) Avogadro's number, N = 6.023×10^{23} /gm. mole

d) Mass of electron, Me = 9.1×10^{-31} kg.

e) Velocity of light, C = 3×10^{8} m/s

f) Charge on electron, e = 1.6×10^{-19} C.

Q1) a) Calculate the average nanoparticle size using Scherrer formula. **[4]**

[Given: Wavelength used for diffraction CUK α – 0.154 nm, full width at half maxima (FWHM) $\beta = 0.05, \theta_B = 45°$]

b) Write a short note on periodic and random signals. **[3]**

c) Write a short note on electron spin resonance. **[3]**

P.T.O.

Q2) a) Calculate energy in eV for photon whose radiation wavelength is 700nm. **[3]**

b) Explain the construction and working of Mcleod quage in brief. **[3]**

c) Write a short note on vacuum measurement. **[4]**

Q3) a) Explain principle, construction and working of Atomic Force Microscope (AFM). **[4]**

b) Discuss the basic principle of optical tweezers. **[3]**

c) Write short note on time and frequency domain analysis. **[3]**

Q4) a) Write the electromagnetic radiations with their wavelength, frequency range and corresponding approximate energies. **[4]**

b) Explain the principle of XPS. **[3]**

c) Explain the principle FTIR spectrometer. **[3]**

Q5) a) What is throttling process? Prove that entropy remains constant in a throttling process. **[4]**

b) In SEM system, calculate the wavelength in nm if the applied voltage is 10 kV. **[3]**

c) Write a short note on error analysis. **[3]**

Q6) a) What is thermistor? Explain its operating principle in brief. **[4]**

b) What are the different pumping concepts used in vacuum pumps? **[3]**

c) Write a short on microwave generator. **[3]**

Q7) a) With the help of schematic diagram, explain the basic components Transmission Electron Microscope. (TEM). **[5]**

b) Explain with neat diagram, x - ray diffraction. **[5]**

Q8) a) Explain principle, construction and working of UV visible spectrometer. **[5]**

b) Explain thermodynamical aspects used in Refrigeration principle. **[5]**

Total No. of Questions :8]

SEAT No. :

P2660

[Total No. of Pages :3

[5022] - 204

M.Sc.

PHYSICS

PHY UT 604: Quantum Mechanics - I

(2013 Pattern) (5 Credits) (Semester - II)

Time : 3 Hours] *[Max. Marks :50*

Instructions to the candidates:

1) ***Attempt any five questions.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of calculators allowed.***

Q1) a) Show that different eigen functions of a particle in an infinite square well potential are orthogonal. **[4]**

b) Show that for harmonic oscillator $< \Delta x > < \Delta p > = \left(n + \frac{1}{2} \right) \hbar$. **[3]**

c) Calculate the probability for transmission through a potential barrier of arbitrary shape, using the WKB method. **[3]**

Q2) a) Show that $[A, B^{-1}] = - B^{-1} [A, B] B^{-1}$. **[4]**

b) Using ladder operators a and a^{+} for harmonic oscillator, show that $H = \left[a^{+} a + \frac{1}{2} \right] \hbar w$ **[3]**

c) Prove that for Pauli matrices $\left[\sigma^2, \sigma_z \right] = 0$. **[3]**

P.T.O.

Q3) a) A linear operator $\hat{F}$ takes a vector $|\Psi\rangle$ into $|X\rangle$ as $F\ |\Psi\rangle = |X\rangle$. Represent $\hat{F}$ as a matrix elements in A - representation. **[4]**

b) Show that $[L_x, L_y] = i\hbar L_z$ and $[L^2, L_z] = 0$. **[3]**

c) Using Dirac notation show that eigen values of a Hermitian operator are real. **[3]**

Q4) a) Using time dependent perturbation theory, show that first order correction in amplitude is given as $a_m^{(1)}(t) = \frac{1}{i\hbar}\int H'_{mm}\ (t')\, e^{iw_{mm}t'}dt'$. **[4]**

b) Explain conditions of validity of WKB approximation. **[3]**

c) Obtain first order correction in energy of harmonic oscillator in ground state when perturbed by $H' = \lambda x^3$. **[3]**

Q5) a) Obtain the matrix of Clebsh-Gordon coefficients for a system having $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$ **[4]**

b) Show that operator equations remain unchanged under unitary transformations. **[3]**

c) For one dimensional harmonic oscillator, show that $[x, H] = -\frac{i\hbar}{m}p$ and $[p, H] = -i\hbar mw^2 x$. **[3]**

Q6) a) Obtain the expression for first order correction in energy using time - independent perturbation theory of non-degenerate state. **[4]**

b) Obtain J^2 and J_z matrices for j = ½. **[3]**

c) Show that operator $\hat{L}_Z = -i\hbar\frac{\partial}{\partial\phi}$ is self-adjoint. **[3]**

Q7) a) Explain completeness and closure property. Show that in the Dirac notation the closure relation can be written as $\sum |\psi_n\rangle\langle\psi_n| = \mathrm{I}$. **[5]**

b) Using as a basic the eigen vectors $|\mathrm{j, m}\rangle$ of J^2 and J_z, obtain the matrix representation of angular momentum operators J_x, J_y and J_z. **[5]**

Q8) a) Describe Schrödinger and Heisenberg pictures regarding the evolution of a system with time. **[5]**

b) Using variational method, obtain ground state energy of linear harmonic oscillator. Use Gaussian wave function $\psi(x) = \mathrm{A}\, e^{-\alpha x^2}$ as trial wave function with α - as variation parameter. **[5]**