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SARDAR PATEL UNIVERSITY

M. Sc. (Physics) (II[nd] Semester) Examination

Day: Monday, Date: 09/04/2018, Time: 02:00 p.m. to 05:00 p.m.

Course No. PS02CPHY21 (Classical and Quantum Mechanics)

Important Note: Q.1: Eight multiple choice questions (MCQ) carry one mark each.
Q.2: Short answer questions carry two marks each (attempt any seven out of nine).
Q.3 to Q.6: Long answer questions carry 12 marks each. **Total Marks: 70**

Q1 (i) The physical quantities in Lagrangian formulation are
(a) vector (b) scalar
(c) tensor (d) none of them

(ii) The solution of $\frac{\partial H}{\partial q_i}$ is _____;
(a) $-\dot{p}_i$ (b) $-\dot{q}_i$ (c) $\dot{p}_i$ (d) $\dot{q}_i$

(iii) If $P_k = P_k(p_i, t)$, then which generating function will not be used _____.
(a) $F_3(p, Q, t)$ (b) $F_4(p, P, t)$ (c) $F_1(q, Q, t)$ (d) $F_2(q, P, T)$

(iv) The equilibrium is said to be unstable if extremum value of potential energy V is a _____.
(a) maximum (b) minimum
(c) zero (d) any value between minimum and maximum

(v) $\frac{1}{2}(J_+ + J_-) =$
(a) J_y (b) J_x (c) 0 (d) J_z

(vi) _____ plays the role of generator of infinitesimal translations.
(a) $p_z/\hbar$ (b) $L_z/\hbar$ (c) $\hbar L_z$ (d) $\hbar p_z$

(vii) $\sum_{a,i} |ai\rangle\langle ai| =$
(a) δ_{ai} (b) $\hat{1}$ (c) δ_{ia} (d) 0

(viii) The azimuthal quantum number m can assume the values _____
(a) -j, -j+1, …0…., j-1, j (b) -j+1, …0…., j-1
(c) 0,….j+1 (d) -j+1,….0

Q2 (i) Discuss symmetry properties of a system in motion and Noether's theorem.

(ii) The Hamilton-Jacobi equations are first-order partial differential equation having (n+1) variables, discuss.

(iii) Discuss in brief the Poisson's brackets. Prove that Poisson's bracket obeys distributive laws of algebra.

(iv) Discuss the secular equation for small oscillations.

(v) Discuss theory of small oscillations and explain with example its equilibrium states.

C.P.T.O.

(vi) Show that any operator is diagonal in its own representation.

(vii) Explain product of operators.

(viii) Find $[J_x, J^2]$.

(ix) What are C-G cpefficients?

Q3 (a) Using D'Alembert's principle, derive the second order Lagrangian's differential equation of motion for a conservative holonomic system. 6

(b) Prove that Poisson brackets are invariant under canonical transformation. Obtained canonical equations in terms of Poisson bracket notation and discuss about its symmetry with respect to the corresponding differential equations. 6

OR

(b) What do you understand by gauge and canonical transformation? Obtain a relation between new and old coordinates, momentum and Hamiltonian function. What are generating functions? 6

Q4 (a) Discuss the problem of one-dimensional harmonic oscillator having Hamiltonian $H = p^2/2m + m\omega^2q^2/2$, $\omega = (k/m)^{1/2}$. Derive the necessary equations using Hamilton-Jacobi method. Here symbols have usual meaning. 6

(b) Discuss the theory of the free vibrations of linear triatomic molecule with necessary mathematical equations. 6

OR

(b) Show that the eigenvectors corresponding to the two distinct eigen frequencies are orthogonal. Explain the meaning of orthogonality. 6

Q5 (a) Explain representation of state vectors and deduce the relation $(\chi)_A = [F]_A (\psi)_A$. 6

(b) Explain the unitary transformation induced by rotation of coordinate system and show that $|x\rangle' = e^{-i\theta_n \hat{L}/\hbar}|x\rangle$. 6

OR

(b) Discuss the algebra of rotation generators. 6

Q6 (a) Obtain the eigen value spectrum of J^2 and J_z. 6

(b) Discuss the matrix representation of **J** in the |jm> basis. 6

OR

(b) Determine the spin wave function for a system of two spin half particles and discuss the triplet and singlet state. 6