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SEAT No.________ **No. of Printed Pages : 2**

SARDAR PATEL UNIVERSITY
M. Sc. (Physics) (IInd Semester) Examination
Day: Tuesday, Date: 23/10/2018, Time: 10:00 A.M. to 01:00 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 constraint equation in case of a particle moving on or outside the surface of a sphere of radius '***a***' is given by $x^2 + y^2 + z^2 \geq a^2$. Name the type of constraint ________________

(a) non-holonomic (b) holonomic (c) independent (d) dependent

(ii) The Poisson bracket $[p_i, H]$ of p_i and Hamiltonian H is equal to ____________.

(a) $-\dot{p}_i$ (b) $-\frac{\partial H}{\partial q_i}$ (c) p_i (d) $\dot{q}_i$

(iii) The equilibrium is said to be stable if extremum value of potential energy V is a ____________.

(a) maximum (b) zero
(c) minimum (d) any value between minimum and maximum

(iv) The *generalized coordinates* represent ________________.

(a) mass (b) angles (c) electric charge (d) all of them

(v) $\sum_{a_i} |a_i\rangle\langle a_i|$

(a) $\hat{1}$ (b) δ_{ia} (c) 0 (d) δ_{ai}

(vi) $\langle\phi|\psi\rangle^* =$

(a) $\langle\psi|\phi\rangle$ (b) $\langle\psi^*|\phi^*\rangle$ (c) 1 (d) $\langle\psi|\phi\rangle^*$

(vii) For Pauli matrices $\sigma_+\sigma_- =$ ____________

(a) $2(1 + \sigma_Z)$ (b) $2(1 - \sigma_Z)$ (c) 0 (d) 1

(viii) $(J_+ + J_-) =$

(a) $2J_z$ (b) 0 (c) $2J_x$ (d) $2J_y$

Q2 (i) What are constraints in mechanics? Elaborate four types of constraints.

(ii) Discuss and derive relation between new and old coordinates in infinitesimal transformation.

(iii) Discuss Poisson brackets of representing the equation of motion in a symmetric form. Prove Kronecker delta property.

(iv) Derive the secular equation for small oscillatory motion.

(v) Define Hilbert space.

(P.T.O.)

(vi) Explain Parity.

(vii) What are C-G coefficients?

(viii) Explain phase convention.

(ix) Write the Hamilton-Jacobi equations and show they are first-order partial differential equations having (n+1) variable.

Q3 (a) Using D'Alembert's principles derive the Lagrange's equation of motion for a conservative holonomic system. 6

(b) Using canonical transformation solve the harmonic oscillator problem. The given generating function for the harmonic oscillator is $F_1 = \frac{1}{2} m\omega q^2 \cot Q$. 6

OR

(b) Discuss the infinitesimal transformations and deduce the conservation theorems in the Poisson bracket formulation. 6

Q4 (a) Derive the expression for Hamilton-Jacobi equation with the help of appropriate generating function. 6

(b) In the theory of small oscillations, solve the problem of two coupled simple pendulum and derive the equations of its characteristic frequencies. 6

OR

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

Q5 (a) Obtain the eigen value spectrum of J^2 and J_z. 6

(b) Write a note on spin angular momentum. 6

OR

(b) Explain the matrix representation of J in the $|jm\rangle$ basis. 6

Q6 (a) For a continuous basis show that $\langle x|\hat{p}|\psi\rangle = -i\hbar \frac{\partial \psi(x)}{\partial x}$. 6

(b) Explain unitary transformation induced by rotation of coordinate system. 6

(b) Explain the algebra of rotation generators. 6

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