Time: 2:30 Hours   **Total Marks: 60**

N.B.: (1) **All** questions are **compulsory**.
  (2) **Figures** to the **right** indicate **full** marks.
  (3) **Symbols** have their usual **meanings** unless otherwise **stated**.
  (4) Use of **log tables / non-programmable** calculator is **allowed**.

1. (a) Attempt any **one** : -   **8**

  (i) Show that the total angular momentum of system of particles about a point 'O' is the angular momentum of motion concentrated at the center of mass plus the angular momentum of motion about the center of mass.
  (ii) Obtain Lagrange's equation of motion using D'Alembert's principle.

  (b) Attempt any **one: -**   **4**
  (i) What are constraints? Explain non-holonomic constraints.
  (ii) Derive the Lagrange's equation for a simple pendulum.

2. (a) Attempt any **one** : -   **8**
  (i) State and prove the Viral theorem and show that how it leads to ideal gas law.
  (ii) Derive differential equation of orbit for a particle under central force.

  (b) Attempt any **one** : -   **4**
  (i) Explain the term impact parameter and the differential cross-section.
  (ii) Show that the central force motion is restricted to plane.

3. (a) Attempt any **one** : -   **8**
  (i) For a particle performing small oscillations near the minima of some potential function, derive the Lagrange equations of motion.
  (ii) What are Legendre transformations? Derive Hamilton's equations from Legendre transformation.

  (b) Attempt any **one** : -   **4**
  (i) Explain forced and damped oscillations
  (ii) Write down the steps to find the Hamiltonian from the Lagrangian.

4. (a) Attempt any **one** : -   **8**
  (i) What is generating function F? For $F = F_1(q, Q, t)$ derive expressions for $p_i, P_i \ and \ K$. (Symbols have their usual meanings.)
  (ii) Show that Poisson Brackets remain invariant under Canonical transformations.

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(b) Attempt any **one : -**   **4**

(i) Show that the following transformation is canonical.

$$Q = p + iaq, \qquad P = \frac{p - iaq}{2ia}$$

(ii) Write down the direct conditions for a transformation to be restricted canonical transformation.

5. Attempt any **four:** -   **12**

(a) Write short note on degrees of freedom.

(b) Show that the shortest distance between two points in a plane is a straight line.

(c) State Kepler's laws of planetary motion.

(d) Explain bounded motion and unbounded motion and give examples.

(e) With proper example, explain the concept of cyclic coordinates.

(f) Show that V_{ij} is symmetric.

(g) Write Hamilton's equations of motion in symplectic form. Explain the terms involved in it.

(h) Show that $[A, BC] = [A, B]C + B[A, C]$

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