S.No- 10275

Unique Paper Code	:	2223510012
Name of the Paper	:	Classical Dynamics (DSE Paper)
Name of the Course	:	B.Sc. Prog.– (Physics)_NEP: UGCF-2022
Semester	:	VII- Semester
Duration	:	3 hours
Maximum Marks	:	90 Marks

Instructions for Candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Question No. **1** is compulsory.
3. Attempt **five** questions in all including question **No. 1**.
4. All questions carry equal marks.

Q1. Attempt any 6 parts 6x3 = 18

a. Explain and derive the D'Alembert's principle.
b. What do you mean by inertial and non-inertial frame of reference?
c. What is a cyclic coordinate? Prove that Hamiltonian of a conservative system is equal to the total energy of the system.
d. If F and G are functions of position co-ordinates q_i and momentum co-ordinates p_i, then define the Poisson's bracket of F and G.
Prove that (a) [F,G] = - [G, F] and (b) $[q_i, p_j] = \delta_{ij}$.
e. What do you mean by Inertia Tensor.
f. Explain the concept of phase space and phase trajectory?
g. Show that the angular momentum of a test particle moving under the influence of a central force is conserved.

Q2. a. Define Poisson bracket of two dynamical variables. For what values of m and n do the transformation equations:

$$Q = q^m \cos np$$
$$P = q^m \sin np$$

present a canonical transformation? Obtain the generating function. 12

b. Obtain the Hamiltonian for an harmonic oscillator, whose Lagrangian is given by

$$L(x, \dot{x}) = \frac{1}{2}\dot{x}^2 - \frac{1}{2}\omega^2 x^2 - ax^3$$

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Q3. A. Determine the canonical transformation defined by the generating function

$$F_1(q, Q, t) = \frac{1}{2}\, m\omega(t) q^2 \cot Q$$

Find also the new Hamiltonian, K. The old Hamiltonian is $H = \frac{p^2}{2m} + \frac{1}{2}\, m\omega^2 q^2$

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b. The parabolic coordinates (ξ, η), are related to the Cartesian coordinates (x,y) by $x = \xi\eta$ and $y = \frac{1}{2}\,(\xi^2 - \eta^2)$. Determine the Lagrangian for a two-dimensional simple harmonic oscillator of mass m and angular frequency ω in parabolic coordinates.

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Q4. a. Explain the Normal modes of oscillation. Determine the frequencies of normal modes and modes of oscillation for a diatomic molecule. 10

b. The potential energy V(x) of a particle is given by $(x) = 3x^4 - 8x^3 - 6x^2 + 24$. Determine the points of stable and unstable equilibrium. 8

Q5. (a) Derive the equation of orbit of a particle moving under the influence of a central force consistent with the inverse square law and discuss briefly the special cases depending upon the energy and hence of eccentricity. 10

(b) A particle, moving in a central force field located at r = 0, describes a spiral $r = e^{-\theta}$ Prove that the magnitude of force is inversely proportional to r^3. 8

Q6. (a) Derive Euler's equations of motion for a rigid body rotating freely about a fixed point. Discuss the torque-free motion of the body. 10

(b) Discussed the Euler's angles as the generalized co-ordinate for a rigid body motion, obtain an expression for the angular velocity of a rigid body motion-in Euler's angle.

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