Exam. Code : 209001
Subject Code : 4870

M.Sc. Physics 1st Semester (Batch 2021-23)

CLASSICAL MECHANICS

Paper—PHY-403

Time Allowed—3 Hours] [Maximum Marks—100

Note :— Attempt **FIVE** questions in all, selecting at least **ONE** question from each section. The fifth question may be attempted from any section. All questions carry equal marks.

SECTION—A

I. (a) State what do you understand by constraints of motion. Classify them by citing suitable examples. State the difficulties associated with a constrained system. Explain in detail the process to get rid of these difficulties. 12

(b) Obtain Lagrangian and equation of motion for the motion of a simple pendulum of fixed length. How these expressions get modified when the pendulum is of varying length ? 8

II. (a) State variational principle and hence derive Lagrange's equations of motion using this principle. 12

(b) Explain the role of symmetry properties in determining the constant of motion. 8

SECTION—B

III. (a) State the importance of two-body central force problem and hence reduce it into an equivalent one-body problem. 10

(b) A particle describes a conic $r = \frac{a}{1 + b\cos\theta}$, where a and b are constant. Show that the force under which particle is moving is a central force. Deduce the force law and hence prove that the energy of the particle is constant. 10

IV. What do you mean by differential and total scattering cross-sections ? Discuss the problem of scattering in a central force field and hence obtain Rutherford's scattering formula. 20

SECTION—C

V. Discuss in brief the role of orthogonal transformation matrix in rigid body kinematics. Hence state and prove the various properties of orthogonal transformation matrix. 20

VI. (a) What do you mean by inertia tensor, principal moments of inertia and principle axes of a rigid body ? Obtain these for a diatomic molecule whose two atoms have coordinates (–1, –1, –1) and (1, 1, 1) respectively. 10

(b) Obtain Euler's equations of motion for a rotating rigid body. What information these equations provide when the motion of the rigid body is not subjected to any force ? 10

SECTION—D

VII. (a) Define Hamiltonian of a system and hence deduce Hamilton's equations of motion from it. Discuss the various features of these equations. Explain the condition under which Hamiltonian is constant of motion and represents total energy of the system. 14

(b) Write Hamiltonian and equations of motion for the motion of a particle on the surface of cone and cylinder. 6

VIII. (a) Distinguish between point and canonical transformations. Hence solve the problem of one-dimensional harmonic oscillator using canonical transformations. 12

(b) For what values of α and β, the equations :

$$Q = q^{\alpha} \cos\beta\ p,\ P = q^{\alpha} \sin\beta\ p$$

represent a canonical transformation ? Hence deduce generating function for the transformation. 8