



K22P 1589

Reg. No. :

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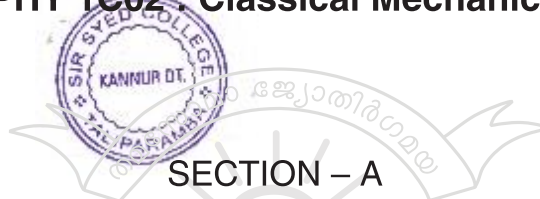
I Semester M.Sc. Degree (CBSS – Reg./Sup./Imp.) Examination, October 2022
(2019 Admission Onwards)

PHYSICS

PHY 1C02 : Classical Mechanics

Time : 3 Hours

Max. Marks : 60



Answer **both** questions (either **a** or **b**). **Each** question carries **12** marks. **(2×12=24)**

1. a) Write down the Lagrangian for a symmetric trilinear CO_2 and obtain the normal mode frequencies of oscillations. Explain the physical oscillations each of these frequencies represent. Choose mass of carbon atom to be M and that of oxygen atom to be m .
OR
b) Demonstrate that the Schrödinger equation for a quantum mechanical particle reduces in the classical limit to the corresponding Hamilton-Jacobi equation.

2. a) Explain the classical scattering in a central force potential $V(r)$ and derive the Rutherford formula for scattering cross-section.
OR
b) State Hamilton's principle and derive Euler-Lagrange equations of motions using calculus of variations.

SECTION – B

Answer **any four** questions. (1 mark for Part **a**, 3 marks for Part **b**, 5 marks for Part **c**) **(4×9=36)**

3. a) Define equilibrium points of a potential and explain how they are classified.
b) Explain normal modes of oscillations.

- c) Can a particle of mass m experiencing a potential $V(r) = \frac{l^2}{2mr^2} - \frac{GMm}{r}$ have stable equilibrium points ? If yes, find the points and the frequency of small oscillations about the stable points. Here the constants l , G , M are positive numbers and the coordinate $r \geq 0$.

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4. a) Explain what is a cyclic coordinate. Provide one example.
- b) Explain the type of constraints and the number of degrees of freedom for the following systems in three dimensional space.
- N particles moving on a cylinder whose radius R change in time.
 - A particle moving inside a cubical box with fixed edges.
- c) Write down the Lagrangian for a pendulum and obtain its Euler-Lagrange equations of motion. What form does the Lagrangian take when this is a simple pendulum ?
5. a) Explain any situation where a Hamiltonian method have an advantage over a Lagrangian method.
- b) Write down the Hamiltonian for a simple harmonic oscillator in one dimension and plot its phase space trajectory. What is the phase space trajectory if it is a damped oscillator ?
- c) i) Write down the Hamiltonian and obtain the Hamilton's equations of motion for a charged particle moving in an electromagnetic field.
- ii) Obtain the Lagrangian for the above from the Hamiltonian.
6. a) Write the generating function of an identity canonical transformation and demonstrate it.
- b) Hamiltonian for a particle is $H = \frac{p_x^2 + p_y^2 + p_z^2}{2m} + \frac{1}{2}mw^2(x^2 + 3y^2 + z^2)$. Find out which of the components of angular momentum vector L are conserved.
- c) For what value of the constant α does the transformation $Q = \frac{p}{2q}$ and $P = -\frac{\alpha q^2}{2}$ becomes a canonical transformation $(q, p) \rightarrow (Q, P)$? Apply this canonical transformation to a simple harmonic oscillator and find the Hamiltonian (Kamiltonian) in coordinates (Q, P) .
7. a) Explain the relevance of Hamilton's characteristic function in Hamilton-Jacobi formalism.
- b) Explain how Hamilton-Jacobi method helps to solve a problem in mechanics.
- c) Solve simple harmonic oscillator using the method of action-angle variables.



8. a) A particle is moving on the surface of rigid body that is rotating with constant angular velocity ω . If the force acting on the particle measured from a space coordinate system $F_s = 0$. What is the acceleration of the particle at position r_b , as measured in the body system ?
- b) Write down the Euler equations for an object that is symmetric about one axis and describe its motion qualitatively.
- c) The moment of inertia tensor for a rigid body in a certain coordinate system is given by the matrix.

$$\begin{pmatrix} 8 & -3 & -3 \\ -3 & 8 & -3 \\ -3 & -3 & 8 \end{pmatrix}$$

Find the moment of inertia tensor in the principal axes coordinate system.

