2031
M.Sc. (Physics)
First Semester
PHY-8012: Classical Mechanics

Time allowed: 3 Hours                                                    Max. Marks: 80

***NOTE***: *Attempt five questions in all, including Question No. IX (Unit-V) which is compulsory and selecting one question each from Unit I - IV. Use of calculator is allowed.*

x-x-x

## UNIT- I

I.  a) A particle of mass m moves in one dimension such that it has Lagrangian

$$L = \frac{m^2 \dot{x}^4}{12} + m\dot{x}^2 V(x) = V^2(x)$$

where V is some differential function *of x*. Find the equation of motion for *x(t)*.

b) Express kinetic energy of system in terms of generalized coordinates or velocities.

c) Describe the nature of constraint: an expanding or contracting container of gas. (6,6,4)

II.  a) What are Lagranage undetermined multiplier? Discuss the significance with an example.

b) Define D'Alembert principle. How does it lead it Euler-Lagrange equations of motion?
(6,10)

## UNIT –II

III.  a) Determine the number of degrees of freedom for a rigid body (i) moving freely in space (ii) having one point fixed (iii) having two points fixed.

b) Discuss the motion of a symmetrical top in a uniform gravitational field with one point fixed on the symmetry axis.                                    (4,12)

IV.  a) Obtain an expression for rotational kinetic energy of a rigid body.

b) Define orthogonal transformations. Discuss their significance in context of rigid body dynamics.                                                              (10,6)

## UNIT – III

V.  a) What is the difference between A and 5-variation and thus obtain the *principle of least action.*

b) What do you mean by stable and unstable equilibrium? Illustrate with examples. (12,4)

VI.  a) What are normal modes and obtain the frequencies of linear triatomic molecule.

b) Discuss Legendre transformation with an example.  (12,4)

## UNIT – IV

VII.  a) Prove that the following transformation is canonical, $Q == aq+bp$, $P = cq+dp$ only if $ad-be =1$.

b) Discuss the harmonic oscillator problem in two sets of canonical coordinate system.  (4,12)

VIII.  a) State and prove Jacobi's identity.

b) Show that following transformation $(q,p)$ to $(Q,P)$ is canonical.

$Q$ = q tan p and P = In sin p  (12,4)

## UNIT – V

IX.  Attempt the following:-

a) What is the type of constraint in a pendulum with variable length?  (3)

b) Show that Hamiltonian does not depend on cyclic coordinate.  (3)

c) Prove the conservation of linear momentum for a free particle.  (3)

d) Under what conditions Hamiltonian will be

i)conserved quantity ii) Total energy?  (4)

e) What is the origin of Coriolis force?  (3)

*x-x-x*