2021

M.Sc.

First Semester

CORE – 01

PHYSICS

Course Code: MPHC 1.11

(Classical Mechanics)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) What is a Routhian function? Derive an expression for Routhian function and formulate the Lagrange's equation of motion in terms of only $(n-k)$ second order differentials equation with only non-ignorable variables. 2+7=9

   (b) Show that the shortest distance between two points in a plane is along the straight line joining them. 5

2. (a) A mass less rod is hinged at the extremity of a vertical spring that is fixed to the ground. Find the equation of motion of a harmonic system by formulating its Lagrangian if a mass point rest on the rod. 7

   (b) A bead slides on a wire in the shape of a cycloid described by the equations $x = b(\theta + \sin\theta), y = b(1 + \sin\theta)$. Formulate the Lagrangian and the Lagrange equations of motion. 7

UNIT–II

3. (a) Derive the expression for Hamilton's canonical equations of motion. 6

   (b) State and prove the principle of least action. 1+7=8

4. (a) A particle of mass m can slide without friction on the inside of a small tube bent in the form of a circle of radius r. The tube can be rotated about a vertical axis and has a moment of inertia I about this axis. Find the Hamiltonian and formulate the Hamilton's equations of motion for the system. 7

(b) Formulate the Hamiltonian and hence the Hamilton's equations of motion for two dimensional isotropic harmonic oscillator. 7

UNIT–III

5. (a) What is the advantage of Hamilton-Jacobi method in canonical transformation? Show that the Hamilton-Jacobi equation is a partial differential equation in $(n+1)$ variables. Find the solution of the Hamilton Jacobi equation. 1+7=8

(b) Find the solution of a one-dimensional simple harmonic oscillator by Hamilton-Jacobi method and show that the Hamilton's principle function is the generator of a contact transformation involving canonical momentum. 4+2=6

6. (a) Calculate the impact parameter and the scattering cross-section of Pb ($z = 82$, A=207) for alpha particle of 7.7 MeV energy with 30 degree, corresponding angle of scattering. 9

(b) A particle moving in a central force located at $r = 0$ describes the spiral $r = e^{-\phi}$ Prove that the magnitude of the force is inversely proportional to r^3. 5

UNIT–IV

7. (a) Explain in detail the generalised coordinates for rigid bodies. 5

(b) Define Euler’s angle. Calculate the matrix of transformation for first, second and third rotation and finally the complete matrix of the transformation. 1+8=9

8. (a) Show that the angular velocity of a body itself precesses about the body z-axis for a rigid body, symmetrical about an axis with one point fixed on the axis if there is no other force acing except the reaction force at the fixed point. 5

(b) Calculate the kinetic energy of rotation of a rigid body with respect to the principal axis in terms of Eulerian angles when two of the principal axes are equal. 4

(c) Determine the rate of change of kinetic energy with respect to time for a body rotating with constant angular velocity under an external torque about an instantaneous axis of rotation. 5

UNIT–V

9. (a) What do you mean by small oscillations? 1

(b) Define normal modes of motion. 1

(c) What is a coupled system? 1

(d) Deduce the Lagrange equations of motion for small oscillations. Find the solution and show that there are n simultaneous homogeneous equations. 6+3+2=11

10. Using the theory of small oscillations, calculate the normal frequencies for a linear triatomic molecule. Show that the displacements of all the atoms are in the same direction and equal in magnitude. Calculate the normal coordinates associated with the normal frequencies. 6+4+4=14