2022

B.A./B.Sc.

Fifth Semester

DISCIPLINE SPECIFIC ELECTIVE – 1

PHYSICS

Course Code: PHD 5.11

(Classical Dynamics)

Total Mark: 70 *Pass Mark: 28*

Time: 3 hours

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

UNIT–I

1. Discuss the formulation of the problem of the calculus of variation. How do you tackle the problem of various paths other than a straight line path? Use the calculus of variation to derive the Euler-Lagrange differential equations of motion. 4+3+7=14

2. (a) Formulate the Lagrangian and the Lagrange equations of motion of a simple pendulum. 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 equation of motion. 7

UNIT–II

3. (a) Discuss the development of the concept of phase space due to Hamiltonian formalism. 5

   (b) State and prove the principle of least action. 1+8 = 9

4. (a) Formulate the Hamiltonian and the Hamilton's equation of motion for a compound pendulum. 7

   (b) Derive the Hamilton's equation of motion of a projectile in space, neglecting the earth's rotation. 7

UNIT–III

5. (a) Deduce the potential energy of a mechanical system about a point of stable equilibrium. 4
   (b) Establish the theory of small oscillation by deducing the Lagrange equations of motion for small oscillation near equilibrium. 10

6. (a) A simple pendulum of length (l) hangs vertically from a fixed point. If the bob of mass (m) is given an initial horizontal velocity (v), calculate the length of the arc. 4
   (b) A solid cylinder of mass (m) remaining on a smooth horizontal table is connected by a massless spring of force constant (k) and the other end of the spring is fixed to the vertical wall. If the cylinder can roll without sliding on the table, calculate the period of small oscillations of the cylinder when the cylinder is slightly pushed away from the wall and then released. 8
   (c) Write four applications of small oscillations. 2

UNIT–IV

7. (a) Show that the Lorentz's transformations are orthogonal transformation in a world space and that the Lorentz's transformations to real coordinates is possible only when $\beta < 1$. 9
   (b) Show that a clock measures a longer time interval placed in a frame at rest compared to a time interval measured by a clock in a frame moving relative to it. 3
   (c) What do you mean by twin paradox? 2

8. (a) Explain four vectors and show that the norm of a four vector velocity is equal to the negative value of the square of the velocity of light in vacuum. 5 + 4=9
   (b) Write short notes on tensor, metric tensor and alternating tensors. 5

UNIT–V

9. (a) Discuss the concept of four forces and derive the components of four forces and conservation of four momentums. Show that the sum of relativistic momenta and the sum of total energy of the two particles will remain conserved separately in their collision. 6+2=9

(b) Discuss relativistic kinematics and show that it is conceivable that a massless particle may carry relativistic energy and momentum when it travels at a speed comparable to the speed of light. 5

10. (a) Discuss the problem of two body decay of an unstable particle by considering a pion at rest being decayed into a muon and a neutrino. Calculate the energy of the muon and the pion. 3+5=8

(b) Define critical velocity of the flow of a fluid. 1

(c) Write short notes on Navier-Stokes equation. 5