**October 2025**
**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 <u>five</u> questions, taking <u>one</u> from each unit.*

## UNIT–I

1.  (a)  Show that the law of conservation of linear momentum can be obtained from the Newton's second law of motion.                2
    (b)  Formulate the importance of generalised coordinates in classical mechanics and show that the Jacobian determinant should be different from zero at all points for a transformation from a set of coordinates to another set of coordinates.                5
    (c)  Generalise the technique of the calculus of variation for many independent variables and hence, establish the Euler-Lagrange's equation of motion.                7

2.  (a)  Formulate the Lagrangian and hence the Lagrange's equation of motion of a charged particle moving under the influence of an external electric and magnetic field.                9
    (b)  Apply the Lagrange equation of motion to establish the time period of a linear harmonic oscillator.                5

## UNIT–II

3.  (a)  Define configuration space and system point.                2
    (b)  Consider the generalised momenta as an independent status to establish the Hamilton's canonical equations of motion.                5
    (b)  Formulate the Hamiltonian of a simple pendulum and establish its time period by applying the Hamilton's canonical equation of motion.                7

4. (a) Consider a particle in a central field of force such that the potential energy is the function of the coordinates to establish the equation of motion involving the actual force and the centrifugal force. 7

   (b) Apply the Hamilton's canonical equation of motion to determine the time period of a compound pendulum. 6

   (c) Write one advantage of Hamiltonian approach. 1

## UNIT–III

5. (a) Explain stable and unstable equilibrium with necessary graphical representations. 4

   (b) Incorporate the concept of normal coordinates of a system by considering a physical system consisting of $n$ equal masses connected by $(n + 1)$ identical elastic springs to each other such that the two ends are fixed to the respective vertical walls. 10

6. (a) Define small oscillation. Write two practical applications of the theory of small oscillation. 1+2=3

   (b) Compute the secular equation of a double pendulum and hence, find the normal frequencies when the two masses and the effective lengths are respectively equal. 11

## UNIT–IV

7. (a) What do you mean by Minkowski space? 2

   (b) Establish the transformation equation for two uniformly moving systems whose origin coincide initially and one of the frames of reference starts moving with respect to the other frame of reference at a velocity comparable to the speed of light in vacuum. 12

8. (a) Based on the special theory of relativity, establish the space-time continuum and explain the concept of space like, time like and light like interval. 6

   (b) Derive an expression for the Lorentz-Fitzgerald contraction. 4

   (c) Prove that the four-dimensional volume element is invariant under Lorentz transformation. 4

## UNIT–V

9. (a) Derive an expression for apparent frequency of the Doppler's effect of light waves from the perspective of relativistic mechanics.     10

   (b) Apply the principle of dimensional analysis to obtain an expression for Reynold's number.     4

10. (a) Derive the equation of continuity for an incompressible fluid.   4

   (b) Write a short note on Navier-stokes equation.     4

   (c) Two horizontal capillary tubes $A$ and $B$ are connected together in series so that a steady stream of fluid flows through them. $A$ is 0.4 mm in internal radius and 256 cm long. $B$ is 0.3 mm in internal radius and 40.5 cm long. The pressure of the fluid at the entrance is 3 inches of mercury above the atmosphere. The atmospheric pressure at the exit end of $B$ is 30 inches of mercury. Calculate the pressure at the junction of $A$ and $B$ if the fluid is liquid for the first case while it is gas for the second case.     6

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