

FYUGP/5th Sem/25(NEP)

2025

Four Year Under Graduate Programme (FYUGP)

5th Semester Examination (Under NEP)
(Session 2023-24)

PHYSICS (Major)

Paper Code : PHSMJ MC-11

(Classical Dynamics)

Full Marks : 30

Time : Two Hours

*The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.*

1. Answer any six questions : 1×6=6

- (a) Why a mechanical system with constraints is best described using generalized coordinates?
- (b) What is the purpose of generating function in classical mechanics?
- (c) Is the Hamiltonian always equal to the total energy? Explain.
- (d) How the invariant interval in relativity is defined?
- (e) When does laminar flow of a liquid becomes turbulent flow?

P.T.O.

(2)

- (f) Calculate the Lorentz factor (γ) for a particle moving with speed $0.6 c$.
- (g) Determine the degree of freedom of diatomic gas molecule.
- (h) Write the Lagrangian of a simple pendulum.

2. Answer any *three* questions :

$3 \times 3 = 9$

- (a) Starting from the Lagrangian

$$L = \frac{1}{2} m (\dot{x}^2 + \dot{y}^2) - V(r),$$
 derive the Euler-Lagrange equation for motion in a central force field.

- (b) Water flows through a capillary tube of radius 1 mm and length 1 m under a pressure difference of 10^5 Pa. Calculate the volume flow rate. (Given viscosity = 10^{-3} Pa-s)
- (c) Define four-vector. Show that the magnitude of a momentum 4-vector is constant.
- (d) A bead of mass m slides on a frictionless wire under the influence of gravity. The shape of the wire is parabolic and it rotates about the z-axis with constant angular velocity ω , obtain the Lagrangian of the system.
- (e) Water flows through a horizontal pipe with an internal diameter of 2 cm at a velocity of 1 m/s. To achieve an exit speed of 4 m/s, calculate the diameter of the nozzle.

3. Answer any *three* questions :

5×3=15

- (a) Define a space-time diagram and explain its significance. Using suitable diagrams represent the motion of (i) a particle at rest and (ii) a particle moving with uniform velocity on a space-time diagram. Hence, explain the concept of the relativity of simultaneity. 1+2+2
- (b) What do you mean by light cone? Show that the Lorentz transformation corresponds to a non-orthogonal (squeezed) transformation in space-time rather than a simple rotation. Further, prove that the four-acceleration vector is always orthogonal to the four-velocity vector. 1+2+2
- (c) What is canonical transformation and what are the different types? Show that the transformation $Q = \ln((\sin p)/q)$, $P = q \cot p$ is canonical. 2+3
- (d) (i) Write the Navier-Stokes equation for a viscous fluid and explain the significance of each term. 3
- (ii) Calculate the Reynolds number for water flowing in a pipe of diameter 2 cm with velocity 0.5 ms^{-1} (Given: density = 1000 kg m^{-3} , viscosity = 10^{-3} Pa s). State the nature of flow. 2

- (e) What do you mean by semi-holonomic constraints? Explain with an example. Obtain the Hamiltonian and Hamilton's equations of motion for a particle in an electromagnetic field.
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