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5 SEM TDC DSE PHY (CBCS) 1 (H)

2025

PHYSICS

(Nov/Dec)

(Discipline Specific Elective)

(For Honours)

Paper : DSE–1

(Classical Dynamics)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×8=8

(a) In classical mechanics, the motion of a charged particle in a uniform magnetic field is

(i) linear

(ii) helical

(iii) parabolic

(iv) None of the above

(b) Generalized coordinates are used to describe a system with

(i) constraints

(ii) infinite degrees of freedom

(iii) only Cartesian coordinates

(iv) None of the above

(c) In Lagrange's equations, the term involving the time derivative of the Lagrangian with respect to velocity is

(i) generalized force

(ii) kinetic energy

(iii) momentum

(iv) None of the above

(d) The configuration space for a system is defined by its

(i) velocities

(ii) generalized coordinates

(iii) forces

(iv) None of the above

(e) In special relativity, the invariant interval ds^2 is given by

(i) $c^2dt^2 - dx^2 - dy^2 - dz^2$

(ii) $dt^2 - dx^2 - dy^2 - dz^2$

(iii) $c^2dt^2 + dx^2 + dy^2 + dz^2$

(iv) None of the above

(f) A four-vector in Minkowski space that is time-like satisfies

(i) $ds^2 > 0$

(ii) $ds^2 < 0$

(iii) $ds^2 = 0$

(iv) None of the above

(g) The four-momentum p^μ for a particle is

(i) $(E/c, p_x, p_y, p_z)$

(ii) (E, p_x, p_y, p_z)

(iii) (m, p_x, p_y, p_z)

(iv) None of the above

(h) In fluid dynamics, streamline flow is characterized by

(i) chaotic motion

(ii) constant velocity layers

(iii) high Reynolds number

(iv) None of the above

2. (a) Describe the motion of a charged particle in a uniform electric field. 4

(b) Define generalized coordinates. Obtain the expression for kinetic energy in terms of generalized coordinates. 1+2=3

Or

Find Lagrange's equation of motion for a simple pendulum of length l and mass m. 3

(c) State Hamilton's principle and use it to find the equation of motion for a simple harmonic oscillator. 3

3. *(a)* Derive Hamilton's equations of motion from the Lagrangian. 4

Or

For a particle in a central force field, show conservation of angular momentum using the Lagrangian formulation.

(b) Explain a cyclic coordinate in the context of Lagrangian mechanics. 2

(c) Discuss one advantage of the Hamiltonian approach over the Lagrangian approach. 2

(d) Using the concept of Hamiltonian, discuss the motion of a particle under an inverse square law force. 5

Or

A particle moves under a force $F = -kr$, where r is the position vector.

(i) Is angular momentum conserved? Explain.

(ii) Find the orbit equation using Lagrange's equations. 2+3=5

4. *(a)* Using a potential energy curve, explain stable equilibrium. 3

(b) What are normal modes? Discuss normal modes for two-coupled pendulums. 2+4=6

Or

Two masses m and $2m$ are connected by a spring of constant k on a frictionless surface. Find the normal frequencies of oscillation.

5. *(a)* Write the postulates of special theory of relativity. 2

(b) Write short notes on any *two* of the following : 3×2=6

(i) Time dilation

(ii) Four-velocity

(iii) Light cone

Or

Two observers A and B are moving relative to each other at $v = 0 \cdot 6c$. If A measures an event duration of 10s, what does B measure? 6

(c) If two events are simultaneous in one inertial reference frame, will they also appear simultaneous in another reference frame moving at constant velocity relative to the first? 3

(d) Write expressions for relativistic energy and relativistic momentum. 1+1=2

6. *(a)* Derive the expression for four-velocity in special theory of relativity. 4

(b) Explain the energy-momentum four-vector and its invariant. 4

Or

A particle has rest mass m and moves at $0 \cdot 8c$. Calculate its relativistic energy and momentum in terms of m and c.

(c) What is a space-time diagram? Draw and explain a world line for a particle at rest. 2+3=5

7. Derive the relativistic Doppler effect for light approaching an observer. 5

Or

A star emits light at 600 nm, observed on Earth at 650 nm. Find the recessional velocity. (Use $c = 3 \times 10^8$ m / s)

8. *(a)* Define pressure in a fluid. Explain why thrust on a surface is perpendicular to it. 1+1+1=3

(b) Distinguish between laminar and turbulent flow. 2

(c) Derive the continuity equation for fluid flow. For a pipe narrowing from radius $2r$ to r, if velocity at wider end is v, find velocity at narrower end. 4

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