

(6)

- (d) Derive the formula for length contraction using Lorentz transformations. [2+4+2+2]

★ ★ ★

Ex/SC/PHY/UG/CORE/TH/02/2025(OLD)

BACHELOR OF SCIENCE EXAMINATION, 2025

(1st Year, 1st Semester)

PHYSICS

PAPER : Core 2

(Mechanics)

Time : 2 Hours

Full Marks : 40

Use separate Answer Script for both Groups A and B.

GROUP—A

Answer Question 1 (**compulsory**), any **one** from Questions 2 and 3, and any **one** from Questions 4 and 5

[Total 3 questions need to be answered from Group A]

1. [CO-2] (a) Find expressions for velocity and acceleration in cylindrical co-ordinate system.

(b) Show that the work-energy theorem is just a mathematical consequence of Newton's laws of motion. Use this theorem to find escape velocity from surface of the Earth. [5+5]

(2)

2. [CO-3] (a) The trajectory of a particle of mass m moving on a plane is given by

$$x = x_0 \cos \omega t \text{ and } y = y_0 \sin \omega t$$

Find the force $\vec{F}$, torque $\vec{\tau}$ and angular momentum $\vec{L}$

about the origin. Hence verify $\vec{\tau} = \frac{d\vec{L}}{dt}$. [5]

(OR)

3. [CO-3] Calculate the inertia tensor of a homogeneous cube of density ρ , mass m and side of length a . Let one corner be at the origin and three adjacent edges lie along the coordinate axes. [5]
4. [CO-3] A straight horizontal beam of negligible weight is rigidly clamped at one end. The free end is loaded with a weight W . When the bending is small, obtain an expression for depression of the free end. [5]

(OR)

5. [CO-3] Distinguish between streamline and turbulent flows of a liquid. Find expression for Reynold's number and hence justify that when viscous force dominates, flow becomes laminar. [2+3]

(5)

(OR)

9. [CO-4] A particle of mass m moves along a trajectory given by $x = x_0 \cos(\omega_1 t)$, and $y = y_0 \sin(\omega_2 t)$.

- (a) Find the x and y components of the force. Under what condition is the force a central force?
- (b) Find the potential energy as a function of x and y .
- (c) Determine the kinetic energy of the particle. Show that the total energy of the particle is conserved.

[(1+1)+1+(1+1)]

10. [CO-5] (a) A rod of length 5 meters is at rest in x - y plane of the S frame and makes an angle $\sin^{-1}(3/5)$ with the x -axis. Find its length and inclination as seen from S' frame, which is moving with a velocity $0.8c$ with respect to S along the x direction.

- (b) Establish the Einstein's mass-energy relation : $E = mc^2$. The symbols are their usual meanings.
- (c) Show that the momentum p of a particle can be expressed in terms of kinetic energy T as

$$p = \sqrt{T(T + 2m_0 c^2)} / c$$

(3)
GROUP—B

Answer *any one* from Questions 6 and 7; *any one* from Questions 8 and 9; and Question 10 (**compulsory**)

[Total 3 questions need to be answered from Group B]

6. [CO-1] A boy crawls outward with a constant speed v along the particular direction of a merry-go-round. It is revolving with constant angular velocity ω about a vertical axis.

- (a) Find all the apparent forces acting on the boy.
- (b) Find how far the boy can crawl before it starts to slip, given the co-efficient of static friction μ_s between the boy and the spoke of the merry-go-round. [3+2]

(OR)

7. [CO-1] (a) Consider a primed coordinate system $S'(X', Y', Z')$ that is in purely translational motion with respect to a fixed stationary unprimed coordinate system $S(X, Y, Z)$. At any time t , a point P in space is located by the vectors r and r' with respect to the origins O and O' respectively, of the two coordinate systems. The origin O' is at a distance τ_0 from the origin O . Find the velocity and the acceleration of the point P with respect to the prime and unprimed coordinate systems S' and S respectively.

PHY-1252

[Turn Over]

(4)

- (b) If the prime coordinate system S' has no acceleration with respect to S , then find the acceleration of the point P with respect to the prime and unprimed coordinate systems S' and S respectively.
- (c) In this context, explain the Newtonian principle of relativity.
- (d) If the coordinate system S' has uniform acceleration with respect to S , then write down the Newton's second law in the prime coordinate system. Explain the fictitious force here. [2+1+1+1]
8. [CO-4] (a) A particle of mass m is subjected to a central force $F(r)$ only. Its angular momentum is L . Let r and θ be the polar coordinates in the plane of the motion of the particle. Derive the following differential equation for orbit of the system (the path of the particle in plane)

$$\frac{d^2u}{d\theta^2} = -u - \frac{m}{L^2u^2} F\left(\frac{1}{u}\right)$$

where the parameter $u = \frac{1}{r}$.

- (b) A particle of mass m moving under a central force describes a spiral orbit $r = e^{b\theta}$ where b is some constant. Find the law of force. [3+2]

PHY-1252

[Continued]