Ref. No.: EX/SC/PHY/UG/CORE/TH/02/2023

B. Sc. (Physics) 1st Year 1st Sem. Examination - 2023

Sub: Mechanics **Time: 2 Hours** **Full Marks: 40**

Paper: Core 2

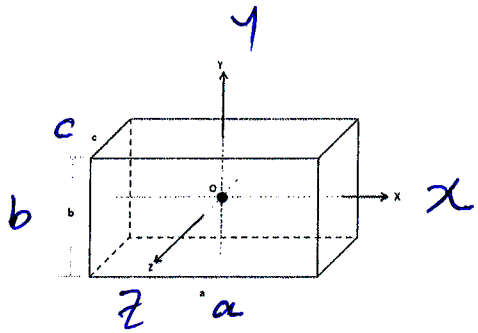
Use separate Answer Script for both Groups A and B

Group: A

Answer any ***Two*** questions

1. (a) Find expressions for velocity and acceleration in cylindrical co-ordinate system. Hence evaluate velocity and acceleration in case of uniform circular motion with constant angular velocity.
(b) A point in space is located, in Cartesian co-ordinates, at $(4, -4\sqrt{3}, 14)$. What is the position of this point in cylindrical co-ordinates? [(5+3)+2]

2. (a) Define angular momentum of a particle. Show that $\vec{l} = \hat{k}(xp_y - yp_x)$ for two dimensional case, where the symbols have their usual meanings.
(b) Find angular momentum of two interacting particles. Hence show that total angular momentum of this system is constant if the net torque acting on the system is zero.
(c) Find the inertia tensor of a homogeneous rectangular block of mass M and density ρ with sides a, b and c about its principal axes through its centre of mass; axes being parallel to the sides (as shown in the figure). [(1+1)+(3+1)+4]



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3. (a) What is internal bending moment of a beam? A beam of length L and cross-section A is clamped at one end. Neglecting the weight of the beam, find an expression for depression of the beam when the free end is loaded with weight W.
(b) Derive an expression for a velocity profile of an incompressible liquid flowing through a narrow tube of length l and radius a when a constant pressure difference P is maintained between the ends of the tube. What is Reynold's number? Explain its physical significance. [(2+3)+(3+1+1)]

Group: B

Answer any ***Two*** questions

4. A mass m is released with zero initial velocity from the point "A", just top of the roof of a residential tower, located at latitude of 12.98°. The point "A" is at a height of 153 m . It is intended that the object dropped from "A" would hit the ground at the point "B", which is directly below the point "A".
(a) Determine the amount of the sideways Coriolis deflection of the object dropped when it hits the ground (Formula derivation is required).
(b) Sketch roughly the Coriolis deflection as a function of latitude, if the latitude is varied from $-90°$ to $+90°$ for a fixed height.
(c) Plot roughly the deflection against height from which the object is dropped, varying it from 100 m to 1.2 km. [(4+2)+2+2]

5. (a) What was the objective of the Michelson-Morley experiment ? Discuss its conclusions. State the postulates of the special theory of relativity.
(b) An observer on a railway platform sees two trains are approaching each other at a speed of (7/5)c. An observer on one train sees the other train is approaching him with a speed of (35/37)c. What are the velocities of the trains relative to the observer on the platform ?
(c) In classical mechanics Newton's law can be written in more familiar form $F = m_o a$. The relativistic equation $F = dp/dt$, can not be so simply expressed. Show, rather than that

$$F = \frac{m_o}{\sqrt{1 - u^2/c^2}}[a + \frac{u(u.a)}{c^2 - u^2}]$$

where $a = du/dt$, is the ordinary acceleration. [(3+4+3)]

6. (a) A particle of mass m is in the inverse-square force field $F(r) = \frac{k}{r^2}$, where k is a negative constant. Its angular momentum is L. Calculate its $V(r)$,

centrifugal potential (V_{cent}) and effective potential (V_{eff}). Draw the energy-diagram of $V(r)$, $V_{cent}(r)$ and $V_{eff}(r)$ as function of r. Suppose the motion is bound and periodic (i.e.,total energy < 0), then find the distance from the center of force where the effective potential (V_{eff}) is minimum. Evaluate the value of minimum effective potential (V_{eff}).

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

Find the x and y components of the force. Under what condition is the force a central force ? Find the potential energy as a function of x and y.

[(1.5+1.5+2+1)+(2+1+1)]