BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: IMSc **SEMESTER : III**
BRANCH: PHYSICS **SESSION : MO/2025**

SUBJECT: PH24201 - MECHANICS

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Define centre of mass. Write the expression for centre of mass of (i) a system of *N* discrete point masses, and (ii) a continuous distribution of mass. Find the centre of mass of three identical masses, placed on three corners of a square.	[5]	1	3
Q.1(b)	Explain how equilibrium points of a system can be identified from its energy diagram. Potential energy of a one-dimensional system is given as $U(x) = 3x^4 + 4x^3 - 12x^2$. Find the stable and unstable equilibrium points of the system.	[5]	1	3
Q.2(a)	Describe an elastic collision in (i) lab frame and (ii) in centre of mass frame. A particle of mass m_1 undergoes an elastic collision with a particle of mass m_2 . Assuming m_2 initially at rest, find the relation between scattering angle in lab frame and scattering angle in centre of mass frame.	[5]	2	3
Q.2(b)	Define (i) Young's modulus, (ii) modulus of rigidity, (iii) Poisson's ratio of an elastic material and write the relation between them. Find Young's modulus of a material that has modulus of rigidity and Poisson's ratio as $7.5 \times 10^{11}\ N/m^2$ and 0.25, respectively.	[5]	2	3
Q.3(a)	Define central force and give an example of central force. Show that angular momentum of a two-body system interacting through a central force is conserved and that the two-body problem can be reduced to a one-body problem. Write the formal solution $r(t)$ for the reduced one-body problem.	[5]	3	2
Q.3(b)	Differentiate between geostationary and geosynchronous orbits. Describe the salient features of a geostationary orbit and find the altitude of a satellite placed in a geostationary orbit.	[5]	3	3
Q.4(a)	Write the equation of simple harmonic oscillator with damping force and obtain its solution for suitable initial conditions.	[5]	4	3
Q.4(b)	A mass $m = 100\ kg$ attached to a spring of spring constant $k = 4 \times 10^4\ \mathrm{N/m}$ is driven by a force $F(t) = 200\cos(6\pi t)$. Find the amplitude of steady-state oscillations if the damping constant $b = 400\ \mathrm{N\ s/m}$.	[5]	4	3
Q.5(a)	What are the fictitious forces arising in a uniformly rotating frame and obtain their expressions.	[5]	5	2
Q.5(b)	Calculate the following at Ranchi (i) centrifugal acceleration of a stationary object (ii) Coriolis force on a car of mass $m = 1000\ \mathrm{kg}$ moving along north to south direction with velocity 30 m/s. Take latitude of Ranchi as $22.5°$ North.	[5]	5	3

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