Birla Institute of Technology & Science - Pilani, Goa Campus

Mid-semester Examination, Semester-I, 2024-2025

PHY F111	**Mechanics Oscillations and Waves**	**Tuesday, 8th Oct, 2024**
Duration: 90 mins		**Maximum Marks: 60**

General Instructions:

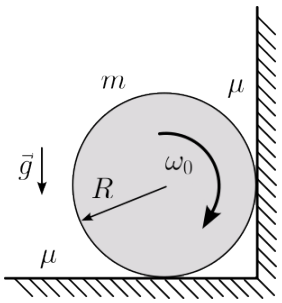
- You may bring one hand-written A4 sheet with formulae. Exchange of sheets is not permitted.
- Answer all parts of a given question together.
- Write all the necessary steps and assumptions for full credit.
- Draw any required diagram with pen.
- Provide an index behind the front page of the main answer book, listing each question number and the corresponding page number on which it is attempted.

Q1. A planet of mass m is in a circular orbit of radius R about a star of mass $M(\gg m)$.

(A) Determine (a) the time period T, (b) the total energy $E = KE + PE$, and (c) the angular momentum L of the planet about the center of its orbit. [3+4+3=10]

(B) An asteroid hits the planet and provides it a radially inward impulse J such that the new trajectory is a parabola. Determine (a) the value of J, and (b) the distance of closest approach between the planet and the star. [4+6=10]

Q2. A solid cylinder of mass m and radius R spinning with angular velocity ω_0 as shown in the figure, is placed at a corner between two walls such that it spins while slipping. The coefficient of friction between cylinder and each wall is μ. Gravity acts downward as shown.



(A) Draw a diagram indicating all forces acting on the cylinder and determine each force in terms of the given parameters.

(B) Find the angular deceleration of the cylinder.

(C) How long will it take for the cylinder to stop rotating?

(D) How many revolutions will the cylinder make before it stops?

[6+6+5+3=20]

Q3. Consider a large circular platform in the x-y plane rotating with a constant angular velocity $\vec{\omega} = \omega_0 \hat{k}$, about its center O. At $t = 0$, a car of mass M leaves O and follows a straight line S painted radially outward on the platform at a constant speed v_0 relative to the platform. The car starts skidding at $t = t_0$ by which time it has traveled a distance R along S. The acceleration due to earth's gravity is $-g\hat{k}$ and the co-efficient of static friction between the tyres of the car and the platform is μ. Work in an inertial coordinate system centered at O for the following.

(A) Calculate R and t_0,

(B) Find the radial and tangential components of the car's acceleration at $t = t_0$.

(C) (a) Find the work done **on** the car (dW) during the infinitesimal time interval dt such that $0 < t < t + dt < t_0$.

(b) Integrate dW to obtain the net work done on the car in the time interval $0 < t < t_0$.

(c) Show that it is consistent with the work energy theorem.

[6+4+(4+3+3)=20]
