भारतीय प्रौद्योगिकी संस्थान पटना
INDIAN INSTITUTE OF TECHNOLOGY PATNA

PH103 (Physics-I) **Tutorial-V (September 20, 2018)**

1. A mass is dropped from a point directly above the equator. Consider the moment when the object has fallen a distance d. If we consider only the centrifugal force, then the correction to g_{eff} at this point (relative to the release point) is an increase by $\omega^2 d$. There is, however, also a second-order Coriolis effect. What is the sum of these corrections?

2. A uniform thin rod of length L and mass M is pivoted at one end. The pivot is attached to the top of a car accelerating at rate a_0.
   (a) What is the equilibrium value of angle θ between the rod and the top of the car?
   (b) Suppose that the rod is displaced by a small angle ϕ from equilibrium. What is its motion for small ϕ?

3. A high speed hydrofoil races across the ocean at the equator at a speed of 200 miles/hr. Let the acceleration due to gravity for an observer at rest on the earth be g. Find the fractional change in gravity $\frac{\Delta g}{g}$ measured by a passenger on the hydrofoil when the hydrofoil heads in the following directions:
   (a) East
   (b) West
   (c) South
   (d) North

4. A particle of mass m is located at $x = 2$, $y = 0$, $z = 3$.
   (a) Obtain the moment of inertia tensor relative to the origin.
   (b) If the particle undergoes pure rotation about the z-axis through a small angle β, show that the moment of inertia tensor is unchanged to first order in β if $\beta \ll 1$.

5. A wheel is at one end of an axle of length l. The other end of the axle is suspended from a string of length L'. The wheel is set into motion so that it executes uniform precession in the horizontal plane. The wheel has mass M and the moment of inertia about its center of mass is I_0. Its spin angular velocity is ω_s. Find the angle β that the string makes with the vertical. [Note: Neglect the masses of the axle and the string and assume that β is so small that approximations like $sin\beta \approx \beta$ are justified.]

6. "The rotational motion of a rigid body is stable about the axis about which the moment of inertia is either a maximum or a minimum". Prove this! [Hint: Use conservation of energy and angular momentum. You may also prove it using Euler's equations discussed in class.]

7. Four masses lie at the points shown on a rigid isosceles right triangle with hypotenuse length $4a$. The mass at the right angle is $3m$, and the other three masses are m. Label them A, B, C, D, as shown. Assume that the object is floating freely in outer space. Mass C is struck with a quick blow, directed into the page. Let the impulse have magnitude $\int F dt = P$. What are the velocities of all the masses immediately after the blow?