PH101 (Physics-I) **Tutorial-VII (September 8, 2014)**

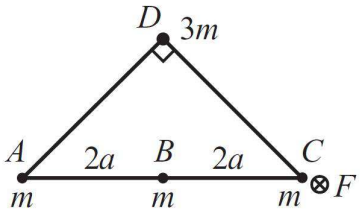
[Rigid Bodies]*

1. 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 $\beta \ll 1$.

2. A gyroscope 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.]

3. In our classroom demonstration, we saw that the rotational motion of a rigid body was stable about the axis about which the moment of inertia was either a maximum or a minimum (in our case the rigid body was a fat book *aka* Manorama Yearbook 2012! You can also check the hypothesis using a tennis racket.) In class, we used Euler's equations to perform a stability analysis to verify this. Establish the validity of the hypothesis without using Euler's equations. You may resort to the relevant conservation laws!

4. 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?



*Note: Please follow the strategies for "Problem Solving" explained in the class.