AA 242A Homework 3

Assigned: **Thursday, October 13th, 2022**

Due: **Thursday, October 20th, 2022**

IMPORTANT: Whenever you use conservation methods in your solutions, please justify why a quantity (linear momentum, angular momentum, or energy) is conserved using methods discussed in lecture/handouts. Not all problems will require conservation methods.

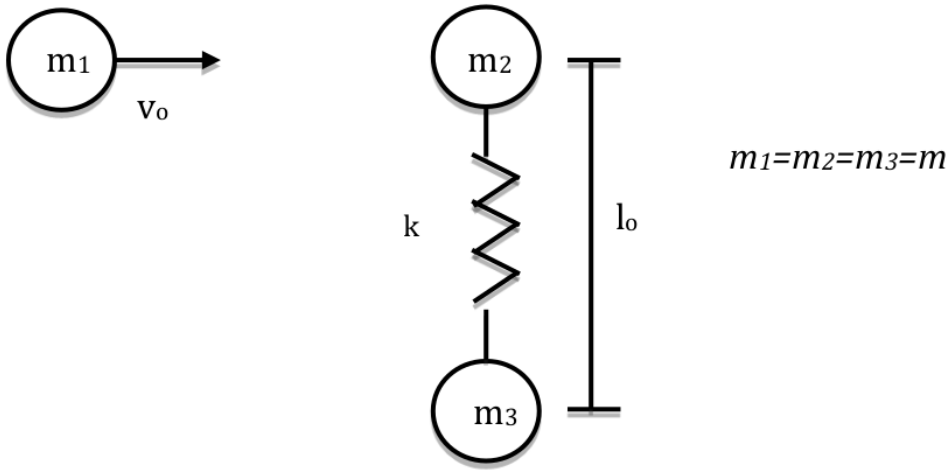
1. [Greenwood, Problem 3-25] A straight tube rotates in the xy plane with a constant angular velocity ω about the z axis. A particle of mass m can slide within the tube which has a friction coefficient μ. Assuming initial conditions $r(0) = R$, $\dot{r}(0) = 0$, and no gravity, obtain the differential equation of motion and solve for $r(t)$, where r is the distance from the origin to the particle.

2. Particles m_1 and m_2, each of mass m, are connected by an inextensible weightless string of length $4l$. Initially, each particle is sliding with velocity v_o along parallel paths separated by a distance $4l$ on a smooth horizontal floor. Suddenly a point on the string at a distance l from particle m_1 strikes a fixed vertical nail of negligible diameter that projects from the floor. Assume that the particles proceed to whirl in opposite directions without colliding, and the string can slide freely on the nail. Find the maximum distance that m_1 can reach from the nail for the ensuing motion. *Hint: a particular quantity may be conserved for a single object, or a group of objects, or not at all. If you find yourself with more unknowns than equations, check if a certain quantity is conserved for multiple individual objects.*

3. A recent proposal for removing space debris uses a satellite with two end modules connected by a long tether of length l_0. One of the modules deploys nets that can catch space debris so that the satellite can drag it down to a lower orbit. Nominally

the satellite is oriented vertically in space and the tether is unstretched. A piece of space debris (m_1) approaches the top end mass (m_2) at a relative speed of v_0 in a direction perpendicular to the spring. It is caught in a net and sticks to the end mass m_2. In the ensuing motion, the tether stretches to a maximum length of $3l_0$. Solve for v_0 assuming that the masses (of the space debris and each of the two end modules) are equal and can be considered as particles. You can read more about this satellite concept here: http://www.space.com/12819-space-junk-cleanup-giant-net-tether.html

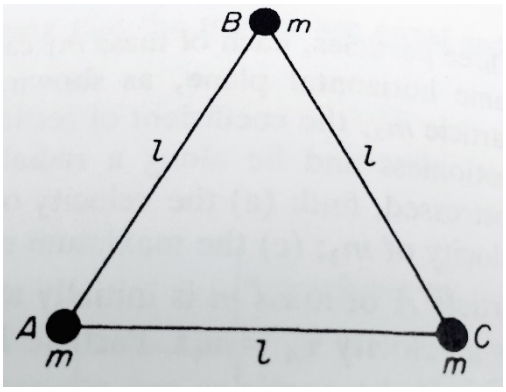
Hint: You can get one equation by considering conservation in the instants before and after collision.



4. [Greenwood, Problem 4-23] Three particles, each of mass m, are connected by massless strings of length l to form a system which is rotating freely with angular velocity ω_0 in planar motion about the motionless center of mass. Suddenly string AC breaks.

   a. Solve for the particle speeds at the instant when the three particles first form a straight line.

   b. Show that the particles A and C can never collide. Assume that strings AB and BC remain taut.



5. For the Classical Dynamics problem that you chose and began on the first homework, once again draw the FBD and provide a short description of what you are trying to solve. Again choose your reference frame and coordinate system and label it on your drawing. **Now determine what is and is not conserved and explain your reasoning (linear momentum, angular momentum and energy)**. Justify your answers clearly (yes or no, and for what objects in your system) using the methods discussed. Finally, "attempt" a solution to your problem. You may do this by using either a conservation law or through force balance. (Note! If you chose a difficult problem, you may not be able to solve your problem yet – hence the reason I asked you to choose a "simple" problem. In this case, attempt a solution and describe the reason why you cannot proceed beyond this point.)