PHYS-3202 Homework 8 Due 23 Nov 2022

This homework is due to `https://uwcloud.uwinnipeg.ca/s/4tyDmt9EEN2RgCy` by 10:59PM on the due date. Your file(s) must be in PDF format; they may be black-and-white scans or photographs of hardcopies (all converted to PDF), PDF prepared by LaTeX, or PDF prepared with a word processor *using an equation editor*.

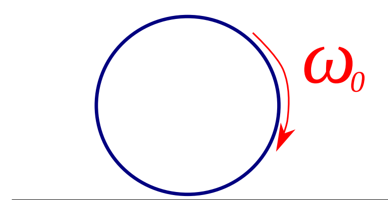
1. **Kater's reversible pendulum** *based on a problem from Thornton & Marion and others*

   Consider an object hung from a pivot a distance L from the center of mass, which is a physical pendulum with frequency $\omega = \sqrt{MgL/I}$, where I is the moment of inertia around the pivot, as we've seen. Suppose we can flip the pendulum over and hang it from a pivot a distance L' on the other side of the center of mass (with a parallel axis of rotation and corresponding moment of inertia I'). If the pendulum has the same frequency of oscillation around this second pivot, show that $MLL' = I_{CM}$, the moment of inertia for the parallel axis through the center of mass. *Hint:* use the parallel axis theorem to relate I_{CM} to both I and I'.

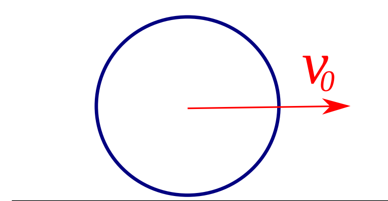
2. **Start Up of Rolling** *a problem seen many places*

   Consider a thin hoop of mass M and radius R that contacts a surface with coefficient of kinetic friction μ_k at time $t = 0$. It is oriented vertically, that is, with its axis of symmetry oriented horizontally, as in the figures below. The moment of inertia of the hoop is $I = MR^2$.

   (a) When the hoop contacts the surface, it has zero initial velocity and initial angular velocity ω_0, as in the figure below. When does the hoop stop slipping (ie, begin rolling without slipping)? How far does it travel before that time?

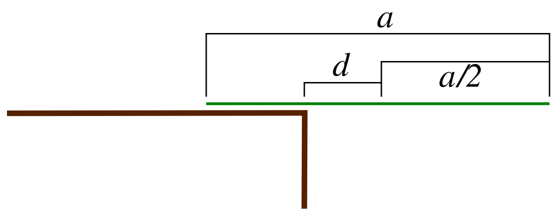


   (b) Suppose instead that the hoop has initial velocity v_0 in the $+x$ direction without rotating (initial angular velocity vanishes), as in the figure below. What is the speed of the hoop when it starts rolling without slipping?



3. **Falling Off a Table**

   At time $t = 0$, a rigid uniform rectangular lamina (flat sheet) with sides of length a and b and mass M lies horizontally off the edge of a table as shown in the figure. The lamina's center of mass is a distance d beyond the edge of the table, and the side of length b is parallel to the edge of the table. As the lamina begins to fall off the table, assume that any normal force on the lamina acts at the edge of the table.



(a) Find the moment of inertia of the lamina around the edge of the table.

(b) Find the torque due to gravity around the edge of the table.

(c) Starting at $t = 0$, the lamina begins to rotate around the edge of the table. Wwhat is the angular acceleration $\dot{\omega}$? Remember that we have assumed that any normal force on the lamina acts at the edge of the table.

(d) Find the acceleration of the center of mass at $t = 0$ assuming that the motion of the lamina is purely rotation around the edge of the table.

(e) Given the acceleration, use Newton's second law to find the magnitude of the normal force at $t = 0$.