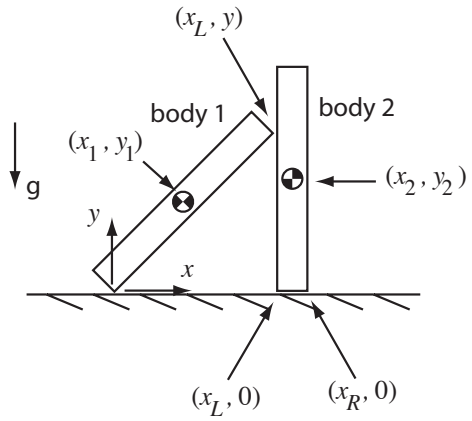
ME 449 Robotic Manipulation
Homework 3
Due at the beginning of class Tuesday May 29, 2012

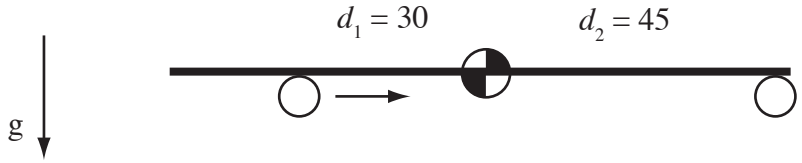
Reading: Mason chapter 5 and 6; handout pages 11-17
Office hours: Tues 11-12 (Vose, LIMS lab), Tues 5-6 (Lynch, B221), Wed 2-3 (Ryu, LIMS lab)

1. In the figure below, body 1, of mass m_1 with center of mass at (x_1, y_1), leans on body 2, of mass m_2 with center of mass at (x_2, y_2). Both are supported by a horizontal line, and gravity acts downward. The friction coefficient at all four contacts (one at $(0,0)$, one at (x_L, y), one at $(x_L, 0)$, and one at $(x_R, 0)$) is $\mu > 0$. We want to know if it is possible for the assembly to stay standing by some choice of contact forces within the friction cones. Write the six equations of force-balance for the two bodies in terms of the gravitational forces and the contact forces, like we did in class, and express the conditions that must be satisfied for it to be possible for this assembly to stay standing. (All your conditions should be specified mathematically, so if we plugged in specific values for m_1, (x_1, y_1), etc., the problem could be solved immediately using Matlab, Mathematica, or similar software.)



2. What is the minimum friction coefficient needed for two-fingered force-closure grasping of a regular pentagon (all sides equal length)? How about a regular hexagon? See Figure 13 of the handout for another example.

3. Two fingers support the meter stick, below. The left finger is 30 cm from the center of mass, and the right finger is 45 cm away. The left finger moves slowly toward the right finger. Of all the contact modes that could occur according to the kinematics, we focus on two possibilities: the case where there is no slip at the left finger but slip at the right finger (`RSr`), and the case where there is slip at the left finger but no slip at the right finger (`SlR`). For each of (a) and (b) below, indicate which of these contact modes is possible. For each case, use moment-labeling drawings to back up your conclusions. For each contact mode that is consistent with quasistatic mechanics, use one sentence to describe how the meter stick moves.



   (a) The static and kinetic (sliding) friction coefficients at both fingers is $\mu = 1$.
   (b) The static friction coefficient of the left finger is $\mu_s = 1$ and its kinetic (sliding) friction coefficient is $\mu_k = 0.5$ (i.e., when the contact is sliding, the friction coefficient is smaller). For the right finger, both friction coefficients are the same, $\mu = 1$.