NYU Physics I—Problem Set 6

Due Thursday 2018 October 18 at the beginning of lecture.

Problem 1: In lecture we dropped a pool ball from a height of about 1 m. It bounced off of the cement floor. Roughly what was the impulse delivered to the ball from the floor? Make reasonable assumptions! And remember that an impulse has a magnitude and a direction. And units!

Problem 2: Finish the elastic collision problem we didn't finish in lecture on 2018-10-04:

(a) Compute the momentum of each block, the kinetic energy of each block, and the total momentum and kinetic energy in the lab frame, before the collision.

(b) Compute the center-of-mass velocity of the system by dividing the total momentum by the total mass. Draw the system (that is, label the blocks with their velocities and masses) in the center-of-mass frame, before the collision.

(c) Compute the momentum of each block, the kinetic energy of each block, and the total momentum and kinetic energy in the center-of-mass frame, before the collision. The total momentum should be zero; if it isn't, then you have made a misake.

(d) In the center-of-mass frame, in an elastic collision, the only option is for the momenta after to have the same magnitudes as the momenta before, but with different directions. Since we are working in one dimension, the only non-trivial option is to make the blocks bounce off of each other, and reverse their momenta. Reverse them, and draw the system after the collision in the center-of-mass frame.

(e) Compute the momentum of each block, the kinetic energy of each block, and the total momentum and kinetic energy in the center-of-mass frame, after the collision. Do your total numbers equal those in part *(c)* above? They should!

(f) Now invert the transformation you made in going from part *(a)* to part *(b)*; that is, transform *back* to the lab frame. Draw the system in the lab frame, after the collision.

(g) Compute the momentum of each block, the kinetic energy of each block, and the total momentum and kinetic energy in the lab frame, after the collision. Do your total numbers equal those in part *(a)* above? They should!

Problem 3: In Problem Set 3, Problem 3, you computed an acceleration a for the hanging block. Now consider the energy and work.

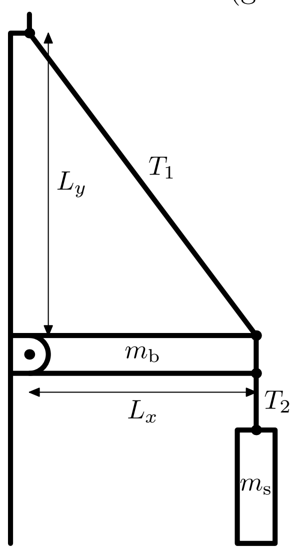
(a) If the hanging block falls by a distance h, what is the change in the potential energy of the hanging block, and how much work is done by friction on the sliding block?

(b) The work done by friction is *lost* to heat, so if the system is released from rest and slides by a distance h, the kinetic energy of the system should

rise to a value that is related to both the potential energy difference and the heat lost. Get that relationship right and compute the kinetic energy you expect the system to have when the hanging mass has dropped by a distance h.

(c) Now interpret your answer in terms of an acceleration. That is, compute the constant acceleration a that would make the result you computed in part *(b)* work out right. You will have to use that $h = (1/2)\,a\,t^2$ and $v = a\,t$, which are both relevant for constant acceleration. Does your answer agree with what you got on Problem Set 3?

Problem 4: In the static problem below, a beam is held horizontal by a diagonal string (cable or tether), and a sign hangs from that beam. The beam is attached to the wall by a pivot that is effectively frictionless, and the strings are (effectively) massless. What is the tension T_1 in the upper string, and the force $\vec{F}$ (give x and y components) on the beam at the pivot?



Extra Problem (will not be graded for credit): Re-do Problem 2, but now for the left-hand block having mass M and the right-hand block having mass $m \ll M$; that is, solve the extreme mass-ratio problem. For initial velocities, use v for the big block and 0 for the small block. Then draw the before and after pictures in the lab and center-of-mass frames, just as you did in Problem 2.

Extra Problem (will not be graded for credit): In Problem 3, It was useful to think about conservation of energy. Why *wasn't* it useful to think about conservation of momentum? What would we have had to take into account to think of this problem in terms of momentum?