Homework 5

Due Wednesday, October 9 at 7pm

Reading for this week: See Hal's lecture notes from class. You now have the tools to understand essentially everything covered in our book's Ch. 9 (p. 214) as well. We are also returning to the flow of the book starting now. So, it would be a good idea to start reading Ch. 5.

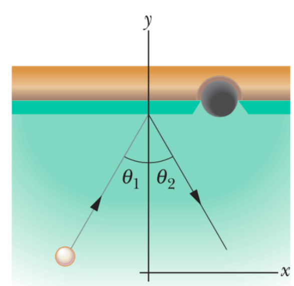
1. **Theory**: A circus acrobat of mass M leaps straight up with initial velocity v_0 from a trampoline. As he rises up, he takes a trained monkey of mass m off a perch at a height h above the trampoline. (a) What is the maximum height attained by the pair? (b) Check your answer with a unit check and at least one limit check. (We haven't covered energy yet in this course, so it's not fair game for this problem.)

Exercises:

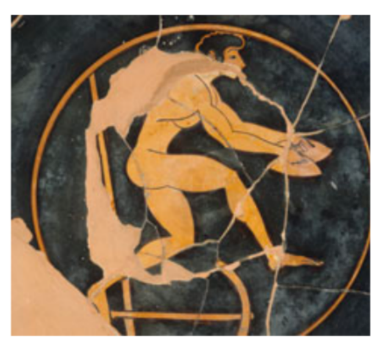
2. Two skaters, one with mass 60 kg and the other with mass 45 kg, stand on an ice rink holding a pole of length 10 m and negligible mass. Starting from the ends of the pole, the skaters pull themselves along the pole until they meet. How far does the 45 kg skater move?

3. A water molecule H_2O consists of a central oxygen atom bound to two hydrogen atoms. The two hydrogenoxygen bonds subtend an angle of 104.5°, and each bond has a length of 0.097 nm. Find the center of mass of the water molecule.

4. The figure at right gives an overhead view of the path taken by a 0.2 kg cue ball as it bounces from a rail of a pool table. The balls initial speed is 2.00 m/s, and the angle θ_1 is 30°. The bounce reverses the y component of the balls velocity but does not alter the x component. What are (a) angle θ_2 and (b) the change in the balls linear momentum in unit-vector notation? (The fact that the ball rolls is irrelevant to the problem.)



5. In the Olympiad of 708 B.C.E., some athletes competing in the standing long jump used handheld weights called halteres to lengthen their jumps (See Figure at right). The weights were swung up in front just before liftoff and then swung down and thrown backward during the flight. Suppose a modern 78 kg long jumper similarly uses two 5.50 kg halteres, throwing them horizontally to the rear at his maximum height such that their horizontal velocity is zero relative to the ground. Let his liftoff velocity be $\vec{v} = (9.4\hat{i} + 4.1\hat{j})$ m/s with or without the halteres, and assume that he lands at the liftoff level. What distance would the use of the halteres add to his range?



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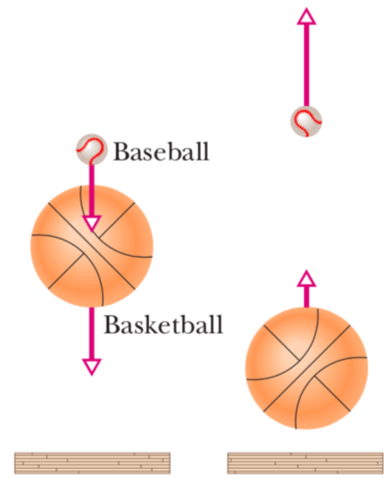
6. A vessel at rest at the origin of an xy coordinate system explodes into three pieces. Just after the explosion, one piece, of mass m, moves with velocity (20 m/s) $\hat{i}$ and a second piece, also of mass m, moves with velocity (20 m/s) $\hat{j}$. The third piece has mass $2m$. Just after the explosion, what are the (a) magnitude and (b) direction of the velocity of the third piece?

7. **Problem**: A small ball of mass m is aligned above a larger ball of mass M (with a slight separation, as with the baseball and basketball pictured at right), and the two are dropped simultaneously from a height of $h = 2$ m. (Assume the radius of each ball is negligible relative to h.) (a) Estimate the mass of the larger basketball M. (b) Assume the small ball has one third the mass of the larger ball, $m = \frac{1}{3}M$. If the larger ball rebounds elastically from the floor and then the small ball rebounds elastically from the larger ball, and the large ball stops after it collides with the small ball, what is the velocity of the small ball after the collision? (c) What height does the small ball then reach (Panel (b) at right)?



(a) Before (b) After