Recitation Problems for Week 7, Thursday

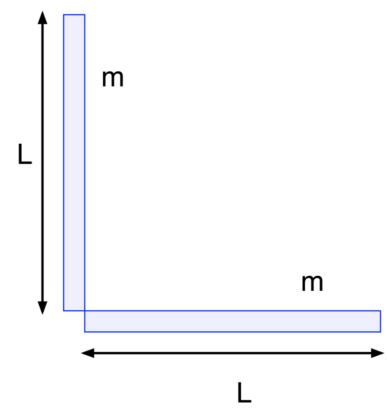

Figure 1: Two identical thin slabs placed in an L-shaped pattern. See problem 5.C3.

5.C3. Consider the L-shaped object as shown in Figure 1. Each “thin” arm has uniform density and a total mass m. Relative to an origin in the lower left-hand corner, where is the center of mass of the object? You may assume that the thicknes of the two arms are much smaller than their length’s, L.

5.C7. A rowboat of mass m_b and length l is floating on a calm pond. Two people are in the boat. The first has a mass of m_1 and is sitting in the back of the boat. The second has a mass of m_2 and is initially sitting in the front of the boat. (a) Where is the center of mass of the boat? (b) If the first person walks to the center of the boat, by how much does the center of the boat move (length and direction)? (c) If the person walks with a speed v, what is the speed of the boat?

5.S42. Many stars are actually two stars orbiting each other. Such systems are known as binary stars, where the two stars orbit there mutual center of mass. (a) As the two stars orbit each other, what sort of trajectory do we expect the center of mass to follow? (b) A not uncommon system is to have two stars excuting circular orbits about their center of mass. Thus we have a star of mass m_1 in an orbit of radius R_1 and a second star of mass m_2 orbiting with a raidus of R_2. Make a sketch of such a system showing the center of mass and the orbits of the two stars. At some instant in time, show where the two stars are located and justify your answer. Based on your work, what is the distance between the two stars? (c) It is often possible to measure the period, T of the two stars orbit as well as the distance between the two stars. What is the mass, m_1, in terms of T, R_1, R_2 and G? What is the mass of m_2? (d) In a particular system, R_1 is measured to be $6 \times 10^{11}\,m$, R_2 is measured as $9 \times 10^{11}\,m$ and the period is measured to be 40 years. What are the masses of the two stars in “solar masses”? (One solar mass is the mass of the Sun.)

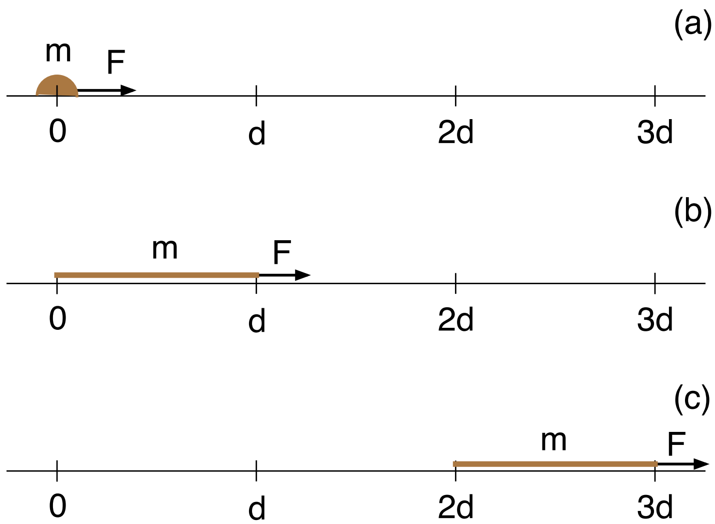

Figure 2: Problem 5.S44.

5.S44. A chain of total mass m and length d is made out of small links. The chain starts in a small pile on a table, and one end is pulled to the right with a force F as shown in Figure 2a. For the following, we will assume that the friction between the chain and the table is very small. (a) After some time, the chain is fully extened as shown in Figure 2b. At this instant, how fast is the chain moving? (b) At some later time, the chain has moved across the table as shown in Figure 2c. At this instant, how fast is the chain moving? (c) What is the change in the internal energy of the chain in going from (a) to (c)?

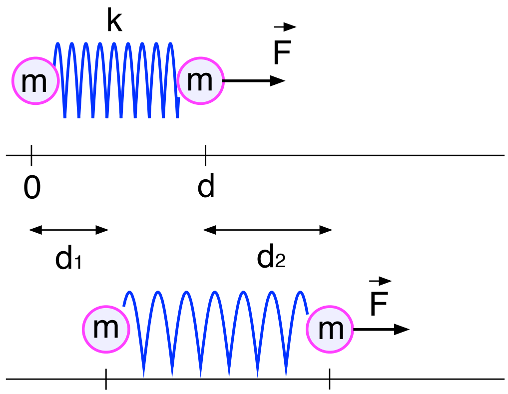

Figure 3: Problem 5.S48.

5.S48. A spring of relaxed length d and spring constant k has a mass m attached to each of its ends. The two masses and the spring are free to slide on a horizontal frictionless surface. You pull on the right-hand mass with a constant force F as shown in Figure 3.

You observe the system a while later and see that the left-hand mass has moved a distance d_1 and the right-hand mass has moved a distance d_2. As indicated in the figure, d_2 is larger than d_1. (a) How much work have you done on the mass-spring system by pulling with the force $\vec{F}$? (b) What is the translational kinetic energy of the mass-spring system? (c) What is the potential energy in the spring in the final configuration? (d) (d) Assuming that the relative kinetic energy and the potential energy are the same, what is the spring constant, k? (e) You are told that $m = 400\,g$, $d = 60\,cm$, $d_1 = 20\,cm$, $d_2 = 140\,cm$ and that $F = 100\,N$. What is the spring constant, k?