Your Name: ________________________________

Teammates: ____

Physics 8, Fall 2023, Worksheet #7.

`http://positron.hep.upenn.edu/p8/files/ws07.pdf`

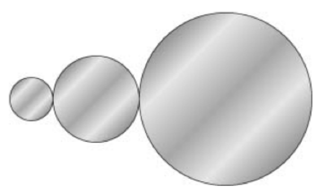
Upload PDF (smartphone scan or tablet edit) to Canvas at end of class on Mon, Sep 25, 2023.

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Discuss each problem with your teammates (usually groups of 3), then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result. Do not hesitate to ask for help from other students or from the instructors — but don't just copy down other people's results!

(Chapter 6 problem.)

1. Let $x = 0$ be the left side of the left circle shown below, and let the x axis point to the right. (a) Find the x coordinate of the center of mass of the system shown below. All three circles are made of sheet metal of the same material, and the diameters are 2.00 m, 4.00 m, and 6.00 m. (b) Repeat the calculation for three solid spheres all made of the same material and having the same diameters as in part a. Hint: to find the CoM, you can replace each circle or sphere with a point mass (of the same mass) at the circle or sphere's own CoM, then find the CoM of those three point masses.



(Chapter 7 problems.)

2. Two toy cars ($m_1 = 0.350\,\text{kg}$, $m_2 = 0.225\,\text{kg}$) are held together rear to rear with a compressed spring between them. When they are released, the cars are free to roll away from the ends of the spring. If you measure the acceleration of car 1 (the 0.350 kg car) to be $2.75\,\text{m/s}^2$ to the right, what is the acceleration of the other car?

3*. Two blocks of inertia (i.e. mass) 3.3 kg each are connected by a string that is draped over the edge of a table, so that one block is on the slippery table and the other is just hanging off the edge. A restraint holds the block on the table in place, and the string is 0.75 m long. After the restraint is released, what speed does each block have at the instant the upper block is pulled off the table? (Think about the two blocks' changes in K.E., and think about the second block's change in G.P.E. Assume that the string stays taut.)

4. You drop a rubber ball from a height of 5.00 m. It bounces off a concrete surface to a height of 4.05 m. (a) What is the coefficient of restitution, e, for this collision? (b) You want to get the ball to bounce upward (assuming same e) to a height of 7.55 m. How fast must you throw it (from the initial height 5.00 m), and in which direction? (Or maybe the direction doesn't matter?) Use the same restitution coefficient that you found in the first part. Neglect air resistance.

5. (a) Show that in an elastic collision between two objects of inertias m_1 and m_2, with initial velocities $v_{1i} > 0$ and $v_{2i} = 0$, the final velocities are

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{1i}, \qquad v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{1i}.$$

Hint: The easy way to do this is to use Equation 5.4 for elastic collisions, along with momentum conservation. The difficult way (which I did when I first solved this problem) is to use the equation for energy conservation instead of Equation 5.4.

(b) Discuss the cases $m_1 \ll m_2$, $m_1 = m_2$, and $m_1 \gg m_2$. Using everyday objects, give an example of each of these three cases.

6. Optional/XC. (From Chapter 6.) A golf club of mass M is moving at speed V_i when it strikes (elastically) a stationary golf ball of mass m. Show that in the limit $M \gg m$, the golf ball's speed after the collision is $v_f = 2V_i$. (a) First solve this problem by using the result of problem 5, with $m_1 = M$ and $m_2 = m$, and taking the limit $m_1 \gg m_2$. (b) Then re-solve the problem by working in the ZM frame of the collision. Hint 1: in the limit $M \gg m$, the ZM frame is the same as the rest frame of the golf club. Hint 2: for an elastic collision as seen in the ZM frame, each final velocity is just the negative of the corresponding initial velocity. You can see this factor of two at `youtu.be/U3j-o3UXRSI` .

7. Optional/XC. The extinction of the dinosaurs has been attributed to a collision between Earth and an asteroid about 10 km in diameter. Assume that the asteroid had about the same density as Earth. (Earth's mass is 6.0×10^{24} kg, and its **circumference** is 40,000 km.) Also assume that the asteroid's initial speed with respect to Earth is about the same as Earth's orbital speed around the sun. (This is equivalent to assuming that the moving Earth slams (totally inelastically) into a stationary asteroid.) Estimate the energy released by such an impact. Express your estimate in terms of "megatons of TNT equivalent." (Detonating 1 megaton of TNT releases an energy of 4.2×10^{15} joules. Earth's orbital speed around the sun is about 30 km/s.)

***** Please check in with one of the instructors before you leave, so that we can give you some quick feedback on your work and get your impressions of the appropriateness of today's assignment. *****