- worksheet: `positron.hep.upenn.edu/p8/files/ws06.pdf`
- Remember to check in with us on your way out (if you leave early) or during the last 10 minutes of class (if you stay to the end), so that we can ask how today's work went for you and perhaps offer you some quick feedback on what you've written down.
- What you need to know for ws06 is the same as for ws05. I think next time there will be one (!) CoM problem.
- Before next Monday's class meeting, either watch my ch07 video or read/skim Mazur ch07. There are only two new "equation" results in ch07:

$$\Delta U^{\mathrm{gravitational}} = mg\Delta x \qquad\qquad \frac{a_{1x}}{a_{2x}} = -\frac{m_2}{m_1}$$

Two administrative questions to ponder!

- (Think about these today, we'll decide another day.)
- **Do we want occasional quizzes?**
- Three reasons you might say yes are: (a) if you are especially concerned about the "free rider" problem, or (b) if you want a stronger incentive to be sure you understand what you are writing down on your worksheets, or perhaps more cynically (c) if you feel that quizzes give you an advantage.
- **Do we want a traditional final exam?**
- Two reasons you might say yes are: (a) it is simpler to schedule than the alternative, which is small-group chalkboard presentations of problem solving, and (b) if you plan to ace the exam and you want me to be able to quantify in a letter of recommendation how much you distinguished yourself on the final exam.
- Ponder, discuss among yourselves, and we can revisit this some time next week.

Key results from ch04/ch05 (momentum + energy)

$$m_1 v_{1x,i} + m_2 v_{2x,i} = m_1 v_{1x,f} + m_2 v_{2x,f}$$

$$K = \frac{1}{2} m v^2$$

$$(v_{1xf} - v_{2xf}) = -e\,(v_{1xi} - v_{2xi})$$

$e =$ "coefficient of restitution"
elastic colllision : $e = 1$
inelastic collision : $0 \leq e < 1$ (some KE is transformed)
totally inelastic collision : $e = 0$
explosive separation: $e = \pm\infty$

$$K_{1i} + K_{2i} + E_{i,\mathrm{internal}} = K_{1f} + K_{2f} + E_{f,\mathrm{internal}}$$

If a specified amount of internal energy is converted between initial and final states.

Physics 8, Fall 2023, Worksheet #6.

Upload PDF (smartphone scan or tablet edit) to Canvas by end of day on Wed, Sep 20, 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. Just don't copy down someone else's result!

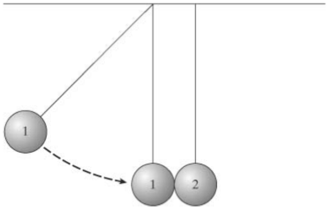
1*. An experienced bartender knows just how fast to push a glass of beer to get it to come to a stop in front any customer sitting along the bar. Say the initial speed needed to move a glass all the way to the end of the bar is v_{end}. In terms of v_{end}, how fast (i.e. what fraction of v_{end}) does she have to push an identical glass of beer if it is to stop at a customer sitting halfway down the bar? (The **only thing** you need to know about friction at this stage is that the kinetic energy converted to thermal energy because of friction is **proportional to the distance** the glass skids. The glass of beer comes to a stop when all of its initial kinetic energy has been dissipated by friction into thermal energy.)

2*. Two carts, of inertias m_1 and m_2, collide head-on on a low-friction track. Before the collision, which is elastic, cart 1 is moving to the right at $6.0\,\mathrm{m/s}$ and cart 2 is at rest. After the collision, cart 1 is moving to the left at $2.0\,\mathrm{m/s}$. (a) What are the speed and direction of motion of cart 2 after the collision? (b) If $m_2 = 6.0\,\mathrm{kg}$, what is the value of m_1?

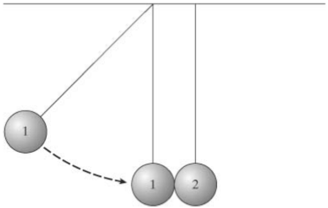
3. A 41.0 kg (including clothing and several 1.00 kg snowballs) ice skater is at rest on the ice. She throws a snowball to the right at 20.0 m/s. (a) What is her speed after the throw? Is her velocity to the left or to the right? (b) Calculate the coefficient of restitution for this event. [The result is a very special "number."] She next throws a second snowball but this time at a speed of 10.0 m/s to the left (10.0 m/s is the snowball's speed in the Earth frame after the throw). Note that before throwing the second snowball, she is still moving at the result of part (a). (c) What is her speed after this throw? Is her velocity to the left or to the right? (d) Calculate the change in kinetic energy in the **first** event (from part a). Where does the added kinetic energy come from? (e) If one food Calorie equals 4184 J, how many Calories does the skater burn when she throws the first snowball? (Assume, unrealistically, that all of the energy burned goes into motion of the snowball and of the skater.)

4. A system consists of a 2.00 kg cart and a 1.00 kg cart attached to each other by a compressed spring. Initially, the system is at rest on a low-friction track. When the spring is released, an explosive separation occurs at the expense of the internal energy of the compressed spring. If the decrease in the spring's internal energy during the separation is 10.0 J (that's 10.0 joules), what is the speed of each cart right after the separation?

5. Two solid spheres hung by thin threads from a horizontal support (figure below) are initially in contact with each other. Sphere 1 has inertia $m_1 = 1.00\,\mathrm{kg}$, and sphere 2 has inertia $m_2 = 2.00\,\mathrm{kg}$. When pulled to the left and then released, sphere 1 collides elastically with sphere 2. At the instant just before the collision takes place, sphere 1 has kinetic energy $K_1 = 0.500\,\mathrm{J}$.
(a) What is the velocity of sphere 1 right before the collision?
(b) What is the kinetic energy of the system before the collision?
(c) What is the velocity of each sphere after the collision?
(d) From part c, calculate the kinetic energy after the collision. Does the value you get equal the result from part b? Explain why or why not. (e) Calculate the coefficient of restitution of the collision. Is this the result you expect?



6. Let's redo the previous problem, but now with two spheres made of modeling clay. As before, sphere 1 has inertia $m_1 = 1.00\,\mathrm{kg}$, and sphere 2 has inertia $m_2 = 2.00\,\mathrm{kg}$. Again, sphere 1 is pulled left, is released, and collides with sphere 2. This time, though, the two spheres stick together. Assume that sphere 1 again has a kinetic energy of 0.500 J just before the collision. (a) What is the initial velocity of sphere 1? (b) What is the kinetic energy of the system before the collision? (c) What is the final velocity of each sphere? (d) What is the kinetic energy of the system after the collision? Is this the same value you calculated in part b? (e) Based on what you have calculated so far, what kind of collision is this?
(f) Calculate the coefficient of restitution. Is the value you get consistent with your answer to part e?



Rubric: 4 points per problem: 2 for effort, 2 for correctness.

- 4 points = correct or very nearly correct
- 3 points = minor mistake
- 2 points = major mistake
- 1 point = you haven't convinced us that you put in much effort to try to solve the problem
- 0 points = nothing or very little of substance written down
- For some problems (such as today's hands-on bridge model), it may be unreasonable for us to look for "correctness," so instead all 4 points will be for effort.
- 4 additional overall points for presenting your work clearly, with adequate reasoning. So if n is the number of problems, the total points will usually be $4n + 4$.