Assignment VII, PHYS 111 (General Physics I)
Fall 2021
Due Thursday, October 14th, 2021

Just as a reminder – in each homework assignment, I will list suggested homework problems out of the book. These are worth practicing – some may even appear on exams verbatim – but since they are in the text, finding answers on-line should be straightforward and these textbook problems will not be graded. I suggest you do them – many of them will be easier than the graded homework and they would be a good thing to tackle in your SI sessions to get comfortable with the content.

After the suggested book problems, I will give a list of problems that I myself wrote. *SOME* of these problems will be graded, but you won't know which ahead of time. The ones that I grade will be the same for everyone in the class.

I will supply you with an answer key to all of the problems that I wrote – even the ones that I did not grade.

As always, please legibly write (or type) your answers on separate paper. Incorrect answers with no work will earn nearly no credit, and consistent correct answers with no work are suspicious – many of these problems your professor can't do in his head, so it is unusual if you can. Please show all relevant work.

To help with this homework, you should read the associated sections of your text and watch the videos associated with the lectures on the course webpage: http://larsenml.people.cofc.edu/phys111_fall21.html.

(Ungraded) suggested textbook practice problems

(All problems are odd problems (that have answers in the back of the book) out of Halliday, Resnick, and Walker, 10th Ed.)

Chapter 8:
Continue practicing the problems noted in previous HW.

Chapter 9:
Questions: 3, 9
Problems: 7, 13, 19, 25, 29, 33, 39, 41, 45, 47, 53, 55, 61, 63, 65, 67, 71, 75, 79, 85, 87, 91, 93, 101, 105

Graded Homework Problems

1. In class, I argued that a careful treatment of two objects undergoing a one-dimensional elastic collision results in the following relationships:

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

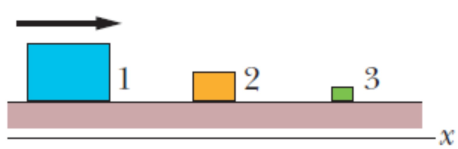
   Start from these expressions and show that $v_{2f} - v_{1f} = v_{1i} - v_{2i}$. (This is a really important result in problem-solving. It tells us that if the objects are approaching each other at speed Δv before the collision, then they separate from each other at the same speed Δv after the collision.)

2. A neutron in a reactor makes a collision with the nucleus of a carbon atom initially at rest. (Assume that the nucleus of a carbon atom is initially equal to 12 times the mass of a neutron). (You may need to look up the mass of a neutron – it shouldn't be hard to find). You may assume that this problem is fully 1-dimensional.

   a) If the collision was completely inelastic (in other words, the neutron combines with the carbon nucleus), what fraction of the initial kinetic energy is lost?

   b) If the collision was perfectly elastic, the what fraction of the neutron's initial kinetic energy was transferred to the carbon nucleus?

3. The figure below shows block 1 (with mass m_1) sliding along the x axis of a frictionless floor with speed $v_{1i} = 4.00$ m/s. Then block 1 undergoes an elastic collision with a stationary block of mass $m_2 = \frac{m_1}{2}$. Next, block 2 undergoes a one-dimensional elastic collision with stationary block 3 having mass $m_3 = \frac{m_2}{2}$.



   a) What then is the final speed of block 3?

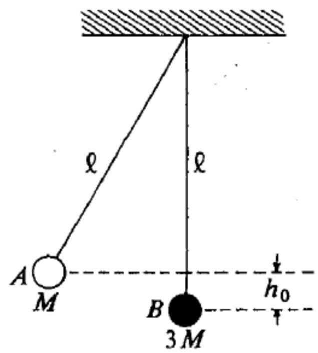
   b) What fraction of the initial kinetic energy is transferred to block 3? (In other words, if the initial kinetic energy is K_i, you can write that the final kinetic energy of block 3 as $(K_f)_3 = \gamma K_i$ with γ some constant between 0 and 1. Find γ).

   c) What fraction of the initial momentum is transferred to block 3? (In other words, if the initial momentum is p_i, you can write the final momentum of block 3 as $(p_f)_3 = \beta p_i$ with β some constant. Find β).

4. During the battle of Gettysburg, the gunfire was so intense that several bullets collided in midair and fused together. Assume a 5.50 g Union musket ball moving to the right at 290 m/s and 24.0° above the horizontal collies with a 3.75 g Conferate ball moving to the left at 312 m/s and 14.0° above the horizontal. In this problem, ignore any effects of gravity.

   a) Immediately after the musket balls collide, what was the velocity of the fused-together bullet?
   b) What fraction of the initial kinetic energy was lost in the fusing-together process?

5. Two small spheres of putty, A and B of masses M and $3M$ respectively, hang from the ceiling on strings of equal length ℓ. Sphere A is drawn aside so that it is raised to h a height $h_\circ$ as shown below and then released. Sphere A collides with sphere B and then they stick together and (while attached to each other) swing to a maximum height h, when the two spheres are momentarily at rest. What is h in terms of $h_\circ$?



6. If a ball of mass m makes a glancing elastic collision with another initially stationary ball of mass m, I stated in class that the trajectories of the two balls post-collision always move off at trajectories at an angle of 90° from each other. (I call this the billiard-ball corollary). In this problem, you are going to show this. I'll get you started. Let the initial ball move in the +x direction at initial speed $v_\circ$. After the collision, this ball moves at speed v_f at an angle θ with respect to its initial trajectory. For simplicity, I'll let θ be aligned so that the ball begins to have a positive y velocity. The other ball moves at speed v' at an angle ϕ with respect to the other ball's initial trajectory. This is a positive angle, but directed with a component in the negative y direction. Thus, using conservation of momentum in the x and y directions and conservation of energy, we get the following relationships:

$$p_x : mv_\circ = mv_f \cos\theta + mv' \cos\phi$$
$$p_y : 0 = mv_f \sin\theta - mv' \sin\phi$$
$$E : \frac{1}{2}mv_\circ^2 = \frac{1}{2}mv_f^2 + \frac{1}{2}m(v')^2$$

   Your goal is to prove that $\theta + \phi$ must equal 90° (or, if you are starting to get into the mode of thinking of angles in radians, you need to show that $\theta + \phi = \pi/2$ radians). Hints: divide the momentum equations by m and multiple the E equation by $2/m$. After that, you can start getting the p equations closer to the E equation by squaring and adding them.