Assignment VII, PHYS 111 (General Physics I)
Fall 2022
Due Friday, October 14th, 2022

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_fall22.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.

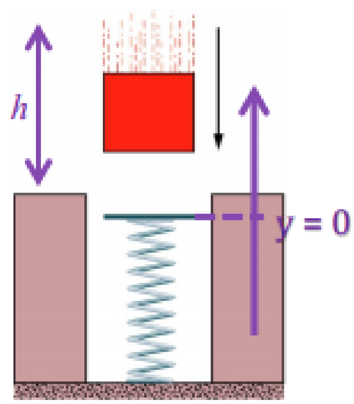
Chapter 9:
Questions: 3, 9
Problems: 7, 13, 19, 25, 29, 33, 39, 41, 45, 47, 53, 55, 61, 63, 65, 67, 71, 75, 79, 85, 87, 91, 93, 101, 105

Please note that this is also your last expected homework assignment before your second midterm exam.

Graded Homework Problems

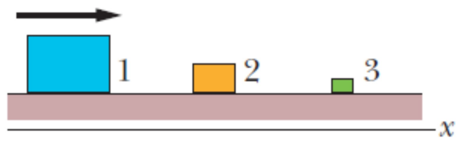
1. A 4.2 kg block is accelerated from rest by a compressed spring of spring constant 732 N/m. The block leaves the spring at the spring's relaxed length and then travels over a horizontal floor with a coefficient of kinetic friction $\mu_k = 0.17$. The frictional force stops the block in distance $D = 11.2$ m. Leave all your answers to this problem numerical (with appropriate units!)
   a) What is the increase in the thermal energy of the block-floor system at the end of the whole process?
   b) What is the maximum kinetic energy of the block?
   c) What is the original compression distance of the spring?
   d) What was the initial velocity of the block right after breaking contact with the spring?
   e) What is the velocity of the block when it has traveled $D/2 = 5.6$ m from the spring?

2. A block of mass $m = 35$ kg is dropped from rest from a height $h = 24.5$ m above the end of a spring. After the block has fallen the 24.5 m it begins to compresses an extremely giant spring with spring constant $k = 372.5$ N/m. How far does the spring compress due to the falling mass? (Warning – leave your answer to a few significant figures; for this problems answers off by less than 5% won't earn full credit).



3. 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?

4. 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 $m_3 = \frac{m_2}{2}$.

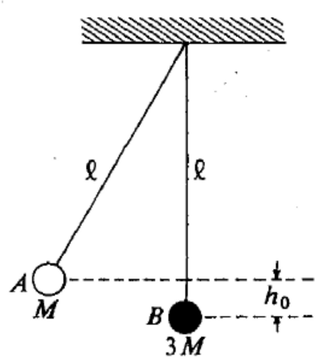


   a) What then is the final speed of block 3?
   b) What fraction of the initial kinetic energy is transferred to block 3? (In other words, if the initial kinetic energy is K_i, you can write that the final kinetic energy of block 3 as $(K_f)_3 = \gamma K_i$ with γ some constant between 0 and 1. Find γ).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

5. 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? (Hint: the fraction lost can be computed by taking $1 - \frac{K_f}{K_i}$.)

6. 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 $h_\circ$?



7. In class, I mentioned that we have lots of techniques for dealing with fully elastic collisions and fully inelastic collisions, but partially elastic collisions are a bit trickier. That doesn't mean they are hopeless, though.

   Consider dropping a ball from height H. If it bounces off of the ground, it will rebound to some height αH where α is a value between 0 and 1. (Bouncier things like super-bouncy-balls may have a value of α near 1, whereas things that barely bounce will have a value of α closer to zero).

   Let's say you are able to reliably see that something bounces if it bounces to a height of at least 1 millimeter. Further, let's say that an object was dropped from a very high height. It turns out that the relationship $v = \sqrt{2gh}$ on impact that we can derive from our kinematic equations only works in the absence of air resistance. In reality, v for a falling object in Earth's atmosphere can't stay larger than something called the "terminal fall velocity" of the object. The terminal fall velocity depends on the size and shape of the object. (For example, the terminal fall speed of a small raindrop is around 1 m/s and for a large raindrop it is about 10 m/s).

   So...finally...the problem. A ball is dropped from a very large height (so large than you can rest assured that it hits the ground at its terminal fall velocity). The height the ball reaches after its first bounce is 13 meters. After the second bounce the ball reaches 4 meters.

   a) How many times does the ball bounce at least 1 mm high?

   b) What was the terminal fall speed of the ball?