Homework 01

Physics II

Due Friday, April 1, 2022

College of the Atlantic. Spring 2022

There are two parts to this assignment.

Part 1: WeBWorK. Do Homework 01 which you will find on your WeBWorK page. I recommend doing the WeBWorK part of the homework first. This will enable you to benefit from WeBWorK's instant, if not necessarily friendly, feedback before you do part two.

Part 2: Not WeBWorK. Below are two non-WeBWorK problems.

- If you want, you can do these problems in pairs and hand in only one write-up.
- More than most other assignments, these problems involve some results from Physics I. If you haven't had intro physics, you might want to partner with someone who has. You can also, of course, seek help from me.
- "Hand in" the problem on google classroom. You can take a picture of your work, or type up your work, or scan your work.

1. In a happier time, Beowulf takes a cruise on an oceanliner. The oceanliner is moving at a constant speed of 17 m/s relative to the shore. Beowulf is playing shuffleboard. He slides a shuffleboard puck at 10 m/s in the -x direction in the boat frame. The puck has a mass of 750 grams. The moving puck hits an identical puck that was at rest. After the collision the first puck is at rest and the other puck is now traveling at 10 m/s in the -x direction. (This is based on problem R1M.8 from Thomas A. Moore, *Six Ideas that Shaped Physics: Unit R (3rd ed.)*, McGraw Hill, 2017.)

   (a) Show that the total x-momentum[1] of the two-puck system is conserved in Beowulf's reference frame.

   (b) It just so happens that the oceanliner cruises under a bridge as this shuffleboard game is happening. And it also just so happens that Anastajia is sitting on the bridge. In Anastajia's reference frame, what velocity will each puck have before and after the collision?

   (c) Show that in Anastajia's reference frame momentum is conserved. Thus, the law of the conservation of momentum holds for both Beowulf and Anastajia, even though they will measure different velocities for the pucks.

2. Anastasia is in an elevator that is moving downward at a constant speed of β. She drops her cell phone from a height h. The phone falls and hits the floor of the elevator. Beowulf watches Ana drop her phone from outside the the elevator. We will analyze the dropping of the phone in the elevator/Anastasia frame and the building/Beowulf frame. We will see

[1] Recall that momentum p of an object with mass m moving at a speed of v is given by the formula $p = mv$. "Conservation of momentum" means that the total momentum of an isolated system remains the same.

that although Ana and Beowulf observe different values for the distance traveled by the phone and the phone's speed, nevertheless the law of conservation of energy holds in both of their reference frames. Your answers for these questions will not be numbers; they will be expressions involving β, g, and h. (This is based on problem R1M.10 from Thomas A. Moore, *Six Ideas that Shaped Physics: Unit R (3rd ed.)*, McGraw Hill, 2017.)

(a) How long does the phone take to fall in the elevator frame?

(b) How long does the phone take to fall in the building frame?

(c) At what speed does the phone hit the floor of the elevator in the elevator frame?

(d) How far does the phone fall in the building frame?

(e) What is the initial speed of the phone in the building frame?

(f) At what speed does the phone hit the floor of the elevator in the building frame?

(g) Show that energy is conserved in the elevator frame.

(h) Show that energy is conserved in the building frame.

Here are some results from Physics I that might be useful.

There are two kinematics equations for objects undergoing free fall (a constant acceleration of g. If an object has a speed of v_0 at time $t = 0$, then at a later time t, its speed is given by:

$$v = v_0 + gt \ . \tag{1}$$

If an object has a height of z_0 and a speed of v_0 at $t = 0$, then at a later time t, its position is given by:

$$z = z_0 + v_0 t + \frac{1}{2} g t^2 \ . \tag{2}$$

The mechanical energy E of an object with a mass m, at an altitude of z, moving at a speed v is given by:

$$E = mgz + \frac{1}{2} m v^2 \ . \tag{3}$$

The first term is the gravitational potential energy and the second term is the kinetic energy. For gravitational potential energy, you are free to choose whatever altitude for $z = 0$ that you wish.