Unit Eight Homework

Physics II

Due Monday, June 1, 2020

College of the Atlantic. Spring 2020

Instructions:

- Do these problems in pairs.
- "Hand in" the problem on google classroom. Please don't email me the homework; it's a lot easier for me if you submit it on classroom.
- In addition to these problems, there are some problems that you should do on Edfinity. There is one Edfinity assignment: Homework 08. You should "hand in" these assignments individually, but of course it's totally fine—and in fact encouraged—to work on the Edfinity problems with others.

1. At exactly 11:00am, a fermenting jar of kombucha explodes on the campus of College of the Atlantic. Three hundred microseconds later, a jar of kombucha explodes in Portland, Maine, 180 km from COA.
   (a) What is the distance from COA to Portland in SR units?
   (b) Could the COA explosion have caused the Portland explosion? Why or why not?
   (c) The Portland explosion is in the [past, future, elsewhere] of the COA explosion?
   (d) Beowulf and Anastajia are flying by earth in a spaceship and they observe the two explosions to occur simultaneously. How fast is their spaceship traveling? (Hint: use the Lorentz transformation.)

2. Two objects of mass m are traveling in opposite directions at a speed of 0.6. They collide and stick together, forming one composite object with a mass of $2m$. This situation is shown in Fig. 1. In this problem we will investigate the conservation of momentum in different reference frames. Recall that the momentum of an object is given by $p = mv$. Momentum can be positive or negative, depending on the direction of motion of the object.
   (a) What is the momentum of object A before the collision?
   (b) What is the momentum of object B before the collision?
   (c) What is the total momentum of the two-mass system before the collision. (Just add together the momentums of A and B.)
   (d) What is the momentum of the system after the collision? (I.e., what is the momentum of object C.)
   (e) Is the momentum of the system conserved? That is, is the momentum of the system before the collision the same as the answer of the momentum of the system after the collision? (The answer should be yes.)

(f) Now suppose that Anastajia and Beowulf fly by in a spaceship moving left to right at a speed of 0.6.

i. In the spaceship frame, what is the velocity of object A?
ii. In the spaceship frame, what is the velocity of object B?
iii. In the spaceship frame, what is the velocity of object C?

(g) What is the momentum of the system in the spaceship frame before the collision? That is, add up the momentum of object A and object B in the spaceship frame?

(h) What is the momentum of the system in the spaceship frame after the collision? That is, what is the momentum of object C in the spaceship frame?

(i) Is the momentum of the system conserved in the spaceship frame. You should find that the answer is no[1].

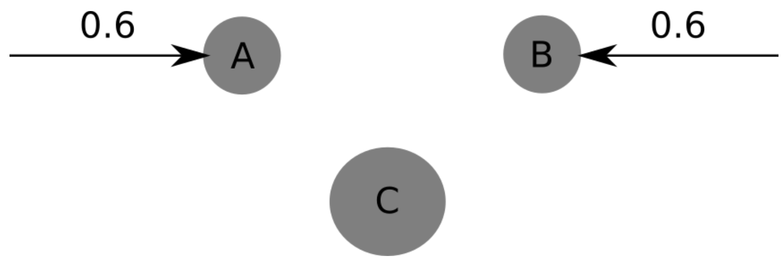

Figure 1: Two objects, labeled A and B, collide head on. Each has a speed of 0.6. The objects collide and stick together, forming a single composite objects, labeled C. Object C is at rest after the collision. The masses of objects A and B are equal.

[1]But wait. This violates the principle of relativity. The laws of physics are supposed to be the same in all reference frames. Here we're seeing that the law of conservation of momentum holds in one reference frame but not the other? How can this be? The issue is that we'll need a new, relativistic, equation for momentum. This will be the topic of the next (and final) unit, and will lead us to discover $E = mc^2$.