Lab 4 - Conservation

Overview

In the previous lab you learned something about forces and Newton's 2nd Law. Forces are vectors, so they point in a particular direction. There is another Newton's Law; Newton's 3rd Law. This law describes what happens when two objects exert forces on each other. This is the famous statement that for *every action there is an equal and opposite reaction*. A better way of stating Newton's 3rd law is if one object exerts a force on another object, then the second object will exert a force of equal magnitude and opposite direction on the first. I'll admit that may not sound better, but the mathematical expression of Newton's 3rd Law if very simple:

$$\vec{F}_{1\to 2} = -\vec{F}_{2\to 1}$$

There is a pretty amazing and fundamental implication of Newton's 3rd Law, any two or more objects interacting with each other can cause an individual object's motion to change, but the motion of the whole system; i.e, all the objects added together does not change! I have to give a proper definition to what I mean by motion; specifically the momentum of an object:

$$\vec{p} = m\vec{v}$$

Any individual object has a momentum depending on its mass and velocity. The total momentum of all the objects *vectorially* added together does not change, even though the individual momentum can, regardless of how that interacts. That means total momentum before an interaction is equal to the total momentum after interaction. In other words, momentum is conserved!

$$\Sigma\vec{p}_i = \Sigma\vec{p}_f$$

Part 1 - Elastic Collision

The first kind of collisions you will study are elastic collisions. Elastic collisions are collisions when two objects bounce off each other. The two objects are two PAScars on a track with their magnetic bumpers facing each other. The magnetic bumpers will repel the two PAScars.

Since momentum is a vector, direction matters. Even in 1-D there is a positive and negative direction, so we will work in the convention right is positive and left is negative. Place the two PAScars on the track; we will call the PAScar on the left car #1 and the PAScar on the right car #2. Car #2 will always start at rest ($v_2 = 0$). The conservation of momentum for the two cars is:

$$m_1\vec{v}_{1,i} = m_1\vec{v}_{1,f} + m_2\vec{v}_{2,f}$$

You can change the masses of the cars by adding masses on top of them. You are going to make some predictions *before* you do the experiment.

1. Given the equation of conservation for the two cars above, if $m_1 = m_2$, what do you predict is the direction of car #1 after collision? Explain your reasoning.
   I predict that the car will be going the opposite direction after colliding with the second car. I think this because the mass is the same, it will transfer all energy into the other car and vice versa.
2. If $m_1 > m_2$, what do you predict is the direction of car #1 after collision? Explain your reasoning.
   If m1 is larger than m2, then car 1 will keep going in the same direction and car 2 will start going in the other direction. This is because car 1 will have more energy and can spare some to change the direction of car 2
3. If $m_1 < m_2$, what do you predict is the direction of car #1 after collision? Explain your reasoning.
   If m2 is larger than m1, car 2 will keep going in the same direction and car 1 will start going in the other direction. This is because car 2 will have more energy and can spare some to change the direction of car 1

Now perform the experiment for each case $m_1 = m_2$, $m_1 > m_2$, and $m_1 < m_2$ using the two motion sensors to measure the velocities before and after a collision. The sensor on the left with measure car #1's velocity and the sensor on the right will measure car #2's velocity. Start by pushing car #1 to the right into car #2. IMPORTANT: when measuring the velocities using the Multi-coordinate tool, make sure it is the velocities just before and just after a collision. Notice there is a damping of the cars' momentum from friction which you measured in the previous lab.

4. Record the masses and the velocities of car #1 and car #2 in the Google Sheet link to the assignment on Moodle. Make sure you record your measurements on the page tabbed at the bottom with Elastic Collision.

done

5. Are the measured velocities of car #1 after collision for each case the same direction as you predicted for questions 1-3? Why or why not?

No, when they were the same velocity, i thought they would both move in different directions but in the experiment, one of the cars ended up stopping moving. The other 2 predictions were the same, for the same reason too, because they had enough energy to keep going forward after moving the other cart.

6. Calculate the initial and final momentum for cars #1 and #2.

On the chart

7. Calculate the initial and final total momentum.

On the chart

8. If momentum is conserved during elastic collision of the two cars, what would you expect the ratio of final to initial total momentum be? Calculate the ratio of final to initial total momentum. Does the ratio agree with your expectation?

It would be some number a little under 1, because friction would be eating away at the momentum as the carts roll

The momentum of an object is not the only thing that is defined by the object's mass and velocity. An object's kinetic energy is too.

$$K = \frac{1}{2}mv^2$$

So maybe there are cases when kinetic energy is conserved too. You have all the measurements you need to calculate the kinetic energies of the two cars.

9. Calculate the initial and final kinetic energies for cars #1 and #2.

10. Calculate the initial and final total kinetic energy.

11. If kinetic energy is conserved during elastic collision of the two cars, what would you expect the ratio of final to initial total kinetic energy be? Calculate the ratio of final to initial total kinetic. Does the ratio agree with your expectation?

I would expect the kinetic energy ratio to be a little under 1 because just like momentum, some is taken away through friction and other forces also acting on the cart.

Part 2 - Inelastic Collision

What happens if the two cars were to stick to each other after colliding. Repeat the experiment; this time when the cars collide inelastically. You can make the cars stick to each other by turning them around so the velcro bumpers face each other. When the cars collide and stick they essentially become one object moving with one velocity.

Repeat the experiment for each case $m_1 = m_2$, $m_1 > m_2$, and $m_1 < m_2$. Again start by making a prediction *before* you do the experiment.

12. Given the equation of conservation for the two cars above, if $m_1 = m_2$, what do you predict is the direction of car #1 after collision? Explain your reasoning.
    I predict that the two cars will end up moving in the same direction, just at a lesser speed.

13. If $m_1 > m_2$, what do you predict is the direction of car #1 after collision? Explain your reasoning. When m1 is greater than m2, they will move in the same direction, but at a greater velocity than if they were the same weight

14. If $m_1 < m_2$, what do you predict is the direction of car #1 after collision? Explain your reasoning.
I predict that the cars will move in the same direction just with a smaller velocity than if they were reversed.

Now repeat the experiment for the three cases.

15. Record the masses and the velocities of car #1 and car #2 in the Google Sheet link to the assignment on Moodle. Make sure you record your measurements on the page tabbed at the bottom with Inelastic Collision.

16. Are the measured velocities of car #1 after collision for each case the same direction as you predicted for questions 12-14? Why or why not?

Yes my predictions are correct, they did end up having the same properties are predicted

17. Calculate the initial and final momentum for cars #1 and #2.

On the sheet

18. Calculate the initial and final total momentum.
On the sheet
19. If momentum is conserved during inelastic collision of the two cars, what would you expect the ratio of final to initial total momentum be? Calculate the ratio of final to initial total momentum. Does the ratio agree with your expectation?

If momentum is conserved i would expect the ratio to be above zero, but still below 1 because you cant create more energy

Finally what happens to the kinetic energy during inelastic collision? Is it still conserved?

The kinetic energy is still conserved, but a lot more needs to be transferred to the second car to get it moving, so the ratio is low, but still above 0 and below 1

20. Calculate the initial and final kinetic energies for cars #1 and #2.

21. Calculate the initial and final total kinetic energy.

22. If kinetic energy is conserved during inelastic collision of the two cars, what would you expect the ratio of final to initial total kinetic energy be? Calculate the ratio of final to initial total kinetic energy.

The ratio of kinetic energy would be above zero and less than one, you cant create kinetic energy, and it won't all be lost if it is conserved

23. Based on the ratio of final to initial kinetic energy, is kinetic energy conserved during inelastic collision? If not, where did some of the kinetic energy go?

kinetic energy is conserved, but a lot is also lost, the kinetic energy goes into getting the second car moving, while bringing the first car along. The same amount of kinetic energy is now being used for an effectively bigger car.