Conservation of Momentum

PES 116 Advanced Physics Lab I

Purpose of the experiment

- Observe collisions between two carts, testing for the conservation of momentum.
- Make sure conservation of momentum continues to hold true for different types of collions (elastic and inelastic).
- [FYI]

[FYI] Armored knights raised their visors to identify themselves when they rode past their king. This custom has become the modern military salute.

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Equipment List

Logger Pro

LabPro

Motion Detectors (x 2)

dynamics cart track

Low-friction dynamics carts (x 2)

Level

Background

By this point in the semester, I hope you have already learned about the conservation of linear momentum. If not, or you are *fuzzy* about it, here we go.

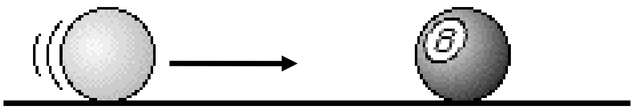
Every good pool player understands the physics of colliding objects even if he/she cannot write down the equations. Unfortunately for physicists, the opposite is not true. Just because we can regurgitate the math, this does not make us expert pool players.

Momentum, just like energy, is conserved. Total momentum within a closed system must remain constant. If two objects collide the sum of the momenta before the collision must be equal the sum of the momenta after the collision.

Momentum (p): $p = m\,v$

Conservation of momentum: $\Sigma p_{Initial} = \Sigma p_{final}$

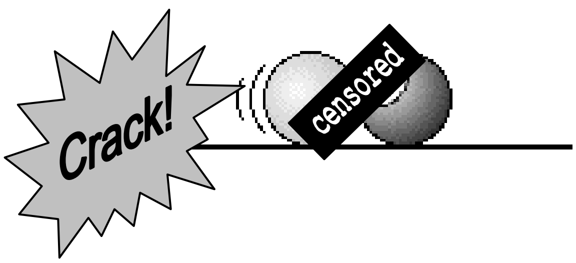
Example: A two-particle collision in one dimension.



Initial case: before the collision.

$m_{cue} = 400$ g $\qquad m_{8ball} = 200$ g

$v_{cue_{initial}} = 1\ {}^{m}\!/_{s} \qquad v_{8ball_{initial}} = 0\ {}^{m}\!/_{s}$



Collision!

Final case: after the collision

$m_{cue} = 400$ g $\qquad m_{8ball} = 200$ g

$v_{cue_{final}} = 0.6\ {}^{m}\!/_{s} \qquad v_{8ball_{final}} = 0.8\ {}^{m}\!/_{s}$

Let's check this experimental data.

Conservation of momentum states that:

$$\Sigma p_i = \Sigma p_f \quad (p = mv)$$

Therefore,

$$m_{cue}\ v_{cue\,i} + m_{8ball}\ v_{8ball\,i} = m_{cue}\ v_{cue\,f} + m_{8ball}\ v_{8ball\,f}$$

Plug in values

$$(0.4\text{ kg})(1\ {}^{m}\!/_{s}) + (0.2\text{ kg})(0\ {}^{m}\!/_{s}) = (0.4\text{ kg})(0.6\ {}^{m}\!/_{s}) + (0.2\text{ kg})(0.8\ {}^{m}\!/_{s})$$

The results

$$0.4\text{ kg}\ {}^{m}\!/_{s} = 0.4\text{ kg}\ {}^{m}\!/_{s}$$

The momentum of the system before the collision is the same as the momentum after the collision.

Momentum is conserved!!

Types of Collisions

Collisions can be classified as:

Elastic (bounce off each other)

or

Inelastic (the objects stick together after collision)

We will be studying both types in today's lab. In both cases momentum is conserved.

The Lab

Part A: Setup

1. Measure the masses of your carts and record them in your data table. The carts are labeled as "1" and "2".
2. Set up the track so that it is horizontal and level. Test this by releasing a cart on the track from rest at various points along its length. The cart should not move. Adjust the "leveling post" accordingly.
3. Practice creating gentle collisions by placing cart 2 at rest in the middle of the track, and release cart 1 so it rolls toward the first cart, magnetic bumper toward magnetic bumper. The carts should smoothly repel one another without physically touching.
4. Place a Motion Detector at each end of the track, allowing for the 0.4 m minimum distance between detector and cart. Connect the Motion Detectors to the DIG/SONIC 1 and DIG/SONIC 2 channels of the interface. Set the Motion Detectors to the "Track" setting.
5. Open the file *PES 116/Cons Momentum/Carts.cmbl*.
6. Click Collect to begin taking data. Repeat the collision you practiced above and use the position graphs to verify that the Motion Detectors can track each cart properly throughout the entire range of motion. You may need to adjust the position of one or both of the Motion Detectors.
7. Place the two carts at rest in the middle of the track, with their Velcro bumpers toward one another and stuck together. Keep your hands clear of the carts and click Zero. Select both sensors and click OK. This procedure will establish the same coordinate system for both Motion Detectors. Verify that the zeroing was successful by clicking Collect and allowing the still-linked carts to roll slowly across the track. The graphs for each Motion Detector should be nearly the same. If not, repeat the zeroing process.

Part B: Magnetic Bumpers

8. Reposition the carts so the magnetic bumpers are facing one another. Click Collect to begin taking data and repeat the collision you practiced earlier. The carts should not stick to each other during the collision. Make sure you keep your hands out of the way of the Motion Detectors after start the data collection.
9. From the position graphs you can determine the velocity before and after the collision for each cart. To measure the velocity during a time interval, drag the cursor across the interval. Click the Linear Fit button and record the value for the velocity. Measure the velocitiy for each cart, before and after collision.

10. Repeat Step 9 two more times with the magnetic bumpers, recording the velocities.

Part C: Velcro Bumpers

11. Change the collision by turning the carts so the Velcro bumpers face one another. The carts should stick together after collision. Practice making the new collision, again starting with cart 2 at rest.
12. Click Collect to begin taking data and repeat the new collision. Using the procedure in Step 9, measure and record the cart velocities.
13. Repeat the previous step two more times with the Velcro bumpers.

Additional Questions

1. Determine the momentum (*mv*) of each cart before the collision, after the collision, and the total momentum before and after the collision. Calculate the ratio of the total momentum after the collision to the total momentum before the collision.
2. If the total momentum for a system is the same before and after the collision, we say that momentum is *conserved*. If momentum were conserved, what would be the ratio of the total momentum after the collision to the total momentum before the collision?
3. Is momentum conserved in the magnetic bumper collisions?
4. How about the Velcro collisions?
5. Classify each of the collisions as elastic or inelastic.