Physics 103
Lab MC-11: Elastic Collisions

Apparatus:

Track
2 collision carts equipped with magnetic bumpers
2 motion sensors (with stands and cables)
2 cardboard vanes
Computer and interface

Problem

You work at the Wisconsin Traffic Safety Board. Your boss is interested in designing a car that will not be damaged if it is involved in collisions. Your boss has two ideas:

A. make the bumpers out of super-strong metal, so they don't crumple in a collision
B. use a magnetic bumper, so that colliding vehicles never even touch each other

Your boss thinks either of these ideas would be better than conventional bumpers, which are supposed to crumple during a collision. You are testing miniature versions of these bumpers before deciding whether to put them into production on passenger automobiles.

You know from taking physics 103 that all collisions ought to conserve momentum, but only some collisions ought to conserve energy. So you go into the lab to find out:

1. Is momentum really conserved with both of these new bumper ideas?
2. Is energy conserved with either (or both, or neither) of these new bumper ideas?

You're worried that there might be other factors you should consider when designing automobile bumpers, such as the safety of passengers during a collision. After taking data in the lab, you reflect on the conventional bumper design, and ask yourself:

3. What factor in a collision makes it bad for the passengers involved?
4. Why are conventional bumpers intended to crumple during a collision?

Armed with the data you used to answer questions 1 and 2, and your reflections about questions 3 and 4, you prepare yourself to go to your boss to the answer to the big question:

Should either bumper A or bumper B be used on passenger automobiles?

Tips on using Equipment

The technician who sets up the labs, and who has worked with the motion sensors for years, gives you the following tips:

When used with the carts, the motion sensors seem to give more reliable data if you tape a cardboard vane to the end of each cart (the end closest to the motion sensor) than if you use a metal vane in the center of the cart.

When used with the carts, the motion sensors seem to give more reliable data if you use them with the narrow beam setting.

There is a "screw foot" on one end of the track that you can use to level the track.

The sampling rate of 50 is bogus. Set the sample rate to 20 or 25 samples per second.

When an object gets closer than 15 cm, the motion sensor can't measure its position accurately.

When analyzing cart collisions, don't bother using the motion sensor to measure the velocity. You get a better answer if you find the velocity yourself directly from the position data, by fitting straight lines to the position data.

The carts are noticeably slowed by friction. Make sure you understand the effect of friction on your data, and make sure you are careful that it doesn't screw up your results.

Exploration

Set up the motion sensors and convince yourself that they make reasonable measurements of position.

Make a plan for how you are going to calculate the velocity of a given cart at a particular time by fitting straight lines to the position data. What is the effect of friction?

Measurements: Super-strong bumpers

	Cart A (initially moving cart)			Cart B (initially stationary cart)		
Mass		±			±	
Velocity before collision		±			±	
Velocity after collision		±			±	
Momentum before collision		±			±	
Momentum after collision		±			±	
Total momentum before collision					±	
Total momentum after collision					±	
Is momentum conserved?						
Energy before collision		±			±	
Energy after collision		±			±	
Total energy before collision					±	
Total energy after collision					±	
Energy efficiency:					±	
Is energy conserved?						

Measurements: magnetic bumpers

	Cart A (initially moving cart)			Cart B (initially stationary cart)		
Mass		±			±	
Velocity before collision		±			±	
Velocity after collision		±			±	
Momentum before collision		±			±	
Momentum after collision		±			±	
Total momentum before collision					±	
Total momentum after collision					±	
Is momentum conserved?						
Energy before collision		±			±	
Energy after collision		±			±	
Total energy before collision					±	
Total energy after collision					±	
Energy efficiency:					±	
Is energy conserved?						

Analysis

Reflect upon what it would be like to be a passenger in each of the collisions you just measured. Which would be worse?

Discuss with your lab partners how you could associate the “badness” of a collision with a single number. What is the most important factor?

Go back to the computer and, for each collision, attempt to calculate a numerical value for the factor you identified in the previous question.

Discuss with your lab partners where there are any other factors that might enter into the “badness” of the collision.

Conclusion

Based on your measurements and your analysis, should either the super-strong bumper or the magnetic bumper be used on passenger automobiles?