Experiment 3: Collisions

3.B. Linear Collisions Between Two Objects

This week you will extend your study of collisions to include a system of two objects colliding in one-dimension on a linear air track. You will specifically look at the total momentum and total kinetic energy of the system before and after the collision to see under which conditions these quantities are conserved.

Equipment/supplies provided:

- Two sonic rangers, air track, gliders, interface box, and computer.

Experimental Tasks:

1. <u>Measure the total momentum and kinetic energy before and after a collision of two air track gliders.</u>

1.1. Measuring the position of two gliders will require using two sonic rangers. Set up Lab Assistant to use two sonic ranger channels called Position 1 and Position 2 with variables x_1 and x_2. Calibrate each of these channels using the same coordinate axis (number line) for both.

1.2. In Lab Assistant, add constants for each mass and derived waveforms for the velocity of each glider. Add formula waveforms for the total linear momentum of the system and the total kinetic energy of the system using appropriate formulas with variables that you have defined previously.

1.3. Set up calculated values for the average momentum, momentum uncertainty (standard error), average kinetic energy, and kinetic energy uncertainty (standard error).

1.4. Using a pair of equal mass gliders, attach a spring to one of the gliders and perform a measurement with Lab Assistant while allowing one of the gliders to collide into the other. Keep one of the gliders nearly stationary and push the other glider gently into it. On the waveform graphs observe the total momentum and total kinetic energy. Do these values appear to be the same before and after the collision? Place the cursors around a short interval before the collision and use the Calculate button to obtain the initial values of the total momentum and total kinetic energy. Do the same for an interval after the collision. Are the total momentum and total kinetic energy conserved within uncertainties?

Note: To test if momentum is conserved, find the change in momentum $\Delta p = p_f - p_i$ and see if this change is equivalent to zero within two standard errors. Of course, both the initial momentum $(p_i \pm \delta p_i)$ and final momentum $(p_f \pm \delta p_f)$ have uncertainties so you can use propagation of uncertainty to find the

$$\delta(\Delta p) = \sqrt{\delta p_i^2 + \delta p_f^2}\,.$$

1.5. Repeat the measurements with a pair of gliders that do not have the same mass, still using a spring attachment between the gliders.

2. <u>Measure the total momentum and kinetic energy before and after a collision of gliders using Velcro.</u>

2.1. Remove the spring attachment from the gliders and arrange them so that so that when they collide the Velcro will cause them to stick together and move with one final speed in a completely inelastic collision. Use Lab Assistant to once again measure the initial and final values of momentum and kinetic energy. Are these quantities conserved?

2.2. Compute the ratio of the final kinetic energy to the initial kinetic energy (with its uncertainty) and compare this result to the value predicted from your pre-lab question for a completely inelastic collision with a stationary target.

3. <u>Measure the total momentum and kinetic energy before and after a collision of gliders using a rubber bumper.</u>

3.1. While the collisions with the spring should have been (nearly) elastic and with the Velcro should have been completely inelastic, most collisions are somewhere between these two extremes. Try colliding one glider into another with a rubber bumper attachment in between the gliders. Is the linear momentum conserved? Is kinetic energy conserved?

For Next Week

For next week you and your partner should prepare draft reports describing the data you collected this week. These partial reports will not be graded, but will form the foundation of a subsequent lab report that WILL be part of your course grade. Bring your reports to next week's lab so we can discuss the various results obtained as a group. The report should include Introduction, Experimental Procedure, Data and Analysis, and Conclusion sections.

- Complete the pre-lab questions for next week.

Name	Partner	Date
Sonic Ranger 1 Calibration (Gain and Offset):	Sonic Ranger 2 Calibration (Gain and Offset):	

Glider colliding with a stationary glider using a spring

Trial	Mass 1 m_1 (kg)	Mass 2 m_2 (kg)	Initial Momentum p_i (kg m/s)	Final Momentum p_f (kg m/s)	Change in Momentum $\Delta p = p_f - p_i$ (kg m/s)
1					
2					

Trial	Initial Kinetic Energy K_i (J)	Final Kinetic Energy K_f (J)	Change in Kinetic Energy $\Delta K = K_f - K_i$ (J)
1			
2			

Glider colliding with (and sticking to) a stationary glider using velcro

Trial	Mass 1 m_1 (kg)	Mass 2 m_2 (kg)	Initial Momentum p_i (kg m/s)	Final Momentum p_f (kg m/s)	Change in Momentum $\Delta p = p_f - p_i$ (kg m/s)
1					

Trial	Initial Kinetic Energy K_i (J)	Final Kinetic Energy K_f (J)	Change in Kinetic Energy $\Delta K = K_f - K_i$ (J)
1			

Name	Partner	Date

What was the ratio of the final to initial kinetic energy $(K_f \ / \ K_i)$?

How did this result compare to the value that is predicted for a completely inelastic collision with a stationary target (as in your prelab question)?

Glider colliding with a stationary glider using rubber bumper

Trial	Mass 1 m_1 (kg)	Mass 2 m_2 (kg)	Initial Momentum p_i (kg m/s)	Final Momentum p_f (kg m/s)	Change in Momentum $\Delta p = p_f - p_i$ (kg m/s)
1					

Trial	Initial Kinetic Energy K_i (J)	Final Kinetic Energy K_f (J)	Change in Kinetic Energy $\Delta K = K_f - K_i$ (J)
1			

Write a paragraph that summarizes your important results