Conservation of Momentum

1 Introduction

In this lab you will investigate conservation of momentum and the concepts of elastic and inelastic collisions. You will use similar techniques that you developed in the Kinematics lab to measure the velocity of the gliders and their uncertainties.

2 Equipment

- airtrack with air pump,
- "pin" bumper and clay bumper,
- rubber band bumpers,
- Two gliders,
- pegs for gliders,
- Two Sonar Rangers,
- computer with measurement software

3 Procedures

Read through the procedures and familiarize yourself with the equipment. This lab write-up will provide space for you to record and analyze your data.

3.1 Conservation of momentum: Inelastic Collisions

1. Carefully level the airtrack. This means that a glider can be released at any point on the track, and it will not accelerate. Adjust the flow of air so that friction on the track is negligible even when masses are added to the gliders.
2. Insert the metal 'vanes' or 'flags' on the top of the glider. Measure the total mass of the glider and flags as well as any additional masses you need below.
3. Set up two Sonar Rangers, one near each end of the airtrack. The glider with the clay bumper (bumper with a little cup filled with clay) should be set at rest in the center of the track.

4. Put a vane in the car with the pin-bumper. You will launch (by hand) the glider down the track. The two gliders should collide and travel together down the track and you can measure the velocity of the pair. Make sure you note the approximate time of the collision so you can determine the velocities before and after the collision.

5. Using the velocity information, and the mass of the gliders, you will calculate the momentum before and after the collisions. Make sure you do proper error propagation to determine the uncertainty in the momentum. Take data for very slow collisions, moderate, and more rapid collisions. Use the techniques you learned from the Kinematics lab to properly determine the uncertainty in the velocities.

Mass of input glider m_1: _____

Mass of target glider m_2 _____

Combined mass of gliders m_1+m_2 _____

Run	$v_{initial}$	v_{final}	$p_{initial}$	p_{final}
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Question: Do you observe momentum conservation? To what level of relative error do you observe it?

3.2 Elastic Collisions:

1. Replace the inelastic pin and clay bumpers with the rubber band bumper. (You only need one.) Weigh the gliders again since their mass will be different with different bumpers.

2. Repeat the above experiment, with one glider at rest in the center of the track. You should add mass to the motionless glider (there are small weights that will fit on the pins on either side of the glider). Be sure to load the glider symmetrically. Record your data on the following page, and calculate the initial and final kinetic energy, and the initial and final momentum. Take data for a number of different initial velocities.

3. Repeat the above experiment with the lighter glider at rest. Again record your data making sure to properly record the uncertainties.

4. Write down the equations using propagation of errors that relate the uncertainties in the mass and velocity to the uncertainties in the momentum and kinetic energy.

Mass of lighter glider: m_1 = _____

Mass of heavier glider: m_2 = _____

Question: Make a prediction *before* doing the experiment: which glider will move with the greater speed after the collision: the lighter one or the more massive one?

You must write down a prediction here before doing the experiment.

Run	v_1	v_1'	v_2'	p_i	p_f	E_i	E_f
1							
2							
3							
4							
5							
6							

Question: Was your prediction correct? If not, what did you neglect, or what was your misconception?

4. Repeat the above experiment, but now have the *lighter* glider at rest in the center of the track.

Question: Make a prediction *before* doing the experiment: which glider will move with the greater speed after the collision: the lighter one or the more massive one?

You must write down a prediction here before doing the experiment.

Run	v_1	v_1'	v_2'	p_i	p_f	E_i	E_f
1							
2							
3							
4							
5							
6							

Question: Was your prediction correct? If not, what did you neglect, or what was your misconception?

4 Questions:

Please answer the following questions on a separate sheet of paper. Use complete sentences, and diagrams when appropriate. Make sure you use statistical arguments to decide whether you observe conservation of momentum and energy.

1. Did you observe conservation of momentum in the case of inelastic collisions? Was there any systematic deviation in your results which depended upon velocity? List the major systematic and random errors that affected your results. How significant were they? How could you minimize the larger ones? Name any uncertainties which you may have neglected in your error calculation.

2. Did you observe conservation of momentum and conservation of energy in the case of elastic collisions? Which one had a smaller relative deviation from the conserved value? Was there any systematic error in your results which depended upon velocity? List any major systematic and random errors that affected your results.

3. One does not expect energy to be conserved in inelastic collisions. How many standard deviations from 0 do you measure E_f-E_i? Can you conclude based on this result that energy is not conserved in inelastic collisions?