The Conservation
Of
Linear Momentum

Equipment Needed

PC or Mac Computer with LoggerPro

LabPro data logger

Air Supply

Air Track

Air Track Kit

Glider, Air Track (2)

LabPro, Vernier

Scale, Digital

Photogates (2)

Introduction

In this experiment you will test the validity of the Law of Conservation of Linear Momentum in one dimension with elastic and inelastic collisions.

Theory

If two objects collide and are subject to no net forces other than those of the collision itself, then it can be shown by the application of Newton's 2nd and 3rd Laws that the total linear momentum of the system of masses will not be altered by the collision. The linear momentum p_1 of an object of mass m_1 and velocity v_1 is given by while the linear momentum p_2 of an object of mass m_2 and velocity v_2 is given by . In a system consisting of two objects of momentum p_1 and p_2, the total linear momentum ***before*** collision is:

Figure 1

If the two masses collide, in general, their velocities will be altered to:

v_1' and v_2', respectively.

And the total momentum after collision is:

Figure 2

According to the conservation of linear momentum principle, the total linear momentum will not be altered by the collision, therefore

Equation 1

that is:

Equation 2

Setup

1. The laptop, LabPro, and photogates should be set up for you by the lab tech.
2. Open LoggerPro 3.4.1. The file is located at

   Probes & Sensors\Photogates\Collision Timer.cmbl.
3. The flag width will need to be entered at 0.025m.
4. Set the photogates with about 40 cm of open space between them.
5. Adjust the height of the photogates so that the flags will interrupt the beams when the gliders slide through the gates. (Test to see if timers work properly.)

Figure 3

Elastic Collision

The gliders should look like Figure 4.
Figure 5 is a close-up of the bumpers mounted between the gliders.

Figure 4

Figure 5

1. Affix a bumper to glider 1 and glider 2 as shown in Figure 5. Balance the gliders by attaching another fixture on the other end as shown in Figure 4. Weigh both gliders (with the bumpers, flags, and counterbalance.)
2. Enter the mass of each glider in Data Table 1. The masses of the gliders should be very close.
3. **Case 1:** Place glider 2 between the two gates and carefully bring it to rest. Start the timer and launch glider 1 toward glider 2. Catch the glider that bounces off.
4. Record your data.
5. Repeat for the following 2 cases:
6. **Case 2:** Add 0.1 kg to glider 1, keep glider 2 at rest.
7. **Case 3:** Have both gliders moving towards each other with the no extra mass (as in Case 1.)
8. The computer records all times and calculates the velocities. Calculate the momentum of each glider and enter the results in Table 1. Compare the total momentum prior to the collision to the total momentum after the collision. [Remember that momentum is a *vector* quantity! It has *direction* (+ or -) as well as magnitude]. Calculate % error between the total initial momentum and total final momentum.

Inelastic Collision

The gliders should look like Figure 6.

Figure 7 is a close-up of the inelastic bumpers mounted between the gliders.

Figure 6

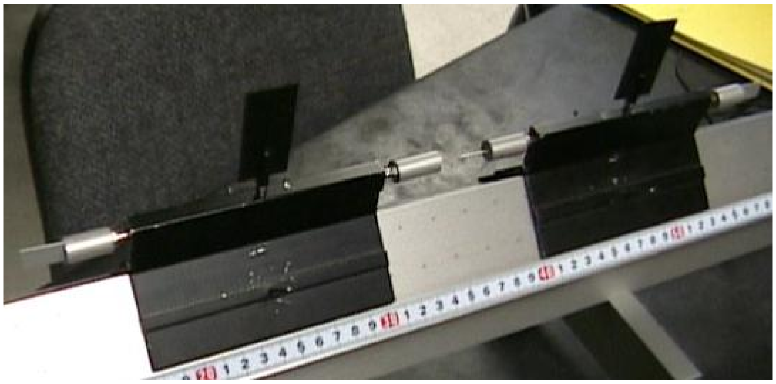
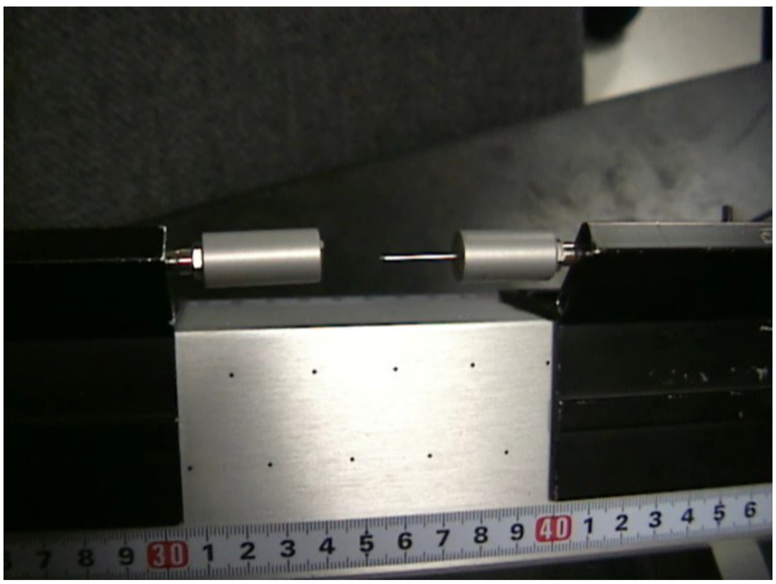


Figure 7



1. Replace the bumpers with inelastic bumpers - a straight pin and clay cup.
2. Repeat steps 3 through 7 of the elastic collision section.

<u>Energy Calculations</u>

1. In the elastic collisions, the total kinetic energy is theoretically the same after the collisions as it is before the collisions. Compare the kinetic energies to verify this. Express the % difference (if any) between them. Remember, the expression for kinetic energy is:

   where *m* is the mass of the glider and *v* is the velocity of the glider.
2. For the completely inelastic collisions where the objects stick together after the collision, prove that some kinetic energy must be "lost" in the collision.

Calculate how much was lost.

Table 1 ELASTIC COLLISION													

Before Collision								After Collision					
m_1 (kg)		**m_2** (kg)	**v_1** (m/s)	**v_2** (m/s)	**p_1** (kg m/s)	**p_2** (kg m/s)	**p_{tot}** (kg m/s)	**v_1'** (m/s)	**v_2'** (m/s)	**p_1'** (kg m/s)	**p_2'** (kg m/s)	**p_{tot}'** (kg m/s)	**% diff.**
1													
2													
3													

Table 2 INELASTIC COLLISION											

Before Collision							After Collision				
	m_1 (kg)	m_2 (kg)	v_1 (m/s)	v_2 (m/s)	p_1 (kg m/s)	p_2 (kg m/s)	p_{tot} (kg m/s)	(m_1+m_2) (kg)	v' (m/s)	p_{tot}' (kg m/s)	% diff.
1											
2											
3											