COLLISIONS AND CONSERVATION OF MOMENTUM

PURPOSE:

The purpose of this experiment is to investigate the momentum transfer between two carts during collisions, and to apply to the law of conservation of momentum to elastic and inelastic collisions.

APPARATUS:

Track, Two carts, Two photogates, Balance, Weights, Computer and DataStudio.

THEORY:

When objects collide, whether locomotives, shopping carts, or your foot and the sidewalk, the results can be complicated. Yet even in the most chaotic of collisions, as long as there are no external forces acting on the colliding objects, one principle always holds and provides an excellent tool for understanding the dynamics of the collision. That principle is called the conservation of momentum. For a two-object collision, momentum conservation is easily stated mathematically by the equation:

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1^{\,'} + m_2\vec{v}_2^{\,'}$$

If external forces such as friction are ignored, the sum of the momenta of two carts prior to a collision is the same as the sum of the carts after the collision.

PROCEDURE:

For this activity, photogates measure the motion of two carts before and after an elastic collision. The DataStudio program calculates speed for both carts.

Part I: Computer Setup

1. Turn on the interface and then turn on the computer.

2. Double click the DataStudio icon. At the Experiment setup window, drag the “Photogate & Picket Fence” from Sensor List to Digital Channel 1 and Drag the “Photogate & Picket Fence” from Sensor List to Digital Channel 2.

   Remember: The photogate connected to Digital Channel 1 will be “Gate 1”. The photogate connected to Digital Channel 2 will be “Gate 2”.

3. Double click the icon “Photogate & Picket Fence” to open “Sensor Properties” window. Click Tab “Constant” and then type 0.02 m for Band Spacing. Click OK to return to Experiment Setup window. (Do this for both of them.)

Part II: Equipment Setup

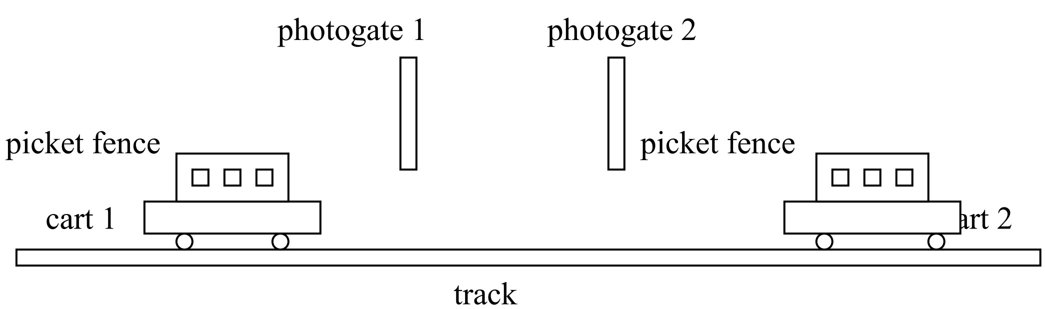
1. Level the track by placing a collision cart on the track. If the cart rolls one way or the other, use the adjustable feet at one end of the track to raise or lower that end until the track is level and cart will not roll one way or the other.

2. Put a picket fence in the notches at each end of the accessory tray of each collision cart. Use the balance to find the mass of each cart including the picket fence and record the values in the Data Table.

3. Place the carts together at the middle of the track. Position the photogates so that “Gate 1” is beyond the left end of the two carts, and “Gate 2” is beyond the right end of the two carts. Adjust the photogates so that the distance between gates is a few centimeters greater than the total length of both collision carts.

4. Adjust the height of each photogate so that as a cart moves through the photogate, the 2 cm band spacing fence on the five pattern picket fence blocks the photogate beam.

5. Move the carts to each end of the track.



Part III: Elastic Collision

1. Prepare to measure the motion of each cart as it moves toward the other cart and then collides elastically. (Be sure the magnetic ends of the collision carts will repel.)

2. Click the Start button to begin data recording.

3. Gently push the carts toward each other at the same time so that they will collide in the space between the two photogates.

4. Let the data recording continue until the carts have collided and returned to the ends of the track. Click the Stop button to end data recording.

5. Using "Table Display" show the recorded data. Each photogate will record two data sets, the data of the cart's velocity before and after collision. Perform the following steps to determine the cart's velocity before and after collision.

   1) Highlight from first data to sixth data on the table displayed. The mean value of these six data is the velocity of cart before collision.
   2) Skip the seventh data (invalid data).
   3) Highlight from eighth data to thirteenth data on the table displayed. The mean value of these data is the velocity of cart after collision.

6. Repeat the data recording procedure a total of three times.

7. Calculate the momentum of each cart before and after collision. Now calculate total momentum of two carts before and after collision.

8. Calculate the kinetic energy of each cart before and after collision. Now calculate total kinetic energy of two carts before and after collision.

9. Now place one cart, at rest, in the center of the track. Gently push the other cart from the end of the track toward the center cart. Find the initial and final velocity of each cart. Repeat step 7 and step 8.

Part VI: Inelastic Collision

1. Place one cart on the middle of track, other cart on the end of track. The velcro bumper will cause the carts to stick together on impact.

2. Click the Start button to begin data recording.

3. Launch cart 1 to collide with cart 2. The collision must occur between the photogates.

4. Click the Stop button to end data recording. After stuck carts passed photogate.

5. Using "Table Display" determine the velocities of two carts before and after collision.

4. Repeat the data recording procedure a total of three times.

7. Calculate the momentum of each cart before and after collision; calculate total momentum of two carts before and after collision.

8. Calculate the kinetic energy of each cart before and after collision; calculate total kinetic energy of two carts before and after collision.

QUESTION:

Discuss your results. Was momentum conserved (approximately) in both type collisions? How about energy conservation? Which collisions were close to being elastic and which were definitely inelastic?

DATA ORGANIZATION SHEET
EXP COLLISIONS AND CONSERVATION OF MOMENTUM

m_1 = ________ kg m_2 = ________ kg

1. Elastic Collision

I. Two carts move facing each other

Before Collision After Collision

V_1	V_2	P_1	P_2	E_{k1}	E_{k2}	V_1'	V_2'	P_1'	P_2'	E_{k1}'	E_{k2}'

ΔP	ΔP	% difference of ΔP	$E_{k\ total}$	$E_{k\ total}'$	% difference of ΔE_k

II. One cart is at rest

Before Collision After Collision

V_1	V_2	P_{total}	$E_{k\ total}$	V_1'	V_2'	P_{total}'	$E_{k\ total}'$	% diff of P	% diff of E_k

2. Inelastic Collision

Before Collision After Collision

V_1	V_2	P_{total}	$E_{k\ total}$	V_1'	V_2'	P_{total}'	$E_k'\ _{total}$	% diff of P	% diff of E_k