Conservation of Momentum

TOPICS AND FILES

Mechanics Topics

Conservation of momentum, inelastic collision

Conservation of momentum, elastic collision

Impulse and change in momentum

Capstone Files

23A Momentum 1.cap

23B Momentum 2.cap

24 Impulse.cap

EQUIPMENT LIST

Qty	Items	Part Numbers
1	PASCO Interface (for two sensors)	
2	Motion Sensor	CI-6742
1	1.2 m Dynamics Track	ME-9435A
2	Dynamics Cart	ME-9430 or ME-9454
1	Balance	SE-8723
1	Force Sensor with rubber stopper	CI-6746
1	Wooden Block and Clamp for end-stop	

INTRODUCTION

This lab has three parts.

The purpose of Experiment 1 is to measure the amount of momentum before and after an inelastic collision. Use motion sensors to measure the motion of two carts before and after an inelastic collision. Use *Capstone* to record and display the data.

The purpose of Experiment 2 is to measure the amount of momentum before and after an elastic collision. Use motion sensors to measure the motion of two carts before and after an elastic collision. Use *Capstone* to record and display the data. Determine the momentum for both carts before and after the collision. Compare the total momentum of the two carts before collision to the total momentum of both carts after collision.

The purpose of Experiment 3 is to determine the similarities between the change in momentum and the impulse (net force multiplied by time) in a collision. Use the motion sensor to measure the motion of a cart as it collides with a block. Use a force sensor mounted on the track to measure the force of the collision over the same interval of time. Compare the change in momentum of the cart with the area of the measured force vs. time graph.

BACKGROUND

When objects collide, whether locomotives, shopping carts, or your foot and the sidewalk, the results can be complicated. Yet even in the most chaotic system of collisions, one principle always holds, providing an excellent tool for understanding the dynamics of the collision: The principle of conservation of momentum. For a two-object collision, momentum conservation is easily stated mathematically by the following equation.

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2' \tag{1}$$

If net external forces are ignored, the sum of the momenta of two carts prior to a collision (left side of equation) is the same as the sum of the momenta of the carts after the collision (right side of equation).

For two carts in an inelastic collision (where the carts stick together after the collision), the momentum after is the product of both masses and their shared velocity

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v' \tag{2}$$

where v_1 is the initial velocity of cart 1; v_2 is the initial velocity of cart 2; v' is the final shared velocity. For carts in an elastic collision, the change in momentum is the mass times the change in velocity.

$$\begin{aligned} m_1 \Delta v_1 &= m_2 \Delta v_2 \\ m_1 (v_1 - v_1') &= m_2 (v_2' - v_2) \end{aligned} \tag{3}$$

The impulse of a force is the product of the average force and the time interval during which the force acts. Impulse is a vector quantity and has the same direction as the average force. The SI unit of impulse is the newton · second (N · s).

$$\text{Impulse} = F \Delta t \tag{4}$$

When a net force acts on an object, the impulse of the net force is equal to the change in momentum of the object.

$$\text{Impuse} = \text{Change in momentum} \tag{5}$$

It is possible for the object to undergo the same change in momentum whether it is involved in an abrupt hard collision or a cushioned collision.