ScienceCube

Momentum and Energy

Verify through experimentation that momentum is conserved regardless of mass before and after a collision.

Fundamental Concept

1. Momentum (P)

Momentum is the product of an object's mass and velocity, expressed as a vector quantity. The unit is kg·m/s.

$P=mv$ [m: mass, v: velocity]

2. Law of Conservation of Momentum

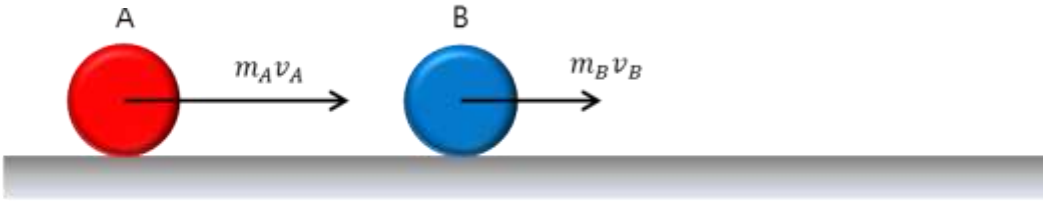
A. Law of Conservation of Momentum

When objects interact through collision, explosion, or fusion, the velocities of each object may change, altering their respective momenta. However, the total momentum before and after the interaction remains constant..

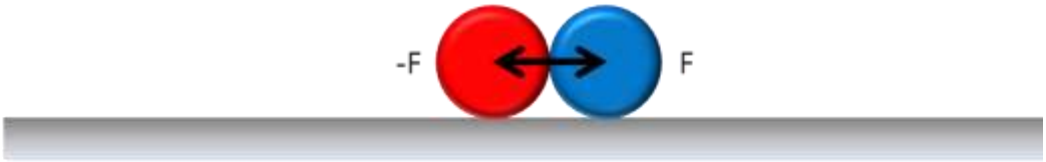
$$P_A+P_B=P'_A+P'_B$$

B. Conservation of Momentum in a Straight Line

<Before collision>



<At the moment of collision>



<After collision>

$m_A v_A + m_B v_B = m'_A v'_A + m'_B v'_B$ [m: mass, v: velocity]

3. Lost Energy (Q)

When two objects undergo an inelastic collision, energy is lost during the collision process. The lost energy (Q) can be calculated as follows.

$$Q = -\frac{1}{2}\left[\frac{m_A({P_B}'^2 - {P_B}^2) + m_B({P'_A}^2 - {P_A}^2)}{m_A m_B}\right]$$

[P: momentum before collision, P': momentum after collision, m: mass]

Experiment

Materials Needed

Interface, Science# program, Two motion sensors, Dynamics experiment apparatus

Preparing the Experimental Setup

1. Use the dynamics experiment apparatus to create a horizontal track.
2. Place two carts with magnets facing each other in front of motion sensor 1.

3. Set up the Interface and Collect Data.

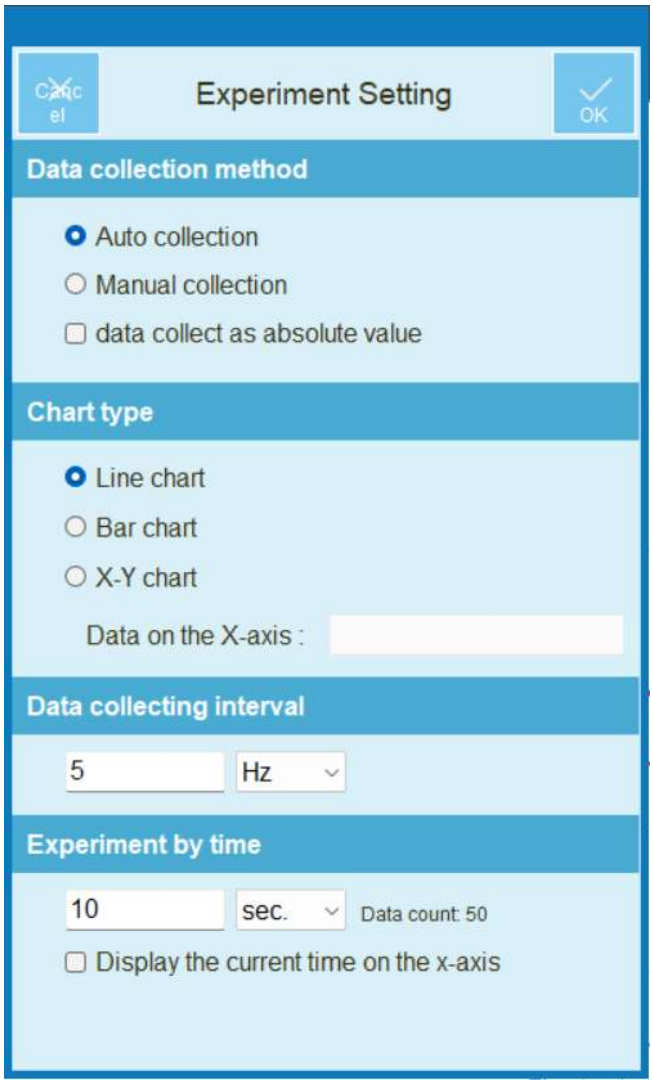
Experiment 2 [Collision of Two Carts with Different Masses]

1. Attach a weight to cart A.
2. Place the two carts with the magnets facing each other in front of motion sensor 1..

3. Set up the Interface and Collect Data.

Interface Setup

1. Launch Science#.
2. Connect two motion sensors to the interface.
3. Press the button to set up the experimental environment as shown below or press the button for automatic setup..

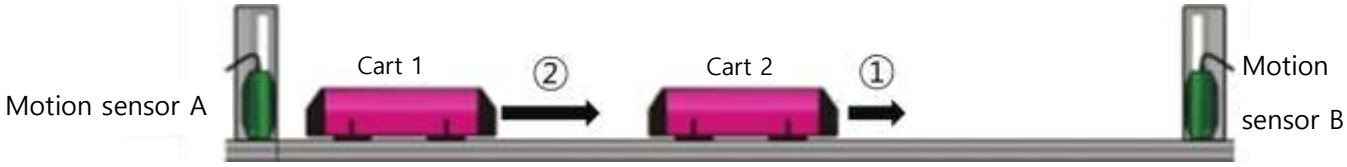


[Automatic Setup]

Data Collection

1. Click the button to start collecting data.
2. Gently push the cart toward motion sensor 2 with your hand, and then push cart A in the

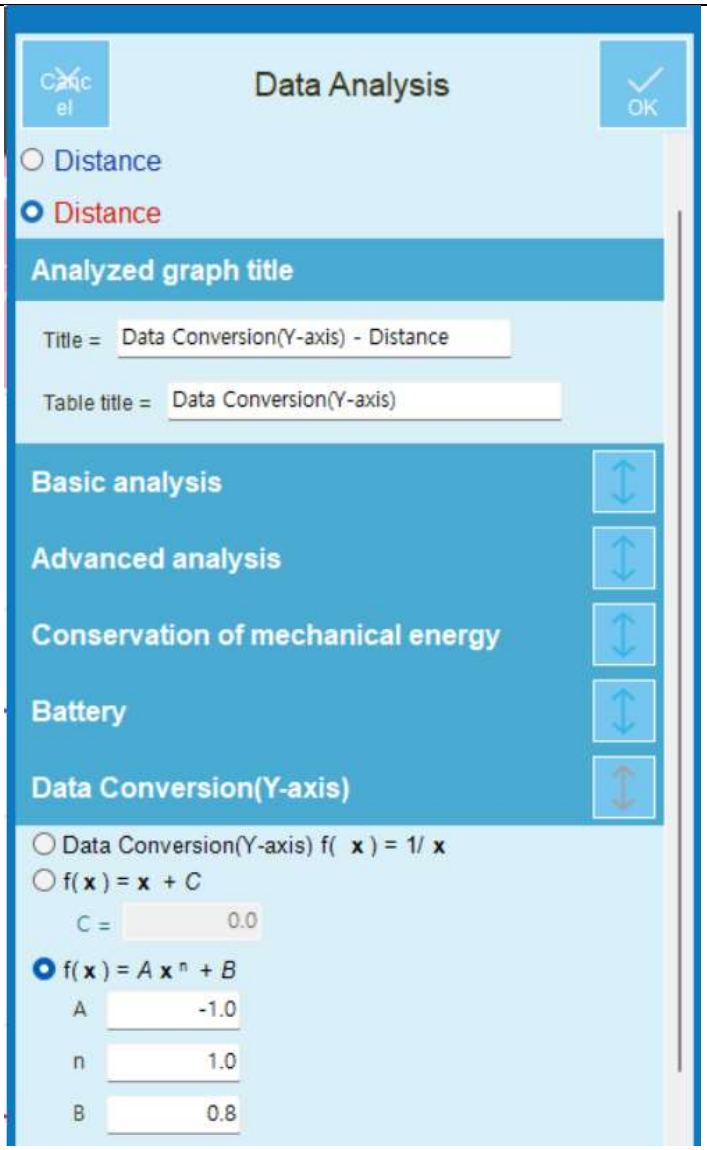
same direction with a bit more force to cause a collision..

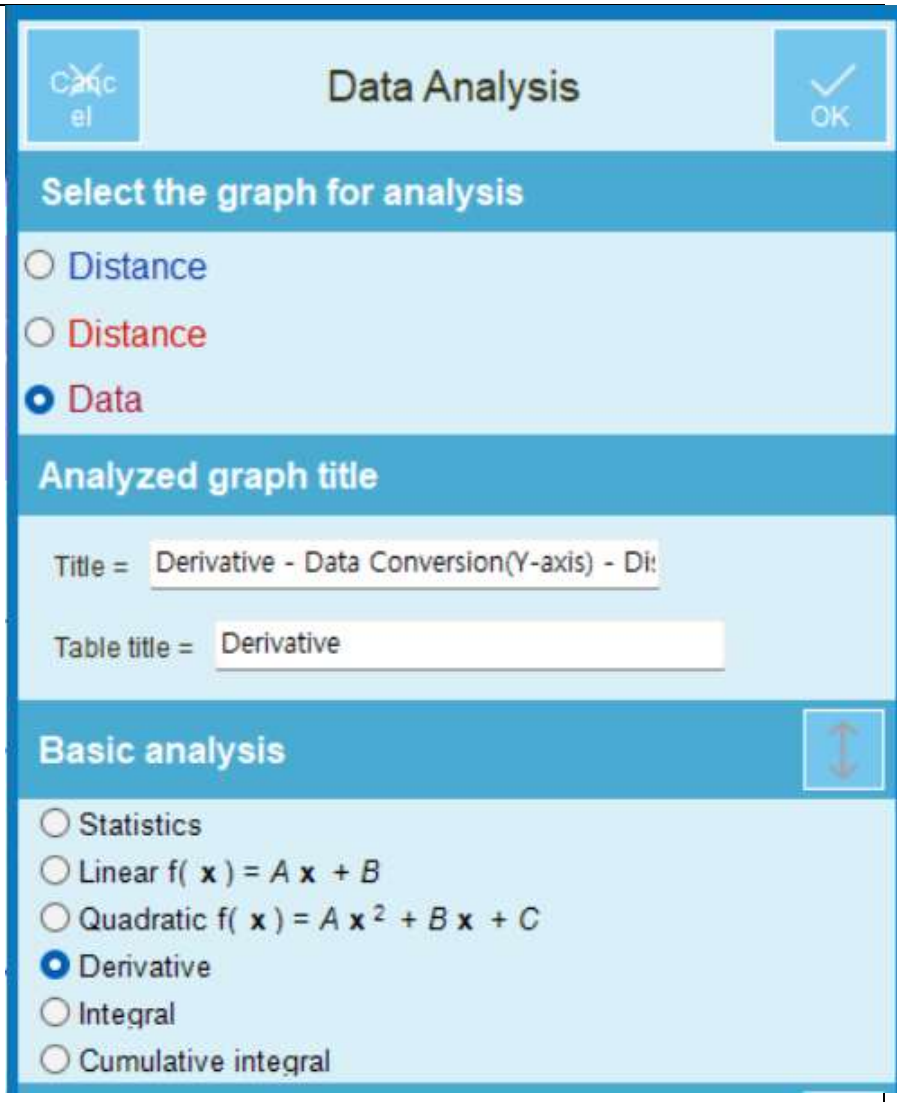


3. After collecting data, proceed with the following analyses

.

Analysis 1	Perform coordinate transformation.	

		
Analysis 2	Calculate the velocity (v).	

		
Analysis 3	Calculate the momentum (mv).	

4. Compare the total momentum of both carts before and after the collision.

5. Attach a weight to cart A to change its mass, and repeat the experiment in the same manner..

6. After collecting data, compare the momentum before and after the collision of the two carts with different masses.

Data Analysis

Recording Data

1. Draw a graph of the distance over time for both carts after coordinate transformation.

2. Create a graph showing the change in momentum over time for the colliding carts..

Data Application and Extended Activities

1. Explain how the velocities of the two carts changed after the collision using the graph.

2. Calculate and record the momentum (mv) before and after the collision..

Momentum (kg·m/s)	Before Collision	After Collision

Cart A		
Cart B		
Total Momentum		

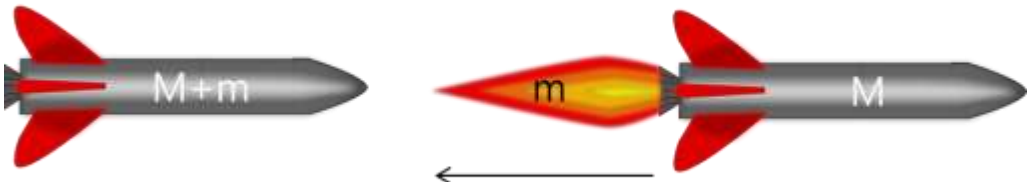
3. Determine whether momentum was conserved before and after the collision. If not, explain the possible reasons.

4. Calculate the lost energy (Q) using the formula:.

$$Q = -\frac{1}{2}\left[\frac{m_A({P_B}'^2 - {P_B}^2) + m_B({P_A}'^2 - {P_A}^2)}{m_A m_B}\right]$$

[P=mv, m: mass, v: velocity]

5. A spaceship with mass $m+M$ is stationary in space..



<Before propulsion> <After propulsion>

When it ejects fuel of mass m at velocity v, determine the resulting velocity V of the spaceship..


Report
(For Students)
Report
(For Teachers)