# Conservation of Momentum

Guided Inquiry

Driving Question | Objective

How is the total linear momentum and kinetic energy of a two-object system affected by a collision? Experimentally demonstrate that linear momentum and kinetic energy are conserved in an elastic collision, and that linear momentum is conserved but kinetic energy is not conserved in an inelastic collision.

NOTE: The word “linear” is used to differentiate momentum from angular momentum. It is often omitted for simplicity.

Design and Conduct Your Experiment

It is your group’s responsibility to design and conduct an experiment whose data will support your answer to the driving question above. Use the answers to the guiding questions below to help guide your experiment design. After you have answered the guiding questions, write an outline of the equipment setup and procedure you will use to collect data, identifying the steps in sequence and the points at which each piece of equipment will be used.

Suggested Materials and Equipment

Although you have the freedom to design your procedure using any reasonable equipment at your disposal, the following equipment is recommended for your experimental setup.

|  |  |
| --- | --- |
| * Data collection system | * PASCO Cart Masses, 250-g (2) |
| * PASCO Smart Cart, blue, with magnetic bumper1 | * PASCO Dynamics Track End Stop (2)3 |
| * PASCO Smart Cart, red, with magnetic bumper1 | * Balance, 0.1-g resolution, 2,000-g capacity |
| * PASCO Dynamics Track with feet2 | (1 per class) |

|  |  |  |
| --- | --- | --- |
| 1[www.pasco.com/ap37](http://www.pasco.com/ap37) | 2[www.pasco.com/ap08](http://www.pasco.com/ap08) | 3[www.pasco.com/ap11](http://www.pasco.com/ap11) |
|  |  |  |
| PASCO Smart Cart | PASCO PAStrack | PASCO Dynamics Track End Stop |

Guiding Questions

* 1. When choosing two objects to collide together, should you be concerned about whether the two objects are rigid? Explain your answer.

* 2. Should the objects you choose have the same size and mass? Explain why this is or isn't important.

* 3. Which will help simplify the experiment, a one-dimensional elastic and inelastic collision or a two-dimensional elastic and inelastic collision and why?

* 4. A perfectly elastic collision is nearly impossible to achieve in real life. How will you produce as perfect an elastic collision as possible between your two objects?

* 5. How will you produce an inelastic collision between your two objects?

* 6. How do you plan to determine the momentum of the system before and after each collision: what quantities can you measure and what tools will you use to measure them?

* 7. How do plan to determine the kinetic energy of the system before and after the collision: what quantities can you measure and what tools will you use to measure them?

* 8. Will your experiment setup and procedure be the same for both elastic and inelastic collisions? Justify your answer.

Experimental Design

Your goal is to experimentally demonstrate that momentum and kinetic energy are conserved in an elastic collision, and that momentum is conserved but kinetic energy is not conserved in an inelastic collision. Use the responses to the Guiding Questions to help finalize your procedure and your equipment configuration.

Once you are convinced that your procedure will accomplish the experiment's objectives, record your experimental setup and procedure in the following sections.

Setup

Draw and/or describe your experimental setup such that a third party could recreate the same setup in an attempt to reproduce your experiment.

Procedure

Outline the procedure you will use in your experiment, listing all of the steps below. Your outline should be written such that a third party could follow the same procedure in an attempt to reproduce your experiment.

Collect Data

Perform your experiment and record all relevant data. Present your data below (or in an attached document) in a form that best suits the experiment format, such that a third party can understand your experimental results in an attempt to reproduce them.

Analysis Questions

* 1. What experimental evidence do you have showing that momentum is conserved in inelastic and elastic collisions?

* 2. How does your data support that kinetic energy is conserved in elastic collisions?

* 3. How does your data support that kinetic energy is NOT conserved in inelastic collisions?

* 4. Why is kinetic energy not conserved in inelastic collisions? Where is the energy lost?

Synthesis Questions

* 1. Two locomotives, each weighing 100,000 kg and having a speed of 100 km/hr, race toward each other and have a completely inelastic collision. What is the final momentum of the system? Justify your answer.

* 2. A 10.0-kg bowling ball sliding across a frictionless surface, with a velocity of 3.00 m/s, collides head-on with a stationary 9.00-kg bowling ball. The collision is perfectly elastic, sending the 9.00-kg ball sliding away and leaving the 10.0-kg ball with a velocity of 0.158 m/s. What is the speed of the 9.00-kg ball after the collision? What is the total kinetic energy of the system after the collision?

* 3. A mother (mass 60.0 kg) skates across an ice rink with negligible friction toward her child (mass 20.0 kg), who is standing still on the ice. If the mother moves at 4.0 m/s before she picks up her child, what is her new speed after she picks up her child and holds onto him? What is the total energy of the mother-child system after she picks up the child?
* 4. A 25.0-kg dog is trapped on a rock in the middle of a narrow river. A 66.0-kg rescuer has assembled a swing with negligible mass that she will use to swing down and catch the trapped dog at the bottom of her swing, and then continue swinging to the other side of the river. The ledge that the rescuer swings from is 5.0 m above the rock, which is not high enough so the rescuer and dog together can reach the other side of the river, which is 3.0 m above the rock. However, the rescuer can use a ladder to increase the height from which she swings. What is the minimum height of the ladder the rescuer must use so both dog and rescuer make it to the other side of the river? Assume that friction and air resistance are negligible.

