For this lab, you will make use of a simulation that should run in your web browser. You will also take some data using things that you can find around your home.

# Overview

In this lab, we will be investigating different kinds of collisions. In particular, we will be looking for which quantities are conserved during the collision, and which are not. We will do this by examining how momentum and kinetic energy change during a collision.

The symbol Δ is the capital Greek character delta, and it means “change.” To find the change in something, subtract the initial value from the final one. For example, a change in velocity would be

*Momentum* is what Newton called an object’s “quantity of motion,” and is equal to the object’s mass times its velocity. In symbols, this is

Since and object’s velocity has a direction (a positive or negative sign, mathematically), so does its momentum.

When considering a *system* of two (or more!) objects, the momentum of the system is found simply by adding the momentum of each object. For example, the momentum of a system of two objects would be

*Kinetic energy* is the energy associated with an object’s motion, and like momentum, involves both mass and velocity. Kinetic energy is

Unlike momentum, kinetic energy is always positive. (Think about it: is mass ever negative? Velocity can be negative, but what happens when you square a negative number?)

When you have multiple objects, the kinetic energy of the system is just the sum of each object’s kinetic energy.

In some interactions, kinetic energy is converted into other types of energy (such as heat or sound), but the total energy of the universe remains constant.

# Part I: Simulation

# Simulation procedure

1. Go to <https://phet.colorado.edu/en/simulation/collision-lab> and click the green “Run Now!” button
2. Make sure you are in the “Introduction” tab (this is the default)
3. Click the button towards the bottom of the screen that says “More Data”
   1. You can adjust the masses and initial velocities by entering in values
   2. You will need to record the velocity and momentum of each ball before and after each collision that you perform

## Elastic collisions

In the green box on the right, there is a slider for elasticity. Set it to 100% and perform the following collisions:

1. Equal mass
2. Different masses

## Inelastic collisions

With the elasticity slider set to 0%, perform the following collisions:

1. Equal mass
2. Different masses

# Simulation data

Velocities “before” and “after” refer to velocities before and after the collision.

## Elastic collisions

### Equal masses

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mass (kg) | *v* before (m/s) | *v* after (m/s) |
| Ball 1 |  |  |  |
| Ball 2 |  |  |  |

### Different masses

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mass (kg) | *v* before (m/s) | *v* after (m/s) |
| Ball 1 |  |  |  |
| Ball 2 |  |  |  |

## Inelastic collisions

### **Equal masses**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mass (kg) | *v* before (m/s) | *v* after (m/s) |
| Ball 1 |  |  |  |
| Ball 2 |  |  |  |

### **Different masses**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mass (kg) | *v* before (m/s) | *v* after (m/s) |
| Ball 1 |  |  |  |
| Ball 2 |  |  |  |

# Simulation analysis

## Elastic collisions

### Equal masses

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *p* before (kg.m/s) | *p* after (kg.m/s) | KE before (J) | KE after (J) |
| Ball 1 |  |  |  |  |
| Ball 2 |  |  |  |  |
| System |  |  |  |  |

1. Did the total momentum of the system () change from before to after the collision?
2. Did the total kinetic energy of the system () change from before to after the collision?

### Different masses

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *p* before (kg.m/s) | *p* after (kg.m/s) | KE before (J) | KE after (J) |
| Ball 1 |  |  |  |  |
| Ball 2 |  |  |  |  |
| System |  |  |  |  |

1. Did the total momentum of the system () change from before to after the collision?
2. Did the total kinetic energy of the system () change from before to after the collision?

## Inelastic collisions

### **Equal masses**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *p* before (kg.m/s) | *p* after (kg.m/s) | KE before (J) | KE after (J) |
| Ball 1 |  |  |  |  |
| Ball 2 |  |  |  |  |
| System |  |  |  |  |

1. Did the total momentum of the system () change from before to after the collision?
2. Did the total kinetic energy of the system () change from before to after the collision?

### **Different masses**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *p* before (kg.m/s) | *p* after (kg.m/s) | KE before (J) | KE after (J) |
| Ball 1 |  |  |  |  |
| Ball 2 |  |  |  |  |
| System |  |  |  |  |

1. Did the total momentum of the system () change from before to after the collision?
2. Did the total kinetic energy of the system () change from before to after the collision?

# Simulation questions

1. For elastic collisions, what was conserved and what was not?
2. For inelastic collisions, what was conserved and what was not?
3. Summarize the difference(s) between elastic and inelastic collisions. Do you think a collision can ever be completely elastic?
4. If you were to modify this experiment, what would you do differently, and why?

# Part II: Elastic and inelastic collisions in the real world

For this part of the lab, you will need a ball that bounces, and a ruler, meter stick/yard stick, or tape measure.

# Real world collision: Procedure

1. Hold the ball some height above the ground.
2. Release it from rest.
3. Measure how high it bounces

# Real world collision: Data

Starting height:

Bounce height:

# Real world collision: Analysis

1. Using the starting height, apply conservation of energy to determine the kinetic energy of the ball just before it reached the ground (after being released from rest).
   * *Show your work in the space below. You can do your work on a separate sheet of paper, scan it into the computer, and insert here:*
2. Using the return height, apply conservation of energy to determine the kinetic energy of the ball just after it leaves the ground (that is, the energy it has after the collision with the ground).
   * *Show your work in the space below. You can do your work on a separate sheet of paper, scan it into the computer, and insert here:*

# Real world collision: Questions

1. Was the ball’s collision with the ground elastic, or was it inelastic?
2. Explain your reasoning.