

The Elasticity of a Collision

Purpose: To understand the nature of a perfectly elastic collision and to contrast such collisions with those having less elasticity.

Getting Ready: Navigate to the **Two-Dimensional Collision Simulator** found in the **Physics Interactives** section at **The Physics Classroom**.

<https://www.physicsclassroom.com/Physics-Interactives/Momentum-and-Collisions/Two-D-Collisions-Simulator>

Navigation:

www.physicsclassroom.com => Physics Interactives => Momentum and Collisions => Two-Dimensional Collision Simulator

Getting Acquainted/Play:

This interactive consists of a Simulation Window on the left side of the screen, some **Simulation Controls** below it, a collection of **Display Parameters** on the right side of the screen, and a **Collision Parameters** shown below it. The Parameters section include **radio buttons**, and **sliders**. Experiment with each of these parameters.

Simulation Window

Inelastic collision
Some kinetic energy lost in collision

0.00 sec

Linear Momentum

Center of mass

Path trace

Grid

Position markers

Show data in table

Include angular data in table

Information

Donate information

Linear Momentum		BEFORE		AFTER	
	x	y	x	y	
Red (kg.m/s)					
Blue (kg.m/s)					
Total (kg.m/s)					

Kinetic Energy		BEFORE		AFTER	
Red (joules)					
Blue (joules)					
Total (joules)					

Collision Parameters

Masses stick together 0.50 = Coefficient of Restitution

2.00 m = x position m = x position

20.00 m = y position m = y position

4.00 m/s = x velocity m/s = x velocity

0.00 m/s = y velocity m/s = y velocity

1.60 m = red radius m = blue radius

2.0 kg = red mass kg = blue mass

Observe the **radio buttons** control the various displays.

Experiment with the various display options, turning each on and off by tapping on the check boxes and observing what they do.

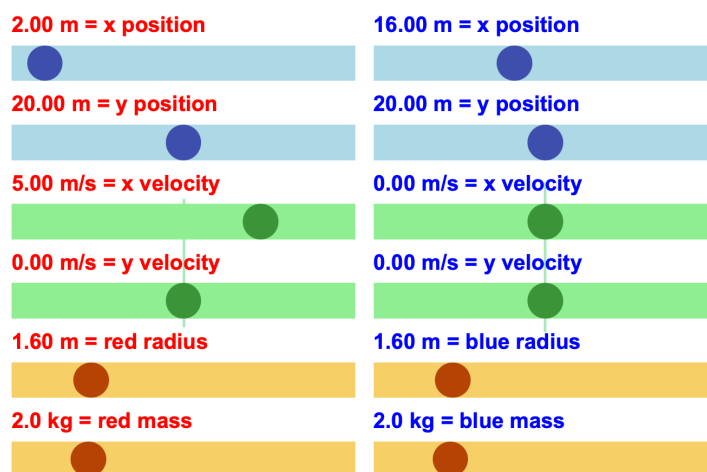
The **sliders** control the values of the motion parameters for the two colliding objects. Experiment with the sliders by dragging them left and right and observing their effect upon the simulated collision. Also note that the velocity vectors can be changed by dragging the arrowhead in the Simulation window. The object positions can be changed by dragging the circles on the screen.

The **Reset** button returns all Collision Parameters to their start-up value. More often than not you will want to be using the **Rewind** button which returns the most recent simulation to its time = 0 s state. Take some time to get acquainted with the interface and various parameters.

Part 1: Coefficient of Restitution

Most of us have dropped a ball from rest and watched it hit the ground and bounce back upward. It never rises to the height of its release point. But some balls have *better bounce* than others. A Super Ball™, sometimes referred to as a *highly elastic ball*, is known to rise as high as $\frac{3}{4}$ -ths of its release height when dropped on a hard, rigid surface. A Super Ball™ is known for its high coefficient of restitution value. Let's explore the concept of the **coefficient of restitution** in Part 1 of this activity.

1. Enable or check the **Velocity** and the **Show data in table** parameters in the Display Parameters section of the window. Leave all other parameters unchecked.
2. Use the slider to set the **Coefficient of Restitution** to **0.00**. This value will change throughout Part 1 of the activity. We will refer to it as the **COR**.
3. Set the remaining Collision Parameters to the values shown at the right.
4. Press the green **Play** button. Record post-collision velocities in the Data Table below. Perform calculations.
5. Tap on the **Rewind** button. Change the value of the COR to match Row 2 of the Data Table.
6. Adjust the COR value to collect data for the entire Part 1 Data Table.



Part 1 Data Table

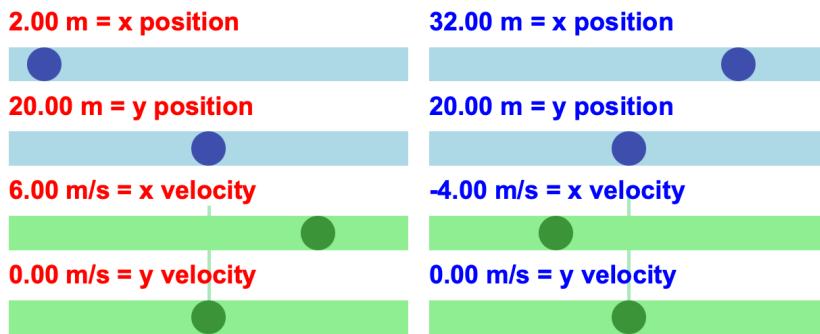
Trial	COR	Before Collision		After Collision		Before Collision	After Collision
		v_{red} (m/s)	v_{blue} (m/s)	v_{red}' (m/s)	v_{blue}' (m/s)	$ v_{\text{red}} - v_{\text{blue}} $ (m/s)	$ v_{\text{red}}' - v_{\text{blue}}' $ (m/s)
1	0.00	5.00	0.00			$ 5.00 - 0.00 = 5.00$	
2	0.10	5.00	0.00				
3	0.20	5.00	0.00				
4	0.40	5.00	0.00				
5	0.50	5.00	0.00				
6	1.00	5.00	0.00				

Part 1 Analysis

Give careful attention to your calculated results in the last two columns. Compare the calculated results to the Coefficient of Restitution (COR) value for that same trial. Make a claim as to what the COR means. Refer to specific evidence from the lab to give reasoning in support of your claim.

Part 2: Head-On Collisions

- Keep the same Display Parameters as Part 1. Change the Collision Parameters to match that shown at the right.
- Repeat a similar study as that performed in Part 1. But the Part 2 study will involve the two objects heading towards each other.
- Consistent with the reference frame provided in the top left of the Simulation window, be sure to include negative signs in your data table and your calculations for any leftward velocity.



Part 2 Data Table

Trial	COR	Before Collision		After Collision		Before Collision	After Collision
		v_{red} (m/s)	v_{blue} (m/s)	v_{red}' (m/s)	v_{blue}' (m/s)	$ v_{red} - v_{blue} $ (m/s)	$ v_{red}' - v_{blue}' $ (m/s)
7	0.00	6.00	-4.00			$ 6.00 - (-4.00) = 10.00$	
8	0.10	6.00	-4.00				
9	0.20	6.00	-4.00				
10	0.40	6.00	-4.00				
11	0.50	6.00	-4.00				
12	1.00	6.00	-4.00				

Part 2 Analysis

Suppose you were provided pre-collision velocities of two colliding objects and post-collision velocities of the same objects. How would you use the values to calculate the COR of the collision? Make a claim and use a specific trial from this lab to support the claim with evidence and reasoning.

Part 3: A Kinetic Energy Analysis

The kinetic energy of an object is the energy of motion. It is calculated as $\frac{1}{2} \cdot m \cdot v^2$ where **m** is the mass (in kg) and **v** is the speed (in m/s). The kinetic energy (KE) unit is the *joule* (abbreviated J). Perform five final collisions with varying values of COR and initial velocities. Note that three of the trials have a COR of 1.00. Use masses of 2.0 kg in all trials. You may need to re-position the x-position of the objects so that you have some post-collision time to record the post-collision velocity values. Make sure all the -y-positions (e.g., 20.00 m) are the same so that the collisions occur in one-dimension.

Part 3 Data Table

Trial	COR	Before Collision		After Collision		Before Collision		After Collision	
		v _{red} (m/s)	v _{blue} (m/s)	v _{red} ' (m/s)	v _{blue} ' (m/s)	KE _{red} (J)	KE _{blue} (J)	KE _{red} ' (J)	KE _{blue} ' (J)
13	0.00	5.00	-5.00						
14	0.50	5.00	-5.00						
15	1.00	5.00	-5.00						
16	1.00	6.00	-2.00						
17	1.00	6.00	2.00						

Part 3 Analysis

A collision with a coefficient of restitution of 1.00 is referred to as a **perfectly elastic collision**. Inspect trials 15-17, giving attention to the last four columns. Calculate the total KE of the system of two objects (red and blue) before and after the collision. Then draw a conclusion in which you state (in terms of the total kinetic energy of the system) what is true of a perfectly elastic collision. Make your claim (conclusion) and support it with evidence and reasoning collected from one of the last three trials.