Name _____ Date _____ Period _____

ZornScience
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Collision Carts Virtual Lab

Physics

Open **activities.zornscience.org/collision-carts/** and follow each step. Right is positive. Show your work with units.

Objective

Use two carts on a track to test whether the **total momentum** and the **total kinetic energy** of a two-cart system stay the same in elastic and inelastic collisions.

NGSS alignment: HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Practices and concepts: Using mathematics and computational thinking; Analyzing and interpreting data; Systems and system models; Energy and matter (conservation).

Meet the simulation

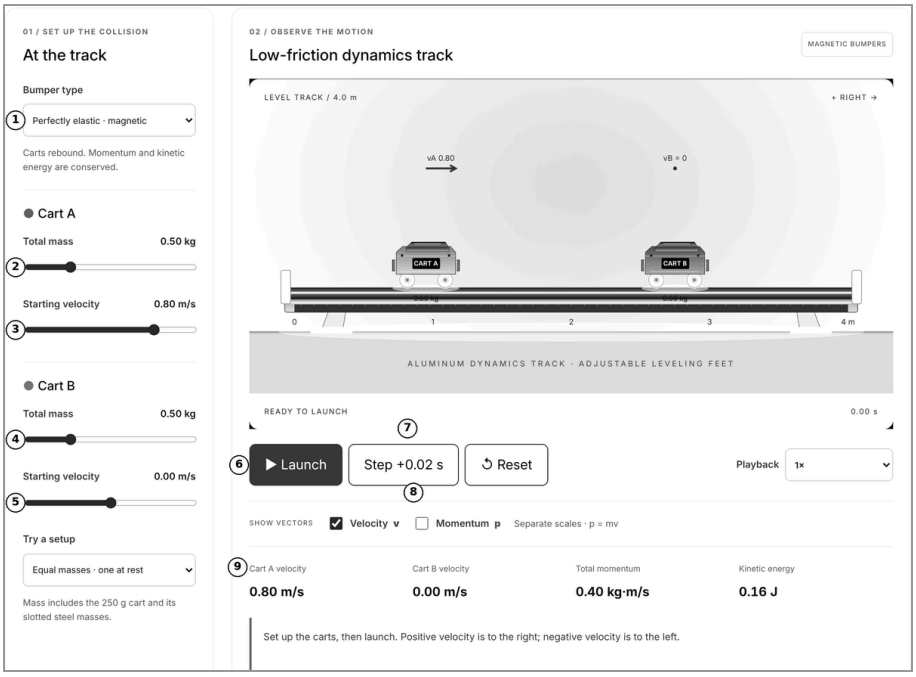


Figure 1. The lab (dark track scene inverted for printing).

(1) Bumper type: elastic (magnetic) or inelastic (hook and loop, carts stick).

(2) Cart A total mass. (3) Cart A starting velocity.

(4) Cart B total mass. (5) Cart B starting velocity.

(6) Launch, pause and resume. (7) Step forward 0.02 s.

(8) Show velocity and momentum arrows.

(9) Readouts: each cart's velocity, total momentum, kinetic energy.

Masses move in 0.25 kg steps and velocities in 0.1 m/s steps. Changing a setting resets the carts.

Pre-lab

1. A 0.50 kg cart moves at 0.80 m/s to the right. Calculate its momentum and its kinetic energy.

2. Two 0.50 kg carts move toward each other, one at +0.80 m/s and one at −0.80 m/s. What is the total momentum of the two-cart system? Why can momentum be zero when both carts are moving?

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Part A. Elastic collisions

1. Set **Bumper type** to **Perfectly elastic · magnetic**. Check the **Momentum** box.
2. Set the masses and starting velocities for each trial. Record total momentum and kinetic energy **before** you launch.
3. Select **Launch**. After the collision, select **Pause** (or wait for the run to stop) and record the readouts **after**.

Trial	Settings				Before		After			
	m_A (kg)	m_B (kg)	v_A (m/s)	v_B (m/s)	p_{total} (kg·m/s)	KE (J)	v_A' (m/s)	v_B' (m/s)	p_{total} (kg·m/s)	KE (J)
1	0.50	0.50	0.80	0.00						
2	0.50	0.50	0.80	−0.80						
3	1.00	0.25	0.80	0.00						
4	0.25	1.00	0.80	0.00						

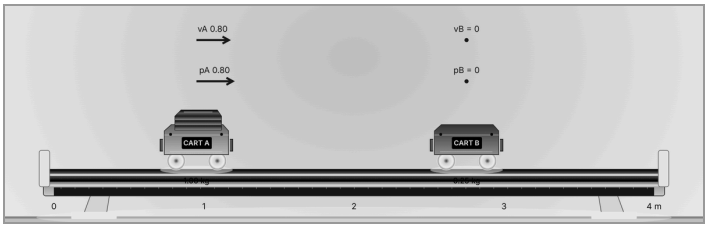


Figure 2. Trial 3 before the collision.

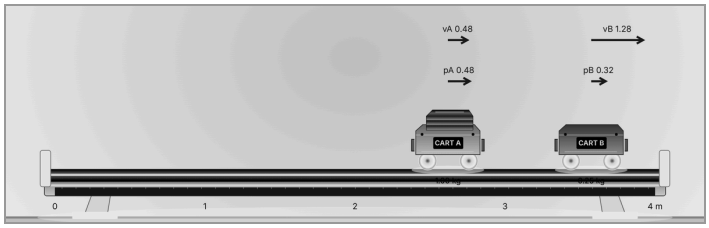


Figure 3. Trial 3 after the collision.

3. Describe what happens to each cart in trials 1 and 2 (equal masses). What pattern do you see?

4. For trial 3, calculate the momentum of each cart after the collision. Show that they add to the total momentum before the collision. Compare with the pA and pB momentum arrows on the screen after the collision.

5. In trial 4 a light cart hits a heavy cart at rest. Which way does cart A move afterward? How can total momentum stay +0.20 kg·m/s when cart A moves backward?

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Part B. Inelastic collisions

1. Set **Bumper type** to **Perfectly inelastic · hook & loop**. The carts stick together when they collide.
2. Run each trial the same way as Part A and record the readouts before and after.

Trial	Settings				Before		After		
	m_A (kg)	m_B (kg)	v_A (m/s)	v_B (m/s)	p_{total} (kg·m/s)	KE (J)	v′ of joined carts (m/s)	p_{total} (kg·m/s)	KE (J)
5	0.50	0.50	0.80	0.00					
6	1.00	0.25	0.80	0.00					
7	0.25	1.00	0.80	0.00					
8	0.50	0.50	0.80	−0.80					

6. For trial 6, use conservation of momentum to predict the final velocity of the joined carts. Show your setup with units, then compare with the simulation.

7. For trial 5, what fraction of the kinetic energy was lost? Where did that energy go?

8. In trial 8, all the kinetic energy disappears. Does this break conservation of momentum? Explain.

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9. Look at all eight trials. Which quantity was conserved in **every** trial? Which was conserved only in elastic collisions?

10. In trial 3, cart B speeds up and cart A slows down. Use Newton's third law to explain why the momentum cart A loses equals the momentum cart B gains.

11. The simulation track has no friction, and the run pauses before a cart hits an end stop. Why are both needed to keep momentum conserved? How would results on a real track differ?

Conclusion

12. Write a claim that answers the objective. Support it with specific numbers from one elastic and one inelastic trial, then explain your reasoning.

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