LESSON MAKER PRO

Collision Check

Track momentum, impulse, and energy.

HIGH SCHOOL · P.3

P.3 "Design and carry out experiments to verify that energy and momentum are conserved in closed systems. a. Use mathematical and computational thinking to explain the relationships among work, power, and time. b..."

NAME _____ **DATE** _____

FOLLOW THE MOMENTUM

Choose a positive direction, then find each object's momentum with $p = mv$. If outside forces give the system negligible impulse, total momentum before a collision equals total momentum after it. For a constant force, impulse is $F\Delta t = \Delta p$; to check whether a collision is elastic, compare total kinetic energy using $KE = 1/2\ mv^2$.

WORKED EXAMPLE

A 7 kg cart moves right at 5 m/s, and an 11 kg cart moves left at 1 m/s. They collide and latch together. Find their shared velocity. Use right as positive.

1. Total momentum before = (7)(+5) + (11)(-1) = 35 - 11 = 24 kg·m/s.
2. Combined mass = 7 + 11 = 18 kg.
3. Shared velocity = 24/18 = 4/3 m/s.

Answer: 4/3 m/s to the right

PRACTICE 6 problems

1 A 2 kg cart travels right at 6 m/s. What is its momentum? Use right as positive.

ANSWER _____

2 A 4 kg cart travels left at 2 m/s. What is its momentum? Use right as positive.

ANSWER _____

3 A cart's momentum changes from -6 kg·m/s to +10 kg·m/s. What impulse acts on the cart?

ANSWER _____

4 A constant force of +8 N acts on a cart for 4 s. What impulse does the force deliver?

ANSWER _____

5 A 6 kg cart moves right at 4 m/s and collides with a stationary 2 kg cart. They stick together. What is their shared velocity?

ANSWER _____

6 A 4 kg cart moving at 2 m/s hits a stationary 4 kg cart. They stick together. What is their total kinetic energy before and after the collision?

ANSWER _____

APPLY IT Show your work

1 At a school robotics competition, an 8 kg robot rolls right at 6 m/s and bumps into a stationary 4 kg robot. Their bumpers latch. Find their shared velocity and the kinetic energy lost during the collision.

WORK SPACE

ANSWER _____

2 At a skate park, a skateboarder and board have a combined mass of 40 kg. Their horizontal speed drops from 6 m/s to 2 m/s in 2 s. If their direction does not change, what is the average net horizontal force on them? Use their direction of travel as positive.

WORK SPACE

ANSWER _____

CHALLENGE One step up

Two carts collide during a robotics test. Use right as positive. Find the total momentum and total kinetic energy before and after the collision. Is momentum conserved? Is the collision elastic? Explain using your results.

CART COLLISION DATA

Cart	Mass (kg)	Velocity before (m/s)	Velocity after (m/s)
A	2	+6	-2
B	4	-2	+2

WORK SPACE AND ANSWER

Collision Check

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	A 2 kg cart travels right at 6 m/s. What is its momentum? Use right as positive.	**+12 kg·m/s**
2	A 4 kg cart travels left at 2 m/s. What is its momentum? Use right as positive.	**-8 kg·m/s**
3	A cart's momentum changes from -6 kg·m/s to +10 kg·m/s. What impulse acts on the cart?	**+16 N·s**
4	A constant force of +8 N acts on a cart for 4 s. What impulse does the force deliver?	**+32 N·s**
5	A 6 kg cart moves right at 4 m/s and collides with a stationary 2 kg cart. They stick together. What is their shared velocity?	**3 m/s to the right**
6	A 4 kg cart moving at 2 m/s hits a stationary 4 kg cart. They stick together. What is their total kinetic energy before and after the collision?	**Before: 8 J. After: 4 J.**

PART 2 · APPLY IT

1. **4 m/s to the right; 48 J lost** Conservation of momentum gives (8)(6) = (8 + 4)v, so v = 4 m/s. Kinetic energy changes from 144 J to 96 J, a loss of 48 J.
2. **-80 N, or 80 N opposite their direction of travel** The change in momentum is 40(2 - 6) = -160 kg·m/s. Divide by 2 s to get an average net force of -80 N.

CHALLENGE

Total momentum is +4 kg·m/s before and +4 kg·m/s after, so momentum is conserved. Total kinetic energy is 44 J before and 12 J after. The collision is not elastic because kinetic energy decreases by 32 J.

Accept N·s or kg·m/s for impulse, and accept equivalent wording for a negative direction. A collision can conserve momentum without conserving kinetic energy.