

Momentum Matchup

Use signs and equations to track motion in collisions.

HIGH SCHOOL • HS-PS2-2

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..."

NAME _____

DATE _____

MOMENTUM STAYS BALANCED

Choose one direction as positive, then give motion in the other direction a negative sign. When the net external force on a two-object system is zero, total momentum before an interaction equals total momentum after it: $p_{\text{before}} = p_{\text{after}}$. Use $p = mv$ for each object.

WORKED EXAMPLE

A 2 kg cart moving +3 m/s collides and sticks to a 4 kg cart moving -1 m/s. Find their final velocity.

1. Take right as positive.
2. $p_{\text{before}} = (2)(+3) + (4)(-1) = +2 \text{ kg m/s}$.
3. $(2 + 4)v_f = +2$.
4. $v_f = +1/3 \text{ m/s}$.

Answer: +1/3 m/s, to the right

PRACTICE 6 problems

- 1** Take right as positive. A 5 kg cart moving +8 m/s sticks to a 7 kg cart moving -5 m/s. Find their final velocity.

ANSWER _____

- 2** Take right as positive. An 8 kg cart moving +5 m/s sticks to a 12 kg cart moving -7 m/s. Find their final velocity.

ANSWER _____

- 3** A 10 kg cart moving -9 m/s collides with a 15 kg cart at rest. The carts stick together. Find their final velocity.

ANSWER _____

- 4** A 14 kg cart moving +9 m/s collides with a 10 kg cart at rest. After the collision, the 14 kg cart moves +7 m/s. Find the velocity of the 10 kg cart.

ANSWER _____

- 5** Two carts stick together. Before the collision, an 11 kg cart has velocity x and a 13 kg cart has velocity -5 m/s. Afterward, the combined carts move +17/12 m/s. Find x .

ANSWER _____

- 6** A 16 kg cart moving +15 m/s collides with a 20 kg cart moving -8 m/s. After the collision, the 16 kg cart moves -5 m/s. Find the velocity of the 20 kg cart.

ANSWER _____

APPLY IT Show your work

- 1** At a skate park, two students on low-friction wheeled platforms push apart from rest. One student and platform have a mass of 45 kg and roll to the right at 8 m/s. The other student and platform have a mass of 72 kg. Find the second student's velocity.

WORK SPACE

ANSWER _____

- 2** During a robotics competition, a 28 kg robot moves right at 15 m/s and collides with a 35 kg robot moving left at 12 m/s. Their magnetic bumpers latch together. Find the velocity of the connected robots after the collision.

WORK SPACE

ANSWER _____

CHALLENGE One step up

CHALLENGE

Take right as positive. An 18 kg cart moves right at 11 m/s while a 30 kg cart moves left at 7 m/s. They collide, and afterward the 18 kg cart moves left at 8 m/s. Find the final velocity of the 30 kg cart. Then use the initial and final total momenta to explain why your answer supports conservation of momentum.

PART 1 • PRACTICE

#	PROBLEM	ANSWER
1	Take right as positive. A 5 kg cart moving +8 m/s sticks to a 7 kg cart moving -5 m/s. Find their final velocity.	+5/12 m/s
2	Take right as positive. An 8 kg cart moving +5 m/s sticks to a 12 kg cart moving -7 m/s. Find their final velocity.	-11/5 m/s
3	A 10 kg cart moving -9 m/s collides with a 15 kg cart at rest. The carts stick together. Find their final velocity.	-18/5 m/s
4	A 14 kg cart moving +9 m/s collides with a 10 kg cart at rest. After the collision, the 14 kg cart moves +7 m/s. Find the velocity of the 10 kg cart.	+14/5 m/s
5	Two carts stick together. Before the collision, an 11 kg cart has velocity x and a 13 kg cart has velocity -5 m/s. Afterward, the combined carts move +17/12 m/s. Find x .	+9 m/s
6	A 16 kg cart moving +15 m/s collides with a 20 kg cart moving -8 m/s. After the collision, the 16 kg cart moves -5 m/s. Find the velocity of the 20 kg cart.	+8 m/s

PART 2 • APPLY IT

- 5 m/s, to the left** The system starts with total momentum of 0. Set $(45)(+8) + (72)v = 0$, so $v = -5$ m/s.
- 0 m/s** Initial momentum is $(28)(+15) + (35)(-12) = 0$ kg m/s. The connected 63 kg robots must therefore have a final velocity of 0 m/s.

CHALLENGE

+22/5 m/s. Initial total momentum = $(18)(+11) + (30)(-7) = -12$ kg m/s. Final total momentum = $(18)(-8) + (30)(+22/5) = -12$ kg m/s, so the totals are equal.

Accept equivalent fractions, decimals, or signed velocities when the direction is clear. Require students to use opposite signs for opposite directions and to conserve total momentum for the two-cart system.