SCIENCE FOUNDATIONS

Conservation of momentum

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how you predict what happens in a crash, like two hockey players colliding or a car rear-ending another car, because the total push of everything involved stays the same before and after the hit. Accident investigators use this to work out how fast the cars were moving before they hit. A rocket works the same way in reverse, throwing exhaust one way so the rocket is pushed the other way. Knowing momentum tells you why a heavy truck is so much harder to stop than a bicycle moving at the same speed.



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Rule

Conservation of momentum: in a closed system with no outside forces, the total momentum before an event equals the total momentum after it.

Momentum: p = m × v, and direction matters, so give opposite directions opposite signs.

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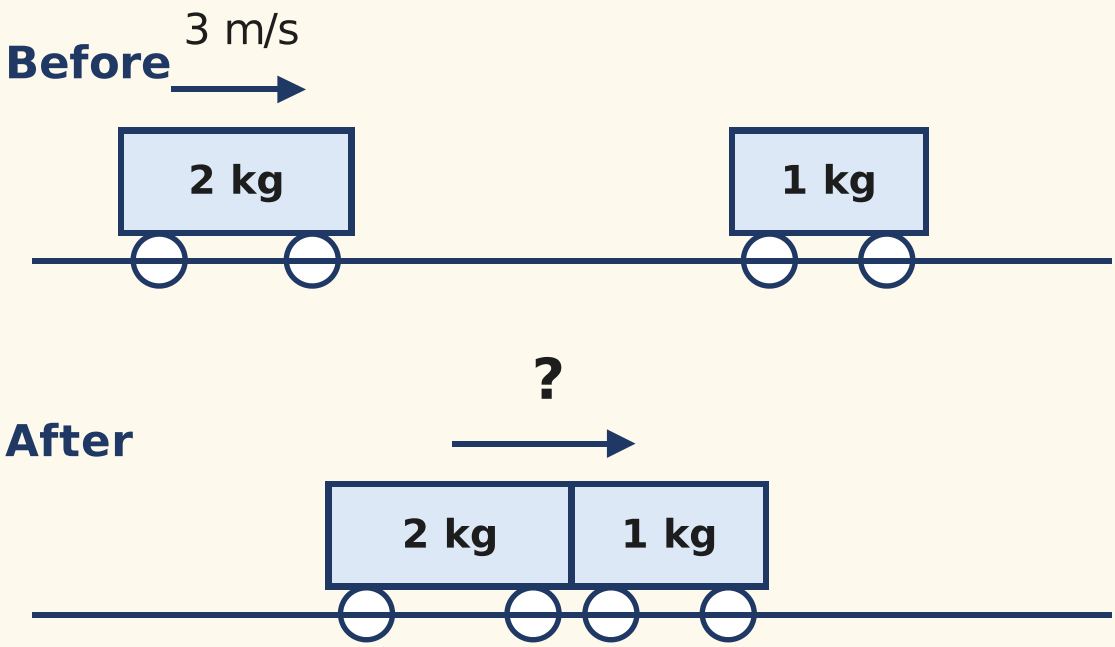
Worked examples

EXAMPLE 1

Q Two trolleys collide and stick: 2 kg at 3 m/s and 1 kg at rest. Final speed?



SOLUTION

Total before:

$2 \times 3 + 1 \times 0 = 6 \text{ kg } \frac{\text{m}}{\text{s}}$

Total after: the trolleys stick together, so they move as one mass of 2 + 1 = 3 kg:

3 kg × v.

Set equal:

3 × v = 6

v = 2 m/s

Result: final speed 2 m/s.

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Momentum is conserved in this inelastic collision, where the trolleys stick together, and it is conserved in elastic collisions too.

EXAMPLE 2

Q A 1 kg trolley at 6 m/s hits a 1 kg trolley at rest and they stick. Final speed?

SOLUTION

Total before:

$1 \times 6 + 0 = 6 \text{ kg } \frac{\text{m}}{\text{s}}$

Total after: the trolleys stick together, so they move as one mass of $1 + 1 = 2$ kg:

$2 \text{ kg} \times v$.

Set equal:

$2 \times v = 6$

$v = 3$ m/s

The result is final speed 3 m/s.

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Practice questions

1 Conservation of momentum in one line?

- **A** Total momentum before equals total after
- **B** Total momentum before is double total after
- **C** Total momentum disappears in a collision
- **D** Total momentum doubles in a collision

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2 3 kg at 4 m/s + 2 kg at rest, stuck: final speed?

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3 A 2 kg object moving at 6 m/s hits a 1 kg object moving at 3 m/s in the same direction, and they stick together. What is their final speed?

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4 What must be true of the system?

- A Closed, no outside forces
- B Open, with outside forces
- C Moving at a steady speed
- D At rest

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5 Do directions matter?

- A Yes, use signs
- B No, ignore direction
- C Only for fast objects
- D Only for heavy objects

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6 Two equal masses, one moving, stick: final speed?

- A Half the moving speed
- B The moving speed
- C Double the moving speed
- D Zero

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7 **Total before 6 kg $\frac{m}{s}$, combined mass 3 kg: final speed?**

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8 **Is momentum conserved in an explosion?**

A Yes, total momentum still balances

B No, momentum is lost

C Only if nothing moves

D Only in a closed room

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Is kinetic energy always conserved?

A Yes

B No

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What is an inelastic collision?

A Objects stick together

B Objects bounce apart

C Objects stop dead

D Objects pass through each other

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ANSWER KEY

1. Total momentum before equals total after

2. 2.4 m/s

3. 5 m/s

4. Closed, no outside forces

5. Yes, use signs

6. Half the moving speed

7. 2 m/s

8. Yes, total momentum still balances

9. No

10. Objects stick together

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