Conservation of momentum

6.5.5.2 · Physics · revision notes

In a closed system, the total momentum before an event equals the total momentum after it. This is Higher tier content. You need to use conservation of momentum to calculate velocities after collisions and explosions, and to explain events such as recoil.

Key facts

- Closed system: total momentum before = total momentum after
- Explosion from rest: total momentum = 0 before and after
- The heavier part moves more slowly
- p = m v for each object; add them, using signs for direction
- Recoil: parts move in opposite directions with equal-sized momentum

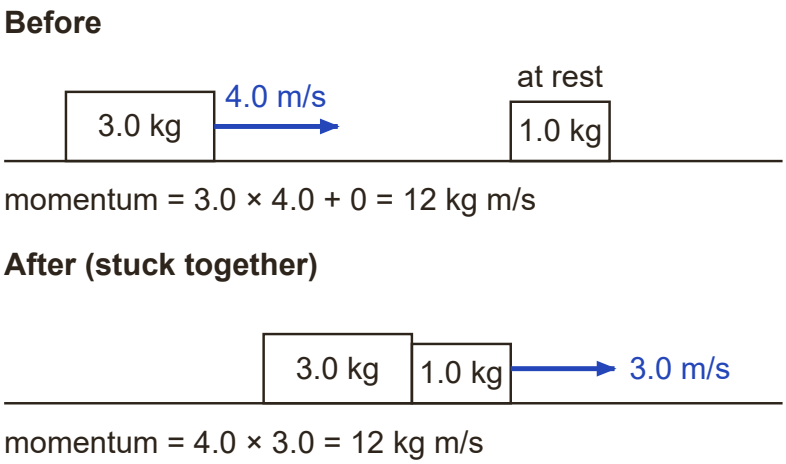
Notes

The law

- In a **closed system**, the total momentum before an event is equal to the total momentum after the event. This is called **conservation of momentum**.
- A closed system is one on which no external forces act.
- Events include collisions (objects hit each other and bounce apart or stick together) and explosions (objects that start together push apart).

Collisions

- Total momentum before = total momentum after: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$.
- In a collision, the momentum one object gains equals the momentum the other loses. So when a moving object hits a stationary one, the moving object slows down and the other speeds up.

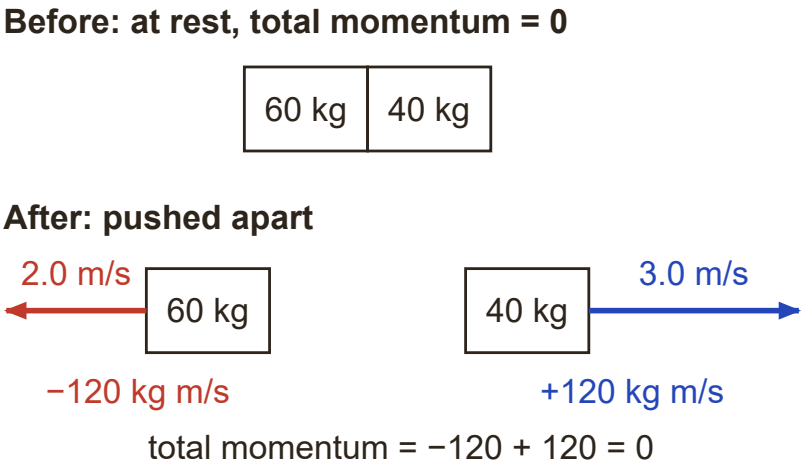


Total momentum before = total momentum after = 12 kg m/s.

- For objects moving towards each other, give one direction + and the other −.
- In the lab, measure trolley velocities before and after a collision with light gates, a data logger or a ticker timer, then compare the total momentum before and after.

Explosions and recoil

- If everything is at rest before an explosion, the total momentum is zero.
- Afterwards the total momentum must still be zero, so the parts move in opposite directions with momentum of equal size.
- Example: when a gun fires a bullet forwards, the gun recoils backwards. The gun moves much more slowly because its mass is much larger.



An explosion or push-apart: the momenta are equal and opposite, so the total stays zero.

How to answer each type of question

State the law of conservation of momentum 2 marks **Grade 6**

1. Say 'in a closed system'.
2. Say 'total momentum before = total momentum after' (the event).

Example. State the law of conservation of momentum.

Model answer.

In a closed system (1)

the total momentum before an event is equal to the total momentum after the event (1).

Explain an event using momentum 3 marks **Grade 7**

1. Give the total momentum before the event.
2. Say that momentum is conserved.
3. Explain what this means for the objects afterwards.

Example. An astronaut is floating at rest in space. She throws a tool away from her. Explain why she moves in the opposite direction.

Model answer.

The total momentum before the throw is zero (1).

Momentum is conserved, so the total momentum after the throw is also zero (1).

The tool has momentum in one direction, so the astronaut must have momentum of equal size in the opposite direction (1).

Don’t lose marks

- Forgetting to add the masses when the objects stick together.
- Ignoring direction for objects moving towards each other (not using a negative sign).
- Using kinetic energy instead of momentum to find the velocities after a collision.
- Leaving the direction out of the final answer.

More tips

Memory tricks

- Before = After. Writing 'total momentum before = total momentum after' first often earns a mark on its own.
- Stuck together? Add the masses on the 'after' side.
- Started at rest? The total momentum is zero, so afterwards the momenta are equal and opposite.
- Sense check: if a moving object hits and sticks to a stationary one, the pair must move more slowly than the moving object did.

Exam technique

- Draw a quick before-and-after sketch with the masses, the velocities and your positive direction.
- Give the final velocity with a direction, or say what the sign means.
- In 'explain' questions, mention the closed system, 'total momentum before = total momentum after', and equal and opposite momentum where relevant.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 6 — **State the law of conservation of momentum**
In a closed system, the total momentum before an event equals the total momentum after it.

Grade 6 — **Calculate the total momentum of a system**
Add the momentum of each object, taking direction into account.

Grade 7 — **Explain explosions and recoil using momentum**
The total momentum is zero before, so the parts move apart with equal and opposite momentum.

Grade 7 — **Explain what a closed system is**
No external forces act on the system, so its total momentum cannot change.

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