

How momentum is conserved in collisions

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to calculate momentum, apply conservation of momentum to collisions and explosions, and link impulse to the forces in everyday safety designs. Early problems use $p = mv$; later ones need signs, energy checks and careful reading of diagrams and graphs.

The set suits GCSE and IGCSE, O Level, WAEC and KCSE, CBSE Class 9-10 and NGSS high school physics. Show every step with units.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS2-2, HS-PS2-3

Problem 1 Units and direction (easy)

Bilal in Lahore is revising momentum.

1. State the SI unit of momentum.
2. State whether momentum is a scalar or a vector.
3. State the direction of the momentum of a moving object.

Problem 2 Momentum of two movers (easy)

Aarav in Pune cycles to school.

1. The total mass of Aarav and his bike is 65 kg and he travels at 4.0 m/s. Calculate his momentum.
2. A golf ball of mass 0.045 kg moves at 40 m/s. Calculate its momentum.

Problem 3 Rearranging $p = mv$ (easy)

1. A 1500 kg car has momentum 9000 kg m/s. Calculate its velocity.
2. A trolley moving at 12 m/s has momentum 36 kg m/s. Calculate its mass.

Problem 4 Convert then calculate (easy)

1. A 250 g ball travels at 72 km/h. Convert both quantities to SI units and calculate its momentum.
2. A 3.0 tonne lorry moves at 10 m/s. Calculate its momentum in kg m/s.

Problem 5 Light and fast or heavy and slow (easy)

Mei in Singapore compares a 0.15 kg ball thrown at 40 m/s with a 60 kg person walking at

0.50 m/s.

1. Calculate the momentum of each.
2. State which has more momentum and by what factor.

Problem 6 Force for a time (easy)

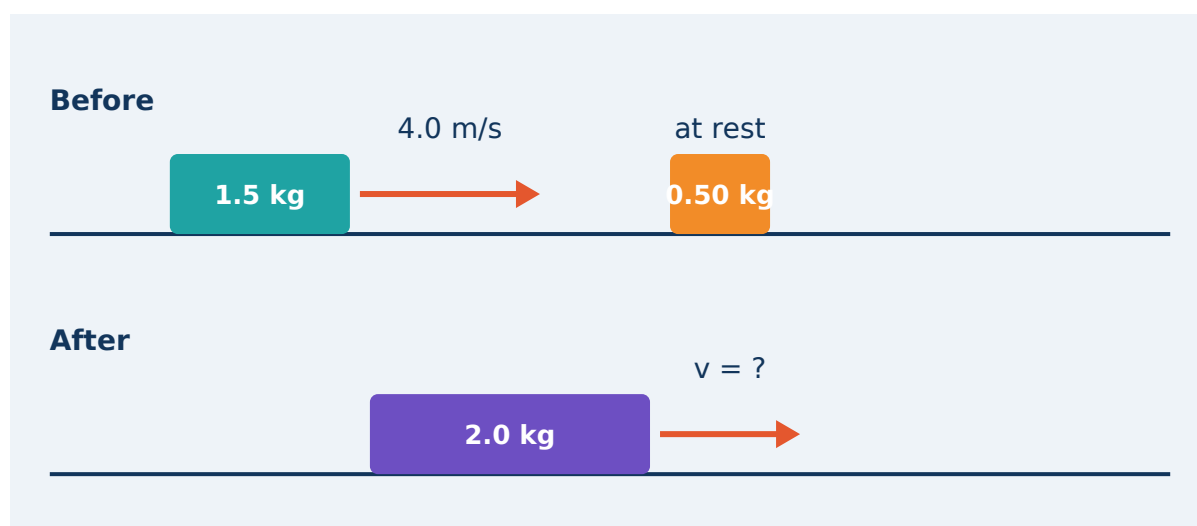
A steady force of 20 N pushes a 2.0 kg trolley, initially at rest, for 0.50 s.

1. Calculate the impulse.
2. State the change in momentum.
3. Calculate the final speed.

Problem 7 Coupling trolleys (medium)

Use the diagram. A 1.5 kg trolley at 4.0 m/s hits a 0.50 kg trolley at rest and they couple.

1. Calculate the total momentum before.
2. Calculate the speed after coupling.
3. Calculate the kinetic energy lost.



Problem 7: coupling collision.

Problem 8 Kicking a football (medium)

Bilal kicks a stationary 0.43 kg football and it leaves at 22 m/s. His boot touches the ball for 0.010 s.

1. Calculate the change in momentum.
2. Calculate the average force on the ball.

Problem 9 Throwing from skates (medium)

Emma in Leeds stands on skates at rest. After she throws a 3.0 kg medicine ball forward at 8.0 m/s, her own mass is 48 kg. Ignore friction.

1. Calculate the momentum of the ball.
2. Calculate Emma's recoil speed.

3. State her direction.

Problem 10 Bouncing off a wall (medium)

A 0.40 kg ball hits a wall at 6.0 m/s and rebounds at 4.0 m/s. Take the direction towards the wall as positive. The contact lasts 0.050 s.

1. Calculate the initial momentum.
2. Calculate the final momentum.
3. Calculate the change in momentum.
4. Calculate the average force.

Problem 11 Seat belts (medium)

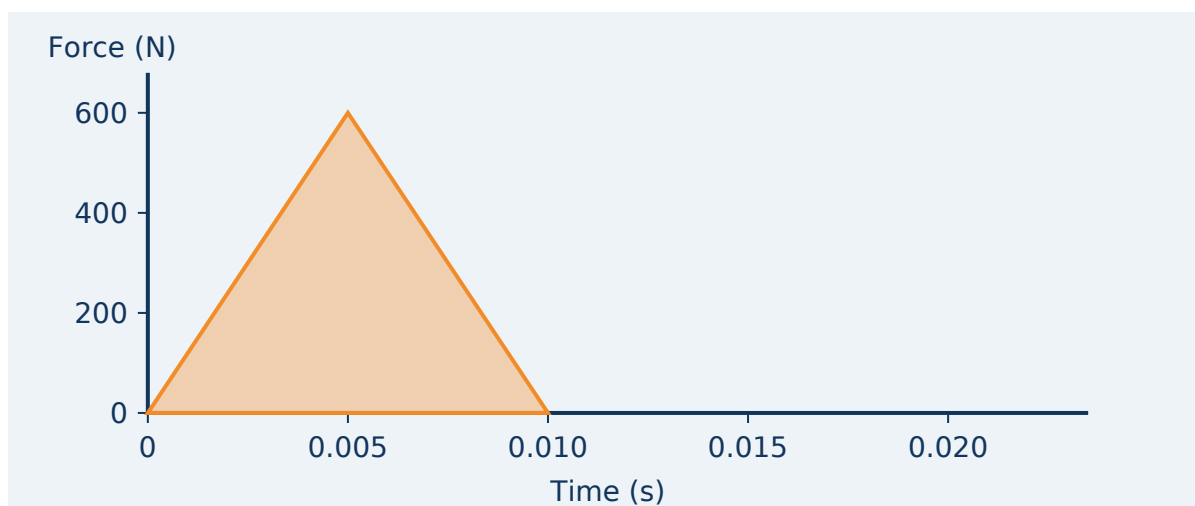
A 70 kg passenger in a car travelling at 15 m/s is stopped in a crash.

1. Calculate the change in momentum.
2. Find the average force if the stop takes 0.10 s.
3. Find the average force if a seat belt stretches the stop to 0.50 s.
4. Explain how this protects the passenger.

Problem 12 Area under a force-time graph (medium)

The graph shows the force on a 0.30 kg football, initially at rest, during a kick.

1. State the peak force.
2. Calculate the impulse as the area of the triangle.
3. Calculate the speed of the ball.
4. Calculate the average force over 0.020 s.



Problem 12: force on a football during a kick.

Problem 13 Spring-loaded trolleys (medium)

Wanjiru in Nairobi releases a spring between a 2.0 kg trolley and a 3.0 kg trolley, both at rest. The 2.0 kg trolley moves left at 6.0 m/s.

1. State the total momentum after release.
2. Calculate the velocity of the 3.0 kg trolley.
3. Calculate the total kinetic energy gained.

Problem 14 Truck and car (medium)

A 4000 kg truck moves at 5.0 m/s and a 1000 kg car moves at 20 m/s.

1. Calculate the momentum of each.
2. Calculate the kinetic energy of each.
3. Both are stopped in the same time. Compare the average forces needed.
4. Explain which is harder to stop in a short distance.

Problem 15 Checking a collision record (medium)

Kofi records a trolley collision on a smooth track.

Trolley	Mass (kg)	Velocity before (m/s)	Velocity after (m/s)
A	0.80	1.50	0.50
B	0.40	0	1.9

1. Calculate the total momentum before.
2. Calculate the total momentum after.
3. Calculate the percentage difference.
4. Decide whether the data support conservation of momentum.

Problem 16 Head-on carts (hard)

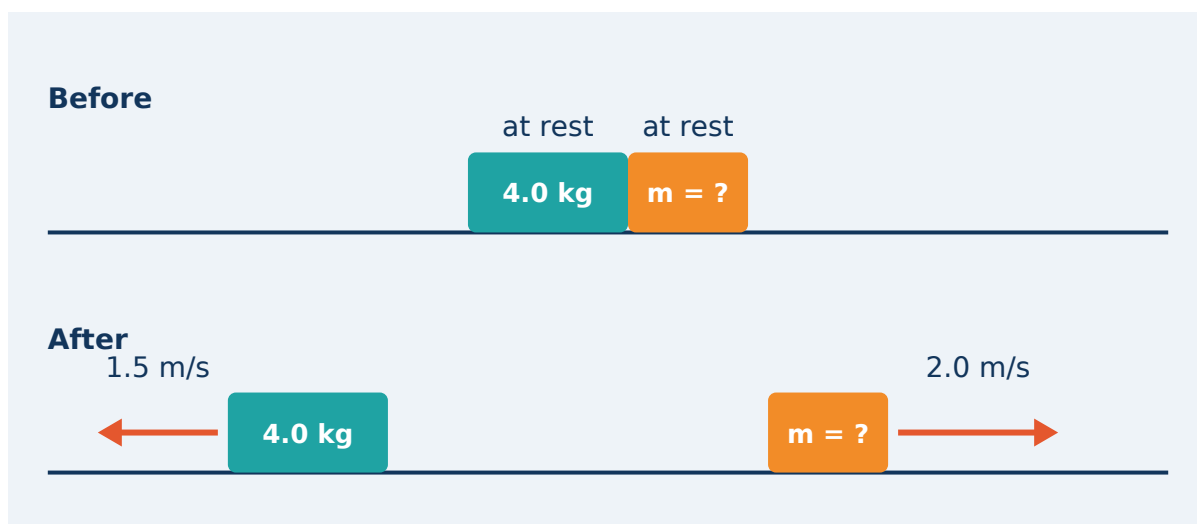
Kofi runs a 3.0 kg cart at +2.0 m/s towards a 1.0 kg cart moving at −4.0 m/s. They stick together.

1. Calculate the total momentum before.
2. Calculate the velocity after, with direction.
3. Calculate the kinetic energy lost.

Problem 17 Find the missing mass (hard)

A spring pushes two carts apart from rest. Use the diagram: the 4.0 kg cart moves left at 1.5 m/s and the other cart moves right at 2.0 m/s.

1. Calculate the momentum of the 4.0 kg cart.
2. Calculate the mass of the other cart.
3. Calculate the total kinetic energy after.



Problem 17: a spring pushes two carts apart.

Problem 18 Does the energy match? (hard)

A 0.60 kg ball at 5.0 m/s hits a 0.40 kg ball at rest. Afterwards the first ball moves on at 1.0 m/s in the same direction.

1. Calculate the velocity of the second ball.
2. Calculate the total kinetic energy before and after.
3. State whether the collision is elastic and justify your answer.

Problem 19 Landing from a vault (hard)

Diego, a 45 kg gymnast, drops from rest through 1.8 m and lands. Use $g = 9.8 \text{ N/kg}$ and ignore his weight during the impact.

1. Calculate his speed just before landing.
2. Calculate his momentum.
3. Find the average force if he stops in 0.050 s on a hard floor.
4. Find the average force if he stops in 0.40 s on a thick mat.

Problem 20 Spot the error (hard)

A student writes: a 2.0 kg trolley at 3.0 m/s and a 1.0 kg trolley at 3.0 m/s move towards each other and stick. Final velocity = $(2.0 \times 3.0 + 1.0 \times 3.0) \div 3.0 = 3.0 \text{ m/s}$.

1. Identify the error.
2. Calculate the correct final velocity.
3. Explain why the final speed must be less than 3.0 m/s.