Momentum of moving objects

4.5.7.1 · Forces · revision notes

Momentum is a property of every moving object: momentum = mass × velocity. It is a vector, so direction matters. This is Higher tier content. Expect calculations with p = m v, often as the first part of a collision question.

Key facts

- p = m v (momentum = mass × velocity)
- Momentum is a vector, in the same direction as the velocity
- Stationary object: p = 0
- Units: p in kg m/s, m in kg, v in m/s
- Opposite directions: opposite signs
- Grade 8+ only Change in momentum = m v − m u (use signs for direction)

Notes

What momentum is

- Momentum is a property of moving objects.
- momentum = mass × velocity: **p = m v**
- p in kilogram metres per second (kg m/s), m in kilograms (kg), v in metres per second (m/s).
- A stationary object has zero momentum.

Momentum is a vector

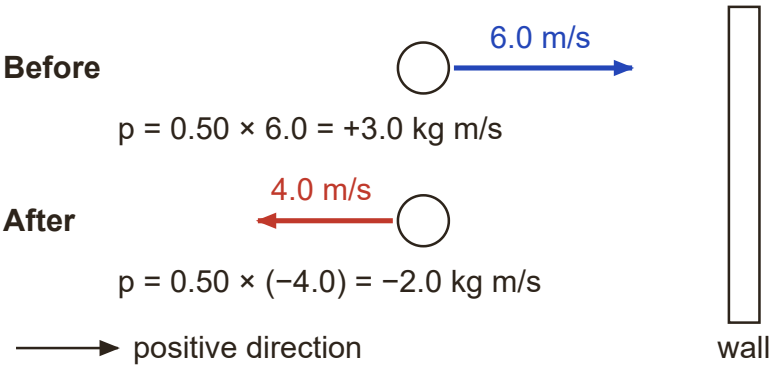
- Momentum has the same direction as the velocity.
- Choose one direction as positive. An object moving the opposite way has negative momentum: a 2.0 kg ball moving at 3.0 m/s to the left has p = −6.0 kg m/s if right is positive.
- Two identical objects moving towards each other at the same speed have a total momentum of zero.

Comparing momentum

- Momentum depends on both mass and velocity. A 1500 kg car moving at 2.0 m/s (3000 kg m/s) has more momentum than a 70 kg sprinter at 10 m/s (700 kg m/s).
- Doubling the mass, or doubling the velocity, doubles the momentum.

Changes in momentum Grade 8+ only

- Change in momentum = final momentum − initial momentum = m v − m u.
- Example: a 0.50 kg ball hits a wall at 6.0 m/s and rebounds at 4.0 m/s. Taking 'towards the wall' as positive: change = 0.50 × (−4.0) − 0.50 × 6.0 = −5.0 kg m/s, so 5.0 kg m/s away from the wall.



Direction matters: the momentum goes from +3.0 to −2.0 kg m/s, a change of −5.0 kg m/s.

- Because the direction reverses, the size of the change (5.0) is bigger than either the initial (3.0) or the final (2.0) momentum.

How to answer each type of question

Calculate momentum 2 marks Grade 6

1. Check the mass is in kg and the velocity in m/s.
2. Write p = m v and substitute.
3. Give the unit kg m/s.

Example. A lorry of mass 12 000 kg travels at 15 m/s.
Calculate the momentum of the lorry.

Model answer.

p = 12 000 × 15 (1)

p = 180 000 kg m/s (1)

Rearrange p = m v

3 marks | Grade 6

1. Convert grams to kilograms.
2. Rearrange: v = p ÷ m or m = p ÷ v.
3. Give the unit.

Example. A cricket ball has a mass of 160 g and a momentum of 5.6 kg m/s. Calculate the velocity of the ball.

Model answer.

m = 160 g = 0.160 kg (1)
v = 5.6 ÷ 0.160 (1)
v = 35 m/s (1)

Compare the momentum of two objects

3 marks | Grade 7

1. Calculate the momentum of each object.
2. Compare the two values.
3. State a conclusion.

Example. A bowling ball of mass 6.0 kg rolls at 3.0 m/s. A football of mass 0.45 kg is kicked at 30 m/s. Which has more momentum? Show your working.

Model answer.

bowling ball: p = 6.0 × 3.0 = 18 kg m/s (1)
football: p = 0.45 × 30 = 13.5 kg m/s (1)
The bowling ball has more momentum (1).

Calculate a change in momentum with a change of direction

3 marks | Grade 8

1. Choose a positive direction.
2. Calculate the initial and final momentum with signs.
3. Change = final − initial; give the size and direction.

Example. A 0.40 kg ball moving at 5.0 m/s to the right hits a wall and rebounds at 3.0 m/s to the left. Calculate the change in momentum of the ball.

Model answer.

taking right as positive: initial p = +2.0 kg m/s and final p = 0.40 × (−3.0) = −1.2 kg m/s (1)
change = −1.2 − (+2.0) (1)
= −3.2 kg m/s, i.e. 3.2 kg m/s to the left (1)

Don’t lose marks

- Using a mass in grams.
- Ignoring direction: for a rebound, subtracting the speeds instead of taking the directions into account.
- Writing the unit as kg/m s or kg/ms. It is kg m/s.
- Confusing momentum (m v) with kinetic energy (½ m v^2).

More tips

Memory tricks

- Momentum is 'mass in motion': no motion, no momentum.
- Grams to kilograms first: divide by 1000.
- For a rebound, add the sizes of the two momenta to get the size of the change (2.0 + 1.2 = 3.2 kg m/s).

Exam technique

- p = m v is on the equation sheet: know what p, m and v stand for, their units, and how to rearrange for m or v.
- In any question with directions, state which direction you are taking as positive at the start.
- Show the momentum of each object separately before combining them.

What each grade needs

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

Grade 5 — **Recall the momentum equation p = m v**
Momentum (kg m/s) = mass (kg) × velocity (m/s).

Grade 6 — **Calculate momentum**
For example, 0.16 kg × 25 m/s = 4.0 kg m/s.

Grade 6 — **Find mass or velocity using p = mv**
m = p ÷ v and v = p ÷ m.

Grade 7 — **Explain that momentum is a vector**
Momentum has the same direction as the velocity; opposite directions have opposite signs.

Grade 7 — **Compare the momentum of different objects**
A slow, heavy object can have more momentum than a fast, light one.

Grade 8 — **Calculate a change in momentum, including direction**
For a rebound, change in momentum = m v − m u with the correct signs.

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