

Exercise walk-through

2.1

Forces, momentum and safe stopping

International Baccalaureate · IB Diploma · Physics · SL

2.1 Forces, momentum and safe stopping

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS momentum • resultant force

Objective

Forces, momentum and safe stopping. Original classroom practice for IB SL; not an official IB paper.

1 Key knowledge and worked examples

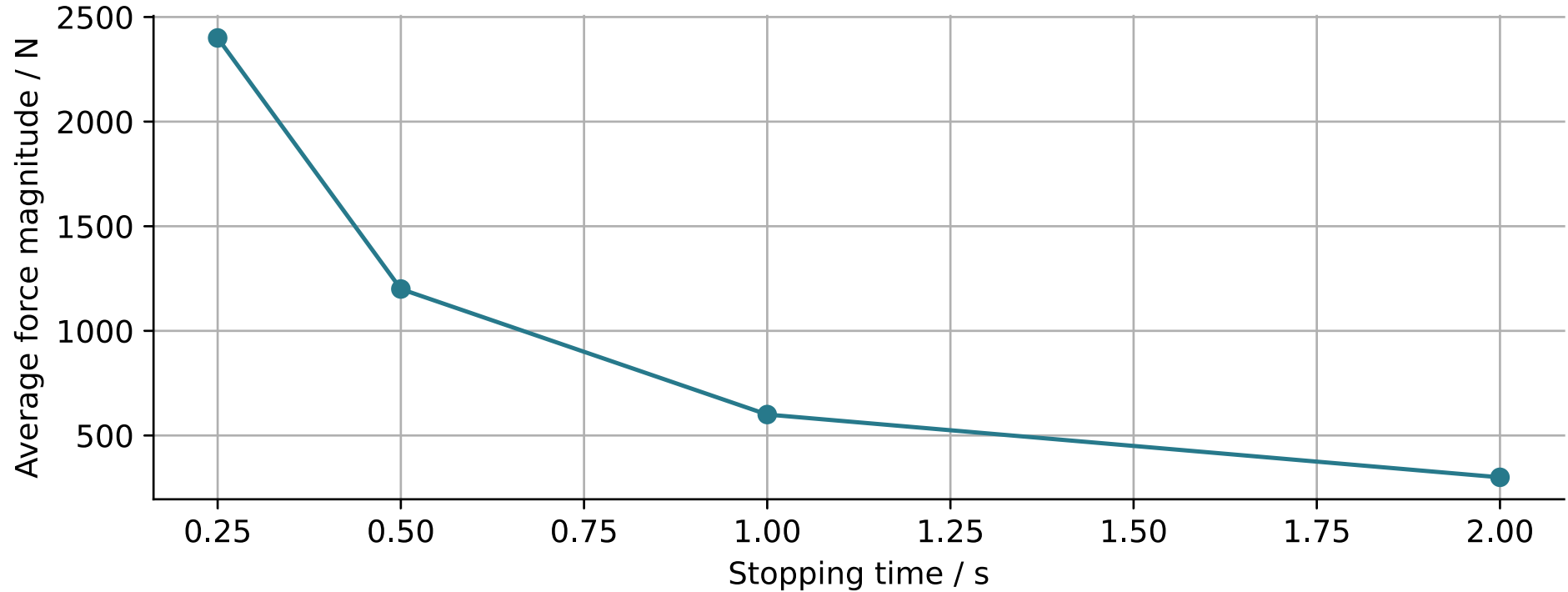
■ What would explain this observation?

- A passenger continues moving when a vehicle brakes. The seat belt provides the force needed to change the passenger **momentum** .

■ **Build the model**

- **Resultant force** causes acceleration, not motion itself.
- Momentum is mass multiplied by velocity.
- For an isolated system, total momentum is conserved even when kinetic energy is not.

- momentum: Mass multiplied by velocity.
- resultant force: The vector sum of forces on an object.



■ Choose evidence that can test it

- Impulse equals momentum change.
- Increasing stopping time for the same momentum change reduces average force.
- Identify external forces before applying momentum conservation.

In the lab: Draw a free-body diagram containing only forces on the selected object. For spring measurements, add loads in steps within the elastic range and measure extension from the unloaded position.

■ Work from known quantities

- Known: a 60 kg passenger slows from 10 to 0 metres per second in 0.50 s. $\Delta p = m(v-u) = 60(0-10) = -600$ kg metres per second.

- Average $F = \Delta p / \Delta t = -600 / 0.50 = -1,200 \text{ N}$.
- The sign shows the force opposes the initial motion.

Your turn: A 2 kg trolley travels at 3 metres per second. Find its momentum.

■ Check the conclusion and its limits

- Balanced forces do not require the object to be at rest.
- Mass and weight have different units and meanings.

Not true: An object moving at constant velocity must have a nonzero resultant force. By Newton's first law, constant velocity - including steady motion - means zero RESULTANT force. Forces can be present, but they balance; a nonzero resultant would change the velocity.

Key:

- Resultant force causes acceleration, not motion itself.
- Impulse equals momentum change.
- Watch for: balanced forces do not require the object to be at rest.

■ Write from a momentum of 21 kilogram metres per second

- A 3 kg trolley travels at 7 metres per second and stops in 0.30 s.
- Find the momentum and the average force. Constant velocity needs zero resultant

force.



Exercises 2.1·2.2

2.1 For fixed momentum change, which reduces average stopping force? Choose one answer.

- **A** Shorter stopping time
- **B** Ignoring external force
- **C** Longer stopping time

[1]

2.2 A 2 kg trolley travels at 3 metres per second. Find its momentum. Show the relation, substitution and units.

[2]

Exercises 2.1·2.2

2.1 For fixed momentum change, which reduces average stopping force? Choose one answer.

- **A** Shorter stopping time
- **B** Ignoring external force
- **C** Longer stopping time

[1]

2.1 C For a fixed momentum change, average force = momentum change / time, so a longer stopping time divides the same change by a larger number and gives a smaller force. Crumple zones and airbags apply exactly this.

2.2 A 2 kg trolley travels at 3 metres per second. Find its momentum. Show the relation, substitution and units.

[2]

2.2 $p=mv=2\times 3=6$ kg m/s.

Exercises 2.3-3.1

2.3 Decide whether this claim is true and justify: An object moving at constant velocity must have a nonzero resultant force. [2]

2.4 Mass multiplied by velocity: write the technical term. [1]

3.1 A 2 kg trolley changes velocity from +3 to -1 m/s in 0.20 s. Find impulse and average force; explain why momentum change is not just change in speed. [4]

Exercises 2.3-3.1

2.3 Decide whether this claim is true and justify: An object moving at constant velocity must have a nonzero resultant force. [2]

2.3 False. By Newton's first law, constant velocity - including steady motion - means zero RESULTANT force. Forces can be present, but they balance; a nonzero resultant would change the velocity.

2.4 Mass multiplied by velocity: write the technical term. [1]

2.4 momentum. momentum means Mass multiplied by velocity.

3.1 A 2 kg trolley changes velocity from +3 to -1 m/s in 0.20 s. Find impulse and average force; explain why momentum change is not just change in speed. [4]

3.1 $\Delta p = 2(-1 - 3) = -8 \text{ kg m/s}$; average force = -40 N. Direction reverses although speed falls from 3 to 1 m/s. Using magnitudes loses the direction information.