

Exercise walk-through

2.1

Forces, momentum and safe stopping

International Baccalaureate · IB Diploma · Physics · HL

2.1 Forces, momentum and safe stopping

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

KEY WORDS momentum • resultant force

Objective

Forces, momentum and safe stopping. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

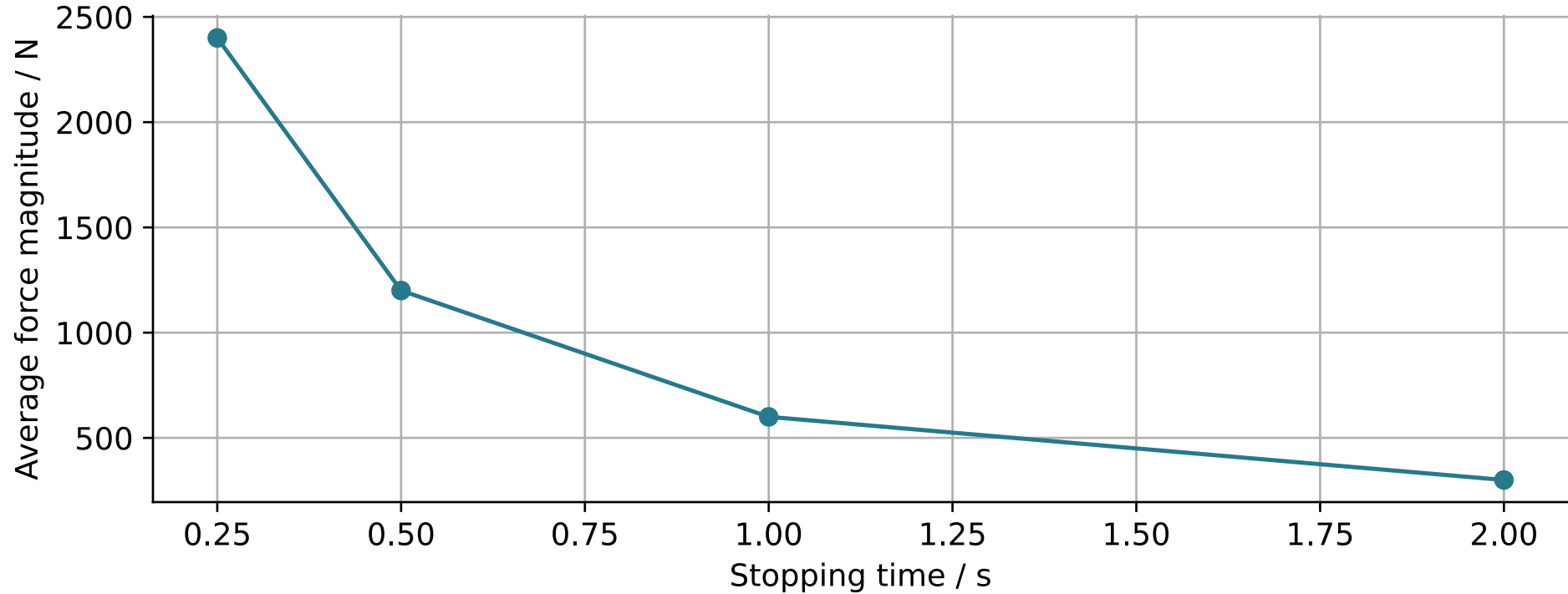
■ What would explain this observation?

- A passenger continues moving when a vehicle brakes. The seat belt provides the force needed to change the passenger **momentum** .
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ 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.
- 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**

- State the known values and their units. Choose the relation because its assumptions

fit this case, then rearrange before substitution.

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

Example:

A 2 kg trolley travels at 3 metres per second. Find its momentum. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ 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.

- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

An object moving at constant velocity must have a nonzero resultant force. This claim is false: Balanced forces do not require the object to be at rest. Mass and weight have different units and meanings.

Key:

Forces, momentum and safe stopping: Impulse equals momentum change. Increasing stopping time for the same momentum change reduces average force. Identify external

forces before applying momentum conservation.

Exercises 2.1·2.3

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

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

[1]

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

[2]

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

[2]

Exercises 2.1·2.3

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

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

[1]

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

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.

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

Exercises 2.4·3.1

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

3 Exam-style questions

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 2.4·3.1

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

3 Exam-style questions

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