

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.

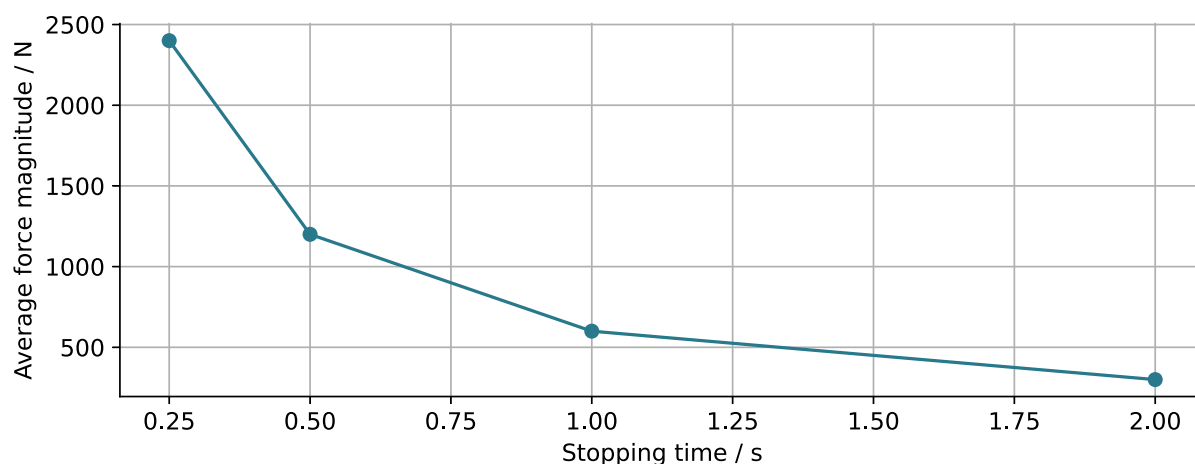
1 Key knowledge and worked examples

■ 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.

2 Practice

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]

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]

Solutions

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

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

2.4 momentum. momentum means Mass multiplied by velocity.

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.