Exercise walk-through

# 2.1 Forces, momentum and safe stopping

International Baccalaureate · IB Diploma · Physics · HL

INTERNATIONAL BACCALAUREATE · IB DIPLOMA · PHYSICS · HL • EXERCISE SHEET

# 2.1 Forces, momentum and safe stopping

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

**KEY WORDS** momentum • resultant force

## Objective

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

## 1 Key knowledge and worked examples

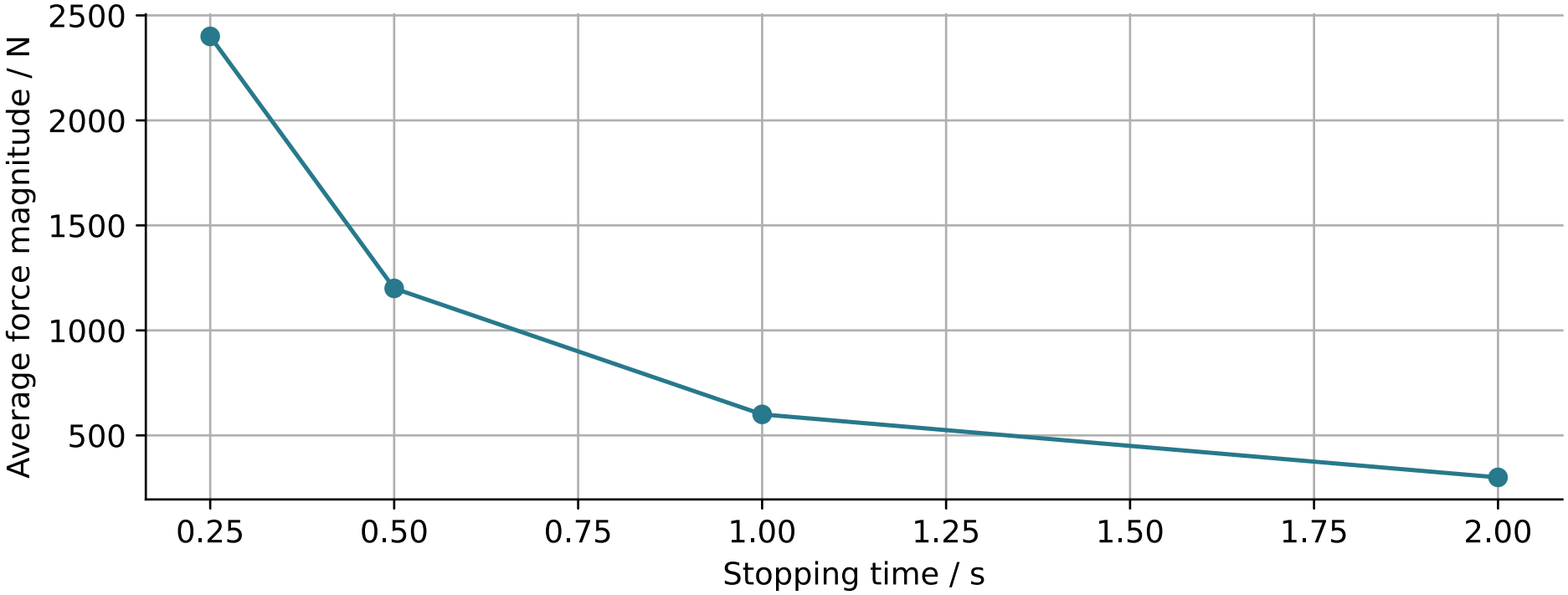
### What would explain this observation?

- 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.

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## 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 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.

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## ■ 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 32 kilogram metres per second

- A 4 kg trolley travels at 8 metres per second and stops in 0.40 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.

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**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.

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

**2.4** momentum. momentum means Mass multiplied by velocity.

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**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.