

## 4.1 Biomechanics: movement and impulse

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 10 marks

**KEY WORDS** base of support • impulse

### Objective

Biomechanics: movement and impulse. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

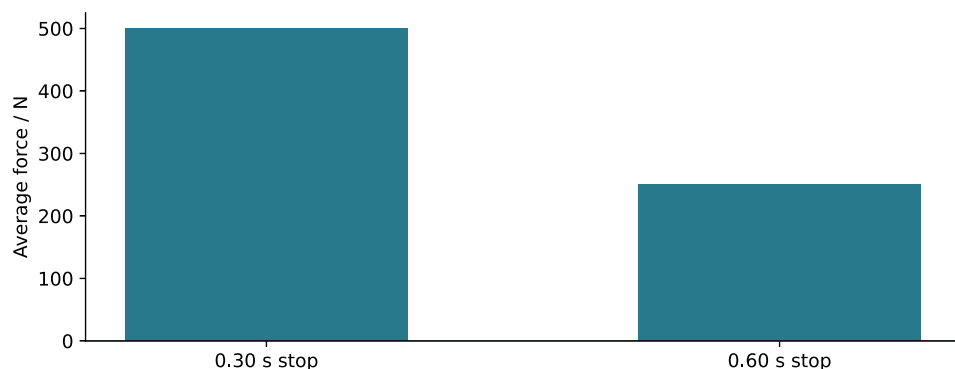
### 1 Key knowledge and worked examples

#### ■ What would explain this observation?

- Landing with bent knees increases the time over which momentum changes. The movement can reduce average impact force for the same momentum change.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

#### ■ Build the model

- Joint movement results from muscle forces acting through lever systems. The centre of mass and **base of support** affect stability. **Impulse** connects force-time evidence to momentum change.
- impulse: Force integrated over time, equal to momentum change; base of support: The area supporting a body.



#### ■ Choose evidence that can test it

- A biomechanical analysis must define the segment, direction and phase of movement. Net force and a single muscle force are not interchangeable. A longer lever arm can change torque without changing applied force.
- Use teacher-approved video of a safe movement with consent. Calibrate distance and time, identify frames consistently, and avoid making medical claims from a two-dimensional recording. Camera perspective can bias apparent joint angles.

#### ■ 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: momentum changes by 150 kg metres per second. Average force magnitude = momentum change/stopping time. For 0.30 s, force =  $150/0.30 = 500$  N. For 0.60 s, force =  $150/0.60 = 250$  N. This idealized average excludes the detail of a changing force curve.

#### Example:

Momentum change is 120 kg metres per second over 0.40 s. Find average force magnitude. Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

#### ■ Check the conclusion and its limits

- The largest force is not the same as average force. A school movement study should not deliberately create high-impact landings to test a prediction.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

#### Warn:

A video from one angle proves the cause of a sports injury. This claim is false: The largest force is not the same as average force. A school movement study should not deliberately create high-impact landings to test a prediction.

#### Key:

Biomechanics: movement and impulse: A biomechanical analysis must define the segment, direction and phase of movement. Net force and a single muscle force are not interchangeable. A longer lever arm can change torque without changing applied force.

## 2 Practice

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**2.1** For a fixed momentum change, doubling stopping time does what to average force? Choose one answer.

- **A** Halves it
- **B** Doubles it
- **C** Leaves it unchanged

[1]

**2.2** Momentum change is 120 kg metres per second over 0.40 s. Find average force magnitude. Show the relation, substitution and units.

[2]

**2.3** Decide whether this claim is true and justify: A video from one angle proves the cause of a sports injury.

[2]

**2.4** Force integrated over time, equal to momentum change: write the technical term.

[1]

## 3 Exam-style questions

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**3.1** Fictional force curves deliver 120 N s impulse over 0.20 and 0.40 s. Compare average forces. Can peaks or injury risk be inferred?

[4]

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## Solutions

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**2.1 A** A biomechanical analysis must define the segment, direction and phase of movement. Net force and a single muscle force are not interchangeable. A longer lever arm can change torque without changing applied force.

**2.2** Average force magnitude=momentum change/time= $120/0.40=300$  N.

**2.3** False. The largest force is not the same as average force. A school movement study should not deliberately create high-impact landings to test a prediction.

**2.4** impulse. impulse means Force integrated over time, equal to momentum change.

**3.1** Averages are 600 and 300 N. Impulse specifies area, not force-curve shape or peak. Injury risk requires suitable evidence beyond this mechanical example; no individual recommendation follows.