4.1 Biomechanics: movement and impulse

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

KEY WORDS base of support • impulse

Objective

Biomechanics: movement and impulse. Original classroom practice for IB HL; not an official IB paper.

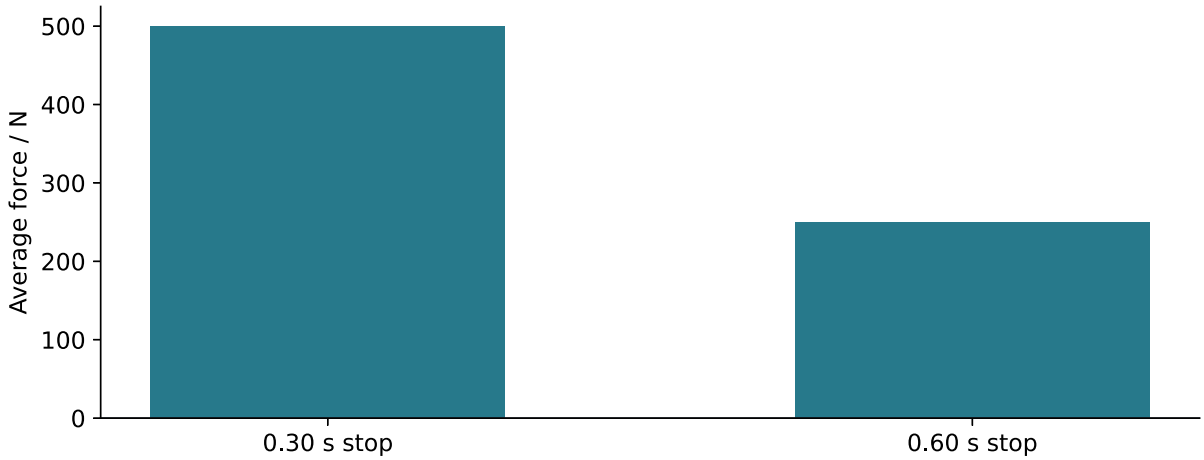
1 Key knowledge and worked examples

■ 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.

■ 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.

In the lab: 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

- 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.

Your turn: Momentum change is 120 kg metres per second over 0.40 s. Find average force magnitude.

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.

Not true: A video from one angle proves the cause of a sports injury. One camera angle shows one projection of a complex movement; forces, surfaces, fatigue and individual anatomy are invisible in it. Injury causation needs multiple views, force data and medical evidence, not a single clip.

Key:

- Joint movement results from muscle forces acting through lever systems.
- A biomechanical analysis must define the segment, direction and phase of movement.
- Watch for: the largest force is not the same as average force.

Write from an average force of 360 N

- Momentum changes by 180 kg metres per second.
- Compare the average force over 0.50 s and over 1.00 s. One camera angle does not prove the cause of an injury.

2 Practice

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

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

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]

Solutions

2.1 A Average force = momentum change / time. Doubling the stopping time divides the same momentum change by twice the time, so the average force halves - the principle behind soft landings and follow-through.

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

2.3 False. One camera angle shows one projection of a complex movement; forces, surfaces, fatigue and individual anatomy are invisible in it. Injury causation needs multiple views, force data and medical evidence, not a single clip.

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.