Exercise walk-through

5.1
Motion, Newton's laws and impulse

International Baccalaureate · IB Diploma · Sports, Exercise and Health Science · SL

Can follow-through keep changing a ball after racket separation?

Choose the body, direction and interval

B2 connects Newton's laws, stability, coordinated movement, projectile paths and movement phases.

All numerical examples and diagrams are invented. Movement after separation cannot supply continued racket–ball contact force.

A throwing sequence is more than adding isolated muscle forces

Identify timing, segment interactions and turning effects

Legs, trunk, shoulder, elbow and wrist can contribute in a coordinated sequence. Task and timing affect endpoint motion.

Torque is force $\times$ perpendicular lever arm. An off-centre force can change angular and linear motion.

A force through the centre of mass has no moment about that centre; a larger isolated muscle force does not guarantee a better throw.

Check the shared calculations before interpreting performance

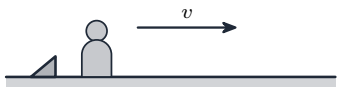
1. **Motion and force.** Lap: speed 5, average velocity zero. Acceleration +2 and −2. Video: 0.20 s, +2.5 metres per second. Net 75 N; driving 90 N.
2. **Impulse.** Triangular **impulse** 120 N s; average 300 N. Rebound change −2.0 and average resultant −250 N. Ground reaction 1,068.6 N.
3. **Angular and projectile models.** Angular momentum 3.0; final angular velocity 10. Range 4.0 m. Each numerical result depends on its stated model.

Exercises 2.1·2.2

2.1 Distinguish between speed and velocity. [2]



2.2 A 70 kg sprinter goes from rest to 10 m s^{-1} in 2.5 s. Calculate her mean acceleration and the mean resultant force on her. [3]



Exercises 2.1·2.2

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2.1

speed is a scalar: distance per unit time, with no direction; velocity is a vector: displacement per unit time, with a direction

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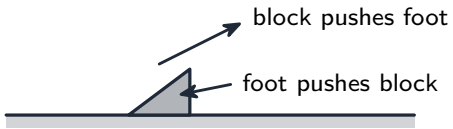


2.2

$a = 10 \div 2.5 = \mathbf{4}$ m s^{-2}; $F = ma = 70 \times 4 = \mathbf{280}$ N

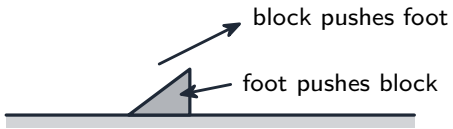
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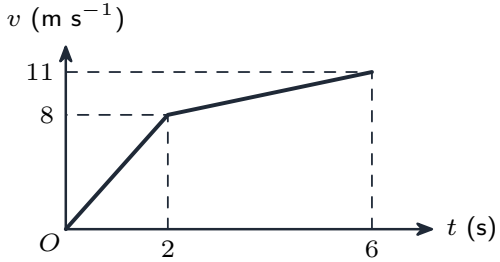
2.3

the sprinter pushes backwards (and down) on the blocks with her legs (action); the blocks push on her with an equal force in the opposite direction (reaction); this forward reaction force accelerates her forward (ground reaction force)

Exercise 3.1 (a)

3.1 The velocity–time graph shows the first 6 s of a 100 m race.

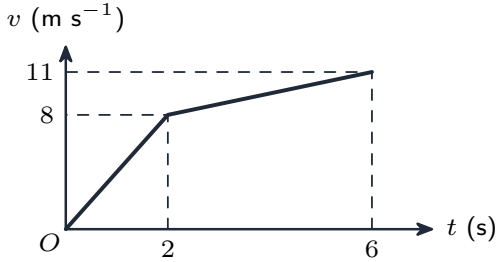
(a) Describe the motion of the sprinter. [2]



Exercise 3.1 (a)

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(a) large acceleration in the first 2 s; then a smaller acceleration up to about 11 m s^{-1}

Exercise 3.1 (b)

3.1 The velocity–time graph shows the first 6 s of a 100 m race.

(b) Calculate the displacement in the first 2 s. [2]

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(b) area of triangle $= \frac{1}{2} \times 2 \times 8 = \mathbf{8}$ m

Exercise 3.2 (a)

3.2 A 40 kg gymnast lands at 5 m s^{-1}. With stiff legs she stops in 0.1 s; with bent knees she stops in 0.4 s.

(a) Calculate her momentum just before landing. [1]

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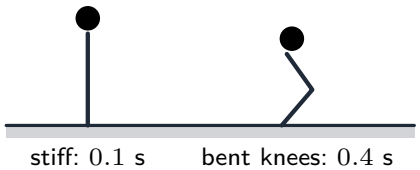
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(a) $p = 40 \times 5 = \mathbf{200}$ kg m s^{-1}

Exercise 3.2 (b)

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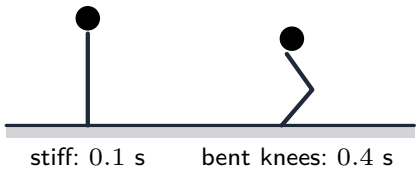
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(b) $F = \Delta p \div \Delta t$; stiff: $200 \div 0.1 = \mathbf{2000}$ N; bent: $200 \div 0.4 = \mathbf{500}$ N

Exercise 3.2 (c)

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(c) Explain why bending the knees reduces the risk of injury. [2]

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(c) the same change in momentum (impulse) happens over a longer time; so the force on bones, joints and ligaments is smaller