Exercise walk-through

5.1
Motion, Newton's laws and impulse

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

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.

AHL: collisions, friction, work/power, environmental effects, buoyancy, lift and drag.

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

Practise with a defined system and signs

Show quantities and interpret the result

Use motion measurements, Newton's laws, force-time area, signed momentum change, ground reaction and angular momentum.

Explain stability, projectile assumptions and operational movement phases.

AHL: combine collision conditions and evaluate friction, work/power, relative flow, buoyancy and equipment claims.

Check the shared calculations before interpreting performance

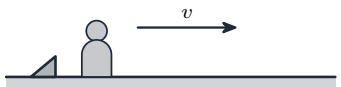
1. **Motion and force.** Lap: speed 5, average velocity zero. Acceleration +2 and −2. Video: 0.20 s, +2.5 metres per second. Net 75 N; driving 90 N.
2. **Impulse.** Triangular **impulse** 120 N s; average 300 N. Rebound change −2.0 and average resultant −250 N. Ground reaction 1,068.6 N.
3. **Angular 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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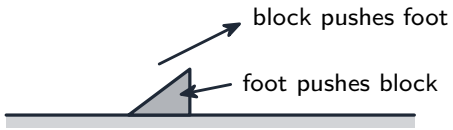


2.2

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

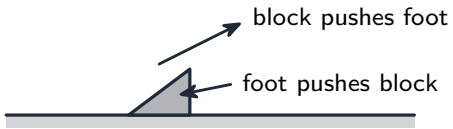
Exercise 2.3

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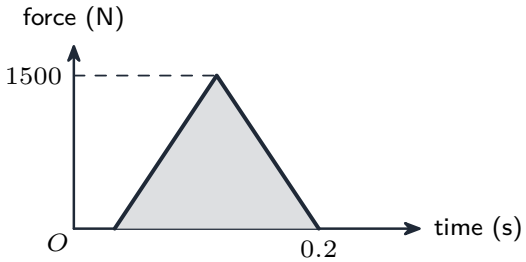


2.3

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)

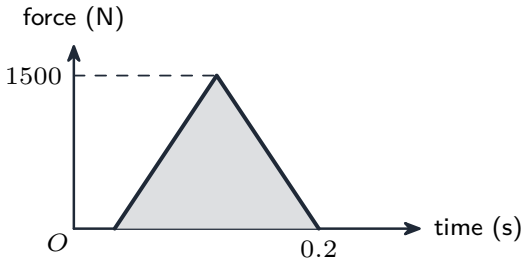
Exercise 2.4

2.4 The force–time graph shows a push-off lasting 0.2 s. The force rises from 0 to 1500 N and falls back to 0 in a triangle shape. The athlete has a mass of 75 kg. Calculate the impulse and the change in velocity. [3]



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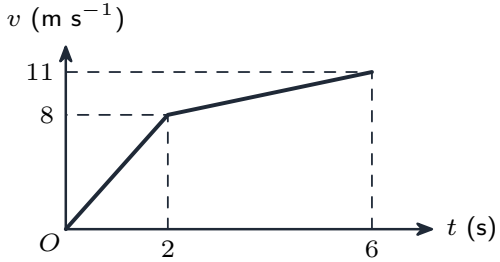
2.4

impulse $= \frac{1}{2} \times 1500 \times 0.2 = \mathbf{150}$ N s; $\Delta v = 150 \div 75 = \mathbf{2}$ m s^{-1}

Exercise 3.1 (a)

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

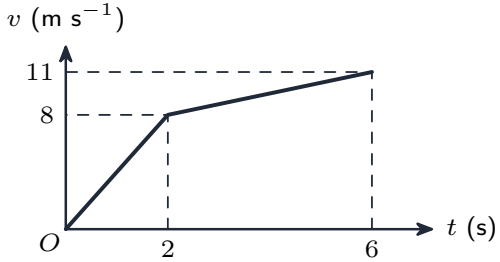
(a) Describe the motion of the sprinter. [2]



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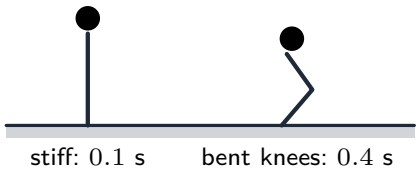
(a) Calculate her momentum just before landing. [1]

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

Exercise 3.2 (b)

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.

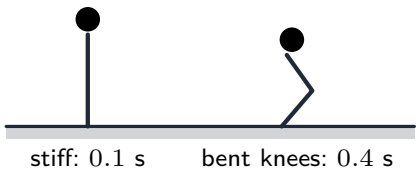
(b) Calculate the mean stopping force in each landing (ignore her weight). [3]



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(b) Calculate the mean stopping force in each landing (ignore her weight). [3]



(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)

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.

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

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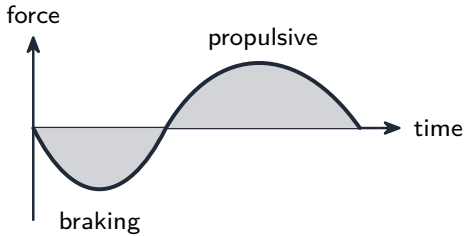
(c) Explain why bending the knees reduces the risk of injury. [2]

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

Exercise 3.3 (a)

3.3 The graph shows the horizontal ground reaction force during one foot contact in running.

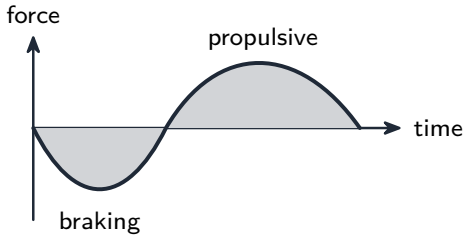
(a) Explain why the first part of the contact slows the runner. [2]



Exercise 3.3 (a)

3.3 The graph shows the horizontal ground reaction force during one foot contact in running.

(a) Explain why the first part of the contact slows the runner. [2]



(a) the foot lands ahead of the body, so the ground pushes backwards on the runner; this braking impulse reduces forward momentum

Exercise 3.3 (b)

3.3 The graph shows the horizontal ground reaction force during one foot contact in running.

(b) Explain how the runner can speed up over several steps. [2]

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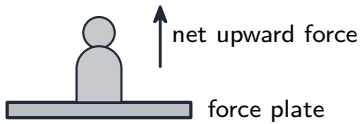
(b) Explain how the runner can speed up over several steps. [2]

(b) the propulsive impulse must be larger than the braking impulse; so the net impulse is forward and momentum (velocity) rises with each step

Exercise 3.4 (a)

3.4 In a vertical jump on a force plate, the net upward impulse is 180 N s. The jumper's mass is 60 kg.

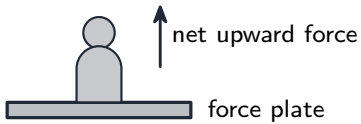
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Exercise 3.4 (a)

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(a) Calculate the take-off velocity. [2]



(a) $v = 180 \div 60 = \mathbf{3.0}$ m s^{-1}

Exercise 3.4 (b)

3.4 In a vertical jump on a force plate, the net upward impulse is 180 N s. The jumper's mass is 60 kg.

(b) Calculate the jump height ($g = 9.81$ m s^{-2}). [2]

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(b) Calculate the jump height ($g = 9.81$ m s^{-2}). [2]

(b) $h = v^2 \div 2g = 9 \div 19.62 \approx \mathbf{0.46}$ m

Exercise 3.4 (c)

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(c) Suggest **one** reason why a jump-and-reach test may give a different height. [1]

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(c) Suggest **one** reason why a jump-and-reach test may give a different height. [1]

(c) e.g. arm reach and shoulder movement add height; the reach is measured at the top of the hand, not the centre of mass; timing error