Exercise walk-through

5.3
Collisions, friction, power and fluid forces

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 yourself

Separate signs, force boundaries and model assumptions

Count frame intervals. Average and peak force differ. Net force is not ground reaction; third-law partners act on different bodies.

Conserved angular momentum requires negligible external torque. Gravity remains at a projectile's apex, and follow-through cannot keep pushing after separation.

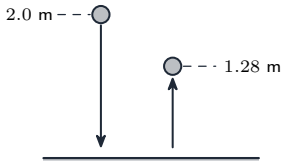
AHL: restitution uses relative speeds, static friction adjusts, buoyancy uses displaced volume and aerodynamic comparisons use relative flow. Mechanical power differs from metabolic cost.

Exercises 2.1·2.2

2.1 Distinguish between static and dynamic friction. [2]



2.2 A ball is dropped from 2.0 m and bounces to 1.28 m. Calculate the coefficient of restitution and state what it shows. [3]



Exercises 2.1·2.2

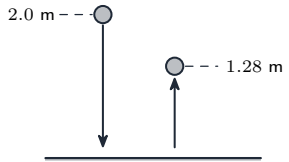
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2.1

static friction acts when the surfaces are not yet sliding; it matches the applied force up to a maximum; dynamic friction acts while sliding and is smaller than the maximum static friction

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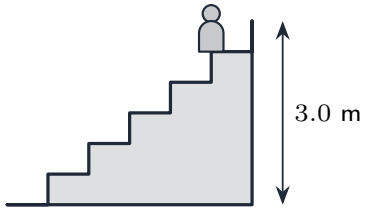
2.2

$e = \sqrt{1.28 \div 2.0} = \sqrt{0.64} = \mathbf{0.8}$; the collision is fairly elastic, but some energy is lost as heat and sound

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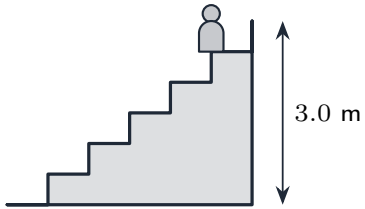
Exercise 2.3

2.3 A 70 kg athlete runs up stairs with a vertical height of 3.0 m in 2.5 s. Calculate the work done against gravity and the mean power ($g = 9.81$ m s^{-2}). [3]



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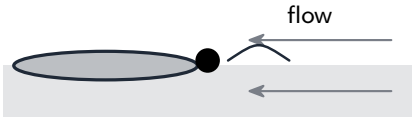
2.3

$W = mgh = 70 \times 9.81 \times 3.0 \approx \mathbf{2060}$ J; $P = 2060 \div 2.5 \approx \mathbf{820}$ W

Exercise 2.4 (a)

2.4 A swimmer wants to reduce drag.

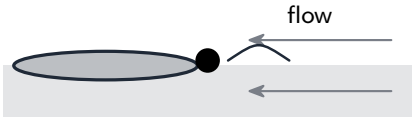
(a) Identify **three** types of drag acting on the swimmer. [3]



Exercise 2.4 (a)

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(a) surface (skin friction) drag; form (pressure) drag; wave drag

Exercise 2.4 (b)

2.4 A swimmer wants to reduce drag.

(b) Suggest how a swimsuit can reduce **one** of them. [1]

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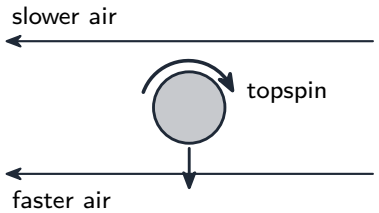
(b) Suggest how a swimsuit can reduce **one** of them. [1]

(b) a smooth, tight suit reduces surface drag / compresses the body to reduce form drag

Exercise 3.1 (a)

3.1 A tennis player hits the ball with heavy topspin.

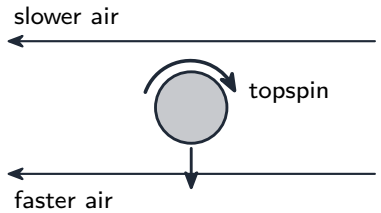
(a) Explain why topspin makes the ball dip. [3]



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(a) the top of the ball moves against the oncoming air, the bottom moves with it; air below the ball moves faster than air above; so pressure is lower below and higher above, giving a downward force

Exercise 3.1 (b)

3.1 A tennis player hits the ball with heavy topspin.

(b) Name this effect. [1]

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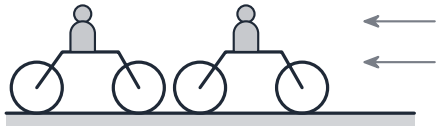
(b) Name this effect. [1]

(b) the Magnus effect

Exercise 3.2 (a)

3.2 A cyclist meets 20 N of air drag at 10 m s^{-1}. Drag is proportional to speed squared.

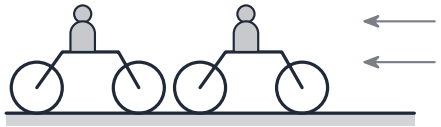
(a) Calculate the drag at 15 m s^{-1}. [2]



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(a) $20 \times (15 \div 10)^2 = \mathbf{45}$ N

Exercise 3.2 (b)

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(b) Calculate the power needed to overcome this drag at 15 m s^{-1}. [2]

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(b) $P = Fv = 45 \times 15 = \mathbf{675}$ W

Exercise 3.2 (c)

3.2 A cyclist meets 20 N of air drag at 10 m s^{-1}. Drag is proportional to speed squared.

(c) Explain why riding close behind another cyclist (drafting) saves energy. [2]

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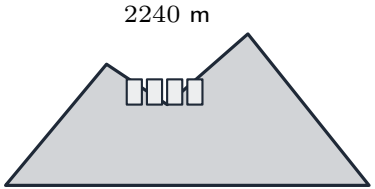
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(c) Explain why riding close behind another cyclist (drafting) saves energy. [2]

(c) the rider in front pushes the air aside, leaving a low-pressure, slower-moving zone behind; the following rider meets less form drag, so needs less power for the same speed

Exercise 3.3

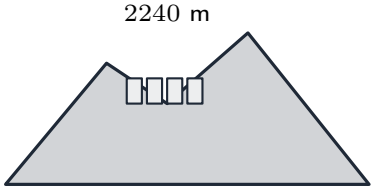
3.3 The 1968 Olympic Games were held in Mexico City, about 2240 m above sea level. Discuss how the altitude was likely to affect performances in different events. [8]



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3.3

award up to [8]: air at altitude is less dense; so drag is lower; short, fast events gain: sprints, jumps and throws, e.g. many sprint and jump records were set there, including Beamon's long jump; lower air pressure means a lower partial pressure of oxygen; so less oxygen reaches the muscles and aerobic events of more than about 2 minutes were slower; athletes from high-altitude regions were less affected, being acclimatized; conclusion: altitude helps anaerobic, high-speed events and harms endurance events