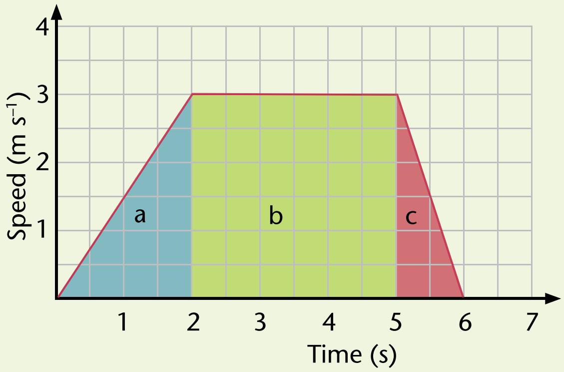
1.1

The **area under a speed-time graph** indicates the **distance** travelled by the object.

In calculating the distance, the area under *each section of the graph* needs to be calculated and then added together.



Area is	triangle a	+	rectangle b	+	triangle c	
	½(3 × 2)	+	(3 × 3)	+	½(3 × 1)	= 3 + 9 + 1.5 = 13.5 m

Force and motion

A **force** (*F*) is a *push* or a *pull*. Forces have both **size** (measured in **newtons**, *N*) and **direction**. Both the size and the direction of a force can be represented by **arrows**:

- *the length of the arrow indicates the size of the force*
- *the direction of the arrow indicates the direction of the force.*

The **combination of all forces acting on the object gives the net force** (F_{net}).

The **net force** determines the **motion of an object**.

If the forces acting on an object are equal and opposite, then they are **balanced** and the **net force is zero**. This results in the object **moving at a constant speed** in a **constant direction**.

If the forces acting on an object are *not equal and/or not opposite*, then the forces are **unbalanced** and the speed and/or direction of the object are **changing**.

friction (from air resistance, from moving parts and between the tyres and the road surface)

thrust

The forces on the car are **balanced** as the forward force (thrust) provided by the engine is *equal and opposite* to the backward force of friction acting on the car (the largest frictional force will be that from **air resistance**). Therefore, the car is **moving at a constant speed** (and does not change direction).

friction (from air resistance, from moving parts and between the tyres and the road surface)

thrust

The forces acting on the car are **unbalanced** as the force from the *forward thrust of the engine is greater than that of the friction force*. Therefore, the car is **accelerating** (speed is increasing, i.e. not constant).

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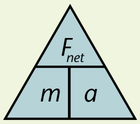
The forces acting on the car are **unbalanced** as the *friction force is greater than the thrust force* provided by the engine. Therefore, the car is **decelerating** (speed is decreasing, i.e. not constant).

The greater the net force, the greater the acceleration or deceleration.



The net force (F_{net}) acting on an object is calculated from:

force = mass × acceleration *or* $F = ma$

The units used in this calculation must be **force** in **newtons** (N), **mass** in **kilograms** (kg), and **acceleration** in m s^{-2}. If, in a calculation, a variable does *not* use one of these units (e.g. a variable was in grams not kilograms), then that variable *must be converted* (e.g. 1 500 g would be need to be converted to 1. 5 kg).

Friction and motion

Friction is the force that *opposes motion*, therefore friction *acts to slow down a moving object.* Friction is *always present when an object is moving.* The **thrust of an engine** is needed to overcome the forces of friction acting on a car, especially that of **air resistance** (friction from the car pushing through air, also referred to as 'drag'). Moving parts of a car's engine or wheels also produce friction. Ground resistance (between tyres and the road) also produce friction. An object (e.g. boat/swimmer) moving through water experiences *water resistance* – friction from the sea/river – which acts to slow down the object. *An object must generate enough force to overcome any/all sources of friction to move / keep moving / accelerate.*

Friction can therefore be *unhelpful* by slowing down movement and wearing out parts. However, it can also be (very) *helpful* by providing traction (e.g. for car tyres, running shoes), slowing down objects (e.g. parachutes), providing grip (e.g. brake pads, holding a sports racket).

Friction may be *reduced* by using lubricants such as oils and greases, streamlining objects, using ball bearings, reducing tread such as using thin tyres on a bicycle, reducing the surface area between two objects. Friction may also be *increased* by increasing surface area such as opening a parachute, increasing tread on tyres and shoes, removing streamlining of an object.

To enable a high-speed plane like the Mig-29 to land on a short runway,
a parachute is used to increase friction to slow the plane down.

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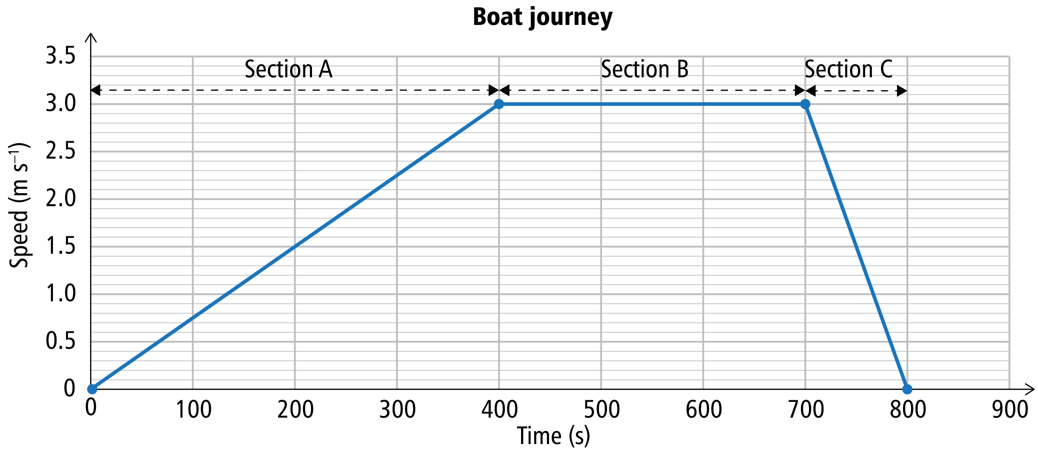
Questions: Straight-line motion and force

Question One: Motion of a boat

Year 2019 Ans. p. 109

A boat travels across a lake to the start of a walking track. The graph below shows the boat's journey.



a. Describe the motion of the boat during each section of the journey.

Section A: ______________________________

____

Section B: ______________________________

____

Section C: ______________________________

____

b. Calculate the acceleration of the boat in the first 400 seconds.

____

____

____

acceleration = ______________ $m\ s^{-2}$

c. Explain the acceleration and motion of the boat shown in Section B of the graph by discussing the horizontal forces acting on the boat.

____

____

____

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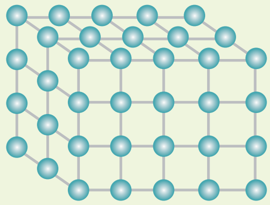
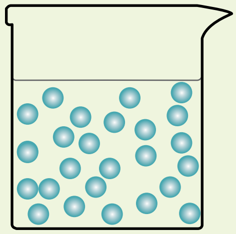
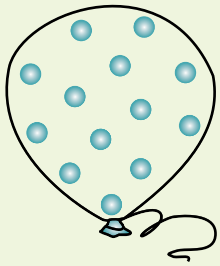
Rates of reaction

The *particle theory* (‘*kinetic theory*’) of matter states that all matter is made up of tiny particles which are in a constant state of motion. The particles can be atoms, ions, molecules. The amount of movement of the particles depends on the *state* of matter.

Solid	Liquid	Gas
		
Particles have low-energy atomic vibration movement only.	Particles have some movement energy, so can slide past each other.	Particles have high energy and rapid movement in all directions.

Collision theory

Particles constantly collide as a result of their movement. A **chemical reaction** occurs when the particles collide with *sufficient kinetic energy*, E_K, to break the bonds that hold the particles together. The number of collisions between particles is increased by the following.

- **Higher temperatures** – higher the E_K of particles.
- **Higher concentrations** – more particles in a volume (e.g. concentrated HCl has more particles than the same volume of dilute HCl).
- **Increasing the surface area** (**SA**) – more particles exposed to each other (e.g. a solid that is a powder has greater SA than a solid that is a lump; mixing/stirring increases SA; solutions have more SA than solids).

Reaction rate (*how fast* a chemical reaction occurs) can be measured in a school lab by the following.

- How fast reactants are used up (e.g. time for a solid to disappear, or colour to disappear or change).
- How fast products are formed (e.g. time for colour to change or form, time for bubbles of gas to form).

Example

Calcium carbonate (marble chips) reacts with hydrochloric acid to form calcium chloride, water, and carbon dioxide. The rate of this reaction could be measured by timing how long it takes for:

- the marble chips to disappear
- CO_2 bubbles to form.

If the CO_2 gas is collected and measured over time to find the reaction rate, the following line graph could be produced:

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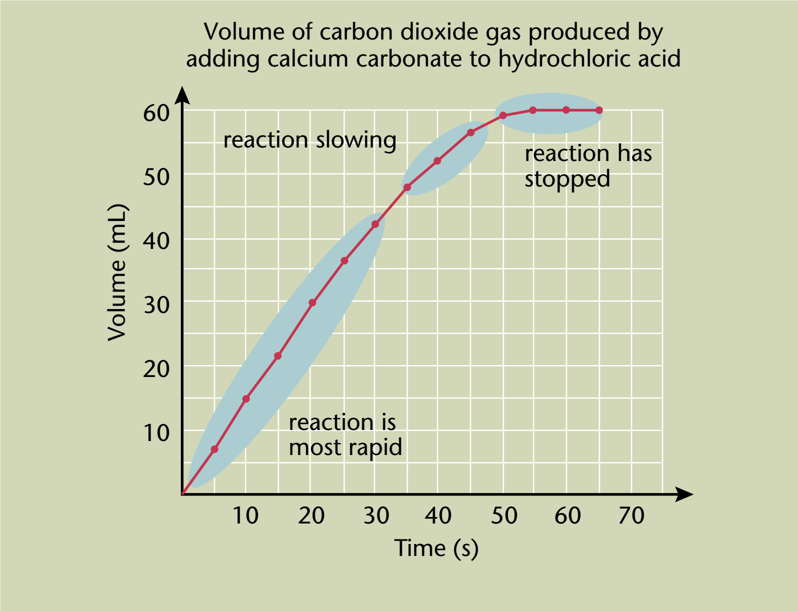

Reactions begin *rapidly* (many reactant particles in the reaction system, i.e. high concentration) then *slow* as reactants are used up (concentration decreases) and *stop* when one of the reactants is used up.

Catalysts increase the rate of some reactions. A catalyst does not get used up in the reaction or become part of the products. *Enzymes* are catalysts found in living things; without them, chemical reactions would take place too slowly for life to exist. Catalysts lower the energy needed for a successful collision – therefore more successful collisions occur, increasing the reaction rate.


Iron rusting – slow reaction rate


Burning wood – high reaction rate

The smaller pieces of wood (kindling) will burn much faster than the larger pieces of wood (logs) as the kindling has a large surface area – higher reaction rate.

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Questions: Rates of reaction

Year 2019
Ans. p. 118

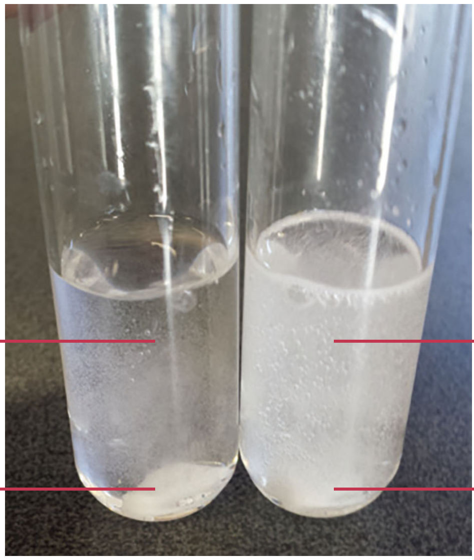
Question One: Reaction between nitric acid and calcium carbonate

Two boiling tubes both contain 10 mL of nitric acid, HNO_3. Boiling tube A contains a 0.1 mol L^{-1} solution of nitric acid and boiling tube B contains a more concentrated 1.0 mol L^{-1} solution of nitric acid. A piece of marble chip (calcium carbonate, $CaCO_3$) with a mass of 0.5 g is added to each boiling tube and the reaction is observed and photographed.

The temperature of the acid in both boiling tubes is 20 °C.

Boiling tube A

Boiling tube B



Less concentrated:
0.1 mol L^{-1} nitric acid, HNO_3

0.5 g calcium carbonate, $CaCO_3$

More concentrated:
1.0 mol L^{-1} nitric acid, HNO_3

0.5 g calcium carbonate, $CaCO_3$

a. Write the word equation AND the balanced symbol equation for the reaction between the nitric acid and calcium carbonate.

Word equation

Balanced symbol equation

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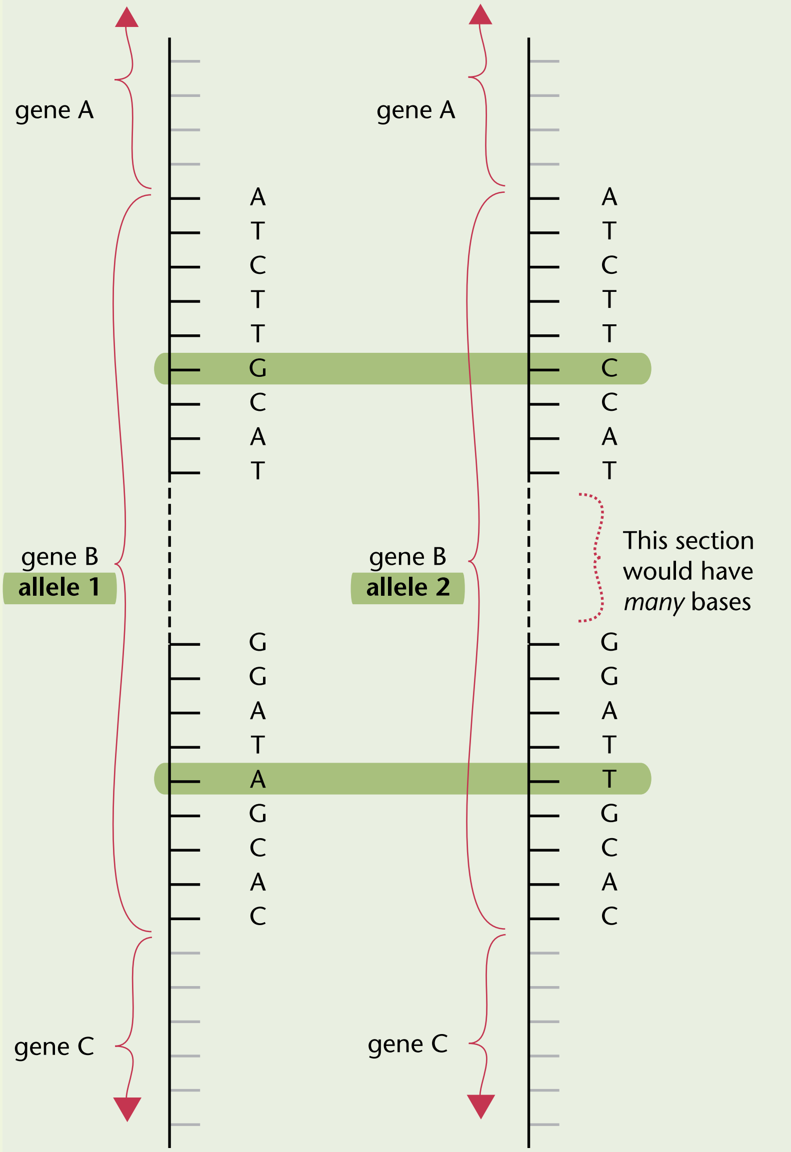
DNA *replicates* prior to cell division (mitosis and meiosis). Errors in replication may cause changes in the base sequence – a **mutation**. Mutations that occur in the formation of **gametes** (sex cells – sperm and ova) during meiosis *may be inherited*; mutations that occur during mitosis in body cells (e.g. skin) are *not* inherited. Mutations produce *new alleles* for a characteristic (e.g. the alleles for blue and green eyes in humans are believed to be caused by mutations in the allele for brown eyes). **Genetic variation** results from *differences in the DNA between individuals* in a population. The amount of genetic variation in a population is determined by the *number of different alleles* in the population. Therefore, mutations *increase genetic variation* in a population.

The information on a pair of alleles is the **genotype**. The outward appearance / visible expression of the genotype is the **phenotype**.

A **dominant** allele is *always expressed in the phenotype* when it occurs in the genotype; it masks the presence of a recessive allele. A **recessive** allele is expressed in the phenotype *only* when accompanied by *another* recessive allele. Upper-case letters represent dominant alleles; lower-case letters represent recessive alleles.

The diagram shows (parts of) three genes A, B and C. Only one strand of DNA is shown (untwisted) for each allele. The alleles for gene B have a slightly different base sequence – these differences are highlighted – therefore the alleles are different and will code for different traits in the individual.



For example, in rabbits, brown-haired allele (**B**) is dominant to white-haired allele (**b**). Genotypes **BB** and **Bb** both produce brown hair; genotype **bb** produces white hair. When both alleles are the *same* (e.g. **BB** or **bb**), genotype is **homozygous.** Homozygous individuals are **pure breeding** as they pass on only one type of allele to their offspring (e.g. **B** from **BB** genotype or **b** from **bb** genotype). When both alleles in a pair are *different* (e.g. **Bb**), genotype is **heterozygous**. Heterozygous individuals are *not* pure breeders because they can pass on *either* type of allele (e.g. **B** *or* **b** from **Bb** genotype).

white rabbit
bb

brown rabbit
BB or **Bb**

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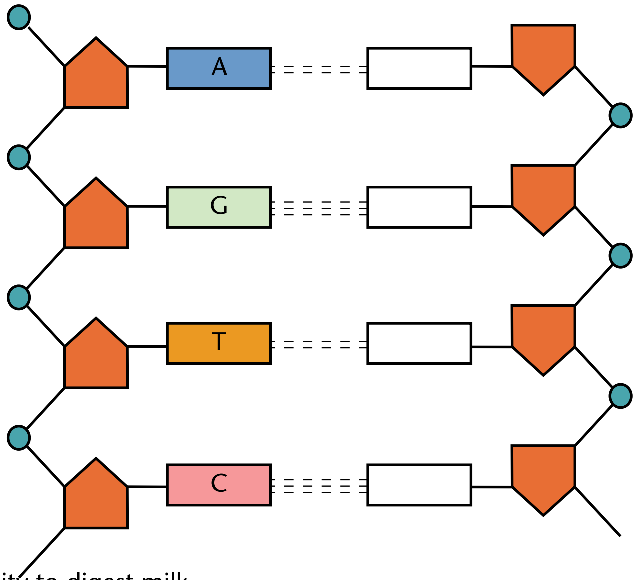
Questions: Chromosomes, DNA, genes, alleles

Year 2019
Ans. p. 120

Question One: DNA structure

a. Label the blank bases A, G, T or C in the diagram of DNA shown alongside.



Some adults can digest milk, but the majority 65% cannot. The ability to digest milk as an adult is caused by a DNA mutation.

b. What is a mutation?

c. Explain how a mutation can give adults the ability to digest milk.
You should include the terms **DNA**, **gene**, **allele**, **phenotype**, and **mutation**.

d. Explain how a mutation can be passed on to the next generation.

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Question Two: Inheritance of colour in tūī

Year 2018
Ans. p. 121

A coloured tūī

A white tūī

1.9

Leucism is a genetic condition caused by a gene mutation that results in some (or all) of an animal being white.

a. How could a change in a **gene** result in the **phenotype** of the white tūī shown above? Your answer should include the terms **DNA** and **allele**. *Punnett squares are not required.*

b. Explain whether the white colouration would be inheritable or not. Your answer should include the terms **inheritable** and **non-inheritable**.

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Answers and explanations

Achievement Standard 90940 (Science 1.1): Demonstrate understanding of aspects of mechanics

In *all* answers involving calculations:

- give the relevant *formula*, e.g. F = ma
- if required, *rearrange* the formula to find the correct quantity,

  e.g. $m = \frac{F}{a}$
- *substitute* the correct values, e.g. $m = \frac{10}{2}$

  (remember to *convert* any non-standard values to standard values first – e.g. kilometres to metres, grams to kilograms – as required in the formula)
- do the *calculation* and give the correct *unit*, e.g. 5 kg.

1.1 Straight-line motion and force

Question One: Motion of a boat

p. 5

a. Section A: Boat has constant acceleration.

Section B: Boat has constant speed.

Section C: Boat has constant deceleration.

b. $a = \frac{\Delta v}{\Delta t} = \frac{3}{400} =$ **0.0075 m s^{-2}**

c. The boat is moving at a **constant speed** and not accelerating (or decelerating) during Section B of the graph. This is because the forces acting on the boat are **balanced** – the forward thrust from the motor is **equal and opposite** to the forces of friction from the air and the water. As the forces are equal and opposite, there is **no net force** acting on the boat. Therefore, it moves at a constant speed.

d. Distance is calculated from the *area under the speed-time graph* = area of Section A plus area of Section B plus area of Section C.

Area of A = $\frac{1}{2}(3 \times 400)$; area of B = 3 × 300;

area of C = $\frac{1}{2}(3 \times 100)$ = 600 + 900 + 150 = **1 650 m**

(**A** – all answers correct in a.; correct calculation in b.; describes the two forces acting on the boat in c.; gives distance as area under graph in d. and attempts calculation;

M – as for **A** and explains balanced forces in c.; completes calculation in d. with minor error;

E – as for **M** and provides full explanation of the net force and effect on motion in c.; correct calculation of area in d.)

Question Two: A 100 m race

p. 7

a. Runner A has the greater acceleration in the first 3 s as the **gradient** on the speed-time graph for Runer A is **steeper/ greater** than that of Runner B.

b. $a = \frac{\Delta v}{\Delta t} = \frac{9-0}{3-0} = \frac{9}{3} =$ **3 m s^{-2}**

c. i. Runner A accelerates at 3 m s^{-2} for the first 3 s (answer to b.) then runs at a constant speed of 9 m s^{-1} between 3 s and 10 s. Runner B accelerates at $\frac{10}{4}$ = 2.5 m s^{-2} for the first 4 s then runs at a constant speed of 10 m s^{-1} between 4 s and 10 s.

Therefore, Runner A initially has greater acceleration than Runner B (3 m s^{-2} compared with 2.5 m s^{-2}), but Runner B subsequently has a higher constant speed (10 m s^{-1} compared with Runner A's 9 m s^{-1}) up to the 10 s mark.

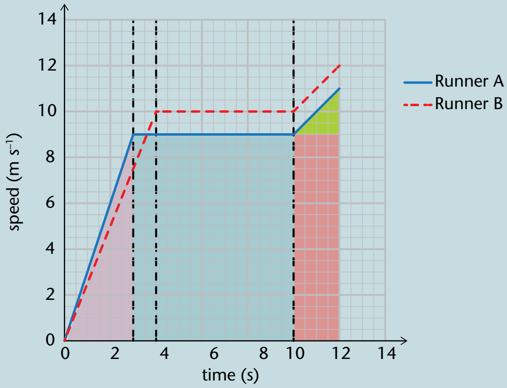
ii. Distance is area under a speed-time graph.

Runner A = ½(9 × 3) + (9 × 7) + ½(2 × 2) + (9 × 2) = 13.5 + 63 + 2 + 18 = **96.5 m**

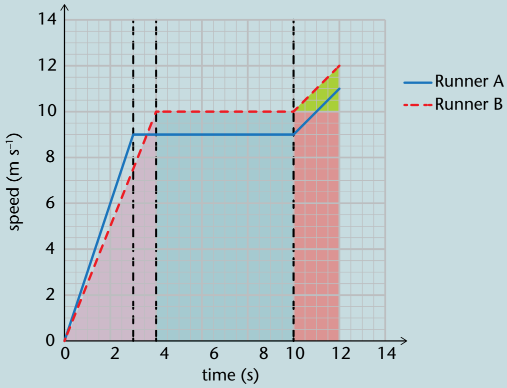
Runner B = ½(4 × 10) + (6 × 10) + ½(2 × 2) + (10 × 2) = 20 + 60 + 2 + 20 = **102 m**

Therefore, Runner B finishes the race first while Runner A does not reach the 100 m mark in the 12 s recorded (Runner A does not finish the race).

Runner A = ½(9 × 3) + (9 × 7) + ½(2 × 2) + (9 × 2) = 13.5 + 63 + 2 + 18 = **96.5 m**



Runner B = ½(4 × 10) + (6 × 10) + ½(2 × 2) + (10 × 2) = 20 + 60 + 2 + 20 = **102**



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d. $P = \frac{F}{A}$, therefore $F = PA = 13\,000 \times (0.0200 \times 2)$

$= 13\,000 \times 0.0400 =$ **520 N**

(**A** – correct calculations in a. and b., c. i. correct description of speed and acceleration of both Runners, c. ii. stated that distance is area under speed-time graph and attempts both calculations but errors present, in d. gave correct formula and attempts both calculations but errors present;

M – as for **A** and in c. i. compares the speed and acceleration of the Runners, and in ii. has both calculations correct, in d. attempts both calculations but minor error(s) prevent correct answer / carried over error present between first and second calculations;

E – as for **M** and in c. i. compares the speed and acceleration of the Runners supported by figures/ data from the graph/calculations, in ii. explains using data why Runner B finished first, in a. both calculations completely correct)

Question Three: Horse and rider

p. 8

a. Section A: horse and rider are accelerating

Section B: horse and rider are at a constant speed

Section C: the horse and rider are decelerating to a stop (at 70 s)

Section D: the horse and rider are stopped

b. $v = \frac{\Delta d}{\Delta t} = \frac{500 - 100}{60 - 30} = \frac{400}{30} = 13.3 \text{ m s}^{-1}$

c. $P = \frac{F}{A}$; therefore $F = P \times A = 200\,155 \times 4 \times 0.0044 =$ $200\,155 \times 0.0176 = 3522.7$ N

d. The rider increases the mass hence the weight of the horse when the horse is mounted. This increases the overall **weight-force due to gravity**. The area (*A*) – the horse's hooves – remains the same. As $P = \frac{F}{A}$, as the force (*F*) increases the pressure (*P*) per unit area will also increase. This results in the horse with rider sinking further into the (soft) sand.

(**A** – all answers correct in a., correct calculation of speed in b. but may have omitted the units or units incorrecct, give formula $P = \frac{F}{A}$ in c. and attempts the calculation but has errors, describes rider as increasing the overall weight of the horse linked to increased sinking into the sand in d.;

M – as for **A** and calculation in b. completely correct, correct calculation of *F* in c. including correct units, explains sinking into the sand in relation to either the pressure of the forces acting in d.;

E – as for **M** with all calculations completely correct throughout and in-depth correct explanations in both c. and d.)

Question Four: Forces

p. 10

a. i. Mass is the amount of matter in an object, while weight is the result of (the downward force of) gravity acting on the mass. Mass is measured in kg (or g), while weight is measured in N.

ii. 630 g = 0.63 kg, $F = mg$, therefore:
weight = 0.63 × 10 = 6.3 N

b. Forces are *balanced* when they are equal and opposite. However, when one of the forces is greater than the other, the forces are *unbalanced* and there is a net force (overall force) in the direction of the greater force. When the two forces are balanced / when there is no net force, then the object is moving at a constant speed (including zero speed / stopped). When a net force is acting on an object, its speed is increasing (the object is accelerating) when the net force is in the same direction as the movement *or* the speed is decreasing (the object is decelerating) when the net force is against the direction of movement. In the left-hand diagram, the forces are equal and opposite, so they are balanced and the kererū flies at a constant speed. In the right-hand diagram, there is a net force against the direction of movement, therefore the kereru is decelerating or slowing down.

c. i. $a = \frac{\Delta v}{\Delta t}$

Bird B is flying at 9 m s^{-1} after 3 s, while **Bird A** is flying at 7.5 m s^{-1} after 3 s. Therefore, **Bird B** has the greater acceleration as *t* (time) is the same for both birds.

ii. *d* (distance travelled) = area under a speed/time graph.

The area under the graph line can be divided into two triangles with a rectangle in between:

- area of a triangle = ½ × base × height
- area of a rectangle = base × height

total area = LHS triangle + rectangle + RHS triangle

For **Bird A**, $d = ½(10 \times 4) + (10 \times 10) + ½(10 \times 2)$

$= 20 + 100 + 10 = 130$ m

Bird A travels 130 m, while **Bird B** travels 121.5 m, therefore **Bird A** travels:

130 – 121.5 = 8.5 m further than **Bird B**.

(**A** – describes/defines both mass and weight and correctly calculates weight of kererū in a., describes/defines net force and links to bird's movement in b., identifies which bird has greater acceleration in c. i.; **M** – as for **A** and explains difference between mass and weight in a., explains link between net force and movement in b., explains which bird has greater acceleration in c. i., identifies area under graph equates to distance and attempts calculation but errors present in c. ii.; **E** – as for **M** and explains fully the relationship between net force, movement, direction of movement in b., correctly calculates distance travelled by **Bird A** and difference between it and **Bird B** in c. ii.)

Question Five: Cycling

p. 12

a. Weight = $m \times g = 99 \text{ kg} \times 10 \text{ N kg}^{-1} = 990$ N

b. i. Section A: The cyclist is accelerating.

Section B: The cyclist is at a constant speed.

Section C: The cyclist is decelerating to a stop (at 14 s).

Section D: The cyclist is stopped.

ii. $v = \frac{\Delta d}{\Delta t} = \frac{15 - 5 \text{ m}}{10 - 5 \text{ s}} = \frac{10 \text{ m}}{5 \text{ s}} = 2 \text{ m s}^{-1}$

c. Weight force of bike = $m \times g = 20 \text{ kg} \times 10 = 200$ N

$W = Fd = 200 \text{ N} \times 1.5 \text{ m} = 300$ J

$P = \frac{W}{t} = \frac{300 \text{ J}}{3 \text{ s}} = 100$ watts

d. As the height remains the same at 1.5 m, the amount of work (hence energy transformed into Joules) remains the same when the bike is pushed up the ramp compared with lifting the bike up. $W = F \times d$, and as *d* has increased (ramp is longer than vertical height), then the force needed to push the bike up the ramp is less than that required to lift it up. $P = \frac{W}{t}$; work remains the same, but the time taken to push the bike up increases. With *W* the same and *t* larger, the power (needed) decreases.

(**A** – correctly calculates weight in a., correctly describes motion for each section in b. and speed calculation (may contain minor error), calculates weight and work in c.; **M** – correctly calculates power in c., explains less power expended in d.; **E** – all parts of question correct with full explanations in d. supported by appropriate equations/calculations)

1.1 Mass, weight, gravity, pressure

Question One: Sinking into sand

p. 16

a. $P = \frac{F}{A}$. The force *F* exerted is the weight of the adult; the area *A* is the combined surface area of the two feet. The force acting on the area of the two feet exerts pressure, which results in the person sinking into the sand.

b. $P = \frac{F}{A} = \frac{690}{0.0200 + 0.0200} = \frac{690}{0.0400} =$ **17 250 Pa**

c. $P = \frac{F}{A}$ applies to both the adult and the child. The adult is larger and therefore has greater weight force (adult has greater mass) and area (adult's feet are larger) than the child. However, both adult and child sink into the sand to the same depth; therefore, both the adult and the child *must be exerting the same pressure*. Therefore, the *ratio of force : area must be the same for both*.

d. *P* is the same for both the adult and the child = 17 250 Pa.

$P = \frac{F}{A}$, therefore, $F = \frac{P}{A}$. Therefore, for the child:

$F = 17\,250 \times (0.0150 + 0.0150) = 17\,250 \times 0.0300 = 517.5$ N

Newtons is the weight (weight-force) of the child; therefore, the mass of the child is $\frac{517.5}{10} =$ **51.75 kg**

Answers

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