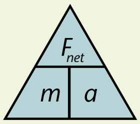
The forces acting on the car are **unbalanced** as the *friction force is greater than the thrust force* provided by the engine. Therefore, the car is **decelerating** (speed is decreasing, i.e. not constant).

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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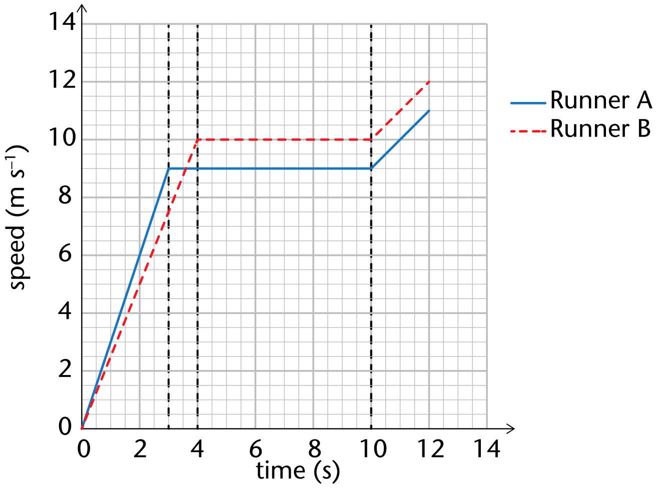
Year 2018
Ans. p. 109

Questions: Straight-line motion and force

Question One: A 100 m race

The speed-time graph shows the motion of two runners in a 100 m race.



a. From the graph, which runner has the greater acceleration in the first 3 seconds?

Explain your answer.

Calculations are not required.

b. Using the graph, calculate Runner A's acceleration during the first 3 seconds.

c. i. Use the information in the graph to compare the speed AND acceleration of Runner A and Runner B in the first 10 seconds.

ii. Use the information in the graph and calculations to show which runner, Runner A or Runner B, finished the 100 m first.

d. **Each** of Runner A's feet has a surface area of 200 cm^2 (0.0200 m^2), which sink into the track. Together, the feet exert a pressure of 13 000 Pa. Calculate the **weight** of Runner A.

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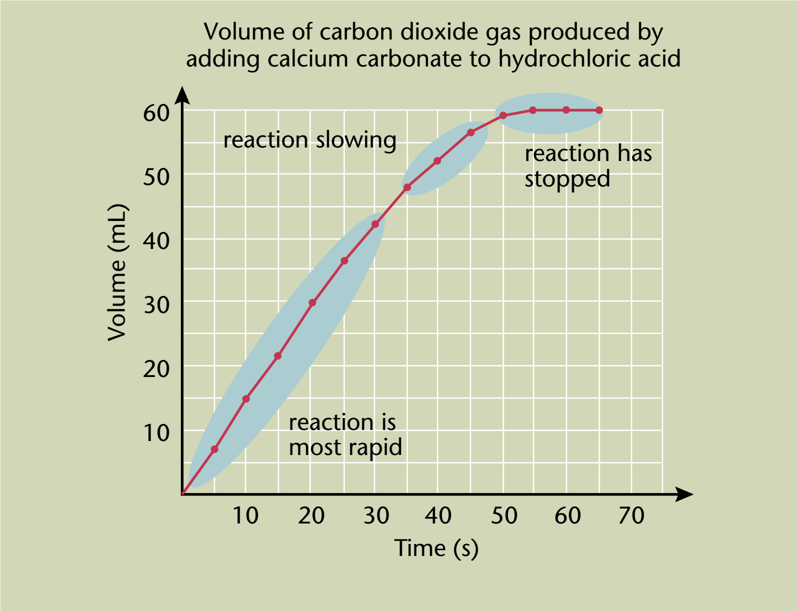

Reactions begin *rapidly* (many reactant particles in the reaction system, i.e. high concentration) then *slow* as reactants are used up (concentration decreases) and *stop* when one of the reactants is used up.

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 2018
Ans. p. 119

Question One: Reaction of magnesium carbonate and nitric acid

Some magnesium carbonate powder is added to dilute nitric acid in an open conical flask. The flask is on an electronic balance, as shown in the illustration.

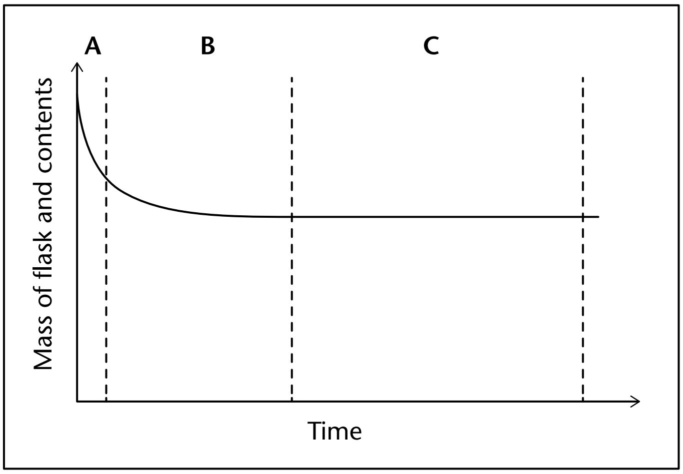
a. Write the word equation AND the balanced symbol equation for the reaction between the nitric acid and magnesium carbonate.

Word equation

Balanced symbol equation

The total mass of the flask and its contents is measured over time and recorded on the graph below.

Change in mass over time



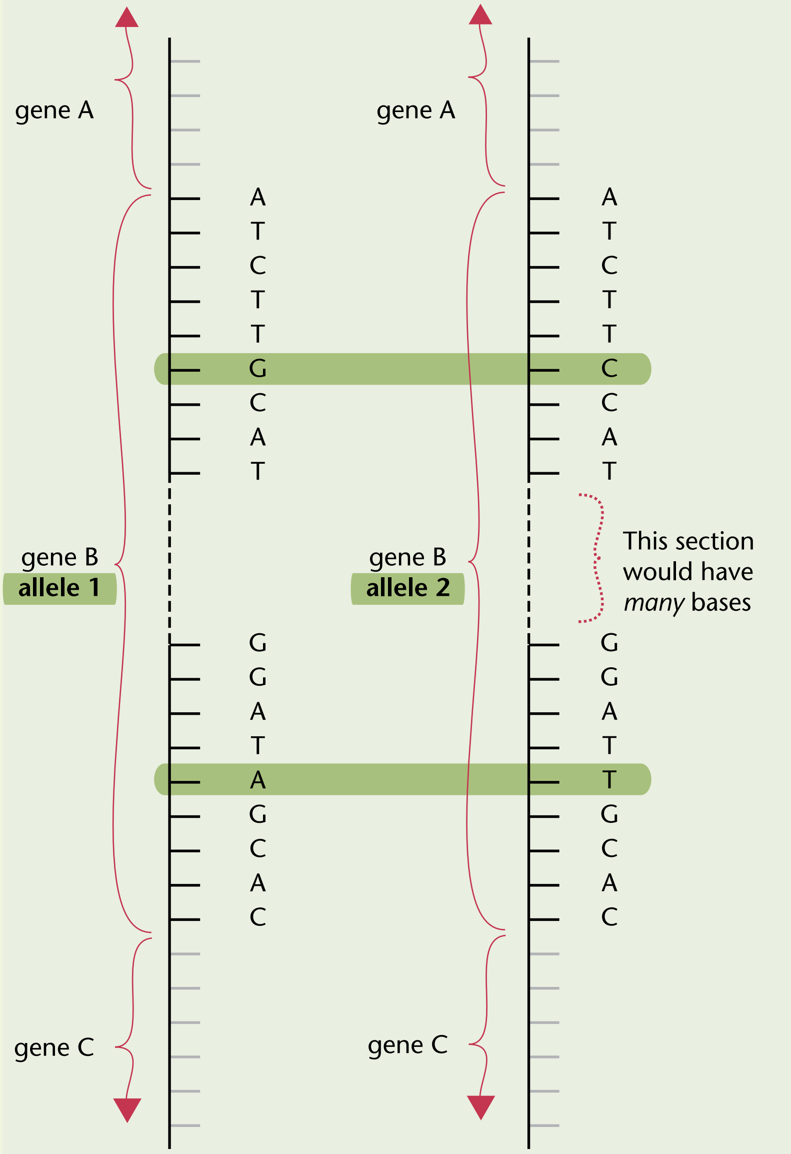
b. i. Why does the mass of the flask and its contents decrease during the reaction?

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). Mutations increase genetic variation in a population, because genetic variation in a population is determined by the *number of different alleles* in the 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 2018
Ans. p. 121

Question One: Inheritance of colour in tūī

A coloured tūī

A white tūī

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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Fertilisation is a chance event *as to which sperm* (with its unique combination of alleles) *fuses with which ovum* (with its unique combination of alleles). No two individuals are genetically and physically identical (except identical twins, who develop from the *same* fertilised ovum).

Meiosis and fertilisation ensure that **variation** occurs within a population, as a result of individuals being different. Individuals produced in sexual reproduction are *different from one another and from their parents*. This variation helps individuals to survive an environmental change such as a change in food supply, water supply or climate. Individuals with favourable variations have an increased chance of surviving the change(s), breeding, and passing on their favourable genes/alleles to their offspring. Over time, these favourable genes/alleles become more common within the population. The arrival of a new pathogen or parasite can be especially dangerous for individuals in a population. If all individuals are genetically identical / lack variation as a result of asexual reproduction, then all are at equal risk from attack by a new pathogen / parasite. If one individual dies then all individuals can die and the population can die out. However, in sexually reproducing organisms, there is a chance that genetic variation present within the population means some individuals survive while others die. Individuals that survive can breed, and so the population/species could survive.

Favourable variations are **adaptive features** (**adaptations**) that assist an individual's survival. Adaptations may be aspects of an individual's *structure*, *behaviour*, *physiology*. Adaptive features from *genetic information* (DNA) are **inheritable** and may be passed on from generation to generation. Features resulting from an individual's *environment* or *lifestyle* are **non-inheritable** – they do *not* enter or change an individual's genetic information (e.g. skin colour in humans is genetically determined, but actual colour depends on exposure to the sun).

Height in most organisms is determined by genetic factors; however, a poor diet / low levels of nutrients may prevent an individual from reaching their potential height (i.e. their growth is *stunted*). In plants, the amount of sunlight / light intensity reaching the plant can be important in determining whether the plant reaches its maximum potential height. Reduced sunlight means reduced photosynthesis, resulting in reduced growth of the plant – the plant is likely to be shorter than it would be in conditions of optimal sunlight.

Variation thus results from a *combination* of *genetic* and *environmental* factors.

Lifestyle events or the environment *modify the phenotype*. Therefore, an individual's phenotype results from the influence of the environment on the genotype:

genotype + environment → phenotype

Aphid producing offspring in asexual reproduction – all the offspring will be females and identical to one another and to the mother unless a mutation has occurred within a gene to form a new allele.

Male and female frog producing offspring in sexual reproduction; fertilised eggs are shown as a floating raft in the right of the photo – they will grow into individuals that will vary from one another and from their parents.

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Questions: Sexual reproduction – meiosis, variation and survival

Question One: Variation in Italian ryegrass

Year 2018
Ans. p. 126

Herbicides are chemicals that are used to kill weeds. Over many years, Italian ryegrass (a common weed) has developed a resistance to some herbicides (it is no longer killed by them).

Italian ryegrass in a cornfield

a. Explain how **variation** in the Italian ryegrass **population** can help the population develop herbicide resistance.

b. Explain how sexual reproduction increases variation in the Italian ryegrass population. Your answer should include **gamete formation** and **fertilisation**.

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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: A 100 m race

p. 5

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.

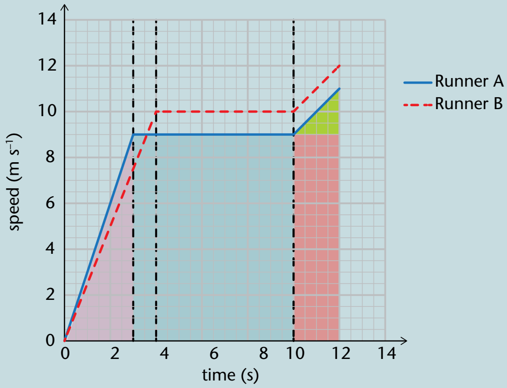
ii. Distance is area under a speed-time graph.

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

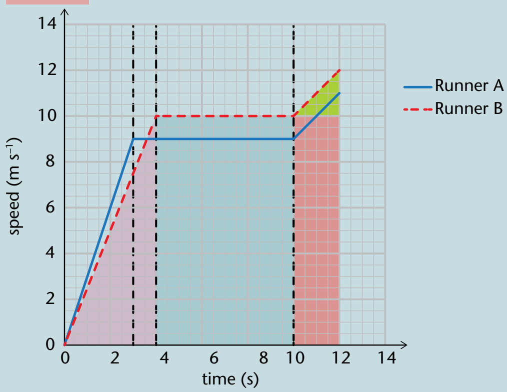
Runner B = ½(4 × 10) + (6 × 10) + ½(2 × 2) + (10 × 2) = 20 + 60 + 2 + 20 = **102 m**

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**



d. $P = \frac{F}{A}$, therefore $F = PA$ = 13 000 × (0.0200 × 2)
= 13 000 × 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 Two: Horse and rider

p. 6

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

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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 Three: Forces

p. 8

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 × 4) + (10 × 10) + ½(10 × 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 Four: Cycling

p. 10

a. Weight = $m \times g$ = 99 kg × 10 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 kg × 10 = 200 N

$W = Fd$ = 200 N × 1.5 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)

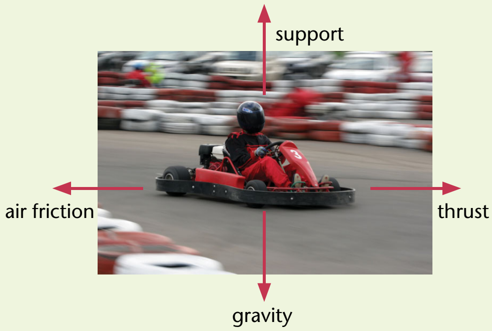
Question Five: Go-cart racing

p. 12

a. $a = \frac{\Delta v}{\Delta t} = \frac{15 - 0}{3} = 5.0\ \text{m s}^{-2}$

b. i.

In Section B, Zane is travelling at a constant speed (of 15 m s^{-1}).



ii. The go-cart is moving at a *constant speed* of 15 m s^{-1} therefore the forces acting on the go-cart are equal and opposite (i.e. balanced) so there is *no net force*. The thrust force from the engine (which creates forward motion) is balanced by the force of air friction (air resistance) which opposes the forward motion. As the go-cart is moving along a level surface, the downward force of gravity on the cart is balanced by the upward support force from the ground on to the cart's wheels.

c. Distance travelled = area under the speed/time graph = the area under sections A and B and C added together for each go-cart.

Zane = Section A + Section B + Section C

$= \frac{1}{2}(15 \times 3) + (15 \times 6) + \frac{1}{2}(3 \times 5) + (15 \times 5)$

$= 22.5 + 90 + 7.5 + 75 = 195$ m

Francis = Section A + Section B + Section C

$= \frac{1}{2}(16 \times 3) + (16 \times 6) + \frac{1}{2}(1 \times 5) + (16 \times 5)$

$= 24 + 96 + 2.5 + 80 = 202.5$ m

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