SCIENCE: 90940 DEMONSTRATE UNDERSTANDING OF ASPECTS OF MECHANICS: MOTION

ANSWERS

2019:1

(a) In Section A, the boat speeds up / accelerates for 400 s. In Section B it has a constant speed of 3 m s–1 for 300 s. In Section C it slows down / decelerating for 100 s.

(b) $a = \Delta v/\Delta t = 3.0/400 = 7.5\times10^{-3}$ ms^{-2} OR 0.0075 ms^{-2}

(c) Thrust and friction / drag are equal and opposite. The boat is moving with a constant speed, meaning that the acceleration is zero. If acceleration is zero, the net force must also be zero. This means that all the forces acting are balanced. Forces are balanced and thus $F_{net} = 0$ and therefore there is no acceleration (in Section B)

(d) Distance travelled = area under the graph.
d = (0 − 400 s) = 1/2 × 400 × 3 = 600 m
d = (400 − 700 s) = 300 × 3 = 900 m
d = (700 − 800 s) = 1/2 ×100 × 3 = 150 m
Total distance = 600 + 900 + 150 = 1650 m

2019:3

(b) $v = d/\Delta t = 450/9.49 = 47.4$ ms^{-1}

2018:1

(a) Runner A has the greater acceleration during the first 3 seconds. The gradient / slope of a speed-time graph equals the acceleration of the object. The steeper the slope, the greater the acceleration. Runner A has a steeper slope than Runner B in the first 3 seconds.

(b) $a = \Delta v/\Delta t = (9.0 - 0.0)/(3.0 - 0.0) = 3.0$ ms^{-2}

(c) (i) Runner A accelerates at 3 ms^{-2} for 3 seconds, reaching a speed of 9 ms^{-1}. Stays at constant speed of 9 ms^{-1} for next 7 seconds. Runner B accelerates at 2.5 ms^{-2} for 4 seconds, reaching a constant speed of 10 ms^{-1}. Stays at constant speed of 10 ms^{-1} for next 6 seconds.

Comparison: Runner A has a greater acceleration during first 3 seconds, but does not accelerate for as long as Runner B. Between 4 and 10 seconds, neither accelerated, they both had a constant speed. Runner B had a higher constant speed during this time.

(ii) Distance = area under graph.
d (Runner A) = (1/2 x 9 x 3) + (9 × 9) + (9 x 2) + (1/2 × 2 × 2) = 13.5 + 63+18 + 2 = 96.5 m
d (Runner B) = (1/2 ×10 × 4) + (8 ×10) + (1/2 × 2 × 2) = 20 + 80 + 2 = 102 m
Therefore, only Runner B has finished the race.

2017:1

(a) Sam accelerates at 0.8 ms^{-2} for 10 seconds, reaching a speed of 8 ms^{-1} . Stays at constant speed of 8 ms^{-1} for next 50 seconds.
Dani accelerates at 0.35 ms^{-2} for 20 seconds, reaching a constant speed of 7 ms^{-1}. Stays at constant speed of 7 ms^{-1} for next 40 seconds.
Comparison: Sam has a greater acceleration during first 10 seconds, but does not accelerate for as long as Dani. Between 20 and 60 seconds, neither accelerated; they both had a constant speed. Sam had a higher constant speed during this time.

(b) $a = \Delta v/\Delta t = (8 - 0)/10 = 0.8$ ms^{-2} F = ma = 308 × 0.8 = 246.4 N W = Fd = 246.4 × 40 = 9856 J

(d) Distance = area under graph. d (Dani) = (1/2 × 7 × 20) + (7 × 40) + (1/2 × 5 × 30) + (30 × 7) = 635 m
Difference = 710 – 635 = 75 m Therefore, Sam and his horse are 75 m ahead of Dani and her horse.

2016:1

(a) A: acceleration /increasing speed B: constant speed C: deceleration / decreasing speed D: stationary / constant speed / stopped

(b) v = d/t = (500 −100)/(60 – 30) = 400/30 = 13.3ms^{-1} = 13ms^{-1} (2sf) (Correct significant figures not required.)

2016:2

(a) Area under the graph = b × h = 200 × 7 = 1400 m

2016:3

(b) a = Δv/Δt = (20 – 0)/(1.2 – 0) = 16.7 ms^{-2} = 17 ms^{-2} (2 sf) (Sig.figs not required.)

2015:1

(a) v = d/t = 2/0.60 = 3.3 ms^{-1}

2015:2

(c) (i) Bird B has the greater acceleration – the gradient / slope of the line is greater. Bird A has an acceleration of: a = Δv/Δt = 10/4 = 2.50 ms^{-2} Bird B has an acceleration of: a = Δv/Δt = 9/3 = 3.00 ms^{-1}

(ii) Bird A travelled:

(A) 0 – 4 s: d = 1/2 × 4 ×10 = 20 m

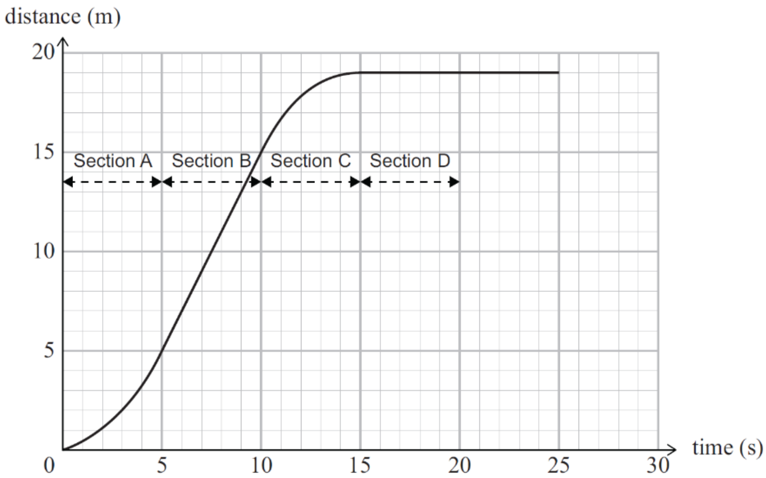
(B) 4 – 14 s: d = 10 ×10 = 100 m

(C) 14 – 16 s: d = 1 2 × 2 ×10 = 10 m

Total distance = 130 m. So Bird A has flown 8.50 m further. (130 – 121.5 = 8.50 m)

2014:1

(b) The cyclist's journey was plotted on the distance / time graph below.



(i) Describe the motion of the cyclist in each of sections A, B, C, and D.
No calculations are required.
Section A: Increasing speed / accelerating
Section B: Constant speed
Section C: Decreasing speed, decelerating
Section D: Stopped / stationary

(ii) Calculate the cyclist's speed during Section B.
v = d/t v = 10/5 = 2 ms^{-1}

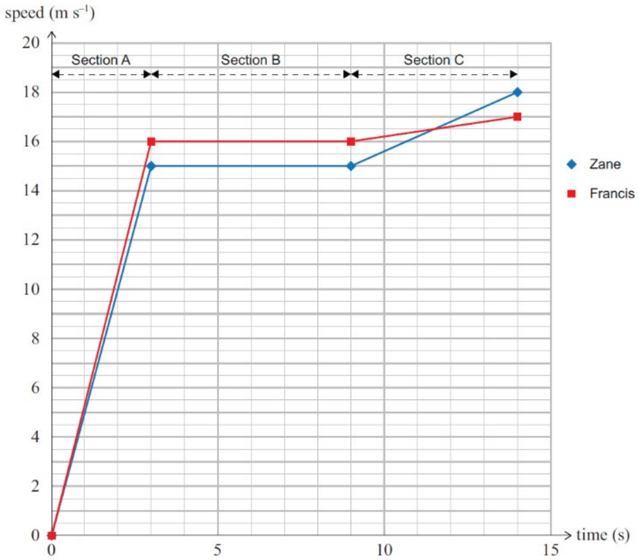
2014 :2

(a) It took 6 seconds to push the footstool a distance of 8.0 m across a room.
Calculate the average speed of the footstool as it is pushed.
v = d/t v = 8/6 = 1.3 ms^{-1} (do not accept 1.4 without working)

2014:4

Two go-carts were racing on a track.

A speed / time graph is shown below for each go-cart. Zane's graph is shown in blue, and Francis's in red.



(a) Calculate the acceleration of Zane in the first 3 seconds.
a = Δv / Δt a = (15-0) / (3-0) = 5 ms^{-2}

(c) Explain which go-cart travelled 200 m around the track first.
In your answer you should:
• use the information in the graph
• show all working for the calculations
• compare the distances travelled by Zane and Francis by the end of 14 s.

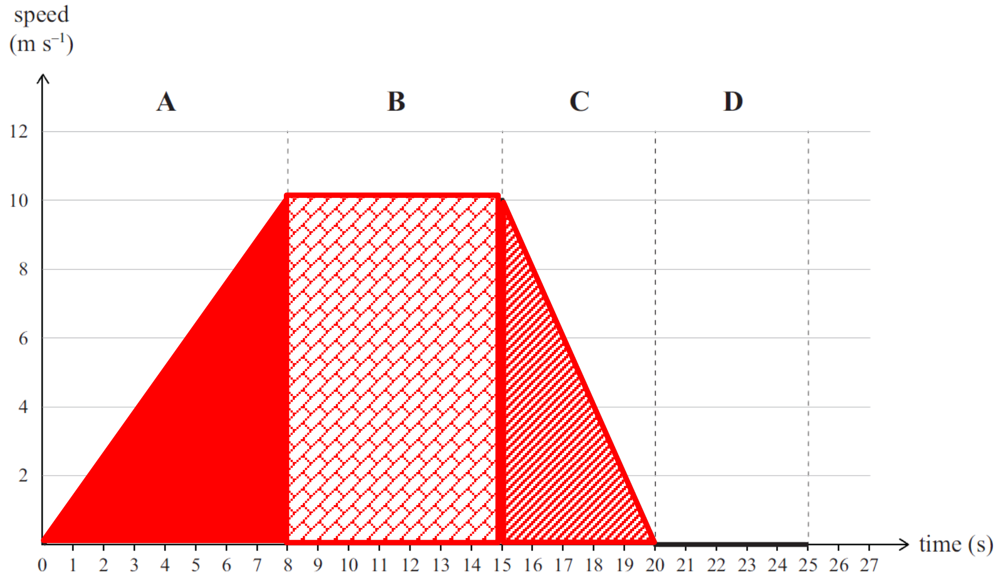
Francis travelled the greater distance.

Distance Francis has covered - Area under the graph is:
d_A = ½ x 3 x 16 = 24 m
d_B = 6 x 16 = 96 m
d_C = (½ x 1 x 5) + (5 x 16) = 82.5 m
d_{TOTAL} = 202.5 m

Distance Zane has covered - Area under the graph is:
d_A = ½ x 3 x 15 = 22.5 m
d_B = 6 x 15 = 90 m
d_C = (½ x 5 x 3) + (5 x 15) = 82.5 m
d_{TOTAL} = 195 m

2013:1

A runner's speed is recorded for 25 seconds and graphed below.



(d) Calculate the total distance the runner travels.

Distance travelled is found by calculating the area under the graph.

Distance travelled, section A: Area = ½ *b* × *h* = ½ × 8 × 10 = 40 m

Distance travelled, section B: Area = *b* × *h* = 7 × 10 = 70 m

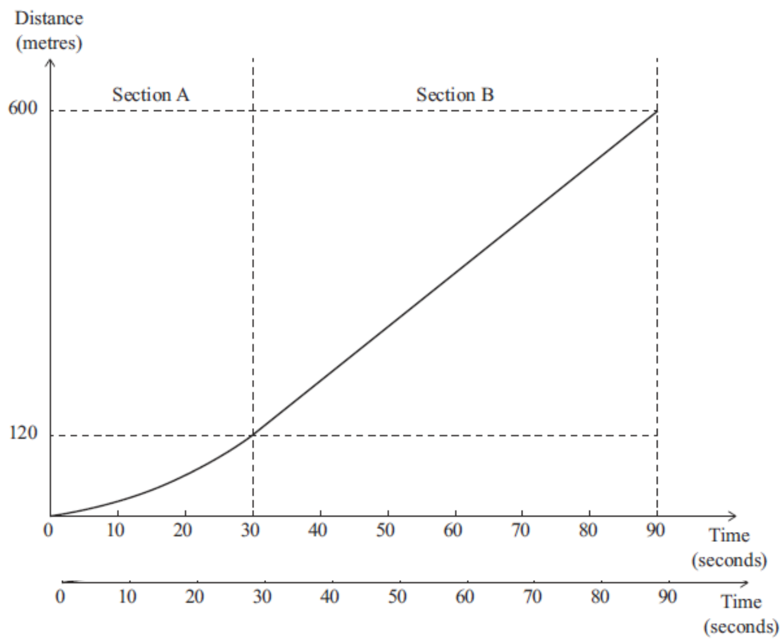
Distance travelled, section C: Area = ½ *b* × *h* = ½ × 5 × 10 = 25 m

Section D: Area = 0

Total Area: Area A + Area B + Area C + Area D = 135 m

2012:1

A woman drives her tractor down a sandy beach to pick up her friend's boat. The distance-time graph below shows part of the journey.

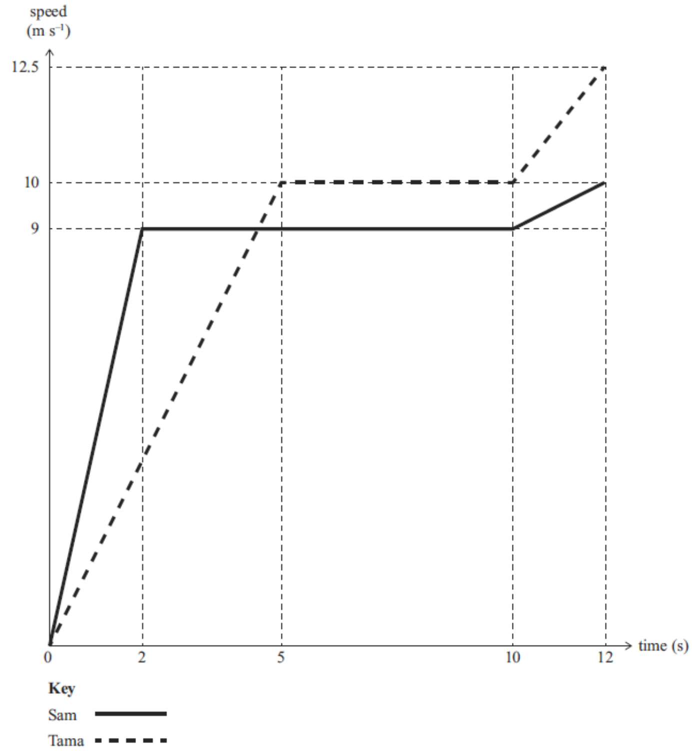


(a) Use the information from the graph to calculate the **average speed** of the tractor during the 90 seconds.

$v = \Delta d/\Delta t = 600/90 = 6.67\ ms^{-1}$ (rounding ignored)

2012:2

On athletics day, two friends compete in the same 100 metre race. The speed-time graphs for 12 seconds of their race are shown here.



(a) From the graph, who has the greater acceleration in the first 2 seconds? Give a reason with your answer. No calculation is required.

Sam has the greater acceleration during the first 2 seconds. Sam's speed changed from 0 to 9 ms^{-1} while Tama from 0 to 4 ms^{-1} (in 2 s) The gradient / slope of a speed-time graph equals the acceleration of the object. The steeper the slope the greater the acceleration. Sam has a steeper slope than Tama in the first 2 seconds.

(c) (i) Use the information in the graph to compare the speed AND acceleration of Sam and Tama in the **first 10 seconds.**

Sam accelerates at 4.5 ms^{-2} for 2 seconds, reaching a speed of 9 ms^{-1}. Stays at constant speed of 9 m s^{-1} for next 8 seconds.

Tama accelerates at 2 ms^{-2} for 5 seconds, reaching a constant speed of 10 ms^{-1}. Stays at constant speed of 10 m s^{-1} for next 5 seconds.

Comparison: Sam has a greater acceleration during first 2 seconds, but does not accelerate for as long as Tama. Between 5 and 10 seconds, neither accelerated, they both had a constant speed. Tama had a higher constant speed during this time.

(ii) At 12 seconds, one of the runners has finished the 100 metre race. Use the information in the graph and any necessary calculations to show which runner, Sam or Tama, finished at 12 seconds.

Distance = area under graph.
d(sam) = (½ x 2 x 9) + (8 x 9) + (2 x 9) + (½ x 2 x 1)
d(sam)= 9 + 72 + 18 + 1 = 100 m

d(Tama) = (½ x 5 x 10) + (5 x 10) + (2 x 10) + (½ x 2 x 2.5)
d(Tama) = 25 + 50 + 20 + 2.5 = 97.5 m
Therefore only Sam has finished the race.

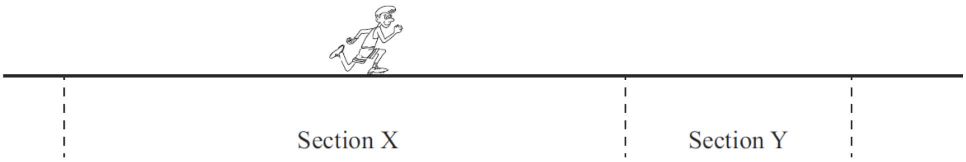
2011:1

A parachutist of mass 75 kg jumps from a plane at a height of 4 000 m above sea level.

(a) The parachutist falls through a distance of 2 400 m during the first 60 seconds. Calculate the average speed of the parachutist during this time.

$v = \Delta d/\Delta t = 2400/60 = 40\ ms^{-1}$.

2011:2



A boy runs along a track, as shown above.

During section X, he runs with a **constant speed** of 2 m s^{-1} for 15 seconds.
During section Y, he runs with a **constant acceleration** of 0.2 m s^{-2}.

(a) Calculate the net force acting on the boy (mass 60 kg) during **section Y**. Give an appropriate unit with your answer.

F = ma F = 60 × 0.2 = 12 N

(b) The boy runs 12.5 m during section Y in 5 seconds. Calculate the power required by the boy to produce the constant acceleration of 0.2 m s^{-2} in 5 seconds during section Y. Give an appropriate unit with your answer.

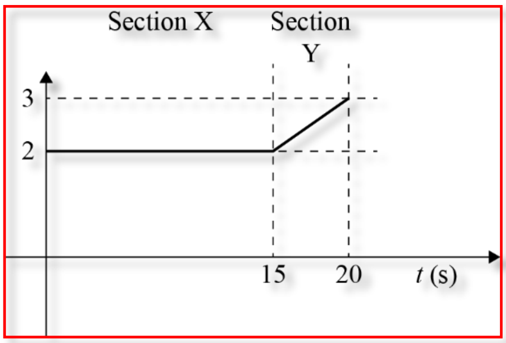
W = Fd
W = 12 × 12.5 = 150 J
P = W/t P = 150/5 = 30 W)or 30 Js^{-1})
Possible follow-on error from 2(a).

(c) (i) Calculate the speed of the boy as he reaches the end of section Y.

(ii) Use this and the other information provided in the question to complete the speed / time graph. On your graph, you should:

- label the speed values on the vertical axis
- draw a line on the graph to show the speeds for section X **and** section Y.

$a = \Delta v/\Delta t$ $0.2 = (v_f - 2)/5$ $v_f = (0.2 \times 5) + 2 = 1 + 2$ $v_f = 3\ ms^{-1}$
OR by reasoning (formula not required), ie 5 s at 0.2 m s^{-2}.
Increase in speed = 1 m s^{-2}.
Started at 2 m s^{-1} now at 3 m s^{-1}.

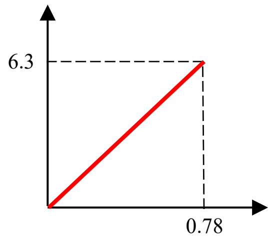


Please note – the questions that follow are from an older Achievement Standard where the questions were more short answer-type questions:

FALLING (2010;3 – AS90191)

(b) The apple (m = 0.15 kg) falls to the ground in 0.78 s, hitting the ground with a speed of 6.3 m s^{-1}.

Complete the speed-time graph.

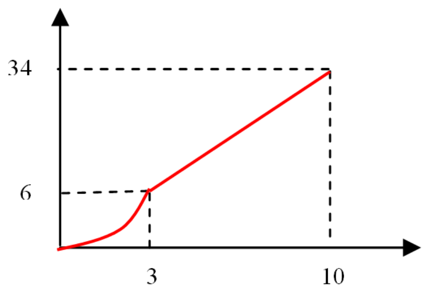


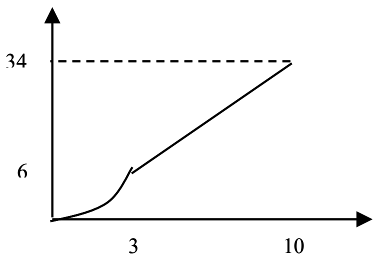
A REMOTE CONTROL CAR (2008;2 – AS90191)

A child plays with a remote control car on concrete.

(a) The car starts from rest and travels a distance of 6 m in 3 seconds. Calculate the average speed of the car in the 3 seconds.
v = d / t v = 6 / 3 v = 2 ms^{-1}

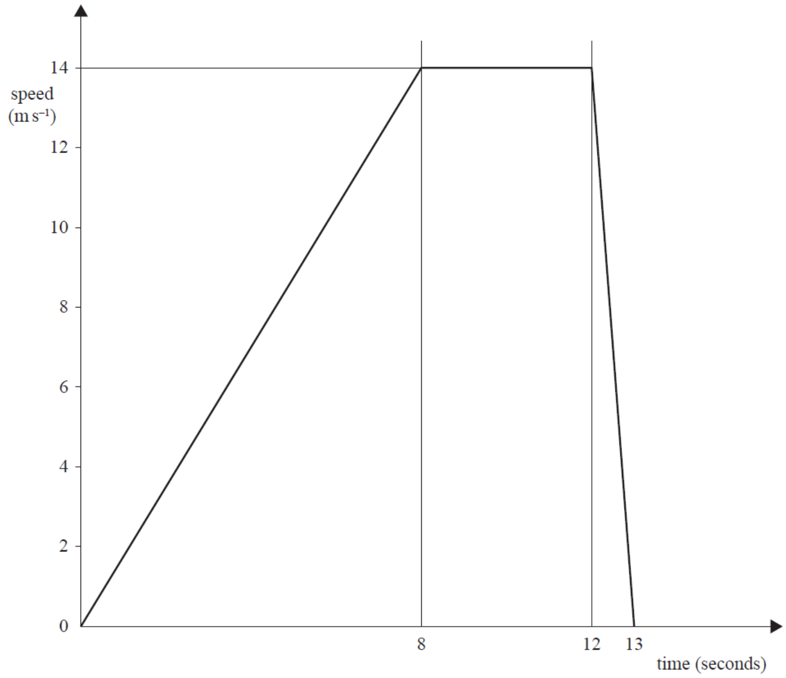
(c) The car then travels a further 28 m at a constant speed of 4 m s^{-1} for 7 seconds. Draw in the appropriate shaped lines on the distance-time graph below to represent the journey of the car during the first 10 seconds.





SPORTS TRAINING (2007;1 – AS90191)

The speed-time graph below represents sprint training for an athlete.



(a) State the speed of the athlete at 10 seconds.

14 m s^{-1}

(b) Describe the motion of the athlete between 12 and 13 seconds.

ONE of:

(Constant) deceleration
Slowing down
Reducing speed
-14ms^{-2}

(c) Calculate the acceleration of the athlete during the first 8 seconds.

a = slope = 14 / 8   a = 1.75 ms^{-2}

(e) Using the graph, calculate the total distance travelled by the athlete in the first 12 seconds.

d = area under graph d = (0.5 × 8 × 14) + (4 × 14) d = 56 + 56   d = 112 m

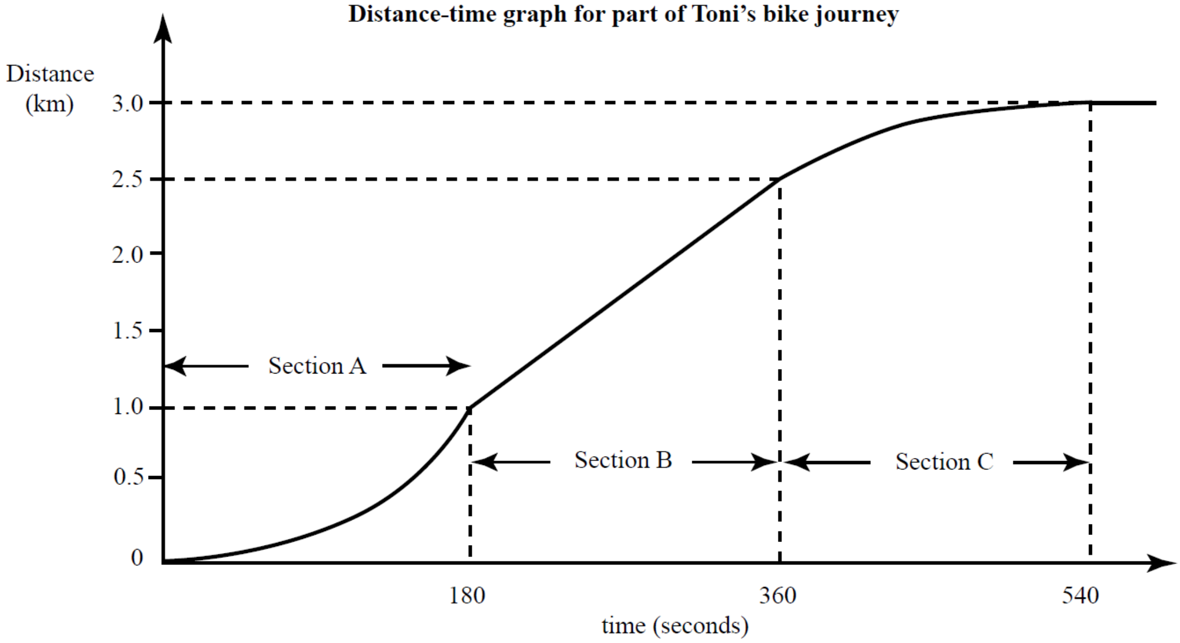
(g) Another part of the athlete's training is swimming. Calculate the average speed of the athlete during the 90 seconds that the athlete swims two lengths (one length = 50 m) of a pool.

v = d/t   v = (2 × 50) / 90 = 1.11 m s^{-1}

CYCLING (2006;1 – AS90191)

Toni cycles each day on her mountain bike. The distance-time graph below shows part of her journey on one day.

Distance-time graph for part of Toni's bike journey



(a) How far, in metres, does Toni travel in the first 360 seconds?

2500 metres

(b) Calculate Toni's average speed over the 540 second bike journey.

$V = d_{total}/t_{total} = 3000/540 = 5.6\ m\ s^{-1}$

(c) Describe the motion of Toni and the bike during Section A.

Accelerating / increase in speed.

(d) Using the graph above show that the speed of Toni and the bike during Section B is $8.3\ ms^{-1}$.

Shows working.

$= 1500/180 = 8.3\ ms^{-1}$

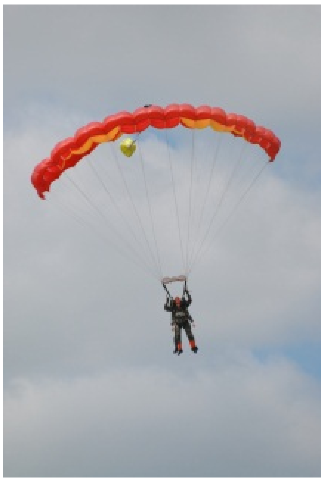
(h) As shown on Section C of the graph, Toni reduces her speed from $8.3\ m\ s^{-1}$ to $0\ m\ s^{-1}$ in 180 seconds to come to a stop. Calculate the deceleration of Toni during these 180 seconds.

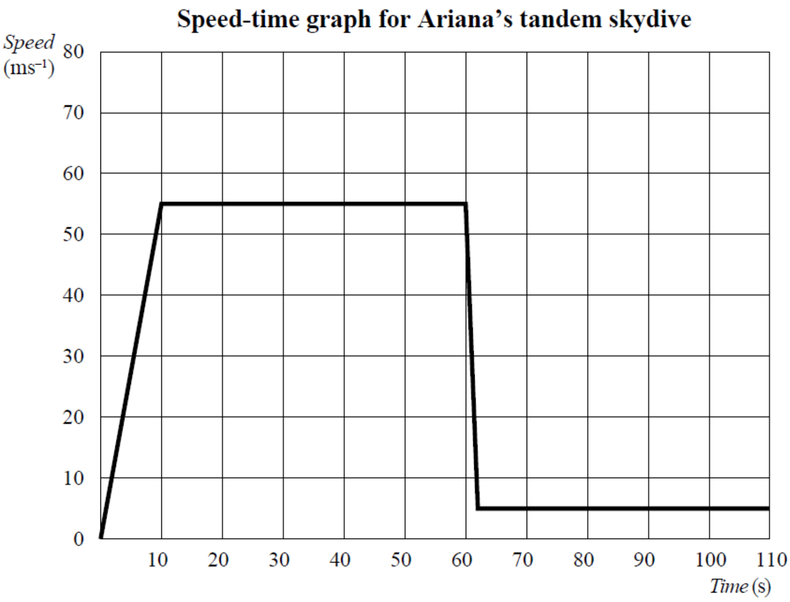
Correct solution (do not need negative)

$a = \Delta v / \Delta t$ $a = (0 – 8.3) / 180$ $a = 0.05$ (or 0.046 unrounded)

TANDEM SKYDIVING (2005;1 – AS90191)

Ariana wins a competition for a Tandem Skydive. The plane flies to a height of 5 000 m above sea level. Ariana is strapped to her jumpmaster. Ariana and the jumpmaster jump out of the plane. After 60 seconds the jumpmaster pulls the cord and releases the parachute. The speed-time graph below shows the motion of Ariana and the jumpmaster from when they leave the plane until after the parachute is released.





(f) Describe the motion of Ariana and the jumpmaster during the first 10 seconds.

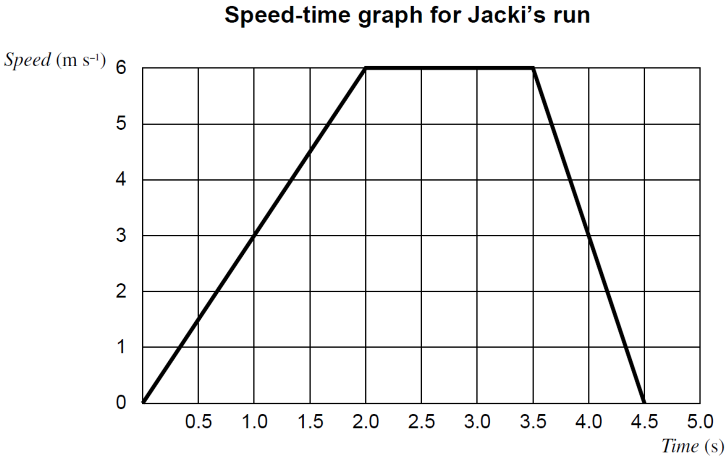
Acceleration OR $5.5\ ms^{-2}$ OR speed increasing

(h) Calculate how far Ariana and the jumpmaster fell during the first 60 seconds.

Distance travelled = area under graph $d = (½ \times 10 \times 55) + (50 \times 55) = 275 + 2\ 750 = 3\ 025\ m$

THE GAME BEGINS! (2004;2 – AS90191)

In the team's first game, Jacki is the opening bowler. The speed-time graph shows the motion of Jacki as she runs in to bowl.



(a) What is the maximum speed Jacki reaches?
6 ms^{-1}

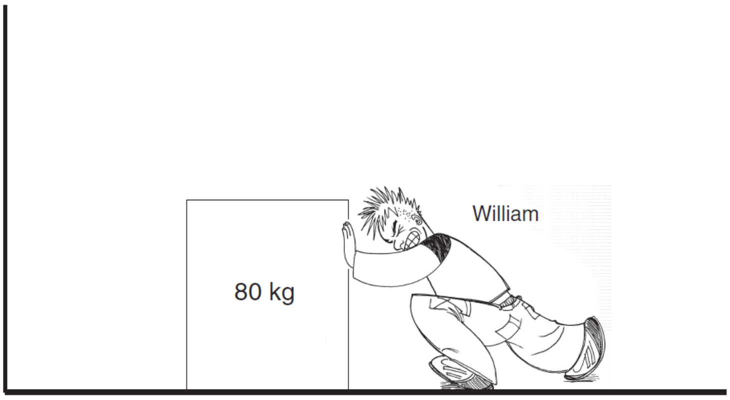
(b) Fully describe the motion of Jacki between 2.0 s and 3.5 s.
constant / steady / same: speed (of $6ms^{-1}$)

(c) Calculate Jacki's acceleration between 0 s and 2.0 s.
$a = \Delta v/\Delta t = (6-0)/(2-0) = 3\ ms^{-2}$

(d) Using the speed-time graph, calculate the total distance travelled by Jacki as she ran in to bowl.
distance = (½ × 2 × 6) + (1.5 × 6) + (½ × 1 × 6) = 6 + 9 + 3 = 18 m

QUESTION TWO (2003;2– AS90191)

A group of friends have decided to help in the school stage production. William helped the sound technician to bring in boxes of sound gear. The boxes were pushed across the stage.



(b) The stage floor is 15 m from one side to the other. It takes 5 seconds to push the box across the stage. Calculate the average speed of the box. Show all working. The units are required.
$v_{av} = d/t = 15\ m / 5s = 3.0\ ms^{-1}$