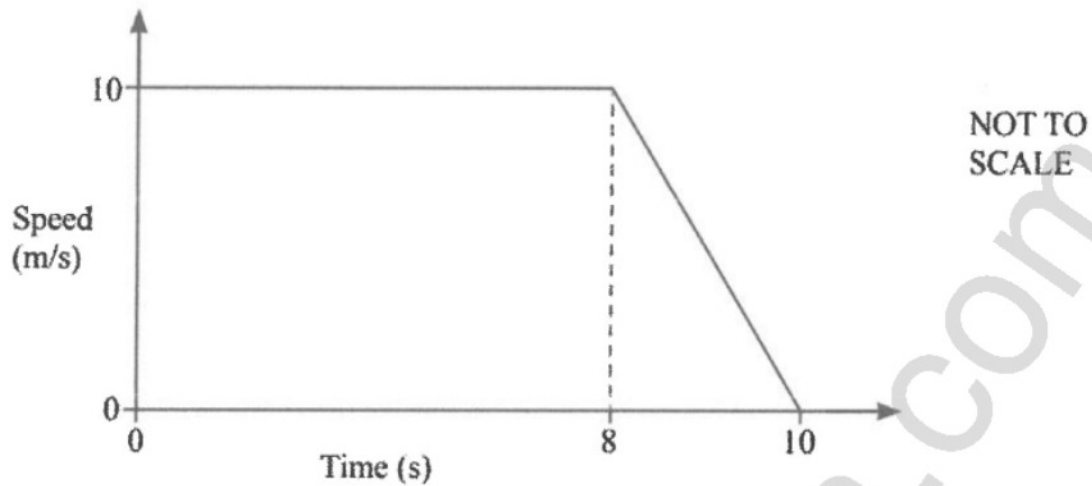


A Speed Time Graphs

13



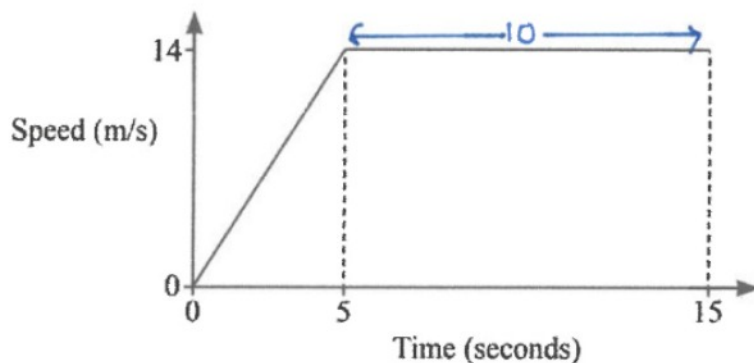
The diagram shows the speed–time graph for part of a car journey.

Calculate the total distance travelled during the 10 seconds.

distance = area

$$\begin{aligned} \text{Area} &= \frac{1}{2}(a+b) \times h \\ &= \frac{1}{2}(10+8) \times 10 \\ &= \frac{1}{2} \times 18 \times 10 \\ &= 9 \times 10 \end{aligned}$$

..... 90 m [2]



NOT TO SCALE

The diagram shows the speed-time graph of the first 15 seconds of a car journey.

acceleration = gradient

- (a) Find the acceleration of the car during the first 5 seconds.

$$a = \frac{14-0}{5-0} = \frac{14}{5} = 2.8$$

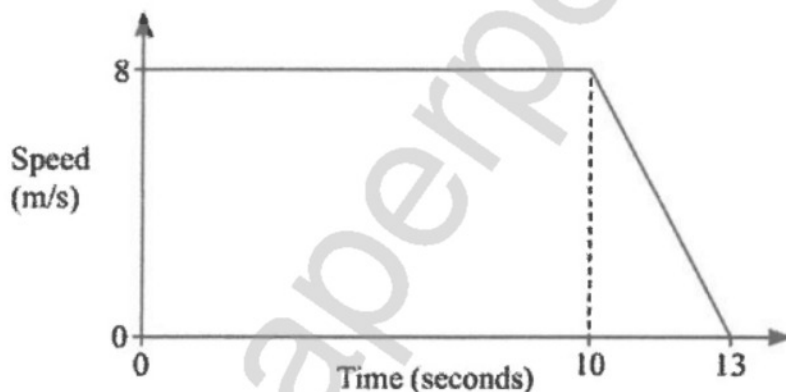
2.8 m/s² [1]

- (b) Find the distance travelled during the 15 seconds.

$$\begin{aligned} \text{Area} &= \frac{1}{2}(a+b) \times h &= \frac{1}{2} \times 25 \times 14 \\ &= \frac{1}{2}(15+10) \times 14 &= 7 \times 25 \end{aligned}$$

175 m [2]

9



NOT TO SCALE

The diagram shows the speed-time graph of part of a car journey.

- (a) Find the deceleration of the car between 10 and 13 seconds.

$$\text{acc.} = \frac{0-8}{13-10} = \frac{-8}{3} = -2.67$$

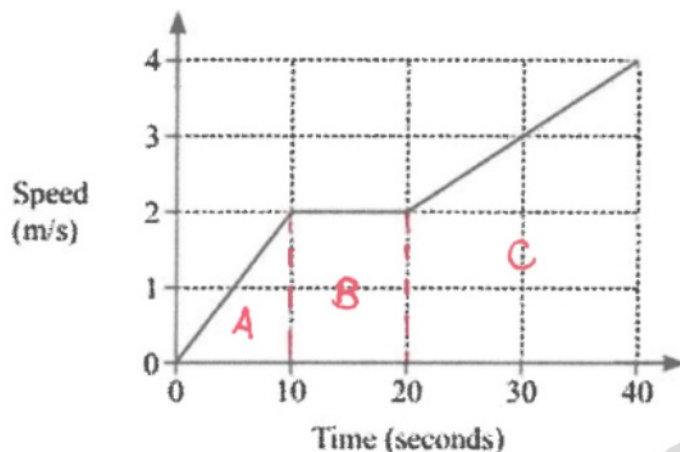
2.67 m/s² [1]

acceleration is negative *deceleration is positive*

- (b) Calculate the total distance travelled during the 13 seconds.

$$\begin{aligned} A &= \frac{1}{2}(a+b) \times h &= \frac{1}{2} \times 23 \times 8 \\ &= \frac{1}{2}(10+13) \times 8 &= 4 \times 23 \end{aligned}$$

92 m [2]



The diagram shows the speed-time graph for the first 40 seconds of a cycle ride.

- (a) Find the acceleration between 20 and 40 seconds.

$$a = \frac{4 - 2}{40 - 20} = \frac{2}{20} = 0.1 \quad \underline{0.1} \text{ m/s}^2 \quad [1]$$

- (b) Find the total distance travelled.

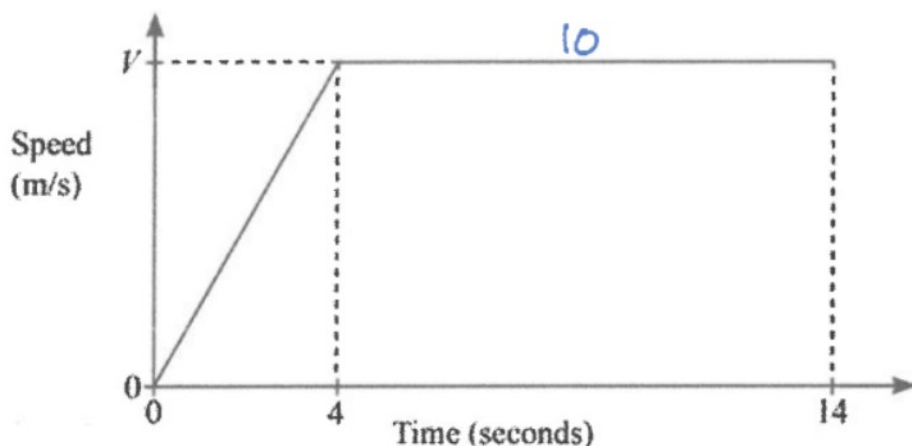
A: $A = \frac{1}{2} \times b \times h$
 $= \frac{1}{2} \times 10 \times 2$
 $= \underline{10}$

B: $A = b \times h$
 $= 10 \times 2$
 $= \underline{20}$

C: $A = \frac{1}{2} (a + b) \times h$
 $= \frac{1}{2} (2 + 4) \times 20$
 $= \frac{1}{2} \times 6 \times 20$
 $= \underline{60}$

$$\text{Total} = 10 + 20 + 60 = \underline{90} \text{ m} \quad [3]$$

- 18 A car starts from rest and accelerates at a rate of 3 m/s^2 for 4 seconds. The car then travels at a constant speed for 10 seconds.



The diagram shows the speed–time graph for this journey.

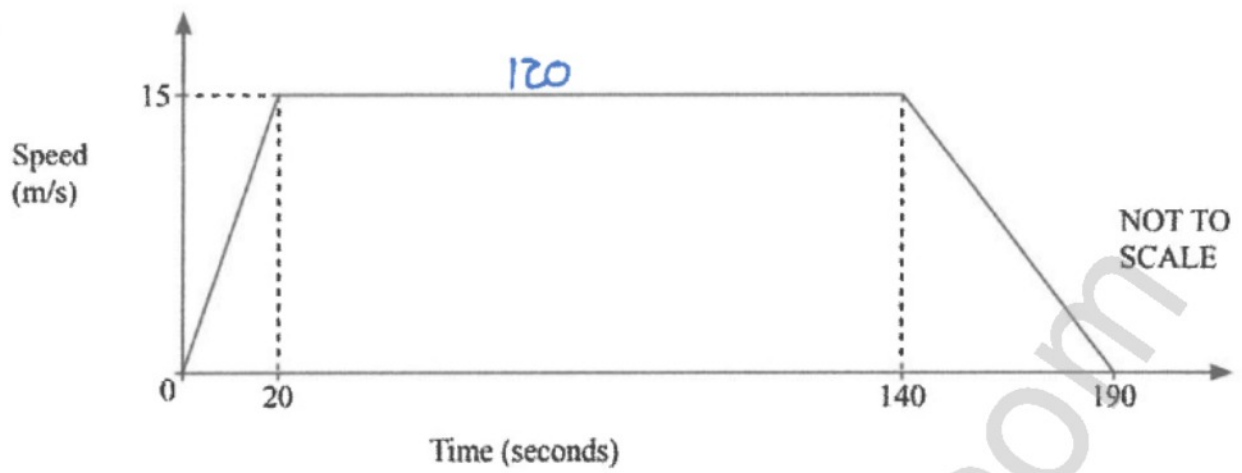
- (a) Find the value of V .

$$a = \frac{V-0}{4-0} = \frac{V}{4} \quad 3 = \frac{V}{4} \quad \times 4 \quad 12 = V \quad V = 12 \quad [1]$$

- (b) Calculate the total distance travelled by the car during the 14 seconds.

$$\begin{aligned} A &= \frac{1}{2}(a+b) \times h &= 12 \times 12 \\ &= \frac{1}{2}(10+14) \times 12 &= 144 \\ &= \frac{1}{2} \times 24 \times 12 & \end{aligned}$$

144 m [2]

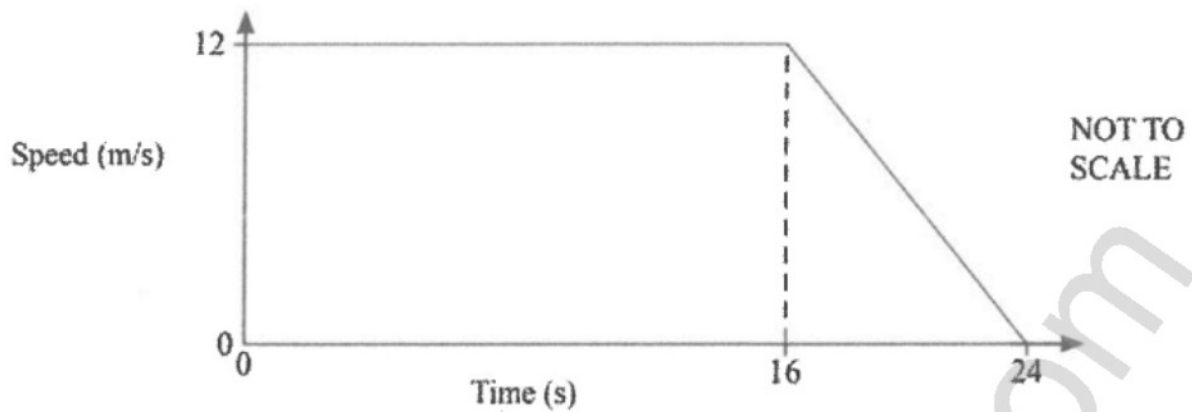


The speed-time graph shows information about a bus journey.

Calculate the total distance travelled by the bus.

$$\begin{aligned}
 A &= \frac{1}{2}(a+b) \times h \\
 &= \frac{1}{2} \times 310 \times 15 \\
 &= 155 \times 15
 \end{aligned}$$

2325 m [3]



The diagram shows the speed–time graph for 24 seconds of a car journey.

Calculate

- (a) the deceleration of the car in the final 8 seconds,

$$a = \frac{0 - 12}{24 - 16} = \frac{-12}{8} = -1.5$$

↑
negative acceleration

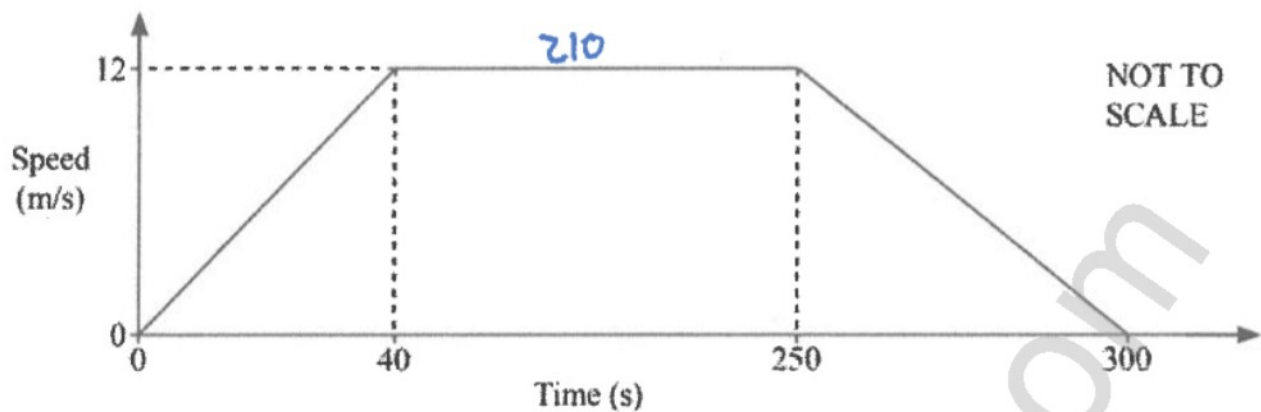
1.5 m/s² [1]

- (b) the total distance travelled during the 24 seconds.

$$\begin{aligned}
 A &= \frac{1}{2}(a+b) \times h & &= 20 \times 12 \\
 &= \frac{1}{2}(16 + 24) \times 12 & &= 240 \\
 &= \frac{1}{2} \times 40 \times 12 & &
 \end{aligned}$$

240 m [2]

14 The diagram shows the speed–time graph of a train journey between two stations.

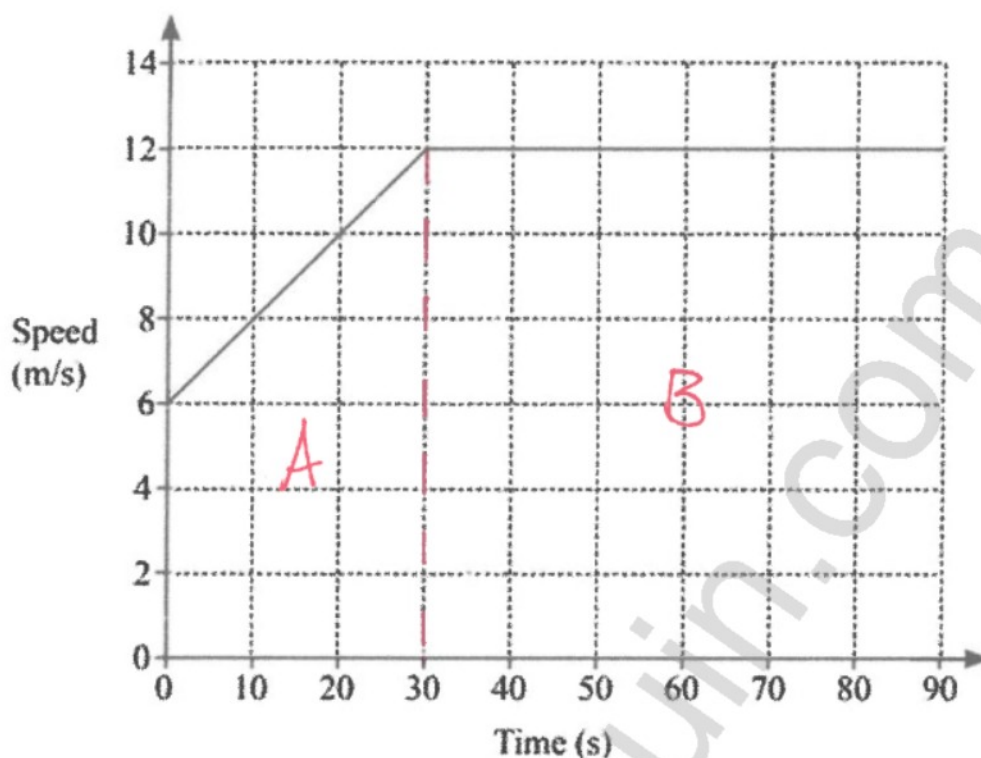


(a) Find the acceleration of the train during the first 40 seconds.

$$a = \frac{12-0}{40-0} = \frac{12}{40} = 0.3 \quad \underline{0.3} \dots \text{m/s}^2 \text{ [1]}$$

(b) Calculate the distance between the two stations.

$$\begin{aligned} A &= \frac{1}{2}(a+b) \times h &= 510 \times 6 \\ &= \frac{1}{2}(210+300) \times 12 &= 3060 \\ &= \frac{1}{2} \times 510 \times 12 &\underline{3060} \dots \text{m [3]} \end{aligned}$$



The diagram shows the speed-time graph for 90 seconds of a journey.

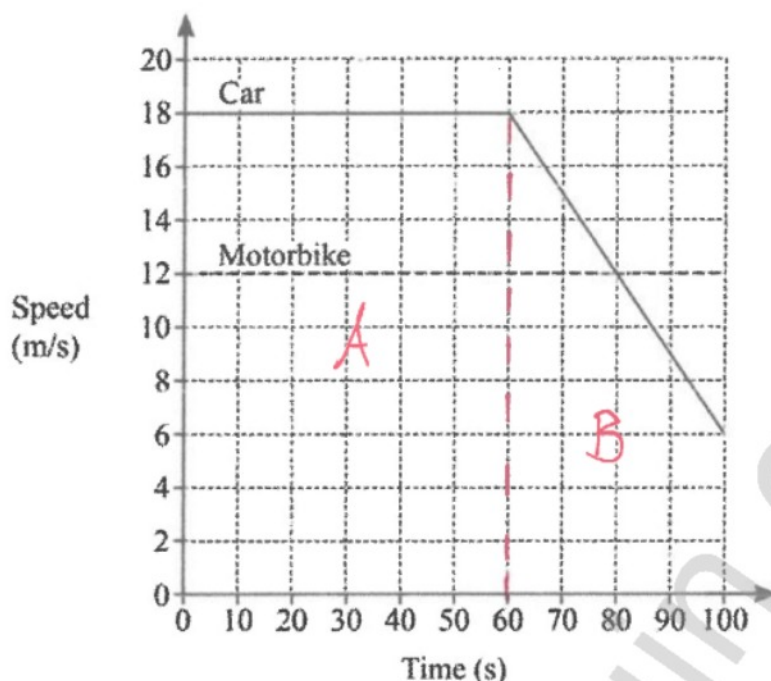
Calculate the total distance travelled during the 90 seconds.

A: $A = \frac{1}{2}(a+b) \times h$
 $= \frac{1}{2}(6+12) \times 30$
 $= \frac{1}{2} \times 18 \times 30$
 $= 9 \times 30$
 $= \underline{270}$

B: $A = b \times h$
 $= 60 \times 12$
 $= \underline{720}$

Total: $270 + 720 = \underline{990}$

990 m [3]



The diagram shows the speed-time graph for 100 seconds of the journey of a car and of a motorbike.

- (a) Find the deceleration of the car between 60 and 100 seconds.

$$a = \frac{6 - 18}{100 - 60} = \frac{-12}{40} = -0.3$$

..... 0.3 m/s² [1]

- (b) Calculate how much further the car travelled than the motorbike during the 100 seconds.

Car:

$$\begin{aligned} A: A &= b \times h \\ &= 60 \times 18 \\ &= \underline{1080} \end{aligned}$$

$$\begin{aligned} B: A &= \frac{1}{2}(a+b) \times h \\ &= \frac{1}{2}(6+18) \times 40 \\ &= \frac{1}{2} \times 24 \times 40 \end{aligned}$$

$$\begin{aligned} &= 12 \times 40 \\ &= \underline{480} \end{aligned}$$

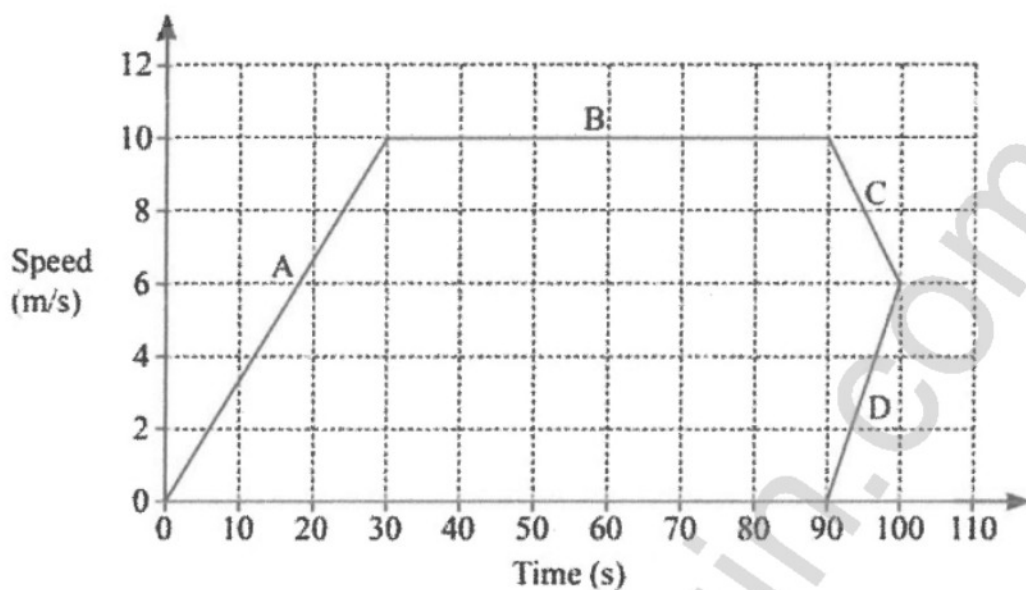
$$\begin{aligned} \text{Total: } &1080 + 480 \\ \text{car} &= \underline{1560} \end{aligned}$$

Motorbike:

$$\begin{aligned} A &= b \times h \\ &= 100 \times 12 \\ &= \underline{1200} \end{aligned}$$

$$\begin{aligned} \text{difference: } &1560 - 1200 = 360 \\ &\underline{360} \text{ m [3]} \end{aligned}$$

- 16 Abdul draws this speed–time graph for a journey.
The graph has four sections A, B, C and D.



Complete these statements about the speed–time graph.

Section D cannot be correct.

Section B shows constant speed.

Section C shows deceleration.

$$a = \frac{10 - 0}{30 - 0} = \frac{10}{30} = \frac{1}{3}$$

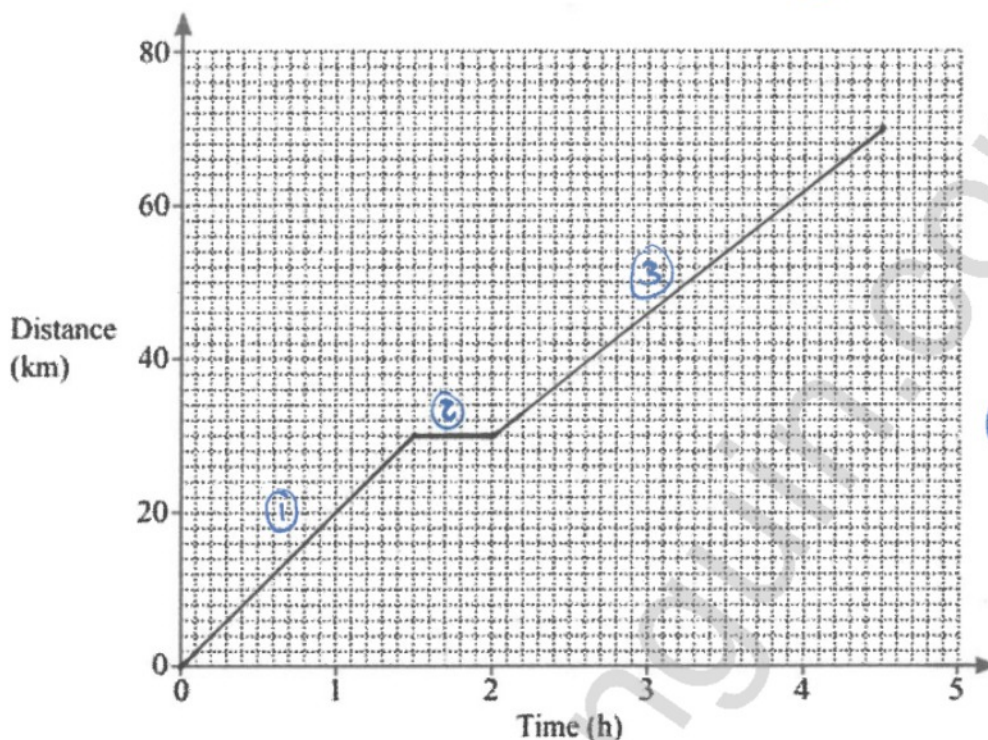
Section A shows acceleration of $\frac{1}{3}$ m/s².

The distance travelled in the first 30 seconds of the journey is 150 m.

[4]

$$\begin{aligned} A &= \frac{1}{2} \times b \times h \\ &= \frac{1}{2} \times 30 \times 10 \\ &= 150 \end{aligned}$$

- 12 Annette cycles a distance of 70 km from Midville to Newtown. ^①
 Leaving Midville, she cycles for 1 hour 30 minutes at a constant speed of 20 km/h and then stops for 30 minutes. ^②
 She then continues the journey to Newtown at a constant speed of 16 km/h. ^③



①:
 $\text{distance} = s \times t$
 $= 20 \times 1.5$
 $= 30 \text{ km}$
 (in 1.5 hours)

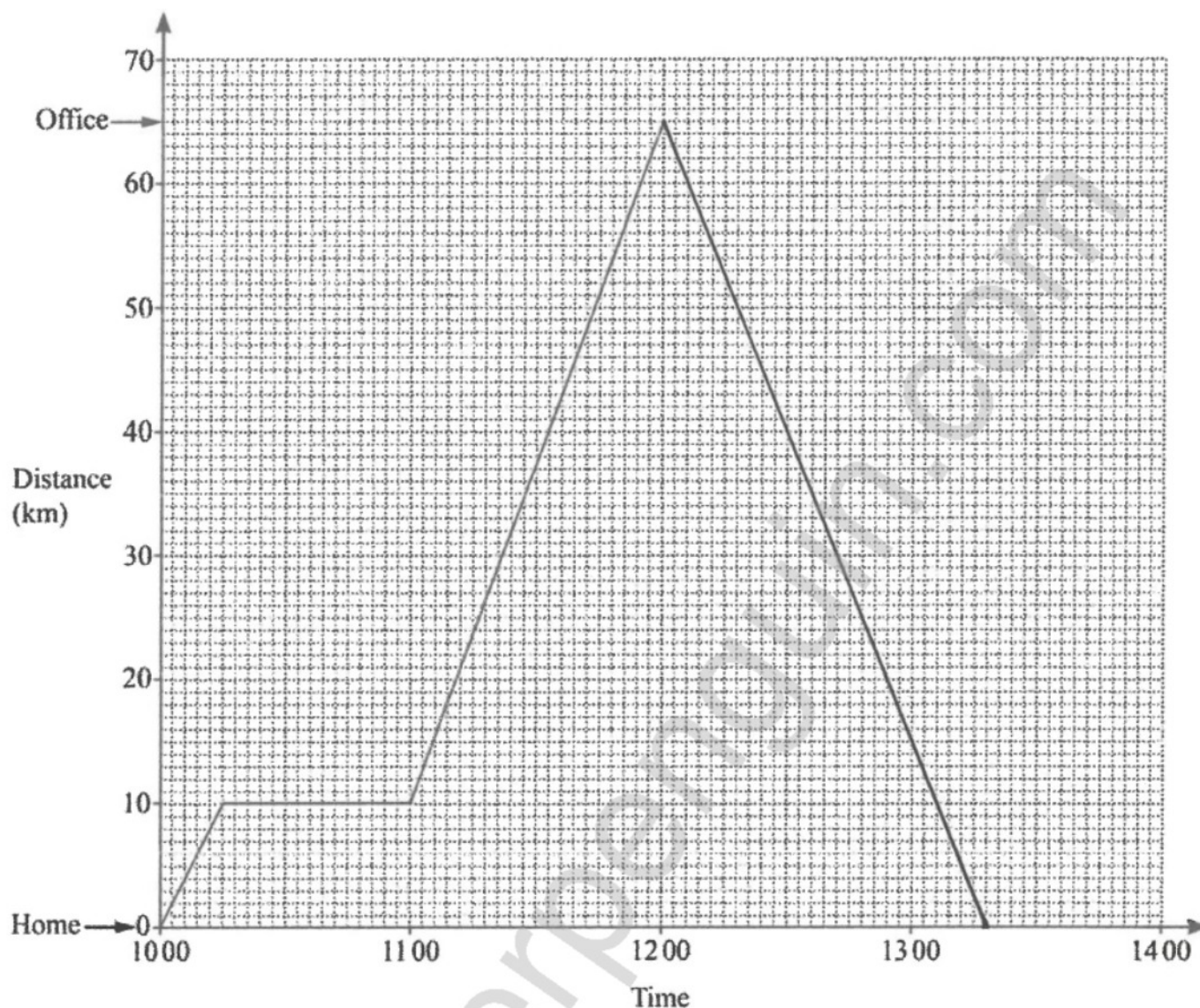
③: 40 km left
 $\text{time} = \frac{d}{s}$
 $= \frac{40}{16}$
 $= 2.5 \text{ hrs}$

- (a) On the grid, draw the distance-time graph for the journey. [3]
 (b) Calculate the average speed for the whole journey.

$$\begin{aligned} \text{Average speed} &= \frac{\text{total distance}}{\text{total time}} \\ &= \frac{70}{4.5} \\ &= 15.6 \end{aligned}$$

15.6 km/h [3]

- 9 The distance–time graph shows information about Kai’s journey from home to the office.



- (a) Calculate the average speed, in km/h, for Kai’s journey from home to the office.

$$\begin{aligned} \text{average speed} &= \frac{\text{total distance}}{\text{total time}} \\ &= \frac{65}{2} = 32.5 \quad \dots\dots\dots 32.5 \quad \text{km/h} \quad [2] \end{aligned}$$

- (b) When Kai arrives at the office, he finds his meeting is cancelled. He immediately returns home at a constant speed of 50 km/h.

Complete the distance–time graph to show his journey home.

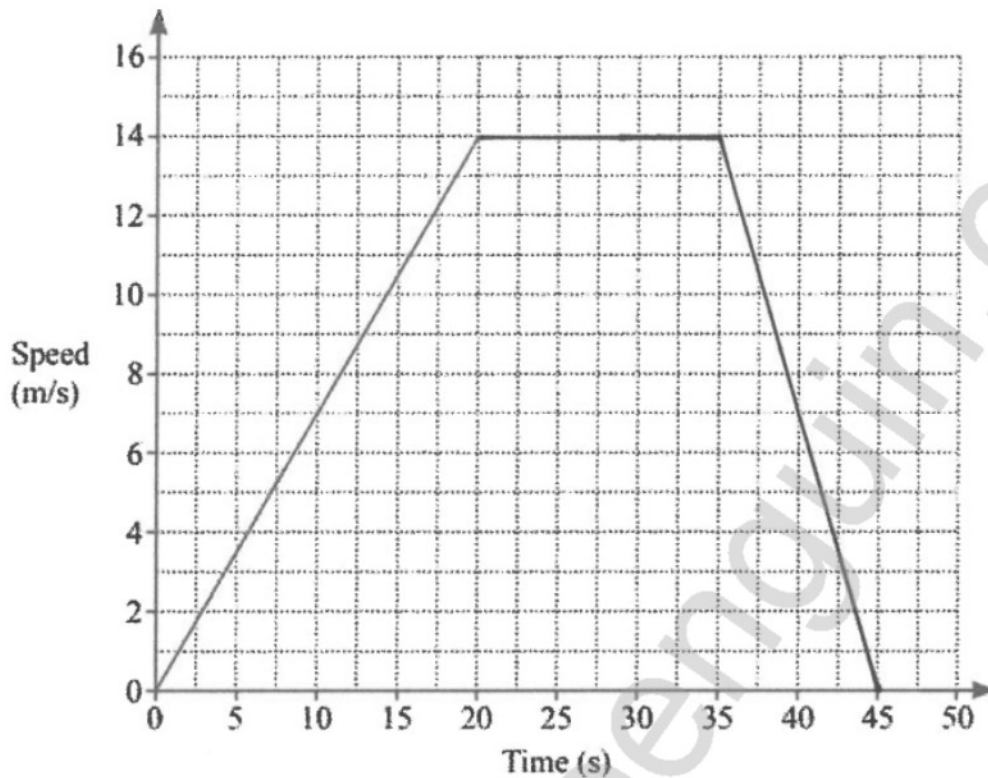
[1]

$$\begin{aligned} \text{time} &= \frac{d}{s} \\ &= \frac{65}{50} \\ &= 1.3 \text{ hours} \end{aligned}$$

→ convert to hours and mins:
 $0.3 \times 60 = 18 \text{ mins}$
 so: 1.3 hrs = 1 hr, 18 mins

- 11 A car starts its journey by accelerating from rest at a constant rate of 0.7 m/s^2 for 20 seconds, before reaching a constant speed of 14 m/s .
 It then travels at 14 m/s for a distance of 210 m .
 The car then decelerates at a constant rate of 1.4 m/s^2 , before coming to a stop.

On the grid, complete the speed–time graph for the car’s journey.



②: $\text{time} = \frac{d}{s}$

$$= \frac{210}{14}$$

$$= 15 \text{ s}$$

③: $a = \frac{0 - 14}{t}$

$$a = \frac{-14}{t}$$

$$-1.4 = \frac{-14}{t} \times t$$

$$-1.4t = -14$$

$$t = 10 \text{ s}$$

[3]

15 The diagram shows the speed–time graph for part of the journey of a car.



The car starts from rest and accelerates at a uniform rate for 15 seconds before reaching a constant speed of 30 m/s.

(a) Calculate the acceleration for the first 15 seconds.

$$a = \frac{30 - 0}{15 - 0} = \frac{30}{15} = 2$$

..... 2 m/s² [1]

(b) After T minutes, the total distance travelled is 45 kilometres.

Find the value of T .

↖ 45 km = 45 000 m

Distance in first 15s: Distance after this:

$$\begin{aligned} A &= \frac{1}{2} \times b \times h \\ &= \frac{1}{2} \times 15 \times 30 \\ &= \underline{225 \text{ m}} \end{aligned}$$

$$A = 30 \times t \quad \leftarrow \text{time in seconds at constant speed}$$

Total distance = 45 000 m:

$$\begin{array}{r} 225 + 30t = 45\,000 \\ -225 \quad -225 \\ \hline 30t = 44\,775 \end{array}$$

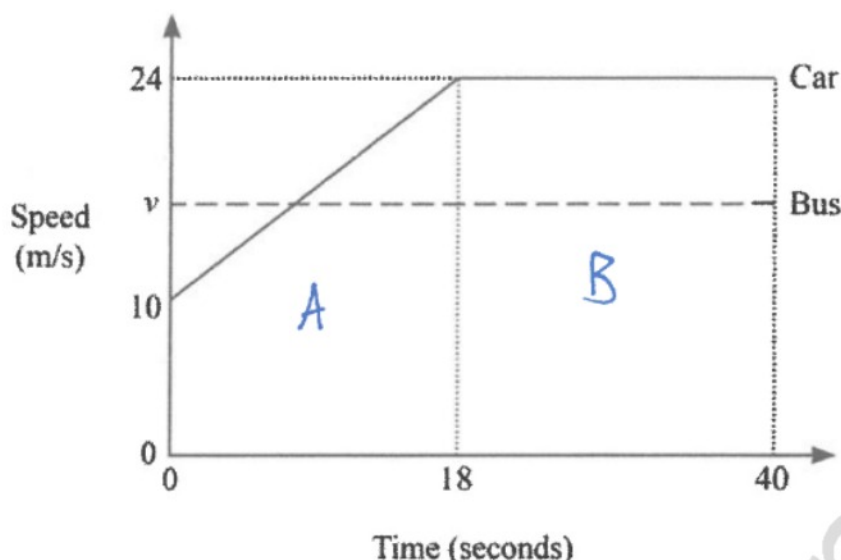
$$\begin{array}{r} 30t = 44\,775 \\ \div 30 \quad \div 30 \\ \hline t = 1492.5 \end{array}$$

$t = 1492.5 \text{ s}$ ← time at constant speed

Total time: $15 + 1492.5 = 1507.5 \text{ s}$

in minutes: $1507.5 \div 60 = \underline{\underline{25.125 \text{ mins}}}$

- 5 (a) The diagram shows the speed–time graph for part of a journey for two vehicles, a car and a bus.



NOT TO
SCALE

- (i) Calculate the acceleration of the car during the first 18 seconds.

$$a = \frac{24 - 10}{18 - 0} = \frac{14}{18} = \frac{7}{9} \quad \dots\dots\dots \frac{7}{9} \dots\dots\dots \text{m/s}^2 \quad [1]$$

- (ii) In the first 40 seconds the car travelled 134 m more than the bus.

Calculate the constant speed, v , of the bus.

Car:

A: $A = \frac{1}{2}(a+b) \times h = 17 \times 18$
 $= \frac{1}{2}(10 + 24) \times 18 = 306$
 $= \frac{1}{2} \times 34 \times 18$

B: $A = b \times h$
 $= 22 \times 24$
 $= 528$

Total for car: $306 + 528 = 834 \text{ m}$

Bus: $834 - 134 = 700 \text{ m}$

$$b \times h = 700$$

$$40v = 700$$

$$\div 40 \quad \div 40$$

$$v = 17.5 \text{ ms}^{-1}$$

- (b) A train takes 10 minutes 30 seconds to travel 16 240 m.

Calculate the average speed of the train.
 Give your answer in kilometres per hour.

Time in minutes: 10.5 mins $\rightarrow \div 60$

Time in hours: 0.175 hours

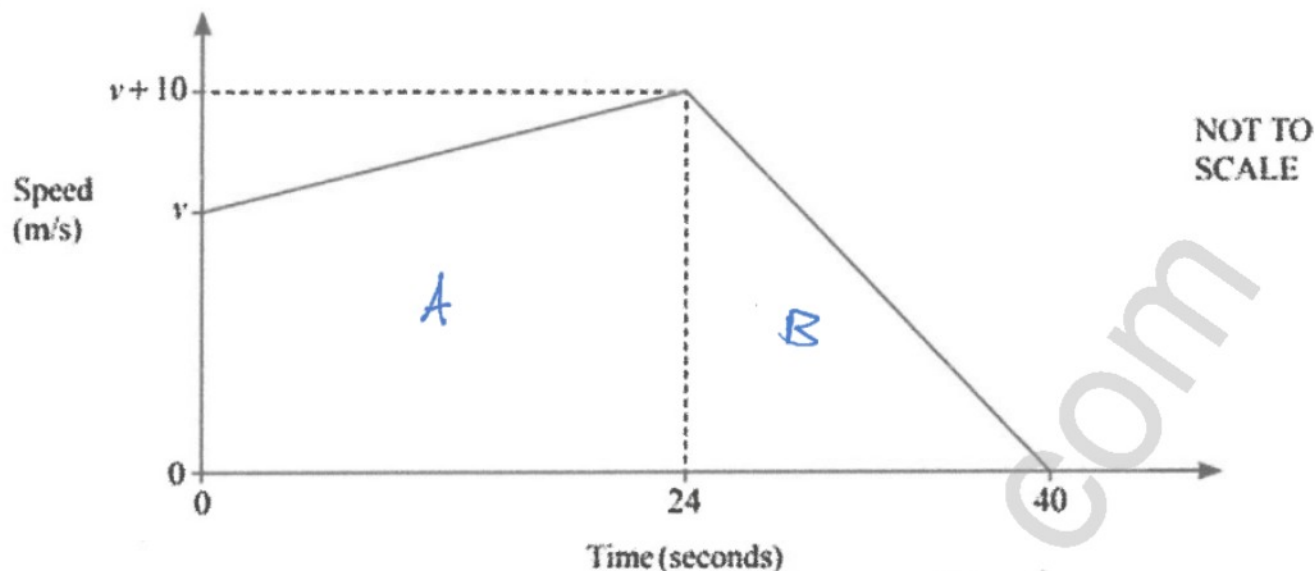
Distance in km: 16.24 km

$$\text{Speed} = \frac{d}{t}$$

$$= \frac{16.24}{0.175}$$

$$= 92.8$$

$\dots\dots\dots 92.8 \dots\dots\dots \text{km/h} \quad [3]$



The diagram shows the speed-time graph for the final 40 seconds of a car journey. At the start of the 40 seconds the speed is v m/s.

- (a) Find the acceleration of the car during the first 24 seconds.

$$a = \frac{v+10 - v}{24} = \frac{10}{24} = \frac{5}{12}$$

..... $\frac{5}{12}$ m/s² [1]

- (b) The total distance travelled during the 40 seconds is 1.24 kilometres.

Find the value of v .

A: $A = \frac{1}{2}(a+b) \times h$

$$= \frac{1}{2}(v + v+10) \times 24$$

$$= \frac{1}{2}(2v + 10) \times 24$$

$$= 12(2v + 10)$$

$$= \underline{24v + 120}$$

B: $A = \frac{1}{2} \times b \times h$

$$= \frac{1}{2} \times 16 \times (v+10)$$

$$= 8(v+10)$$

$$= \underline{8v + 80}$$

$A + B = 1240:$

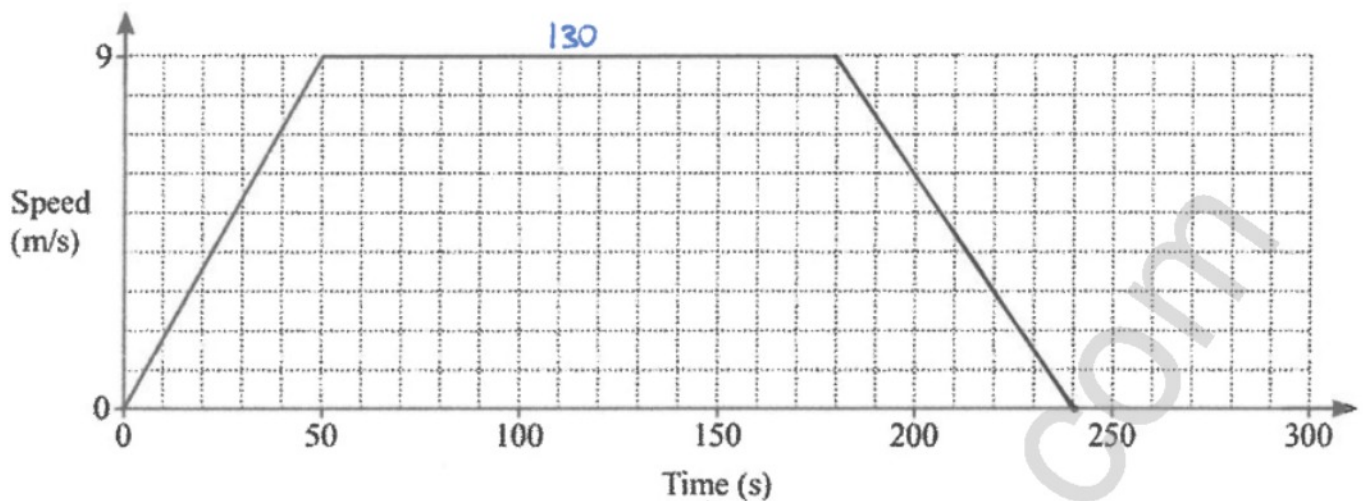
$$24v + 120 + 8v + 80 = 1240$$

$$32v + 200 = 1240$$

$$32v = 1040$$

$$v = \underline{32.5} \text{ m/s} \quad [4]$$

- 2 The diagram shows the speed–time graph for the first 180 seconds of a train journey.



- (a) Find the acceleration, in m/s^2 , of the train during the first 50 seconds.

$$a = \frac{9 - 0}{50 - 0} = \frac{9}{50} = 0.18 \quad \dots\dots\dots 0.18 \quad \text{m/s}^2 \quad [1]$$

- (b) After 180 seconds, the train decelerates at a constant rate of 1944 km/h^2 .

Show that the train decelerates for 60 seconds until it stops.

$$\begin{aligned}
 1944 \text{ km/h}^2 &= 1944000 \text{ m/h}^2 \\
 &= 540 \text{ m/min}^2 \quad \downarrow \div 60^2 \\
 &= 0.15 \text{ m/s}^2 \quad \downarrow \div 60^2
 \end{aligned}$$

$$\begin{aligned}
 a &= \frac{\text{change in speed}}{\text{change in time}} \\
 -0.15 &= \frac{0 - 9}{t} \\
 -0.15 &= \frac{-9}{t} \\
 \times t &\quad \times t \\
 -0.15t &= -9 \\
 \div -0.15 &\quad \div -0.15 \\
 t &= 60 \text{ s}
 \end{aligned}$$

- (c) Complete the speed–time graph.

- (d) Calculate the average speed of the train for the whole journey.

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

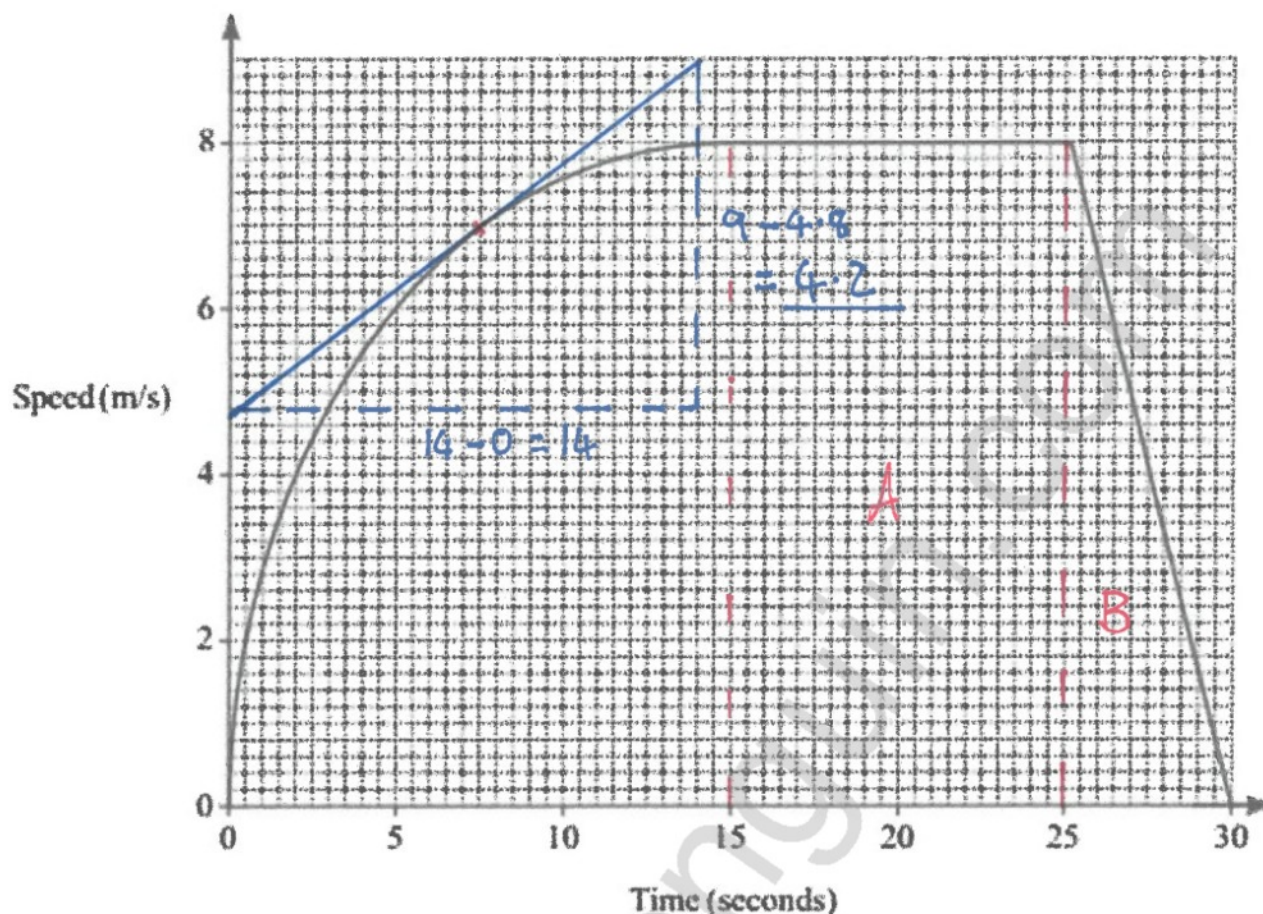
Distance:

$$\begin{aligned}
 A &= \frac{1}{2}(a+b) \times h \\
 &= \frac{1}{2}(130 + 240) \times 9 \\
 &= \frac{1}{2} \times 370 \times 9
 \end{aligned}$$

$$\begin{aligned}
 \text{Speed} &= \frac{1665}{240} \\
 &= 6.9375
 \end{aligned}$$

$$\dots\dots\dots 6.9375 \quad \text{m/s} \quad [4]$$

16 The graph shows the speed of a cyclist during a journey of 30 seconds.



(a) Write down the acceleration of the cyclist between 15 seconds and 25 seconds.

No change in speed $\rightarrow a = 0$ 0 m/s² [1]

(b) By drawing a tangent, find an estimate for the acceleration of the cyclist at 7.5 seconds.

$$a = \frac{9 - 4.8}{14 - 0} = \frac{4.2}{14} = 0.3 \text{ m/s}^2$$

..... 0.3 m/s² [2]

(c) Work out the average speed of the cyclist between 15 seconds and 30 seconds.

Distance: A: $A = b \times h$

$$= 10 \times 8$$

$$= 80$$

B: $A = \frac{1}{2} \times b \times h$

$$= \frac{1}{2} \times 5 \times 8$$

$$= 20$$

Total distance:

$$80 + 20 = 100 \text{ m}$$

$$\text{Average speed} = \frac{100}{15}$$

$$= 6.67 \text{ m/s [3]}$$