**1.** Two cars $P$ and $Q$ are moving in the same direction along the same straight horizontal road. Car $P$ is moving with constant speed 25 m s$^{-1}$. At time $t = 0$, $P$ overtakes $Q$ which is moving with constant speed 20 ms$^{-1}$. From $t = T$ seconds, P decelerates uniformly, coming to rest at a point $X$ which is 800 m from the point where $P$ overtook $Q$. From $t = 25$ s, $Q$ decelerates uniformly, coming to rest at the same point $X$ at the same instant as $P$.

(a) Sketch, on the same axes, the speed-time graphs of the two cars for the period from $t = 0$ to the time when they both come to rest at the point $X$.

**(4)**

(b) Find the value of $T$.

**(8)**
**(Total 12 marks)**

**2.** An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of 8 ms$^{-1}$. This speed is then maintained for $T$ seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 s.

(a) Sketch a speed-time graph to illustrate the motion of the athlete.

**(3)**

(b) Calculate the value of $T$.

**(5)**
**(Total 8 marks)**

**3.** A small ball is projected vertically upwards from ground level with speed $u$ m s$^{-1}$. The ball takes 4 s to return to ground level.

(a) Draw a velocity-time graph to represent the motion of the ball during the first 4 s.

**(2)**

(b) The maximum height of the ball above the ground during the first 4 s is 19.6 m. Find the value of $u$.

**(3)**
**(Total 5 marks)**

**4.** A car is moving along a straight horizontal road. The speed of the car as it passes the point *A* is 25 m s$^{-1}$ and the car maintains this speed for 30 s. The car then decelerates uniformly to a speed of 10 m s$^{-1}$. The speed of 10 m s$^{-1}$ is then maintained until the car passes the point *B*. The time taken to travel from *A* to *B* is 90 s and *AB* = 1410 m.

(a) Sketch, in the space below, a speed-time graph to show the motion of the car from *A* to *B*.

**(2)**

(b) Calculate the deceleration of the car as it decelerates from 25 m s$^{-1}$ to 10 m s$^{-1}$.

**(7)**
**(Total 9 marks)**

**5.** A car is moving along a straight horizontal road. At time $t = 0$, the car passes a point *A* with speed 25 m s$^{-1}$. The car moves with constant speed 25 m s$^{-1}$ until $t = 10$ s. The car then decelerates uniformly for 8 s. At time $t = 18$ s, the speed of the car is $V$ m s$^{-1}$ and this speed is maintained until the car reaches the point *B* at time $t = 30$s.

(a) Sketch a speed–time graph to show the motion of the car from *A* to *B*.

**(3)**

Given that *AB* = 526 m, find

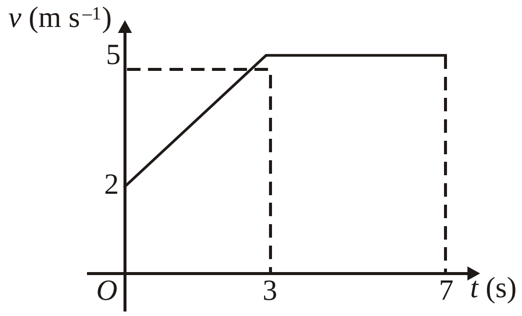
(b) the value of $V$,

**(5)**

(c) the deceleration of the car between $t = 10$ s and $t = 18$s.

**(3)**
**(Total 11 marks)**

**6.**




The figure above shows the speed-time graph of a cyclist moving on a straight road over a 7 s period. The sections of the graph from $t$ = 0 to $t$ = 3, and from $t$ = 3 to $t$ = 7, are straight lines. The section from $t$ = 3 to $t$ = 7 is parallel to the $t$-axis.

State what can be deduced about the motion of the cyclist from the fact that

(a) the graph from $t$ = 0 to $t$ = 3 is a straight line,

**(1)**

(b) the graph from $t$ = 3 to $t$ = 7 is parallel to the $t$-axis.

**(1)**

(c) Find the distance travelled by the cyclist during this 7 s period.

**(4)**
**(Total 6 marks)**

**7.** A train is travelling at 10 m $s^{-1}$ on a straight horizontal track. The driver sees a red signal 135 m ahead and immediately applies the brakes. The train immediately decelerates with constant deceleration for 12 s, reducing its speed to 3 m $s^{-1}$. The driver then releases the brakes and allows the train to travel at a constant speed of 3 m $s^{-1}$ for a further 15 s. He then applies the brakes again and the train slows down with constant deceleration, coming to rest as it reaches the signal.

(a) Sketch a speed-time graph to show the motion of the train.

**(3)**

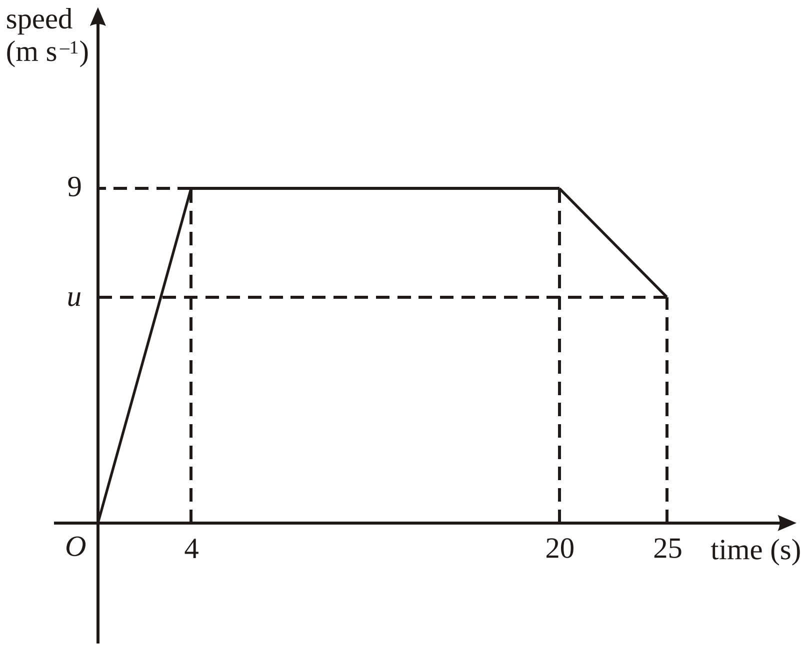
(b) Find the distance travelled by the train from the moment when the brakes are first applied to the moment when its speed first reaches 3 m $s^{-1}$.

**(2)**

(c) Find the total time from the moment when the brakes are first applied to the moment when the train comes to rest.

**(5)**
**(Total 10 marks)**

**8.**




A sprinter runs a race of 200 m. Her total time for running the race is 25 s. The diagram above is a sketch of the speed-time graph for the motion of the sprinter. She starts from rest and accelerates uniformly to a speed of 9 m $s^{-1}$ in 4 s. The speed of 9 m $s^{-1}$ is maintained for 16 s and she then decelerates uniformly to a speed of $u$ m $s^{-1}$ at the end of the race. Calculate

(a) the distance covered by the sprinter in the first 20 s of the race,

**(2)**

(b) the value of $u$,

**(4)**

(c) the deceleration of the sprinter in the last 5 s of the race.

**(3)**
**(Total 9 marks)**

**9.** A man is driving a car on a straight horizontal road. He sees a junction *S* ahead, at which he must stop. When the car is at the point *P*, 300 m from *S*, its speed is 30 m $s^{-1}$. The car continues at this constant speed for 2 s after passing *P*. The man then applies the brakes so that the car has constant deceleration and comes to rest at *S*.

(a) Sketch, in the space below, a speed-time graph to illustrate the motion of the car in moving from *P* to *S*.

**(2)**

(b) Find the time taken by the car to travel from *P* to *S*.

**(3)**
**(Total 5 marks)**

**10.** A train starts from rest at a station *A* and moves along a straight horizontal track. For the first 10 s, the train moves with constant acceleration 1.2 m $s^{-2}$. For the next 24 s it moves with constant acceleration 0.75 m $s^{-2}$. It then moves with constant speed for *T* seconds. Finally it slows down with constant deceleration 3 m $s^{-2}$ until it comes to rest at a station *B*.

(a) Show that, 34 s after leaving *A*, the speed of the train is 30 m $s^{-1}$.

**(3)**

(b) Sketch a speed-time graph to illustrate the motion of the train as it moves from *A* to *B*.

**(3)**

(c) Find the distance moved by the train during the first 34 s of its journey from *A*.

**(4)**

The distance from *A* to *B* is 3 km.

(d) Find the value of *T*.

**(4)**
**(Total 14 marks)**

**11.** A car starts from rest at a point $S$ on a straight racetrack. The car moves with constant acceleration for 20 s, reaching a speed of 25 m s$^{-1}$. The car then travels at a constant speed of 25 m s$^{-1}$ for 120 s. Finally it moves with constant deceleration, coming to rest at a point $F$.

(a) In the space below, sketch a speed-time graph to illustrate the motion of the car.

**(2)**

The distance between $S$ and $F$ is 4 km.

(b) Calculate the total time the car takes to travel from $S$ to $F$.

**(3)**

A motorcycle starts at $S$, 10 s after the car has left $S$. The motorcycle moves with constant acceleration from rest and passes the car at a point $P$ which is 1.5 km from $S$. When the motorcycle passes the car, the motorcycle is still accelerating and the car is moving at a constant speed. Calculate

(c) the time the motorcycle takes to travel from $S$ to $P$,

**(5)**

(d) the speed of the motorcycle at $P$.

**(2)**
**(Total 12 marks)**

**12.** Two trains $A$ and $B$ run on parallel straight tracks. Initially both are at rest in a station and level with each other. At time $t = 0$, $A$ starts to move. It moves with constant acceleration for 12 s up to a speed of 30 m s$^{-1}$, and then moves at a constant speed of 30 m s$^{-1}$. Train $B$ starts to move in the same direction as $A$ when $t = 40$, where $t$ is measured in seconds. It accelerates with the same initial acceleration as $A$, up to a speed of 60 m s$^{-1}$. It then moves at a constant speed of 60 m s$^{-1}$. Train $B$ overtakes $A$ after both trains have reached their maximum speed. Train $B$ overtakes $A$ when $t = T$.

(a) Sketch, on the same diagram, the speed-time graphs of both trains for $0 \leq t \leq T$.

**(3)**

(b) Find the value of $T$.

**(9)**
**(Total 12 marks)**

**13.** A racing car is travelling on a straight horizontal road. Its initial speed is 25 m $s^{-1}$ and it accelerates for 4 s to reach a speed of $V$ m $s^{-1}$. It then travels at a constant speed of $V$ m $s^{-1}$ for a further 8 s. The total distance travelled by the car during this 12 s period is 600 m.

(a) Sketch a speed-time graph to illustrate the motion of the car during this 12 s period.

**(2)**

(b) Find the value of $V$.

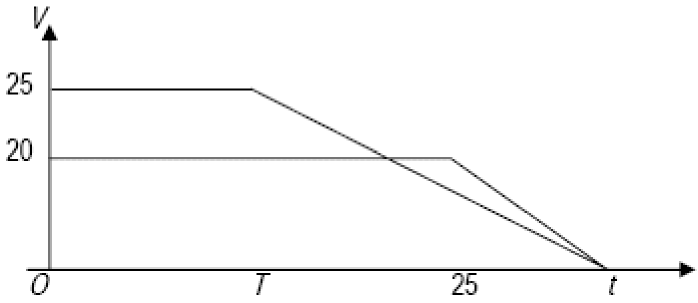
**(4)**

(c) Find the acceleration of the car during the initial 4 s period.

**(2)**

**(Total 8 marks)**

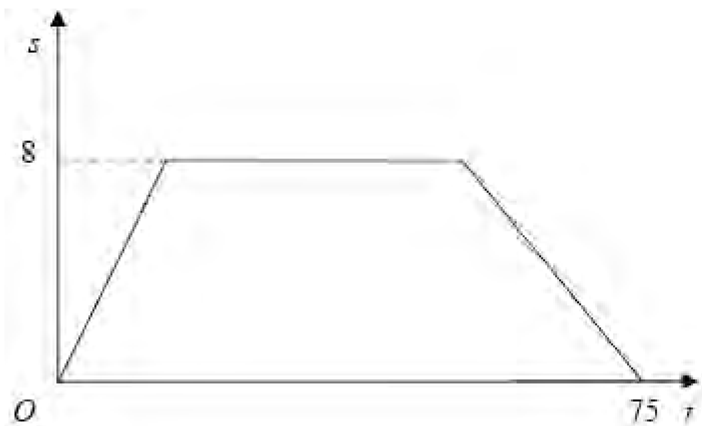
| | | | | |
|---|---|---|---|---|
| **1.** | (a) | Shape (both) | B1 | |
| | | Cross | B1 | |
| | | Meet on $t$-axis | B1 | |
| | | Figures 25, 20, $T$, 25 | B1 | 4 |




| | | | | |
|---|---|---|---|---|
| | (b) | For $Q$: $20\left(\dfrac{t+25}{2}\right)=800$ | A1 | |
| | | $t = 55$ | DM1 A1 | |
| | | For $P$: $25\left(\dfrac{T+55}{2}\right)=800$ | A1 | |
| | | solving for $T$: $T = 9$ | DM1 A1 | 8 |

**[12]**

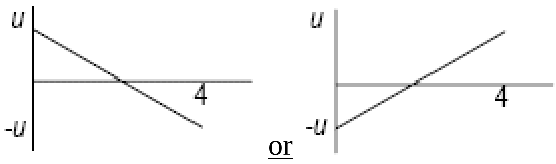
**2.** (a)




| | | | | |
|---|---|---|---|---|
| | | First two line segments | B1 | |
| | | Third line segment | B1 | |
| | | 8, 75 | B1 | 3 |
| | (b) | $\frac{1}{2}\times 8\times(T+75)=500$ | A2 (1,0) | |
| | | Solving to $T = 50$ | DM1 A1 | 5 |

**[8]**

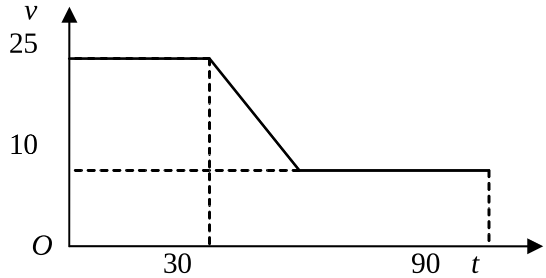
**3.** (a)




| | | |
|---|---|---|
| shape | B1 | |
| values | B1 | 2 |
| (b) $19.6 = \frac{1}{2} \times 2 \times u$ | A1 | |
| $u = 19.6$ | A1 | 3 |

**[5]**

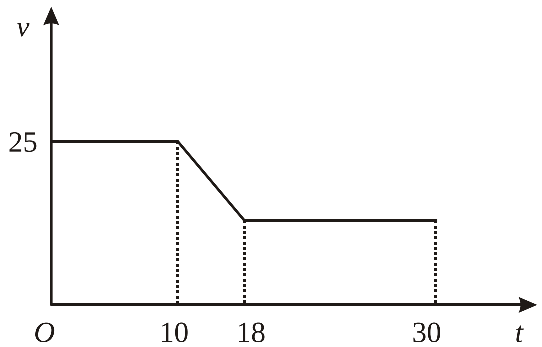
**4.** (a)




| | | |
|---|---|---|
| shape | B1 | |
| 25, 10, 30, 90 | B1 | 2 |
| (b) $30 \times 25 + \underline{\frac{1}{2}(25+10)t} + 10(60-t) = 1410$ | M1<u>A1</u>A1 | |
| $7.5t = 60$ | | |
| $t = 8$ (s) | DM1A1 | |
| $a = \frac{25-10}{8} = 1.875$ (m s$^{-2}$) $\quad 1\frac{7}{8}$ | M1A1 | 7 |

**[9]**

**5.** (a)




| | | |
|---|---|---|
| 2 horizontal lines | B1 | |
| Joined by straight line sloping down | B1 | |
| 25, 10, 18, 30 oe | B1 | 3 |

(b) $25 \times 10 + \underline{\frac{1}{2}(25+V)\times 8} + 12 \times V = 526$ M1$\underline{\text{A1}}$A1

Solving to $V = 11$ DM1A1 5

(c) "$v = u + at$" $\Rightarrow 11 = 25 - 8a$ ft their $V$ M1A1ft

$a = 1.75$ (m s$^{-2}$) A1 3

**[11]**

**6.** (a) Constant acceleration B1 1

(b) Constant speed / velocity B1 1

*(a) and (b) Accept 'steady' instead of 'constant.*
*Allow 'o.e.' (= 'or equivalent') within reason! But must have idea of constant.*

*'constant speed and constant acceleration' for (a) or (b) is B0*

(c) Distance = ½ (2 + 5) × 3, + (4 × 5) A1, B1

= 30.5 m A1 4

*for valid attempt at area of this trap. as area of a trap.*
*Or this trap. as = triangle + rectangle, i.e. correct formula used with at most a slip in numbers.*

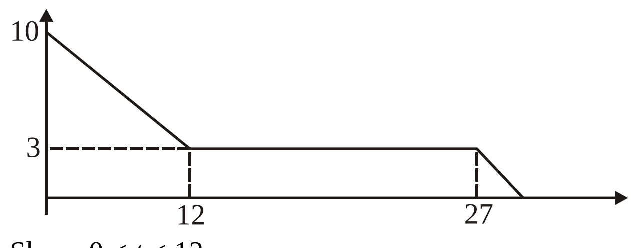
*B1 for area of rectangle as 5 × 4*

*Treating whole as a single const acceln situation, or whole as a single trapezium, is M0.*

*If assume that top speed is 5.1 or 5.2, allow full marks on f.t. basis (but must be consistent)*

**[6]**

**7.** (a)




Shape $0 < t < 12$ B1

Shape $t > 12$ B1

Figures B1 3

(b) Distance in 1st 12 s = ½ × (10 + 3) × 12 *or* (3 × 12) + ½ × 3 × 7

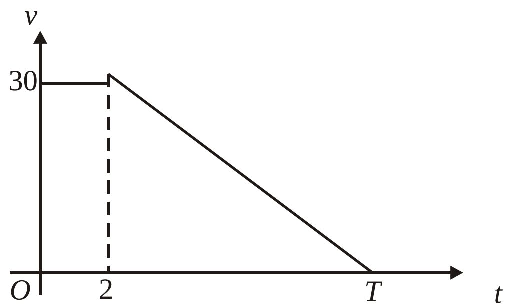
= $\underline{78\text{ m}}$ A1 2

| | | | | |
|---|---|---|---|---|
| | (c) | **either** | | |
| | | distance from $t$ = 12 to $t$ = 27 = 15 × 3 = 45 | | |
| | | ∴ distance in last section = 135 – 45 = 12 m | B1ft | |
| | | ½ × 3 × $t$ = 12, | A1ft | |
| | | ⇒ $t$ = 8 s | A1 | |
| | | hence total time = 27 + 8 = <u>35 s</u> | A1 | 5 |
| | **or** | Distance remaining after 12 s = 135 – 78 = 57 m | B1ft | |
| | | ½ × (15 + 15 + $t$) × 3 = 57 | A1ft | |
| | | ⇒ $t$ = 8 | A1 | |
| | | Hence total time = 27 + 8 = <u>35 s</u> | A1 | |

| | | | | |
|---|---|---|---|---|
| **8.** | (a) | Distance = ½ × 4 × 9 + 16 × 9 **or** ½ (20 + 16) × 9 | | |
| | | = <u>162 m</u> | A1 | 2 |
| | (b) | Distance over last 5 s = ½(9 + $u$) × 5 | | |
| | | 162 + ½(9 + u) × 5 = 200 | A1ft | |
| | | ⇒ $u$ = <u>6.2 m s$^{-1}$</u> | A1 | 4 |
| | (c) | 6.2 = 9 + 5$a$ | A1ft | |
| | | $a$ = (–) <u>0.56 m s$^{-2}$</u> | A1 | 3 |

**[9]**

**9.** (a)



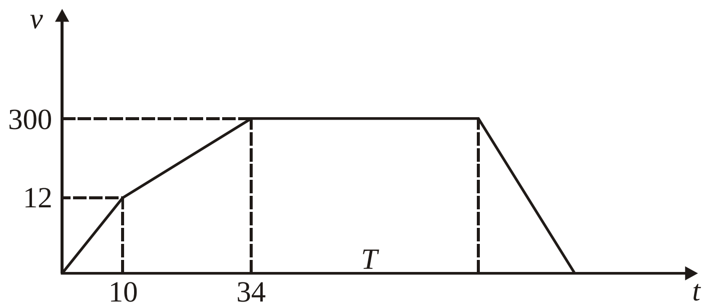

| | | | |
|---|---|---|---|
| | Shape | B1 | |
| | Figs (2, 30) | B1 | 2 |
| (b) | 300 = ½ (2 + $T$) × 30 | A1 | |
| | ⇒ $T$ = <u>18 s</u> | A1 | 3 |
| | **Or** | | |
| | If $t$ is time decelerating (and clear from working): | | |
| | 300 = 30 × 2 + ½ .30.$t$ | A1 | |
| | ⇒ $t$ = 16 s ⇒ total time = 18 s | A1 | 3 |

**[8]**

**10.** (a) After 10 s, speed = 1.2 × 10 = 12 m s$^{-1}$ B1

After next 24 s, $v$ = "$u + at$" = 12 + 0.75 × 24 = 30 m s$^{-1}$ A1 3

(b)




Shape $0 \le t \le 34$ B1
Shape $t \ge 34$ B1
Figures B1

(c) Distance = $\frac{1}{2} \times 10 \times 12, + \frac{1}{2}(30 + 12)\,24$ B1, A1
= 60 + 504 = <u>564 m</u> A1 4

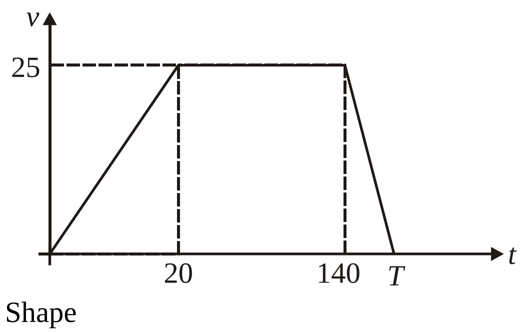
(d) Distance travelled decelerating = $\frac{1}{2} \times 30 \times 10$ B1

$564 + 30T + \frac{1}{2} \times 30 \times 10 = 3000$ A1 ft

$\Rightarrow$ T = <u>76.2 s</u> A1 4

**[11]**

**11.** (a)

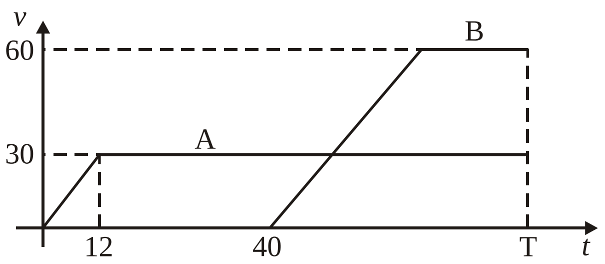



Shape B1
Figs B1 2

| | | | |
|---|---|---|---|
| (b) | $\frac{1}{2}(T + 120) \times 25 = 4000$ | A1 | |
| | $\left[\textbf{or } \frac{1}{2}.20.25, +120.25 + \frac{1}{2}(T - 140).25 = 4000\right]$ | | |
| | $T = \underline{200 \text{ s}}$ | A1 | 3 |
| (c) | Car: $\frac{1}{2}.20.25, + 25(t - 20) = 1500$ | A1, A1 | |
| | $\rightarrow t = 70$ s | | |
| | Hence motorcycle travels for 60s | A1 | 5 |
| (d) | $1500 = \left(\frac{0 + v}{2}\right).60$ | | |
| | $v = \underline{50 \text{ ms}^{-1}}$ | A1 | 2 |

**[12]**

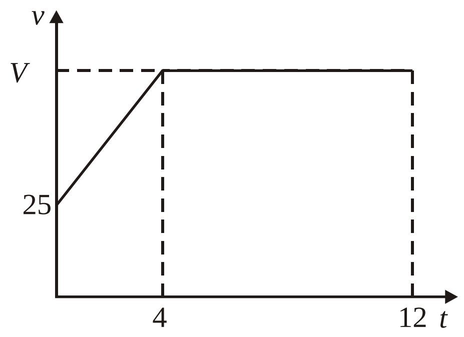
**12.**




| | | | | |
|---|---|---|---|---|
| (a) | Shape for *A* | | B1 | |
| | Shape for *B* with parallel slope | | B1 | |
| | Figures | | B1 | 3 |
| (b) | Distance moved by $A = \frac{1}{2} \times 12 \times 30, + 30(T - 12)$ | B1, | A1 | |
| | *B* accelerates for 24 s | | B1 | |
| | Distance moved by $B = \frac{1}{2} \times 24 \times 60, + 60(T - 64)$ | B1, | A1 | |
| | $\frac{1}{2} \times 12 \times 30, + 30(T - 12) = \frac{1}{2} \times 24 \times 60, + 60(T - 64)$ | | | |
| | $\Rightarrow T = 98$ s | | A1 | 9 |

**[12]**

**13.** (a)




B1 (shape)
B1 (figs) 2

(b) $600 = 8V, + \frac{1}{2}(25 + V).4$ A1, A1

$\Rightarrow \text{V} = 55$ A1 4

(c) $a = \frac{55-25}{4} = 7.5 \text{ m s}^{-2}$ A1 2

**[8]**

**1.** A large number of entirely (or almost) correct solutions were seen to this question. Most candidates drew their velocity-time graphs correctly and included appropriate annotations, with the most common error being that the lines drawn did not cross. This did not deny candidates access to full marks in the rest of the question though and many went on to solve the problem correctly. Most realised that they needed to equate the expressions for area under the graph to 800 for both $P$ and $Q$. Attempts to use constant acceleration formulae over the whole distance were occasionally seen and scored no marks although a few used this approach in a valid way for the separate parts of the motion. Most commonly, a combination of rectangles and triangles were used to represent area rather than the area of a trapezium which made the subsequent algebra more difficult, and there were occasional errors seen in simplification. A relatively common error was to calculate a correct time for $Q$ ($t = 30$) but to misinterpret this as the time when they both came to rest leading to errors in the motion of $P$.

**2.** In part (a) the speed-time graph was almost universally correct. Most candidates realised, in the second part, that the area under the graph was equal to the distance travelled and were able to calculate the correct area of 20 for the first part of the motion. Errors in the interpretation of $T$ caused most of the problems in the calculations of the other areas. Comparatively few used an area of a trapezium which provided the neatest solution.

**3.** Only a relatively small number of candidates had a correct graph in part (a). There was a whole variety of incorrect attempts seen. Many of the graphs were curved and in some cases the path that the ball would take in the air was drawn. Of those who had a straight line many were reluctant to go below the $t$-axis into negative velocities and drew a speed-time graph instead. Part (b) was more successfully answered but a common error was to use a wrong time value. Students generally used constant acceleration formulae rather than the area under their graph.

**4.** The speed-time graph in part (a) was well drawn with sufficient detail although a few candidates went beyond 90 on the $t$-axis. In the second part most tried to equate the area under their graph to 1410 but there were occasional errors and inconsistent use of the unknown time within the equation. Some found the area of the triangle to be 60 (correctly) but then used this as a distance in a constant acceleration formula to find the deceleration. The final two marks required the use of an appropriate value of $t$ (i.e. not 38) and this was usually achieved although some, using the correct time value of 8, lost a mark by giving the deceleration as a negative value. More inexplicably, a few calculated the hypotenuse of a right-angled triangle rather than the gradient. Those who tried to use constant acceleration formulae for more than one stage of the motion at a time received no credit; such attempts were only very rarely seen.

**5.** This question was well answered by many candidates.

(a) Almost all drew a graph with the correct relevant sections, and most labelled the significant values on the axes.

(b) A few candidates tried to apply the constant acceleration formulae to more than one section of the motion at a time, showing a complete lack of understanding of the problem and received no credit.. However, most tried to equate the area under the graph to the given distance, many successfully, but there were errors seen. These included treating the first two sections as a single trapezium (despite having five sides), using a wrong value for at least one of the dimensions, omitting a part (e.g. using just a triangle rather than either a trapezium or triangle and rectangle for the middle section), and omitting the '1/2' from the triangle area formula. Those candidates who approached the problem systematically and who made good use of brackets tended to complete the simplification correctly and reach the required answer of 11 m $s^{-1}$.

(c) Many recognised a valid approach here by either using $v = u + at$ (or a combination of other constant acceleration formulae) or using the fact that the gradient represents the acceleration.
Some candidates who did not gain any credit in (b) because of an invalid method often managed to achieve two out of the three available marks here by following through with their wrong $V$ value. The many candidates who produced fully correct solutions thus far sometimes failed to achieve the final mark by giving their answer as negative when the (positive) deceleration was required.

**6.** The question was generally well answered and proved to be a reasonably friendly opening question. Most recognised the significance of the straight lines in parts (a) and (b), though some simply stated in part (a) that the cyclist was 'accelerating' (without mentioning the constancy). In part (c), most attempted to find the area under the graph. Some weaker candidates assumed that the whole area was that of a single trapezium; and some made errors in find the area of the rectangle on the right hand side (with e.g. $5 \times 7$ instead of $5 \times 4$ seen).

**7.** Some very good answers were seen to this question with many fully correct (or all but correct) answers. Nearly all could draw a good sketch for the speed-time graph, with values appropriately put on the axes. A few made errors in part (b), finding only the area of the triangle under the speed time graph for that section of the motion, though many then recovered and correctly answered part (c). A few incorrectly assumed that the deceleration in the final part of the motion was the same as the deceleration in the first part. Generally though it was very pleasing to see this part of the syllabus so well mastered.

**8.** This proved to be a good source of marks for many candidates, with full marks often being obtained. Constant acceleration equations appeared to be generally well known. Mistakes, if they occurred, tended to be in part (b) where some failed to take the full area under the graph into consideration (perhaps only considering the area of a triangle) and then fudging their answer obtained in relation to the sign.

**9.** This was generally found to be a straightforward first question and most could make good attempts at the whole question. The sketching of the graph was generally well done. The second part was also often fully correct, though some found only the time during the deceleration period and forgot to add in the initial 2 seconds to get the total time. A few however thought that they could use constant acceleration equations for the whole time period.

**10.** This proved to be a good source of marks for many. The general principles were well known as well as interpretation of different quantities on the graph in relation to the data (e.g. that the slope of the speed-time graph is the acceleration, that the area under the graph is the distance travelled). Graphs were however not always very well drawn; examiners are generally as accommodating as they can be in marking sketches, and certainly they do not expect highly accurate drawings, but the sketches given were as often as not rather poorly drawn. Parts (b) and (c) were also generally well done.

Some took the time at constant speed to be '$T + 34$' rather than just $T$; others made small slips in solving the questions; but generally good work, and resulting high marks, were often seen here.

**11.** Parts (a) and (b) were generally well done, though a number of weaker candidates still used equations for constant acceleration for the whole motion in part (b). In part (c) some correct solutions were seen but the presentation of the solutions was very often extremely poor with little or no explanations explicitly offered for the calculations performed. Candidates must be encouraged to make their working clear and not to leave it to the examiner to try to guess the method being adopted. In part (d) a number effectively assumed that the motion of the motor cyclist was one of constant motion (hence dividing the distance by the time).

**12.** Most candidates were able to sketch the speed-time graphs reasonably well: several spent too long in trying to produce an accurate diagram on graph paper, though some who did not do so had graphs where the gradients of the two sloping parts were nowhere near parallel. In part (b), a fairly common misunderstanding (or misreading) of the data given assumed that the trains were level at the time when $B$ reached its maximum speed. Most had some idea that the areas under the two graphs must be equal; but the algebraic manipulation required to set up a correct equation for $T$ and then solve it was too demanding for the majority of candidates.

**13.** No Report available for this question.