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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Kinematics in a Straight Line (M1.1)

International A Level Mathematics · M1: Mechanics 1 (WME01)

26 questions · 261 marks · Mark schemes included

Past papers January 2020 - June 2025 · 2 sub-topics

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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2. Q1	IAL M1 (WME01) January 2021	6	5
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QUESTIONS

26 questions · 261 marks · 2 sub-topics

SUB-TOPIC M1.1a

CONSTANT ACCELERATION (SUVAT) & VERTICAL MOTION

Sub-topic M1.1a · 12 questions · 113 marks · lowest tariff first



Question 6 continued

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(Total 5 marks)

Q6



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1. A small stone is projected vertically upwards with speed 20 ms^{-1} from a point O which is 5 m above horizontal ground. The stone is modelled as a particle moving freely under gravity.

Find

- (a) the speed of the stone at the instant when it is 2 m above the ground, (2)
- (b) the total time between the instant when the stone is projected from O and the instant when it first strikes the ground. (4)

Question 1 continued

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Q1

(Total 6 marks)



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2. A motorbike is moving with constant acceleration along a straight horizontal road.

The motorbike passes a point P and 10 seconds later passes a point Q .

The speed of the motorbike as it passes Q is 28 m s^{-1}

Given that $PQ = 220\text{ m}$,

- (a) find the acceleration of the motorbike,

(3)

- (b) find the distance travelled by the motorbike during the fifth second after passing P

(4)



Question 2 continued

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Question 2 continued

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Question 2 continued

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(Total 7 marks)

Q2

Mark box for Question 2.



2. A car moves along a straight horizontal road with constant acceleration $a \text{ m s}^{-2}$ where $a > 0$

The car is modelled as a particle.

At time $t = 0$, the car passes point A and is moving with speed $u \text{ m s}^{-1}$

In the first three seconds after passing A the car travels 20 m.

In the fourth second after passing A the car travels 10 m.

The speed of the car as it passes point B is 20 m s^{-1}

Find the time taken for the car to travel from A to B .

(8)

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Question 2 continued

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Question 2 continued

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Question 2 continued

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(Total 8 marks)

Q2



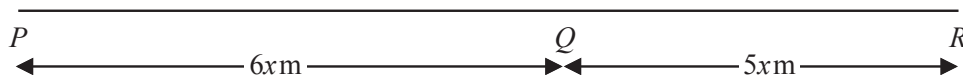
Question 3 continued

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(Total for Question 3 is 8 marks)



5.

**Figure 2**

Three points P , Q and R are on a horizontal road where PQR is a straight line.

The point Q is between P and R , with $PQ = 6x$ metres and $QR = 5x$ metres, as shown in Figure 2.

A vehicle moves along the road from P to Q with constant acceleration.

The vehicle is modelled as a particle.

At time $t = 0$, the vehicle passes P with speed $u \text{ m s}^{-1}$

At time $t = 12 \text{ s}$, the vehicle passes Q with speed $2u \text{ m s}^{-1}$

Using the model,

(a) show that $x = 3u$

(2)

As the vehicle passes Q , the acceleration of the vehicle changes instantaneously to 1.5 m s^{-2}

The vehicle continues to move with a constant acceleration of 1.5 m s^{-2} and passes R with speed $3u \text{ m s}^{-1}$

Using the model,

(b) find the value of u ,

(3)

(c) find the distance travelled by the vehicle during the first 14 seconds after passing P

(4)

Question 5 continued



Question 5 continued



Question 5 continued

(Total for Question 5 is 9 marks)



Question 3 continued

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Question 3 continued

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Question 3 continued

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(Total 10 marks)

Q3



Question 3 continued

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(Total for Question 3 is 10 marks)



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3. A particle, P , is projected vertically upwards with speed U from a fixed point O . At the instant when P reaches its greatest height H above O , a second particle, Q , is projected with speed $\frac{1}{2}U$ vertically upwards from O .
- (a) Find H in terms of U and g . (2)
- (b) Find, in terms of U and g , the time between the instant when Q is projected and the instant when the two particles collide. (6)
- (c) Find where the two particles collide. (3)

Question 3 continued

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Question 3 continued

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Question 3 continued

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(Total 11 marks)

Q3



- 7 At time $t = 0$, a small ball A is projected vertically upwards with speed 8 m s^{-1} from a fixed point on horizontal ground.

The ball hits the ground again for the first time at time $t = T_1$ seconds.

Ball A is modelled as a particle moving freely under gravity.

- (a) Show that $T_1 = 1.63$ to 3 significant figures.

(2)

After the first impact with the ground, A rebounds to a height of 2 m above the ground.

Given that the mass of A is 0.1 kg,

- (b) find the magnitude of the impulse received by A as a result of its first impact with the ground.

(5)

At time $t = 1$ second, another small ball B is projected vertically upwards from another point on the ground with speed 5 m s^{-1}

Ball B is modelled as a particle moving freely under gravity.

At time $t = T_2$ seconds ($T_2 > 1$), A and B are at the same height above the ground for the first time.

- (c) Find the value of T_2

(4)



Question 7 continued



Question 2 continued

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Question 2 continued

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Question 2 continued

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(Total 14 marks)

Q2

Grading boxes for Q2.



Question 5 continued

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Question 5 continued

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Question 5 continued

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(Total for Question 5 is 14 marks)



SUB-TOPIC M1.1b

SPEED-TIME & VELOCITY-TIME GRAPHS

Sub-topic M1.1b · 14 questions · 148 marks · lowest tariff first



Question 8 continued

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Question 8 continued

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Question 8 continued

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Question 8 continued

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Handwriting practice area with horizontal lines.

(Total 8 marks)

Q8

TOTAL FOR PAPER = 75 MARKS

END



- (2)

Question 4 continued

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Question 4 continued

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(Total 8 marks)

Q4

Mark box for Q4.



Question 3 continued

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Question 3 continued

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Question 3 continued

Lined area for writing the answer to Question 3.

(Total for Question 3 is 8 marks)



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5. A small ball is projected vertically upwards with speed 29.4 m s^{-1} from a point A which is 19.6 m above horizontal ground.

The ball is modelled as a particle moving freely under gravity until it hits the ground. It is assumed that the ball does not rebound.

- (a) Find the distance travelled by the ball while its speed is less than 14.7 m s^{-1} (3)
- (b) Find the time for which the ball is moving with a speed of more than 29.4 m s^{-1} (3)
- (c) Sketch a speed-time graph for the motion of the ball from the instant when it is projected from *A* to the instant when it hits the ground. Show clearly where your graph meets the axes. (3)

Question 5 continued

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Question 5 continued

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Question 5 continued

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(Total 9 marks)

Q5



Question 5 continued

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Question 5 continued

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Q5

1. A train travels along a straight horizontal track between two stations A and B .

The train starts from rest at station A and accelerates uniformly for T seconds until it reaches a speed of 20 m s^{-1}

The train then travels at a constant speed of 20 m s^{-1} for 3 minutes before decelerating uniformly until it comes to rest at station B .

The magnitude of the acceleration of the train is twice the magnitude of the deceleration.

- (a) On the axes below, sketch a speed–time graph to illustrate the motion of the train as it moves from station A to station B .



If you need to redraw your graph, use the axes on page 3

(3)

Stations A and B are 4.8 km apart.

- (b) Find the value of T

(5)

- (c) Find the acceleration of the train during the first T seconds of its motion.

(2)

Question 1 continued

Only use these axes if you need to redraw your graph.



(Total for Question 1 is 10 marks)

Question 2 continued

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Question 2 continued

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Question 2 continued

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(Total for Question 2 is 10 marks)

5.

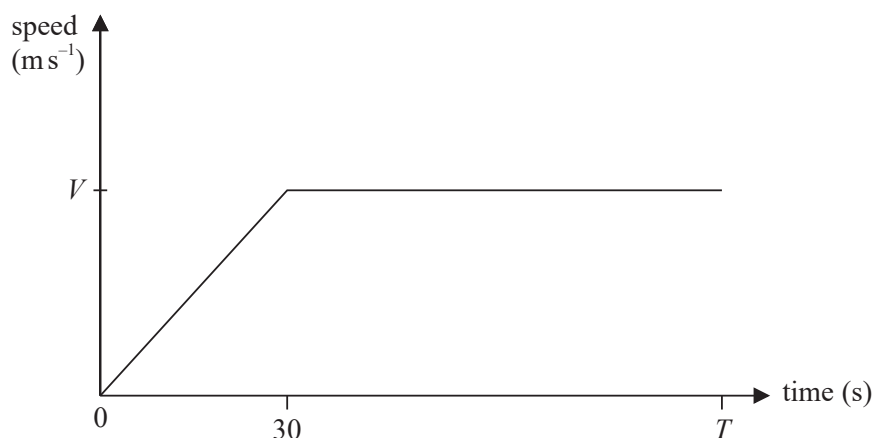


Figure 2

The speed-time graph in Figure 2 illustrates the motion of a car travelling along a straight horizontal road.

At time $t = 0$, the car starts from rest and accelerates uniformly for 30 s until it reaches a speed of $V \text{ m s}^{-1}$.

The car then travels at a constant speed of $V \text{ m s}^{-1}$ until time $t = T$ seconds.

- (a) Show that the distance travelled by the car between $t = 0$ and $t = T$ seconds is $V(T - 15)$ metres.

(2)

A motorbike also travels along the same road.

- The motorbike starts from rest at time $t = 10 \text{ s}$ and accelerates uniformly for 40 s
- The acceleration of the motorbike is the **same** as the acceleration of the car
- The motorbike then travels at a constant speed for a further 10 s before decelerating uniformly until it reaches a speed of $V \text{ m s}^{-1}$ at time T seconds

- (b) On Figure 2, sketch a speed-time graph for the motion of the motorbike.

[If you need to redraw your sketch, there is a copy of Figure 2 on page 15.]

(2)

- (c) Show that the constant speed of the motorbike is $\frac{4V}{3} \text{ m s}^{-1}$

(2)

At time $t = T$ seconds, the distance travelled by each vehicle is the same.

- (d) Find the value of T

(5)

Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5 continued.







(Total for Question 2 is 11 marks)



Question 7 continued

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Question 7 continued

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Question 7 continued

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(Total 12 marks)

Q7	



6. A particle is projected vertically upwards from a point A with speed 24 m s^{-1}

The point A is 2.5 m vertically above the point B .

Point B lies on horizontal ground.

The particle moves freely under gravity until it hits the ground at B with speed $V \text{ m s}^{-1}$

After hitting the ground the particle does not rebound.

- (a) Find the value of V . (3)
- (b) Find the time taken for the particle to reach B . (3)
- The point C is 10 m vertically above A .
- (c) Find the length of time for which the particle is above C . (4)
- (d) Sketch a speed-time graph for the motion of the particle from projection to the instant that it reaches B . (No further calculations are required.) (2)

- (b) Find the time taken for the particle to reach B . (3)

The point C is 10m vertically above A .

- (c) Find the length of time for which the particle is above C . (4)
- (d) Sketch a speed-time graph for the motion of the particle from projection to the instant that it reaches B . (No further calculations are required.) (2)

- (d) Sketch a speed-time graph for the motion of the particle from projection to the instant that it reaches B . (No further calculations are required.) (2)







Question 6 continued

(Total for Question 6 is 12 marks)



Question 8 continued

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Handwriting practice area with 30 horizontal lines.



Question 8 continued

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Question 8 continued

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Question 8 continued

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Q8

(Total 13 marks)

END

TOTAL FOR PAPER: 75 MARKS

Question 7 continued

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Question 7 continued

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Question 7 continued

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(Total 13 marks)

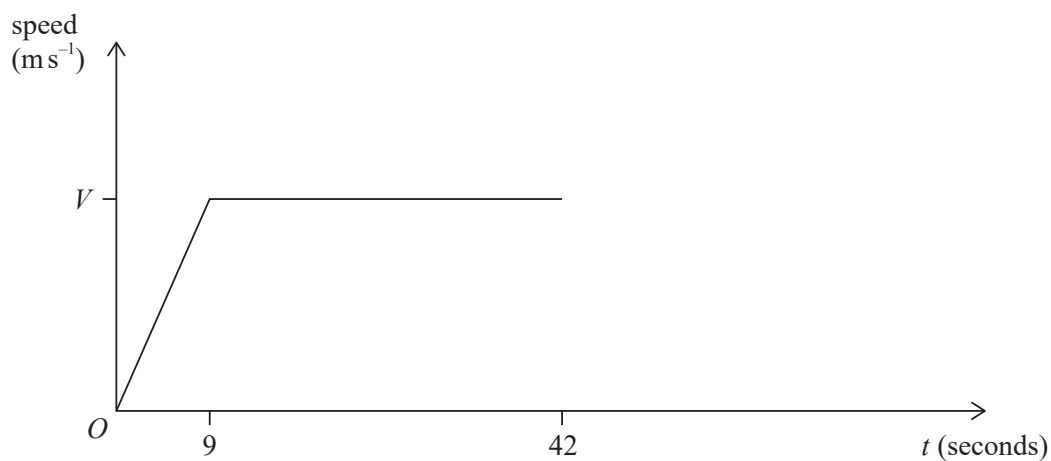
Q7





Question 4 continued

Only use this copy of Figure 2 if you need to redraw your answer to part (c).



Copy of Figure 2

(Total for Question 4 is 13 marks)



MARK SCHEMES

official mark schemes, in the same order as the questions



Question Number	Scheme	Marks
6(a)	$0 = u - 9.8 \times 2.5$ oe using gradient of graph. Allow g or 9.81 instead of 9.8	M1
	$u = 24.5$ or $25 \text{ (m s}^{-1}\text{)}$ Allow $2.5g$	A1
	Many other methods	(2)
6(b)	$s = 24.5 \times 2 + \frac{1}{2} \times 9.8 \times 2^2$ OR $s = 24.5 \times 7 - \frac{1}{2} \times 9.8 \times 7^2$ OR $s = \frac{1}{2} \times 9.8 \times 4.5^2 - (24.5 \times 2.5 + \frac{1}{2} \times (-9.8) \times 2.5^2)$ OR $s = \frac{1}{2} \times 9.8 \times 4.5^2 - \frac{1}{2} \times 9.8 \times 2.5^2$ Many other methods, using <i>suvat</i> and/or the graph (e.g. similar triangles and area under graph) Allow g or 9.81 instead of 9.8 in all equations.	M1A1ft
	68.6 or 69 (m)	A1
		(3)
		(5)
	Notes for question 6	
	For use of $g = 9.81$, which will only affect the final A mark in each part, penalise once for whole question	
6(a)	M1 for complete method using <i>suvat</i> or the graph to produce an equation in u only, with correct number of terms, condone sign errors.	
	A1 cao (must be positive)	
6(b)	M1 Complete method to give a final displacement, condone sign errors within a <i>suvat</i> equation.	
	A1ft Correct equation ft on their u	
	A1 cao	

Question Number	Scheme	Marks
1(a)	$v^2 = 20^2 - 2g \times (-3)$	M1
	$v = 21 \text{ or } 21.4 \text{ (m s}^{-1}\text{)}$	A1 (2)
1(b)	<u>Complete</u> method to find the <u>total</u> time: e.g. either: $-5 = 20t - \frac{1}{2}gt^2$ using one equation or: $0 = 20 - gt_1 \Rightarrow t_1 = \frac{100}{49} = 2.040816..$ $s_1 = \left(\frac{20+0}{2}\right)t_1 \left(= \frac{1000}{49} = 20.40816..$ (or $s_1 = 20t_1 - \frac{1}{2}gt_1^2$) using four equations $25.408.. = \frac{1}{2}gt_2^2 \Rightarrow t_2 = 2.2771..$ $t = t_1 + t_2 = 4.31795..$ and many other methods	M1
	There are two A marks for all the equations they use, -1 each error	A1
	N.B. The second M mark should be treated as an A mark	M(A)1
	$t = 4.3 \text{ or } 4.32 \text{ (s)}$	A1
		(6)
	Notes for question 1	
1(a)	M1 Complete method to find the speed, must be using 3 or -3 (Allow 9.81 for g or just g), condone sign errors	
	A1 Correct answer (Must have used 9.8 and be positive)	
1(b)	M1 Complete method to find the total time, condone sign errors	
	A1	
	M(A)1 There are now two A marks for the equation(s) that they use, -1 for each error. (Allow 9.81 for g or just g)	
	A1 Correct answer (Must have used 9.8)	
	N.B. No isw for this question e.g. If they had the correct quadratic but went on to add the roots, this would lose the M mark.	

Question Number	Scheme	Marks
2(a)	$220 = (28 \times 10) - \frac{1}{2}a \times 10^2$	M1 A1
	Other possible equations, any 2 of which could be used to obtain an equation in a only : $28 = u + 10a$ $220 = \frac{(u + 28)}{2} \times 10$ $220 = 10u + \frac{1}{2}a \times 10^2$ $28^2 = u^2 + 2a \times 220$	
	$a = 1.2 \text{ (m s}^{-2}\text{)}$	A1
		(3)
2(b)	Any ONE of these: $28 = u_4 + 1.2 \times 6 \Rightarrow u_4 = 20.8$ $28 = u_5 + 1.2 \times 5 \Rightarrow u_5 = 22$ $s_4 = 16 \times 4 + \frac{1}{2} \times 1.2 \times 4^2 = 73.6$ $s_5 = 16 \times 5 + \frac{1}{2} \times 1.2 \times 5^2 = 95$ Allow distances from Q e.g. $s_6 = 28 \times 6 - \frac{1}{2} \times 1.2 \times 6^2 = 146.4$ $s_5 = 28 \times 5 - \frac{1}{2} \times 1.2 \times 5^2 = 125$	M1A1ft
	e.g. $s = 20.8 \times 1 + \frac{1}{2} \times 1.2 \times 1^2$ OR $s = 22 \times 1 - \frac{1}{2} \times 1.2 \times 1^2$ OR $s = 95 - 73.6$ OR $22^2 = 20.8^2 + 2 \times 1.2s$ OR $s = 146.4 - 125$	M1
	21.4 (m) Allow 21 (m).	A1 (4)
		(7)
	Notes for question 2	
	N.B. Use of an incorrect <i>suvat</i> formula is M0.	
2(a)	M1 Complete method to find an equation in a only (note that $u = 16$) N.B. Allow $220 = (28 \times 10) + \frac{1}{2}a \times 10^2$ ($s = ut + \frac{1}{2}at^2$ for 'reverse' motion) leading to $a = -1.2$ M1A0A0 but if they then change a to 1.2, then it becomes M1A1A1 retrospectively) M0 if they assume $u = 0$	
	A1 Correct equation	

	A1 cao	
2(b)	M1 Complete method to find the speed at $t = 4$ or 5 OR a distance at $t = 4$ or 5 M0 if they assume $u = 0$	
	A1ft A correct speed or distance, follow through on their a and u but only if u has been used to find a in part (a).	
	M1 Complete method to find the required distance	
	A1 cao	



2.	Use of $s = ut + \frac{1}{2}at^2$	M1	Form equation in u and a . N.B. Marks are available if they use two other unknowns, rather than u and a
	$20 = 3u + \frac{9a}{2}$	A1	Correct unsimplified equation
	Use of <i>suvat</i>	M1	Form second equation in u and a . N.B. Marks are available if they use the same two other unknowns, rather than u and a
	$10 = (u + 3a) + \frac{a}{2}$ or $30 = 4u + 8a$	A1	Correct unsimplified equation
	$30 = 3u + \frac{21a}{2} \Rightarrow 10 = 6a, a = \frac{5}{3}$	M1	Solve for u or a Or for one of their unknowns.
	$u = \frac{25}{6}$	A1	u and a both correct or both their unknowns correct. Accept equivalent forms. 1.7, 4.2 or better
	Use of $v = u + at$, $20 = \frac{25}{6} + \frac{5}{3}t$	M1	Complete method using <i>suvat</i> to find t . Correct unsimplified for their u, a .
	$t = 9.5$ (s)	A1	cao
		[8]	

Question Number	Scheme	Marks
3(a)	$1.5 = 0 + \frac{1}{2} g t^2$	M1 A1
	$t = 0.55$ or $0.553(\text{s})$	A1
		(3)
3(b)	$1.5 = 0 + \frac{1}{2} a (0.6)^2$	M1 A1
	$0.2g - R = 0.2a$	M1 A1
	$R = 0.293, 0.29$	A1
		(5)
		(8)
Notes for Question 3		
(a)		
M1	Complete method to find the time taken using $a = g$	
A1	Correct unsimplified equation in t only	
A1	Cao	
(b)		
M1	Complete method to form an equation in a only, $a \neq g$, using $t = 0.6$	
A1	Correct unsimplified equation in a only	
M1	Use $F = ma$ to form an equation of motion with correct terms, condone sign errors, $a \neq g$	
A1	Correct unsimplified equation	
A1	Cao	
	N.B. Allow consistent use of $(-a)$ instead of a and penalise in the second equation if inconsistent. N.B. Penalise use of $g = 9.81$ once for the whole question. Also penalise once for the whole question, answers as fractions, penalise the first one, if both answers are fractions.	

	M(B) $(R_D \times 0.36) = W(1.26 - x)$	
Question Number	Scheme	Marks
5(a)	P to Q	M1
	$6x = \left(\frac{u+2u}{2}\right)12$	
	OR $6x = 12u + \frac{1}{2} \times \frac{u}{12} \times 12^2$	
	OR $(2u)^2 = u^2 + 2 \times \frac{u}{12} \times 6x$	
	Reaches given answer from correct working $x = 3u$ *	A1*
		(2)
5(b)	Q to R	M1
	e.g. $(3u)^2 = (2u)^2 + 2(1.5)(15u)$	A1
	$u = 9$	A1
		(3)
5(c)	Q to S ($t = 14$ position)	M1
	$QS = 2u \times 2 + \frac{1}{2} \times 1.5 \times 2^2$	A1
	$(4u + 3) + 18u$	M1
	201 (m)	A1
		(4)
(9)		
	NOTES	
(a)		
M1	Considers P to Q and forms a relevant equation in terms of u and x	
A1*	Reaches given answer from correct working	
(b)		
M1	Uses the given answer in (a) to form an equation in u only	
	N.B. If brackets missing, allow M1, but allow recovery.	
A1	Correct unsimplified equation in u only	
A1	Correct answer	
(c)		
M1	Complete method to find the distance travelled in the 2 seconds after passing Q	
A1	Correct unsimplified expression in u only (or 39 m)	
M1	Complete method to find the required distance (need $18u$ or $6x$)	
A1	Correct answer	

Question Number	Scheme	Marks
3(a)	$v^2 = 25^2 - 2 \times 6 \times 48$	M1
	$v = 7 \text{ (m s}^{-1}\text{)}$	A1
		(2)
3(b)	$\frac{25-13}{6} \quad (2)$	M1
	$13^2 = 25^2 - 2 \times 6s \quad \text{OR} \quad 25 \times 2 - \frac{1}{2} \times 6 \times 2^2 \quad \text{OR} \quad \frac{(25+13)}{2} \times 2$ $\text{OR} \quad 13 \times 2 - \frac{1}{2} \times (-6) \times 2^2 \quad ((s =) 38)$	M1
	Total time = $\frac{(48-38)}{13} + 2$	DM1
	$\frac{36}{13} = 2\frac{10}{13} \text{ (s)} \quad (2.76923\dots)$	A1
		(4)
3(c)	$\frac{25-13}{6} \quad (2) \quad (\text{could be implied by 2.2})$	M1
	$(0.2 \times 25) + (25 \times 2 - \frac{1}{2} \times 6 \times 2^2) \quad (5 + 38)$	M1
	Total time = $\frac{48 - [(0.2 \times 25) + 38]}{13} + 0.2 + 2$	DM1
	$\frac{168}{65} = 2\frac{38}{65} \text{ (s)} \quad (2.58461538\dots)$	A1
		(4)
		(10)
	Notes for question 3	
3(a)	M1 Complete method to find v (condone sign errors)	
	A1 cao	
3(b)	M1 Complete method to find time to reach 13 m s^{-1}	
	M1 Complete method to find distance travelled in reaching 13 m s^{-1} ft on their 2 if necessary	
	DM1 Dependent on previous two M marks, Complete method to find the total time, ft on their 2 and 38	
	A1 Correct answer. Allow 2.8 or better	
3(c)	M1 Complete method to find the time taken to reach 13 m s^{-1} once it starts decelerating	
	M1 Complete method to find total distance travelled in reaching 13 m s^{-1} ft on their 2 if necessary	
	DM1 Dependent on previous two M marks, Complete method to find the total time, ft on their 2 and 38	
	A1 Correct answer. Allow 2.6 or better	

QUESTION NUMBER	SCHEME	MARKS
3(a)	A to B : $s = \left(\frac{u+v}{2} \right) t : \quad 400 = \left(\frac{u+28}{2} \right) 20$ Other possible equations: $28 = u + 20a$ $400 = 20u + \frac{1}{2} a \times 20^2$ $28^2 = u^2 + 2 \times 400a$ $400 = (28 \times 20) - \frac{1}{2} a \times 20^2$	M1
	$u = 12^*$	A1* cso
		(2)
3(b)	A to B : Any of the above equations with $u = 12$ e.g. $v = u + at \quad 28 = 12 + 20a$ (leads to $a = 0.8$)	M1 A1
	A to midpoint: $200 = 12t + \frac{1}{2} 0.8t^2$ OR: find v and use it to find t e.g. $v^2 = 12^2 + (2 \times 0.8 \times 200) \Rightarrow v = \sqrt{464}$ and then one of : $\sqrt{464} = 12 + 0.8t$ $200 = \left(\frac{12 + \sqrt{464}}{2} \right) t$ $200 = \sqrt{464}t - \frac{1}{2} \times 0.8t^2$	M1 A1
	$t = 12$ (s) or better (11.9258..), $5\sqrt{29} - 15$	A1
		(5)
3(c)	$D - 260 = 1200(0.8)$	M1A1ft
	$D = 1220$ (N)	A1
		(3)
		(10)

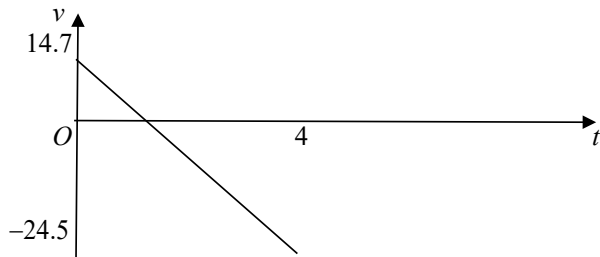


	Notes for question 3	
(a) M1 A1*	Complete method to find the value of u . (they may use two equations, eliminate a and solve for u) Correctly reaches the given answer. N.B. If they use 2 equations, we need to see a eliminated and u found correctly for this A mark. N.B. No marks if they use $u = 12$ in (b) to find a and then use it in (a) to show that $u = 12$.	
(b) M1 A1 M1 A1 A1	Relevant suvat equation to find acceleration. This could be found in (a) or in (c) to earn these marks, but not necessarily used in (b). Correct equation(s). Complete method to find an equation in t only. (they may find v (21.54065..) first). Must use their calculated acceleration and 12. Correct unsimplified equation in t only. Correct answer, $t = 12$ or better, $t = 11.9258...$ If seen, the negative value for t ($- 41.9258...$) must be rejected.	
(c) M1 A1ft A1	Use of $F=ma$. Correct no. of terms, dimensionally correct, a does not need to be substituted, condone sign errors. M0 if they use $a = g$. Correct unsimplified equation, ft on their a . Accept 1200 (N)	

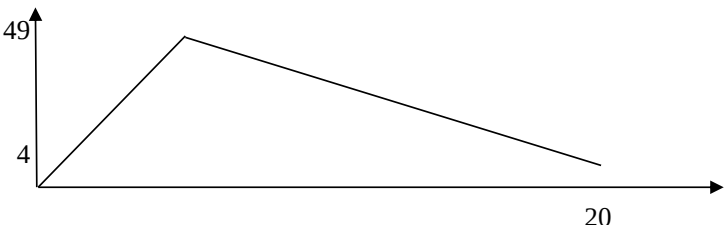
Question Number	Scheme	Marks
3.	Allow a numerical value of g used anywhere apart from the final A marks in (a) and (b) but penalise use of $g = 9.81$ once for whole question	
(a)	$0^2 = U^2 - 2gH$	M1
	$H = \frac{U^2}{2g}$	A1
		(2)
(b)	$s_p = \frac{1}{2}gt^2$ OR $s_p = Ut - \frac{1}{2}gt^2$	M1A1
	$s_Q = \frac{1}{2}Ut - \frac{1}{2}gt^2$ $s_Q = \frac{1}{2}U(t - \frac{U}{g}) - \frac{1}{2}g(t - \frac{U}{g})^2$	M1A1
	$s_p + s_Q = H$ $s_p = s_Q$ $\Rightarrow \frac{1}{2}Ut = \frac{U^2}{2g}$ $\Rightarrow Ut - \frac{1}{2}gt^2 = \frac{1}{2}U(t - \frac{U}{g}) - \frac{1}{2}g(t - \frac{U}{g})^2$	M1
	$t = \frac{U}{g}$ Answer = $(t - \frac{U}{g}) = \frac{U}{g}$	A1
		(6)
(c)	$s_p = \frac{1}{2}g\left(\frac{U}{g}\right)^2$ OR $s_p = U\left(\frac{2U}{g}\right) - \frac{1}{2}g\left(\frac{2U}{g}\right)^2$ or $s_Q = \frac{1}{2}U\left(\frac{U}{g}\right) - \frac{1}{2}g\left(\frac{U}{g}\right)^2$ or $s_Q = \frac{1}{2}U\left(\frac{U}{g}\right) - \frac{1}{2}g\left(\frac{U}{g}\right)^2$	M1 A1
	Collide at the point O or at the point of projection. (At the same level as O is A0)	A1
		(3)
		(11)
	Notes for question 3	
3(a)	M1 Complete method to find an equation in H , U and g <i>only</i> . Condone sign errors	
	A1 Correct expression for H in terms of U and g . (A0 if they use h or s in their answer but allow for the M mark)	
3(b)	N.B. When awarding marks, must use EITHER the LH column OR the RH column, not a mixture of both. Award as many marks as possible. M1 Complete method to find s_p in terms of t , where $t = 0$ is when Q is projected upwards. The alternative arises when $t = 0$ is taken to be when P is projected <i>upwards</i> . Condone sign errors.	
	A1 Correct equation (using their H where it is used) Allow: $s_p = \frac{1}{2}gt^2$ or $s_p = -\frac{1}{2}gt^2$ or $s_p = H - \frac{1}{2}gt^2$ or $s_p = -(H - \frac{1}{2}gt^2)$	

Q	Scheme	Marks	Notes
7a	$-8 = 8 - gT_1$ OR $0 = 8T_1 - \frac{1}{2} \times 9.8T_1^2$ OR $0 = 8 - gt$ and $T_1 = 2 \times \frac{8}{g}$	M1	Complete method using <i>suvat</i> . Condone sign error
	$T_1 = 1.63$ *	A1*	Given single answer correctly obtained (Allow T or $t = 1.63$ or just 1.63)
		[2]	
7b	$0 = u^2 - 2g \times 2$	M1	Complete method to find speed immediately after 1st impact N.B. Could use energy.
	$u = 2\sqrt{g} = 6.26099..$	A1	Seen or implied. Do not penalise for > 3 sf
	Use of $I = mv - mu$	DM1	Dependent on M1, condone sign errors and a recalculated '8'.
	$I = 0.1(8 - (-6.3))$	A1	Must have 8 and 6.3 or better.
	$= 1.4$ or 1.43 (Ns)	A1	2sf or 3sf
		[5]	
7c	Equal heights	M1	Complete method using <i>suvat</i> to form an equation in T_2 Allow with $T_2 + 1, T_2$ with $T_2 + 1$ used for A and T_2 used for B Allow t instead of T_2 N.B. M0 if they use the same times for both or a mixture of t and $t + 1$. ALT 1 At $t = 1$, A is $(8 - 4.9) = 3.1\text{m}$ above the ground and moving downwards with speed $(9.8 - 8) = 1.8 \text{ m s}^{-1}$ then use $h - s_A = s_B$ oe to find $T_2 - 1$. Must find both height and speed.
	$8T_2 - \frac{1}{2}gT_2^2 = 5(T_2 - 1) - \frac{1}{2}g(T_2 - 1)^2$ OR $8(T_2 + 1) - \frac{1}{2}g(T_2 + 1)^2 = 5T_2 - \frac{1}{2}gT_2^2$	A1 A1 A1 A1	One distance correct Both distances correct One distance 'correct' Both distances 'correct'

	ALT 1: $3.1 - (1.8t + 4.9t^2) = (5t - 4.9t^2)$	A1 A1	Allow t instead of T_2 in either. One side correct Both sides correct
	$(t = \frac{3.1}{6.8}) \quad (T_2 =) \quad 1.5 \text{ or } 1.46$ ALT 2: $8(T_1 - T_2) - \frac{1}{2}g(T_1 - T_2)^2 = 5(T_2 - 1) - \frac{1}{2}g(T_2 - 1)^2$	A1 A1 A1	Must be rounded to 2 sf or 3 sf A0 for $\frac{99}{68} = 1.45588..$ N.B. Only penalise overaccuracy after $g = 9.8$, ONCE for parts (b) and (c) only.
		[4]	
		(11)	

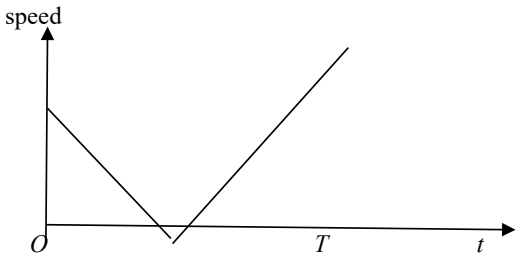
Question Number	Scheme	Marks
2(a)	<u>Complete</u> method to find the <u>total</u> time: e.g. $-19.6 = 14.7t + \frac{1}{2}(-9.8)t^2$ using one equation OR: $0 = 14.7 - 9.8t_1 \Rightarrow t_1 = 1.5$ $s_1 = 14.7 \times 1.5 - \frac{1}{2} \times 9.8 \times 1.5^2 = 11.025$ using four equations $30.625 = \frac{1}{2} \times 9.8 \times t_2^2 \Rightarrow t_2 = 2.5$ $t = t_1 + t_2 = 4$ (s) and many other methods	M1
	There are two A marks for all the equations they use, -1 each error	A1
	$t = 4$ (s) only	M(A)1
		A1
		(4)
(b)	$v^2 = 14.7^2 + 2(-9.8)(-19.6)$ OR $v = 14.7 + (-9.8) \times 4$	M1 A1
	Speed = 24.5 or 25 (m s^{-1})	A1
		(3)
(c)	e.g. $0^2 = 14.7^2 + 2(-9.8)s$ or $24.5^2 = 2 \times 9.8s$	M1
	$s = 11.025$ (11 or better) $s = 30.625$	A1
	Total distance = $2 \times 11.025 + 19.6$ Total distance = $2 \times 30.625 - 19.6$	M1
	= 41.7 (3 sf) or 42 (2 sf) (m)	A1
		(4)
(d)		B1 line B1 start pt (0,14.7) OR on axes B1ft end pt (4,-24.5) OR on axes
		(3)
		(14)

	Notes for Question 2	
2(a)	M1 Complete method to find the total time	
	A1	
	M(A)1 There are now two A marks for the equation(s) that they use, -1 for each error.	
	A1 Correct answer N.B. If using a quadratic, ignore the other solution, even if it's incorrect. If they combine the 2 solutions in some way, A0	
2(b)	M1 Complete method to find the speed	
	A1 Correct equation(s)	
	A1 Correct answer must be positive	
2(c)	M1 Method to find a relevant distance	
	A1 A correct relevant distance	
	M1 Method to find the total distance	
	A1 Correct answer	
2(d)	B1 Straight line starting on the v -axis and crossing the t -axis (line may be reflected in the t -axis) (B0 if solid vertical line at $t = 4$)	
	B1 Correct appropriate coordinates (start point) Allow these to be marked on the axes.	
	B1ft Correct appropriate coordinates (end point) ft on their answers to (a) and (b) Allow these to be marked on the axes.	

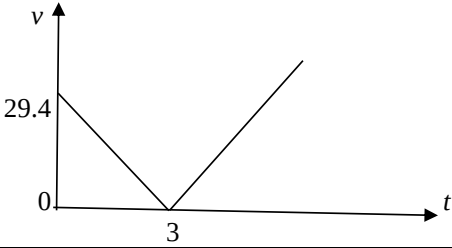
Question Number	Scheme	Marks
5(a)	$s = \frac{1}{2} \times 9.8 \times 5^2$	M1
	$= 123 \text{ or } 120 \text{ (m)}$	A1 (2)
5(b)	$v = 9.8 \times 5 = 49$ OR $v = \sqrt{2 \times 9.8 \times 122.5} = 49$	B1
	OR $122.5 = 5v - \frac{1}{2} \times 9.8 \times 5^2 \Rightarrow v = 49$	
	$250g - 3200 = \pm 250a$	M1A1
	Correct value for their a (3 or -3)	A1
	$v^2 = 49^2 - 2 \times 3 \times (520 - 122.5)$	M1 A1ft
	$v = 4 \text{ (m s}^{-1}\text{)}$	A1 (7)
	N.B. They may do (c) first and then use their t value to obtain v : $v = 49 + (-3 \times 15)$ OR $(520 - 122.5) = 15v - \frac{1}{2} \times (-3) \times 15^2$ M1A1ft $v = 4 \text{ (m s}^{-1}\text{)}$ A1	
5(c)	$4 = 49 - 3t$ OR $(520 - 122.5) = \frac{(49 + 4)}{2} t$ OR $(520 - 122.5) = 49t - \frac{1}{2} \times 3t^2$ OR $(520 - 122.5) = 4t + \frac{1}{2} \times 3t^2$	M1
	$t = 15$ (other root of quadratic is $\frac{53}{3}$ which leads to $v < 0$)	A1
	Total time = $5 + 15 = 20 \text{ (s)}$	A1ft (3)
5(d)		B1 shape B1 ft figs (2)
		(14)
Notes		
5(a)	M1: Complete method to find the distance	
	A1: cao	
(b)	B1: 49 or -49. Allow $5g$ or $-5g$ or 49^2 (2401) seen.	
	M1: Equation of motion, correct terms, condone sign errors	
	A1: Correct equation (allow + or -)	
	A1: cao	
	M1: Complete method to find speed at ground (must have found a new a) M0 if they use $u = 0$ either explicitly in (b) or implicitly, by using it in (c) to get the time, which is then used in (b).	
	A1ft: Correct equation, ft on their s , v and a .	
	N.B. This mark can be awarded even if it leads to a negative value for v^2	
	A1: cao	

(c)	M1: Complete method to find time from when the parachute opens to when P lands on the ground (must have found and use a new a) M0 if they use $s = 520$ and/or $u = 0$
	A1:cao.
	A1ft: Their $t + 5$ N.B. The final answer should be rounded to 2 or 3 sf, if they haven't already been penalised following use of $g = 9.8$ earlier in the question.
(d)	B1: Correct shape (B0 if continuous vertical line at the end or graph ends on the t -axis)
	B1ft: Correct figs, ft on their 49, 4 and 20, but B0ft if they just assume it stops as it reaches the ground. The ft is only available if the graph has just 2 straight lines, one starting at the origin with positive gradient and the second line has negative gradient with second line not meeting the t -axis. This B1ft is available if the graph has a vertical line at the end but is otherwise correct.

Question Number	Scheme	Marks
8(a)	$s = \frac{1}{2} \times 3 \times 4^2$ OR $s = \frac{1}{2} \times 4 \times 12$	M1
	= 24 (m)	A1
		(2)
(b)	12 (m s ⁻¹); 42 (m s ⁻¹)	B1
	$12 \times 20 + \frac{1}{2} \times 1.5 \times 20^2$ (= 540) OR $\left(\frac{12+42}{2}\right) \times 20$	M1 A1ft
	$42 \times 2 + \frac{1}{2}(-4) \times 2^2$ (= 76) OR $\left(\frac{42+34}{2}\right) \times 2$	M1 A1ft
	Total = 640 (m)	A1 cao
		(6)
		(8)
	Notes for Question 8	
8(a)	M1 Complete method to find distance travelled in first 4 s Must be area of a triangle from a v-t graph	
	A1 Correct answer	
8(b)	B1 Both speeds seen anywhere e.g. on a diagram or in part (a)	
	M1 Complete method to find total distance travelled in next 20 s Must be area of a trapezium from a v-t graph (they may use a rectangle + triangle)	
	A1 ft Correct unsimplified distance, ft on their 12	
	M1 Complete method to find total distance travelled in next 2 s Must be area of a trapezium from a v-t graph (they may use a rectangle + triangle)	
	A1 ft Correct unsimplified distance, ft on their 42	
	A1 cao for total distance	

Question Number	Scheme	Marks
4(a)	$0^2 = u^2 - 2 \times g \times 19.6$	M1 A1
	$-24.5 = uT - \frac{1}{2}gT^2$	M1 A1
	Produce an equation in T only and solve for T	DM1
	$T = 5$	A1
		(6)
4(b)		B1 Shape DB1 Second line longer than the first, approx. equal angles and T or their answer for T marked
		(2)
		(8)
	Notes for question 4	
4(a)	M1 Attempt at a relevant <i>suvat</i> equation which uses $s = 19.6$ (or -19.6), with correct no. of terms but condone sign errors.	
	A1 A correct equation (g does not need to be substituted)	
	M1 Attempt at another relevant <i>suvat</i> equation which uses 24.5 or 44.1 e.g. finding time from B to the ground, with correct no. of terms but condone sign errors,	
	A1 A correct equation (neither u nor g need to be substituted)	
	DM1 dependent on both M marks, for finding an equation in T only and solving for T i.e. for a complete method to find T N.B. This mark cannot be awarded if their equation has NO solutions.	
	A1 $T = 5$ N.B. If $g = 9.8$ has not been used, A0	
4(b)	B1 A V-shape (<i>and nothing else</i>) starting on the speed axis, with point on the t -axis	
	DB1 Dependent on the first B1, for approximately equal angles between the 2 lines and the t -axis, second line longer than the first, T or their T marked correctly. B0 if clearly unequal angles. N.B. If graph reflected, B0 DB0.	

3a	Use <i>suvat</i> to form an equation in <i>U</i> only	M1	Complete method using <i>suvat</i> Condone sign errors
	$-12 = 4U - \frac{1}{2}g \times 16$	A1	Correct unsimplified equation in <i>U</i> only
	Obtain $U = 16.6$ or $U = 17$	A1	Correct answer only A0 for $2g - 3$
		(3)	
3b	Use <i>suvat</i> to form an equation in the speed or the velocity only	M1	Complete method using <i>suvat</i> Condone sign errors. N.B. Allow this mark, even if the <i>U</i> that was found in (a) came from an incorrect method.
	e.g $12 = 4v - \frac{1}{2}g \times 16$ OR $-v = 16.6 - 4g$ OR $v = \sqrt{16.6^2 + 2g \times 12}$ OR $12 = \frac{(-16.6 + v)}{2} \times 4$ OR $h = \frac{16.6^2}{2g}$ and $v = \sqrt{2g \times (h + 12)}$	A1	Correct unsimplified equation in the speed or the velocity only. Allow $\pm v$
	speed = 22.6 or $23(\text{ms}^{-1})$	A1	Correct answer only, must be positive A0 for $2g + 3$
		(3)	
3c		B1	Correct V shape with a longer 2 nd line and the vertex on the <i>t</i> -axis. Two lines with gradients of (roughly) equal magnitude. B0 if a continuous vertical line at $t = 4$
		B1ft	Values 4 and their 16.6 and 22.6 marked correctly Dependent on the correct shape, a longer 2 nd line and the vertex on the <i>t</i> -axis and two lines with gradients of (roughly) equal magnitude.
		(2)	
		(8)	

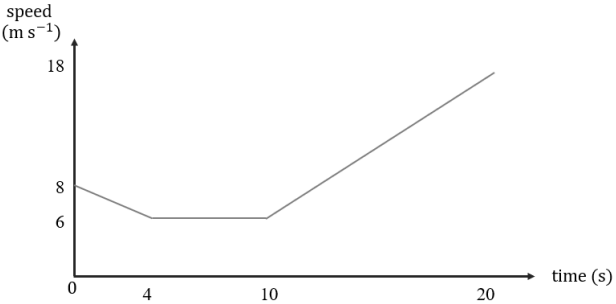
Question Number	Scheme	Marks
5(a)	$0 = 14.7^2 - 2gs$	M1A1
	22 or 22.1 (m)	A1
		(3)
5(b)	$19.6 = 29.4t + \frac{1}{2}gt^2$ N.B. $19.6 = 29.4t - \frac{1}{2}gt^2$ is M0A0 $-19.6 = 29.4t + \frac{1}{2}gt^2$ is M0A0 $-19.6 = 29.4t - \frac{1}{2}gt^2$ is M0A0 unless they go on to subtract 6 from the positive root $t = 0.61$ or 0.606 (s)	M1A1
		A1
		(3)
5(c)		B1 shape B1 29.4 B1 3
		(3)
		(9)
	Notes for question 5	
5(a)	M1 Complete method to find distance UP N.B. They may find time UP (1.5s) AND use it to find distance UP OR: (Distance from A to top – Distance from ‘14.7’ to top) $= (44.1 - 33.075)$	
	A1 Correct equation(s) used	
	A1 cao	
5(b)	M1 Complete method to find required time N.B. They may find the speed as it hits the ground ($g\sqrt{13} = 35.334\dots$) AND use it to find the time.	
	A1 Correct equation(s) used	
	A1 cao	
	N.B. If they add to or subtract from 0.606, it’s M0 for an incorrect method.	
5(c)	B1 V shape with v coord of end pt > 29.4 and each half roughly equally inclined to the t-axis. B0 if a vertical line is included at the end.	
	B1 29.4 independent	
	B1 3 independent	

Question Number	Scheme	Marks
5(a)		B1 shape B1 40, 15, 15+T Correctly Placed (2)
5(b)	$40 = 4t_1 \Rightarrow t_1 = 10$	M1 A1 (2)
5(c)	$60 \text{ (m s}^{-1}\text{)}$	B1
	$60 + T \text{ (m s}^{-1}\text{)}$	B1 ft
	$\frac{1}{2} \times 15 \times 60 + \frac{1}{2} T(60 + 60 + T) = 40(15 + T)$ OR $\frac{1}{2} \times 15 \times 60 + 60T + \frac{1}{2} T \times T = 40(15 + T)$ OR $\frac{1}{2} (T + T + 15) \times 60 + \frac{1}{2} T \times T = 40(15 + T)$	M1 A2
	$T^2 + 40T - 300 = 0 ; (k = 40)$	A1
		(6) (10)
	Notes for question 5	
5(a)	B1 Correct graph shapes on same axes with intersection, a horizontal line and 2 lines, both with positive gradient, the second less steep than the first and both ending at the same t -value. B0 for a solid vertical line at the end but allow intermediate solid vertical lines.	
	B1 Figs. correctly placed. Allow appropriate delineators.	
5(b)	M1 Complete method to give an equation in t_1 only	
	A1 $t_1 = 10$	
5(c)	B1 60 m s^{-1} seen	
	B1 ft $60 + T$ seen or <u>implied</u> ; ft on their graph (i.e. on their interpretation of T) N.B. If they use $s = ut + \frac{1}{2}at^2$, $60 + T$ is not needed	
	M1 Equating distances to give an equation in T only, with correct structure (e.g. M0 if a ' $\frac{1}{2}$ ' is omitted or a 'section' is omitted but give BOD where possible e.g. treat middle term below as an attempt at a trapezium, with 60 and T as the parallel sides $\frac{1}{2} \times 15 \times 60 + \frac{1}{2} T(60 + T) = 40(15 + T)$ B1B0M1A1A0A0)	
	A2 Correct unsimplified equation -1 e.e.	
	A1 Correct quadratic with $k = 40$	
	N.B. If they take T to be the end of the time period (instead of $15 + T$), can score max: (a) B1B0 (b) M1A1 (c) B1B1ft M1A0A0A0 where T is replaced consistently by $(T - 15)$ in the scheme above.	



Question Number	Scheme	Marks
1(a)		B1 shape B1 20 B1 T, T+180, 3T+180
		(3)
1(b)	T and 2T seen or implied, for acceleration and deceleration in that order Any of: $4800 = \left(\frac{20 \times T}{2}\right) + (180 \times 20) + \left(\frac{20 \times 2T}{2}\right)$ $4800 = \left(\frac{20 \times T}{2}\right) + \frac{1}{2} \times 20(180 + (180 + 2T))$ $4800 = \frac{1}{2} \times 20(180 + T + 180) + \left(\frac{20 \times 2T}{2}\right)$ $4800 = \frac{1}{2} \times 20(180 + 3T + 180)$ $4800 = 20 \times (180 + 3T) - \left(\frac{20 \times T}{2}\right) - \left(\frac{20 \times 2T}{2}\right)$	B1 M1 A1 A1
	T = 40 (allow t)	A1
		(5)
1(c)	20 = a x their T oe	M1
	Acceleration = $\frac{1}{2}(\text{m s}^{-2})$	A1 ft
		(2)
(10)		
NOTES		
(a) B1 B1 B1	Correct shape with acceleration steeper than deceleration (ignore entries on the axes). Correct vertical label. Correct horizontal labels. Accept use of their T or appropriately labelled delineators.	

(b) B1	Correct relationship seen or implied between the time accelerating and the time decelerating.	
M1	A clear attempt to use the total area under the graph (or use <i>suvat</i> formulae) and equate to 4800 (or 4.8) to form an equation in T only or their unknown only (e.g. replace T by $\frac{20}{a}$). Must involve a triangle or a trapezium (M0 if they use a <i>single suvat</i> formula for the whole motion)	
A1	An equation with at most one error. (use of 3 instead of 180 is one error) Having T and $2T$ round the wrong way, treat as one error	
A1	A fully correct equation	
A1	cao N.B. If attempting to use a single trapezium, and '180' appears in the bracket i.e. $\frac{1}{2} \times 20('T \text{ terms}' + 180)$, allow at least M1A1 for one correct parallel side. N.B. $\frac{1}{2} \times 20(x + 180) = 4800 \Rightarrow x = 300$ ONLY scores B0M1A1A0A0	
(c) M1 A1 ft	Correct equation in a , using their T Correct answer, follow through on their '40'	

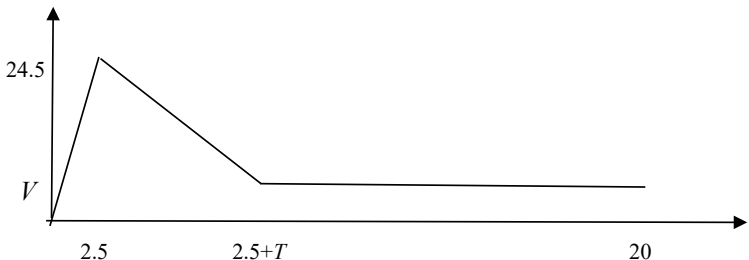
QUESTION NUMBER	SCHEME	MARKS
2(a)	$v = u + at$: $w = 8 + (-0.5)(4)$ (the value of w may not be seen)	M1
	$v = u + at$: $v = w + (1.2)(10)$	M1
	$v = 18^*$	A1*
		(3)
2(b)		B1 shape B1 time labels 4, 10, 20 B1 speed labels 6, 8, 18
		(3)
2(c)	Clear attempt to find distance using the area under their graph from $t = 0$ to $t = 20$ or another suitable method, <u>even if they are using the wrong shapes</u> . $\text{Distance} = \frac{(8 + "6") \times 4}{2} + (6 \times "6") + \frac{("6" + 18) \times 10}{2}$ $\text{OR } = (6 \times 4) + \frac{1}{2} \times 4 \times (8 - 6) + (6 \times 6) + (6 \times 10) + \frac{1}{2} \times 10 \times (18 - 6)$	M1 A1ft A1ft
	$= 184 \text{ (m)}$	A1
		(4)
		(10)
	Notes for question 2	
(a)	Complete method for finding the velocity (w) when $t = 4$ M0 if $u = 0$. N.B. 6 on its own can imply this mark.	
M1	Method completed to show the speed when $t = 20$ M0 if initial speed is not w .	
A1*	Fully correct solution leading to given answer	
(b)	Correct shape of graph	
B1	Correct time labels	
B1	Correct speed labels	
	N.B. Solid vertical line(s) B0 for the shape.	
(c)	Complete method to find distance travelled in 20 seconds. May use speed-time graph or <i>suvat</i> equations for three sections (28m, 36m, 120m) of the journey. Award this mark for a clear attempt to find the area and penalise errors in the A marks. M0 if graph does not have three sections.	
M1	Equation with at most one error, ft their "6"	
A1ft	Correct equation, ft their "6"	
A1ft	Correct final answer	

Question number	Scheme	Marks
5(a)	For car: $\left(\frac{T+T-30}{2}\right)V$	M1
	$V(T-15)$ (metres) * Allow $(T-15)V$	A1*
		(2)
5(b)		B1 shape B1 Horiz labels (10,50,60)
		(2)
5(c)	$\frac{\text{speed}}{40} = \frac{V}{30}$	M1
	$(\text{speed}) = \frac{4V}{3} \text{ (m s}^{-1}\text{)*}$	A1*
		(2)
5(d)	For motorbike OR: $\frac{1}{2}\left(\frac{4V}{3} \times 40\right) + \left(\frac{4V}{3} \times 10\right) + \frac{1}{2}\left(\frac{4V}{3} + V\right)(T-60)$ OR: $\frac{1}{2}\left(\frac{4V}{3} \times 40\right) + \left(\frac{4V}{3} \times 10\right) + \frac{1}{2}\left(\frac{4V}{3} - V\right)(T-60) + V(T-60)$ OR: $\frac{1}{2} \times \frac{4V}{3} \times (10+50) + \frac{1}{2}\left(\frac{4V}{3} + V\right)(T-60)$ (Simplified: $\frac{7VT}{6} - 30V$)	M1 A1 A1
	Equate their motorbike distance to $V(T-15)$ to give an equation in T only	M1
	$T = 90$	A1
	ALT: Find area of upper trapezium and parallelogram (differences in areas)	M1
	$\frac{1}{2}\left(\frac{V}{3}\right)(T-40+10)$	A1
	and $10V$	A1
	Equate to give an equation in T only (V cancels)	M1
	$T = 90$	A1
		(5)
		(11)

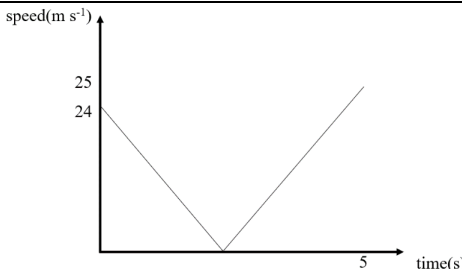
Notes for Question 5	
(a)	
M1	Uses total area under graph to find an expression for the distance in terms of V and T only May use: Trapezium: $\left(\frac{T + T - 30}{2}\right)V$ triangle + rectangle : $\frac{1}{2}(30V) + V(T - 30)$ a triangle subtracted from a rectangle: $VT - \frac{1}{2}(30 \times V)$ OR use of <i>suvat</i>: $\frac{1}{2}(30V) + V(T - 30)$
A1*	Given answer correctly obtained (allow omission of 'metres'.
(b)	
	N.B. If graph is not done on either of the given graphs on the question paper, they score B0B0.
B1	Correct shape with acceleration lines parallel and meeting at (T, V) B0 if continuous vertical line at $t = T$
B1	Correct horizontal labels. Accept appropriately labelled delineators. N.B. This mark is independent of the first B1.
(c)	
M1	Correct method using gradients or <i>suvat</i> to obtain an equation in V only
A1*	Given answer correctly obtained
(d)	
M1	For motorbike: find an expression for the TOTAL area under the graph (or use <i>suvat</i>) to find the total distance travelled in terms of V and T only. N.B. $\frac{1}{2}\left(\frac{4V}{3} \times 40\right) + \left(\frac{4V}{3} \times 10\right) + \frac{1}{2}\left(\frac{4V}{3} - V\right)(T - 60)$ is M0 as it omits a part of the area.
A1	Correct unsimplified expression with at most one error/slip
A1	Correct unsimplified expression
M1	Clear attempt to equate their distance to the given distance in part (a) to give an equation in T only i.e. the V 's must cancel but they do not need to be cancelled for this mark. N.B. This is an independent mark.
A1	cao

QUESTION NUMBER	SCHEME	MARKS
2(a)		B1 shape B1 time labels B1 speed labels
		(3)
2(b)(i)	$132 = \frac{(5+V)T_1}{2}$ OR $132 = 5T_1 + \frac{1}{2}T_1(V-5)$	M1
	$T_1 = \frac{264}{5+V}$ oe	A1
2(b)(ii)	$136 = \frac{VT_2}{2}$	M1
	$T_2 = \frac{272}{V}$ oe	A1
		(4)
2(c)	$\frac{264}{5+V} + \frac{272}{V} = 28$	M1
	$(28V^2 - 396V - 1360 = 0$ OR $7V^2 - 99V - 340 = 0)$	
	$V = 17$ only	A1
		(2)
2(d)	Deceleration = $\frac{\text{their } V}{\text{their } T_2}$ OR $\frac{(\text{their } V)^2}{272}$	M1
	$\frac{17}{16}$ oe = 1.0625 Accept 1.1 or better (m s ⁻²)	A1
		(2)
		(11)
	Notes for Question 2	
	N.B. If you think a candidate has misread the question and consistently uses T_2 as the time from A to C, send to Review.	
	Allow use of t_1 and t_2 instead of T_1 and T_2 throughout.	
2(a)		
B1	Correct graph shape. Must start on the vertical axis and not at the origin and finish on the t -axis. B0 if they have any extra continuous lines.	
B1	Correct time labels. Accept delineators (B0 if delineators missing)	

B1	Correct speed labels.	
2(b)(i)		
M1	Complete method using 132 to form an equation in V and T_1 . May use area or <i>suvat</i> equation(s). N.B. M0 for $132 = \frac{(5 + 5 + V)T_1}{2}$	
A1	Correct expression for T_1 .	
2(b)(ii)		
M1	Complete method using 136 to form an equation in V and T_2 . May use area or <i>suvat</i> equation(s). N.B. Allow a correct method based on their graph IF IT HELPS THE CANDIDATE, but must produce an equation in V and T_2 only . e.g. $136 = \frac{1}{2}V(T_2 - T_1)$ with T_1 then replaced in terms of V	
A1	Correct expression for T_2 .	
2(c)		
M1	Use 28 and sums their expressions for T_1 and T_2 to form an equation in V only. N.B. Allow a restart for either T_1 or T_2 or both.	
A1	Correct answer for V . If seen, a negative value ($-\frac{20}{7}$) should be rejected.	
2(d)		
M1	Use their V and their T_2 (or their V in the alternative) to find an expression for the deceleration (allow minus sign).	
A1	Correct deceleration must be positive. 1.1 or better. The exact answer is $\frac{17}{16}$, 1.0625.	

Question Number	Scheme	Marks
7(a)	$v = 2.5 \times 9.8 = 24.5 \text{ (m s}^{-1}\text{)}$ Allow 2.5g	B1 (1)
7(b)		B1 shape B1 figures (2)
7(c)	$73.75 = \frac{(24.5 + (24.5 - 3.9T))T}{2}$ OR $73.75 = 24.5T - \frac{1}{2} \times 3.9T^2$ OR $73.75 = (24.5 - 3.9T)T + \frac{1}{2} \times 3.9T \times T$ OR $V^2 = 24.5^2 + 2 \times (-3.9) \times 73.75$ and then $5 = 24.5 - 3.9T$ $T = 5$ N.B. The second M mark should be treated as an A mark	M1 A1A1M1 A1 (5)
7(d)	Height = Total area under graph	
	$= \left(\frac{1}{2} \times 24.5 \times 2.5 \right) + 73.75 + (20 - 2.5 - 5) \times (24.5 - 3.9 \times 5)$	M1A2
	= 167 (m) nearest metre.	A1 (4)
		(12)
	Notes for question 7	
7(a)	B1 cao	
7(b)	B1 Correct shape of graph with the second line less steep than the first Graph may be reflected in the t -axis. B0 if solid vertical line at $t = 20$	
	B1 All five values correctly placed (allow omission of 0 and appropriate delineators)	
7(c)	M1 for a complete method to obtain an equation, with a correct structure, in T only.	
	A1A1M1(A1) For a correct equation or equations, -1 each error.	
	A1 cao (must be a single answer i.e the other root (7.56) must be clearly rejected.	
7(d)	M1 for a complete method, using the total area under the graph oe, with a correct structure (i.e. triangle + trapezium + rectangle oe), to obtain an expression for the height of H above the ground.	
	A2 For a correct equation, -1 each error.	
	A1 cao	



QUESTION NUMBER	SCHEME	MARKS
6(a)	A to B: $V^2 = 24^2 + 2(-g)(-2.5)$	M1 A1
	OR: e.g. $0 = 24^2 - 2gh$ and $V^2 = 2g(h + 2.5)$ oe	
	$V = 25$	A1
		(3)
6(b)	Some possible equations in t : $25 = -24 + gt$ $2.5 = \frac{(25 + (-24))t}{2}$ $2.5 = -24t + \frac{1}{2}gt^2$ $2.5 = 25t - \frac{1}{2}gt^2$ Or they may find $t_{UP} \left(\frac{24}{g} \right)$ and $t_{DOWN} \left(\frac{25}{g} \right)$ AND add	M1 A1
	$t = 5 \text{ (s)}$	A1
		(3)
6(c)	From A to C: $10 = 24t + \frac{1}{2}(-g)t^2$	M1 A1
	Complete method to find the required time: e.g. solving the above quadratic and finding the positive difference in the roots N.B. Allow this mark if they solve their quadratic, and give the answer as a range of values: $t_1 \leq t \leq t_2$	M1
	4, 4.0 or 3.98 (s)	A1
	ALT 1: From A to C: $W^2 = 24^2 - 2 \times 10g$	M1A1
	$0 = W - g\left(\frac{1}{2}t\right)$	M1
	4.0 or 3.98 (s)	A1
	ALT 2: From A to C: $W^2 = 24^2 - 2 \times 10g$	M1A1
	$0 = Wt + \frac{1}{2}(-g)t^2$	M1
	4.0 or 3.98 (s)	A1
		(4)
6(d)		B1 shape B1 ft labels
		(2)
		(12)



	Notes for question 6	
(a)		
M1	Complete method to find an equation in V only. Condone sign errors.	
A1	Correct equation in V only using g . Note the sign of 2.5 and g should be the same.	
A1	cao	
(b)		
M1	Complete method to find an equation in t only. Condone sign errors.	
A1	Correct equation in t only using g .	
A1	cao	
(c)		
M1	Forming an equation or equations which could lead to a relevant time. Condone sign errors.	
A1	Correct equation(s)	
M1	Complete method to find the required time.	
A1	cao	
(d)		
B1	Correct shape. It should appear symmetrical with regards to gradients but the end point should be higher than the start point. Vertex on horizontal axis.	
B1ft	Correct labels (24, 25 and 5), ft on their answers to (a) and (b), provided they are positive. N.B. ignore an incorrect time when $v = 0$. Neither mark available if using a velocity-time graph.	

8a			
	Correct shape for sketch for A , starting at the origin.	B1	B0 if solid vertical line at the end of either.
	Correct shape for sketch for B , must be correct relative to A , crossing it and ending at same time. Must be done on the same axes.	B1	Tram B starts later and acceleration greater.
	5, 20, 24 shown	DB1	Dependent on previous two marks
		(3)	
8b	$t = 20 + \frac{10}{3} \left(= \frac{70}{3} \right)$	B1	
	Distance travelled for either vehicle	M1	
	$\frac{1}{2} \times \frac{10}{3} \times 10$ OR $\frac{1}{2} \times 5 \times 10 + \frac{55}{3} \times 10$; $\frac{1}{2} \left(\frac{70}{3} + \frac{70}{3} - 5 \right) \times 10$	A1	
	Find second distance and subtract	M1	
	$d = \frac{625}{3} - \frac{50}{3} = \frac{575}{3} = 191\frac{2}{3}$	A1	Accept 192 or better.
		(5)	
8c	Equate distances from O	M1	Find both distances at time t seconds and equate, using correct structure – see examples.
	$\left(\frac{t+t-5}{2} \right) \times 10 = \left(\frac{t-20+t-24}{2} \right) \times 12$ OR $\left(\frac{1}{2} \times 5 \times 10 \right) + 10(t-5) = \left(\frac{1}{2} \times 4 \times 12 \right) + 12(t-24)$	A2	Correct unsimplified equation, –1 each error (up to a maximum of 2)
	$t = 119.5$	M1	Solve for t
	Distance = $5 \times (6 \times 44 - 30) = 1170$ (m)	A1	Accept 1200 or better
		(5)	
		[13]	

Question Number	Scheme	Marks
7(a)		B1 for A B1 for B B1 4 & T Allow their numerical value of T (3)
7(b)	$\frac{4}{0.8} = 5$ (s)	B1
	$100 = \frac{(t+t-5)}{2} \times 4$ OR $100 = \frac{1}{2} \times 5 \times 4 + 4(t-5)$	M1A1ft
	$t = 27.5$ (s)	A1
		(4)
7(c)	$100 = \frac{(27.5+27.5-T)}{2} \times T$ OR $100 = \frac{1}{2} \times T \times T + T(27.5-T)$	M1A1ft
	$T^2 - 55T + 200 = 0$ oe	A1
	$T = 3.915047\dots$ accept 3.9 or better	A1
		(4)
7(d)	$4 - 3.915\dots$	M1
	0.085 or better (m s^{-1})	A1ft
		(2)
		(13)
Notes for question 7		
7(a)	B1 Correct shape for A's graph.	
	B1 Correct shape for B's graph with steeper gradient initially and must cross A's graph. <u>Both graphs must end at the same time.</u> B0 once if solid vertical line at the end	
	B1 4 and T correctly marked. Allow appropriate delineators. N.B. If graphs are on separate axes can score max B1B0B1 If no labels, give BOD. If incorrect labels, max B1B0B1	
7(b)	B1 5 (s) seen – could be on graph	
	M1 Attempt at equation in <i>t</i> only, with correct structure i.e. trapezium or (rectangle + triangle) or (rectangle – triangle) oe including $\frac{1}{2}$ where appropriate, based on total area (OR distance using 2 or more <i>suvat</i> formulae) being 100 M0 for a <i>single suvat</i> equation for the <i>whole</i> motion. N.B. If they clearly use T (for t) in their equation and in their answer , it's M0 but give BOD where possible.	
	A1ft Correct equation in <i>t</i> only, ft on their 5	
	A1 cao	
7(c)	M1 Attempt at equation in <i>T</i> only, with correct structure, i.e. trapezium or (rectangle + triangle) or (rectangle – triangle) oe based on total area (OR distance using 2 or more <i>suvat</i> formulae) being 100 M0 for a <i>single suvat</i> equation for the <i>whole</i> motion.	

	A1ft Correct equation in T only, ft on their 27.5	
	A1 Correct 3 term quadratic	
	A1 cao	
7(d)	M1 for $4 - T$. (Allow $T - 4$)	
	A1 ft follow through on their T value provided it's < 4 . Must be correct to at least 2 SF .	



Q	Scheme	Marks	Notes
1			
(a)	Use of CLM Or equating impulses	M1	Dimensionally correct. Condone sign errors and allow missing m 's and extra g 's.
	$(4m \times 2x) - 3mx = (3m \times 5y) - 4my$ Or: $3m(5y - x) = 4m(y - 2x)$	A1	Correct unsimplified equation and must see all 4 terms but allow missing m 's.
	$y = \frac{5}{11}x$ *	A1*	Obtain given answer from correct working with m 's seen. Allow $y = \frac{5x}{11}$ but A0 if x is <i>clearly</i> in the denominator of the fraction.
		[3]	
(b)	Use of $I = mv - mu$	M1	Dimensionally correct. Condone sign errors and y not substituted but mass and velocities must match. M0 if m is used for mass or g is included or m is missing.
	$\pm 3m \left(\frac{25}{11}x + x \right)$ or $\left(\pm 4m \left(\frac{5}{11}x + 2x \right) \right)$	A1	Correct unsimplified expression
	$\frac{108}{11}mx$ oe	A1	$9.8mx$ or better ($9.8181..mx$), must be positive.
		[3]	
		(6)	

Q	Scheme	Marks	Notes
2a	Resolve vertically or take moments	M1	First equation in R_C and/or R_D . Dimensionally correct, correct no. of terms. Condone sign errors. N.B. $3R_C + 2R_D = 75g$ or $5R_C = 75g$ are both M0A0 unless they recover.
			N.B. They may use: $R_C = 2R$ and $R_D = 3R$ so $5R = 75g$ is M1A1
	$\uparrow R_C + R_D = 50g + 25g (= 75g)$	A1	Correct unsimplified equation but A0 if they assume $R_C = R_D$. N.B. This mark can be awarded even if they clearly have $R_C = 3X$ and $R_D = 2X$ oe
	Form a moments equation or resolve vertically	M1	Second equation in R_C and/or R_D . Dimensionally correct, correct no. of terms. Condone sign errors
	M(D): $50gx + 25g \times 1.2 = 3.3R_C$ M(A): $0.9R_C + 4.2R_D = 3 \times 25g + (4.2 - x)50g$ M(B): $5.1R_C + 1.8R_D = 3 \times 25g + (1.8 + x)50g$ M(C): $3.3R_D = 2.1 \times 25g + (3.3 - x)50g$ M(E): $2.1R_C = (x - 1.2)50g + 1.2R_D$ M(G): $R_D x = 25g(x - 1.2) + R_C(3.3 - x)$	A1	Correct unsimplified equation in R_D or R_C seen but give A0 if the equation is incorrect e.g if they put $3R$ (in place of R_C) straight into the equation. A0 if they assume $R_C = R_D$.
	$(2R_D = 3R_C \Rightarrow R_C = 30g)$ $50x + 30 = 99$	M1	Complete method, using either $2R_D = 3R_C$ or $2R_C = 3R_D$ to find an equation in x only
	$x = \frac{69}{50} = 1.38^*$ N.B. Two correct equations and use of $2R_C = 3R_D$ leads to $x = 2.37$ and could score max : M1A1M1A1M1A0*	A1*	Obtain given answer from correct working, with no incorrect equations seen.
		[6]	
2b	Complete method to form an equation in M only.	M1	e.g. moments about D or vertical resolution and

			moments about another point or two moments equations. Dimensionally correct equation. Condone sign errors
	$M(D) \quad 25g \times 1.2 + 50g \times 1.38 = 1.8Mg$ OR any two of : $(50 + 25 + M)g = R_D$ $M(A) \quad 4.2R_D = 3 \times 25g + (4.2 - 1.38)50g + 6Mg$ $M(B) \quad 1.8R_D = 3 \times 25g + (1.8 + 1.38)50g$ $M(C) \quad 3.3R_D = 2.1 \times 25g + (3.3 - 1.38)50g + 5.1Mg$ $M(E) \quad 3Mg = (1.38 - 1.2)50g + 1.2R_D$ $M(G) \quad R_D \times 1.38 = 25g(1.38 - 1.2) + Mg(1.38 + 1.8)$ AND R_D eliminated	A1	Correct unsimplified equation in M
	$(M) = 55$	A1	Correct only
		[3]	
		(9)	



			Allow use of column vectors apart from in given answer.
Q	Scheme	Marks	Notes
3a	Use of $\mathbf{v} = \frac{\mathbf{r} - \mathbf{r}_0}{2}$ to find $\mathbf{v}$	M1	Or equivalent, allow difference reversed. Allow 120 min
	$\mathbf{v} = \frac{1}{2}((55\mathbf{i} + 34\mathbf{j}) - (25\mathbf{i} + 10\mathbf{j}))$ $(= 15\mathbf{i} + 12\mathbf{j})$	A1	Correct unsimplified expression for $\mathbf{v}$
	$\mathbf{r}_A = 25\mathbf{i} + 10\mathbf{j} + t(15\mathbf{i} + 12\mathbf{j})$	M1	With the correct structure Possible use of $\mathbf{r}_A = (55\mathbf{i} + 34\mathbf{j}) + (t - 2)(15\mathbf{i} + 12\mathbf{j})$.
	$(\mathbf{r}_A =) (25 + 15t)\mathbf{i} + (10 + 12t)\mathbf{j} *$	A1*	We are looking for the RHS only to be correct. Allow order of terms to be reversed in the brackets. N.B Use of i's and j's in columns i.e. poor notation, can score Max M1A1M1A0*
		[4]	
3b	$\sqrt{12^2 + 15^2}$	M1	Correct use of Pythagoras for their $\mathbf{v}$
	$\sqrt{12^2 + 15^2} \times \frac{1000}{3600} = \frac{5\sqrt{369}}{18} = \frac{5\sqrt{41}}{6}$	A1	5.3 or better (5.3359.....)
		[2]	
3c	Position of B at $t = 1.5$ (allow $t = 1.30$)	M1	Correct use of position and direction vectors with correct structure.
	$\mathbf{r}_B = (35\mathbf{i} + 51\mathbf{j}) + 1.5(20\mathbf{i} - 6\mathbf{j})$	A1	Correct unsimplified
	$\Rightarrow \begin{pmatrix} 65 \\ 42 \end{pmatrix} = \begin{pmatrix} 25 + 15t \\ 10 + 12t \end{pmatrix} \text{ oe}$	M1	Use $\mathbf{r}_p = \mathbf{r}_A$ and use one component to solve for t N.B. If they use $\frac{65}{42} = \frac{25 + 15t}{10 + 12t}$ oe and solve for t , it's M0 unless they go on and substitute $t = \frac{8}{3}$ into $\mathbf{r}_A$ and obtain $65\mathbf{i} + 42\mathbf{j}$, in which case it is M1A1, and could earn the final A1* with a correct conclusion.
	Obtain $t = \frac{8}{3}$ for one component	A1	N.B. Allow $t = 2.7$ or better for A1 but not for the second A1* but allow 2.6 recurring for both A marks.

	Obtain $t = \frac{8}{3}$ for both components and hence confirm A passes through P OR sub $t = \frac{8}{3}$ into $\mathbf{r}_A$ and obtain $65\mathbf{i} + 42\mathbf{j}$ and hence confirm A passes through P	A1*	Obtain given result from correct work. N.B Use of i's and j's in columns i.e. poor notation, can score Max M1A1M1A1A0* but only penalise ONCE for the whole question.
		[5]	
		(11)	

Q	Scheme	Marks	Notes
4a	Correct method to form an equation in V only using either area = distance travelled or <i>suvat</i> .	M1	Condone confusion over units for time.
	$120 = \frac{1}{2}(42 + 33) \times V$ OR $\frac{1}{2} \times 9V + 33V = 120$ OR $42V - \frac{1}{2} \times 9V = 120$	A1	Correct unsimplified equation in V only.
	$V = 3.2^*$	A1*	Obtain given answer from correct working Allow v . N.B. A correct equation is required but NO intermediate line(s) of working.
		[3]	
4b	$a = \frac{3.2}{9}$	M1	Correct method
	$= \frac{16}{45} = 0.3555... = 0.36$ or better (ms^{-2})	A1	cao
		[2]	
4c		B1	Correct shape for Q. Allow crossing before $t = 9$ and ignore gradients but horizontal line must be above the P graph. B0 if it starts at the origin.
		DB1	3.6 and 6 marked
		B1	Correct shape for P (line extended) and both ending at $t = 54$ (or equiv) marked
	N.B. Allow dotted vertical lines but withhold the first B1 if any continuous vertical lines.		
		[3]	

4d	Dist. travelled by $P = 120 + (12 \times 3.2)$ OR $\frac{1}{2}(54 + 45) \times 3.2$ OR $\frac{3.2 \times 9}{2} + (45 \times 3.2)$	B1	Seen, or implied by 158.4 used
	Distance travelled by Q : Clear attempt to use area or <i>suvat</i> to form an expression in T only. Must be attempting to use 54 i.e. extended graph, with correct structure (i.e. triangle + rectangle or trapezium)	M1	Any complete method.
	$\frac{(48 + (48 - T))}{2} \times 3.6$ OR $\frac{1}{2} \times T \times 3.6 + (48 - T) \times 3.6$	A1	Correct unsimplified expression in T only.
	$\frac{(48 + (48 - T))}{2} \times 3.6 = 158.4$ ($= \frac{1}{2}(54 + 45) \times 3.2$)	DM1	Dependent on previous M mark, form and solve an equation in T only using total distances.
	$T = 8$	A1	Correct only
		[5]	
		(13)	