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

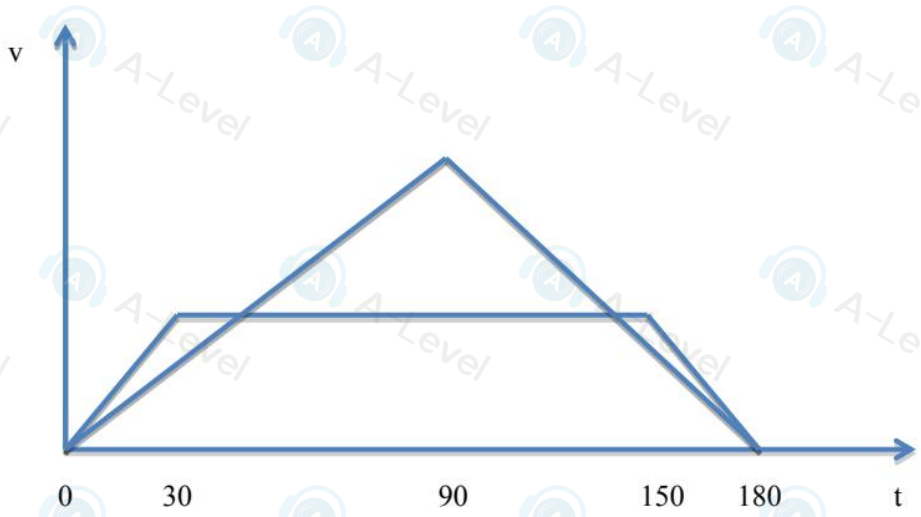
4a	Resolve perpendicular to the direction of motion to form an equation in α only. **OR** sine rule on a vector triangle.	M1	Dimensionally correct. Both forces resolved. Condone sign errors. Condone sine / cosine confusion but M0 for $800\cos 25° + 500\cos \alpha° = 0$ if **clearly** resolving in the direction of motion.
	$800\sin 25° = 500\sin \alpha°$ oe	A1	Correct unsimplified equation
	43 or better (must be correctly rounded to however many figs they choose)	A1	$\alpha = 42.5465...$ is A0
		(3)	
4b	Use $F = ma$ parallel to the direction of the motion, to form an equation in α and a only. **N.B.** The resultant of the two tensions may be found using the sine rule or cosine rule on a vector triangle.	M1	Dimensionally correct. Both forces resolved. Condone sine / cosine confusion. Condone sign errors. All relevant terms. Condone 15 or incorrect zeros for the mass. **N.B.** An extra g in a resolution is counted as an A error not an M error.
	$800\cos 25° + 500\cos \alpha° - 750 = 15000a$ **OR** $\frac{500\sin(180^o - 25^o - \alpha^o)}{\sin 25^o} - 750 = 15000a$ **OR** $\frac{800\sin(180^o - 25^o - \alpha^o)}{\sin \alpha^o} - 750 = 15000a$ **OR** $F - 750 = 15000a$ where $F = \sqrt{800^2 + 500^2 - 2\times 800\times 500\cos(180° - 25° - \alpha°)}$	A1 A1	Unsimplified equation with at most one error. Correct unsimplified equation. α does not need to be substituted. **N.B.** If they haven't attempted part (a) and use a 'random' numerical value for α, can score max A1A0. **N.B.** Allow a replaced by $-a$
	Accept 0.023 $\left(\text{m s}^{-2}\right)$ or better, (must be correctly rounded to however many figs they choose)	A1	$a = 0.02289...$ is A0 **N.B.** Penalise the use of … in their answer, ONCE for the question.
		(4)	
		(7)	

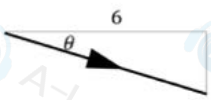
Question Number	Scheme	Marks
	Third A1 for $4m(0.8u-2u)$ or $-4m(0.8u-2u)$ **OR** for $m(0.8u+4u)$ or $-m(0.8u+4u)$ Fourth A1 for $4.8mu$ (must be positive since magnitude)	
4(i)	$\lvert\mathbf{F}_2\rvert^2 = 8^2+14^2-2\times8\times14\cos30$	M1 A1
	Solve for $\lvert\mathbf{F}_2\rvert$ = 8.1 (N) or better	M1 A1 (4)
	OR: $\lvert\mathbf{F}_2\rvert\cos\alpha = 14\cos30-8$ $\lvert\mathbf{F}_2\rvert\sin\alpha = 14\sin30$	M1 A1
	Solve for $\lvert\mathbf{F}_2\rvert$ = 8.1 (N) or better	M1 A1 (4)
4(ii)	$\frac{\sin\theta}{8} = \frac{\sin30}{8.12467}$ or $\frac{\sin\phi}{14} = \frac{\sin30}{8.12467}$	M1 A1
	Solve: $\theta = 29.49^o$ or $\phi = 120.51^o$	M1 A1
	Bearing is 149° (nearest degree)	A1 (5)
	OR: $\lvert\mathbf{F}_2\rvert\cos\alpha = 14\cos30-8 = 4.124(355.)$ $\lvert\mathbf{F}_2\rvert\sin\alpha = 14\sin30$	M1 A1
	Solve: $\alpha = 59.49^o$	M1 A1
	Bearing is 149° (nearest degree)	A1 (5)
	Notes	
4(i)	First M1 for use of cos rule with 30° First A1 for a correct equation **OR:** First M1 for 'resolving' in 2 directions with 30° / 60° (**N.B.** M0 here if cos/sin confused) First A1 for TWO correct equations Second M1 for solving for $\lvert\mathbf{F}_2\rvert$, independent *but* must be solving a 'correct cosine formula but with wrong angle' if using method 1 **OR** for eliminating α from two equations, independent *but* equations must have the correct structure if using method 2 Second A1 for 8.1 (N) or better	
4(ii)	First M1 for use of sin rule with 30° First A1 for a correct equation (allow 8.12 or better) **OR:** First M1 for 'resolving' in 2 directions with 30° / 60°	

Question Number	Scheme	Marks
	First A1 for TWO correct equations (allow 4.12 or better) Second M1, independent, for solving a 'correct sine formula' for θ or ϕ **OR** independent for solving two equations, with correct structure, for α Second A1 for $\theta =$ **AWRT** 29° or $\phi =$ **AWRT** 121° **OR** $\alpha =$ **AWRT** 59°	
	Third A1 for Bearing is 149° (nearest degree)	
	N.B. First M1A1 Could use cos rule to find an angle	
	N.B. If the resolving method is used and there are no (i) or (ii) labels, only award M1A1 in both cases when an answer is reached.	
5a	$0 = 14.7^2 - 2 \times 9.8h$	M1A1
	$h = 11.025$	A1
	max ht $= 13.5$ or 14 (m)	A1 (4)
5b	$-1.5 = 14.7t - 4.9t^2$	M1A1
	$4.9t^2 - 14.7t - 1.5 = 0$	
	$t = \dfrac{14.7 \pm \sqrt{14.7^2 + 6 \times 4.9}}{9.8}$	**DM1**
	$t = 3.1$ or 3.10 (s)	A1 (4)
5c	$v^2 = 14.7^2 + 2 \times (-9.8) \times (-2.5)$	M1 A1
	$v = 16.3$ or 16 (m s^{-1})	A1 (3)
		11
	Notes	
5a	**N.B.** If they use $g = 9.81$, lose first A mark (once for whole question) but all other A marks can be scored. First M1 for a complete method to find the height (Could involve two *suvat* equations) condone sign errors. First A1 for a correct equation (or equations) Second A1 for $h = 11$ (may be unsimplified) or better (For other methods, give this A1 for any correct (may be unsimplified) intermediate answer) Third A1 for 13.5 or 14 (m)	
5b	First M1 for a complete method to find the required time (they may find the time up (1.5 s) and then add on the time down. Condone sign errors First A1 for a correct equation or equations Second DM1, dependent, for solving to find required time Second A1 for 3.1 or 3.10 (s)	

6a	Resolve perpendicular to the slope: $R = mg\cos\theta \left(= \frac{4}{5}mg\right)$ **OR** $R = W\cos\theta \left(= \frac{4}{5}W\right)$	M1	Condone sine / cosine confusion and use of α, or similar, for θ
	Use of $F = \frac{1}{4}R$	M1	R does not need to be substituted.
	Friction $= \frac{1}{4} \times mg\cos\theta$	A1	Seen or implied.
	Equation of motion	M1	Need all 3 terms. Condone sign errors and sine / cosine confusion
	$F + mg\sin\theta = ma$ **OR** $F + W\sin\theta = \frac{W}{g}a$	A1	Correct unsimplified equation. Allow with $-a$
	$(a =)\frac{4}{5}g$ *	A1*	Given answer A0 for 0.8g If using $-a$, allow $-a = \frac{4}{5}g$ but not $a = -\frac{4}{5}g$ as the final answer.
			N.B. Full marks available if m replaced with 2 throughout.
			N.B. The first 3 marks are for finding the friction and just stating that $F = \frac{1}{5}mg$, scores M0M0A0. **N.B.** Since this is a 'Show that…' question the final A1* can only be scored for a fully correct solution, including use of $\cos\theta = \frac{4}{5}$ and $\sin\theta = \frac{3}{5}$,
		(6)	
6b	Use of *suvat* to form an equation in U only	M1	e.g. $0 = U^2 - 2 \times \frac{4}{5}g \times 1.5$ **N.B.** Must use $a = \pm\frac{4}{5}g$
	Obtain $U = 4.8$ or $U = 4.85$	A1	2 sf or 3 sf only Not $\sqrt{\frac{12}{5}g}$ nor $\frac{14\sqrt{3}}{5}$
		(2)	

6c	Resolve parallel to the slope: $X + F = 2g\sin\theta$	M1	Correct terms. M0 if using R in their equation. Condone sign errors and sine / cosine confusion. **N.B.** Allow m for the mass.
	$X + \frac{1}{4}2g\cos\theta = 2g\sin\theta$	A1	Correct unsimplified equation in X and θ
	$X = \frac{4}{5}g = 7.8$ or 7.84	A1	2 sf or 3 sf only Allow $\frac{4}{5}g$ or $0.8g$
		(3)	
		(11)	

Question Number	Scheme	Marks
8. (a)		B1 trapezium B1 triangle & overlap B1 figs (3)
(b)	$\frac{1}{2}(90+60).20=1500$ $1500=\frac{1}{2}a.90^2$ $a=\frac{10}{27}$ ms^{-1} or decimal	M1 A1 M1 A1 **ft** A1 (5)
(c)	$\frac{10t}{27}=20$ $t=54$ s $t=126$ s	M1 A1 A1 A1 **ft** (4)
(d)	$\frac{10}{27}\times 90\ \left(=\frac{100}{3}\right)$ $\frac{100}{3}\times 6-\frac{1}{2}.\frac{10}{27}.6^2\ \left(=\frac{580}{3}\right)$ $d=\frac{580}{3}-(20\times 6)$ $=\frac{220}{3}$ m or decimal	M1 DM1 A1 DM1 A1 (5) **17**

Question Number	Scheme	Marks
3(a)	$\text{Velocity} = (14\mathbf{i} - 5\mathbf{j}) + 2(-4\mathbf{i} + \mathbf{j})$	M1
	$\text{Speed} = \sqrt{6^2 + (-3)^2}$	M1
	$\text{Speed} = \sqrt{45} = 3\sqrt{5} = 6.7\left(\text{ms}^{-1}\right)$ or better	A1 cso
		(3)
3(b)	 $\tan^{-1}\left(\frac{3}{6}\right)$	M1 A1ft
	27° or better **OR** 333° or better 0.46 rads or better **OR** 5.8 rads or better	A1
		(3)
3(c)	$\mathbf{v} = (14\mathbf{i} - 5\mathbf{j}) + (-4\mathbf{i} + \mathbf{j})T$ (allow t) **OR** $\mathbf{v} = (6\mathbf{i} - 3\mathbf{j}) + (-4\mathbf{i} + \mathbf{j})t$ $(t = T - 2)$	M1
	$\frac{14 - 4T}{-5 + T} = \frac{2}{-3}$	M1 A1
	$T = 3.2$	A1
		(4)
(10)		

	NOTES	
	Accept the use of column vectors throughout	
(a)		
M1	Correct use of $t = 2$ to find the velocity (unsimplified).	
M1	Use of Pythagoras to find the speed when $t = 2$ with <u>their</u> velocity.	
A1	$\sqrt{45} = 3\sqrt{5} = 6.7\left(\text{ms}^{-1}\right)$ or better (6.70820…). Must come from correct velocity.	
(b)		
M1	Use trig to find an equation in a relevant angle e.g. $(90° - \theta)$ for their *velocity*.	
A1ft	Correct equation for a relevant angle, ft on their **v**	
A1	Cao. No isw (A0 for a negative answer)	

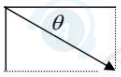
(c) **M1** **M1** **A1** **A1**	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ to obtain a velocity vector in T (allow t) Use ratios, using *their* **velocity**, to produce an equation in T only (Allow reciprocal and incorrect sign) Correct equation in T only Cao **N.B.** If they use their answer to (a) instead of $\mathbf{u} = (14\mathbf{i} - 5\mathbf{j})$ but never correct their value of t, can score M1M1A0A0 **N.B.** If they use $\mathbf{v} = k(2\mathbf{i} - 3\mathbf{j})$ to produce 2 simultaneous equations in k and T, and then they use a calculator to solve and get $T = 3.2$, award all the marks, but if they get the wrong answer, they lose the last 3 marks.	

Question Number	Scheme	Marks
5c	First M1 for a complete method to find the speed / velocity(Could involve two *suvat* equations) Condone sign errors but must have correct numbers in their equation(s) First A1 for a correct equation (or equations) Second A1 for 16 or 16.3 (m s^{-1}) Must be *positive (speed)*	
6a		B1 shape B1 270, V (2)
6b	$\frac{V}{0.6}=\frac{5V}{3}$ **Given answer**	M1A1 (2)
6c	Time decelerating is $5V$	B1
	$\frac{1}{2}V\frac{5V}{3}+(270-5V-\frac{5V}{3})V+\frac{1}{2}V.5V=1500$ **OR:** $\frac{1}{2}(270+270-5V-\frac{5V}{3})V=1500$	M1 A2
	$V^2-81V+450=0$ **Given answer**	**DM1**A1 (6)
6d	$V^2-81V+450=0$ $(V-6)(V-75)=0$ or $V=\frac{81\pm\sqrt{81^2-4\times450}}{2}$	M1 solving
	$V=6$ or 75	A1 A1
	$V=6$ since $(5\times75)>270$ or $V=75$ unrealistic	**B**1 (4)
		14
	Notes	
6a	First B1 for a trapezium with line starting at the origin Second B1 for 270 and V correctly marked	
6b	M1 for $(t=)\frac{V}{0.6}$; **N.B.** M1A0 for V=0.6t then answer Must see division or intermediate step from V=0.6t e.g. Changing 0.6 into 3/5. A1 for $t=\frac{5V}{3}$ **Given answer**	

Question Number	Scheme	Marks
6c	B1 for $5V$ identified appropriately First M1 for clear attempt to equate the *total* area under graph to 1500. (Must include all 3 parts (if not using the trapezium rule) with $\frac{1}{2}$ seen at least once to give equation in V only; may use (1 triangle + 1 trapezium) or (rectangle - trapezium) (May use *suvat* for one or more parts of the area) A2 for a correct equation, -1 e.e.o.o. Second **DM**1 dependent on first M1 for multiplying out and collecting terms and putting into appropriate form Third A1 for correct equation. **Given answer**	
6d	First M1 for solving their 3 term quadratic equation for V N.B. This M1 can be implied by two correct roots but if either answer incorrect then an explicit method must be shown for this M mark. First A1 for $V = 6$ Second A1 for $V = 75$ B1 on ePEN but treat as **DM**1, dependent on both previous A marks, for either reason	
7a	$T - 3mg\sin\alpha - F = 3ma$	M1A1
	$4mg - T = 4ma$	M1A1 (4)
7b	$F = \frac{1}{4}R;\ R = 3mg\cos\alpha$	B1; M1A1
	$T - 2.4mg = 3ma$ $4mg - T = 4ma$	M1
	$a = \frac{8g}{35}$ **Given answer**	A1 (5)
7c	Particles have same acceleration	B1 (1)
7d	$v^2 = 2 \times \frac{8g}{35} \times 1.75$ $(= 0.8g)$	M1 A1
	$-3mg\sin\alpha - F = 3ma'$	M1
	$a' = -0.8g$	A1
	$0 = 0.8g + 2 \times (-0.8g)s$	M1 A1
	Total distance = 0.5 + 1.75 = 2.25 (m) Accept 2.3 (m)	A1 (7)
		17
	Notes	
7a	First M1 for equation of motion for A with usual rules First A1 for a correct equation Second M1 for equation of motion for B with usual rules Second A1 for a correct equation **N.B.** If using different tension in second equation, M0 for that equation	

Question Number	Scheme	Marks
6c	B1 for $5V$ identified appropriately First M1 for clear attempt to equate the *total* area under graph to 1500. (Must include all 3 parts (if not using the trapezium rule) with $\frac{1}{2}$ seen at least once to give equation in V only; may use (1 triangle + 1 trapezium) or (rectangle - trapezium) (May use *suvat* for one or more parts of the area) A2 for a correct equation, -1 e.e.o.o. Second **DM**1 dependent on first M1 for multiplying out and collecting terms and putting into appropriate form Third A1 for correct equation. **Given answer**	
6d	First M1 for solving their 3 term quadratic equation for V N.B. This M1 can be implied by two correct roots but if either answer incorrect then an explicit method must be shown for this M mark. First A1 for $V = 6$ Second A1 for $V = 75$ B1 on ePEN but treat as **DM**1, dependent on both previous A marks, for either reason	
7a	$T - 3mg\sin\alpha - F = 3ma$	M1A1
	$4mg - T = 4ma$	M1A1 (4)
7b	$F = \frac{1}{4}R;\ R = 3mg\cos\alpha$	B1; M1A1
	$T - 2.4mg = 3ma$ $4mg - T = 4ma$	M1
	$a = \frac{8g}{35}$ **Given answer**	A1 (5)
7c	Particles have same acceleration	B1 (1)
7d	$v^2 = 2 \times \frac{8g}{35} \times 1.75$ $(= 0.8g)$	M1 A1
	$-3mg\sin\alpha - F = 3ma'$	M1
	$a' = -0.8g$	A1
	$0 = 0.8g + 2 \times (-0.8g)s$	M1 A1
	Total distance = 0.5 + 1.75 = 2.25 (m) Accept 2.3 (m)	A1 (7)
		17
	Notes	
7a	First M1 for equation of motion for A with usual rules First A1 for a correct equation Second M1 for equation of motion for B with usual rules Second A1 for a correct equation **N.B.** If using different tension in second equation, M0 for that equation	

Question Number	Scheme	Marks
7b	B1 for $F = \frac{1}{4}R$ seen e.g. on diagram First M1 for resolving for A perp to the plane First A1 for correct equation N.B. These first 3 marks can be earned in (a). Second M1 (Hence) for substituting for R and F and trig. and solving for a (must be some evidence of this) their equations of motion from part (a) Second A1 for **given answer (Not available if not using exact values for trig ratios)**	
7c	B1 for particles have same acceleration (B0 for same velocity or if incorrect extras given)	
7d	First M1 for attempt to find speed (or speed^2) when B hits the ground (M0 if uses g) First A1 for a correct expression Second M1 for attempt to find deceleration of A Second A1 for correct deceleration Third M1 for using deceleration (must have found a deceleration) with $v = 0$ to find distance (M0 if uses g) Third A1 for a correct equation Fourth A1 for 2.25 (m)	

Question Number	Scheme	Marks	Notes
5 (a)	Speed = $\sqrt{3^2+(-2)^2}$ or $\sqrt{3^2+2^2}$ $=\sqrt{13}$ m s^{-1}	M1 A1(2)	Use Pythagoras Accept 3.6 or better Ignore their diagram if it does not support their working
(b)			
	$\tan\theta=\frac{2}{3}$, $\theta=33.7$ OR $\tan\theta=\frac{3}{2}$, $\theta=56.3$	M1	Find a relevant angle
	OR find another useful angle	A1	Their angle correct (seen or implied)
	Bearing = 124	A1 (3)	Correct bearing. Accept 124° or awrt 124/124° Accept N 124 E or S 56 E
(c)	$\mathbf{r}_B=10\mathbf{j}+t(3\mathbf{i}-2\mathbf{j})$	M1 A1	Find the position vector of B or G at time t Correct for B
	$\mathbf{r}_G=4\mathbf{i}-2\mathbf{j}+t\left(\frac{5}{3}\mathbf{i}+2\mathbf{j}\right)$	A1	Correct for G
	$3t=4+\frac{5}{3}t$ OR $10-2t=-2+2t$	DM1	Compare coefficients of **i** or of **j** to form an equation in t.
	(i) $t=3$ s	A1	Correct unambiguous conclusion.
	(ii) $\mathbf{r}=10\mathbf{j}+3(3\mathbf{i}-2\mathbf{j})=(9\mathbf{i}+4\mathbf{j})$ m		
	OR $\mathbf{r}=4\mathbf{i}-2\mathbf{j}+3\left(\frac{5}{3}\mathbf{i}+2\mathbf{j}\right)=(9\mathbf{i}+4\mathbf{j})$ m	A1 (6)	Final answer. Accept with no units. Do not ignore subsequent working.
		[11]	

Question Number	Scheme	Marks
6.	$s_A = 35t + \frac{1}{2}0.4t^2 ; s_B = 44t + \frac{1}{2}0.5t^2$ $44t + \frac{1}{2}0.5t^2 = 200 + 35t + \frac{1}{2}0.4t^2$ $\frac{1}{20}t^2 + 9t - 200 = 0$ $(t-20)(t+200) = 0$ $t = 20$ $v = 44 + \frac{1}{2}.20 = 54 \text{ ms}^{-1}$	M1 A1 A1 M1 A1 M1 A1 **DM1** A1 **9**
	Notes	
	First M1 for use of $s = ut + \frac{1}{2}at^2$ for either *A* or *B* First A1 for a correct equation for *A* Second A1 for a correct equation for *B* Second M1 for producing a quadratic in *t* only from their s_A = their $s_B \pm 200$ Third A1 for a correct '3 term = 0' equation Third M1 (can be implied by one correct answer) for attempt to solve their quadratic (M0 if linear). Must include 200, must be 3 terms and must have come from using both distance expressions. Fourth A1 for $t = 20$ Fourth M1 dependent on third M1 for correctly using their *t* value to find *v* Fifth A1 for 54 **N.B. SC for trial and error to find *t* ; can score max M1A1A1M1A0M0A0M1A1 6/9**	

7 (a)	$108 \times 1000/3600 = 30 \text{ m s}^{-1}$	M1 A1 (2)
(b)		B1 shape **DB1 ft** figs (2)
(c)	$12000 = \frac{1}{2} \times 30(480 + 480 - 4T)$ $T = 40$ $a = 30/40 = 0.75 \text{ m s}^{-2}$	M1 A2 A1 M1 A1 (6) **10**

NOTES

Question 7(a)
M1 for 108 x 1000/3600 oe
A1 for 30

Question 7(b)
First B1 for trapezium (B0 for triangle), from the origin, finishing on the *t*-axis.
Second dependent B1 **ft** on their '30' and 480 or 108 and (8/60 oe).

Question 7(c)
First M1 for clear attempt at equating *total* area under a trapezium to distance travelled oe (equation must include at least one '1/2') to give equation in ONE unknown.
A2 for a correct equation , -1 each error. **N.B.** Repeated use of an incorrect v from part (a) is ONE error.
Third A1 for $T = 40$ (or 120)
N.B. (First M1 **only** for ½(480 + *x*).30 = 12000
First A1 for 480 – *x* = 160; Second A1 if they divide 160 in ratio 1:3)
(First M0 if they use *s* = the full distance in any single *suvat* equation)
Second M1 (independent) for a complete method to find *a*.
Fourth A1 for 0.75