

Section A

Q 1		mark		Sub
(i)	$\frac{-15}{6} = -2.5$ so -2.5 m s^{-2}	M1 A1	Use of $\Delta v / \Delta t$. Condone use of v/t . Must have - ve sign. Accept no units.	2
(ii)	$\frac{1}{2} \times 10 \times 4 = 20 \text{ m}$	M1 A1	Attempt at area or equivalent	2
(iii)	Area under graph is $\frac{1}{2} \times 5 \times 5 = 12.5$ (and -ve) closest is $20 - 12.5 = 7.5 \text{ m}$	M1 A1	May be implied. Area from 4 to 9 attempted. Condone missing -ve sign. Do not award if area beyond 9 is used (as well). cao	2
				6

Q 2		mark		Sub
(i)	Pulley is smooth (and the string is light)	E1	Only require pulley is smooth. Do not accept only 'string is light'.	1
(ii)	$4g = 39.2 \text{ N}$	B1	Accept either	1
(iii)	Let tension in each string be T $39.2 = 2T \cos 20$ $T = 20.85788\dots$ so 20.9 N (3 s.f.)	M1 B1 F1	Equating 39.2 to attempt at tensions in both BC and BD. Tensions need not be equal. No extra forces. Must attempt resolution. Condone $\sin \leftrightarrow \cos$. For one occurrence of $T \cos 20$ in any equation. Accept reference to only one string. FT their $4g$ If Lami's Theorem used: M1 correct format B1 equation correct. FT their $4g$ F1 FT their $4g$ If Triangle of Forces used: M1 triangle with their $4g$ labelled and an	

		attempt to use this triangle. Ignore arrows. B1 for correct equation. FT their 4g. F1 FT their 4g.	3
			5

Q		mark		Sub
3				
(i)	$ \mathbf{F} = 12.5$ so 12.5 N bearing is $90 - \arctan \frac{12}{3.5}$ = (0)16.260... so (0)16.3° (3 s. f.)	B1 M1 A1	Use of arctan with 3.5 and 12 or equiv May be obtained directly as $\arctan \frac{3.5}{12}$	3
(ii)	$24/7 = 12/3.5$ or $\mathbf{G} = 2\mathbf{F}$ so $ \mathbf{G} = 2 \mathbf{F} $	E1 B1	Accept statement following $\mathbf{G} = 2\mathbf{F}$ shown. Accept equivalent in words.	2
(iii)	$\frac{9+12}{3.5} = \frac{-18+q}{12}$ so $q = 6 \times 12 + 18 = 90$	M1 A1	Or equivalent or in scalar equations. Accept $\frac{21}{q-18}$ or $\frac{q-18}{21} = \tan(i)$ or $\tan(90 - (i))$ Accept 90j	2
				7
4				
(i)	N2L in direction of motion $D - (100 + 300) = (900 + 700) \times 1.5$ $D = 2800$ so 2800 N	M1 A1 A1	Apply N2L. Allow 1 resistance omitted and sign error but total mass must be used. Condone use of $F = mga$. No extra forces. All correct cao	3
(ii)	N2L on trailer $T - 300 = 700 \times 1.5$ $T = 1350$ so 1350 N	M1 A1	Use either car or trailer. All forces present. No extras. Correct mass and a Allow sign error. Must use $F = ma$. cao	2
				5

Q 5		mark		Sub
(i)	$9\mathbf{i} \text{ m s}^{-2}; (9\mathbf{i} - 12\mathbf{j}) \text{ m s}^{-2}$	B1	Award for either. Accept no units. (isw e.g. finding magnitudes)	1
(ii)	N2L $\mathbf{F} = 4(9\mathbf{i} - 12\mathbf{j}) = (36\mathbf{i} - 48\mathbf{j}) \text{ N}$	B1	Accept factored form. isw. FT $\mathbf{a}(3)$. Accept 60 N or their $4 \mathbf{a} $	1
(iii)	$\mathbf{v} = \int \begin{pmatrix} 9 \\ -4t \end{pmatrix} dt = \begin{pmatrix} 9t + C \\ -2t^2 + D \end{pmatrix}$ Using $\mathbf{v} = 4\mathbf{i} + 2\mathbf{j}$ when $t = 1$ $\begin{pmatrix} 4 \\ 2 \end{pmatrix} = \begin{pmatrix} 9 + C \\ -2 + D \end{pmatrix}$ $\Rightarrow C = -5, D = 4$ so $\mathbf{v} = (9t - 5)\mathbf{i} + (4 - 2t^2)\mathbf{j}$	M1 A1 M1 A1	Integration. At least one term correct. Neglect arbitrary constant(s) Sub at $t = 1$ to find arb const(s) Any form	4
				6

Q 6		mark		Sub
(i)	$14 = 2u + 0.5a \times 4$ $19 = u + 5a$ Solving gives $u = 4$ and $a = 3$	M1 A1 A1 M1 F1	Use of appropriate <i>uvast</i> for either equn Any form Any form Attempt at solution of 2 eqns in 2 unknowns. At least one value found . Must have complete correct solution to their eqns. .	5
(ii)	$19^2 = 4^2 + 2 \times 3 \times s$ or $s = 4 \times 5 + 0.5 \times 3 \times 25$ $s = 57.5$ so 57.5 m	M1 A1	Use of appropriate <i>uvast</i> and their u, a & $t = 5$. cao [Accept 50 if $t = 7$ instead of $t = 5$ in (i) for 2/2]	2
				7

Section B

Q 7		mark		Sub
(i)	60 N	B1		1
(ii)	$60 + 70 \cos 30 = 120.62\dots$ so 121 N (3 s. f.)	M1 A1	70 cos30 or 70 sin 30 used only with 60N. Accept sign errors. cao. Any reasonable accuracy	2
(iii)	resolve \uparrow $R + 70 \sin 30 - 50g = 0$ $R = 455$ so 455 N	M1 A1 A1	Resolve \uparrow All forces present. No extras. Allow sign errors and $\sin \leftrightarrow \cos$. All correct. cao	3
(iv)	N2L \rightarrow $160 - 125 = 50a$ $a = 0.7$ so 0.7 m s^{-2}	M1 A1	N2L. No extra forces. Accept 125 N omitted but not use of $F = mga$	2
(v)	N2L \rightarrow $-125 = 50a$ $a = -2.5$ $0 = 1.5^2 + 2 \times -2.5 \times s$ $s = 0.45$ so 0.45 m	M1 A1 M1 A1	N2L to find new accn. Accept +125 but not $F = mga$. May be implied. Accept +2.5 Appropriate (sequence of) <i>uvast</i> using a new value for acceln. Allow use of \pm their new a cao. Signs must be justified.	4
(vi)	N2L \rightarrow $160 + Q \cos 30 - 115 = 50 \times 3$ $Q = 121.24\dots$ so 121 (3 s. f.)	M1 B1 A1 A1	Use of N2L with cpt of Q attempted. Accept 115 omitted or taken to be 125 and a wrong. Do not allow $F = mga$. $Q \cos 30$ seen in any eqn. All correct cao	4
				16

Q 8		mark		Sub
(i)	$x = 14 \cos 60t$ so $x = 7t$ $y = 14 \sin 60t - 4.9t^2 + 1$ $y = 7\sqrt{3}t - 4.9t^2 + 1$ $(y = 12.124...t - 4.9t^2 + 1)$	M1 A1 M1 A1 A1	Consider motion in x direction. Need not resolve. Allow $\sin \leftrightarrow \cos$. Condone +1 seen. Need not be simplified. Suitable $uvast$ used for y with $g = \pm 9.8, \pm 10, \pm 9.81$ soi Need not resolve. Allow $\sin \leftrightarrow \cos$. Allow +1 omitted. Any form and 2 s. f. Need not be simplified All correct. +1 need not be justified. Accept any form and 2 s. f. Need not be simplified.	5
(ii) (A)	time taken to reach highest point $0 = 7\sqrt{3} - 9.8T$ so $\frac{5\sqrt{3}}{7}$ s (1.23717.... = 1.24 s (3 s. f.))	M1 A1	Appropriate $uvast$. Accept $u = 14$ and $\sin \leftrightarrow \cos$ and $u \leftrightarrow v$. Require $v = 0$ or equivalent. $g = \pm 9.8, \pm 10, \pm 9.81$ soi. cao [If time of flight attempted, do not award M1 if twice interval obtained]	2
(B)	distance from base is $7 \times \frac{5\sqrt{3}}{7} = 5\sqrt{3}$ m (= 8.66025... so 8.66 m (3 s. f.))	M1 B1	Use of their $x = 7t$ with their T FT their T only in $x = 7t$. Accept values rounding to 8.6 and 8.7.	2
(C)	either Height at this time is $H = 7\sqrt{3} \times \frac{5\sqrt{3}}{7} - 4.9 \times \left(\frac{5\sqrt{3}}{7}\right)^2 + 1$ = 8.5	M1 A1 A1	Subst in their quadratic y with their T . Correct subst of their T in their y which has attempts at all 3 terms. Do not accept $u = 14$.	

	<p>clearance is $8.5 - 6 = 2.5$ m</p> <p>or for height above pt of projection</p> $0 = (7\sqrt{3})^2 + 2 \times -9.8 \times s$ <p>$s = 7.5$ so clearance is $7.5 - 5 = 2.5$ m</p>	<p>E1 Clearly shown.</p> <p>M1 Appropriate <i>uvast</i> . Accept $u = 14$. $g = \pm 9.8, \pm 10, \pm 9.81$ soi</p> <p>A1 Attempt at vert cpt accept $\sin \leftrightarrow \cos$.Accept sign errors but not $u = 14$.</p> <p>A1</p> <p>E1 Clearly shown.</p>	4
(iii)	See over		

Q 8	continued	mark	su b
(iii)	<p>Elim t between $y = 7\sqrt{3}t - 4.9t^2 + 1$ and $x = 7t$</p> <p>so $y = 7\sqrt{3}\frac{x}{7} - 4.9\left(\frac{x}{7}\right)^2 + 1$</p> <p>so $y = \sqrt{3}x - 0.1x^2 + 1$</p>	<p>M1 Must see their $t = x/7$ fully substituted in their quadratic y (accept bracket errors)</p> <p>F1 Accept any form correctly written. FT their x and 3 term quadratic y (neither using $u = 14$)</p>	2
(iv)	<p>either</p> <p>need $6 = 7\sqrt{3}t - 4.9t^2 + 1$</p> <p>so $4.9t^2 - 7\sqrt{3}t + 5 = 0$</p> <p>$t = \frac{5(\sqrt{3} \pm 1)}{7}$ (0.52289.... or 1.95146...)</p> <p>moves by $\left(\frac{5(\sqrt{3} + 1)}{7} - \frac{5\sqrt{3}}{7}\right) \times 7$</p> <p>$[(1.95146.. - 1.23717...) \times 7]$</p> <p>$= 5$ m</p> <p>or</p> <p>using equation of trajectory with $y = 6$</p>	<p>M1 their quadratic y from (i) = 6, or equivalent.</p> <p>M1 Dep. Attempt to solve this 3 term quadratic. (Allow $u = 14$).</p> <p>A1 for either root</p> <p>M1 Moves by $\text{their root} - \text{their (ii)(A)} \times 7$ or equivalent.</p> <p>A1 Award this for recognition of correct dist (no calc)</p> <p>A1 cao [If new distance to wall found must have larger of 2 +ve roots for 3rd M and award max 4/5 for 13.66]</p>	

	$6 = \sqrt{3}x - 0.1x^2 + 1$ <p>Solving $x^2 - 10\sqrt{3}x + 50 = 0$</p> $x = 5(\sqrt{3} \pm 1) \text{ (13.660... or 3.6602...)}$ <p>distance is $5(\sqrt{3} + 1) - 5\sqrt{3}$</p> $= 5 \text{ m}$	M1 Equating their quadratic trajectory equn to 6 M1 Dep. Attempt to solve this 3 term quadratic. (Allow $u = 14$). A1 for either root M1 distance is their root - their(ii)(B) Award this for recognition of correct dist (no calc) A1 Cao [If new distance to wall found must have larger of 2 + ve roots for 3 rd M and award max 4/5 for 13.66]	5 20
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