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)	$\frac{1}{2} \times 10 \times 4 = 20$ 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 $20 - 12.5 = 7.5$ 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 N	B1	Accept either	1
(iii)	Let tension in each string be T $39.2 = 2T \cos 20$ T = 20.85788… 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** 4*g*. F1 FT **their** 4*g*.	3
				5

Q 3		**mark**		**Sub**
(i)	$\lvert\mathbf{F}\rvert = 12.5$ 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 …. **G** = 2**F** so $\lvert\mathbf{G}\rvert = 2\lvert\mathbf{F}\rvert$	E1 B1	Accept **statement** following **G** = 2**F** shown. Accept equivalent in words.	2
(iii)	$\frac{9+12}{3.5} = \frac{-18+q}{12}$ so $q = 6\times12+18 = 90$	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 90**j**	2
				7

Q 4		**mark**		**Sub**
(i)	N2L in direction of motion $D - (100+300) = (900+700)\times1.5$ 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 $T - 300 = 700\times1.5$ 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)	$9\mathbf{i}$ m s^{-2}; $(9\mathbf{i} - 12\mathbf{j})$ m s^{-2}	B1	Award for either. Accept no units. (isw e.g. finding magnitudes)	1
(ii)	N2L $\mathbf{F} = 4(9\mathbf{i} - 12\mathbf{j}) = (36\mathbf{i} - 48\mathbf{j})$ N	B1	Accept factored form. isw. FT **a**(3). Accept 60 N or **their** $4\lvert\mathbf{a}\rvert$	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 *uvast* for either equn Any form Any form Attempt at solution of 2 equns in 2 unknowns. At least one value found . Must have complete correct solution to **their** equns. .	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 *uvast* 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)	$60 + 70\cos 30 = 120.62...$ 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 ↑ $R + 70\sin 30 - 50g = 0$ R = 455 so 455 N	M1 A1 A1	Resolve ↑ All forces present. No extras. Allow sign errors and $\sin \leftrightarrow \cos$. All correct. cao	3
(iv)	N2L → $160 - 125 = 50a$ 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 → $-125 = 50a$ $a = -2.5$ $0 = 1.5^2 + 2\times -2.5\times s$ 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) *uvast* using a new value for acceln. Allow use of ± **their new** a cao. Signs must be justified.	4
(vi)	N2L → $160 + Q\cos 30 - 115 = 50\times 3$ Q = 121.24… 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 $F = mga$. Qcos30 seen in any equn. All correct cao	4
				16

Q 8		mark		Sub
(i)	$x = 14\cos 60t$	M1	Consider motion in x direction. Need not resolve. Allow $\sin \leftrightarrow \cos$. Condone +1 seen.	
	so $x = 7t$	A1	Need not be simplified.	
	$y = 14\sin 60t - 4.9t^2 + 1$	M1	Suitable *uvast* used for y with g $= \pm 9.8, \pm 10, \pm 9.81$ soi Need not resolve. Allow $\sin \leftrightarrow \cos$.	
	$y = 7\sqrt{3}t - 4.9t^2 + 1$ $(y = 12.124...t - 4.9t^2 + 1)$	A1 A1	Allow + 1omitted. 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 $0 = 7\sqrt{3} - 9.8T$	M1	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.	
	so $\frac{5\sqrt{3}}{7}$ s (1.23717…. = 1.24 s (3 s. f.))	A1	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 $H = 7\sqrt{3} \times \frac{5\sqrt{3}}{7} - 4.9 \times \left(\frac{5\sqrt{3}}{7}\right)^2 + 1$	M1	Subst in **their quadratic** y with **their** T.	
	= 8.5	A1 A1	Correct subst of **their** T in **their** y which has attempts at all 3 terms. Do not accept u = 14.	

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

Q 8	**continued**	**mark**		**sub**
(iii)	Elim t between $y=7\sqrt{3}t-4.9t^2+1$ and $x = 7t$ so $y=7\sqrt{3}\frac{x}{7}-4.9\left(\frac{x}{7}\right)^2+1$ so $y=\sqrt{3}x-0.1x^2+1$	M1 F1	Must see **their** $t = x/7$ fully substituted in **their** quadratic y (accept bracket errors) Accept any form correctly written. FT **their** x and 3 term quadratic y (neither using u = 14)	2
(iv)	**either** need $6=7\sqrt{3}t-4.9t^2+1$ so $4.9t^2-7\sqrt{3}t+5=0$ $t=\frac{5\left(\sqrt{3}\pm1\right)}{7}$ (0.52289…. or 1.95146…) moves by $\left(\frac{5(\sqrt{3}+1)}{7}-\frac{5\sqrt{3}}{7}\right)\times7$ $[(1.95146..-1.23717\ldots)\times7]$ = 5 m **or** using equation of trajectory with y = 6	M1 M1 A1 M1 A1	**their** quadratic y from (i) = 6, or equivalent. Dep. Attempt to solve this 3 term quadratic. (Allow u = 14). for either root Moves by $\lvert$**their** root - **their** (ii)(A)$\rvert\times7$ or equivalent. Award this for recognition of correct dist (no calc) 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]	

	$6 = \sqrt{3}x - 0.1x^2 + 1$	M1	Equating **their** quadratic trajectory equn to 6	
	Solving $x^2 - 10\sqrt{3}x + 50 = 0$	M1	Dep. Attempt to solve this 3 term quadratic. (Allow u = 14).	
	$x = 5\left(\sqrt{3} \pm 1\right)$ (13.660… or 3.6602….)	A1	for either root	
	distance is $5\left(\sqrt{3}+1\right) - 5\sqrt{3}$	M1	distance is $\lvert$**their** root – **their**(ii)(B)$\rvert$ Award this for recognition of correct dist (no calc)	
	= 5 m	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]	5
				20