Q 1

	mark		Sub
$0 = u - 9.8\times 3$	M1	*uvast* leading to u with $t = 3$ or $t = 6$	
$u = 29.4$ so 29.4 m s^{-1}	A1	Signs consistent	
	M1	*uvast* leading to s with $t = 3$ or $t = 6$ or **their** u	
$s = 0.5\times 9.8\times 9 = 44.1$ so 44.1 m	F1	FT **their** u if used with $t = 3$. Signs consistent. Award for 44.1, 132.3 or 176.4 seen. [Award maximum of 3 if one answer wrong]	
			4
			4

Q 2

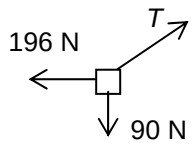
		mark		Sub
(i)	$\sqrt{(-6)^2 + 13^2} = 14.31782...$	M1	Accept $\sqrt{-6^2 + 13^2}$	
	so 14.3 N (3 s. f.)	A1		
				2
(ii)	Resultant is $\begin{pmatrix}-6\\13\end{pmatrix} - \begin{pmatrix}-3\\5\end{pmatrix} = \begin{pmatrix}-3\\8\end{pmatrix}$	B1	May not be explicit. If diagram used it must have correct orientation. Give if final angle correct.	
	Require 270 + $\arctan\frac{8}{3}$	M1	Use of $\arctan\left(\pm\frac{8}{3}\right)$ or $\arctan\left(\pm\frac{3}{8}\right)$ (±20.6° or ±69.4°) or equivalent on **their** resultant	
	so 339.4439…° so 339°	A1	cao. Do not accept -21°.	
				3
(iii)	$\begin{pmatrix}-3\\5\end{pmatrix} = 5\mathbf{a}$	M1	Use of N2L with accn *used* in vector form	
	so ($-0.6\,\mathbf{i} + \mathbf{j}$) m s^{-2}	A1	Any form. Units not required. isw.	
	change in velocity is ($-6\,\mathbf{i} + 10\,\mathbf{j}$) m s^{-1}	F1	10**a** seen. Units not required. Must be a vector. [SC1 for $a = \sqrt{3^2 + 5^2}/5 = 1.17$]	
				3
				8

Q 3		mark		Sub
(i)	$F = 14000 \times 0.25$	M1	Use of N2L . Allow $F = mga$ and wrong mass. No extra forces.	
	so 3500 N	A1		2
(ii)	$4000 - R = 3500$ so 500 N	B1	FT F from (i). Condone negative answer.	1
(iii)	$1150 - R_T = 4000 \times 0.25$	M1	N2L applied to truck (or engine) using all forces required. No extras. Correct mass. Do not allow use of $F = mga$. Allow sign errors.	
	so 150 N	A1	cao	2
(iv)	**either**			
	Component of weight down slope is	M1	Attempt to find cpt of *weight* (allow wrong mass). Accept $\sin \leftrightarrow \cos$. Accept use of $m \sin\theta$.	
	Extra driving force is cpt of mg down slope	M1	May be implied. Correct mass. No extra forces. Must have resolved weight component. Allow $\sin \leftrightarrow \cos$	
	$14000g \sin 3°$ $= 14000 \times 9.8 \times 0.0523359... = 7180.49...$ so 7180 N (3 s. f.)	A1		
	or			
		M1	Attempt to find cpt of *weight* (allow wrong mass). Accept $\sin \leftrightarrow \cos$. Accept use of $m \sin\theta$.	
	$D - 500 - 14000g \sin 3 = 14000 \times 0.25$	M1	N2L with all terms present with correct signs and mass. No extras. FT 500 N. Accept **their** 500 + 150 for resistance. Must have resolved weight component. Allow $\sin \leftrightarrow \cos$.	
	D = 11180.49… so extra is 7180 N (3 s. f.)	A1	Must be the extra force.	3
				8

Q 4		**mark**		**Sub**
(i)	**either**			
	Need **j** cpt 0 so $18t^2 - 1 = 0$	M1	Need not solve	
	$\Rightarrow t^2 = \frac{1}{18}$. Only one root as $t > 0$	E1	Must establish only one of the two roots is valid	
	or			
	Establish sign change in **j** cpt	B1		
	Establish only one root	B1		
				2
(ii)	$\mathbf{v} = 3\,\mathbf{i} + 36t\,\mathbf{j}$	M1	Differentiate. Allow **i** or **j** omitted	
		A1		
	Need **i** cpt 0 and this never happens	E1	Clear explanation. Accept '**i** cpt always there' or equiv	
				3
(iii)	$x = 3t$ and $y = 18t^2 - 1$	B1	Award for these two expressions seen.	
	Eliminate t to give			
	$y = 18\left(\frac{x}{3}\right)^2 - 1$	M1	t properly eliminated. Accept any form and brackets missing	
	so $y = 2x^2 - 1$	A1	cao	
				3
				8

Q 5		**mark**		**Sub**
(i)	$0^2 = V^2 - 2 \times 9.8 \times 22.5$	M1	Use of appropriate *uvast*. Give for correct expression	
	$V = 21$ so 21 m s^{-1}	E1	Clearly shown. Do not allow $v^2 = 0 + 2gs$ without explanation. Accept using $V = 21$ to show $s = 22.5$.	
				2
(ii)	$28\sin\theta = 21$	M1	Attempt to find angle of projection. Allow $\sin \leftrightarrow \cos$.	
	so $\theta = 48.59037...$	A1		
				2
(iii)	Time to highest point is $\frac{21}{9.8} = \frac{15}{7}$	B1	Or equivalent (time of whole flight)	
	Distance is $2 \times \frac{15}{7} \times 28 \times \cos(\mathbf{their}\,\theta)$..	M1	Valid method for horizontal distance. Accept ½ time. Do not accept 28 used for horizontal speed or vertical speed when calculating time.	
		B1	Horizontal speed correct	
	79.3725… so 79.4 m (3 s. f.)	A1	cao. Accept answers rounding to 79 or 80. [If angle with vertical found in (ii) allow up to full marks in (iii). If $\sin \leftrightarrow \cos$ allow up to B1 B1 M0 A1] [If $u^2 \sin 2\theta / g$ used then M1* Correct formula used. FT their angle. M1 Dep on *. Correct subst. FT their angle. A2 cao]	
				4
				8

Q 6		mark		Sub
(i)	$0.5\times2\times12+0.5\times4\times12$ so 36 m	M1 A1	Attempt at sum of areas or equivalent. No extra areas.	2
(ii)	$8-\frac{36}{12}=5$ seconds	B1	cao	1
(iii)	-6 m s^{-2}	M1 B1	Attempt at accn for $0\le t\le2$ must be - ve or equivalent	2
(iv)	$58.5=12\times6+0.5\times a\times36$ so $a=-0.75$	M1 A1	Use of *uvast* with 12 and 58.5	2
(v)	$a=-10+\frac{9}{2}t-\frac{3}{8}t^2$ $a(1)=-10+\frac{9}{2}-\frac{3}{8}=-5.875$	M1 A1 A1	Differentiation cao	3
(vi)	$s=\int\left(12-10t+\frac{9}{4}t^2-\frac{1}{8}t^3\right)\mathrm{d}t$ $=12t-5t^2+\frac{3}{4}t^3-\frac{1}{32}t^4+C$ $s=0$ when $t=0$ so $C=0$ $s(8)=32$	M1 A1 A1* A1	Attempt to integrate At least one term correct All correct. Accept + C omitted Clearly shown cao (award even if A1* is not given)	5
(vii)	**either** $s(2)=9.5$ and $s(4)=8$ Displacement is negative Car going backwards **or** Evaluate $v(t)$ where $2<t<4$ or appeal to shape of the graph Velocity is negative Car going backwards	B1 E1 E1 B1 E1 E1	Both calculated correctly from **their** s. No further marks if **their** $s(2)\le s(4)$ Do *not* need car going backwards *throughout* the interval. e.g. $v(3)=-1.125$ No further marks if **their** $v\ge0$ Do *not* need car going backwards *throughout* the interval [Award WW2 for 'car going backwards'; WW1 for velocity or displacement negative]	3 18

Q 7		mark		Sub
(i)	$T_{AB}\sin\alpha = 147$	M1	Attempt at resolving. Accept sin ↔ cos . Must have *T* resolved and equated to 147.	
	so $T_{AB} = \dfrac{147}{0.6}$	B1	Use of 0.6. Accept correct subst for angle in wrong expression.	
	= 245 so 245 N	A1	Only accept answers agreeing to 3 s. f. [Lami: M1 pair of ratios attempted; B1 correct sub;A1]	3
(ii)	$T_{BC} = 245\cos\alpha$	M1	Attempt to resolve 245 and equate to *T*, or equiv Accept sin ↔ cos	
	$= 245\times 0.8 = 196$	E1	Substitution of 0.8 clearly shown [SC1 $245\times 0.8 = 196$] [Lami: M1 pair of ratios attempted; E1]	2
(iii)	Geometry of A, B and C and weight of B the same and these determine the tension	E1 E1	Mention of two of: same weight: same direction AB: same direction BC Specific mention of same geometry & weight or recognition of same force diagram	2
(iv)			No extra forces.	
		B1	Correct orientation and arrows	
		B1	'*T*' 196 and 90 labelled. Accept 'tension' written out.	
	either			
	Realise that 196 N and 90 N are horiz and vert forces where resultant has magnitude and line of action of the tension	M1	Allow for only β or *T* attempted	
	$\tan\beta = 90/196$	B1	Use of arctan (196/90) or arctan (90/196) or equiv	
	$\beta = 24.6638...$ so 24.7 (3 s. f.)	A1		
	$T = \sqrt{196^2 + 90^2}$	M1	Use of Pythagoras	
	T = 215.675… so 216 N (3 s. f.)	E1		
	or			
	$\uparrow\ T\sin\beta - 90 = 0$	B1	Allow if *T* = 216 assumed	
	$\rightarrow\ T\cos\beta - 196 = 0$	B1	Allow if *T* = 216 assumed	
	Solving $\tan\beta = \dfrac{90}{196} = 0.45918...$	M1	Eliminating *T*, or…	
	$\beta = 24.6638...$ so 24.7 (3 s. f.)	A1	[If *T* = 216 assumed, B1 for β ; B1 for check in 2nd	
	T = 215.675… so 216 N (3 s. f.)	E1	equation; E0]	7
(v)	Tension on block is 215.675.. N (pulley is smooth and string is light)	B1	May be implied. Reasons not required.	
	$M\times 9.8\times\sin 40 = 215.675... + 20$	M1	*Equating* their tension on the block unresolved ± 20 to weight component. If equation in any other direction, normal reaction must be present.	
		A1	Correct	
	M = 37.4128… so 37.4 (3 s. f.)	A1	Accept answers rounding to 37 and 38	4
				18