Mark Scheme

Q1.

Question	Scheme	Marks	AOs	Notes
(a)	Equation of motion for Q	M1	3.3	Equation of motion for Q with correct no. of terms, condone sign errors.
	$0.6g - T = 0.6a$	A1	1.1 b	A correct equation
	Equation of motion for P	M1	3.3	Equation of motion for Q with correct no. of terms, condone sign errors.
	$T = 0.8a$	A1	1.1 b	A correct equation
	$a = 4.2\ (\text{m s}^{-2})$ *	A1*	2.2 a	Given acceleration obtained correctly. **You must see an equation in a only before reaching $a = 4.2$**
		(5)		**N.B.** if they just use the whole system equation: $0.6g = 1.4a$, can only score max M1A1M0A0A0 **N.B.** Use of $g = 9.81$ or 10 loses final A mark only. **N.B.** Complete verification, using both equations, can score full marks.

(b)	$0.4=\frac{1}{2}\times 4.2\times t_1^2$ or e.g. they may find v first and then use $v=4.2t_1$	M1	2.1	Complete method (they may use more than one *suvat* equation) to find time for Q to hit the floor (M0 if 0.4 **not** used as distance moved and/or if 4.2 is **not** used as acceleration and this applies to finding v as well if they use v to find t_1)
	$t_1 = 0.436(4357\ldots..)$ Allow 0.43, 0.44, 0.436, or better, or any surd form e.g. $\frac{2}{\sqrt{21}}$	A1	1.1 b	See alternatives
	$v=4.2\times t_1$ or $v=\sqrt{2\times 4.2\times 0.4}$ or $0.4=\frac{(0+v)}{2}\times t_1$ $(v=1.8330\ldots)$	M1	3.4	Complete method to find speed of Q as it hits the floor (M0 if 0.4 **not** used as distance moved and/or if 4.2 is **not** used as acceleration and this applies to finding t_1 as well if they use t_1 to find v)
	$t_2=\frac{1.5-0.4}{v}$	M1	1.1 b	Uses distance/speed to find time for P to hit the pulley after Q has hit the floor. N.B. This is independent of previous M mark.
	Complete strategy to solve the problem by finding the sum of the two times t_1+t_2	**DM 1**	3.1 b	Complete method to solve the problem by finding and adding the two required times, dependent on previous three M marks
	1.0 (s) or 1.04 (s)	A1	1.1 b	
		(6)		

(c)	e.g. rope being light; rope being inextensible; pulley being smooth; pulley being small; balls being particles	B1	3.5 b	Clear statement. Allow negatives of these i.e. the rope may not be light, the rope may not be inextensible etc Must be a limitation of the model stated in the question Penalise incorrect or irrelevant extras
		(1)		B0 for: Air resistance, table being smooth
		(12 marks)		

Q2.

Question	Scheme	Marks	AOs
(a)	(i) Equation of motion for P	M1	3.3
	$T-2mg=2ma$	A1	1.1b
	(ii) Equation of motion for Q	M1	3.3
	$5mg-T=5ma$	A1	1.1b
	N.B. (allow $(-a)$ in both equations)	(4)	
(b)	Solve equations for a or use whole system equation and solve for a	M1	3.4
	$a=\frac{3g}{7}=4.2$	A1	1.1b
	$v=\sqrt{2\times\frac{3g}{7}\times h}=\sqrt{8.4h}$ or $v^2=2\times\frac{3g}{7}\times h\ (=8.4h)$	M1	1.1b
	$0=\frac{6gh}{7}-2gH$	M1	1.1b
	$H=\frac{3h}{7}$	A1	1.1b
	Total height $=2h+h+H$	M1	2.1
	Total height $=\frac{24h}{7}$	A1	1.1b
		(7)	
(c)	e.g. The distance that Q falls to the ground would not be exactly h oe	B1	3.5b
		(1)	
(d)	e.g. The accelerations of the balls would not have equal magnitude (allow 'wouldn't be the same' oe) B0 if they say 'inextensible => acceleration same'	B1	3.5a
		(1)	
			(13 marks)

Notes:		
a	M1	Translate situation into the model and set up the equation of motion for P (must contain T and a)
	A1	Correct equation
	M1	Translate situation into the model and set up the equation of motion for Q(must contain T and a)
	A1	Correct equation
		N.B. Allow the above 4 marks if the equations appear in (b).
		If m's are omitted consistently, max (a) M1A0M1A0 (b)M1A0M1M1A1M1A0
b	M1	Solve for a
	A1	Allow 4.2 ($m\,s^{-2}$) or must be in terms of g only.
		N.B. Allow the above 2 marks if they appear in (a).
	M1	Complete method to produce an expression for v or v^2 in terms h, using their a
	M1	Complete method to produce an expression for H in terms of h ,using $a = -g$ and $v = 0$
	A1	Correct expression for H
	M1	Complete method to find the total distance
	A1	cao but allow $3.4h$ or better
c	B1	B0 if any incorrect extras are given
d	B1	B0 if any incorrect extras are given or for an incorrect statement e.g. tension is not constant so accelerations will be different

Q3.

Question	Scheme	Marks	AOs
	N.B. Use the mass in the *ma* term to determine which part of the system the equation refers to.		
(a)	Equation of motion:	M1	3.3
	$1740-400-R=(600+800)\times 0.6$ Or $\begin{cases}1740-T-400=800\times 0.6\\ T-R=600\times 0.6\end{cases}$ with T eliminated or found (860) from the first equation, and then used in the second to find R.	A1	1.1b
	$R=1740-840-400=500$ *	A1*	2.2a
		(3)	
(b)	Equation of motion for car or trailer	M1	3.4
	$1740-T-400=800\times 0.6$ or $T-500=600\times 0.6$	A1	1.1b
	$T=860$	A1	1.1b
		(3)	
(c)	Use of $500=\pm 600a$ to obtain * **N.B.** Need to see explicitly deceleration $=\frac{5}{6}$	B1*	1.1b
		(1)	
(d)	Complete method to find distance with $a=\pm\frac{5}{6}$	M1	3.4
	$0=12.5^2-2\times\frac{5}{6}\times d$ **OR e.g.** $t=\frac{12.5}{\frac{5}{6}}=15$ then $d=\frac{1}{2}\times\frac{5}{6}\times 15^2$ or $d=\frac{1}{2}\times(0+12.5)\times 15$ or $d=12.5\times 15+\frac{1}{2}\times(-\frac{5}{6})\times 15^2$	A1	1.1b
	93.75 oe	A1	1.1b
		(3)	

(e)	**N.B.** If **more than two** answers given, subtract 1 from any marks earned for each incorrect extra answer which are in group 7 below but do **not** penalise answers which are in group 8 and then, on ePEN, award as appropriate either: B1B1, B1B0 or B0B0 but NOT B0B1.	B1 B1	3.5b 3.5b
		(2)	
			(12 marks)

Notes:	
(a)	**N.B.** Mark (a) and (b) together if no labelling.

M1	Use one or two equations of motion to form an equation in R only but allow a different letter, with $a = 0.6$ substituted. For each equation used, need all terms and dimensionally correct but condone sign errors.
A1	Correct unsimplified equation in R or their R
A1*	Obtain given answer from correct working but condone missing brackets around 600+800 if they are implied by subsequent working. **N.B.** Need to see $R = 500$ **N.B.** Allow verification with $R = 500$ used to show that $a = 0.6$, but must state that $R = 500$ at the end to earn this mark.
(b)	**N.B.** The working for this part may appear in (a).
M1	Use the equation of motion for the car or trailer to form an equation in T need all terms and dimensionally correct but condone sign errors, with $a = 0.6$ substituted.
A1	Correct unsimplified equation in T only
A1	Correct only
(c)	
B1*	Correct justification of given answer
(d)	
M1	Use a complete *suvat* method to find an equation in d only **N.B.** Allow the use of another letter other than d, e.g. s, for this mark.
A1	Correct unsimplified equation in d or s **N.B.** if they use s, allow $0 = 12.5^2 \pm 2 \times \frac{5}{6} \times s$
A1	94 or better **N.B.** if they use s in their equation, they must then state $d =$ or have said that $s = d$ to earn this mark.

(e)	**N.B. On Epen, these are the only possible marks: B1B1, B1B0 or B0B0**
B1 **B1**	Any two **different** appropriate reasons. Do not accept more than **one** from each of the 6 groups below. Award B1 for any **one** reason which is in any of the 6 groups. **Correct answers (not verbatim but equivalent to)** **1.** Resistance to motion of the trailer will be different (when not in the slipstream of the car). or there will be more air or wind resistance. Resistance to motion of the trailer will not be constant/ be exactly 500 N. Wind or air resistance would not be constant. The deceleration won't be constant/ be exactly 5/6 m s^{-2}. **2.** The model takes no account of forces acting side to side. The trailer may not continue to move in a straight line.
	3. The trailer could be affected by any unevenness of the road e.g. potholes, bumps etc Does not take account of the type of ground. **4.** Not considered the mass of the towbar. **5.** Trailer emergency brake may engage. **6.** After the towbar breaks the trailer will tip and drag on the road. The trailer will be unstable. **Incorrect answers which incur a penalty (not verbatim but equivalent to).** 7. Any answer which mentions the car. The acceleration wouldn't be equal. Not considered the length of the trailer. Road might not be straight and/or horizontal. Mass of the trailer. Does not take friction (between the tyres and the ground) into account. Does not take air resistance into account. Does not take wind resistance into account. **Incorrect answers which do NOT incur a penalty (not verbatim but equivalent to).** **8.** Obstacles in the road or cars which the trailer could hit. Does not take account of weather conditions e.g. wind, rain, snow etc The dimensions/shape of the trailer would slow it down. It won't be travelling at a constant speed oe.

Q4.

Question Number	Scheme	Marks
(a)	$T - 0.5g - 1.5g = 2 \times 0.5$ $T = 20.6$ (N) or 21 (N)	M1 A1 A1 (3)
(b)	$R - 1.5g = 1.5 \leftrightarrow 0.5$ Force = 15.5 (N) or 15 (N) OR: $T - R - 0.5g = 0.5 \leftrightarrow 0.5$ Force = 15.5 (N) or 15 (N)	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **6**
	Notes	
(a)	**N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered M1 is for an equation for whole system in T only, with usual rules First A1 for a correct equation Second A1 for 20.6 or 21	
(b)	First M1 is for an equation for the brick only (1st alternative) or for the scale pan only (2nd alternative) with usual rules. First A1 for a correct equation (in the second alternative T does not need to be substituted) Second A1 for 15.5 or 15	
	N.B. If R is replaced by $-R$ in either equation, can score M1A1. This would lead to $R = -15.5$ or -15. The second A1 can then only be scored if the candidate explains why the –ve sign is being ignored.	

Q5.

Question Number	Scheme	Marks
(a)	For A, $T = 2ma$	B1
	For B, $3mg - T = 3ma$	M1 A1
	$3mg = 5ma$	**DM**1
	$\frac{3g}{5} = a$ (5.9 or 5.88 m s^{-2})	A1
		(5)
(b)	$T = 6mg/5$; $12m$; $11.8m$	B1
		(1)
(c)	$F = \sqrt{T^2 + T^2}$	M1 A1 **ft**
	$F = \frac{6mg\sqrt{2}}{5}$; $1.7mg$ (or better); $16.6m$; $17m$	A1
	Direction clearly marked on a diagram, with an arrow, and 45° (oe) marked	B1
		(4)
		[10]
	Notes for Question	
Q (a)	B1 for $T = 2ma$ First M1 for resolving vertically (up or down) for B, with correct no. of terms. (allow omission of m, provided 3 is there) First A1 for a correct equation. Second M1, dependent on first M1, for eliminating T, to give an equation in a only. Second A1 for 0.6g, 5.88 or 5.9. N.B. 'Whole system' equation: $3mg = 5ma$ earns first 4 marks but any error loses all 4.	
Q (b)	B1 for $\frac{6mg}{5}$, $11.8m$, $12m$	
Q (c)	M1 $\sqrt{(T^2 + T^2)}$ or $\frac{T}{\sin 45°}$ or $\frac{T}{\cos 45°}$ or $2T\cos 45°$ or $2T\sin 45°$ (allow if m omitted) (M0 for $T \sin 45°$) First A1 ft on their T. Second A1 cao for $\frac{6mg\sqrt{2}}{5}$ oe, $1.7mg$ (or better), $16.6m$, $17m$ B1 for the direction clearly shown on a diagram with an arrow and 45° marked.	

Q6.

Question	Scheme	Marks	AOs
	N.B. Use the mass in the '*ma*' term of an equation to determine which part of the system (cage and block, cage or block) it applies to.		
(a)	Translate situation into the model and set up the **equation** of motion for the cage and the block to obtain an equation in T only.	M1	3.3
	$T-40g-10g=50\times0.2$	A1	1.1b
	500 (N) Must be positive	A1	1.1b
	Some examples: $T-50=50\times0.2$ and $T-40g-10g=50g\times0.2$ both score M1A0A0		
		(3)	
(b)	Use the model to set up the equation of motion for the block to obtain an equation in R only.	M1	3.4
	$R-10g=10\times0.2$ Allow $-R$ instead of R	A1	1.1b
	100 (N) Must be positive.	A1	1.1b
	OR: Use the model to set up the equation of motion for the cage to obtain an equation in R only.	M1	3.4
	$T-40g-R=40\times0.2$ with their T substituted	A1	1.1b
	100 (N) Must be positive	A1	1.1b
		(3)	
			(6 marks)

Notes: **N.B. Only penalise the use of an incorrect value of *g* ONCE for the whole question, so max (a) M1A1A0 (b) M1A1A1**		
a	M1	Correct number of terms, condone sign errors
	A1	Correct equation in T only
	A1	cao
b	M1	Correct number of terms, condone sign errors
	A1	Correct equation in R only
	A1	cao

Q7.

Question Number	Scheme	Marks
	$T_P\cos 55 = T_Q\cos 35$ $T_P\sin 55 + T_Q\sin 35 = 2g$ Eliminating T_P or T_Q $T_P = 16\text{N}$ or 16.1N; $T_Q = 11\text{N}$ or 11.2N	M1 A1 M1 A1 M1 A1 A1 7
ALT 1	$\left(\text{Along } RP\right)\ T_P = 2g\cos 35° = 16\text{N}$ or 16.1N $\left(\text{Along } RQ\right)\ T_Q = 2g\cos 55° = 11\text{N}$ or 11.2N	M1 M1 A1 A1 M1 A1 A1
	Notes	
	First M1 for resolving horizontally with correct no. of terms and both T_P and T_Q terms resolved. (M0 if they assume $T_P = T_Q$) First A1 for a correct equation. Second M1 for resolving vertically with correct no. of terms and both T_P and T_Q terms resolved. (M0 if they assume $T_P = T_Q$) Second A1 for a correct equation. Third M1 (independent) for eliminating either T_P or T_Q Third A1 for T_P = 16 (N) or 16.1 (N) Fourth A1 for T_Q = 11 (N) or 11.2 (N) N.B. If both are given to more than 3SF, deduct the third A1.	
ALT 1	**Alternative 1 (resolving along each string)** First M2 for resolving along one of the strings (e.g. $T_P = 2g\cos 35°$) First A1 for a correct equation ($T_P = 2g\sin 35°$ scores M2A0A0) Third A1 for T_P = 16 (N) or 16.1 (N) Third M1 for resolving along the other string (e.g. $T_Q = 2g\cos 55°$) Second A1 for a correct equation ($T_Q = 2g\sin 55°$ scores M1A0A0) Fourth A1 for T_Q = 11 (N) or 11.2 (N)	

ALT 2	**Alternative 2 (using a Triangle of Forces)** Both of the equations in Alternative 1 could come from using *sohcahtoa* or The Sine Rule on a triangle of forces, so mark in the same way. Note that, in either case, once they have found either T_P or T_Q , they could then use $T_P = T_Q \tan 55°$ or $T_Q = T_P \tan 55°$ to find the other one. (Note that both of these are equivalent to the horizontal resolution) or Pythagoras. e.g. $T_P = 2g\cos 35°$ M2 First A1 $= 16$ (N) or 16.1 (N) Third A1 $T_Q = T_P \tan 35°$ or $\sqrt{\{(2g)^2 - (T_P)^2\}}$ M1 Second A1 $= 11$ (N) or 11.2 (N) Fourth A1 N.B. If they are clearly using The Sine Rule but have say 35°, 55° and 80° in their triangle, all 3 M marks would be available and at most 1 A mark e.g. $T_P = \frac{2g\sin 55}{\sin 80}$ M2 A0A0 $T_Q = \frac{T_P \sin 35}{\sin 55}$ M1 SecondA1 A0	