Connected Particles Yr 1 (Sheet 2) 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
	$a = 4.2$ (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)

Q3.

Question Number	Scheme	Marks
	(a) N2L A: $5mg - T = 5m \times \frac{1}{4}g$	M1 A1
	$T = \frac{15}{4}mg$ ✱ cso	A1 (3)
	(b) N2L B: $T - kmg = km \times \frac{1}{4}g$	M1 A1
	$k = 3$	A1 (3)
	(c) The tensions in the two parts of the string are the same	B1 (1)
	(d) Distance of A above ground $s_1 = \frac{1}{2} \times \frac{1}{4}g \times 1.2^2 = 0.18g \ (\approx 1.764)$	M1 A1
	Speed on reaching ground $v = \frac{1}{4}g \times 1.2 = 0.3g \ (\approx 2.94)$	M1 A1
	For B under gravity $(0.3g)^2 = 2gs_2 \Rightarrow s_2 = \frac{(0.3)^2}{2}g \ (\approx 0.441)$	M1 A1
	$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m)	A1 (7) **[14]**

Q4.

Question Number	Scheme	Marks
	$T - 0.5g = 0.5a$ $15 - T - 0.75g = 0.75a$ (OR: $15 - 0.5g - 0.75g = 1.25a$) $(a = 2.2 \text{ m s}^{-2})$ $T = 6$ N	M1 A1 M1 A1 M1 A1 **6**
	Notes	
	First M1 for an equation of motion for either P or Q with usual rules i.e. correct no. of terms, dimensionally correct but condone sign errors First A1 for a correct equation (allow T replaced by $-T$ and/or a replaced by $-a$) Second M1 for another equation of motion (for either P or Q or whole system) with usual rules as above Second A1 for a correct equation (allow T consistently replaced by $-T$ and/or a consistently replaced by $-a$) Third M1 for solving two THREE term equations of **motion** for T Third A1 for 6 (N). Must be positive but allow a change from – 6 to 6, if they have consistently used $-T$ instead of T.	

Q5.

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.	

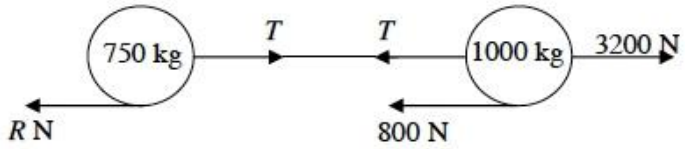
Q6.

Question Number	Scheme	Marks
(a)	$4mg - T = 4ma$	M1A1
	$T - 3mg = 3ma$	M1A1
	Condone the use of $4mg - 3mg = 4ma + 3ma$ in place of one of these equations.	M1A1
	Reach **given answer** $a = \frac{g}{7}$ correctly ***	A1
	Form an equation in T: $T = 3mg + 3\left(mg - \frac{T}{4}\right)$, $T = 3mg + 3m\frac{g}{7}$, or $T = 4mg - 4m\frac{g}{7}$	M1
	$T = \frac{24}{7}mg$ or equivalent, $33.6m$, $34m$	A1 (7)
(b)	$v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4$ ms^{-1}	M1A1 (2)
(c)	$3mg - T = 3ma$ $T - 2mg = 2ma$ $a = \frac{g}{5}$	M1A1 A1 A1 (4)
(d)	$0 = 1.96 - 2 \times \frac{g}{5} \times s$	M1
	$s = \frac{5 \times 1.96}{2g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2$ (m)	A1 ft (3)
Alt d	Using energy: $3mgs - 2mgs = \frac{1}{2}3m \times 1.4^2 + \frac{1}{2}2m \times 1.4^2$	M1
	$s = \frac{2.5 \times 1.96^2}{g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2$ (m)	A1 ft (3)
		[16]

Q7.

Question Number	Scheme	Marks
(a)	For crate, $55g - 473 = 55a$ $a = 1.2 \text{m s}^{-2}$	M1 A1 A1 (3)
(b)	For system, $55g + 200g \pm T - 150 = 255a$ Magnitude $= 2040$ N or 2000 N OR For lift, $200g + 473 - 150 \pm T = 200a$ Magnitude $= 2040$ N or 2000 N	M1 A2 A1 M1 A2 A1 (4) 7
	Notes	
(a)	M1 for an equation in a only, with usual rules. First A1 for a correct equation Second A1 for 1.2 (m s^{-2}). Allow – 1.2 (m s^{-2}) if appropriate	
(b)	M1 for an equation, in T and a , for the system or the lift only, with usual rules. (a does not need to be a numerical value) A2 (-1 each error) for a correct equation (**Allow** $\pm T$). We do **not** need to see a numerical value for a. Third A1 for 2040 (N) or 2000 (N) **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.	

Q8.

Question Number	Scheme	Marks
(a)	 For the whole system R(→) $3200-800-R=1750\times0.88$ Leading to $R=860$ *	M1 A1 A1 (3)
(b)	For the caravan R(→) $T-860=750\times0.88$ Leading to $T=1520$ (N)	M1 A1 A1 (3) **6**
	Alternative for (b) For the car R(→) $3200-800-T=1000\times0.88$ Leading to $T=1520$ (N)	M1 A1 A1 (3)

Q9.

Question Number	Scheme	Marks
	(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 3.15 = \frac{1}{2}a \times \frac{9}{4}$	M1 A1
	$a = 2.8 \ \left(\text{ms}^{-2}\right)$ * cso	A1 **(3)**
	(b) N2L for P: $0.5g - T = 0.5 \times 2.8$	M1 A1
	$T = 3.5 \ (\text{N})$	A1 **(3)**
	(c) N2L for Q: $T - mg = 2.8m$	M1 A1
	$m = \frac{3.5}{12.6} = \frac{5}{18}$ * cso	DM1 A1 **(4)**
	(d) The acceleration of P is equal to the acceleration of Q.	B1 **(1)**
	(e) $v = u + at \Rightarrow v = 2.8 \times 1.5$	M1 A1
	(or $v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 2.8 \times 3.15$)	
	$\left(v^2 = 17.64, v = 4.2\right)$	
	$v = u + at \Rightarrow 4.2 = -4.2 + 9.8t$	DM1 A1
	$t = \frac{6}{7}$, 0.86, 0.857 (s)	DM1 A1 **(6)**
		[17]

Q10.

Question Number	Scheme	Marks
(a) Mark together	$(\downarrow) 0.4g - T = 0.4a$ $(\uparrow) T - 0.3g = 0.3a$ solving for T $T = 3.36$ or 3.4 or $12g/35$ (N)	M1 A1 M1 A1 DM1 A1 (6)
(b)	$0.4g - 0.3g = 0.7a$ $a = 1.4$ m s^{-2}, $g/7$	DM1 A1 (2)
(c)	$(\uparrow) v = u + at$ $v = 0.5$ x 1.4 $= 0.7$	M1 A1 ft on a
	$(\uparrow) s = ut + \frac{1}{2}at^2$ $s = 0.5$ x 1.4 x 0.5^2 $= 0.175$	M1 A1 ft on a
	$(\downarrow) s = ut + \frac{1}{2}at^2$ $1.175 = -0.7t + 4.9t^2$ $4.9t^2 - 0.7t - 1.175 = 0$ $t = \frac{0.7 \pm \sqrt{0.7^2 + 19.6 \text{ x } 1.175}}{9.8}$ $= 0.5663..$or $-...$	DM1 A1 ft DM1 A1 cao
	Ans 0.57 or 0.566 s	A1 cao (9) [17]