Y1M10 XMQs and MS

(Total: 49 marks)

1. P32(AS)_2018 Q9 . 9 marks - Y1M10 Forces and motion

2. P32(AS)_2019 Q2 . 12 marks - Y1M10 Forces and motion

3. P32(AS)_2020 Q2 . 9 marks - Y1M10 Forces and motion

4. P32(AS)_2021 Q3 . 13 marks - Y1M10 Forces and motion

5. P32(AS)_2022 Q4 . 6 marks - Y1M10 Forces and motion

9.

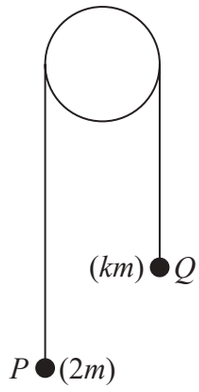

Figure 1

Two small balls, P and Q, have masses $2m$ and km respectively, where $k < 2$.
The balls are attached to the ends of a string that passes over a fixed pulley.
The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

The system is released from rest and, in the subsequent motion, P moves downwards with an acceleration of magnitude $\frac{5g}{7}$

The balls are modelled as particles moving freely.
The string is modelled as being light and inextensible.
The pulley is modelled as being small and smooth.

Using the model,

(a) find, in terms of m and g, the tension in the string,

(3)

(b) explain why the acceleration of Q also has magnitude $\frac{5g}{7}$

(1)

(c) find the value of k.

(4)

(d) Identify one limitation of the model that will affect the accuracy of your answer to part (c).

(1)

Question	Scheme	Marks	AOs
9(a)	Equation of motion for *P*	M1	3.3
	$2mg - T = 2m \times \frac{5g}{7}$	A1	1.1b
	$T = \frac{4mg}{7}$	A1	1.1b
		(3)	
(b)	Since the string is modelled as being inextensible	B1	3.4
		(1)	
(c)	Equation of motion for *Q* **OR** for whole system	M1	3.3
	$T - kmg = km \times \frac{5g}{7}$ **OR** $2mg - kmg = (km + 2m)\frac{5g}{7}$	A1	1.1b
	$\frac{4mg}{7} - kmg = km \times \frac{5g}{7}$ oe and solve for *k*	DM1	1.1b
	$k = \frac{1}{3}$ or 0.333 or better	A1	1.1b
		(4)	
(d)	e.g The model does not take account of the mass of the string (SEE BELOW for alternatives)	B1	3.5b
		(1)	
		(9 marks)	

Notes: Condone both equations of motion appearing in (a) if used in (c)

(a)

M1: Resolving vertically for *P* with usual rules, correct no. of terms but condone sign errors and *a* does not need to be substituted (N.B. inconsistent omission of *m* is M0). Allow *ma* on RHS for M1

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

A1: A correct answer of form *cmg*, where *c* = $\frac{4}{7}$ oe or 0.57 or better

(b)

B1: String is inextensible. N.B. B0 if any extras (wrong or irrelevant) given

(c)

M1: Resolving vertically for *Q* or for a whole system equation, with usual rules, correct no. of terms but condone sign errors and neither *T* nor *a* does need to be substituted

(N.B. inconsistent omission of *m* is M0 and M0 if *k* is omitted from LHS or RHS or both.)

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

DM1: Sub for *T* using their answer from (a), if necessary, and solve to give a numerical value of *k* (i.e. *m*'s must cancel)

A1: $k = \frac{1}{3}$ or 0.333 or better.

(d)

B1: e.g. Pulley may not be smooth

Pulley may not be light

Particles may not be moving freely e.g. air resistance

Balls may not be particles

String may not be light

String may not be inextensible

(but allow converses in all cases e.g. 'pulley smooth')

N.B. B0 if any extra incorrect answer is given BUT ignore incorrect consequence of a correct answer.

Also note: B0 : Use of a more accurate value of *g*

2.

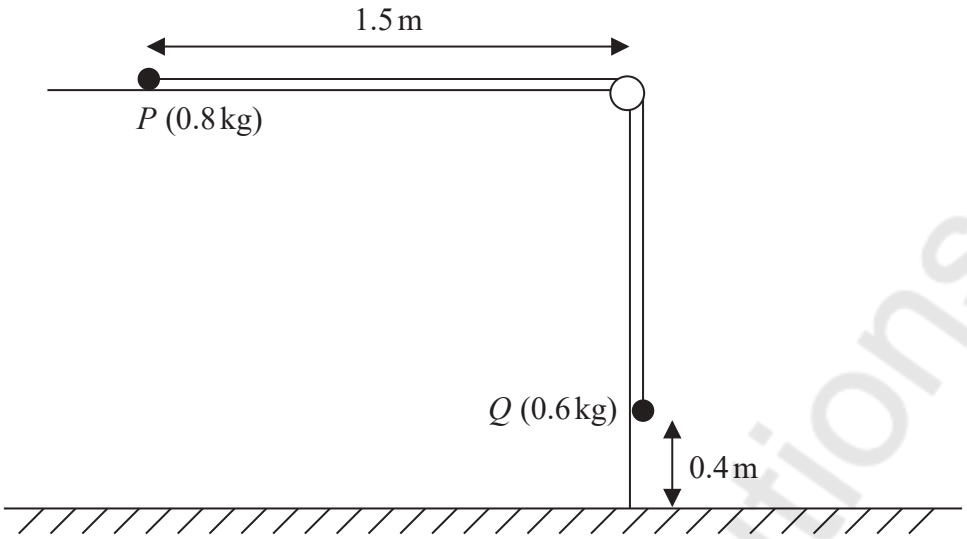

Figure 1

A small ball, P, of mass 0.8 kg, is held at rest on a smooth horizontal table and is attached to one end of a thin rope.

The rope passes over a pulley that is fixed at the edge of the table.

The other end of the rope is attached to another small ball, Q, of mass 0.6 kg, that hangs freely below the pulley.

Ball P is released from rest, with the rope taut, with P at a distance of 1.5 m from the pulley and with Q at a height of 0.4 m above the horizontal floor, as shown in Figure 1.

Ball Q descends, hits the floor and does not rebound.

The balls are modelled as particles, the rope as a light and inextensible string and the pulley as small and smooth.

Using this model,

(a) show that the acceleration of Q, as it falls, is $4.2\,\text{m s}^{-2}$

(5)

(b) find the time taken by P to hit the pulley from the instant when P is released.

(6)

(c) State one limitation of the model that will affect the accuracy of your answer to part (a).

(1)

N.B. Omission or extra g in a resolution is an accuracy error not a method error

In 2(a), use the mass which appears in the '*ma*' term of an equation of motion, to identify which particle that equation of motion applies to.

Question	Scheme	Marks	AOs	Notes
2(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	1.1b	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	1.1b	A correct equation
	$a = 4.2$ (m s^{-2}) *	A1*	2.2a	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	1.1b	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	1.1b	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	3.1b	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	1.1b	
		(6)		
(c)	e.g. rope being light; rope being inextensible; pulley being smooth; pulley being small; balls being particles	B1	3.5b	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)		

2.

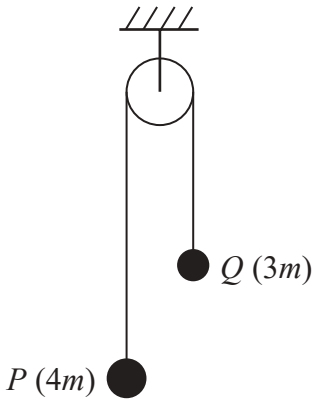

Figure 1

One end of a string is attached to a small ball P of mass $4m$.

The other end of the string is attached to another small ball Q of mass $3m$.

The string passes over a fixed pulley.

Ball P is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

Ball P is released.

The string is modelled as being light and inextensible, the balls are modelled as particles, the pulley is modelled as being smooth and air resistance is ignored.

(a) Using the model, find, in terms of m and g, the magnitude of the force exerted on the pulley by the string while P is falling and before Q hits the pulley.

(8)

(b) State one limitation of the model, apart from ignoring air resistance, that will affect the accuracy of your answer to part (a).

(1)

Question	Scheme	Marks	AOs
2(a)	Equation of motion for P with usual rules	M1	3.3
	$4mg - T = 4ma$	A1	1.1b
	Equation of motion for Q with usual rules	M1	3.3
	$T - 3mg = 3ma$	A1	1.1b
	Solve these equations for T (does not need to be in terms of mg)	M1	1.1b
	$T = \frac{24mg}{7}$ in any form (does not need to be a single term)	A1	1.1b
	Force on pulley = $2T$	M1	3.4
	$\frac{48mg}{7}$ Accept $6.9mg$ or better	A1	1.1b
		(8)	
2(b)	Weight of the rope or extensibility of rope Or: pulley may not be smooth	B1	3.5b
		(1)	
			(9 marks)

Notes:

(a)	M1	Translate situation into the model and set up the equation of motion for P M0 if they omit m's i.e. $4g - T = 4a$
	A1	Correct equation
	M1	Translate situation into the model and set up the equation of motion for Q M0 if they omit m's i.e. $T - 3g = 3a$
	A1	Correct equation
		N.B. Condone either of the above equations being replaced by the 'whole system equation': $4mg - 3mg = 7ma$ (N.B. $a = g/7$) **N.B.** a replaced by $-a$ consistently can score all the marks
	M1	Solve equations for T
	A1	$T = \frac{24mg}{7}$ oe
	M1	T does not need to be substituted.
	A1	$\frac{48mg}{7}$ oe <u>Must be in terms of m and g</u> and be a single term
(b)	B1	B0 if any incorrect extras are given

3.

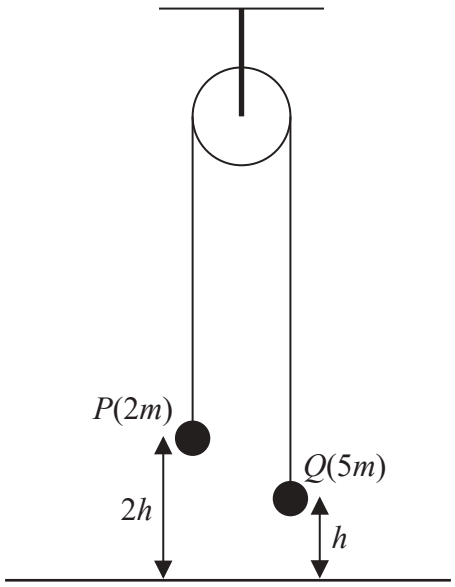

Figure 1

A ball P of mass $2m$ is attached to one end of a string.

The other end of the string is attached to a ball Q of mass $5m$.

The string passes over a fixed pulley.

The system is held at rest with the balls hanging freely and the string taut.

The hanging parts of the string are vertical with P at a height $2h$ above horizontal ground and with Q at a height h above the ground, as shown in Figure 1.

The system is released from rest.

In the subsequent motion, Q does not rebound when it hits the ground and P does not hit the pulley.

The balls are modelled as particles.

The string is modelled as being light and inextensible.

The pulley is modelled as being small and smooth.

Air resistance is modelled as being negligible.

Using this model,

(a) (i) write down an equation of motion for P,

(ii) write down an equation of motion for Q,

(4)

(b) find, in terms of h only, the height above the ground at which P first comes to instantaneous rest.

(7)

(c) State one limitation of modelling the balls as particles that could affect your answer to part (b).

(1)

In reality, the string will not be inextensible.

(d) State how this would affect the accelerations of the particles.

(1)

Question	Scheme	Marks	AOs
3(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)**	
3(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)	
3(c)	e.g. The distance that Q falls to the ground would not be exactly h oe	B1	3.5b
		(1)	
3(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:

3a	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
3b	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 3.4*h* or better
3c	B1	B0 if any incorrect extras are given
3d	B1	B0 if any incorrect extras are given or for an incorrect statement e.g. tension is not constant so accelerations will be different

4.

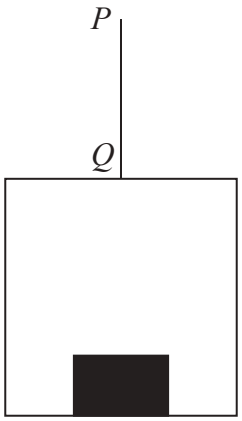

Figure 1

A vertical rope PQ has its end Q attached to the top of a small lift cage.

The lift cage has mass 40 kg and carries a block of mass 10 kg, as shown in Figure 1.

The lift cage is raised vertically by moving the end P of the rope vertically upwards with constant acceleration $0.2\,\text{m s}^{-2}$

The rope is modelled as being light and inextensible and air resistance is ignored.

Using the model,

(a) find the tension in the rope PQ

(3)

(b) find the magnitude of the force exerted on the block by the lift cage.

(3)

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.		
4(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

4a	M1	Correct number of terms, condone sign errors
	A1	Correct equation in T only
	A1	cao
4b	M1	Correct number of terms, condone sign errors
	A1	Correct equation in R only
	A1	cao