Connected particles F=ma As level Edexcel Mechanics Maths Past Papers Answers

01.

Question	Scheme	Marks	AOs
☐	Uses $\sin^2 x = 1-\cos^2 x \Rightarrow 12(1-\cos^2 x)+7\cos x-13=0$	M1	3.1a
	$\Rightarrow 12\cos^2 x-7\cos x+1=0$	A1	1.1b
	Uses solution of quadratic to give $\cos x =$	M1	1.1b
	Uses inverse cosine on their values, giving two correct follow through values (see note)	M1	1.1b
	$\Rightarrow x =$ 430.5°, 435.5°	A1	1.1b
			(5 marks)

Notes

M1: Uses correct identity
A1: Correct three term quadratic
M1: Solves their three term quadratic to give values for $\cos x$ – (The correct answers are $\cos x = \frac{1}{3}$ or $\frac{1}{4}$ but this is not necessary for this method mark)
M1: Uses inverse cosine on their values, giving two correct follow through values - may be outside the given domain
A1: Two correct answers in the given domain

02.

Question	Scheme	Marks	AOs
a	Equation of motion for P	M1	3.3
	$2mg - T = 2m \leftrightarrow \frac{5g}{7}$	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
	$T - kmg = km \leftrightarrow \frac{5g}{7}$ **OR** $2mg - kmg = (km + 2m)\frac{5g}{7}$	A1	1.1b
	$\frac{4mg}{7} - kmg = km \leftrightarrow \frac{5g}{7}$ 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

03.

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	1.1b	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)
	$t_1 = 0.436 (4357.....)$ 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 $0.4 = \frac{(0+v)}{2} \times t_1$ $(v = 1.8330...)$	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 $t_1 + t_2$	DM1	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)		

04.

Question	Scheme	Marks	AOs
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)	
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 Must be in terms of m and g and be a single term
(b)	B1	B0 if any incorrect extras are given

05.

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

06.

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

07.

Question	Scheme	Marks	AOs
a	Equation of motion for the car	M1	3.3
	$7400-2R-2400=1200a$	A1	1.1b
	Equation of motion for the trailer	M1	3.4
	$2400-R=400a$	A1	1.1b
	$a=0.5$	A1	1.1b
		(5)	
	N.B. Either equation could be replaced by: Equation of motion for the whole system $7400-3R=1600a$		
b	The value of a_1 would be less than the value of a. Allow 'a_1 would be slower than a', **N.B.** Allow 'it would be less than a'	B1	3.5a
		(1)	
c	The resistance won't be constant or just 'it won't be constant.' Allow the negative also: The resistance is constant or just 'it is constant' B0 for 'it doesn't take account of air resistance'	B1	3.5b
		(1)	
			(7 marks)

Notes:		
a		**N.B. When entering marks on ePEN for the two equations of motion, enter them in the order in which they appear on the script.** For any equation of motion, use the mass in the '*ma*' term to determine to which part of the system it relates.
	M1	Correct no.of terms and condone sign errors, with the driving force as 7400 (when appropriate) and the tension as 2400.
	A1	Correct equation
	M1	Correct no.of terms and condone sign errors, with the driving force as 7400 (when appropriate) and the tension as 2400.
	A1	Correct equation
	A1	cao
b	B1	cao
c	B1	B0 if any incorrect extras are given or for an incorrect statement