Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Monday 21 January 2019

Afternoon (Time: 1 hour 30 minutes) | Paper Reference **WME01/01**

Mechanics M1

Advanced/Advanced Subsidiary

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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Pearson

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1. Two particles, A and B, have masses $2m$ and $3m$ respectively. They are moving towards each other in opposite directions along the same straight line on a smooth horizontal plane when they collide directly. Immediately before they collide, the speed of A is $3u$ and the speed of B is u. As a result of the collision, the speed of A is halved and the direction of motion of each particle is reversed.

(i) Find the speed of B immediately after the collision.

(ii) Find the magnitude of the impulse exerted on A by B in the collision.

(6)

Question Number	Scheme	Marks
1(i)	$6mu - 3mu = -2m.\frac{3u}{2} + 3mv$ $v = 2u$	M1 A1 A1
(ii)	$I = \pm 2m(\frac{3u}{2} - -3u)$ Magnitude $= 9mu$ **OR**: $I = \pm 3m(2u - -u)$ Magnitude $= 9mu$	M1 A1 A1 M1 A1 A1 **6**
	Notes	
1(i)	M1 for CLM with correct no. of terms to give an equation in one unknown. Allow consistent extra g's and/or cancelled m's. Condone sign errors (They may obtain this equation by finding the impulse on each and eliminating the impulse – apply the *same* criteria, including condone sign errors)	
	First A1 for a correct unsimplified equation. Allow: $6mu - 3mu = -2m.\frac{3u}{2} - 3mv$	
	Second A1 for $2u$ (must be positive) (**N.B.** If all terms in the CLM are given the same sign, this leads to $2u$ M1A0A0)	
(ii)	M1 for dimensionally correct Impulse-momentum equation with consistent use of $2m$ or $3m$ (i.e. M0 if g included or m omitted.) **N.B**. Mark the actual equation not the formula (some candidates use $I = m(v+u)$ when the direction has been reversed)	
	First A1 for a correct unsimplified equation	
	Second A1 for $9mu$ (must be positive)	

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2. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given relative to a fixed origin O.*]

At time $t = 0$, a bird A leaves its nest, that is located at the point with position vector $(20\mathbf{i} - 17\mathbf{j})$ m, and flies with constant velocity $(-6\mathbf{i} + 7\mathbf{j})\,\text{m s}^{-1}$. At the same time a second bird B leaves its nest which is located at the point with position vector $(-8\mathbf{i} + 9\mathbf{j})$ m and flies with constant velocity $(p\mathbf{i} + 2p\mathbf{j})\,\text{m s}^{-1}$, where p is a constant. At time $t = 4$ s, bird B is south west of bird A.

(a) Find the direction of motion of A, giving your answer as a bearing to the nearest degree.

(3)

(b) Find the speed of B.

(10)

Question Number	Scheme	Marks
2(a)	$\tan\theta = \frac{6}{7}$ $\theta = 40.60°...$ Bearing is $360° - 40.60° = 319°$ nearest degree	M1 A1 A1 (3)
(b)	$\mathbf{r}_A = (20\mathbf{i} - 17\mathbf{j}) + 4(-6\mathbf{i} + 7\mathbf{j}) = (-4\mathbf{i} + 11\mathbf{j})$ $\mathbf{r}_B = (-8\mathbf{i} + 9\mathbf{j}) + 4(p\mathbf{i} + 2p\mathbf{j}) = (-8 + 4p)\mathbf{i} + (9 + 8p)\mathbf{j}$ $\mathbf{r}_A - \mathbf{r}_B = (4 - 4p)\mathbf{i} + (2 - 8p)\mathbf{j}$ $-8 + 4p - -4 = 9 + 8p - 11$ $p = -0.5$ $\mathbf{v}_B = (-0.5\mathbf{i} - \mathbf{j})$ $\lvert\mathbf{v}_B\rvert = \sqrt{(-0.5)^2 + (-1)^2}$ $= \frac{\sqrt{5}}{2} = 1.1 \text{ ms}^{-1}$ or better	M1 A1 A1 **DM**1 M1 A1 A1 M1 M1 A1 (10) **13**
	Notes	
2(a)	M1 for any trig ratio using 6 and 7: $\tan\theta = \pm\frac{6}{7}$ or $\pm\frac{7}{6}$: $\sin\theta$ or $\cos\theta = \pm\frac{6}{\sqrt{6^2+7^2}}$ or $\pm\frac{7}{\sqrt{6^2+7^2}}$	
	A1 for a correct angle from their *correct* equation e.g. 49°, 41°, 139°, 131°,….	
	A1 for 319° cao	
2(b)	First M1 for attempt at use of $\mathbf{r}_4 = \mathbf{r}_0 + 4\mathbf{v}$ for either *A* or *B*	
	First A1 for $(-4\mathbf{i} + 11\mathbf{j})$ **i**'s and **j**'s must be collected at some stage	
	Second A1 for $(-8 + 4p)\mathbf{i} + (9 + 8p)\mathbf{j}$ **i**'s and **j**'s must be collected at some stage	
	Second **DM**1, dependent on first M1, for finding the difference between their two $\mathbf{r}_4$ vectors (must be an attempt to subtract both **i** and **j** components)	
	Third M1 for equating the **i** cpt and **j** cpt of their difference (M0 if no difference) to give an equation in *p only*. oe e.g. $\frac{(4-4p)}{(2-8p)} = \frac{(-)1}{(-)1}$	
	Third A1 for a correct equation in *p* only	
	Fourth A1 for a correct value of *p*	
	Fourth M1 for using their *p* value to obtain a velocity vector for *B*	
	Fifth M1 for finding the magnitude of their $\mathbf{v}_B$ (**N.B.** This M mark is available, even if their $\mathbf{v}_B$ does not have the correct form)	
	Fifth A1 for $\frac{\sqrt{5}}{2}$ oe or 1.1 or better	

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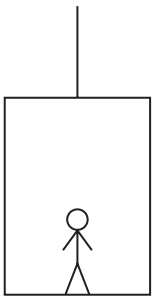

Figure 1

A lift of mass M kg is being raised by a vertical cable attached to the top of the lift. A person of mass m kg stands on the floor inside the lift, as shown in Figure 1. The lift ascends vertically with constant acceleration $1.4\,\text{m}\,\text{s}^{-2}$. The tension in the cable is 2800 N and the person experiences a constant normal reaction of magnitude 560 N from the floor of the lift. The cable is modelled as being light and inextensible, the person is modelled as a particle and air resistance is negligible.

(a) Write down an equation of motion for the person only.

(2)

(b) Write down an equation of motion for the lift only.

(2)

(c) Hence, or otherwise, find

(i) the value of m,

(ii) the value of M.

(3)

Question Number	Scheme	Marks
3(a)	$560 - mg = 1.4m$	M1 A1 (2)
(b)	$2800 - Mg - 560 = 1.4M$	M1 A1 (2)
(c) (i)	$560 = 11.2m$	**DM**1
	$m = 50$	A1
(ii)	$2240 = 11.2M$	A1
	$M = 200$	A1 (3) **7**
	Notes	
(a)	M1 for equation of motion for the person only, with usual rules, condone sign errors, and with at least one value (560 or 1.4) substituted. *Credit given for this equation only if it appears in (a).*	
	A1 for a correct equation	
(b)	M1 for equation of motion for the lift only, with usual rules, condone sign errors, and with at least one value (2800, 560 or 1.4) substituted. *Credit given for this equation only if it appears in (b).*	
	A1 for a correct equation	
(c)	**Hence**: DM1, dependent on appropriate previous M mark, for solving one of their equations, wherever it appears, for either *m* or *M* **Otherwise**: DM1, dependent on appropriate previous M mark, for solving one of their equations and/or the whole system equation, wherever they appear, for either *m* or *M* **N.B.** There are no marks available for the whole system equation	
	First A1 for $m = 50$	
	Second A1 for $M = 200$	

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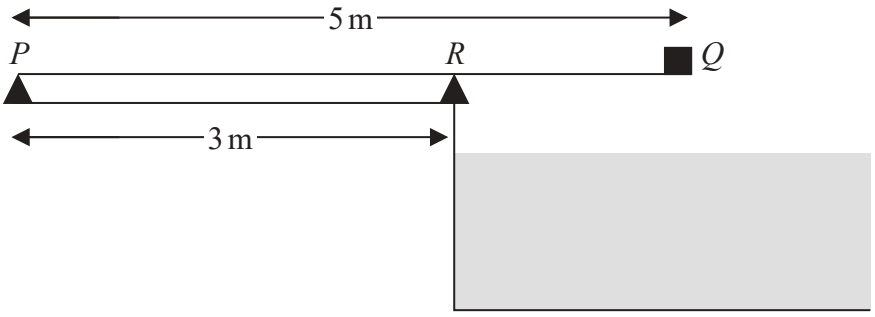

Figure 2

A boy sees a box on the end Q of a plank PQ which overhangs a swimming pool. The plank has mass 30 kg, is 5 m long and rests in a horizontal position on two bricks. The bricks are modelled as smooth supports, one acting on the rod at P and one acting on the rod at R, where $PR = 3$ m. The support at R is on the edge of the swimming pool, as shown in Figure 2. The boy has mass 40 kg and the box has mass 2.5 kg. The plank is modelled as a uniform rod and the boy and the box are modelled as particles.

The boy steps on to the plank at P and begins to walk slowly along the plank towards the box.

(a) Find the distance he can walk along the plank from P before the plank starts to tilt.

(4)

(b) State how you have used, in your working, the fact that the box is modelled as a particle.

(1)

A rock of mass M kg is placed on the plank at P. The boy is then able to walk slowly along the plank to the box at the end Q without the plank tilting. The rock is modelled as a particle.

(c) Find the smallest possible value of M.

(4)

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Question Number	Scheme	Marks
4(a)	$M(R),\ 40g(x-3)+2.5g\times 2=30g\times 0.5$ $x=3.25$ m from P	M1 A2 A1 (4)
(b)	Mass of the box is concentrated at the point Q oe	B1 (1)
(c)	$M(R),\ 3Mg\ +\ 30g\times 0.5=2.5g\times 2+40g\times 2$ $M=\frac{70}{3}$, 23 or better	M1 A2 A1 (4) **9**
	Notes	
4(a)	M1 for moments about *R* to give an equation in *x* (or another unknown distance) *only* (i.e. M0 if reaction at *P* is non-zero) Correct no. of terms, dimensionally correct	
	A2 for a correct equation in *x only* (allow consistent omission of *g*) -1 each error	
	Alternative: Instead of $M(R)$, they may write down 2 equations and eliminate the normal reaction at *R*, N_R, to obtain an equation in a distance *only* : Possible equations: $(\uparrow)N_R=40g+30g+2.5g$ $M(P),40gx+30g\times 2.5+2.5g\times 5=3N_R$ $M(Q),40g(5-x)+30g\times 2.5=2N_R$ $M(G),40g(2.5-x)+0.5N_R=2.5g\times 2.5$ Equations must have correct no. of terms and be dimensionally correct but M0 if reaction at *P* is non-zero	
	Third A1 for $\frac{13}{4}$ m oe Allow 3.3 m	
(b)	B1 for *mass* or *weigh*t of box acts at Q but B0 if extra wrong answers	
(c)	M1 for moments about *R* to give an equation in *M only* (i.e. M0 if reaction at *P* is non-zero) Correct no. of terms, dimensionally correct	
	A2 for a correct equation in *M only* (allow consistent omission of *g*) -1 each error	
	Alternative: Instead of $M(R)$, they may write down 2 equations and eliminate the normal reaction at *R*, S_R , to obtain an equation in *M only* : Possible equations: $(\uparrow)S_R=40g+30g+2.5g+Mg$ $M(P),42.5g\times 5+30g\times 2.5=3S_R$ $M(Q),Mg\times 5+30g\times 2.5=2S_R$ $M(G),Mg\times 2.5+0.5S_R=42.5g\times 2.5$ Equations must have correct no. of terms and be dimensionally correct but M0 if reaction at *P* is non-zero	
	Third A1 for $\frac{70}{3}$ oe or 23 or better Accept 24	

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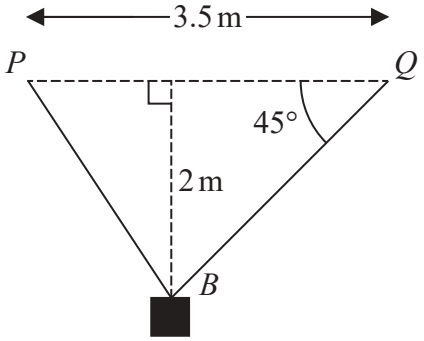

Figure 3

A small metal box of mass 6 kg is attached at B to two ropes BP and BQ. The fixed points P and Q are on a horizontal ceiling and $PQ = 3.5$ m. The box hangs in equilibrium at a vertical distance of 2 m below the line PQ, with the ropes in a vertical plane and with angle $BQP = 45°$, as shown in Figure 3. The box is modelled as a particle and the ropes are modelled as light inextensible strings. Find

(i) the tension in BP,

(ii) the tension in BQ.

(10)

Question Number	Scheme	Marks
5.	$PM = 3.5 - 2\tan 45^o = 1.5$ OR $PB = \sqrt{3.5^2 + (\frac{2}{\sin 45})^2 - 2\times 3.5\times(\frac{2}{\sin 45})\cos 45^o} = 2.5$	M1
	$\tan\alpha = \frac{1.5}{2}; \cos\alpha = \frac{4}{5}; \sin\alpha = \frac{3}{5}$	A1
	OR $\alpha = 37^o$ *or* $(90^o - \alpha) = 53^o$ (at least 2SF)	
	$T_P\cos\alpha + T_Q\cos 45^o = 6g$	M1 A2 -1 ee
	$T_P\sin\alpha = T_Q\cos 45^o$	M1 A1
	$T_P = \frac{30g}{7} = 42$ N; $T_Q = 36$ or 35.6 N	**DM1** A1; A1
		10
	Notes	
	First M1 for finding the length of *PM* or *PB*	
	First A1 for a correct trig ratio for α or $(90^o - \alpha)$ or a correct value for α or $(90^o - \alpha)$ Do not penalise accuracy here if their final answers for the tensions are correct.	
	N.B. If they assume the tensions are the same , no further marks available If they think α = 30 or 60 or....., they could get all 5 resolving marks as a value of α is not required **but if α = 45, only M marks available.** However, if α and 45 are interchanged in the resolving equations - no marks available for resolving	
	Second M1 for resolving vertically with usual rules	
	Second/Third A1's for a correct equation, (α does not need to be substituted) -1 each error	
	Third M1 for resolving horizontally with usual rules	
	Fourth A1 for a correct equation (α does not need to be substituted but if it is , follow through on their value)	
	Fourth DM1, dependent on all **THREE** previous M marks, for solving for either tension	
	Fifth A1 for T_P Allow 42.0 Units not needed	
	Sixth A1 for T_Q Units not needed	
	Alternative, using Triangle of Forces/Lami's Theorem, for middle 5 marks.	
	$\frac{T_P}{\sin 45^o} = \frac{6g}{\sin(45^o + \alpha)}$ OR $\frac{T_Q}{\sin(180^o - \alpha)} = \frac{6g}{\sin(45^o + \alpha)}$	M1 A2 -1 ee
	$\frac{T_Q}{\sin(180^o - \alpha)} = \frac{6g}{\sin(45^o + \alpha)}$ OR $\frac{T_P}{\sin 45^o} = \frac{6g}{\sin(45^o + \alpha)}$ OR $\frac{T_P}{\sin 45^o} = \frac{T_Q}{\sin(180^o - \alpha)}$	M1 A1
	N.B. Treat omission of *g* as one error	

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6. A train travels for a total of 270 s along a straight horizontal track between two stations A and B. The train starts from rest at A and moves with constant acceleration for 60 s until it reaches a speed of V m s^{-1}. The train then travels at this constant speed V m s^{-1} before it moves with constant deceleration for 30 s, coming to rest at B.

(a) Sketch below a speed-time graph for the journey of the train between the two stations A and B.

(2)

Given that the distance between the two stations is 4.5 km,

(b) find the value of V,

(3)

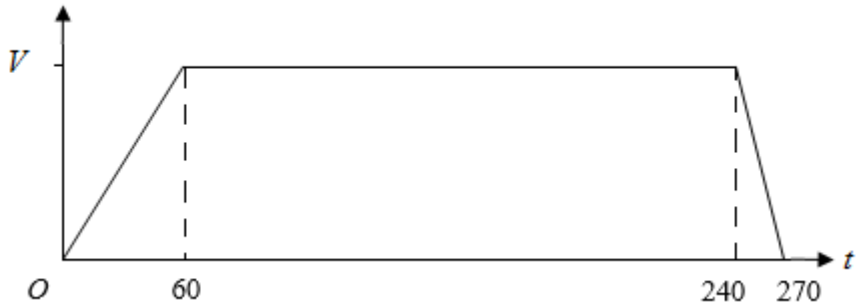
(c) find how long it takes the train to travel from station A to the point that is exactly halfway between the two stations.

(4)

The train is travelling at speed $\frac{1}{4}V$ m s^{-1} at times T_1 seconds and T_2 seconds after leaving station A.

(d) Find the value of T_1 and the value of T_2

(5)

Question Number	Scheme	Marks
6(a)		B1 Shape B1 Figs. and V (2)
(b)	$4500 = \frac{(270+180)}{2}V$ OR $4500 = \frac{1}{2}60V + 180V + \frac{1}{2}30V$ $V = 20$	M1 A1 A1 (3)
(c)	$\frac{(T+T-60)}{2} \times 20 = 2250$ OR $\frac{1}{2}60.20 + (T-60).20 = 2250$ $T = 142.5$ s	M1 A2 **ft** A1 (4)
(d)	$T_1 = \frac{1}{4} \times 60$ $= 15$ $T_2 = 270 - \left(\frac{1}{4} \times 30\right)$ OR $240 + \left(\frac{3}{4} \times 30\right)$ $= 262.5$	M1 A1 M1 A1 A1 (5) **14**
	Notes	
6(a)	First B1 for a trapezium (not to scale) starting and finishing on the t-axis but B0 if solid vertical lines included	
	Second B1 for 3 figs. (60, 270 and use of 30 with a delineator or 240) and V. 270 can be implied by 3 correct delineators	
6(b)	M1 for a complete method to produce an equation, in V only, with the correct structure i.e. one trapezium or two triangles + rectangle or triangle + trapezium or trapezium + triangle or rectangle – two triangles = 4500 (allow 4.5 for the M mark) (M0 if a single *suvat* equation is used)	
	First A1 for a correct unsimplified equation	
	Second A1 for $V = 20$	
6(c)	M1 for a complete method to produce an equation, in *ONE* variable e.g. t where $t = (T - 60)$, with the correct structure i.e. one trapezium or triangle + rectangle or rectangle – triangle = 2250 (allow 2.25 for the M mark) (M0 if a single *suvat* equation is used)	
	First and second A1's for a correct unsimplified equation **ft on their 20** -1 each error	
	Third A1 for 142.5 (s) cao Accept 143.	
6(d)	First M1 for a complete method to give an equation in T_1 *only*	

	First A1 for 15 (independent of V so allow even if their V is wrong)	
	Second M1 for a complete method to give an equation in T_2 *only*	
	Second A1 for a correct equation	
	Third A1 for 262.5 (independent of V so allow even if their V is wrong) **Accept 263**	
	N.B. Accept $T_1 = 262.5$ and $T_2 = 15$	

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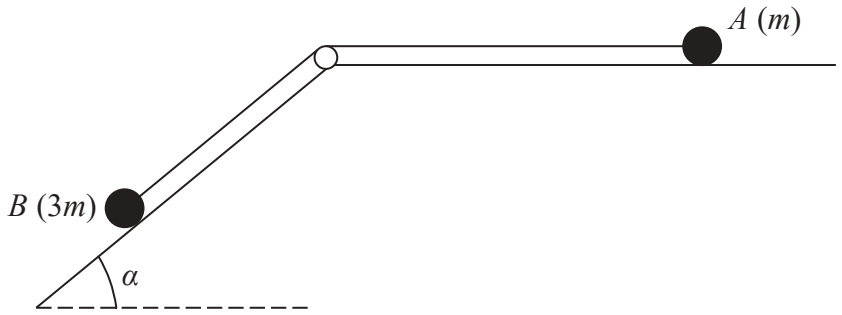

Figure 4

Two particles A and B have masses m and $3m$ respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a rough horizontal table. The coefficient of friction between particle A and the table is $\frac{1}{5}$. The string lies along the table and passes over a small smooth light pulley that is fixed at the edge of the table. Particle B is at rest on a rough plane that is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{4}{3}$, as shown in Figure 4. The coefficient of friction between particle B and the inclined plane is $\frac{1}{3}$. The string lies in the vertical plane that contains the pulley and a line of greatest slope of the inclined plane. The system is released from rest with the string taut and B slides down the inclined plane. Given that A does not reach the pulley,

(a) find the tension in the string,

(11)

(b) state where in your working you have used the fact that the string is modelled as being light,

(1)

(c) find the magnitude of the force exerted on the pulley by the string.

(4)

Question Number	Scheme	Marks
7(a)	For B, $S = 3mg\cos\alpha$ For B, $3mg\sin\alpha - T - F_1 = 3ma$ For A, $R = mg$ For A, $T - F_2 = ma$ $F_1 = \frac{1}{3}S$; $F_2 = \frac{1}{5}R$ Solving for T $T = \frac{3mg}{5}$ or $5.88m$	M1 A1 M1 A2 B1 M1 A1 M1 **DM**1 A1 (11)
(b)	Constant tension throughout the string.	B1 (1)
(c)	$R = 2T\cos\frac{(180^o - \alpha)}{2}$ $(= 2T\sin\frac{1}{2}\alpha)$ $(2T\cos 63.4^o)$ $= 2\times\frac{3mg}{5}\times\frac{\sqrt{5}}{5}$ $= \frac{6mg\sqrt{5}}{25}$ $(5.3m$ or $5.26m)$ **OR:** $R = \sqrt{(T - T\cos\alpha)^2 + (T\sin\alpha)^2}$ or $R = \sqrt{(T^2 + T^2 - 2T^2\cos\alpha}$ Substitute their expression for T (MUST be in terms of m) and a correct value of α $= \frac{6mg\sqrt{5}}{25}$ $(5.3m$ or $5.26m)$	M1 A1 DM1 A1 (4) **16** M1A1 DM1 A1
	Notes	
	N.B. Use of sin(4/5) or similar, treat as an A error but allow recovery	
7(a)	First M1 for resolving perp to the plane , with usual rules	
	First A1 for a correct equation	
	Second M1 for equation of motion parallel to the inclined plane, with usual rules	
	Second and Third A1's for a correct equation -1 each error	
	B1 cao	
	Third M1 for equation of motion horizontally, with usual rules	
	Fourth A1 for a correct equation	
	Fourth M1 for using '$F = \mu R$' correctly twice	
	Fifth DM1, dependent on all M marks, for solving for T in terms of *m only*	
	Fifth A1 cao	
	N.B. Either equation of motion can be replaced by the whole system equation: $3mg\sin\alpha - F_1 - F_2 = 4ma$ (M1A2 or M1A1 as appropriate)	
(b)	Penalise extra wrong answers	
(c)	First M1 for attempt at correct expression for R in terms of T and α with usual rules i.e. condone cos/sin confusion but must be using the correct angle (can be in terms of α)	

	Special Case: Allow max M1A1DM0A0 if *m* is lost from their *T* but expression for *R* is otherwise correct.	
	First A1 for a correct expression for R in terms of T and α	
	Second DM1 for substituting in their expression for T and a correct value for α but must be in terms of m	
	Second A1 for a correct answer (any equivalent surd form)	