Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Wednesday 24 October 2018

Morning (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.

Turn over ▶

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1. A particle P of mass 0.8 kg is moving along a straight horizontal line on a smooth hoizontal surface with speed $4\,\text{m s}^{-1}$. A second particle Q of mass 2 kg is moving, in the opposite direction to P, along the same straight line with speed $2\,\text{m s}^{-1}$. The particles collide directly. Immediately after the collision the direction of motion of each particle is reversed and the speed of P is $2.5\,\text{m s}^{-1}$.

(a) Find the speed of Q immediately after the collision.

(3)

(b) Find the magnitude of the impulse exerted by Q on P in the collision, stating the units of your answer.

(3)

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Question Number	Scheme	Marks
1(a)	$0.8\times4-2\times2=2v-0.8\times2.5$	M1A1
	$v=0.6$ m s^{-1}	A1 (3)
(b)	$I=0.8(4+2.5)=5.2$, Ns or kg m s^{-1}	M1A1,B1 (3)
	OR: $I=2(0.6+2)=5.2$, Ns or kg m s^{-1}	M1A1,B1 **[6]**
	Notes for qu 1	
1a	M1 for CLM, correct no. of terms, dim correct, condone extra g's throughout and sign errors, in one unknown, with correct pairings of mass and velocity. N.B. Apply <u>same</u> criteria to an equation that has been found by eliminating the impulse from two imp-mom equations.	
	First A1 for a correct equation (condone extra g's)	
	Second A1 for 0.6 (Must be positive)	
1b	M1 for Impulse – Momentum equation for either particle, correct no. of terms, with correct velocities, condone sign errors N.B. Mark the actual equation not the formula (some candidates use $I=m(v+u)$ when the direction has been reversed)	
	M0 if g included on momentum terms	
	A1 for 5.2 (Must be positive)	
	B1 for Ns or kg m s^{-1} **N.B.** M0A0B1 is possible	

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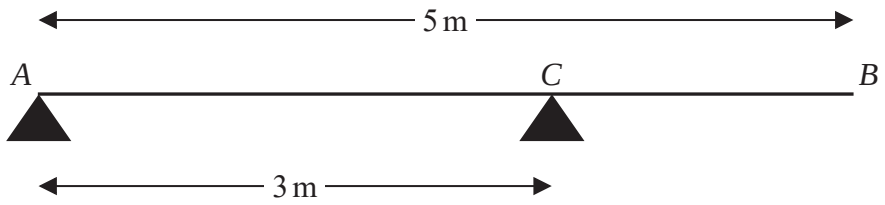

Figure 1

A non-uniform plank AB has weight 60 N and length 5 m. The plank rests horizontally in equilibrium on two smooth supports at A and C, where $AC = 3$ m, as shown in Figure 1. A parcel of weight 12 N is placed on the plank at B and the plank remains horizontal and in equilibrium. The magnitude of the reaction of the support at A on the plank is half the magnitude of the reaction of the support at C on the plank.

By modelling the plank as a non-uniform rod and the parcel as a particle,

(a) find the distance of the centre of mass of the plank from A.

(6)

(b) State briefly how you have used the modelling assumption

(i) that the parcel is a particle,

(ii) that the plank is a rod.

(2)

Question Number	Scheme	Marks
2(a)	**N.B.** Consistent use of extra *g*'s in **two** equations can score the A marks for the equations and could score full marks for part (a). **N.B.** If they assume that the rod is uniform, can only score marks for a vertical resolution. $\text{R}(\uparrow)$: $0.5R_C + R_C = 60 + 12$ (N.B. $R_A = \frac{1}{2}R_C$)	M1A1
	Possible moments equations: $\text{M}(A)$: $60x + (12\times 5) = R_C \times 3$ $\text{M}(B)$: $(2\times R_C) + \left(\frac{1}{2}R_C \times 5\right) = 60(5-x)$ $\text{M}(C)$: $(\frac{1}{2}R_C \times 3) + (12\times 2) = 60(3-x)$ $\text{M}(G)$: $12(5-x) + \frac{1}{2}R_C x = R_C(3-x)$	M1A1
	Eliminate R_C and solve for x (AG) $x = 1.4$ m	**DM1** A1 (6)
(b)	(i) the weight of the parcel acts at B (ii) the plank remains straight (or equivalent statements)	B1 B1 (2) **[8]**
	Notes for qu 2	
	N.B. If R and $\frac{1}{2}R$ are reversed, max score is M1A1 (resolution) M1A0 (moments)	
2a	First M1 for first equation, correct no. of terms, dim correct, condone sign errors and allow R and S at this stage and for moments equations allow a different length variable	
	First A1 for a correct resolution in one unknown or moments equation in two unknowns	
	Second M1 for second equation, correct no. of terms, dim correct, condone sign errors and allow R and S at this stage and for moments equations allow a different length variable	
	Second A1 for a correct resolution in one unknown or moments equation in two unknowns	
	Third DM1, dependent on both previous M marks, for eliminating and solving for AG	
	Third A1 for 1.4 (m) oe	
2b (i)	First B1 e.g. mass is concentrated **at *B*** B0 if incorrect extras	
(ii)	Second B1 e.g. the plank doesn't buckle or bend B0 if incorrect extras	

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3. At time $t = 0$, a stone is thrown vertically upwards with speed $19.6\,\text{m}\,\text{s}^{-1}$ from a point A which is h metres above horizontal ground. At time $t = 3\,\text{s}$, another stone is released from rest from a point B which is also h metres above the same horizontal ground. Both stones hit the ground at time $t = T$ seconds. The motion of each stone is modelled as that of a particle moving freely under gravity.

Find

(i) the value of T,

(ii) the value of h.

(7)

Question Number	Scheme	Marks
3	**EITHER:** $h=-19.6(t+3)+\frac{1}{2}g(t+3)^2$ and $h=\frac{1}{2}gt^2$	M1A1A1
	OR : $h=-19.6T+\frac{1}{2}gT^2$ and $h=\frac{1}{2}g\left(T-3\right)^2$	M1A1A1
	$-19.6T+\frac{1}{2}gT^2=\frac{1}{2}g\left(T-3\right)^2$ **OR** $-19.6(t+3)+\frac{1}{2}g(t+3)^2=\frac{1}{2}gt^2$	M1
(i)	$T=4.5$	A1
(ii)	$h=\frac{1}{2}\times 9.8\times\left(T-3\right)^2$ oe	M1
	$=11$ or 11.0	A1 **[7]**
	Notes for qu 3	
3	First M1 for use of $s=ut+\frac{1}{2}at^2$ (or any other complete method) to produce an equation in *h* and *T only* or *h* and *t only* for stone 1 or 2, correct no. of terms but condone sign errors	
	First A1 for a correct equation for **stone 1** (*g* does not need to be substituted but if it is , it must be 9.8)	
	Second A1 for a correct equation for **stone 2** **N.B**. Both A marks can be earned if they use *s* (instead of *h* or -*h*) in one of the two equations and then use *s* consistently in the other equation. **N.B.** When *h* and *T* are used in any equation, they must be used correctly (including sign of *h*) to obtain A marks	
(i)	Second M1 for eliminating *h*	
	Third A1 for *T* = 4.5	
(ii)	Third M1 for using their *T* or *t* value in one of their equations to obtain an *h* value	
	Fourth A1 for *h* = 11 or 11.0	

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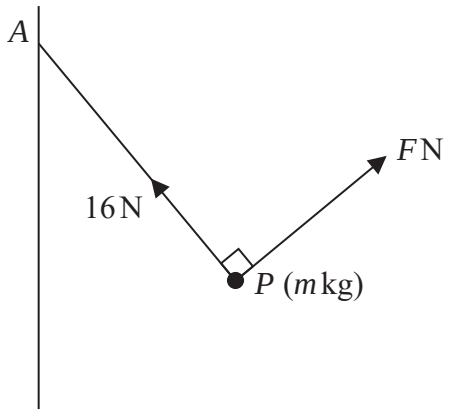

Figure 2

A particle P of mass m kg is attached to one end of a light inextensible string of length 2.5 m. The other end of the string is attached to a fixed point A on a vertical wall. The tension in the string is 16 N. The particle is held in equilibrium by a force of magnitude F newtons, acting in the vertical plane which is perpendicular to the wall and contains the string. This force acts in a direction perpendicular to the string, as shown in Figure 2.

Given that the horizontal distance of P from the wall is 1.5 m, find

(i) the value of F,

(ii) the value of m.

(7)

Question Number	Scheme	Marks
4.	$\sin\theta = \frac{3}{5}$ or $\cos\theta = \frac{4}{5}$ or $\tan\theta = \frac{3}{4}$ oe (may use the angle the string makes with the horizontal, the complementary angle) seen or implied by use of a trig function of e.g. 37° or 53° anywhere. **N.B.** If they assume angles are 45° can score max B0M1A0A1M0A0A0	B1
	Any *two* of the following equations: R$(\rightarrow)$: $F\cos\theta = 16\sin\theta$ oe e.g. $F = 16\tan\theta$ (from triangle of forces) R($\nearrow$): $F = mg\sin\theta$ R$(\uparrow)$: $mg = 16\cos\theta + F\sin\theta$ R($\nwarrow$): $16 = mg\cos\theta$ $(mg)^2 = F^2 + 16^2$ (Pythagoras from triangle of forces) **N.B**. In all of these equations, θ is what they *think* the angle that the string makes with the vertical is.	M1A1 (1st equation) M1A1 (2nd equation)
(i)	$F = 12$ (A0 if 12 obtained from rounding an inaccurate answer and A0 for 12.0) **N.B. If $F = 12$ is given as answer, without any evidence of rounding, give BOD and award A1.**	A1
(ii)	$m = 2.04$ or 2.0 (A0 for 2)	A1
		[7]
	Notes for qu 4	
	B1 for any correct trig ratio seen	
	First M1 for 1st equation seen with usual rules	
	First A1 for a correct equation	
	Second A1 is now M1 for 2nd equation seen with usual rules	
	Second M1 is now A1 for a correct equation	
	Third A1 for 12	
	Fourth A1 for 2.04 or 2.0 (A0 for 2)	

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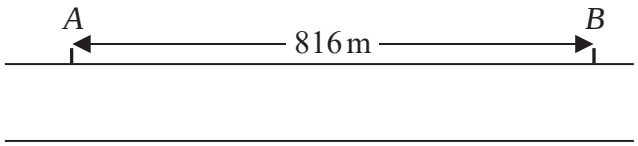


Figure 3

Two posts, A and B, are fixed at the side of a straight horizontal road and are 816 m apart, as shown in Figure 3. A car and a van are at rest side by side on the road and level with A. The car and the van start to move at the same time in the direction AB. The car accelerates from rest with constant acceleration until it reaches a speed of $24\,\text{m s}^{-1}$. The car then moves at a constant speed of $24\,\text{m s}^{-1}$. The van accelerates from rest with constant acceleration for 12 s until it reaches a speed of $V\,\text{m s}^{-1}$. The van then moves at a constant speed of $V\,\text{m s}^{-1}$. When the car has been moving at $24\,\text{m s}^{-1}$ for 30 s, the van draws level with the car at B, and each vehicle has then travelled a distance of 816 m.

(a) Sketch, on the same diagram, a speed-time graph for the motion of each vehicle from A to B.

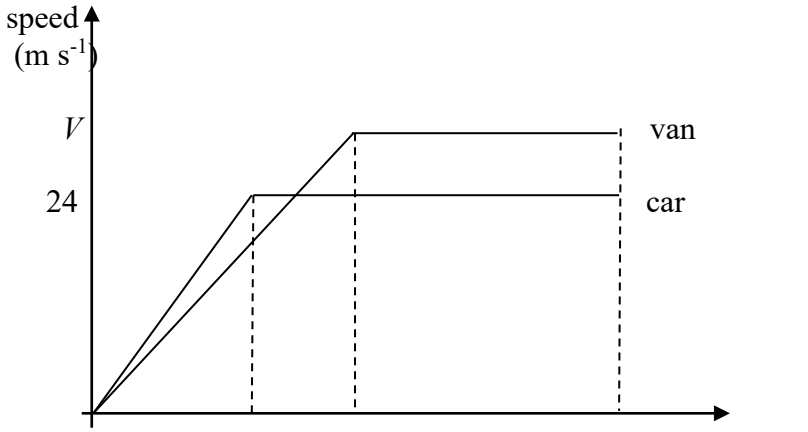
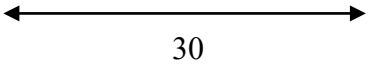
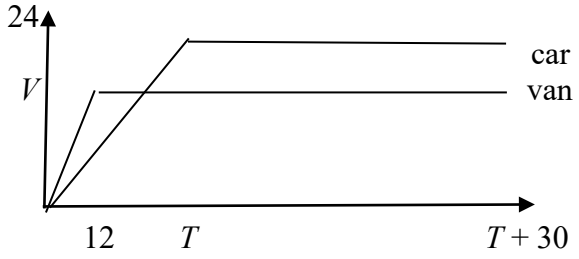
(3)

(b) Find the time for which the car is accelerating.

(3)

(c) Find the value of V.

(3)

Question Number	Scheme	Marks
5(a)	 **OR** 	B1 shape of either B1 shape of second (must cross first and end at the same t value) B1 V,24,12, T, T+30 oe with delineator B0 if vertical solid lines (3)
	N.B. 	**This graph can score all 3 marks.**
(b)	$\frac{1}{2}(T+30+30)\times 24=816$ **OR** $\frac{1}{2}\times T\times 24+30\times 24=816$ $T=8$ (s)	M1A1 A1 (3)
(c)	$\frac{1}{2}\big((T+30)+(T+18)\big)V=816$ **OR** $\frac{1}{2}\times 12V+V(18+T)=816$ $V=25.5$	M1A1 **ft** A1 (3) **[9]**
ALT	(b) Dist travelled while accelerating $=816-720=96$ m $s=\frac{u+v}{2}t \Rightarrow\left(\frac{0+24}{2}\right)T=96$ M1A1 $T=8$ (s) A1	

Question Number	Scheme	Marks
	(c) Dist travelled by the van $= \frac{1}{2} \times 12V + (18+T) \times V = 816$ M1A1**ft** $V = 25.5$ A1	
	Notes for qu 5	
5a	First B1 for shape of graph	
	Second B1 for shape of graph, crossing first graph	
	Third B1 for V, 12, 24, T and T+30 placed correctly oe e.g. with delineators. Allow their T and (their T + 30) where they find T in (b) first.	
5b	M1 for equation in T or t (= T + 30) *only* , using 816 distance travelled by CAR, *with correct structure* i.e. a trapezium or (triangle + rectangle)	
	First A1 for a correct equation	
	Second A1 for 8 (s)	
5c	M1 for equation in V *only* , using 816 distance travelled by VAN , *with correct structure* i.e. a trapezium or (triangle + rectangle) **N.B.** M0 if they assume the TOTAL time is 30 (or 42) when setting up the equation.	
	First A1 **ft** on their T value , for a correct equation	
	Second A1 for V = 25.5	

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

6. The point A on a horizontal playground has position vector $(3\mathbf{i} - 2\mathbf{j})$ m. At time $t = 0$, a girl kicks a ball from A. The ball moves horizontally along the playground with constant velocity $(4\mathbf{i} + 5\mathbf{j})\,\text{m s}^{-1}$.

Modelling the ball as a particle, find

(a) the speed of the ball,

(2)

(b) the position vector of the ball at time t seconds.

(2)

The point B on the playground has position vector $(\mathbf{i} + 6\mathbf{j})$ m. At time $t = T$ seconds, the ball is due east of B.

(c) Find the value of T.

(2)

A boy is running due east with constant speed $v\,\text{m s}^{-1}$. At the instant when the girl kicks the ball from A, the boy is at B.

Given that the boy intercepts the ball,

(d) find the value of v.

(5)

Question Number	Scheme	Marks
6(a)	Speed $= \sqrt{4^2+5^2} = \sqrt{41}$ or 6.4031...m s^{-1} (Accept 6.4 or better)	M1A1 (2)
(b)	$(\mathbf{r} =)\left(3\mathbf{i}-2\mathbf{j}\right)+t\left(\mathbf{4i}+5\mathbf{j}\right)$.	M1A1 (2)
(c)	$\mathbf{j}$ comp $=6$	
	$5T-2=6$	M1
	$T=\frac{8}{5}\ \left(=1.6\right)$	A1 (2)
(d)	$t=1.6\ \Rightarrow\ (\mathbf{r} =)(3+(4\times1.6))\mathbf{i}\ \ \left(+6\mathbf{j}\right)$	M1A1**ft**
	boy travels $9.4-1=8.4$ m (allow 8.4**i)**	A1
	$\frac{8.4}{1.6}$ or $\frac{8.4\mathbf{i}}{1.6}$ $v = 5.25$	**DM**1 A1 (5) **[11]**

	Notes for qu 6	
6a	M1 for attempt to find magnitude of velocity	
	A1 6.4 or better	
6b	M1 for attempt at pv with correct structure i.e. $\mathbf{r}_0 + t\mathbf{v}$	
	A1 for a correct expression seen (ie use isw)	
6c	M1 for equating **j** cpt of their **r** to 6 (Must be of form: $a+bT=6$ oe)	
	A1 for 1.6 oe	
6d	First M1 for substituting their answer for (c), their T, into **i** cpt of their answer for (b) oe	
	First A1 **ft ,** with or without **i**	
	Second A1 for 8.4 or 8.4**i** cao	
	Second DM1, dependent on first M1, for dividing their distance or vector (c**i)** by their T (> 0) value to find the value of v. (9.4/T oe is DM0)	
	Third A1 for 5.25 cao	

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7. A truck of mass 1600 kg is towing a car of mass 960 kg along a straight horizontal road. The truck and the car are joined by a light rigid tow bar. The tow bar is horizontal and is parallel to the direction of motion. The truck and the car experience constant resistances to motion of magnitude 640 N and R newtons respectively. The truck's engine produces a constant driving force of magnitude 2100 N. The magnitude of the acceleration of the truck and the car is $0.4\,\text{m s}^{-2}$.

(a) Show that $R = 436$

(3)

(b) Find the tension in the tow bar.

(3)

The two vehicles come to a hill inclined at an angle α to the horizontal where $\sin\alpha = \frac{1}{15}$.

The truck and the car move down a line of greatest slope of the hill with the tow bar parallel to the direction of motion. The truck's engine produces a constant driving force of magnitude 2100 N. The magnitudes of the resistances to motion on the truck and the car are 640 N and 436 N respectively.

(c) Find the magnitude of the acceleration of the truck and the car as they move down the hill.

(4)

Question Number	Scheme	Marks
7(a)	$2560\times0.4=2100-640-R$	M1A1
	$R=436$ * GIVEN ANSWER	A1 * (3)
(b)	Truck: $1600\times0.4=2100-640-T$ **OR** car: $960\times0.4=T-436$	M1A1
	$T=820$ N	A1 (3)
(c)	$2560a'=2100-640-436+1600g\sin\alpha+960g\sin\alpha$ (omission of g is one error)	M1A1A1
	$a'=1.05$ or 1.1 m s^{-2}	A1 (4) **[10]**
	Notes for qu 7	
	Use the *mass* which is being used, in $F=ma$, to decide which part of the system an equation applies to.	
7a	M1 for an equation of motion, dim correct with correct no.of terms, condone sign errors, *in R only*	
	First A1 for a correct equation	
	Second A1 for $R = 436$ GIVEN ANSWER **N.B**. They may do (b) first, using the Truck equation to find $T = 820$, and then use Car equation here to show that $R = 436$	
7b	M1 for an equation of motion, dim correct with correct no.of terms, condone sign errors, for either truck or car, in T only. (Equation could appear in (a) but must be being used in (b))	
	First A1 for a correct equation	
	Second A1 for $T = 820$ (N)	
7c	M1 for an equation of motion *in a' only*, dim correct with correct no.of terms, condone sign errors and missing g's,	
	First and second A1 for a correct equation, -1 each error (Omission of g is one error) If both weight cpts are negative, treat as one error.	
	Third A1 for 1.05 or 1.1 (m s^{-2}) **N.B.** Note that $T = 820$ again but if they just assume that $T = 820$, M0	

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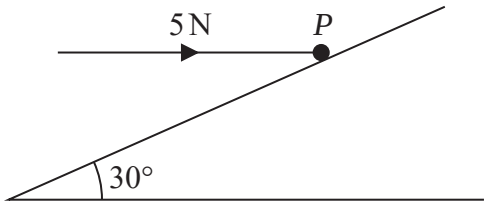

Figure 4

A rough plane is inclined at 30° to the horizontal. A particle P of mass 0.5 kg is held at rest on the plane by a horizontal force of magnitude 5 N, as shown in Figure 4. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The particle is on the point of moving up the plane.

(a) Find the magnitude of the normal reaction of the plane on P.

(4)

(b) Find the coefficient of friction between P and the plane.

(5)

The force of magnitude 5 N is now removed and P accelerates from rest down the plane.

(c) Find the speed of P after it has travelled 3 m down the plane.

(8)

Question Number	Scheme	Marks
8(a)	R$(\perp$ plane$)$: $R = 0.5g\cos 30^\circ + 5\sin 30°$	M1A1A1
	$R = 6.743... = 6.7$ or 6.74 N	A1 (4)
(b)	R$(\|\|$ plane$)$: $F = 5\cos 30° - 0.5g\sin 30°$ $(= 1.880...)$	M1A1A1
	$\mu = \frac{F}{R} = \frac{1.880}{6.743}$, $= 0.27880... = 0.28$ or 0.279	M1A1 (5)
(c)	NL2: $0.5g\sin 30° - F' = 0.5a$	M1A1
	R$(\perp$ plane$)$: $R' = 0.5g\cos 30^\circ$ $(= 4.2435...)$	M1A1
	Use of $F' = \mu R' = 0.2787... \times R'$ $(= 1.18345...)$ and solve for a	**DM**1
	$a = 2.53...$ m s^{-2}	A1
	$v^2 = 2as = 2 \times 2.533 \times 3$	M1
	$v = 3.9$ or 3.90 ms^{-1}	A1 (8) **[17]**
	Notes for qu 8	
8a	M1 for resolution perp to the plane, with usual rules	
	First and second A1 for a correct equation, -1 each error	
	Third A1 for 6.7 or 6.74 (N) must be positive	
8b	First M1 for resolution parallel to the plane, with usual rules	
	First and second A1 for a correct equation, -1 each error	
	Second M1 for *use* of $\mu = \frac{F}{R}$	
	Third A1 for 0.28 or 0.279	
8c	**SC: If 5N force is not removed, can score max:** **M1A0M1A0DM1A0M0A0** with usual rules applying for M marks assuming that 5N force still acting.	
	First M1 for equation of motion parallel to plane, with usual rules	
	First A1 for a correct equation (F' does not need to be substituted and allow if they use the value of F from part (b))	
	Second M1 for resolution perp to the plane, with usual rules	
	Second A1 for a correct equation	
	Third DM1, dependent on both previous M marks, for use of $F' = \mu R'$ and	

Question Number	Scheme	Marks
	solving for a	
	Third A1 for $a = 2.53$ or better, if they get v wrong, but if they get $v = 3.9$ then allow $a = 2.5$ or 2.54	
	Fourth M1 (independent but must have used an equation of motion to find a) for complete method to find v using their a M0 if particle is decelerating i.e if their a is negative down the plane.	
	Fourth A1 for $v = 3.9$ or $3.90\ \text{ms}^{-1}$	