

## Y2M7 XMQs and MS

(Total: 99 marks)

1. P3\_Sample Q7 . 8 marks - Y2M7 Applications of forces
2. P3\_Sample Q9 . 13 marks - Y2M4 Moments
3. P3\_Specimen Q8 . 11 marks - Y2M5 Forces and friction
4. P3\_Specimen Q9 . 14 marks - Y2M4 Moments
5. P32\_2019 Q3 . 12 marks - Y2M5 Forces and friction
6. P32\_2020 Q1 . 9 marks - Y2M5 Forces and friction
7. P32\_2021 Q2 . 12 marks - Y2M7 Applications of forces
8. P32\_2021 Q3 . 10 marks - Y2M4 Moments
9. P32\_2022 Q2 . 10 marks - Y2M5 Forces and friction



Question	Scheme	Marks	AOs
<b>7(a)</b>	$R = mg\cos\alpha$	B1	3.1b
	Resolve parallel to the plane	M1	3.1b
	$-F - mg\sin\alpha = -0.8mg$	A1	1.1b
	$F = \mu R$	M1	1.2
	Produce an equation in $\mu$ only and solve for $\mu$	M1	2.2a
	$\mu = \frac{1}{4}$	A1	1.1b
		<b>(6)</b>	
<b>(b)</b>	Compare $\mu mg\cos\alpha$ with $mg\sin\alpha$	M1	3.1b
	Deduce an appropriate conclusion	A1 ft	2.2a
		<b>(2)</b>	
			<b>(8 marks)</b>
<b>Notes:</b>			
<b>(a)</b>			
<b>B1:</b> for $R = mg\cos\alpha$			
<b>1<sup>st</sup> M1:</b> for resolving parallel to the plane			
<b>1<sup>st</sup> A1:</b> for a correct equation			
<b>2<sup>nd</sup> M1:</b> for use of $F = \mu R$			
<b>3<sup>rd</sup> M1:</b> for eliminating $F$ and $R$ to give a value for $\mu$			
<b>2<sup>nd</sup> A1:</b> for $\mu = \frac{1}{4}$			
<b>(b)</b>			
<b>M1:</b> comparing size of limiting friction with weight component down the plane			
<b>A1ft:</b> for an appropriate conclusion from their values			

9.

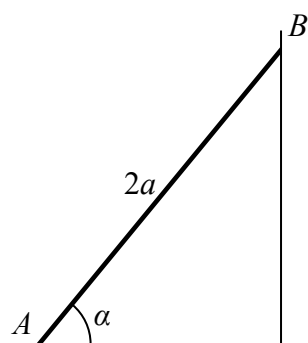


Figure 1

A uniform ladder  $AB$ , of length  $2a$  and weight  $W$ , has its end  $A$  on rough horizontal ground.

The coefficient of friction between the ladder and the ground is  $\frac{1}{4}$ .

The end  $B$  of the ladder is resting against a smooth vertical wall, as shown in Figure 1.

A builder of weight  $7W$  stands at the top of the ladder.

To stop the ladder from slipping, the builder's assistant applies a horizontal force of magnitude  $P$  to the ladder at  $A$ , towards the wall.

The force acts in a direction which is perpendicular to the wall.

The ladder rests in equilibrium in a vertical plane perpendicular to the wall and makes an angle  $\alpha$  with the horizontal ground, where  $\tan \alpha = \frac{5}{2}$ .

The builder is modelled as a particle and the ladder is modelled as a uniform rod.

- (a) Show that the reaction of the wall on the ladder at  $B$  has magnitude  $3W$ . (5)
- (b) Find, in terms of  $W$ , the range of possible values of  $P$  for which the ladder remains in equilibrium. (5)

Often in practice, the builder's assistant will simply stand on the bottom of the ladder.

- (c) Explain briefly how this helps to stop the ladder from slipping. (3)

Question	Scheme	Marks	AOs
<b>9(a)</b>	Take moments about $A$ (or any other complete method to produce an equation in $S$ , $W$ and $\alpha$ only)	M1	3.3
	$W \cos \alpha + 7W \cos \alpha = S \sin \alpha$	A1 A1	1.1b 1.1b
	Use of $\tan \alpha = \frac{5}{2}$ to obtain $S$	M1	2.1
	$S = 3W$ *	A1*	2.2a
		<b>(5)</b>	
<b>(b)</b>	$R = 8W$	B1	3.4
	$F = \frac{1}{4} R (= 2W)$	M1	3.4
	$P_{\text{MAX}} = 3W + F$ or $P_{\text{MIN}} = 3W - F$	M1	3.4
	$P_{\text{MAX}} = 5W$ or $P_{\text{MIN}} = W$	A1	1.1b
	$W \leq P \leq 5W$	A1	2.5
		<b>(5)</b>	
<b>(c)</b>	M(A) shows that the reaction on the ladder at $B$ is unchanged	M1	2.4
	also $R$ increases (resolving vertically)	M1	2.4
	which increases max $F$ available	M1	2.4
		<b>(3)</b>	
			<b>(13 marks)</b>

**Question 9 continued****Notes:****(a)****1<sup>st</sup> M1:** for producing an equation in  $S$ ,  $W$  and  $\alpha$  only**1<sup>st</sup> A1:** for an equation that is correct, or which has one error or omission**2<sup>nd</sup> A1:** for a fully correct equation**2<sup>nd</sup> M1:** for use of  $\tan \alpha = \frac{5}{2}$  to obtain  $S$  in terms of  $W$  only**3<sup>rd</sup> A1\*:** for given answer  $S = 3W$  correctly obtained**(b)****B1:** for  $R = 8W$ **1<sup>st</sup> M1:** for use of  $F = \frac{1}{4} R$ **2<sup>nd</sup> M1:** for either  $P = (3W + \text{their } F)$  or  $P = (3W - \text{their } F)$ **1<sup>st</sup> A1:** for a correct max or min value for a correct range for  $P$ **2<sup>nd</sup> A1:** for a correct range for  $P$ **(c)****1<sup>st</sup> M1:** for showing, by taking moments about  $A$ , that the reaction at  $B$  is unchanged by the builder's assistant standing on the bottom of the ladder**2<sup>nd</sup> M1:** for showing, by resolving vertically, that  $R$  increases as a result of the builder's assistant standing on the bottom of the ladder**3<sup>rd</sup> M1:** for concluding that this increases the limiting friction at  $A$

8.

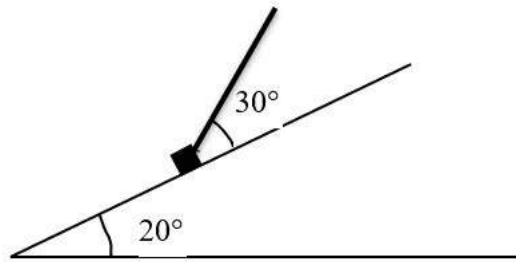


Figure 1

A small box of mass 3 kg moves on a rough plane which is inclined at an angle of  $20^\circ$  to the horizontal.

The box is pulled up a line of greatest slope of the plane using a rope which is attached to the box.

The rope makes an angle of  $30^\circ$  with the plane, as shown in Figure 1.

The rope lies in the vertical plane which contains a line of greatest slope of the plane.

The coefficient of friction between the box and the plane is 0.3.

The tension in the rope is 25 N.

The box is modelled as a particle, the rope is modelled as a light inextensible string and air resistance is ignored.

(a) Using the model, find the acceleration of the box. (7)

(b) Suggest one improvement to the model that would make it more realistic. (1)

The rope now breaks and the box slows down and comes to rest.

(c) Show that, after the box comes to rest, it immediately starts to move down the plane. (3)

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## 9MA0/03 Mock Paper: Statistics and Mechanics mark scheme

Question	Scheme	Marks	AOs
<b>3(a)</b>	Resolve perp to the plane	M1	3.1b
	$R + 25 \sin 30^\circ = 3g \cos 20^\circ$	A1	1.1b
	Equation of motion up the plane	M1	3.1b
	$25 \cos 30^\circ - 3g \sin 20^\circ - F = 3a$	A1	1.1b
	$F = 0.3R$	B1	1.2
	Correct strategy: sub for $F$ and solve for $a$	M1	3.1b
	$a = 2.4$ or $2.35 \text{ (m s}^{-2}\text{)}$	A1	2.2a
		<b>(7)</b>	
<b>(b)</b>	e.g. Include air resistance	B1	3.5c
		<b>(1)</b>	
<b>(c)</b>	$R = 3g \cos 20^\circ$ so $F_{\max} = 0.9 g \cos 20^\circ$	B1	3.1b
	Consider $3g \sin 20^\circ - 0.9g \cos 20^\circ$	M1	2.1
	Since $> 0$ , box moves down plane. *	A1*	2.2a
		<b>(3)</b>	
<b>(11 marks)</b>			
<b>Notes:</b>			
<p><b>(a)</b>  <b>M1:</b> Using an appropriate strategy to set up first of two equations, with usual rules applying  <b>A1:</b> <math>g</math> does not need to be substituted  <b>M1:</b> Using an appropriate strategy to set up second of two equations, with usual rules applying  <b>A1:</b> Neither <math>g</math> nor <math>F</math> need to be substituted (-1 each error)  <b>B1:</b> <math>F = 0.3R</math> seen  <b>M1:</b> Correct overall strategy to solve problem by substituting for <math>F</math> and solving for <math>a</math>  <b>A1:</b> Only possible answers, since <math>g = 9.8</math> used.</p>			
<p><b>(b)</b>  <b>B1:</b> e.g. include air resistance, allow for the weight of the rope</p>			
<p><b>(c)</b>  <b>B1:</b> Correct overall strategy (First equation could be implied)  <b>M1:</b> Must be difference or a comparison of the two values  <b>A1*:</b> Given answer</p>			

9.

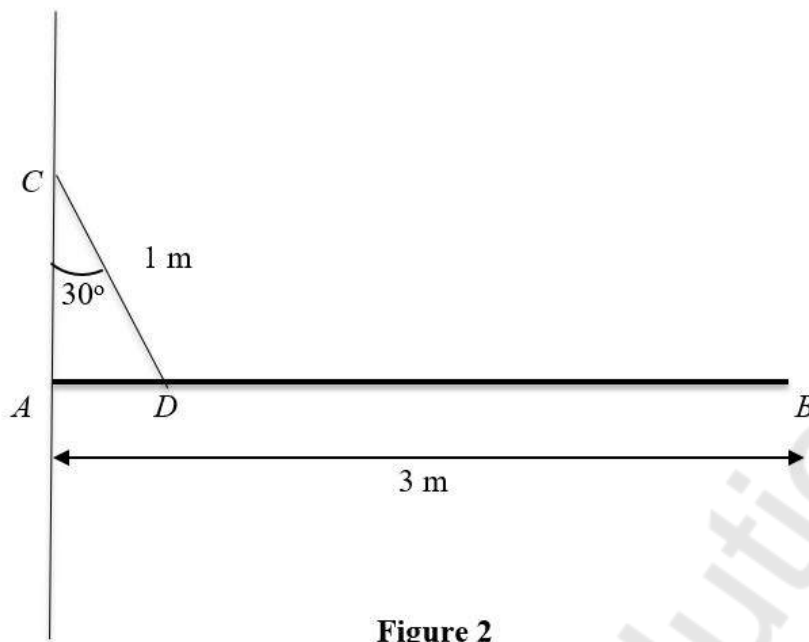


Figure 2

A beam  $CD$ , of mass  $20\text{ kg}$  and length  $3\text{ m}$ , is smoothly hinged to a vertical wall at one end  $C$ .

The beam is held in equilibrium in a horizontal position by a rope of length  $1\text{ m}$ . One end of the rope is fixed to a point  $E$  on the wall which is vertically above  $C$ . The other end of the rope is fixed to the point  $F$  on the beam so that angle  $CEF$  is  $30^\circ$ , as shown in Figure 2.

The beam is modelled as a uniform rod and the rope is modelled as a light inextensible string.

Using the model, find

(a) the tension in the rope,

\*6+

Use the diagram to show that the tension in the rope is  $20\sqrt{3}\text{ N}$ .

\*8+

Find the reaction force at the hinge  $C$ .

\*4+

Use the diagram to show that the reaction force at the hinge  $C$  is  $20\sqrt{3}\text{ N}$ .

Use the diagram to show that the reaction force at the hinge  $C$  acts horizontally.

\*4+

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**9MA0/03 Mock Paper: Statistics and Mechanics mark scheme**

Question	Scheme	Marks	AOs
<b>4(a)</b>	Moments about $A$ (or any other complete method)	M1	3.3
	$T \cos 30^\circ \times (1 \sin 30^\circ) = 20g \times 1.5$	A1	1.1.b
	$T \cos 30^\circ \times (1 \sin 30^\circ) = 20g \times 1.5$	A1	1.1.b
	$T = 679$ or $680$ (N)	A1	1.1.b
		<b>(4)</b>	
<b>(b)</b>	Resolve horizontally	M1	3.1b
	$X = T \cos 60^\circ$	A1	1.1b
	Resolve vertically	M1	3.1b
	$Y = T \cos 30^\circ - 20g$	A1	1.1b
	Use of $\tan \theta = \frac{Y}{X}$ and sub for $T$	M1	3.4
	$49^\circ$ (or better), below horizontal, away from wall	A1	2.2a
		<b>(6)</b>	
<b>(c)</b>	Tension would increase as you move from $D$ to $C$	B1	3.5a
	Since each point of the rope has to support the length of rope below it	B1	2.4
		<b>(2)</b>	
<b>(d)</b>	Take moments about $G$ , $1.5Y = 0$	M1	3.3
	$Y = 0$ hence force acts horizontally.*	A1*	2.2a
		<b>(2)</b>	

**(14 marks)**

**Notes:**

**(a)**

**M1:** Correct overall strategy e.g.  $M(A)$ , with usual rules, to give equation in  $T$  only

**A1:** (A1A0 one error) Condone 1 error

**A1:** (A0A0 two or more errors)

**A1:** Either 679 or 680 (since  $g = 9.8$  used)

**(b)**

**M1:** Using an appropriate strategy to set up first of two equations, with usual rules applying e.g. Resolve horiz. or  $M(C)$

**A1:** Correct equation in  $X$  only

**M1:** Using an appropriate strategy to set up second of two equations, with usual rules applying e.g. Resolve vert. or  $M(D)$

**A1:** Correct equation in  $Y$  only

## 9MA0/03 Mock Paper: Statistics and Mechanics mark scheme

<p><b>M1:</b> Using the model and their <math>X</math> and <math>Y</math></p> <p><b>A1:</b> 49 or better (since <math>g</math> cancels) Need all three bits of answer to score this mark or any other appropriate angle e.g <math>41^\circ</math> to wall, downwards and away from wall</p>
<p><b>(c)</b></p> <p><b>B1:</b> Appropriate equivalent comment</p> <p><b>B1:</b> Appropriate equivalent reason</p>
<p><b>(d)</b></p> <p><b>M1:</b> Using the model and any other complete method e.g. the three force condition for equilibrium</p> <p><b>A1*:</b> Correct conclusion GIVEN ANSWER</p>

3.

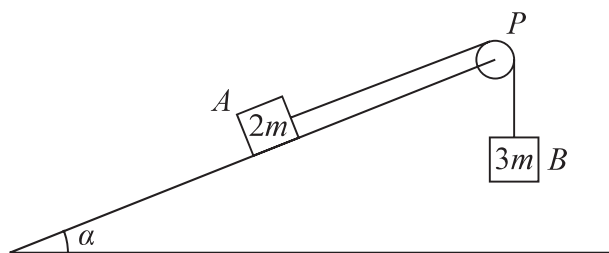


Figure 1

Two blocks,  $A$  and  $B$ , of masses  $2m$  and  $3m$  respectively, are attached to the ends of a light string.

Initially  $A$  is held at rest on a fixed rough plane.

The plane is inclined at angle  $\alpha$  to the horizontal ground, where  $\tan \alpha = \frac{5}{12}$

The string passes over a small smooth pulley,  $P$ , fixed at the top of the plane.

The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane. Block  $B$  hangs freely below  $P$ , as shown in Figure 1.

The coefficient of friction between  $A$  and the plane is  $\frac{2}{3}$

The blocks are released from rest with the string taut and  $A$  moves up the plane.

The tension in the string immediately after the blocks are released is  $T$ .

The blocks are modelled as particles and the string is modelled as being inextensible.

(a) Show that  $T = \frac{12mg}{5}$  (8)

After  $B$  reaches the ground,  $A$  continues to move up the plane until it comes to rest before reaching  $P$ .

(b) Determine whether  $A$  will remain at rest, carefully justifying your answer. (2)

(c) Suggest two refinements to the model that would make it more realistic. (2)

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Question	Scheme	Marks	AO
3(a)			
	$R = 2mg \cos \alpha$	B1	3.4
	$F = \frac{2}{3} R$	B1	1.2
	Equation of motion for A:	M1	3.3
	$T - F - 2mg \sin \alpha = 2ma$	A1	1.1b
	Equation of motion for B:	M1	3.3
	$3mg - T = 3ma$	A1	1.1b
	Complete strategy to find an equation in $T$ , $m$ and $g$ only.	M1	3.1b
	$T = \frac{12mg}{5} \quad *$	A1*	2.2a
		(8)	
(b)	$(F_{\max} =) \frac{16mg}{13} > \frac{10mg}{13}$	M1	2.1
	..... so A will not move.	A1	2.2a
		(2)	
(c)	<ul style="list-style-type: none"> <li>• Extensible string</li> <li>• Weight of string</li> <li>• Friction at pulley e.g. rough pulley</li> <li>• Allow for the dimensions of the blocks e.g. "Do not model blocks as particles"; "(include) air resistance"; "include rotational effects of forces on blocks i.e. spin"</li> </ul>	B1 B1	3.5c 3.5c
		(2)	
		(12)	

Marks		Notes
3a	B1	Normal reaction between A and the plane seen or implied, $\cos \alpha$ does not need to be substituted.
	B1	$F = \frac{2}{3}R$ seen or implied anywhere, including part (b)
	M1	Form an equation of motion for A. Must include all relevant terms. Must be the correct mass but condone consistent missing $m$ 's. Condone sign errors and sin/cos confusion
	A1	Correct unsimplified equation ( $F$ does not need to be substituted). Allow consistent use of $(-a)$ <b>N.B.</b> If $T - 2mg = 2ma$ is seen with no working, M0A0 unless both B1 marks have been scored.
	M1	Form an equation of motion for B. Must be the correct mass on RHS but condone consistent missing $m$ 's. Condone sign errors and sin/cos confusion.
	A1	Correct unsimplified equation ( $F$ does not need to be substituted). Allow consistent use of $(-a)$
		<b>N.B.</b> Allow the 'whole system' equation to replace the equation for A or B. $3mg - F - 2mg \sin \alpha = 5ma$ Must be the correct mass on RHS but condone consistent missing $m$ 's. Condone sign errors and sin/cos confusion.
	M1 Complete method to give an equation in $T$ , $m$ and $g$ only. <b>N.B.</b> Allow $\theta$ in the equation if they have defined what $\theta$ is: e.g. $\theta = \tan^{-1}(\frac{5}{12})$ This is an <u>independent</u> mark but they must have two simultaneous equations in $T$ and $a$ unless one of the equations is the whole system equation in which case one equation will be in $T$ and $a$ and the other equation will be in $a$ only.	
	A1* Obtain the <b>given answer</b> from correct working using EXACT trig ratios. (not available if using a decimal angle)	
3b	M1	Comparison of their $F_{\max}$ ( $\frac{2}{3}R$ ) and their component of weight down the slope, must be comparing numerical values. oe e.g. if they consider the difference <b>N.B.</b> Allow comparison of $\mu$ and $\tan \alpha$ with numerical values
	A1	Correctly justified conclusion and no errors seen <b>N.B.</b> If they equate their difference to an ' $ma$ ' term then A0
3c	B1	Deduct 1 mark for each extra (more than 2) incorrect answer up to a maximum of 2 incorrect answers. Ignore extra correct answers. e.g. two correct, one incorrect B1 B0 one correct, one incorrect B1 B0 one correct, two incorrect B0 B0 Ignore incorrect reasons or consequences. Ignore any mention of wind or a general reference to friction.
	B1	



Question	Scheme		Marks	AOs
<b>1.(a)</b>	Resolve perpendicular to the plane		M1	3.4
	$R = mg \cos \alpha = \frac{4}{5}mg$		A1	1.1b
			(2)	
<b>1(b)</b>	Resolve parallel to the plane or horizontally or vertically		M1	3.4
	$F = mg \sin \alpha$ or $R \sin \alpha = F \cos \alpha$		A1	1.1b
	Use $F = \mu R$ and solve for $\mu$		M1	2.1
	$\mu = \frac{3}{4}$ *		A1*	2.2a
			(4)	
<b>1(c)</b>	The forces acting on $Q$ will still balance as the $m$ 's cancel oe Other possibilities: e.g. the <u>friction</u> will increase <u>in the same proportion</u> as <u>the weight component or force down the plane.</u> The <u>force pulling the brick down the plane</u> increases <u>by the same amount</u> as the <u>friction</u> oe This mark can be scored if they do the calculation.		B1	2.4
			(1)	
<b>1(d)</b>	Brick $Q$ slides down the plane with <b>constant</b> speed.		B1	2.4
	No resultant force down the plane (so no acceleration) oe		B1	2.4
	These marks can be scored if they do the calculation.		(2)	
<b>(9 marks)</b>				
<b>Notes:</b>				
<b>1a</b>	M1	Correct no. of terms, condone sin/cos confusion		
	A1	cao with no wrong working seen. $mg \cos 36.86$ is A0		
<b>1b</b>	M1	Correct no. of terms, condone sin/cos confusion		
	A1	Correct equation		
	M1	Must use $F = \mu R$ (not merely state it) to obtain a numerical value for $\mu$ . This is an independent M mark.		
	A1*	Given answer correctly obtained		
<b>1c</b>	B1	Must have the 3 underlined phrases/word oe		
<b>1d</b>	B1	Must say <b>constant</b> speed.		
	B1	Any appropriate equivalent statement		

2.

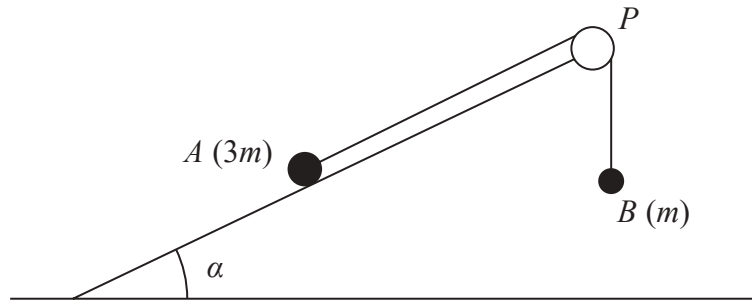


Figure 1

A small stone  $A$  of mass  $3m$  is attached to one end of a string.

A small stone  $B$  of mass  $m$  is attached to the other end of the string.

Initially  $A$  is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle  $\alpha$ , where  $\tan \alpha = \frac{3}{4}$

The string passes over a pulley  $P$  that is fixed at the top of the plane.

The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane.

Stone  $B$  hangs freely below  $P$ , as shown in Figure 1.

The coefficient of friction between  $A$  and the plane is  $\frac{1}{6}$

Stone  $A$  is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before  $B$  reaches the pulley,

(a) write down an equation of motion for  $A$  (2)

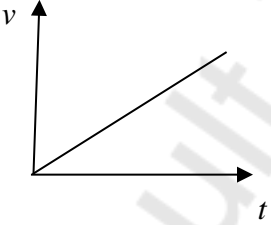
(b) show that the acceleration of  $A$  is  $\frac{1}{10}g$  (7)

(c) sketch a velocity-time graph for the motion of  $B$ , from the instant when  $A$  is released from rest to the instant just before  $B$  reaches the pulley, explaining your answer. (2)

In reality, the string is not light.

(d) State how this would affect the working in part (b). (1)



Question	Scheme	Marks	AOs
	<b>Mark parts (a) and (b) together</b>		
<b>2(a)</b>	Equation of motion for A	M1	3.3
	$3mg \sin \alpha - F - T = 3ma$	A1	1.1b
		(2)	
<b>2(b)</b>	Resolve perpendicular to the plane	M1	3.4
	$R = 3mg \cos \alpha$	A1	1.1b
	$F = \frac{1}{6}R$	B1	1.2
	Equation of motion for B <b>OR</b> for whole system	M1	3.3
	$T - mg = ma$ <b>OR</b> $3mg \sin \alpha - F - mg = 3ma + ma$	A1	1.1b
	Complete method to solve for $a$	DM1	3.1b
	$a = \frac{1}{10}g$ *	A1*	2.2a
		(7)	
<b>2(c)</b>		B1	1.1b
	e.g. acceleration (of B) is constant; dependent on first B1	DB1	2.4
		(2)	
<b>2(d)</b>	e.g. the tensions in the two equations of motion would be different. Tension on A would be different to tension on B	B1	3.5a
		(1)	
<b>(12 marks)</b>			
<b>Notes:</b> <b>N.B.</b> If m's are consistently missing treat as a MR, so max (a) M1A0 (b) M1A0B0M1A1M1A1 (c) B1B1 (d) B1  For (a) and (b), allow verification, but must see full equations of motion.			
<b>2a</b>	M1	Equation in $T$ and $a$ with correct no. of terms, condone sign errors and sin/cos confusion (If one of the 3's is missing, allow M1) N.B. Treat sin(3/5) etc as an A error but allow recovery	
	A1	Correct equation (allow $(-a)$ instead of $a$ in <u>both</u> equations)	

<b>2b</b>	M1	Correct no. of terms, condone sign errors and sin/cos confusion Allow if appears in (a)
	A1	Correct equation
	B1	Seen anywhere in (a) or (b), including on a diagram
	M1	Equation (for $B$ ) in $T$ and $a$ with correct no. of terms, condone sign errors and sin/cos confusion <b>OR Whole system equation</b> with correct no. of terms, condone sign errors and sin/cos confusion
	A1	Correct equation
	DM1	Complete method (trig may not be substituted), dependent on M1 in (a) and second M1 in (b) if they use two equations, or second M1 in (b) if they use one equation.
	A1*	Correct answer correctly obtained.
<b>2c</b>	B1	Straight line starting at the origin (could be reflected in the $t$ -axis). B0 if continuous vertical line at the end.
	DB1	Dependent on first B1, for any equivalent statement
<b>2d</b>	B1	B0 if incorrect extras

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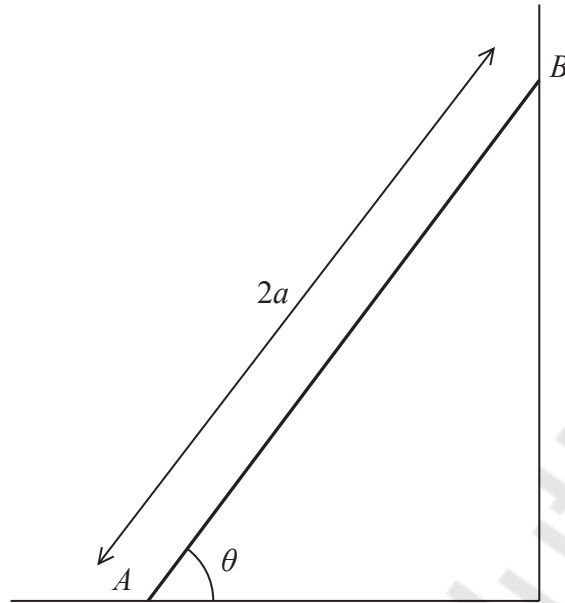


Figure 2

A beam  $AB$  has mass  $m$  and length  $2a$ .

The beam rests in equilibrium with  $A$  on rough horizontal ground and with  $B$  against a smooth vertical wall.

The beam is inclined to the horizontal at an angle  $\theta$ , as shown in Figure 2.

The coefficient of friction between the beam and the ground is  $\mu$

The beam is modelled as a uniform rod resting in a vertical plane that is perpendicular to the wall.

Using the model,

(a) show that  $\mu \geq \frac{1}{2} \cot \theta$  (5)

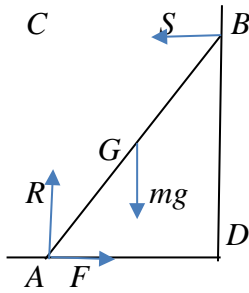
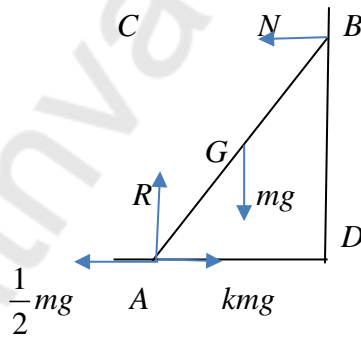
A horizontal force of magnitude  $kmg$ , where  $k$  is a constant, is now applied to the beam at  $A$ .

This force acts in a direction that is perpendicular to the wall and towards the wall.

Given that  $\tan \theta = \frac{5}{4}$ ,  $\mu = \frac{1}{2}$  and the beam is now in limiting equilibrium,

(b) use the model to find the value of  $k$ . (5)



Question	Scheme	Marks	AOs
	Part (a) is a 'Show that..' so equations need to be given in full to earn A marks		
3(a)			
	Moments equation: (M1A0 for a moments inequality)	M1	3.3
	$M(A), mga \cos \theta = 2Sa \sin \theta$ $M(B), mga \cos \theta + 2Fa \sin \theta = 2Ra \cos \theta$ $M(C), F \times 2a \sin \theta = mga \cos \theta$ $M(D), 2Ra \cos \theta = mga \cos \theta + 2Sa \sin \theta$ $M(G), Ra \cos \theta = Fa \sin \theta + Sa \sin \theta .$	A1	1.1b
	$(\updownarrow) R = mg$ <b>OR</b> $(\leftrightarrow) F = S$	B1	3.4
	Use their equations ( <u>they must have enough</u> ) and $F \leq \mu R$ to give an inequality in $\mu$ and $\theta$ <b>only</b> (allow DM1 for use of $F = \mu R$ to give an equation in $\mu$ and $\theta$ only)	DM1	2.1
	$\mu \geq \frac{1}{2} \cot \theta^*$	A1*	2.2a
	(5)		
3(b)			
	Moments equation:	M1	3.4
	$M(A), mga \cos \theta = 2Na \sin \theta$ $M(B), mga \cos \theta + 2kmga \sin \theta = 2Ra \cos \theta + \frac{1}{2}mg 2a \sin \theta$ $M(D), 2Ra \cos \theta = mga \cos \theta + N2a \sin \theta$ $M(G), kmg a \sin \theta + Na \sin \theta = \frac{1}{2}mga \sin \theta + Ra \cos \theta$	A1	1.1b

		<p><b>S.C. M(C), <math>mg a \cos \theta + \frac{1}{2} mg 2a \sin \theta = kmg 2a \sin \theta</math>    <b>M1A1B1</b></b></p> <p><math>1 + \frac{5}{4} = \frac{5k}{2}</math>    <b>M1</b></p> <p><math>k = 0.9</math>    <b>A1</b></p>		
		$N = kmg - F$ <b>OR</b> $R = mg$	B1	3.3
		Use their equations ( <u>they must have enough</u> ) to solve for $k$ (numerical)	DM1	3.1b
		$k = 0.9$ oe	A1	1.1b
			<b>(5)</b>	
<b>(10 marks)</b>				
<b>Notes:</b>				
<b>3a</b>	M1	Any moments equation with correct terms, condone sign errors and sin/cos confusion		
	A1	Correct equation		
	B1	Correct equation		
	DM1	Dependent on M1, for using their equations ( <u>they must have enough</u> ) and $F \leq \mu R$ to give an inequality in $\mu$ and $\theta$ only (allow M1 for use of $F = \mu R$ to give an equation in $\mu$ and $\theta$ only)		
	A1*	Given answer correctly obtained with no wrong working seen (e.g. if they use $F = \mu R$ anywhere, A0)		
<b>3b</b>	M1	Any moments equation with correct terms, condone sign errors		
	A1	Correct equation		
	B1	Correct equation		
	DM1	Dependent on M1, for using their equations ( <u>they must have enough</u> ) with trig substituted, to solve for $k$ , which must be numerical.		
	A1	cao		



Question	Scheme	Marks	AOs
2(a)(i)	Resolve vertically	M1	3.1b
	$F$ acting UP the plane: <b>OR</b> $F$ acting DOWN the plane: $(\uparrow) F \sin \alpha + 68.6 \cos \alpha = 5g$ <span style="margin-left: 100px;"><math>-F \sin \alpha + 68.6 \cos \alpha = 5g</math></span>	A1	1.1b
	Other possible equations from which $X$ would need to be eliminated to give an equation in $F$ <b>only</b> to earn the M mark are shown below.  The equation in $F$ <b>only</b> must then be correct to earn the A mark.  Possible equations: $(\nwarrow) 68.6 = X \sin \alpha + 5g \cos \alpha$ (leads to $X = 49$ with $g = 9.8$ )		
	$F$ acting UP the plane: <b>OR</b> $F$ acting DOWN the plane: $(\nearrow) F + X \cos \alpha = 5g \sin \alpha$ <span style="margin-left: 100px;"><math>-F + X \cos \alpha = 5g \sin \alpha</math></span> $(\rightarrow) F \cos \alpha + X = 68.6 \sin \alpha$ <span style="margin-left: 100px;"><math>-F \cos \alpha + X = 68.6 \sin \alpha</math></span>		
	9.8 (N) (49/5 is A0) <b>N.B.</b> If sin and cos are interchanged in all equations, this leads to an answer of 9.8 in the wrong direction and can only score (a) (i) M1A0A0 (ii) A0	A1	1.1b
		<b>(3)</b>	
2(a)(ii)	Down the plane (Allow down or downwards or an arrow $\searrow$ , but must appear as the answer to (a) (ii) not just on the diagram.)	A1	2.2a
		<b>(1)</b>	
2(b)	<b>N.B.</b> If they use $R = 68.6$ in this part, the maximum they can score is M1A1M0A0M0A0  If they use $F = 9.8$ or their $F$ from (a) in this part, the maximum they can score is M1A1M0A0M0A0		
	Equation of motion down the plane	M1	2.1
	$5g \sin \alpha - F = 5a$ Allow $(-a)$ instead of $a$	A1	1.1b
	Resolve perpendicular to the plane	M1	3.1b
	$R = 5g \cos \alpha$	A1	1.1b
	$F = 0.5R$ seen	M1	3.4
	$a = 1.96$ or $2.0$ or $2$ ( $\text{m s}^{-2}$ ) or $\frac{1}{5}g$	A1	1.1b
		<b>(6)</b>	
<b>(10 marks)</b>			

<b>Notes:</b>		
<b>2a (i)</b>	M1	Complete method to obtain an equation in $F$ <b>only</b> . For <b>each</b> equation used, correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved.
	A1	Correct equation in $F$ only, trig does <b>not</b> need to be substituted
	A1	cao (must be <b>positive</b> )
<b>2a (ii)</b>	A1	cao. Note that this mark is <b>dependent</b> on an answer of 9.8 or -9.8 for (a)(i) <u>from a fully correct solution</u> unless they have used $g = 9.81$ , in which case the answer will be 9.7 or -9.7 (2sf) see <b>SC2</b> below. <b>N.B.</b> Allow this mark, if their answer to (a)(i) is fully correct apart from a small error due to use of inaccurate trig i.e using an angle $36.9^\circ$
		<b>SC 1:</b> If they use $\mu R$ at any point (with an unknown $\mu$ ) for $F$ in part (a), can score (a)(i) max M1A1A0 (a) (ii) A1, where they must have obtained $\mu R = 9.8$ or $-9.8$ , <b>from correct working</b> .  <b>SC 2:</b> <b>If <math>g = 9.81</math> is used consistently throughout 2(a)</b> , (leading to $X = 48.9\dots$ and $F = 9.7$ (2sf)) can score max (a)(i) M1A1A0 (a)(ii) A1
<b>2b</b>	M1	Correct no.of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved.
	A1	Correct equation <b>for their <math>F</math></b> .
	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors, each term that needs to be resolved must be resolved. <b>(N.B. M0 if <math>R = 68.6</math> (N) is used in this equation)</b>
	A1	Correct equation
	M1	Could be seen on a diagram <b>(N.B. M0 if <math>R = 68.6</math> (N) is used)</b>
	A1	Cao. <b>Must be positive</b> .