Applications of Forces and Moments A level Edexcel Past Papers Answers

01.

Question	Scheme	Marks	AOs
a.	Take moments about A (or any other complete method to produce an equation in S, W and α only)	M1	3.3
	$W a\cos\alpha + 7W2a\cos\alpha = S2a\sin\alpha$	A1 A1	1.1b 1.1b
	Use of $\tan\alpha = \frac{5}{2}$ to obtain S	M1	2.1
	$S = 3W$ *	A1*	2.2a
		(5)	
b.	$R = 8W$	B1	3.4
	$F = \frac{1}{4} R\ (= 2W)$	M1	3.4
	$P_{MAX} = 3W + F$ or $P_{MIN} = 3W - F$	M1	3.4
	$P_{MAX} = 5W$ or $P_{MIN} = W$	A1	1.1b
	$W \leq P \leq 5W$	A1	2.5
		(5)	
c.	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
		(3)	

(13 marks)

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

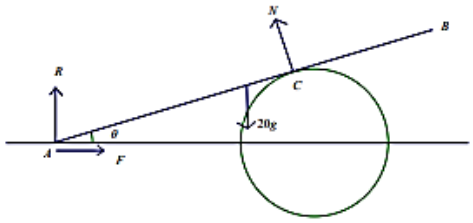
02.

Question	Scheme	Marks	AOs
a	Moments about A (or any other complete method)	M1	3.3
	$T2a\sin\alpha = Mga + 3Mgx$	A1	1.1b
	$T = \frac{Mg(a+3x)}{2a \times \frac{3}{5}} = \frac{5Mg(3x+a)}{6a}$ * GIVEN ANSWER	A1*	2.1
		(3)	

b.	$\frac{5Mg(3x+a)}{6a}\cos\alpha = 2Mg$ **OR** $2Mg.2a\tan\alpha = Mga + 3Mgx$	M1	3.1b
	$x = \frac{2a}{3}$	A1	2.2a
		(2)	
c.	Resolve vertically **OR** Moments about B	M1	3.1b
	$Y = 3Mg + Mg - \frac{5Mg(3.\frac{2a}{3}+a)}{6a}\sin\alpha$ $2aY = Mga + 3Mg(2a - \frac{2a}{3})$ **Or:** $Y = 3Mg + Mg - \left(\frac{2Mg}{\cos\alpha}\right)\sin\alpha$	A1ft	1.1b
	$Y = \frac{5Mg}{2}$ **N.B.** May use $R\sin\beta$ for Y and/or $R\cos\beta$ for X throughout	A1	1.1b
	$\tan\beta = \frac{Y}{X}$ or $\frac{R\sin\beta}{R\cos\beta} = \frac{\frac{5Mg}{2}}{2Mg}$	M1	3.4
	$= \frac{5}{4}$	A1	2.2a
		(5)	
d.	$\frac{5Mg(3x+a)}{6a} \le 5Mg$ and solve for x	M1	2.4
	$x \le \frac{5a}{3}$	A1	2.4
	For rope not to break, block can't be more than $\frac{5a}{3}$ from A oe Or just: $x \le \frac{5a}{3}$, if no incorrect statement seen. **N.B. If the correct inequality is not found,** their comment must mention 'distance from A'.	B1 A1	2.4
		(3)	
			(13 marks)

Notes:
(a) **M1**: Using M(A), with usual rules, or any other complete method to obtain an equation in a, M, x and T only. **A1:** Correct equation **A1*:** Correct PRINTED ANSWER, correctly obtained, need to see $\sin\alpha=\frac{3}{5}$ used.
(b) **M1:** Using an appropriate strategy to find x. e.g. Resolve horizontally with usual rules applying OR Moments about C. Must use the given expression for T. **A1:** Accept $0.67a$ or better
(c) **M1:** Using a complete method to find Y (or $R\sin\beta$) e.g. resolve vertically or Moments about B, with usual rules **A1 ft:** Correct equation with their x substituted in T expression or using $T=\frac{2Mg}{\cos\alpha}$ **A1:** Y (or $R\sin\beta$) $=\frac{5Mg}{2}$ or $2.5Mg$ or $2.50Mg$ **M1:** For finding an equation **in tan β only** using $\tan\beta=\frac{Y}{X}$ or $\tan\beta=\frac{X}{Y}$ This is independent but must have found a Y. **A1:** Accept $\frac{-5}{4}$ if it follows from their working.
(d) **M1:** Allow $T=5Mg$ or $T<5Mg$ and solves for x, showing all necessary steps (M0 for $T>5Mg$) **A1:** Allow $x=\frac{5a}{3}$ or $x<\frac{5a}{3}$. Accept $1.7a$ or better. **B1: Treat as A1.** For any appropriate equivalent fully correct comment or statement. E.g. maximum value of x is $\frac{5a}{3}$

03.

Question	Scheme	Marks	AO
a.	Drum **smooth**, or no friction, (therefore reaction is perpendicular to the ramp)	B1	2.4
		(1)	
b.	**N.B.** In (b), for a moments equation, if there is an extra $\sin\theta$ or $\cos\theta$ on a length, give M0 for the equation e.g. M(A): $20g\times4\cos\theta=5N\sin\theta$ would be given M0A0		
			
	Possible equns $(\nearrow): F\cos\theta+R\sin\theta=20g\sin\theta$ $(\nwarrow): N+R\cos\theta=20g\cos\theta+F\sin\theta$ $(\uparrow) R+N\cos\theta=20g$ $(\rightarrow): F=N\sin\theta$ M(A): $20g\times4\cos\theta=5N$ M(B): $3N+R\times8\cos\theta=F\times8\sin\theta+20g\times4\cos\theta$ M(C): $R\times5\cos\theta=F\times5\sin\theta+20g\times\cos\theta$ M(G): $R\times4\cos\theta=F\times4\sin\theta+N$	M1 A1 M1 A1 M1 A1	3.3 1.1b 3.4 1.1b 3.4 1.1b
	(The values of the 3 unknowns are: $N=150.528$; $F=42.14784$; $R=51.49312$)		

Alternative 1: using cpts along ramp (X) and perp to ramp(Y) Possible equations: $(\nearrow): X=20g\sin\theta$ $(\nwarrow): Y+N=20g\cos\theta$ $(\uparrow): X\sin\theta+Y\cos\theta+N\cos\theta=20g$ $(\rightarrow): X\cos\theta=Y\sin\theta+N\sin\theta$ M(A): $20g\times4\cos\theta=5N$ M(B): $20g\times4\cos\theta=8Y+3N$ M(C): $20g\times\cos\theta=5Y$ M(G): $4Y=N\times1$	M1 A1 M1 A1 M1 A1	3.3 1.1b 3.4 1.1b 3.4 1.1b
(The values of the 3 unknowns are: $N=150.528$; $X=54.88$; $Y=37.632$)		

∴	**Alternative 2: using horizontal cpt (H) and cpt perp to ramp (S)**		
	$(\nearrow): H\cos\theta = 20g\sin\theta$	M1	3.3
	$(\nwarrow): S + N = H\sin\theta + 20g\cos\theta$	A1	1.1b
	$(\uparrow): S\cos\theta + N\cos\theta = 20g$	M1	3.4
	$(\rightarrow): H = S\sin\theta + N\sin\theta$	A1	1.1b
	$\text{M}(A): 20g\times 4\cos\theta = 5N$	M1	3.4
	$\text{M}(B): 20g\times 4\cos\theta + H\times 8\sin\theta = 8S + 3N$	A1	1.1b
	$\text{M}(C): 20g\times\cos\theta + H\times 5\sin\theta = 5S$		
	$\text{M}(G): 4S = N\times 1 + H\times 4\sin\theta$		
	(The values of the 3 unknowns are: $N = 150.528$; $H = 57.1666\ldots$; $S = 53.638666\ldots$)		
	Solve their 3 equations for F and R **OR** X and Y **OR** H and S	M1	1.1b
	$\lvert\text{Force}\rvert = \sqrt{R^2 + F^2}$ Main scheme **OR** $= \sqrt{X^2 + Y^2}$ Alternative 1 **OR** $= \sqrt{(H^2 + S^2 - 2HS\cos(90^o - \theta)}$ Alternative 2	M1	3.1b
	Magnitude = 67 or 66.5 (N)	A1	2.2a
		(9)	
c.	Magnitude of the normal reaction (at C) will **decrease**.	B1	3.5a
		(1)	
		(11)	

Marks		Notes
a.	B1	Ignore any extra incorrect comments.
		Generally 3 independent equations required so **at least one moments equation.**: M1A1M1A1M1A1. More than 3 equations, give marks for the best 3. For each: M1 All terms required. Must be dimensionally correct so if a length is missing from a moments equation it's M0 Condone sin/cos confusion. A1 For a correct equation (trig ratios do not need to be substituted and allow e.g. cos(24/25) if they recover Enter marks on ePEN in order in which equations appear. **N.B.** If reaction at C is not perpendicular to the ramp, can only score marks for M(C) Allow use of (μR) for F
b.	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation
	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation
	M1	All terms required, dim correct, condone sin/cos confusion
	A1	Correct unsimplified equation
		N.B. They can find F and R using only TWO equations, the 1st and 7th in the list. Mark the better equation as M2A2 (-1 each error). Mark the second equation as M1A1

Alt 1	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation
	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation
	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation

		N.B. They can find X and Y using only TWO equations, the 1st and 7th in the list. Mark the better equation as M2A2 (-1 each error). Mark the second equation as M1A1
Alt 2	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation
	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion.
	A1	Correct unsimplified equation
	M1	All terms required. Must be dimensionally correct.
	A1	Correct unsimplified equation
		N.B. They can find H and S using only TWO equations, the 1st and 7th in the list. Mark the better equation as M2A2 (-1 each error). Mark the second equation as M1A1
	M1	Substitute for trig and solve for their two cpts. This is an independent mark but must use 3 equations (unless it's the special case when 2 is sufficient)
	M1	Use Pythagoras to find magnitude (this is an independent M mark but must have found a value for F (or X) and a value for R (or Y)) **OR** a complete method to find magnitude e.g. cosine rule but must have found a value for H and a value for S
	A1	Correct answer only
	B1	Ignore reasons

04.

Question	Scheme	Marks	AOs
4(a)	Take moments about A	M1	3.3
	$N \times \frac{4a}{\sin\alpha} = Mg \times 3a\cos\alpha$	A1	1.1b
	$\frac{9Mg}{25}$ *	A1*	1.1b
		(3)	
4(b)	Resolve horizontally	M1	3.4
	$(\rightarrow)\ F = \frac{9Mg}{25}\sin\alpha$	A1	1.1b
	Resolve vertically	M1	3.4
	$(\uparrow) R + \frac{9Mg}{25}\cos\alpha = Mg$	A1	1.1b
	Other possible equations: $(\nwarrow), R\cos\alpha + \frac{9Mg}{25} = Mg\cos\alpha + F\sin\alpha$ $(\nearrow), Mg\sin\alpha = F\cos\alpha + R\sin\alpha$ $\text{M}(C), Mg.2a\cos\alpha + F.5a\sin\alpha = R.5a\cos\alpha$ $\text{M}(G), \frac{9Mg}{25}.2a + F.3a\sin\alpha = R.3a\cos\alpha$ $\text{M}(B), Mg.3a\cos\alpha + F.6a\sin\alpha = R.6a\cos\alpha + \frac{9Mg}{25}a$ $(F = \frac{36Mg}{125}, R = \frac{98Mg}{125})$		
	$F = \mu R$ used	M1	3.4
	Eliminate R and F and solve for μ	M1	3.1b
	Alternative equations if they have at A: X horizontally and Y perpendicular to the rod. $(\nwarrow), Y + \frac{9Mg}{25} = Mg\cos\alpha + X\sin\alpha$ $(\nearrow), Mg\sin\alpha = X\cos\alpha$ $(\uparrow), \frac{9Mg}{25}\cos\alpha + Y\cos\alpha = Mg$ $(\rightarrow), Y\sin\alpha + \frac{9Mg}{25}\sin\alpha = X$		

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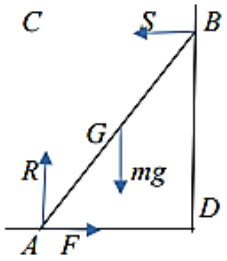
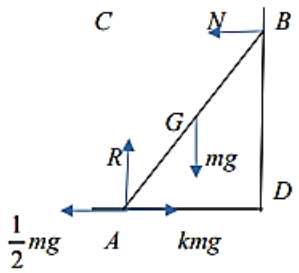
	M(C), $Mg.2a\cos\alpha + X.5a\sin\alpha = Y.5a$ M(G), $\frac{9Mg}{25}.2a + X.3a\sin\alpha = Y.3a$ M1A1 M1A1 M(B), $Mg.3a\cos\alpha + X.6a\sin\alpha = Y.6a + \frac{9Mg}{25}a$ $(X = \frac{4Mg}{3}, Y = \frac{98Mg}{75})$ Then $F = \mu R$ becomes: $X - Y\sin\alpha = \mu Y\cos\alpha$ M1 Eliminate X and Y and solve for μ M1		
	$\mu = \frac{18}{49}$ (0.3673…..accept 0.37 or better)	A1	2.2a
		(7)	
			(10 marks)

Notes:		
4a	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors for an equation in N and Mg only. For perp distance allow any of : $\frac{4a}{\sin\alpha}, \frac{4a}{\cos\alpha}, 5a$ but use of any of : $6a, 5a\sin\alpha, 4a\cos\alpha, \ldots$ or anything involving $\tan\alpha$ is M0 Also M0 if no a's in their first equation.
	A1	Correct equation, trig does not need to be substituted
	A1*	Given answer correctly obtained.
4b	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1	Correct equation, trig does not need to be substituted but N does.
	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1	Correct equation, trig does not need to be substituted but N does.
		N.B. The above 4 marks are for any two equations, either resolutions or moments or one of each. Mark best two equations. Equations may appear in part (a) but must be used in (b) to earn marks.
	M1	Must be used, e.g. seen on the diagram. i.e. M0 if merely quoting it. (M0 if $F = \mu \times \frac{9Mg}{25}$ used)
	M1	Must have 3 equations (and all 3 previous M marks)
	A1	Accept 0.37 or better

05.

Question	Scheme	Marks	AOs
a.	**Part (a) is a 'Show that..' so equations need to be given in full to earn A marks**		
			
	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
	($\updownarrow$) $R = mg$ **OR** ($\leftrightarrow$) $F = S$	B1	3.4
	Use their equations (they must have enough) and $F \le \mu R$ to give an inequality in μ and θ **only** (allow DM1 for use of $F = \mu R$ to give an *equation* in μ and θ only)	DM1	2.1
	$\mu \ge \frac{1}{2}\cot\theta$ *	A1*	2.2a
		(5)	
b.			
	Moments equation:	M1	3.4
	M(A), $mga\cos\theta = 2Na\sin\theta$ M(B), $mga\cos\theta + 2kmga\sin\theta = 2Ra\cos\theta + \frac{1}{2}mg2a\sin\theta$ M(D), $2Ra\cos\theta = mga\cos\theta + N2a\sin\theta$ M(G), $kmga\sin\theta + Na\sin\theta = \frac{1}{2}mga\sin\theta + Ra\cos\theta$	A1	1.1b

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	S.C. M(C), $mga\cos\theta+\frac{1}{2}mg2a\sin\theta=kmg2a\sin\theta$ **M1A1B1** $1+\frac{5}{4}=\frac{5k}{2}$ **M1** $k=0.9$ **A1**		
	$N=kmg-F$ **OR** $R=mg$	B1	3.3
	Use their equations (they must have enough) to solve for k (numerical)	DM1	3.1b
	$k=0.9$ oe	A1	1.1b
		(5)	
			(10 marks)

Notes.

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 (they must have enough) and $F \le \mu R$ to give an inequality in μ and θ only (allow M1 for use of $F=\mu R$ to give an equation in μ and θ only)
A1*	Given answer correctly obtained with no wrong working seen (e.g. if they use $F=\mu R$ anywhere, A0)
M1	Any moments equation with correct terms, condone sign errors
A1	Correct equation
B1	Correct equation
DM1	Dependent on M1, for using their equations (they must have enough) with trig substituted, to solve for k, which must be numerical.
A1	cao

06.

Question	Scheme	Marks	AOs
a.	The horizontal component of T acts to the left and since the **only** other horizontal force is friction, it must act to the right oe	B1	2.4
		(1)	
b.	Take moments about A or any other complete method to obtain **an equation in T, M and θ only.** (see possible equations below that they may use)	M1	3.1b
	$T.2a = Mga\cos\theta + 2Mg \times 1.5a\cos\theta$ (A0 if a's missing)	A1	1.1b
	Other possible equations but F and R would need to be eliminated. $(\nwarrow), R\cos\theta + T = F\sin\theta + Mg\cos\theta + 2Mg\cos\theta$ $(\nearrow), R\sin\theta + F\cos\theta = Mg\sin\theta + 2Mg\sin\theta$ $(\rightarrow),\ F = T\sin\theta$ M(B), $R.2a\cos\theta = Mga\cos\theta + 2Mg \times 0.5a\cos\theta + F.2a\sin\theta$ M(G), $Fa\sin\theta + Ta = Ra\cos\theta + 2Mg \times 0.5a\cos\theta$ M(C), $R \times 1.5a\cos\theta = T \times 0.5a + Mg \times 0.5a\cos\theta + F \times 1.5a\sin\theta$		
	$T = 2Mg\cos\theta$ *	A1*	1.1b
		(3)	
c.	e.g. Resolve vertically	M1	3.4
	$(\uparrow), R + T\cos\theta = Mg + 2Mg$	A1	1.1b
	$R = \frac{57Mg}{25}$ *	A1*	1.1b
		(3)	
	Other possible equations but F would need to be eliminated. $(\nwarrow), R\cos\theta + T = F\sin\theta + Mg\cos\theta + 2Mg\cos\theta$ $(\nearrow), R\sin\theta + F\cos\theta = Mg\sin\theta + 2Mg\sin\theta$ $(\rightarrow),\ F = T\sin\theta$ M(B), $R.2a\cos\theta = Mga\cos\theta + 2Mg \times 0.5a\cos\theta + F.2a\sin\theta$ M(G), $Fa\sin\theta + Ta = Ra\cos\theta + 2Mg \times 0.5a\cos\theta$ M(C), $R \times 1.5a\cos\theta = T \times 0.5a + Mg \times 0.5a\cos\theta + F \times 1.5a\sin\theta$		
d.	Find an equation containing F e.g. Resolve horizontally	M1	3.4
	$(\rightarrow),\ F = T\sin\theta$	A1	1.1b
	Other possible equations		

	$(\nwarrow), R\cos\theta + T = F\sin\theta + Mg\cos\theta + 2Mg\cos\theta$ $(\nearrow), R\sin\theta + F\cos\theta = Mg\sin\theta + 2Mg\sin\theta$ $(\rightarrow),\ F = T\sin\theta$ M(B), $R.2a\cos\theta = Mga\cos\theta + 2Mg\times 0.5a\cos\theta + F.2a\sin\theta$ M(G), $Fa\sin\theta + Ta = Ra\cos\theta + 2Mg\times 0.5a\cos\theta$ M(C), $R\times 1.5a\cos\theta = T\times 0.5a + Mg\times 0.5a\cos\theta + F\times 1.5a\sin\theta$		
	$F = \mu R$ used i.e. both F and R are substituted.	M1	3.1b
	$\mu = \frac{8}{19}$ *	A1*	2.2a
		(4)	
			(11 marks)

Notes

B1	Any equivalent explanation
M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors
A1	Correct equation, trig does not need to be substituted (Allow: $T.2a = Mga\cos\theta + 3Mga\cos\theta$)
A1*	Given answer correctly obtained with no wrong working seen. Allow $2Mg\cos\theta = T$ But not $T = 2\cos\theta Mg$
M1	For an equation in R, M, T and θ **only** 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, T and trig do not need to be substituted
A1*	Given answer correctly obtained with no wrong working seen
M1	For any equation with F in it 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, trig does not need to be substituted
M1	Must be used i.e M0 if merely quoting it.
A1*	Given answer correctly obtained with no wrong working seen

07.

Question	Scheme	Marks	AOs
a	The normal reaction at *B* is acting to the left so it must act to the right, right as it needs to balance (oppose, counter) the force at *B*, right as it prevents the rod from sliding (slipping, falling), right as the weight (mass) of the rod will mean the rod tends to slip left, mass or weight will be pushing the rod to the left so friction will oppose that. **N.B.** You may see an arrow on the diagram at *A*, instead of 'right'. B0 if they say the rod is moving oe Accept towards the wall instead of to the right.	B1	2.4
		(1)	
b	Take moments about *A*	M1	3.4
	$S \times 2a\sin\theta = Mga\cos\theta$	A1	1.1b
	$S = \frac{1}{2}Mg\cot\theta$ *	A1*	2.2a
		(3)	
c	Resolve vertically, $R = Mg$	B1	3.3
	Resolve horizontally, $F = S$	B1	3.3
	Other possible equations: Resolve along the rod, $F\cos\theta + R\sin\theta = S\cos\theta + Mg\sin\theta$ Resolve perp to the rod, $R\cos\theta + S\sin\theta = F\sin\theta + Mg\cos\theta$ M(*B*), $R \times 2a\cos\theta = F \times 2a\sin\theta + Mga\cos\theta$ M(*G*), $Ra\cos\theta = Fa\sin\theta + Sa\sin\theta$ **N.B.** When entering these two B marks on ePEN, **First** B1 is for a **vertical** resolution, **second** B1 is for a **horizontal** resolution, and if either is replaced by a different equation, enter appropriately. If both are replaced by other equations, enter in the order in which they appear in their working.		
	$F = \mu R$	B1	1.2
	$\frac{1}{2}Mg \times \frac{4}{3} = \mu Mg$	**dM1**	2.1
	$\mu = \frac{2}{3}$ oe Accept 0.67 or better	A1	2.2a
	S.C. For F „ μR, B0 $\frac{1}{2}Mg \times \frac{4}{3}$ „ μMg M1		

	$\frac{2}{3}$ „ μ A0 **N.B.** If $\mu = \frac{2}{3}$ follows this, they could score all the marks.		
		(5)	
d	$\sqrt{F^2 + R^2}$	M1	3.1a
	$\sqrt{\left(\frac{2}{3}Mg\right)^2 + (Mg)^2}$	M1	1.1b
	$\frac{1}{3}Mg\sqrt{13}$ or $1.2Mg$ or better	A1	2.2a
		(3)	
e	New value of S would be **larger** as the **moment** of the **weight** about ***A*** would be larger	B1	3.5a
		(1)	
			(13 marks)

Notes:

a	B1	Any equivalent appropriate statement.
b	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors. **N.B.** If a's never appear, M0
	A1	Correct equation
	A1*	Correct given answer correctly obtained, **with no wrong working seen.** Allow $\frac{1}{2}Mg\cot\theta = S$ or $S = \frac{Mg\cot\theta}{2}$ or $\frac{Mg\cot\theta}{2} = S$ or $S = \frac{Mg}{2}\cot\theta$ or similar but NOT $S = \frac{1}{2}\cot\theta\ \text{Mg}$ or similar **N.B.** Allow m instead of M Must be θ in final answer but allow a different angle in the working.
c	B1	cao
	B1	cao
	B1	Seen anywhere, e.g. on the diagram
	dM1	Using $F = \mu R$, their two equations and substitute for trig (not necessarily correctly) to produce an equation in μ only. This mark is **dependent** on the 3 previous B marks.
	A1	Accept 0.67 or better

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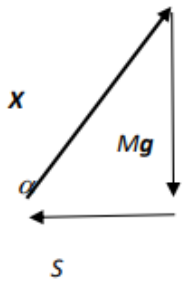
d	M1	Use of Pythagoras with square root to find the required magnitude, but *F* and *R* do not need to be substituted
	M1	Substitute for their *F* and their *R* in terms of *Mg* and take square root to obtain magnitude in terms of *M* and *g* only. **N.B.** Must be using Pythagoras
		ALTERNATIVE: Using trig on triangle of forces  M1: $X = \frac{Mg}{\sin\alpha}$ or $\frac{S}{\cos\alpha}$ M1: substitute for $\sin\alpha$ or $\cos\alpha$ and *S*, where $\tan\alpha = \frac{Mg}{S}$ $(=\frac{3}{2})$, to obtain *X* in terms of *M* and *g* only.
	A1	Any equivalent surd form or 1.2*Mg* or better Must be in terms of *M* and *g*
e	B1	Correct answer and any equivalent appropriate statement.