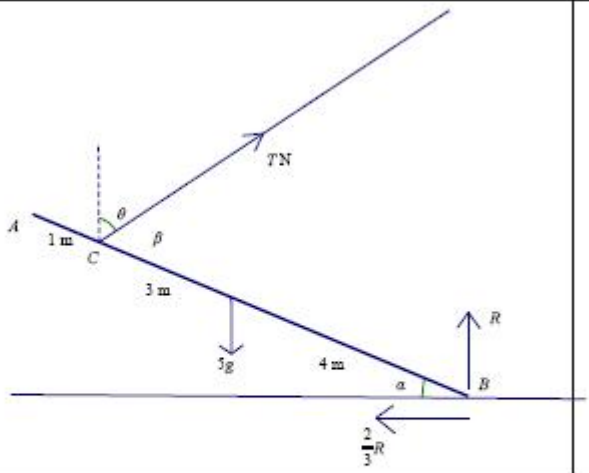
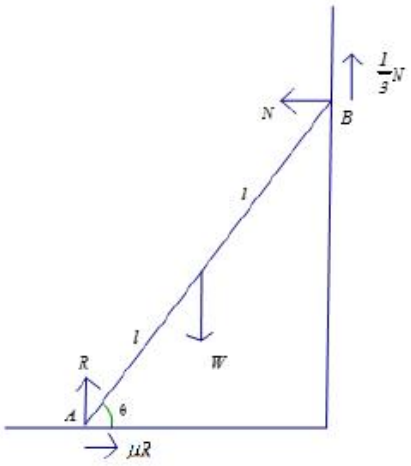
Mark Scheme

Q1.

Q.	Scheme	Marks	Notes
a			
	$F=\frac{2}{3}R$ seen or implied	B1	Use of $F=\mu R$. Could be on diagram. Allow in (b) if not seen before
	$\text{M}(C): 5g\times 3\cos\alpha + F\times 7\sin\alpha = 7\cos\alpha\times R$	M1	Moments about C or alternative complete method to find equation in F and R or R only. Dimensionally correct and all terms needed. Condone sin/cos confusion and sign error(s).
		A1	At most one error
		A1	Correct unsimplified equation
	$15g\cos\alpha = R\left(7\cos\alpha - \frac{14}{3}\sin\alpha\right)$		
	$15g\times\frac{4}{5} = R\left(7\times\frac{4}{5} - \frac{14}{3}\times\frac{3}{5}\right) = \frac{14}{5}R$	dM1	Substitute for F and trig and solve for R Dependent on previous M1
	$R=\frac{30}{7}g = 42\,(\text{N})$	A1	
		(6)	
	e.g. of alternative for M1A1A1:		
	$\text{M}(A): T\sin\beta + 8R\cos\alpha = 8F\sin\alpha + 20g\cos\alpha$ **and** $\text{M}(B): 7T\sin\beta = 20g\cos\alpha$	(M1)	
		(A1)	At most 1 error
	$\frac{20g}{7}\cos\alpha + 8R\cos\alpha = 8F\sin\alpha + 20g\cos\alpha$	(A1)	Correct unsimplified equation in F and R or R only

Q.	Scheme	Marks	Notes
b	Resolve ↕: $T\cos\theta + R = 5g$ $R + T\sin(\beta-\alpha) = 5g$	M1	Need all terms. Condone sin/cos confusion and sign error(s).
		A1	Correct in R or *their* R
	Resolve ↔: $T\sin\theta = F\,(=28)$ $F\left(=\frac{2}{3}R\right) = T\cos(\beta-\alpha)$	M1	Need both terms. Condone sin/cos confusion
		A1	Correct in R or *their* R
	Solve simultaneous equations for $\beta-\alpha$		
	$\tan(\beta-\alpha)=4$, $\beta = 50.9°$ $(51°)$	A1	cso . Max 3 s.f.
		(5)	
Alt b	M(B): $7\times T\sin\beta = 5g\cos\alpha\times 4$	M1	Moments equation. Dimensionally correct. Condone sin/cos confusion and sign error(s).
	$\left(T\sin\beta = \frac{16}{7}g\right)$	A1	
	OR: resolve perpendicular to the rod: $T\sin\beta + R\cos\alpha = 5g\cos\alpha + \frac{2}{3}R\sin\alpha$	(M1) (A1)	
	Resolve parallel to rod: $T\cos\beta + 5g\sin\alpha = F\cos\alpha + R\sin\alpha$ $\left(=\frac{2}{3}R\cos\alpha + R\sin\alpha\right)$	M1	All terms needed. Condone sin/cos confusion and sign error(s).
	$\left(T\cos\beta = \frac{13}{7}g\right)$	A1	
	Solve simultaneous equations for β		
	$\tan\beta = \frac{16}{13}$, $\beta = 50.9°$ $(51°)$	A1	cso. Max 3 s.f.
		(5)	
		[11]	

Q2.

Question Number	Scheme	Marks	
			NB: If μ and $\frac{1}{3}$ are used the wrong way round the candidate loses the first A1 and the final A1.
	Resolve horizontally or vertically:	M1	Allow without friction $= \mu R$
	$\mu R = N$ or $W = R + \frac{1}{3}N$	A1	With coefficient(s) of friction . Condone Wg
	Take moments about A or B.	M1	All terms required but condone sign errors and sin/cos confusion. Terms must be resolved.
	$M(A)$: $2lN\sin\theta + 2l\frac{N}{3}\cos\theta = Wl\cos\theta$ $M(B)$: $2l\cos\theta R = Wl\cos\theta + \mu R 2l\sin\theta$	A2	-1 each error. Could be in terms of Fs. -1 if see Wg in place of W. Any Friction force used should be acting in the right direction. Mark the equation, not what they have called it.

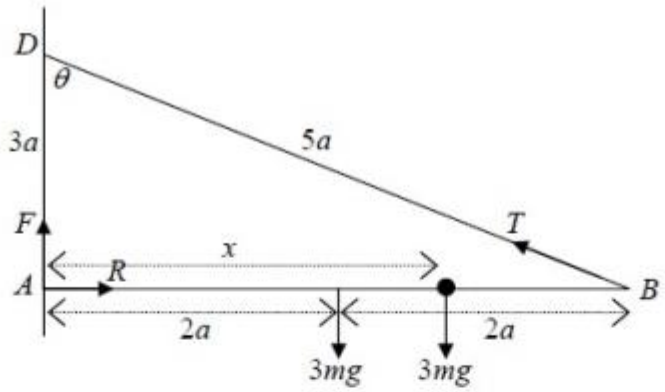
	$\frac{10}{3}N+\frac{2}{3}N=W$ or $2R=W+2\mu R\times\frac{5}{3}$	M1	Use $\tan\theta=5/3$ (substitute values for the trig ratios)
	$\Rightarrow 4N=W\Rightarrow 4N-R=\frac{1}{3}N$	DM1	Equation in N and R (Eliminate one unknown) Dependent on the moments equation
	$\frac{11}{3}\mu R=R$	DM1	Solve for μ Dependent on the moments equation
	$\mu=\frac{3}{11}(\simeq 0.273)$	A1	0.27 or better
Alt 1	Resolve horizontally or vertically:	M1	Allow without friction $=\mu R$
	$\mu R=N$ or $W=R+\frac{1}{3}N$	A1	With coefficient(s) of friction
		M1	Take moments about A or B. All terms required but condone sign errors and sin/cos confusion. Terms must be resolved.

	$M(A)$: $2lN\sin\theta+2l\frac{N}{3}\cos\theta=Wl\cos\theta$ $M(B)$: $2l\cos\theta R=Wl\cos\theta+\mu R2l\sin\theta$	A2	-1 each error, Could be in terms of Fs. -1 if Wg used. Mark the equation, not what they have called it. Any Friction force used should be acting in the right direction. For this method they need two moments equations – allows the marks for their best equation.
	$2lN\sin\theta+2l\frac{N}{3}\cos\theta=2l\cos\theta R-$ $=2l\cos\theta R-\mu R2l\sin\theta$	M1	Use two moments equations to eliminate W Dependent on the moments equation
	Use of $\tan\theta$: $2\mu\times\frac{5}{3}+\frac{2}{3}\mu=2-2\mu\times\frac{5}{3}$	M1	Substitute for the trig ratios
	Solve for μ: $\left(\frac{20}{3}+\frac{2}{3}\right)\mu=2$,	DM1	Dependent on the moments equation
	$\mu=\frac{3}{11}(\simeq 0.273)$	A1	0.27 or better

Alt 2	Resolving horizontally or vertically:	M1	Allow without friction $= \mu R$
	$\mu R = N$ or $W = R + \frac{1}{3}N$	A1	With coefficient(s) of friction (condone Wg)
	$l\cos\theta \times R = l\cos\theta \times \frac{1}{3}N + l\sin\theta \times N + l\sin\theta \times \mu R$	M1	Moments about the centre of the rod. All terms required. Terms must be resolved. Condone sign errors and sin/cos confusion. Allow without friction $= \frac{1}{3}N$. Any Friction force used should be acting in the right direction.
		A2	-1 each error. Could be in terms of Fs. -1 if Wg used.

	$l\cos\theta \times R = l\cos\theta \times \frac{1}{3}\mu R + l\sin\theta \times \mu R + l\sin\theta \times \mu R$	DM1	Obtain an equation in μ and θ $\left(\cos\theta = \cos\theta \times \frac{1}{3}\mu + \sin\theta \times \mu + \sin\theta \times \mu\right)$ Dependent on the moments equation
	$\cos\theta\left(1 - \frac{1}{3}\mu\right) = 2\mu\sin\theta \Rightarrow$ $\tan\theta = \frac{1 - \frac{1}{3}\mu}{2\mu} = \frac{5}{3}$	M1	Use of $\tan\theta$ (substitute values for the trig ratios)
	Solve for μ: $10\mu = 3 - \mu$,	DM1	Dependent on the moments equation
	$\mu = \frac{3}{11} (= 0.273)$	A1	0.27 or better
		[9]	

Q3.

Question Number	Scheme	Marks
(a)		
	M(A) $3mg \times 2a + 3mgx = T\cos\theta \times 4a$ $= \frac{12}{5}aT$	M1 A2,1,0
	$\frac{12}{5}aT = 6mga + 3mgx$	
	$T = \frac{25}{4}mg \qquad \frac{12}{5}a \times \frac{25}{4}mg = 6mga + 3mgx$	M1
	$15a = 6a + 3x$ $x = 3a$ **	A1 (5)
(b)	R$(\rightarrow)$ $R = T\sin\theta$	M1
	$= \frac{25}{4}mg \times \frac{4}{5}$	A1
	$= 5mg$ **	A1 (3)
(c)	R$(\uparrow)$ $F + \frac{25}{4}mg \times \frac{3}{5} = 3mg + 3mg$	M1 A2,1,0
	$F = 6mg - \frac{15}{4}mg = \frac{9}{4}mg$	
	$\mu = \frac{F}{R} = \frac{\frac{9}{4}mg}{5mg} = \frac{9}{20}$	DM1 A1
		(5) **13**

Q4.

	$m(B): R \times 4\cos\alpha = F \times 4\sin\alpha + 20g \times 2\cos\alpha$	M1 A2
	Use of $F = \frac{1}{2}R$	M1
	Use of correct trig ratios	B1
	R = 160N or 157N	DM1 A1
		[7]

Q5.

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
	$Wa\cos\alpha + 7W2a\cos\alpha = S\,2a\sin\alpha$	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 $P = (3W + \text{their } F)$ or $P = (3W - \text{their } F)$

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

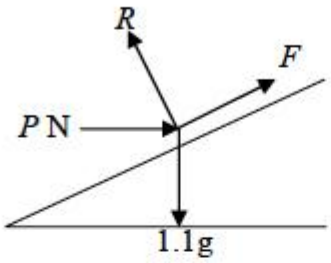
2nd M1: for showing, by resolving vertically, that R increases as a result of the builder's assistant standing on the bottom of the ladder

3rd M1: for concluding that this increases the limiting friction at A

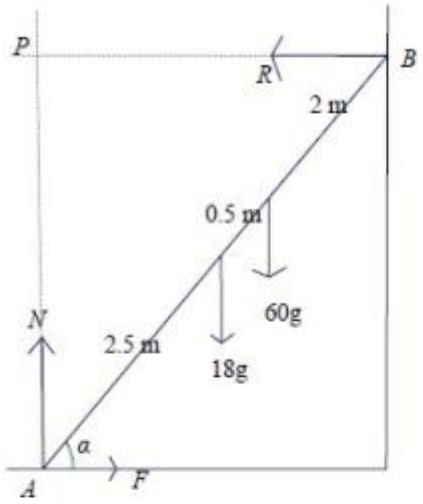
Q6.

Question Number	Scheme	Marks
(a)	B: $2mg - T = 2m \times 4g/9$	M1 A1
	$\Rightarrow T = \underline{10mg/9}$	A1 (3)
(b)	A: $T - \mu mg = m \times 4g/9$	M1 B1 A1
	Sub for T and solve: $\mu = 2/3$ *	DM1 A1 (5)
(c)		
	When B hits: $v^2 = 2 \times 4g/9 \times h$	M1 A1
	Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$	M1 A1 f.t.
	Speed of A at P: $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$	DM1
	$\Rightarrow V = \frac{2}{3}\sqrt{(gh)}$	A1 (6)
(d)	Same tension on A and B	B1 (1)
		15

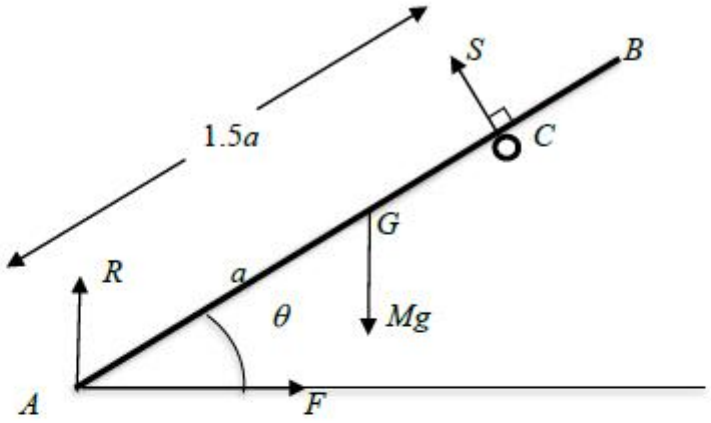
Q7.

Question Number	Scheme	Marks
(a)		B2 -1 e.e.o.o. (labels not needed) (2)
(b)	$F = \frac{1}{2}R$ $(\uparrow),\ R\cos\alpha + F\sin\alpha = mg$ $R = \dfrac{1.1g}{(\cos\alpha + \frac{1}{2}\sin\alpha)} = 9.8\ \text{N}$ $(\rightarrow),\ P + \frac{1}{2}R\cos\alpha = R\sin\alpha$ $P = R(\sin\alpha - \frac{1}{2}\cos\alpha)$ $= 1.96$	B1 M1 A2 M1 A1 (6) M1 A2 M1 A1 (5) **[13]**

Q8.

Q	Scheme	Marks	
			
	$F = \mu N$	B1	Used. Condone an inequality.
	$R(\uparrow)$ $18g + 60g = N$	M1	Resolve vertically
	$=78g$	A1	
	$R(\rightarrow)$ $R = F = \mu N$		
P	$2.5 \times 18g\cos\alpha + 3 \times 60g\cos\alpha = 5F\sin\alpha$	M1A2	Moments equation. Condone sign errors. Condone sin/cos confusion
A	$18g \times 2.5\cos\alpha + 60g \times 3\cos\alpha = R \times 5\sin\alpha$		-1 each error
C	$\frac{1}{2}\cos\alpha \times 18g + 3\sin\alpha F + 2\sin\alpha R = 3\cos\alpha N$		
B	$5\cos\alpha N = 5\sin\alpha F + 2.5\cos\alpha \times 18g + 2\cos\alpha \times 60$		
W	$60g \times \frac{1}{2}\cos\alpha + 2.5N\cos\alpha = 2.5R\sin\alpha + 2.5F\sin\alpha$		
	$45\times\frac{3}{5}g + 180\times\frac{3}{5}g = 4R$	DM1	Eliminate α. Dependent on the second M1.
	$R = \frac{135}{4}g$		
	$78g\mu = \frac{135}{4}g$	DM1	Equation in μ only. (Dependent on the first two M marks.)
	$\mu = \frac{135}{4\times 78} = \frac{135}{312} = 0.432... = 0.43$	A1	NB g cancels. 0.43269..., $\frac{225}{520}$, $\frac{45}{104}$, awrt 0.433 Do not accept an inequality.
	NB If use just two moments equations, M1A2 for the better attempt, M1A1 for the other. Remaining marks as above.		

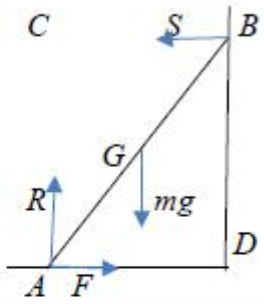
Q9.

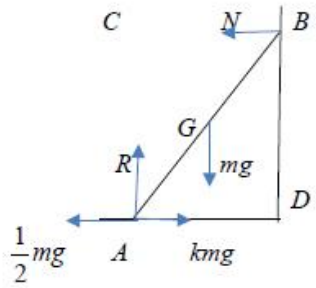
Question	Scheme	Marks	AOs
			
(a)	Take moments about A	M1	3.1a
	$S\times 1.5a = Mga\cos\theta = (Mga\times\frac{3}{5})$	A1	1.1b
	$S=\frac{2}{5}Mg$ *	A1*	2.2a
		(3)	
(b)	**N.B. Marks for the equations should be awarded in the order in which they appear on the script.**		
	Resolve horizontally:	M1	3.4
	$F = S\sin\theta$	A1	1.1b
	Resolve vertically:	M1	3.3
	$R = Mg - S\cos\theta$	A1	1.1b

	Other possible equations: (any of which is worth max M1A1) (parallel to the rod): $F\cos\theta + R\sin\theta = Mg\sin\theta$ (perp to the rod): $F\sin\theta + Mg\cos\theta = S + R\cos\theta$ M(B): $(S\times 0.5a)+(R\times 2a\cos\theta)=(Mg\times a\cos\theta)+(F\times 2a\sin\theta)$ M(C): $(R\times 1.5a\cos\theta)=(Mg\times 0.5a\cos\theta)+(F\times 1.5a\sin\theta)$ M(G): $(R\times a\cos\theta)=(S\times 0.5a)+(F\times a\sin\theta)$ **N.B. If they have more than two equations, mark only those that they use to try to find μ**		
	$F=\mu R$ and two of their equations used to solve for μ	DM1	3.1a
	$\mu=\frac{8}{19}=0.42105\ldots$	A1	2.2a

		(6)	
			(9 marks)
Notes:			
a	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors. Allow use of a different letter for the angle. **N.B.** They may resolve the weight into two components, parallel and perpendicular to the rod, and then take the moment of each about A, one of which is 0. (see **N.B.** below) **N.B.** M0 if one or both a's aren't there originally.	
	A1	Correct equation, $\cos\theta$ may or may not be replaced by $\frac{3}{5}$ **N.B.** you may see: $S\times 1.5a = Mg\cos\theta\times a$	
	A1*	Given answer correctly obtained, need to see $\cos\theta=\frac{3}{5}$ used Allow: $S=\frac{2Mg}{5}$ or $\frac{2Mg}{5}=S$ A0 if S is missing	
b	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors	
	A1	Correct first equation, S does not need to be substituted	
	M1	Correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors	
	A1	Correct second equation, S does not need to be substituted	
	DM 1	Dependent on previous two M marks for using $F=\mu R$ and two equations to solve for μ	
	A1	Accept 0.42 or better (as g cancels)	

Q10.

Question	Scheme	Marks	AOs
	Part (a) is a 'Show that..' so equations need to be given in full to earn A marks		
(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
	($\updownarrow$) $R = mg$ **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), $kmga\sin\theta + Na\sin\theta = \frac{1}{2}mga\sin\theta + Ra\cos\theta$ 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**	A1	1.1b
	$N = kmg - F$ **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)

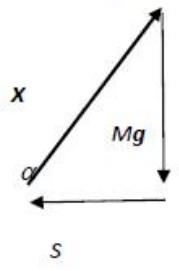
Notes:		
a	M1	Any moments equation with correct terms, condone sign errors and sin/cos confusion
	A1	Correct equation
	B1	Correct equation
	DM1	Dependent on M1, for using their equations (they must have enough) and $F \le \mu R$ to give an inequality in μ and θ only (allow M1 for use of $F = \mu R$ to 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)
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 (they must have enough) with trig substituted, to solve for k, which must be numerical.
	A1	cao

Q11.

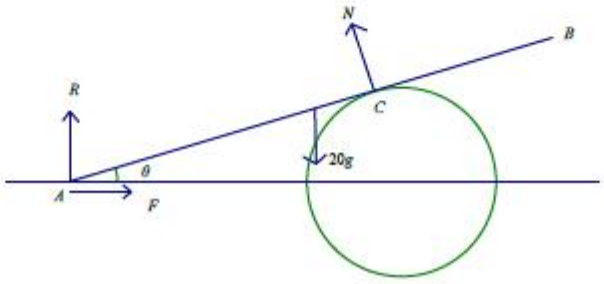
Question	Scheme	Marks	AOs
(a)	The normal reaction at *B* is acting to the left so it must act to the right, right as it needs to balance (oppose, counter) the force at *B*, right as it prevents the rod from sliding (slipping, falling), right as the weight (mass) of the rod will mean the rod tends to 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 1.2*Mg* 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 α'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 $S = \frac{1}{2}\cot\theta\,\mathrm{Mg}$ 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

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.

Q12.

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** $= \sqrt{(H^2 + S^2 - 2HS\cos(90^\circ - \theta)}$ Alternative 2	M1	3.1b
	Magnitude = 67 or 66.5 (N)	A1	2.2a
		(9)	

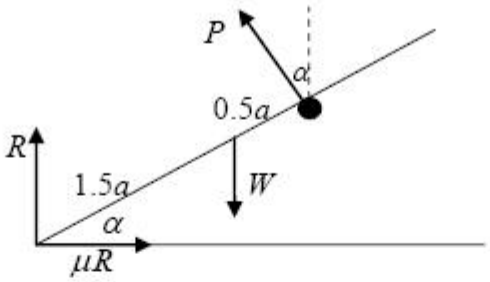
(c)	Magnitude of the normal reaction (at C) will **decrease**.	B1	3.5a
		(1)	
		(11)	

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

Q13.

Question Number	Scheme		Marks
(a)			
	$R(\uparrow)\quad R+P\cos\alpha=W$		M1 A1
	$M(A)\quad P\times 2a=W\times 1.5a\cos\alpha$		M1 A1
	$\left(P=\frac{3}{4}W\cos\alpha\right)$		
	$R=W-P\cos\alpha=W-\frac{3}{4}W\cos^2\alpha$		DM1
	$=\frac{1}{4}\left(4-3\cos^2\alpha\right)W$ *	cso	A1 (6)
(b)	Using $\cos\alpha=\frac{2}{3}$, $\quad R=\frac{2}{3}W$		B1
	$R(\rightarrow)\quad \mu R=P\sin\alpha$		M1 A1
	Leading to $\mu=\frac{3}{4}\sin\alpha$		
	$\left(\sin\alpha=\sqrt{\left(1-\frac{4}{9}\right)}=\frac{\sqrt{5}}{3}\right)$		
	$\mu=\frac{\sqrt{5}}{4}$	awrt 0.56	M1 A1 (5)
			(11 marks)