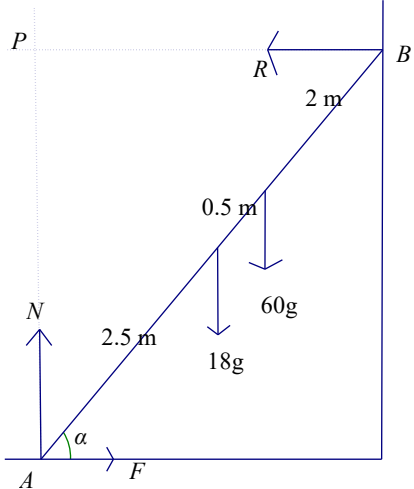


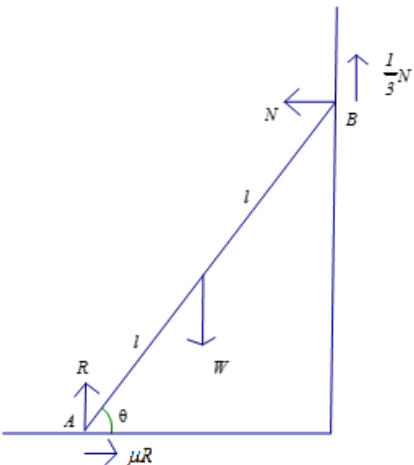
A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme	Marks
1		
	$F = \mu N$	B1
	$R(\uparrow) \quad 18g + 60g = N$	M1
	$= 78g$	A1
	$R(\rightarrow) \quad R = F = \mu N$	
P	$2.5 \times 18g \cos \alpha + 3 \times 60g \cos \alpha = 5F \sin \alpha$	M1 A1 A1
A	$18g \times 2.5 \cos \alpha + 60g \times 3 \cos \alpha = R \times 5 \sin \alpha$	
C	$\frac{1}{2} \cos \alpha \times 18g + 3 \sin \alpha F + 2 \sin \alpha R = 3 \cos \alpha N$	
B	$5 \cos \alpha N = 5 \sin \alpha F + 2.5 \cos \alpha \times 18g + 2 \cos \alpha \times 60g$	
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
	$R = \frac{135}{4}g$	
	$78g\mu = \frac{135}{4}g$	M1
	$\mu = \frac{135}{4 \times 78} = \frac{135}{312} = 0.432\dots = 0.43$	A1
		(9 marks)

A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme		Marks
2(a)	$M(A), F \ 4 \sin 40^\circ = 5g \ 2 \cos 25^\circ$	A complete method to find F , e.g. take moments about A . Condone sin/cos confusion. Requires correct ratio of lengths.	M1
		Correct terms with at most one slip	A1
		All correct	A1
	$F = 35$	35 or 34.5 (>3sf not acceptable due to use of 9.8, but only penalise once in a question)	A1
			(4)
2(b)	$F \cos 75^\circ \pm Y = 5g$	Resolve vertically. Need all three terms but condone sign errors. Must be attempting to work with their 75° or 15° .	M1
		Correct equation (their F)	A1
	$Y = 40$	40 or 40.1 Apply ISW if the candidate goes on to find R .	A1
	UP	Cso (the Q does specifically ask for the direction, so must be clearly stated)	A1
			(4)
			(8 marks)

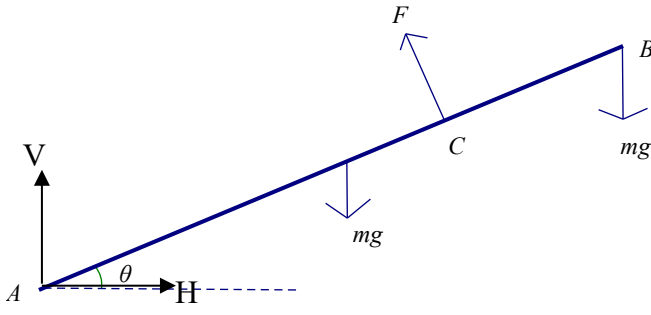
A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme	Marks
3		
	Resolve horizontally or vertically:	M1
	$\mu R = N$ or $W = R + \frac{1}{3} N$	A1
	Take moments about A or B .	M1
	$M(A): 2lN \sin \theta + 2l \frac{N}{3} \cos \theta = Wl \cos \theta$ $M(B): 2l \cos \theta R = Wl \cos \theta + \mu R 2l \sin \theta$	A2
	$\frac{10}{3} N + \frac{2}{3} N = W$ or $2R = W + 2\mu R \times \frac{5}{3}$	M1
	$\Rightarrow 4N = W \Rightarrow 4N - R = \frac{1}{3} N$	dM1
	$\frac{11}{3} \mu R = R$	dM1
	$\mu = \frac{3}{11} (\approx 0.273)$	A1
		(9 marks)

A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme	Marks
4	$AC = 4a \tan 60^\circ = 4a\sqrt{3}.$	M1 A1
		(2)
	use of $F = \mu R$ at either A or C	M1
	3 independent equations required. Award M1A1 for each in the order seen. If more than 3 relevant equations seen, award the marks for the best 3.	
	$M(A), \quad R_C \cdot 4a\sqrt{3} = W \cdot 3a\sqrt{3} \cos 60^\circ$	M1 A1
	$(\uparrow), \quad R_A + R_C \cos 60^\circ + F_C \cos 30^\circ = W$	M1 A1
	$(\rightarrow), \quad F_A - R_C \cos 30^\circ + F_C \cos 60^\circ = 0$	M1 A1
	$M(C) \quad a\sqrt{3} \cos 60^\circ W + F_A \cdot 4a\sqrt{3} \sin 60^\circ = R_A \cdot 4a\sqrt{3} \cos 60^\circ$	
	Parallel: $F_A \cos 60^\circ + R_A \cos 30^\circ + F_C = W \cos 30^\circ$	
	Perpendicular: $R_C + R_A \cos 60^\circ = F_A \cos 30^\circ + W \cos 60^\circ$	
	solving to give $\mu = \frac{\sqrt{3}}{5}$; 0.346 or 0.35.	DM1 A1
	Reactions in the wrong direction(s) – check carefully	
		(9)
		(11 marks)

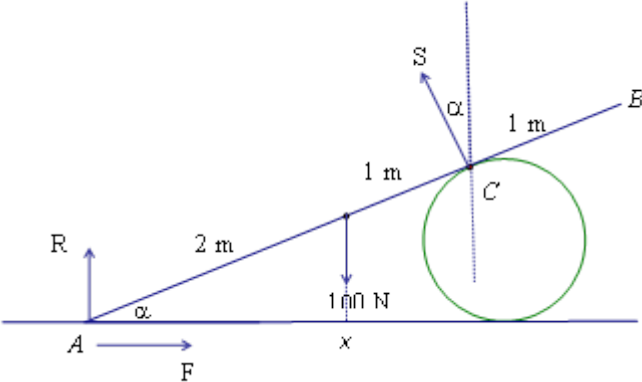
A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme	Marks
5(a)		
	Moments about A:	M1
	$bF = a \cos \theta mg + 2a \cos \theta mg (= 3a \cos \theta mg)$	A2
	$F = \frac{3amg \cos \theta}{b}$ *Answer given*	A1
		(4)
5(b)	$\rightarrow: H = F \sin \theta = \frac{3amg \cos \theta \sin \theta}{b}$	M1 A1
	$\uparrow: 2mg = \pm V + F \cos \theta$	M1 A1
	$\pm V = 2mg - \frac{3amg \cos \theta}{b} \times \cos \theta \left(= 2mg - \frac{3amg \cos^2 \theta}{b} \right)$	A1
		(5)
5(c)	$\frac{2mg - \frac{3amg \cos^2 \theta}{b}}{\frac{3amg \cos \theta \sin \theta}{b}} = \tan \theta$	M1 A1
	$\frac{2b - 3a \cos^2 \theta}{3a \cos \theta \sin \theta} = \frac{\sin \theta}{\cos \theta}$ $\Rightarrow 2b - 3a \cos^2 \theta = 3a \sin^2 \theta \Rightarrow 2b = 3a, \frac{a}{b} = \frac{2}{3}$	DM1 A1
		(4)
		(13 marks)

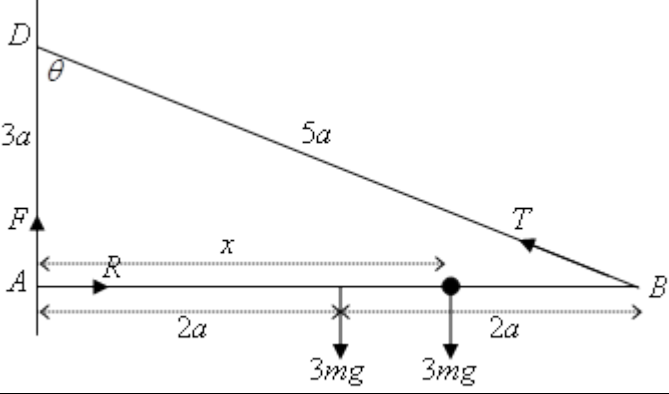
A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme	Marks
6(a)	Taking moments about A:	M1
	$4g \times 0.7 \times \cos 20^\circ = 1.4T$	A1 A1
	$T = 18.4 \text{ N}$	A1
		(4)
6(b)	$\uparrow R + T \cos 20 = 4g$	
	$R = 4g - T \cos 20^\circ$	M1 A1
	$\rightarrow F = T \sin 20$	M1 A1
	$F = \mu R \Rightarrow T \sin 20^\circ = \mu(4g - T \cos 20^\circ)$	M1 A1
	$\mu = \frac{T \sin 20^\circ}{4g - T \cos 20^\circ} = 0.29$	A1
		(7)
		(11 marks)
7(a)	Resolving vertically: $Y + P \cos \theta = W$	M1
		A1
	Moments about A: $Wl \cos \theta = 2lP$	M1
		A1
	$P = \frac{W \cos \theta}{2} \Rightarrow Y = W - \frac{W \cos^2 \theta}{2} = \frac{W}{2}(2 - \cos^2 \theta) \quad **$	DM1 A1
		(6)
7(b)	NB $W + Y = P \cos \theta$ with correct conclusion is possible	
	$\theta = 45^\circ \Rightarrow Y = \frac{3W}{4}$	B1
	$X = P \sin 45$	M1
	$= \frac{W \cos 45}{2} \cdot \sin 45 \left(= \frac{W}{4} \right)$	DM1 A1
	Resultant at A = $\frac{W}{4} \sqrt{3^2 + 1^2} = \frac{W\sqrt{10}}{4} \quad (0.79W)$	DM1 A1
		(6)
		(12 marks)

A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

Question	Scheme	Marks
8		
	Taking moments about A:	
	$3S = 100 \times 2 \times \cos \alpha$	M1 A1
	Resolving vertically:	
	$R + S \cos \alpha = 100$	M1 A1
	Resolving horizontally:	
	$S \sin \alpha = F$	M1 A1
	(Most alternative methods need 3 independent equations, each one worth M1A1. Can be done in 2 e.g. if they resolve horizontally and take moments about X then $R \times 2 \times \cos \alpha = S \times (3 - 2 \times \cos^2 \alpha)$ scores M2A2)	
	Substitute trig values to obtain correct values for F and R (exact or decimal equivalent).	DM1
	$\left(S = \frac{200\sqrt{8}}{9} \right), R = 100 - \frac{1600}{27} = \frac{1100}{27} \approx 40.74, F = \frac{200\sqrt{8}}{27} \approx 20.95\dots$	A1
	$F \leq \mu R, 200\sqrt{8} \leq \mu \times 1100, \mu \geq \frac{200\sqrt{8}}{1100} = \frac{2\sqrt{8}}{11}.$	M1
	Least possible μ is 0.514 (3sf), or exact.	A1
		(10 marks)

A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

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

A level Mathematics Practice Paper – Statics of rigid bodies – Mark scheme

	Source paper	Question number	New spec references	Question description	New AOs
1	M2 Jan 2013	3		Statics of rigid bodies	1.1b, 1.2, 3.1b
2	M2 2012	3		Statics of rigid bodies	1.1b, 2.1, 2.2a, 3.1b
3	M2 2015	4		Statics of rigid bodies	1.1b, 2.1, 3.1b, 3.3
4	M2 2013R	4		Statics of rigid bodies	1.1b, 2.1, 3.1b, 3.4
5	M2 2013	5		Statics of rigid bodies	1.1b, 2.1, 2.2a, 3.1b
6	M2 Jan 2012	5		Statics of rigid bodies	1.1b, 1.2, 2.2a, 3.1b
7	M2 2014	7		Statics of rigid bodies	1.1b, 2.1, 2.2a, 3.1b
8	M2 Jan 2011	7		Statics of rigid bodies	1.1b, 1.2, 2.1, 2.2a, 2.5, 3.1b
9	M2 2011	7		Statics of rigid bodies	1.1b, 1.2, 2.2a, 3.1b