AQA Mechanics

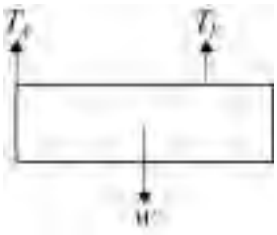
Topic Questions from Papers

Moments and Equilibrium

Answers

1	$5T_A = 20\times 9.8\times 1.5$	M1		Moment equation.
		A1		Correct equation
	$T_A = \dfrac{20\times 9.8\times 1.5}{5} = 58.8$ N	A1		Correct tension
	$T + 58.8 = 20\times 9.8$	M1		Vertical equation with T or moments equation.
		A1		Correct equation
	$T = 137.2$ N	A1	6	Correct tension
	Total		**6**	

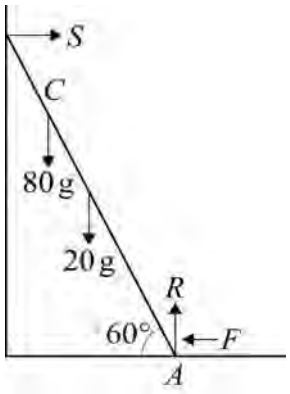
(Q1, Jan 2006)

2 (a)		B1	1	Arrows + labels, w in centre
(b)	M(A) $0.4W = 0.6T_B$	M1		Moments equation
	$T_B = \dfrac{2W}{3}$	A1		Accept 2 dp
	Res$\uparrow$ or M (B) $T_A = \dfrac{W}{3}$	M1 A1	4	for each A1
(c)	Lamina is uniform $\Rightarrow$ weight acts at centre	B1	1	
	Total		**6**	

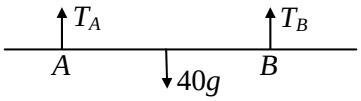
(Q2, Jan 2007)

3 (a)	Centre of mass of rod is 3 m from river bank	B1		Use of centre of mass is centre of rod
	Taking moments about A, edge of bank:			Or resolve $R = 65g$ B1
	$3 \times 15 = 50x$	M1		Moments about any point (correct) M1
	$x = 0.9$	A1	3	0.9 A1
(b)	Taking moments about A:			
	$50 \times 2 = 15 \times 3 + m \times 8$	M1A1		M1 3 terms, 2 correct
	$55 = 8m$	A1		
	$m = 6\frac{7}{8}$			
	Mass is $6\frac{7}{8}$ kg	A1	4	Accept 6.88 and 6.87
(c)	Centre of mass of rod is 3 m from river bank	E1	1	Centre of mass is at centre of rod
(d)	eg Woman is a particle The mass is a particle The plank is a rigid rod	E1	1	
	Total		**9**	

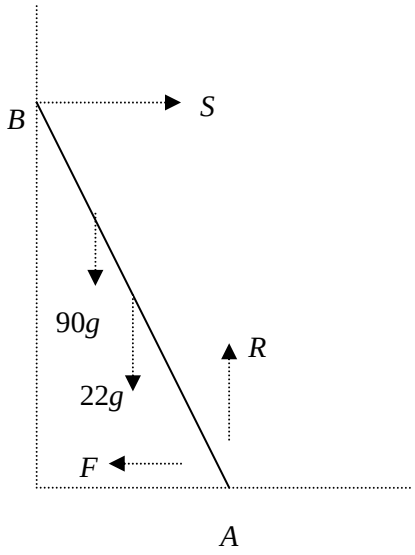
(Q4, June 2007)

4 (a)		B2	2	B1 for any 4 correct
(b)	Resolve vertically:			
	$R = 20g + 80g$			Must see $20g + 80g$ or $100g$ to obtain any marks in (b)
	$= 100g$	B1		
	Using $F = \mu R$:	m1		Dep on B1
	$F = 0.4 \times 100g$			
	$= 40g$ or 392 N	A1	3	AG
(c)	Resolve horizontally:			
	$S = 40g$	B1		
	Moments about A:			
	$80gx\cos 60 + 20g.2\cos 60$	M1A1		M1 for 3 terms, all moments
	$= S.4\cos 30$	A1		
	$40gx + 20g = 138.56g$			
	$x = \frac{118.56}{40}$	m1		Dep on M1
	= 2.96 m	A1	6	Accept $2\sqrt{3} - \frac{1}{2}$
	Total		**11**	

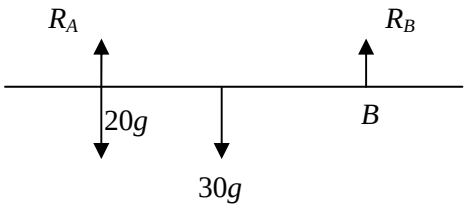
(Q3, Jan 2008)

5 (a)		B1	1	
(b)	Taking moments about A			
	$2.1 \times 40g = T_B \times 4$	M1 B1		B1 for 2.1
	$T_B = 21g$	A1	3	
(c)	Resolve vertically $T_A + T_B = 40g$	M1		
	$T_A = 19g$ or 186 N	A1	2	
(d)	Gravitational force acts through mid point of the rod	E1	1	
	Total		**7**	

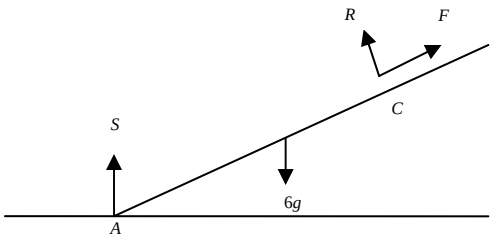
(Q2, June 2008)

6 (a)				
	Resolve vertically: $R = 22g + 90g$ $= 112g$	B1		
	Using $F = \mu R$: $F = 0.6R$	M1		
	$F = 0.6 \times 112g$	A1		[Needs $0.6\times112g$ or 0.6×1097.6 NOT 0.6×1097 unless 658.56 seen]
	$= 67.2g$ or 658.56 $F = 659$ N	A1	4	AG (659 must be shown from correct working)
(b)	Resolve horizontally: $S = F$	B1		
	Moments about A: $90g \times 5 \times \cos\theta + 22g \times 3 \times \cos\theta$	M1A1		M1 (one term, force × distance × cos or sin)
	$= 67.2g \times 6 \times \sin\theta$ $450g + 66g = 403.2g \tan\theta$ $\tan\theta = \frac{516}{403.2}$	A1		
	$\theta = 52.0°$	A1	5	accept 52 **Alternative**: or moments about B: M1 A2, 1 or 0 for four-term moment equation + M1 for rearranging etc (dep on 4 term) + A1 for answer
	Total		**9**	

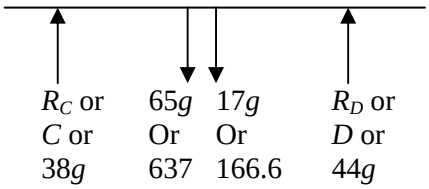
(Q3, June 2009)

7 (a)		B2	2	B1 for four forces B2 for two different reactions and 30g and 20g marked
(b)	Taking moments about A: $3.2\times 30g = R_B \times 5$ $R_B = 19.2g$	 M1B1 A1	 3	 B1 for 3.2 AG
(c)	Resolve vertically: $R_A + R_B = 50g$ $R_A = 30.8g$ or 302 N	M1 A1	 2	Can be awarded in (b)
(d)	Gravitational force acts through mid-point of the rod	E1	1	
	Total		**8**	

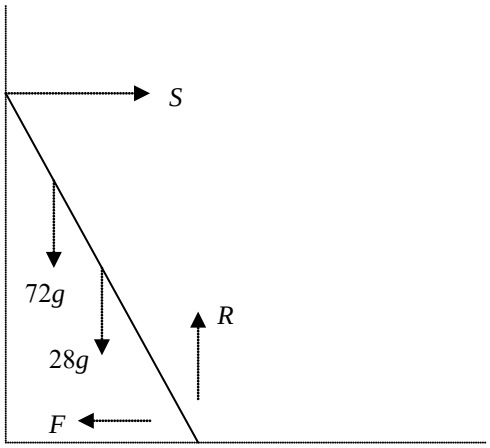
(Q3, Jan 2010)

8 (a)		B2	2	B1 for S and 6g (in correct place) B1 for R and F or combined vertical force at C
(b)	Moments about C: $3 \times S \times \cos 20 = 6g \times 1 \times \cos 20$ S = 19.6 N or 2g	 M1A1 A1	 3	 M1 2 terms, 1 term correct R, F not correct 0 marks in (c)(i) and (c)(ii)
(c)(i)	Moments about A: $2 \times 6g \times \cos 20 = R \times 3$ R = 36.8 N (or resolving, $R = 6g\cos 20 - S\cos 20$ $= 4g\cos 20$)	 M1A1 A1		**Or** Moments about mid-point of rod: $2 \times S \times \cos 20 = P \times 1 \times \cos 20$ P = 39.2 N or 4g (Or resolving vertically $P = 4g$)
(ii)	Resolve parallel to AB: $S\cos 70 + F = 6g\cos 70$ $F = 4g\cos 70$ = 13.4 N (or $F = 6g\sin 20 - S\sin 20 = 4g\sin 20$)	 M1 A1	 5	$R = P \times \cos 20$ M1 A1 = 36.8 N A1 $F = P \times \sin 20$ M1 = 13.4 N A1
(d)	Using $F = \mu R$: $13.4 = \mu \times 36.8$ μ = 0.364 or tan20	M1 A1√	 2	M1 '(c)(ii)' = μ '(c)(i)' (condone ≥)
	Total		**12**	

(Q7, June 2010)

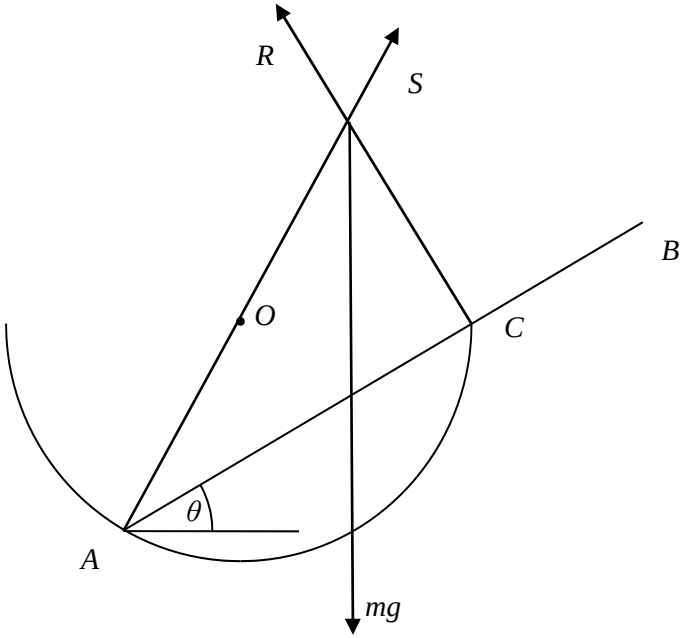
9 (a)		B1 B1	2	B1: Two weights correct and in correct relative positions. B1: Two upward reaction forces, labelled differently. Note all forces must be shown as arrows and have labels. Condone use of $g = 9.81$ for calculating weights.
(b)	Taking moments about C $3 \times 17g + 2.6 \times 65g = 44g \times d$	B1 M1 A1		B1: Seeing 2.6. M1: Three term moment equation including $17g$, $65g$ and $44g$ or 17, 65 and 44, with different distances for the $17g$ and $65g$. A1: Correct equation.
	$44d = 220$ $d = 5$			
	Distance is $5 - 4.6 = 0.4$ m	A1	4	A1: Correct final answer.
	Alternative $R_C = 38g$ Taking moments about D $38g(4.6 + x) = 65g(2 + x) + 17g(1.6 + x)$ $174.8 - 130 - 27.2 = 44x$ $x = 0.4$	(B1) (M1) (A1) (A1)		Could take moments about any other point
(c)	Gravitational force (centre of mass or weight) at mid-point (or centre) of the plank	E1	1	E1: Correct explanation.
	Total		**7**	

(Q4, June 2011)

10 (a)				accept 'weight of man' or w_m etc for $72g$
	force diagram	B2	2	B1 for any error
(b)(i)	moments about P:			
	$72g \times 6 \times \cos 69 + 28g \times 4 \times \cos 69$	M1		3 terms including distance and angles
	$= S \times 8 \times \sin 69$	A1A1		A1 2 correct terms
	$(432g + 112g)\cos 69 = 8\ S \sin 69$			
	$S = 255.8$	A1		accept division seen eg $\frac{544g}{8\tan 69}$
	$= 256$N		4	
(ii)	resolve vertically:			
	$R = 28g + 72g$			
	$= 100g$	B1		
	resolve horizontally:			
	$S = F$	B1		
	using $F = \mu R$:			
	$\mu = 256 \div 100g$	M1		
	$= 0.261$	A1	4	
	Total		**10**	

(Q3, Jan 2012)

11 (a)	Smooth, hence reaction is perpendicular to possible movement	E1	1	
(b)				



		B2	2	B1 for 2 forces correct
(c)	Resolving along the rod:			Or geometrically:
	$S\cos\theta = mg\sin\theta$	M1A1		three forces act through a point B1 M1 is for 2 or 3 terms; 1 term correct (could be horizontal force at C used)
	Moment about C: $S\,2a\cos\theta\,.\sin\theta$			[forces act through point D]
	$= mg(2a\cos\theta - \frac{1}{2}l)\cos\theta$	M1A1		$AD\cos 2\theta = \frac{l}{2}\cos\theta$ M1A1
	$4a.S\sin\theta = mg(4a\cos\theta - l)$			$AD\cos\theta = 2a\cos\theta$ M1
	Dividing: $4a\tan\theta = \frac{4a\cos\theta - l}{\sin\theta}$			$l = \frac{4a\cos 2\theta}{\cos\theta}$ A1
	$l = 4a\cos\theta - 4a\sin\theta\tan\theta$			
	$l = \frac{4a\cos 2\theta}{\cos\theta}$	A1	5	

cont	**or** Resolving perpendicular to S: $R\cos\theta = mg\cos 2\theta$ Moments about A: $R\ 2a\cos\theta = mg\frac{1}{2}l\cos\theta$ $4a\ R = mgl$ $4amg\ \cos 2\theta = mgl\cos\theta$ $l = \dfrac{4a\cos 2\theta}{\cos\theta}$ **or** Resolving horizontally: $R\sin\theta = S\cos 2\theta$ Resolving vertically: $R\cos\theta + S\sin 2\theta = mg$ Moments about A: $R\ 2a\cos\theta = mg\frac{1}{2}l\cos\theta$ $4a\ R = mgl$ $R\cos\theta + R\dfrac{\sin\theta}{\cos 2\theta}\ \sin 2\theta = 4a\dfrac{R}{l}$ $l = \dfrac{4a\cos 2\theta}{\cos\theta}$	(M1A1) (M1A1) (A1) (M1A1) (M1A1) (A1)		Both attempted for M1 Both correct for A1
	Total		**8**	

(Q9, Jan 2013)

12 (a)(i)	Moments about Q $2.2 \times 25g = T_P \times 4.2$ $T_P = 13.095 \times g$ $T_P = 128$ N Resolving vertically $T_P + T_Q = 25g$ or 245 $T_Q = 117$ N	M1 A1 A1 M1 A1	 5	**Or** Moments about any point M1A1 Moments about any other point M1 T_P A1 ; T_Q A1
(ii)	Weight of plank acts through its centre	E1	1	
(b)	Resolve vertically $T_P + T_Q = (25 + m)g = 2T_P$ Moments about B $T_P \times 5 + T_Q \times 0.8 = 25g \times 3$ $(25 + m)g \times 2.9 = 25g \times 3$ $2.9mg = 25g \times 0.1$ $29m = 25$ $m = 0.862$ or $\frac{25}{29}$	M1 A1 M1 A1 M1 A1	 6	Could use T rather than T_P , T_Q **Or** Moments about Q $T_P \times 4.2 = 25g \times 2.2 - mg \times 0.8$ $\frac{1}{2} \times (25 + m)g \times 4.2$ $= 25g \times 2.2 - mg \times 0.8$ $2.9mg = 25g \times 0.1$ $29m = 25$ **OR** Moments about any point M1A1 Moments about any other point M1A1 Solution M1A1
	Total		**12**	

(Q4, June 2013)