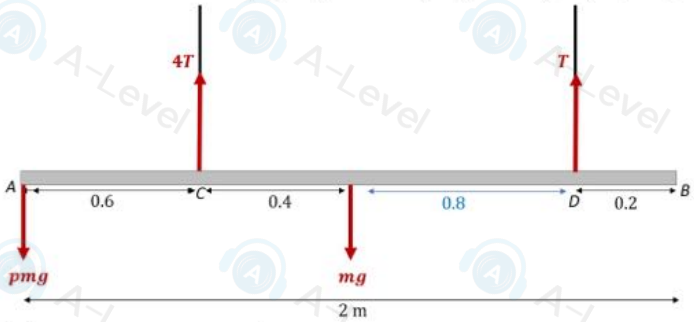
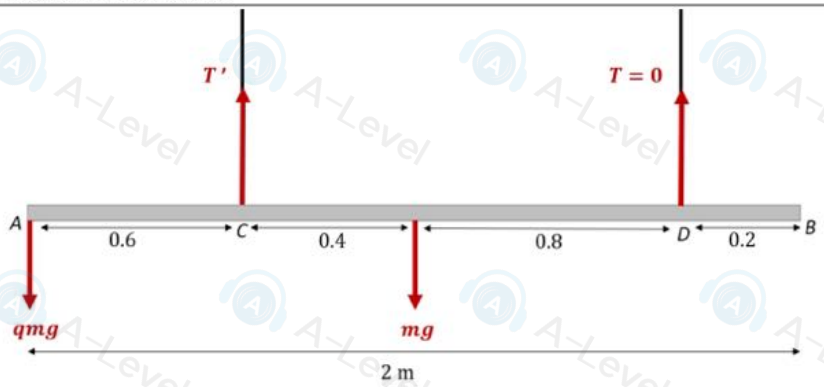
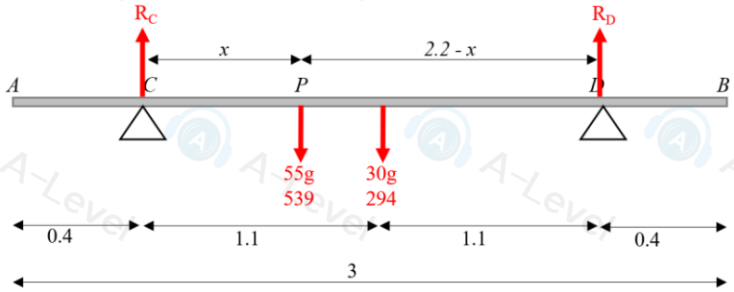
Question Number	Scheme	Marks
2(a)	**N.B.** Consistent use of extra g's in **two** equations can score the A marks for the equations and could score full marks for part (a). **N.B.** If they assume that the rod is uniform, can only score marks for a vertical resolution. R$(\uparrow)$: $0.5R_C + R_C = 60 + 12$ (N.B. $R_A = \frac{1}{2}R_C$)	M1A1
	Possible moments equations: M(A): $60x + (12\times 5) = R_C \times 3$ M(B): $(2\times R_C) + \left(\frac{1}{2}R_C \times 5\right) = 60(5-x)$ M(C): $(\frac{1}{2}R_C \times 3) + (12\times 2) = 60(3-x)$ M(G): $12(5-x) + \frac{1}{2}R_C x = R_C(3-x)$	M1A1
	Eliminate R_C and solve for x (AG)	**DM1**
	$x = 1.4$ m	A1 (6)
(b)	(i) the weight of the parcel acts at B	B1
	(ii) the plank remains straight	B1 (2)
	(or equivalent statements)	**[8]**
	Notes for qu 2	
	N.B. If R and $\frac{1}{2}R$ are reversed, max score is M1A1 (resolution) M1A0 (moments)	
2a	First M1 for first equation, correct no. of terms, dim correct, condone sign errors and allow R and S at this stage and for moments equations allow a different length variable	
	First A1 for a correct resolution in one unknown or moments equation in two unknowns	
	Second M1 for second equation, correct no. of terms, dim correct, condone sign errors and allow R and S at this stage and for moments equations allow a different length variable	
	Second A1 for a correct resolution in one unknown or moments equation in two unknowns	
	Third DM1, dependent on both previous M marks, for eliminating and solving for AG	
	Third A1 for 1.4 (m) oe	
2b (i)	First B1 e.g. mass is concentrated **at *B*** B0 if incorrect extras	
(ii)	Second B1 e.g. the plank doesn't buckle or bend B0 if incorrect extras	

Question Number	Scheme	Marks
7(a)	For B, $S = 3mg\cos\alpha$ For B, $3mg\sin\alpha - T - F_1 = 3ma$ For A, $R = mg$ For A, $T - F_2 = ma$ $F_1 = \frac{1}{3}S$; $F_2 = \frac{1}{5}R$ Solving for T $T = \frac{3mg}{5}$ or $5.88m$	M1 A1 M1 A2 B1 M1 A1 M1 **DM1** A1 (11)
(b)	Constant tension throughout the string.	B1 (1)
(c)	$R = 2T\cos\frac{(180^o - \alpha)}{2}$ $(= 2T\sin\frac{1}{2}\alpha)$ $(2T\cos 63.4^o)$ $= 2\times\frac{3mg}{5}\times\frac{\sqrt{5}}{5}$ $= \frac{6mg\sqrt{5}}{25}$ $(5.3m$ or $5.26m)$	M1 A1 DM1 A1 (4) **16**
	OR: $R = \sqrt{(T - T\cos\alpha)^2 + (T\sin\alpha)^2}$ or $R = \sqrt{(T^2 + T^2 - 2T^2\cos\alpha}$ Substitute their expression for T (MUST be in terms of m) and a correct value of α $= \frac{6mg\sqrt{5}}{25}$ $(5.3m$ or $5.26m)$	M1A1 DM1 A1
	Notes	
	N.B. Use of sin(4/5) or similar, treat as an A error but allow recovery	
7(a)	First M1 for resolving perp to the plane , with usual rules	
	First A1 for a correct equation	
	Second M1 for equation of motion parallel to the inclined plane, with usual rules	
	Second and Third A1's for a correct equation -1 each error	
	B1 cao	
	Third M1 for equation of motion horizontally, with usual rules	
	Fourth A1 for a correct equation	
	Fourth M1 for using '$F = \mu R$' correctly twice	
	Fifth DM1, dependent on all M marks, for solving for T in terms of m *only*	
	Fifth A1 cao	
	N.B. Either equation of motion can be replaced by the whole system equation: $3mg\sin\alpha - F_1 - F_2 = 4ma$ (M1A2 or M1A1 as appropriate)	
(b)	Penalise extra wrong answers	
(c)	First M1 for attempt at correct expression for R in terms of T and α with usual rules i.e. condone cos/sin confusion but must be using the correct angle (can be in terms of α)	

	Special Case: Allow max M1A1DM0A0 if *m* is lost from their *T* but expression for *R* is otherwise correct.	
	First A1 for a correct expression for R in terms of T and α	
	Second DM1 for substituting in their expression for T and a correct value for α but must be in terms of m	
	Second A1 for a correct answer (any equivalent surd form)	

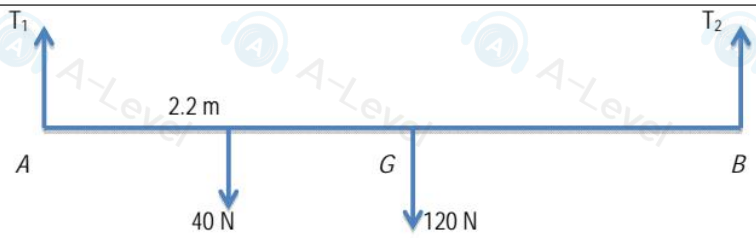
Question Number	Scheme	Marks
4(a)	T and $4T$ correctly placed	B1
	Vertical resolution $T+4T=pmg+mg$ **OR** a moments equation, see below.	M1 A1
	$\mathrm{M}(A):\ (4T\times0.6)+(T\times1.8)=(mg\times1)$  Other moments equations: $\mathrm{M}(C):\ (pmg\times0.6)+(T\times1.2)=(mg\times0.4)$ $\mathrm{M}(G):\ (pmg\times1)+(T\times0.8)=(4T\times0.4)$ $\mathrm{M}(D):\ (pmg\times1.8)+(mg\times0.8)=(4T\times1.2)$ $\mathrm{M}(B):\ (4T\times1.4)+(T\times0.2)=(pmg\times2)+(mg\times1)$	M1 A1
	Eliminate T $5\left(\frac{5mg}{21}\right)=pmg+mg$	M1
	$p=\frac{4}{21}$ (exact ratio of 2 positive integers)	A1
		(7)
4(b)	Tension at D is zero, seen or implied.	B1
	$\mathrm{M}(C):\ (qmg\times0.6)=(mg\times0.4)$	M1 A1
	$q=\frac{2}{3}$ (exact ratio of 2 positive integers), accept 0.666….. or $0.\dot{6}$	A1
		(4)
4(c)	The centre of mass (or gravity) of the beam is in the middle; the mass (weight) of the beam acts at the middle, mass at centre, centre of mass at the centre. Penalise incorrect extras.	B1
		(1)
		(12)
Notes for Question 4		
(a)	**N.B.** Full marks can be scored if consistent omission of g's in a **complete solution,** but otherwise penalise omission of g's	
B1	Correct relationship between the tensions and placed correctly, seen or implied.	
M1	Vertical resolution. Condone forces at C and D the wrong way round or written as T_C and T_D. This equation may be replaced with a moments equation.	

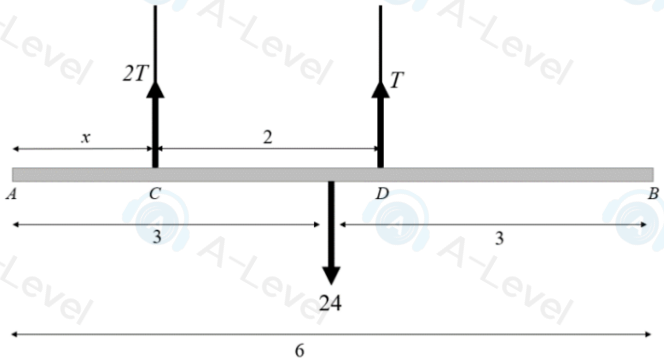
A1	Correct unsimplified equation (<u>even if T and $4T$ are the wrong way round on their diagram</u>)
M1	Moments equation. Correct forces multiplied by a length. Condone consistent forces at C and D the wrong way round or written as T_C and T_D
A1	Correct unsimplified equation, **in a variable consistent with their first equation.**
M1	Eliminate T to give an equation in p only allow extra m's or g's or both
A1	Cao. Must be exact.
	N.B. If they write down more than two equations, award the marks for those equations which they use to solve the problem.
(b)	
B1	Recognise tension at D is 0, seen or implied
M1	Complete method to obtain an equation q only. e.g. Moments about C equation.
A1	Correct unsimplified equation in q only.
A1	Cao. Must be exact.
ALT (b)	
M1	Two other equations could be used and solved to find q. M0 if tension at D is never zero.
A1	Correct unsimplified equation in q only.
A1	Cao. Must be exact.
	 Alternative equations: vert : $T' = qmg + mg$ M(A): $(T' \times 0.6) = (mg \times 1)$ M(G): $(qmg \times 1) = (T' \times 0.4)$ M(D): $(qmg \times 1.8) + (mg \times 0.8) = (T' \times 1.2)$ M(B): $(qmg \times 2) + (mg \times 1) = (T' \times 1.4)$
(c)	
B1	Any appropriate comment

QUESTION NUMBER	SCHEME	MARKS
5		
5(a)	M(D) $(R_C \times 2.2) = 55g(2.2-x) + 30g(1.1)$	M1A1
	$(R_C) = (686 - 245x)$ (N) *	A1 *
	N.B. The M mark here is not available if they use $R_C = 4R_D$ to obtain the given result.	
		(3)
5(b)	$R_C = 4R_D$	M1
	Vert: $R_C + R_D = 55g + 30g \Rightarrow \frac{5}{4}(686 - 245x) = 55g + 30g$ Relevant moments equations: M(C): $55gx + 30g(1.1) = R_D(2.2)$ M(A): $R_C(0.4) + R_D(2.6) = 55g(x+0.4) + 30g(1.5)$ M(P): $R_C x + 30g(1.1-x) = R_D(2.2-x)$ M(G): $R_C(1.1) = 55g(1.1-x) + R_D(1.1)$ M(B): $R_D(0.4) + R_C(2.6) = 30g(1.5) + 55g(2.6-x)$	M1A1
	$x = 0.08$	A1
		(4)
5(c)	M(C): $Mg(0.4) = 30g(1.1)$	M1 A1
	$M = 83$ or 82.5 or $\frac{165}{2}$ oe	A1
	Other possible equations with $S_D = 0$ Vert: $S_C = Mg + 30g$ M(A): $S_C(0.4) = 30g(1.5)$ M(G): $S_C(1.1) = Mg(1.5)$ M(D): $S_C(2.2) = 30g(1.1) + Mg(2.6)$ M(B): $S_C(2.6) = 30g(1.5) + Mg(3)$	

	from which S_C would need to be eliminated to give an equation in M only.	
		(3)
		(10)

	Notes for question 5	
(a)		
M1	Forms an equation in R_C and x only. Dimensionally correct and the correct no. of terms. Either a moments equation about D or two other equations combined to eliminate R_D.	
A1	Correct unsimplified equation	
A1*	Correctly reaches the given answer with at **least one line of intermediate working.**	
(b)		
M1	**Use** of $R_C = 4R_D$	
M1	Complete method to form an equation in x only. Dimensionally correct and the correct no. of terms. Either vertical resolution or a moments equation(s) with R_C and R_D eliminated. R_C **must be replaced with the given expression in (a)**. R_D replaced with $\frac{1}{4}R_C$ but condone $4R_C$ for the method mark.	
A1	Correct unsimplified equation in x only.	
A1	Correct answer	
(c)		
M1	Use $S_D = 0$ and forms an equation in M only. Dimensionally correct and the correct no. of terms. M0 if $S_D \neq 0$.	
A1	Correct unsimplified equation	
A1	Correct answer, 83 or 82.5 o.e.	

Question Number	Scheme	Marks
5(a)		
(i)	$M(B),\ 4T_1 = 120 \text{ x } 1.8 + 40(4-x)$ $T_1 = 94 - 10x$	M1 A1 A1
(ii)	$M(A),\ 4T_2 = 120 \text{ x } 2.2 + 40x$ $T_2 = 66 + 10x$	M1 A1 A1 (6)
(b)	$94 - 10x \le 84$ $x \ge 1$ $66 + 10x \le 84$ $x \le 1.8$ $1 \le x \le 1.8$	M1 M1 A1 both CV A1 (4) **10**
	Notes	
5(a)(i) **(ii)**	First M1 for a complete method to find an equation in T_A and x only. First A1 for a correct equation in T_A and x only. Second A1 for $94 - 10x$ Second M1 for a complete method to find an equation in T_B and x only. First A1 for a correct equation in T_B and x only. Second A1 for $66 + 10x$	
5(b)	First M1 for their $T_A \le 84$ or $= 84$ or < 84 to give equation or inequality in x only. (> 84 is M0) Second M1 for their $T_B \le 84$ or $= 84$ or < 84 to give equation or inequality in x only. (> 84 is M0) First A1 for both critical values of x, 1 and 1.8 SEEN. Second A1 $1 \le x \le 1.8$ or $1 \le x$ AND $x \le 1.8$ or [1, 1.8]	

QUESTION NUMBER	SCHEME	MARKS
1		
	Form a moments equation M(A): $(2T\times x)+T(x+2)=(24\times 3)$	M1 A1
	Form a second equation vert $3T=24$	M1
	Alternative moments equations in x and T M(C): $24(3-x)=T\times 2$ M(G): $2T(3-x)=T(x-1)$ M(D): $(2T\times 2)=24\times(x-1)$ M(B): $2T(6-x)+T(4-x)=(24\times 3)$ M(C): $\frac{24x}{6}\times\frac{x}{2}+2T=\frac{24(6-x)}{6}\times\frac{(6-x)}{2}$	
	$T=8\,(\text{N})$	A1
	$x=\frac{7}{3}$ accept 2.3 or better	A1
		(5)
	Notes for question 1	
M1	Forms a moments equation in x and T only with the correct no. of terms. Allow consistent extra g' s. M0 if no x.	
A1	Correct unsimplified moments equation. Where two moments equations are used, award this mark for the first correct equation.	
M1	Resolves vertically to give equation in T only or a second moments equation in x and T (M0 if no x.). Must be dimensionally correct with the correct no. of terms.	
A1	Correct value for tension at D	
A1	Correct value for x. Accept 2.3 or better **N.B.** If T and $2T$ the wrong way round or they use $24g$, can score max M1A0M1A0A0.	

Question Number	Scheme	Marks	Notes
7			
(a)	$3g - T = 3a$	M1 A1	Eqn of motion for Q: must have the correct terms but condone sign errors Correct equation
	$T - 2g\cos 60 = 2a \qquad (T - g = 2a)$	M1 A1	Eqn of motion for P: must have the correct terms but condone sign errors. Weight must be resolved. Correct equation
	Allow M1A1 for $3g - 2g\cos 60 = 5a$ in place of either of these two equations		
	$2g = 5a \qquad a = \frac{2g}{5}$ *	DM1 A1	Use an exact method to solve for a (i.e. not the equation solver on their calculator). Dependent on the first 2 M marks or the M for the combined equation. Given answer derived correctly from exact working.
	$T = 2\times\frac{2g}{5} + g = \frac{9g}{5}$	M1 A1 (8)	Use given acceleration to solve for T. accept 18 or 17.6
(b)	$v^2 = 2\times\frac{2g}{5}\times 0.6 = \frac{2.4g}{5}$	M1	Use the given acceleration to find the speed
	$v = \frac{2}{5}\sqrt{3g}$ oe involving g	A1 (2)	Accept 2.2 or 2.17

Question Number	Scheme	Marks	Notes
(c)	String slack: accel of P (up plane) $= -g\cos 60 = -\frac{1}{2}g$	B1	
	$0 = \frac{2.4g}{5} - gs$	M1	Use of $v^2 = u^2 + 2as$ or equivalent for their acceleration $\neq \frac{2g}{5}$
	$s = \frac{2.4g}{5} \times \frac{1}{g} = \frac{2.4}{5} = 0.48$	A1	
	Total dist = 1.08 m	A1ft (4)	0.6 + their 0.48
(d)	$0 = \frac{2}{5}\sqrt{3g} - \frac{g}{2}t \quad (0 = 2.17 - 4.9t)$	M1	Use of $v = u + at$ or equivalent with their acceleration $\neq \frac{2g}{5}$ to find t.
	$t = \frac{4\sqrt{3g}}{5g} = 0.4426\ldots$ $= 0.44$ or 0.443	A1 (2)	only
		[16]	

Q	Scheme	Marks	Notes
2a	Resolve vertically or take moments	M1	**First** equation in R_C and/or R_D. Dimensionally correct, correct no. of terms. Condone sign errors. **N.B.** $3Rc + 2R_D = 75g$ or $5Rc = 75g$ are both M0A0 unless they recover.
			N.B. They may use: $R_C = 2R$ and $R_D = 3R$ so $5R = 75g$ is M1A1
	$\updownarrow R_C + R_D = 50g + 25g\,(= 75g)$	A1	Correct unsimplified equation but A0 if they assume $R_C = R_D$. **N.B.** This mark can be awarded even if they clearly have $R_C = 3X$ and $R_D = 2X$ oe
	Form a moments equation or resolve vertically	M1	**Second** equation in R_C and/or R_D. Dimensionally correct, correct no. of terms. Condone sign errors
	M(D): $50gx + 25g \times 1.2 = 3.3R_C$ M(A): $0.9R_C + 4.2R_D = 3 \times 25g + (4.2 - x)50g$ M(B): $5.1R_C + 1.8R_D = 3 \times 25g + (1.8 + x)50g$ M(C): $3.3R_D = 2.1 \times 25g + (3.3 - x)50g$ M(E): $2.1R_C = (x - 1.2)50g + 1.2R_D$ M(G): $R_D x = 25g(x - 1.2) + R_C(3.3 - x)$	A1	Correct unsimplified equation in R_D or R_C seen but give A0 if the equation is incorrect e.g if they put $3R$ (in place of R_C) straight into the equation. A0 if they assume $R_C = R_D$.
	$(2R_D = 3R_C \Rightarrow R_C = 30g)$ $50x + 30 = 99$	M1	Complete method, using either $2R_D = 3R_C$ or $2R_C = 3R_D$ to find an equation in x only
	$x = \frac{69}{50} = 1.38$ * **N.B.** Two **correct** equations and use of $2R_C = 3R_D$ leads to $x = 2.37$ and could score max : M1A1M1A1M1A0*	A1*	Obtain given answer from correct working, with no incorrect equations seen.
		[6]	
2b	Complete method to form an equation in M only.	M1	e.g. moments about D or vertical resolution and

			moments about another point or two moments equations. Dimensionally correct equation. Condone sign errors
	M(D) $25g\times1.2+50g\times1.38=1.8Mg$ **OR any two of :** $(50+25+M)g=R_D$ M(A) $4.2R_D=3\times25g+(4.2-1.38)50g+6Mg$ M(B) $1.8R_D=3\times25g+(1.8+1.38)50g$ M(C) $3.3R_D=2.1\times25g+(3.3-1.38)50g+5.1Mg$ M(E) $3Mg=(1.38-1.2)50g+1.2R_D$ M(G) $R_D\times1.38=25g(1.38-1.2)+Mg(1.38+1.8)$ **AND** R_D eliminated	A1	Correct unsimplified equation in M
	$(M)=55$	A1	Correct only
		[3]	
		(9)	