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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Moments (M1.4)

International A Level Mathematics · M1: Mechanics 1 (WME01)

16 questions · 125 marks · Mark schemes included

Past papers January 2020 - June 2025 · 1 sub-topic

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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QUESTIONS

16 questions · 125 marks · 1 sub-topic

SUB-TOPIC M1.4a

MOMENTS & EQUILIBRIUM OF RODS

Sub-topic M1.4a · 16 questions · 125 marks · lowest tariff first



1.

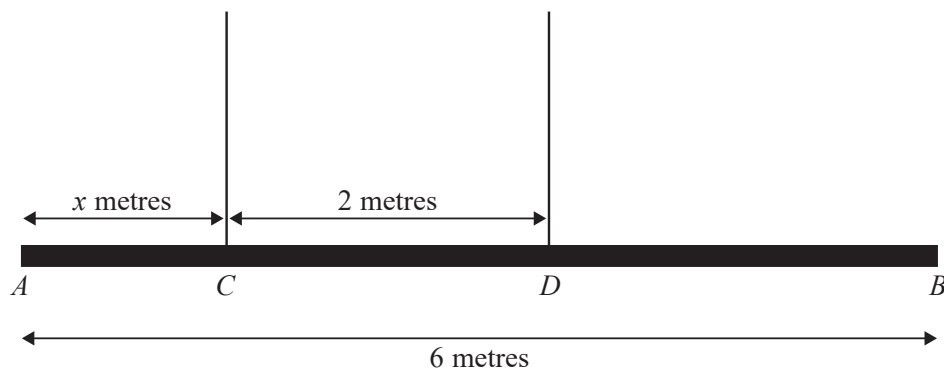
**Figure 1**

Figure 1 shows a beam AB with weight 24 N and length 6 m .

The beam is suspended by two light vertical ropes. The ropes are attached to the points C and D on the beam where $AC = x$ metres and $CD = 2\text{ m}$.

The tension in the rope attached to the beam at C is double the tension in the rope attached to the beam at D .

The beam is modelled as a uniform rod, resting horizontally in equilibrium.

Find

- (i) the tension in the rope attached to the beam at D .
- (ii) the value of x .

(5)

Question 1 continued

(Total for Question 1 is 5 marks)



Question 4 continued

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(Total 6 marks)

Q4

Box for marking the question.



Question 1 continued

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Question 1 continued

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Question 1 continued

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(Total 6 marks)

Q1



Question 2 continued

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Question 2 continued

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Question 2 continued

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(Total 6 marks)

Q2



Question 4 continued

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Question 4 continued

Lined area for writing the answer to Question 4 continued.



Question 4 continued

Lined area for writing the answer to Question 4.

(Total for Question 4 is 6 marks)



Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5.

(Total for Question 5 is 6 marks)



Q2



Question 3 continued

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Question 3 continued

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Question 3 continued

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Handwriting practice area with horizontal lines.

(Total 7 marks)

Q3



Question 4 continued

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Question 4 continued

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Question 4 continued

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(Total 8 marks)

Q4

Box for marking the question.



4.

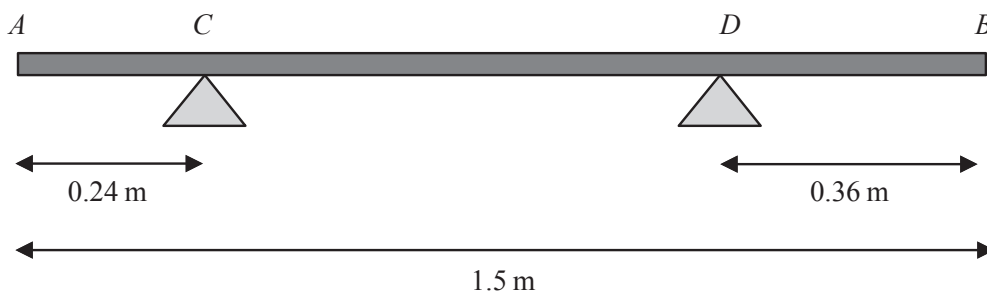


Figure 1

A branch AB , of length 1.5 m , rests horizontally in equilibrium on two supports.

The two supports are at the points C and D , where $AC = 0.24\text{ m}$ and $DB = 0.36\text{ m}$, as shown in Figure 1.

When a force of 150 N is applied vertically upwards at B , the branch is on the point of tilting about C .

When a force of 225 N is applied vertically downwards at B , the branch is on the point of tilting about D .

The branch is modelled as a non-uniform rod AB of weight W newtons.

The distance from the point C to the centre of mass of the rod is x metres.

Use the model to find

- (i) the value of W
- (ii) the value of x

(8)

Question 4 continued



Question 4 continued

(Total for Question 4 is 8 marks)



Question 5 continued

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Question 5 continued

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Question 5 continued

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Q5

(Total 9 marks)



Question 2 continued





(Total for Question 2 is 9 marks)



Question 7 continued

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Question 7 continued

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Question 7 continued

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(Total 10 marks)

Q7



5.

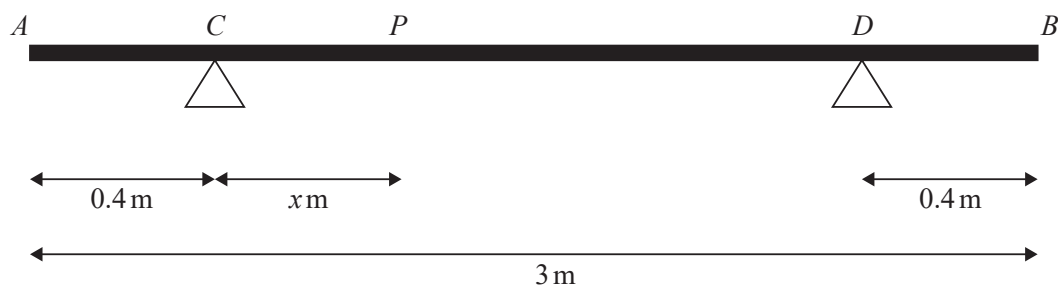


Figure 4

A beam AB has mass 30 kg and length 3 m.

The beam rests on supports at C and D where $AC = 0.4$ m and $DB = 0.4$ m, as shown in Figure 4.

A person of mass 55 kg stands on the beam between C and D .

The person is modelled as a particle at the point P , where $CP = x$ metres and $0 < x < 2.2$

The beam is modelled as a uniform rod resting in equilibrium in a horizontal position.

Using the model,

(a) show that the magnitude of the reaction at C is $(686 - 245x)$ N.

(3)

The magnitude of the reaction at C is **four** times the magnitude of the reaction at D .

Using the model,

(b) find the value of x

(4)

The person steps off the beam and places a package of mass M kg at A .

The package is modelled as a particle at the point A .

The beam is now on the point of tilting about C .

Using the model,

(c) find the value of M

(3)

Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5 continued.



(Total for Question 5 is 10 marks)



4.

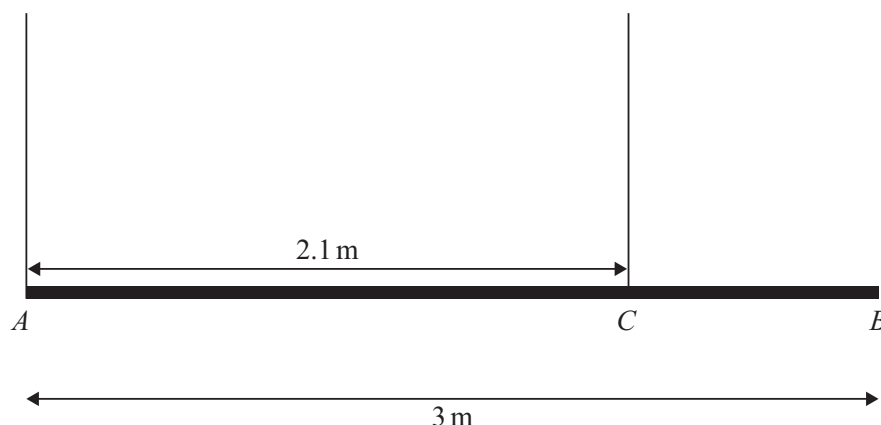


Figure 2

A uniform rod AB has length 3 m and weight W newtons.

The rod is suspended by two light vertical ropes.

One rope is attached to the rod at A and the other rope is attached to the rod at C , where $AC = 2.1$ m.

The rod is in equilibrium in a horizontal position, as shown in Figure 2.

The tension in the rope at C is 350 N.

(a) Show that $W = 490$

(3)

A particle P of weight 210 N is attached to the rod at a distance d metres from A .

The tension in the rope at C is now 600 N.

The rod remains in equilibrium in a horizontal position.

(b) Find the value of d .

(3)

Particle P is removed from the rod.

A particle Q of weight X newtons is now attached at B .

The rod remains in equilibrium in a horizontal position and is now on the point of tilting.

(c) Find the value of X .

(4)



Question 4 continued

Lined area for writing the answer to Question 4 continued.



(Total for Question 4 is 10 marks)



4.

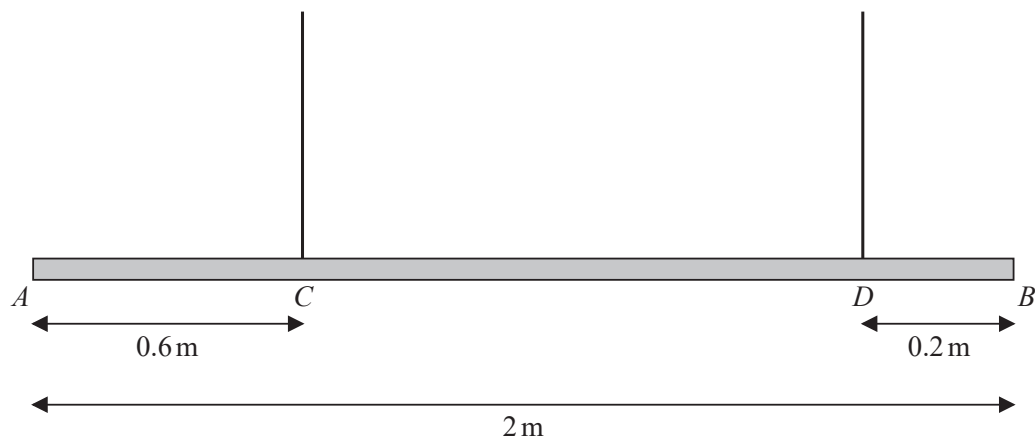


Figure 1

Figure 1 shows a beam AB , of mass m kg and length 2 m, suspended by two light vertical ropes.

The ropes are attached to the points C and D on the beam, where $AC = 0.6$ m and $DB = 0.2$ m

The beam is in equilibrium in a horizontal position.

A particle of mass pm kg is attached to the beam at A and the beam remains in equilibrium in a horizontal position.

The beam is modelled as a uniform rod.

- (a) Given that the tension in the rope attached at C is four times the tension in the rope attached at D , use the model to find the exact value of p .

(7)

The particle of mass pm kg at A is removed and replaced by a particle of mass qm kg at A .

The beam remains in equilibrium in a horizontal position but is now on the point of tilting.

- (b) Using the model, find the exact value of q

(4)

- (c) State how you have used the modelling assumption that the beam is uniform.

(1)

Question 4 continued

Lined area for writing the answer to Question 4 continued.



Question 4 continued

Lined area for writing the answer to Question 4 continued.



Question 4 continued

Lined area for writing the answer to Question 4.

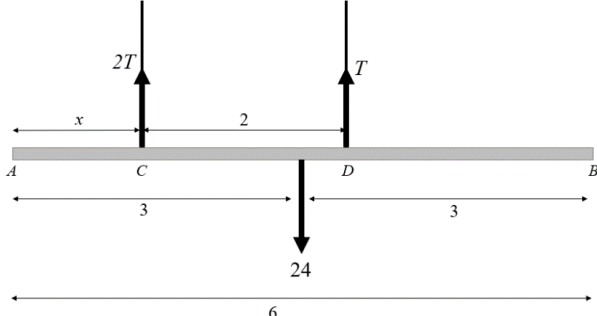
(Total for Question 4 is 12 marks)



MARK SCHEMES

official mark schemes, in the same order as the questions



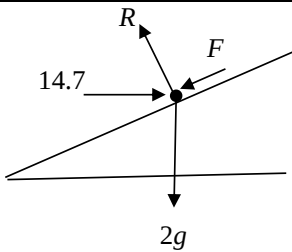
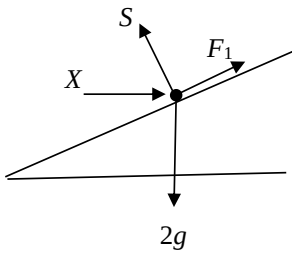
QUESTION NUMBER	SCHEME	MARKS
1		
	Form a moments equation M(A): $(2T \times x) + T(x + 2) = (24 \times 3)$	M1 A1
	Form a second equation vert $3T = 24$	M1
	Alternative moments equations in x and T M(C): $24(3 - x) = T \times 2$ M(G): $2T(3 - x) = T(x - 1)$ M(D): $(2T \times 2) = 24 \times (x - 1)$ M(B): $2T(6 - x) + T(4 - x) = (24 \times 3)$ 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
4.	$M(D), 900 \times 5 = W(5 - x)$ Other possible equations: $(\uparrow), 900 + R_D = W$ $M(A), Wx = 5R_D$ $M(B), (900 \times 6) + (R_D \times 1) = W(6 - x)$ $M(C), (900 \times 1) + W(x - 1) = 4R_D$ $M(G), 900x = R_D(5 - x)$ BUT R_D then needs to be eliminated to produce an equation in W and x only in order to earn the M mark. N.B. M0 if they never put $R_C = 0$ Allow consistent use of Mg for W	M1A1
	$M(C), 1500 \times 5 = W(x - 1)$ Other possible equations: $(\uparrow), 1500 + R_C = W$ $M(A), (1500 \times 6) + (R_C \times 1) = Wx$ $M(B), W(6 - x) = 5R_C$ $M(D), W(5 - x) + (1500 \times 1) = 4R_C$ $M(G), 1500(6 - x) = R_C(x - 1)$ BUT R_C then needs to be eliminated to produce an equation in W and x only in order to earn the M mark. N.B. M0 if they never put $R_D = 0$ Allow consistent use of Mg for W	M1A1
	Solving for x	DM1
	$x = 3.5$	A1
		(6)
	Notes for question 4	
	M1 For an equation in W and one unknown length. Correct no. of terms, dim correct but condone sign errors. An extra g on one side is an A error.	
	A1 Correct equation	
	M1 For an equation in W and the same unknown length. Correct no. of terms, dim correct but condone sign errors. An extra g on one side is an A error.	
	A1 Correct equation	
	DM1 Solving for x , dependent on the two previous M marks.	
	A1 cao with no wrong working seen.	

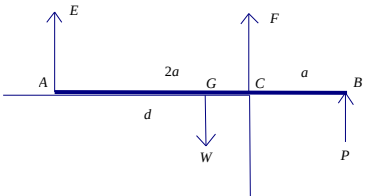
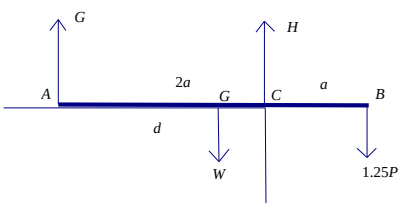


Question Number	Scheme	Marks
1.		
	1 st Equation in d (or another defined unknown), R and M (as appropriate) only	M1 A1
	2 nd Equation in d (or the same defined unknown, R and M (as appropriate) only	M1 A1
	Possible equations: $(\uparrow), R + 2R = Mg$ $M(C), 2R \times 4.5 = Mg(d - 2.5)$ $M(D), R \times 4.5 = Mg(7 - d)$ $M(A), 2.5R + (7 \times 2R) = Mgd$ $M(B), 6.5R + (2 \times 2R) = Mg(9 - d)$ SC: $M(G), R(d - 2.5) = 2R(7 - d)$	M2 A2,1,0
	Solve for d , must be a numerical value	DM1
	$d = 5.5$	A1 (6)
		(6)
	Notes for question 1	
	N.B. Allow M marks for equations if they use R_c and R_D	
	M1 Correct number of terms, dimensionally correct, condone sign errors and missing g	
	A1 Correct equation	
	M1 Correct number of terms, dimensionally correct, condone sign errors and missing g	
	A1 Correct equation	
	DM1 Dependent on previous two M marks, for solving for d	
	A1 $d = 5.5$ oe Ignore an extra m (but not M)	
	N.B. If g is omitted consistently in both equations, all three A marks are available. If they use Rg consistently in both equations, all three A marks are available. If they have 3 equations, mark the ones that are used to obtain d . If R and $2R$ are consistently the wrong way round, apply the scheme, unless an MR gives a better total.	

Question Number	Scheme	Marks
2(a)	$M(D), \frac{3a}{5} Xg = \frac{2a}{5} Mg$ Other possible equations: $(\uparrow)T_D = Mg + Xg$ $M(A), Mga + Xg2a = T_D \frac{7a}{5}$ $M(B), Mga = T_D \frac{3a}{5}$ T_D <u>would then need to be eliminated</u> $M(C), Mg \frac{3a}{5} + Xg \frac{8a}{5} = T_D a$ $M(G), Xga = T_D \frac{2a}{5}$	M1A1
	$X = \frac{2M}{3}$, 0.67 M or better	A1 (3)
2(b)	$M(D), T_c a + \frac{1}{2} Mg \frac{3a}{5} = \frac{2a}{5} Mg$ Other possible equations: $(\uparrow)T_c + T_D = Mg + \frac{1}{2} Mg$ $M(A), Mga + \frac{1}{2} Mg2a = T_c \frac{2a}{5} + T_D \frac{7a}{5}$ $M(B), Mga = T_c \frac{8a}{5} + T_D \frac{3a}{5}$ T_D <u>would need eliminating</u> $M(C), Mg \frac{3a}{5} + \frac{1}{2} Mg \frac{8a}{5} = T_D a$ $M(G), T_c \frac{3a}{5} + \frac{1}{2} Mga = T_D \frac{2a}{5}$	M1A1
	$T_c = \frac{1}{10} Mg$ oe	A1 (3)
		(6)
	Notes for question 2	
2(a)	M1 For an equation (or inequality,,) in X , M and a only (allow consistent missing a 's) with correct no. of terms. Allow if one g is missing. N.B. M0 if T_c appears and never becomes zero	
	A1 Correct equation or inequality	
	A1 cao	
2(b)	M1 For an equation in T_c , M , g and a only (allow consistent missing a 's or if g 's) missing) with correct no. of terms M0 if they assume that $T_c = T_D$ or if they assume their X value from (a).	
	A1 Correct equation	
	A1 cao	

Question Number	Scheme	Marks
3(a)		
	(□), $14.7 \cos \alpha = 2g \sin \alpha + F$ (could be $-F$) (→), $14.7 + F \cos \alpha = R \sin \alpha$ OR: (↑), $R \cos \alpha + F \sin \alpha = 2g$ AND eliminate R to give an equation in F only. <u>Verificaton methods</u> $14.7 \cos \alpha = (11.76) = 2g \sin \alpha$ (i.e. verification that $X = 14.7 \Rightarrow F = 0$) OR: $X \cos \alpha = 2g \sin \alpha \Rightarrow X = 14.7$ (i.e. verification that $F = 0 \Rightarrow X = 14.7$)	M1 A1
	so $F = 0^*$ oe	A1*
		(3)
		
3(b)	$F_1 = 0.5S$	B1
	Two equations taken from: (□), $X \cos \alpha + F_1 = 2g \sin \alpha$ (□), $S = X \sin \alpha + 2g \cos \alpha$ (→), $X + F_1 \cos \alpha = S \sin \alpha$ (↑), $S \cos \alpha + F_1 \sin \alpha = 2g$	M1A2 M1A2

Question Number	Scheme	Marks
4(a)	$M(C), Mg \times 4.5 + 1.2g \times 2 = 4g \times 1.5$	M1A1
	$M = 0.8$ oe	A1 (3)
	Other possible equations: $(\uparrow), Y = 4g + 1.2g + Mg$ $M(A), 5Y = 1.2g \times 3 + 4g \times 6.5 + Mg \times 0.5$ $M(B), 1.5Y = 1.2g \times 3.5 + Mg \times 6$ $M(G), 2Y + Mg \times 2.5 = 4g \times 3.5$ from which Y would need to be eliminated.	
4(b)	$M(E), R_C \times 0.6 = 1.2g \times 2.6$	M1A1
	$R_C = 5.2g$ isw	A1 (3)
	Other possible equations: $(\uparrow), Xg + 1.2g = R_C$ $M(C), Xg \times 0.6 = 1.2g \times 2$ $M(A), 1.2g \times 3 + Xg \times 5.6 = R_C \times 5$ $M(B), 1.2g \times 3.5 + Xg \times 0.9 = R_C \times 1.5$ $M(G), Xg \times 2.6 = R_C \times 2$ from which Xg would need to be eliminated. (Note that $X = 4$) Xg may appear as a single letter.	
		(6)
	Notes	
4(a)	M1: For an equation in M only, with correct number of terms, condone sign errors and missing g 's	
	A1: Correct equation	
	A1: cao	
4(b)	M1: For an equation in R_C only, with correct number of terms, condone sign errors and missing g 's	
	A1: Correct equation	
	A1: $\frac{26g}{5}$, 51 or 51.0	

5	 M(A) OR $\begin{cases} F = 0, E + P = W \text{ and} \\ M(C), M(B), \text{ or } M(G) \end{cases}$	M1	Use of sufficient equations to form an equation in a, d, P and W only All equations dimensionally correct with correct no. of terms. N.B. Must be using P in this case, unless a clear misread. $M(C): aP + W(2a - d) = 2aE$ $M(B): 3aE = (a + 2a - d)W$ $M(G): P(a + 2a - d) = dE$
	$3aP = dW$	A1	Correct unsimplified equation in a, d, P and W only
	 M (C) OR $\begin{cases} G = 0, H = 1.25P + W \text{ and} \\ M(A), M(B), \text{ or } M(G) \end{cases}$	M1	Use of sufficient equations to form another equation in a, d, P and W only All equations dimensionally correct with correct no. of terms. N.B. Must be using $1.25P$ in this case, unless a clear misread. $M(A): Wd + 3a \times 1.25P = 2aH$ $M(B): aH = (a + 2a - d)W$ $M(G): 1.25P(a + 2a - d) = (2a - d)H$
	$1.25Pa = W(2a - d)$	A1	Correct unsimplified equation in a, d, P and W only
	Solve for d in terms of a	DM 1	Complete method. Dependent on the two preceding M marks
	Obtain $(d =) \frac{24a}{17}$	A1	Accept $d = 1.4a$ or better $(d = 1.41176\dots a)$ but NOT $\frac{6a}{4.25}$ or similar.
			N.B. If W is replaced by say, Mg or M etc, can score all the marks but if they use Wg with P in their equations, can score max M1A0M1A0DM1A0.
		(6)	
		(6)	
	N.B. Enter marks on ePEN for the two equations in the same order as they appear in the MS.		

Question Number	Scheme	Marks
2.		
(a)	$T + (T + 20) = W$ $M(A), 4.5(T + 20) = 2.625W$ <u>Any two of these</u> $M(G), 2.625T = 1.875(T + 20)$ $M(C), 4.5T = 1.875W$ $M(B), 6T + 1.5(T + 20) = 3.375W$ N.B. The A marks and the DM1 can only be scored if the candidate is using T and $T + 20$ or T and $T - 20$ in both equations. N.B. Can score M1A1 for a correct vertical resolution, even if T and $T + 20$ are the wrong way round. N.B. If they just use T_A and T_C, can score max M1A0 M1A0DM0A0 If they assume that $T_A = T_C$, can score max M1A0 M1A0DM0A0 If they assume that the tensions are T and 20, can score max M1A0 M1A0 DM0A0 If they use T and $20T$, can score max M1A0 M1A0DM0A0 N.B. If it's not clear from their working which way round they have the two tensions, use their diagram to decide.	M1 A1 M1 A1
	Solve for W	DM1
	$W = 120$	A1
		(6)
(b)	The beam remains straight, or rigid, or in a straight line or 1-dimensional or it doesn't bend	B1 (1)
		(7)
	Notes for question 2	
(a)	M1 First equation (vertical resolution or moments) with usual rules	
	A1 Correct equation (T may be replaced by $T - 20$)	
	M1 Second equation (vertical resolution or moments) with usual rules	
	A1 Correct equation (T may be replaced by $T - 20$)	
	DM1 Dependent on previous two M marks, for solving for W	
	A1 cao	
(b)	B1 any appropriate comment. N.B. Penalise incorrect extras.	



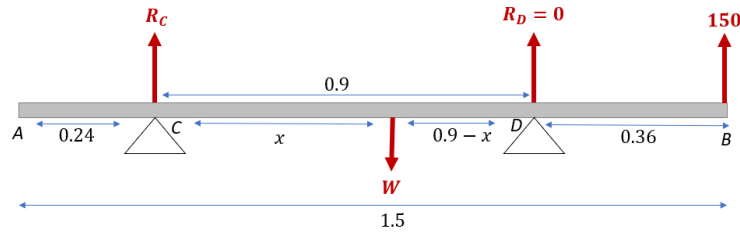
Question Number	Scheme	Marks
2(a)		
	CLM: $km \times 3u - mu = -km \times \frac{3}{2}u + m \times \frac{1}{2}u$	M1 A1 A1
	$k = \frac{1}{3}$	A1
		(4)
2(b)	$I = m \left(\frac{1}{2}u - -u \right)$ OR $I = \frac{1}{3}m \left(\frac{3}{2}u - -3u \right)$	M1 A1
	$I = \frac{3}{2}mu$ must be positive	A1
		(3)
		(7)
	Notes for question 2	
2(a)	M1 Correct no. of terms, dim correct, condone sign errors but structure must be correct – allow consistently cancelled m 's or extra g 's	
	A1 Correct equation with one error	
	A1 Correct equation	
	A1 Allow 0.33 or better	
2(b)	M1 Condone sign errors but must have masses and speeds paired correctly and must be attempting a difference of momenta. Allow M1 if k is not substituted. M0 if g included	
	A1 Allow $\pm m \left(\frac{1}{2}u - -u \right)$ OR $\pm \frac{1}{3}m \left(\frac{3}{2}u - -3u \right)$ (no ft on k)	
	A1 cao Allow them to change a negative expression into a positive one	
	N.B. If they do (b) first, and obtain an impulse of magnitude I , then they do (a) : $I = km \left(\frac{3u}{2} - -3u \right)$, apply CLM scheme to their equation.	

Question Number	Scheme	Marks
3(a)	$M(D), mg \times 1.2 = 30g \times 0.8$	M1 A1
	Other possible equations: $(\uparrow) R = mg + 30g$ $M(A) \ 2.5mg + 30g \times 4.5 = 3.7R$ $M(G) \ 30g \times 2 = 1.2R$ $M(C) \ mg \times 2 = 0.8R$ $M(B) \ 2.5mg + 30g \times 0.5 = 1.3R$	
	$m = 20 \text{ (kg)}$	A1
	N.B. Allow an inequality if they state $m = 20 \text{ (kg)}$ at the end	(3)
3(b)	$M(D), Xg \times 3.7 + 20g \times 1.2 = 30g \times 1.3$ N.B. Allow inequality $\geq \dots$ the correct way round for M1A1ft	M1A1ft
	Other possible equations: $(\uparrow) S = mg + 30g + Xg$ $M(A) \ 2.5mg + 30g \times 5 = 3.7S$ $M(G) \ 30g \times 2.5 = 1.2S + Xg \times 2.5$ $M(B) \ 2.5mg + Xg \times 5 = 1.3S$ where m is their answer from (a).	
	$X = \frac{150}{37}, 4.1 \text{ or better } (4.05405\dots)$	A1
		(3)
3(c)	The mass of the block is concentrated at a point. oe	B1
	N.B. Must mention either mass or weight and ‘acting at a point’ or ‘concentrated at a point’.	(1)
		(7)
Notes for question 3		
3(a)	M1 Complete method to give an equation in m only. Allow M1 if they use weight instead of mg N.B. If they don’t use $M(D)$, e.g. $(\uparrow)$ and $M(A)$, they will need to eliminate the reaction at D to obtain the M mark. Each equation used must have the correct no. of terms and be dimensionally correct. M0 if they don’t have the reaction acting at D .	
	A1 Correct equation	
	A1 cao	
3(b)	M1 Complete method to give an equation in X only. Allow M1 if they use weight instead of Xg N.B. If they don’t use $M(D)$, e.g. $(\uparrow)$ and $M(A)$, they will need to eliminate the reaction at D to obtain the M mark. Each equation used must have the correct no. of terms and be dimensionally correct. M0 if they don’t have the reaction acting at D .	
	A1ft Correct equation. Follow through on their 20	
	A1 cao	
3(c)	B1 Any equivalent statement.	

Question Number	Scheme	Marks
4.		
	Use of $T_2 = 0$	M1
	$M(C), 64g \times 0.625 = Mg(d - 2.5)$ OR e.g. $M(C), 64g \times 0.625 = Mgx$	M1 A1
	Other equations: (T_1 would then have to be eliminated to give an equation in M and d only, to earn the M mark) $T_1 = Mg + 64g$ $M(A), 64g \times 1.875 + Mgd = 2.5T_1$ $M(G), 64g \times (d - 1.875) = T_1 \times (d - 2.5)$ $M(D), 64g \times 4.125 + Mg(6 - d) = 3.5T_1$ $M(B), 64g \times 6.125 + Mg(8 - d) = 5.5T_1$ $M(X), Mg(d - 1.875) = 0.625T_1$	
	Use of $S_1 = 0$	M1
	$M(D), 48g \times 1.5 = Mg(6 - d)$ OR e.g. $M(D), 48g \times 1.5 = Mg(3.5 - x)$	M1 A1
	Other equations: (S_2 would then have to be eliminated to give an equation in M and d only, to earn the M mark) $S_2 = Mg + 48g$ $M(A), 48g \times 7.5 + Mgd = 6S_2$ $M(C), 48g \times 5 + Mg(d - 2.5) = 3.5S_2$ $M(G), 48g \times (7.5 - d) = S_2 \times (6 - d)$ $M(B), 48g \times 0.5 + Mg(8 - d) = 2S_2$ $M(Y), Mg(7.5 - d) = 1.5S_2$	
	Solve for M	DM1
	$M = 32$ exact answer.	A1
		(8)
		(8)

	Notes for Question 4	
	M1 $T_2 = 0$ seen or implied	
	M1 Correct number of terms, dimensionally correct equation <u>in M and one unknown length</u> . (allow without g 's, omission of a length is an M error)	
	A1 Correct equation in M and d <i>only</i> or another unknown length.	
	M1 $S_1 = 0$ seen or implied	
	M1 Correct number of terms, dimensionally correct equation <u>in M and same unknown length</u> . (allow without g 's, omission of a length is an M error)	
	A1 Correct equation in M and d <i>only</i> or same unknown length.	
	DM1 Solving for M , dependent on all previous M marks	
	A1 Correct exact answer	

Question Number	Scheme	Marks
4.	$R_D = 0$ for scenario 1 or $R_C = 0$ for scenario 2	B1
	Scenario 1 $M(C) \quad (150 \times 1.26) = Wx$	M1 A1
	Scenario 2 $M(D) \quad (225 \times 0.36) = W \times (0.9 - x)$	M1 A1
	Solve simultaneously for W (or x) e.g. $0.81W = 243$	dM1
	$W = 300$	A1
	$x = 0.63$	A1
(8)		
NOTES		
B1	N.B. B0 means there are no other marks available. $R_D = 0$ for scenario 1 seen on a diagram or implied by working.	
M1	OR: $R_C = 0$ for scenario 2 seen on a diagram or implied by working. Complete method to form an equation in W and a consistent unknown distance <i>only</i> , for scenario 1. All equations used must be dimensionally correct and have the correct no. of terms but condone sign errors. (M0 if $R_D = 0$ is never used)	
A1	Correct unsimplified equation in W and x or their defined unknown distance.	
M1	Complete method to form an equation in W and a consistent unknown distance <i>only</i> , for scenario 2. All equations used must be dimensionally correct and have the correct no. of terms but condone sign errors. (M0 if $R_C = 0$ is never used)	
A1	Correct unsimplified equation in W and x or their defined unknown distance	
dM1	Dependent on both M's, solve simultaneous equations for either W or their unknown	
A1	Correct answer for W	
A1	Correct answer for x This must be the distance stated in the question, from C to the centre of mass.	
	N.B. If they include g in a moments equation, they lose the A mark for that equation and both final A marks.	

Scenario 1

Equations with unknown distance, x , measured from C.

Complete method will involve one moments equation with $R_D = 0$ or two equations with R_C eliminated and $R_D = 0$.

M0 if R_D never equals zero

$$\text{Vert } R_C + 150 = W$$

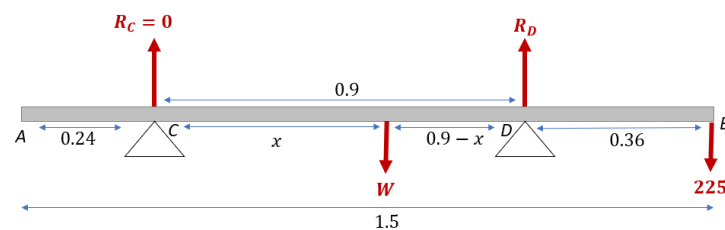
$$\text{M(A) } (R_C \times 0.24) + (150 \times 1.5) = W(x + 0.24)$$

$$\text{M(C) } (150 \times 1.26) = Wx$$

$$\text{M(G) } R_C x = 150(1.26 - x)$$

$$\text{M(D) } (R_C \times 0.9) = (150 \times 0.36) + W(0.9 - x)$$

$$\text{M(B) } (R_C \times 1.26) = W(1.26 - x)$$

Scenario 2

Equations with unknown distance, x , measured from C

Complete method will involve one moments equation with $R_C = 0$ or two equations with R_D eliminated and $R_C = 0$.

M0 if R_C never equals zero

$$\text{Vert } R_D = 225 + W$$

$$\text{M(A) } (R_D \times 1.14) = (225 \times 1.5) + W(x + 0.24)$$

$$\text{M(C) } (225 \times 1.26) + Wx = (R_D \times 0.9)$$

$$\text{M(G) } R_D(0.9 - x) = 225(1.26 - x)$$

$$\text{M(D) } (225 \times 0.36) = W(0.9 - x)$$

Question Number	Scheme	Marks
5.		
5(a)	$M(D), 2 \times R_C + 2Mg = 0.5 \times 5g + 3 \times 10g$	M1 A1
	$R_C = 16.25g - Mg$ oe or $R_C = 159 - 9.8M$ or $160 - 9.8M$	A1
		(3)
	Other possible equations that could be used in (a), to obtain an equation in R_C and M only, or in (b), to obtain an equation in R_D and M only ($\uparrow$), $R_C + R_D = 10g + 5g + Mg$ $M(A), R_C + 3R_D = 5g \times 2.5 + 5Mg$ $M(B), 4R_C + 2R_D = 5g \times 2.5 + 5 \times 10g$ $M(G), 1.5R_C + 2.5Mg = 0.5 \times 5g + 2.5 \times 10g$	
5(b)	$M(C), 2 \times R_D + 1 \times 10g = 1.5 \times 5g + 4 \times Mg$	M1A1
	$R_D = 2Mg - 1.25g$ oe or $R_D = 19.6M - 12.3$ or $20M - 12$	A1
		(3)
5(c)	Use of when $R_C \geq 0$ or $R_D \geq 0$ Allow equality or > 0 N.B. They may take moments about D or C again, with respectively $R_C = 0$ or $R_D = 0$	M1
	$M \leq 16.25$ OR $M \geq 0.625$ Allow equality N.B. Allow 2SF or better.	A1ft
	$0.625 \leq M \leq 16.25$ N.B. Allow 2SF or better. If either critical value appears, without working or from working done in parts (a) and/or (b), they can score M1A1ft and also potentially, the final A1.	A1
		(3)
		(9)
	Notes for question 5	
	N.B. Only penalise over accuracy, after use of $g = 9.8$, ONCE in this question.	
5(a)	M1 Complete method to give an equation in R_C and M only , correct number of terms, condone sign errors, dim correct M0 if they assume that the reactions are equal.	
	A1 Correct equation(s)	
	A1 Correct expression (g 's must be collected)	
5(b)	M1 Complete method to give an equation in R_D and M only , correct number of terms, condone sign errors, dim correct	

	M0 if they assume that the reactions are equal.	
	A1 Correct equation(s)	
	A1 Correct expression (g 's must be collected)	
5(c)	M1 Use of either of their reactions to find one critical value	
	A1ft Critical value of R_c OR Critical value of R_d but must be POSITIVE.	
	A1 cao Allow $0.625\text{kg} \leq M\text{kg} \leq 16.25\text{kg}$	

Q	Scheme	Marks	Notes
1			
(a)	Use of CLM Or equating impulses	M1	Dimensionally correct. Condone sign errors and allow missing m 's and extra g 's.
	$(4m \times 2x) - 3mx = (3m \times 5y) - 4my$ Or: $3m(5y - x) = 4m(y - 2x)$	A1	Correct unsimplified equation and must see all 4 terms but allow missing m 's.
	$y = \frac{5}{11}x$ *	A1*	Obtain given answer from correct working with m 's seen. Allow $y = \frac{5x}{11}$ but A0 if x is <i>clearly</i> in the denominator of the fraction.
		[3]	
(b)	Use of $I = mv - mu$	M1	Dimensionally correct. Condone sign errors and y not substituted but mass and velocities must match. M0 if m is used for mass or g is included or m is missing.
	$\pm 3m \left(\frac{25}{11}x + x \right)$ or $\left(\pm 4m \left(\frac{5}{11}x + 2x \right) \right)$	A1	Correct unsimplified expression
	$\frac{108}{11}mx$ oe	A1	$9.8mx$ or better ($9.8181..mx$), must be positive.
		[3]	
		(6)	

7a	Possible equations: $\uparrow R + 3R (= 4R) = 60g$ $M(A), 60gx = R \times a + 3R \times 6a$ $M(B), 60g(8a - x) = R \times 7a + 3R \times 2a$ $M(C), 60g(x - a) = 3R \times 5a$ $M(D), 60g(6a - x) = R \times 5a$	M1A1 M1A1	Two equations required. For each equation, M1 for correct no. of terms, dim correct but condone sign errors. A1 for a correct unsimplified equation. Consistent omission of g could score full marks. Inconsistent omission of g is an A error. All four of these marks could be scored for consistent use of another unknown length which is clearly defined e.g. on a diagram N.B. M marks only available if using R and $3R$ oe but allow if wrong way round. For vertical resolution, can score M1A1, even if wrong way round.
	S.C. $M(G), R(x - a) = 3R(6a - x)$	M2A2	-1 each error
	$x = \frac{19a}{4}$ oe	A1	Or equivalent
		(5)	
7b			
	Possible equations: $(\uparrow), 60g + Mg = S + S$ $M(A), 60gx + Mg \times 2a = S \times a + S \times 6a$ $M(B), 60g(8a - x) + Mg \times 6a = S \times 7a + S \times 2a$ $M(C), 60g(x - a) + Mga = S \times 5a$ $M(D), 60g(6a - x) + Mg \times 4a = S \times 5a$ $M(G), S(x - a) = S(6a - x) + Mg(x - 2a)$	M1A1ft M1A1ft	Two equations in two unknowns (M and S) required. For each equation, M1 for correct no. of terms, dim correct but condone sign errors. A1ft for a correct unsimplified equation, follow their x. x must be substituted to earn the A marks. Consistent omission of g could score full marks. Inconsistent omission of g is an A error.
	$M = 50$	A1	Exact answer only.
		(5)	
		[10]	

QUESTION NUMBER	SCHEME	MARKS
N.B. They may do (ii) first using the OR method to find α (and possibly β) and then use either angle to do (i), using the Sine Rule or Cosine Rule.		
4		
4(i)	Complete method to find an equation in X only: - Using correct vector triangle with cosine rule: $129 = X^2 + (5\sqrt{3})^2 - 2X \times 5\sqrt{3} \cos 30^\circ$ - Using correct vector triangle with sine rule to find α : $\frac{\sqrt{129}}{\sin 30^\circ} = \frac{5\sqrt{3}}{\sin \alpha}$ $\alpha = 22.4109..^\circ \Rightarrow \beta = 180^\circ - 30^\circ - 22.4109..^\circ = 127.589..^\circ$ Then sine rule: $\frac{X}{\sin \beta} = \frac{\sqrt{129}}{\sin 30^\circ} = \frac{5\sqrt{3}}{\sin \alpha}$ or cosine rule: $(5\sqrt{3})^2 = X^2 + 129 - 2X\sqrt{129} \cos \alpha$ or $X^2 = (5\sqrt{3})^2 + 129 - 2 \times 5\sqrt{3} \times \sqrt{129} \cos \beta$ to find X. - Using components with magnitude: $\sqrt{129} = \sqrt{(X \cos 30^\circ - 5\sqrt{3})^2 + (X \sin 30^\circ)^2}$	M1 A1
	Solves their equation (if quadratic, must include an X term) to find an X value.	M1
	$X = 18$	A1

QUESTION NUMBER	SCHEME	MARKS
4(ii)	EITHER Finds an equation in β only using their X: e.g. $\frac{18}{\sin \beta} = \frac{\sqrt{129}}{\sin 30^\circ}$ or $18^2 = (5\sqrt{3})^2 + 129 - 2 \times 5\sqrt{3} \times \sqrt{129} \cos \beta$ or $\cos \beta = \frac{\mathbf{R} \cdot \mathbf{Q}}{ \mathbf{R} \mathbf{Q} }$ where $\mathbf{R}$ is the resultant (β) = 128° to nearest degree OR Finds a relevant angle (not β) first - Using triangle of forces: $\alpha = \sin^{-1} \left(\frac{\sin 30^\circ \times 5\sqrt{3}}{\sqrt{129}} \right) = 22.4109^\circ$ Or: $\alpha = \cos^{-1} \left(\frac{18^2 + 129 - (5\sqrt{3})^2}{2 \times 18 \times \sqrt{129}} \right) = 22.4109^\circ$ - Using components: Resultant force = $(18 \cos 30^\circ - 5\sqrt{3})\mathbf{i} + (18 \sin 30^\circ)\mathbf{j}$ Leading to $\tan^{-1} \left(\frac{4\sqrt{3}}{9} \right) = 37.589^\circ$ or $\tan^{-1} \left(\frac{9}{4\sqrt{3}} \right) = 52.411^\circ$ or e.g. $\sin^{-1} \left(\frac{9}{\sqrt{129}} \right) = 52.411^\circ$	M2 A1 A1 M1 A1
	Completes the method to find required angle (β) eg $150^\circ - \alpha$ or $210^\circ + \alpha$ $180^\circ - 52.411^\circ$ or $180^\circ + 52.411^\circ$ $90^\circ + 37.859^\circ$ or $270^\circ - 37.859^\circ$	M1
	(β) = 128° to nearest degree Accept 232°	A1
		(8)



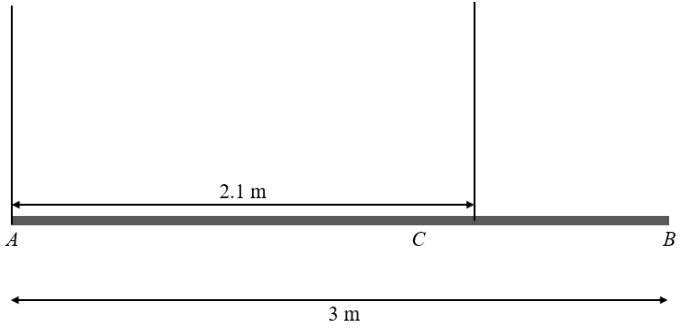
	Notes for question 4	
N.B. If 150° is used in either the sine or cosine rule, they are using an incorrect vector triangle and no M marks are available.		
(i)		
M1	Complete method to form an equation in X only. This could involve cosine rule and/or sine rule or components. Note the component forms: $\mathbf{P} = X \cos 30^\circ \mathbf{i} + X \sin 30^\circ \mathbf{j}$, condone cos/sin confusion $\mathbf{Q} = -5\sqrt{3}\mathbf{i}$ oe (they could have chosen different + directions)	
A1	Correct equation	
M1	Provided they have found an X value, not necessarily correctly, this mark can be awarded.	
A1	Correct answer. If seen, a negative value must be rejected.	
(ii)	EITHER	
M2	Complete method to find an equation in β only	
A1	Correct equation	
A1	cao	
	OR	
M1	Complete method to find a relevant angle	
A1	Correct relevant angle: $22.4109^\circ, 37.589^\circ, 52.411^\circ$	
M1	Completes the method to find the required angle	
A1	cao	

QUESTION NUMBER	SCHEME	MARKS
5		
5(a)	M(D) $(R_C \times 2.2) = 55g(2.2 - x) + 30g(1.1)$	M1A1
	$(R_C) = (686 - 245x) \text{ (N) }^*$	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
	$M = 83 \text{ or } 82.5 \text{ or } \frac{165}{2} \text{ oe}$	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)



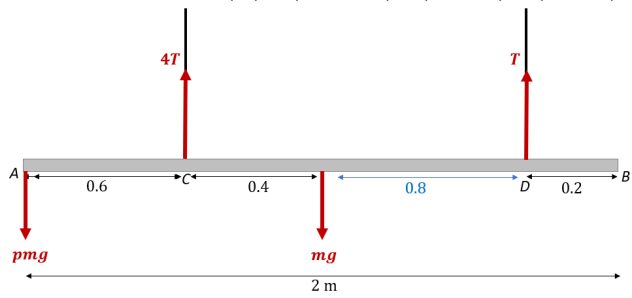
	Notes for question 5	
(a) M1 A1 A1*	Forms an equation in R_C and x only. Dimensionally correct and the correct no. of terms. Either a moments equation about D or two other equations combined to eliminate R_D . Correct unsimplified equation Correctly reaches the given answer with at least one line of intermediate working.	
(b) M1 M1 A1 A1	Use of $R_C = 4R_D$ 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. Correct unsimplified equation in x only. Correct answer	
(c) M1 A1 A1	Use $S_D = 0$ and forms an equation in M only. Dimensionally correct and the correct no. of terms. M0 if $S_D \neq 0$. Correct unsimplified equation Correct answer, 83 or 82.5 o.e.	

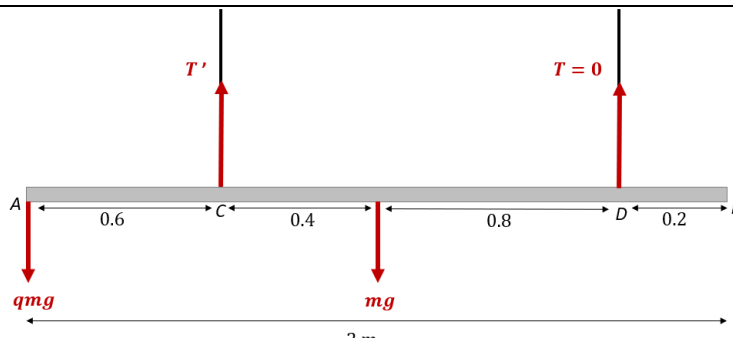


QUESTION NUMBER	SCHEME	MARKS
4		
4(a)	$M(A): 350 \times 2.1 = W \times 1.5$ $W = 490 \quad *$	M1 A1 A1* (3)
4(b)	$M(A): (600 \times 2.1) = (490 \times 1.5) + (210 \times d)$ $d = 2.5$	M1 A1 A1 (3)
4(c)	Tension at $A = 0$	B1
	$M(C): 490 \times 0.6 = X \times 0.9$ $X = \frac{980}{3} = 326.6666... \quad (330 \text{ or better})$	M1 A1 A1 (4) (10)
Notes for Question 4		
4(a)		
M1	Uses a complete method to form an equation in W only. Dimensionally correct and the correct number of terms. Extra g is an A error. May use two equations and eliminate T_A ($= 140$) G is the centre of the rod Vert: $T_A + 350 = W$ $M(C): T_A \times 2.1 = W \times 0.6$ $M(G): T_A \times 1.5 = 350 \times 0.6$ $M(B): T_A \times 3 + (350 \times 0.9) = W \times 1.5$	
A1	Correct unsimplified equation in W only.	
A1*	Cso.	
4(b)		
M1	Uses a complete method to form an equation in d only. Dimensionally correct and the correct number of terms. Extra g is an A error.	

	$M(A): (600 \times 2.1) = (490 \times 1.5) + (210 \times d)$ May use two equations and eliminate T_A (=100) G is the centre of the rod and P is the position of the particle Vert: $T_A + 600 = 490 + 210$ $M(C): (T_A \times 2.1) = (490 \times 0.6) + 210(2.1 - d)$ $M(G): (T_A \times 1.5) = (600 \times 0.6) + 210(1.5 - d)$ $M(P): (T_A \times d) + 490(1.5 - d) = 600(2.1 - d)$	
A1	Correct unsimplified equation in d only	
A1	Correct answer	
4(c)		
B1	Tension at A is 0, seen or implied by the M mark.	
M1	Uses a complete method to form an equation in X only. Dimensionally correct and the correct number of terms. Extra g is an A error. M0 if tension at A is never 0. $M(C): 490 \times 0.6 = X \times 0.9$ May use other equations and eliminate T_C ($= \frac{2450}{3} = 816.666\dots$) Vert: $T_C = 490 + X$ $M(A): (T_C \times 2.1) = (490 \times 1.5) + (X \times 3)$ $M(G): T_C \times 0.6 = X \times 1.5$ $M(B): T_C \times 0.9 = 490 \times 1.5$	
A1	Correct unsimplified equation in X only.	
A1	Correct answer $\frac{980}{3}$ oe, 330 or better (326.666...)	



Question Number	Scheme	Marks
4(a)	T and $4T$ correctly placed	B1
	Vertical resolution $T + 4T = pmg + mg$	M1 A1
	OR a moments equation, see below. $M(A): (4T \times 0.6) + (T \times 1.8) = (mg \times 1)$	M1 A1
	 Other moments equations: $M(C): (pmg \times 0.6) + (T \times 1.2) = (mg \times 0.4)$ $M(G): (pmg \times 1) + (T \times 0.8) = (4T \times 0.4)$ $M(D): (pmg \times 1.8) + (mg \times 0.8) = (4T \times 1.2)$ $M(B): (4T \times 1.4) + (T \times 0.2) = (pmg \times 2) + (mg \times 1)$	
	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
	$M(C): (qmg \times 0.6) = (mg \times 0.4)$	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 <u>consistent</u> 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