Question Number	Scheme	Marks	Notes
4a	Resolve perpendicular to the surface	M1	Condone sin/cos confusion
	$R = 2g\cos\alpha \quad (15.68)$	A1	Correct resolution
	$F = \frac{1}{4}R = \frac{2g}{5} = 3.9$ N or 3.92 N	A1	Max 3 sf for decimal answer
		(3)	
4b	$-2g\sin\alpha - F = 2a$	M1	Equation of motion parallel to the plane. Require all terms and dimensionally correct. Condone sign errors and sin/cos confusion
		A1ft	Correct unsimplified equation in F (or their F)
	$\frac{-4g}{5} = a$	A1	Or $-7.84\,(\text{m s}^{-2})$ Accept +/-
	$0^2 = 6^2 - \frac{8g}{5}s$	DM1	Complete method using *suvat* and $a \neq g$ to find s Dependent on the previous M1
	$s = \frac{45}{2g} = 2.3$ m or 2.30 m	A1	Max 3 sf
		(5)	
4c	$2g\sin\alpha - F = 2a'$	M1	Equation for motion down the plane to find new acceleration. Require all terms and dimensionally correct. Condone sign errors and sin/cos confusion
		A1ft	Correct unsimplified equation in F (or their F)
	$\frac{2g}{5} = a'$	A1	Or $3.92\,(\text{m s}^{-2})$
	$v^2 = \frac{4g}{5}\frac{45}{2g} = 18 \Rightarrow$	DM1	Complete method using *suvat*, $a' \neq g$ and $a' \neq a$, to find v Dependent on the previous M1
	$v = \sqrt{18} = 4.2$ m s^{-1} (or better)	A1	g cancels Condone 4.25 (from using rounded values).
		(5)	
		[13]	

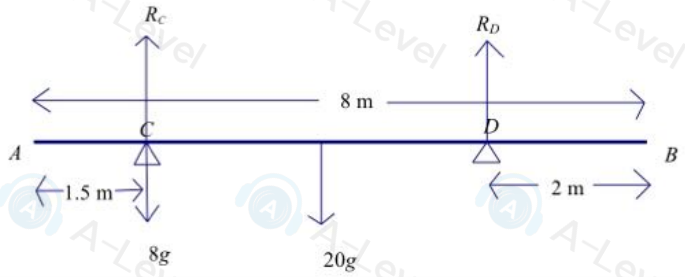
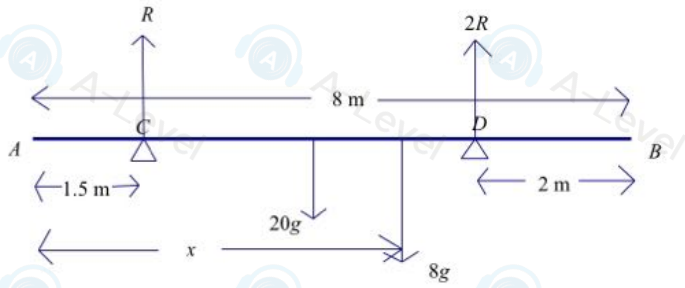
Question Number	Scheme	Marks
2(a)	**N.B.** Consistent use of extra g's in **two** equations can score the A marks for the equations and could score full marks for part (a). **N.B.** If they assume that the rod is uniform, can only score marks for a vertical resolution. R$(\uparrow)$: $0.5R_C + R_C = 60 + 12$ (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	

A1	**N.B.** They may find q (M1A1) and subtract from $5m$	
Question Number	**Scheme**	**Marks**
8(a)	Perpendicular to the plane: $R + 18\sin 40° = 2g\cos 30°$	M1 A1
	Equation of motion parallel to the plane: $18\cos 40° - F - 2g\sin 30° = 2a$ (or -2a)	M1 A1 A1
	$F = 0.3R$	B1
	$18\cos 40° - 0.3\left(2g\cos 30° - 18\sin 40°\right) - 2g\sin 30° = 2a$	dM1
	$a = 1.18$ or 1.2 $\left(\text{m s}^{-2}\right)$	A1 cao
		(8)
8(b)	$v^2 = 2^2 + 2('1.18')5$	M1 A1**ft**
	$v = 3.98$ or 4.0 or 4 (m s^{-1})	A1 cao
	N.B. For (a) and (b), penalise over accurate answers ONCE only.	(3)
8(c)	$R = 2g\cos 30°\left(= g\sqrt{3}\right)$	B1
	Friction = $0.3\times 2g\cos 30°$ OR $0.3\times 2g\sin 30°$	M1
	Compares Friction with weight component parallel to plane Eg Consider: $2g\sin 30° - 0.3\left(2g\cos 30°\right)$ $(= 2a)$ **OR** $0.3\left(2g\cos 30°\right) - 2g\sin 30°$ $(= 2a)$	dM1
	$(a) > 0$ **OR** $(a) < 0$ Concludes that P will not remain at rest oe	A1
		(4)
(15)		
NOTES		
(a)		
M1	Correct number of terms, forces resolved *perp to the plane* where appropriate, condone sign errors and sin/cos confusion, forces and angles paired up correctly	
A1	Correct unsimplified equation.	
M1	Equation of motion parallel to the slope. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion, forces and angles paired up correctly	
A1	Correct unsimplified equation with at most one error	
A1	Fully correct unsimplified equation	
B1	Use of $F = 0.3R$	
dM1	Eliminate F and R to form an equation in a, dependent on two M's	
A1	Correct value for a. Must be 2 or 3sf	

(b)		
M1	Complete method to form an equation in v or v^2	
A1ft	Correct unsimplified equation. Follow through on their value for a.	
A1	Cao. Must be positive. Note that $a = 1.2$ leads to $v = 4$.	
(c)		
B1	Correct expression or value for **new** R	
M1	Find the max friction. M0 if the previous R is used.	
dM1	Correct comparison between max friction value and weight component (force parallel to slope), dependent on previous M	
A1	Correct statement from fully correct working. Concludes that P will not remain at rest.	

Question Number	Scheme	Marks
5(a)	$M(C),\ Mg\times1.5=12g\times1.75$	M1A1
	$M=14$	A1 (3)
5(b)	A moments equation, with usual rules i.e. dim correct, correct no. of terms, condone sign errors	M1A1
	$(\uparrow),\ T_A+2T_A=12g+15g$ or another Moments equation	M1A1
	Possible moments equations: $M(A),\ 2T_A\times3.5=12g\times1.75+15gx$ $M(B),\ (2T_A\times1.5)+(T_A\times5)=12g\times3.25+15g(5-x)$ $M(C),\ T_A\times3.5=12g\times1.75+15g(3.5-x)$ $M(D),\ 2T_A\times1.75=T_A\times1.75+15g(x-1.75)$ $M(G),\ T_Ax=2T_A(3.5-x)+12g(x-1.75)$ **N.B.** These equations could be in terms of T_C and/or in terms of their own unknown length (e.g. y) where y is clearly defined in terms of x.	
	$x=2.8$	A1 (5)
		(8)
	Notes on qu 5	
5(a)	M1 for a complete method to obtain an equation <u>in M only</u>. **N.B.** they may use 2 equations in T_C and M and then eliminate T_C to give an equation <u>in M only</u>. Possible equations: $(\uparrow),\ T_C=12g+Mg$ M(A), $12g\times1.75+5Mg=3.5T_C$ M(B), $12g\times3.25=1.5T_C$ M(G), $T_C\times1.75=3.25Mg$ **N.B.** M0 if they never use $T_A=0$	
	First A1 for a correct equation <u>in M only</u>	
	Second A1 for $M=14$	
	N.B. If g's are <u>consistently</u> omitted in <u>all</u> equations used in 5(a), full marks can be scored.	
5(b)	First M1 for a moments equation with the usual rules, in x and at most 2 further unknowns	
	First A1 for a correct equation in x and one other unknown	
	Second M1 for a vertical resolution in 2 unknowns or a second moments equation in x and at most 2 further unknowns	
	Second A1 for a correct resolution in one unknown or for a correct moments equation in x and the same one other unknown	
	Third A1 for $x=2.8$ **N.B.** If g's are <u>consistently</u> omitted in <u>both</u> equations in 5(b), full marks can be scored.	

Question Number	Scheme	Marks
4(a)	$R = kmg\cos\theta + mg\sin\theta$ (perpendicular to the plane)	M1A2
	$F = kmg\sin\theta - mg\cos\theta$ (parallel to the plane)	M1A2
	$F = \mu R$ seen or implied	B1
	Eliminate F and R and **explicitly cancel *m*** to give an equation in k, θ and μ **only** (allow inconsistent or no g's)	M1
	Use of $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ to obtain an expression for μ in terms of k and $\tan\theta$ only (all g's must have been cancelled) , dependent on previous three M marks. **Need to see division by $\cos\theta$ <u>top and bottom</u> oe for this mark**.	**DM**1
	$\mu = \dfrac{k\tan\theta - 1}{k + \tan\theta}$ GIVEN ANSWER (Must be **exactly** the same)	A1 (10)
Aliter	**N.B. Horizontal and/or vertical resolutions are possible**	
	$mg + F\cos\theta = R\sin\theta$ (horizontal) **M1A2**	
	$R\cos\theta + F\sin\theta = kmg$ (vertical) **M1A2**	
4(b)	$\dfrac{\tan\theta - 1}{1 + \tan\theta} > 0$ **OR** $mg\sin\theta - mg\cos\theta > 0$	M1
	$\tan\theta > 1 \Rightarrow \theta > 45^o$ GIVEN ANSWER	A1 (2)
		(12)
	Notes for qu 4	
4(a)	First M1 for resolving perp to the plane, dimensionally correct, with correct no. of terms, kmg and mg both resolved, condone sign errors	
	First A2 for a correct equation, -1 each error (allow X for mg anywhere) Consistent omission of g, treat as **one** error	
	Second M1 for resolving parallel to the plane, dimensionally correct, with correct no. of terms, kmg and mg both resolved, condone sign errors	
	First A2 for a correct equation, -1 each error (allow X for mg anywhere) Consistent omission of g, treat as **one** error	
	$F = \mu R$ seen or implied, even on a diagram	
	Third M1 (independent) for eliminating F and R and cancelling m's	
	Fourth DM1, dependent on previous three M marks	
	Fifth A1 for correctly obtaining the GIVEN ANSWER	
4(b)	M1 for either using $k = 1$ and the given answer > 0 or $= 0$ or using $F > 0$ or $F = 0$ Allow M1A0 for using $k = 1$ and $\theta = 45^o$ to show $\mu = 0$ M0 if first thing seen is $\tan\theta - 1 > 0$	
	A1 for correctly obtaining the GIVEN ANSWER and must have used an inequality throughout. Need to see $\tan\theta - 1 > 0$ oe.	

Question Number	Scheme	Marks
4a		
	Moments about D: $20g\times 2+8g\times 4.5=R_C\times 4.5$ **OR** Resolve: $R_C+R_D=28g$	M1A1
(i)	$R_C=\frac{152}{9}g\,(=166 \text{ or } 170)$	A1
	Moments about C: $20g\times 2.5=R_D\times 4.5$ **OR** Resolve: $R_C+R_D=28g$	M1A1
(ii)	$R_D=\frac{100}{9}g\,(=109 \text{ or } 110)$	A1
		(6)
4b		
	Moments about A: $R\times 1.5+2R\times 6=20g\times 4+8g\times x$	M1A1
	Resolve: $3R=28g$, $\left(R=\frac{28}{3}g\,(=91.5)\right)$	M1A1
	Substitute for R and solve for x: $\frac{27}{2}\times\frac{28}{3}g=80g+8g\times x$	M1
	$126=80+8x$, $8x=46$, $x=5.75\,(\text{m})$	A1
		(6)
4c	The weight of the package acts at point C (or E)	B1 (1)
		[13]
	Notes **N.B.** In both parts, enter marks on ePen for the *equations* as they appear **BUT** in part (a) second A1 is for R_C and fourth A1 is for R_D Remember to only penalise overaccuracy, after use of g, ONCE per whole question	

Question Number	Scheme	Marks
4a	**Omission of g is an A error in this part.** If answers are given as decimal multiples of g, penalise once If answers given as (fraction x g), fraction must be ratio of two integers First M1 for any moments equation (even if it contains both reactions) or vertical resolution First A1 for a correct equation Second A1 for $R_C = \frac{152}{9}g \left(= 166 \text{ or } 170\right)$ Second M1 for another moments equation (even if it contains both reactions) or vert resolution Third A1 for a correct equation Fourth A1 for $R_D = \frac{100}{9}g \left(= 109 \text{ or } 110\right)$	
4b **4c**	**Notes** **N.B. Consistent omission of g can score full marks in this part.** **If they use the values of the reactions from part(a), no marks for part b.** If R and $2R$ reversed, can score max M1A1 (vert res) M1A0 (mom about C or D) M1A0 First M1 for a moments equation in R and x only (x may not be AE) First A1 for a correct equation e.g. M(A) $R \times 1.5 + 2R \times 6 = 20g \times 4 + 8g \times x$ Second M1 for another moments equation in R and x only or vert resolution in R only Second A1 for a correct equation Third M1 for solving for AE Third A1 for 5.75 (m) (Must be EXACT) Mass or wt of package is or acts at (point) C (or E)	