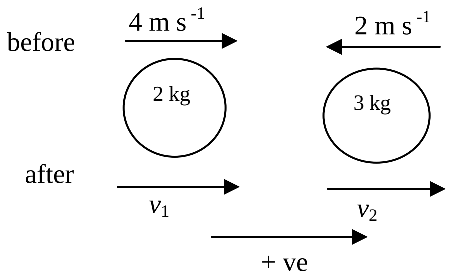
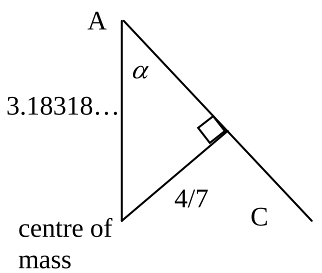
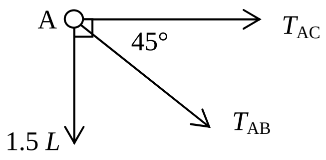
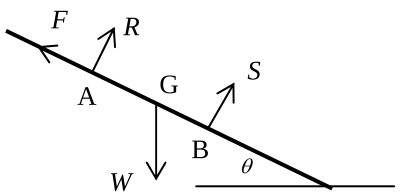
Q 1		mark		Sub
(a) (i)	240 **i** N s $\rightarrow$	B1		1
(ii) (A) (B) (C)	 240 **i** = 70 **i** +50 **v** so **v** = 3.4 **i** m s $^{-1}$ 240 **i** = 70*u* **i** – 50*u* **i** *u* = 12 so **v** = – 12 **i** m s $^{-1}$ 240 **i** = 280(**i** + **j**) +50$\mathbf{v}_B$ so $\mathbf{v}_B$ = (-0.8 **i** – 5.6 **j**) m s $^{-1}$	 M1 A1 M1 A1 M1 A1	 Equating to **their** 240 **i** in this part FT 240 **i** Must have *u* in both RHS terms and opposite signs FT 240 **i** FT 240 **i** Must have all terms present cao	6
(b) (i)	 NEL $\frac{v_2 - v_1}{-2-4} = -0.5$ so $v_2 - v_1 = 3$ PCLM $8 - 6 = 2v_1 + 3v_2$ Solving v_2 = 1.6 so 1.6 m s $^{-1}$ $\rightarrow$ v_1 = – 1.4 so 1.4 m s $^{-1}$ $\leftarrow$	M1 A1 M1 A1 A1 A1	NEL Any form PCLM Any form Direction must be clear (accept diagram) Direction must be clear (accept diagram). [Award A1 A0 if v_1 & v_2 correct but directions not clear]	6
(ii)	1.6 m s $^{-1}$ at 60° to the wall (glancing angles both 60°) No change in the velocity component parallel to the wall as no impulse No change in the velocity component perpendicular to the wall as perfectly elastic	B1 B1 E1 E1	FT **their** 1.6 Must give reason Must give reason	4
	total	17		

Q 2		mark		Sub
(i)	We need $\dfrac{mgh}{t} = \dfrac{850\times 9.8\times 60}{20}$ = 24 990	M1	Use of $\dfrac{mgh}{t}$	
	so approx 25 kW	E1	Shown	2
(ii)	Driving force – resistance = 0	B1	May be implied	
	$25000 = 800v$	M1	Use of $P = Fv$	
	so v = 31.25 and speed is 31.25 m s^{-1}	A1		3
(iii)	Force is $\dfrac{25000}{10} = 2500$ N	B1		
	N2L in direction of motion			
	$2500 - 800 = 850a$	M1	Use of N2L with all terms	
	a = 2 so 2 m s^{-2}	A1		3
(iv)	$0.5\times 850\times 20^2 = 0.5\times 850\times 15^2$	M1	W-E equation with KE and power term	
		B1	One KE term correct	
	$+25000\times 6.90$	B1	Use of Pt .Accept wrong sign	
	$-800x$	B1	WD against resistance. Accept wrong sign	
		A1	All correct	
	x = 122.6562… so 123 m (3 s. f.)	A1	cao	6
(v)	**either**			
	$0.5\times 850\times v^2 = 0.5\times 850\times 20^2$	M1	W-E equation inc KE, GPE and WD	
	$-850\times 9.8\times \dfrac{105}{20}$	M1	GPE term with attempt at resolution	
		A1	Correct. Accept expression. Condone wrong sign.	
	-800×105	B1	WD term. Neglect sign.	
	$v^2 = 99.452...$ so 9.97 m s^{-1}	A1	cao	
	or			
	N2L + ve up plane			
	$-(800 + 850g\times 0.05) = 850a$	M1	N2L. All terms present. Allow sign errors.	
	a = -1.43117…	A1	Accept ±	
	$v^2 = 20^2 + 2\times(-1.43117...)\times 105$	M1	Appropriate *uvast*. Neglect signs.	
		A1	All correct including consistent signs. Need not follow sign of a above.	
	$v^2 = 99.452...$ so 9.97 m s^{-1}	A1	cao	5
		19		

Q 3		mark		Sub
(i)	$28\begin{pmatrix}\bar{x}\\\bar{y}\end{pmatrix}=16\begin{pmatrix}2\\2\end{pmatrix}+2\begin{pmatrix}5\\0\end{pmatrix}+2\begin{pmatrix}6\\1\end{pmatrix}+2\begin{pmatrix}5\\2\end{pmatrix}$ $+2\begin{pmatrix}0\\5\end{pmatrix}+2\begin{pmatrix}1\\6\end{pmatrix}+2\begin{pmatrix}2\\5\end{pmatrix}$ $\bar{x}=2.5$ $\bar{y}=2.5$	M1 B1 B1 A1 A1	Complete method Total mass correct 3 c. m. correct (or 4 *x*- or *y*-values correct) [Allow A0 A1 if only error is in total mass] [If $\bar{x}=\bar{y}$ claimed by symmetry and only one component worked replace final A1, A1 by B1 explicit claim of symmetry A1 for the 2.5]	5
(ii)	$\bar{x}=\bar{y}$ $28\bar{x}=16\times2+6\times4+2\times0+2\times1+2\times2$ $\bar{x}=\frac{31}{14}$ (2.21428…) $\bar{z}=\frac{8\times(-1)+4\times(-2)}{28}=-\frac{4}{7}$ (- 0.57142…) Distance is $\sqrt{\left(\frac{31}{14}\right)^2+\left(\frac{31}{14}\right)^2+\left(\frac{4}{7}\right)^2}$ = 3.18318.. so 3.18 m (3 s. f.)	B1 M1 A1 A1 A1 A1 M1 F1	Or by direct calculation Dealing with 'folded' parts for $\bar{x}$ or for $\bar{z}$ At least 3 terms correct for $\bar{x}$ All terms correct allowing sign errors Use of Pythagoras in 3D on **their** c.m.	8
(iii)	 $\sin\alpha=\frac{4}{7}/3.18318..$ so α = 10.3415… so 10.3° (3 s. f.)	M1 B1 M1 A1	c.m. clearly directly below A Diagram showing α and known lengths (or equivalent). FT their values. Award if final answer follows **their** values. Appropriate expression for α. FT **their** values. cao	4
	total	17		

Q 4		mark		Sub
(a) (i)	Moments c.w. about A $2R = 5L$ so $R = 2.5L$ Resolve $\rightarrow$ $U = 0$ Resolve $\uparrow$ $V + R = L$ so $V = -1.5L$	 E1 E1 M1 E1	 Resolve vertically or take moments about B (or C)	4
(ii)	 For equilibrium at A $\uparrow$ $T_{AB}\cos 45 + 1.5L = 0$ so $T_{AB} = -\frac{3\sqrt{2}L}{2}$ so $\frac{3\sqrt{2}L}{2}$ N (C) in AB $\rightarrow$ $T_{AC} + T_{AB}\cos 45 = 0$ so $T_{AC} = \frac{3L}{2}$ so $\frac{3L}{2}$ N (T) in AC At C $\downarrow$ $L + T_{BC}\cos\theta = 0$ $\tan\theta = 3/2 \Rightarrow \cos\theta = 2/\sqrt{13}$ so $T_{BC} = -\frac{\sqrt{13}L}{2}$ so $\frac{\sqrt{13}L}{2}$ N (C) in BC	M1 M1 A1 F1 M1 B1 A1 F1	Equilibrium at a pin-joint Attempt at equilibrium at A or C including resolution with correct angle (2.12L (3 s. f.)) (1.5L) Must include attempt at angle (1.80 L (3 s. f.)) Award for T/C correct from their internal forces. Do not award without calcs	8
(b) (i)		B1	All forces present with arrows and labels. Angles and distances not required.	1
(ii)	c.w.moments about B $R \times 3 - W \times 1\cos\theta = 0$ so $R = \frac{1}{3}W\cos\theta$	 M1 A1 A1	 If moments about other than B, then need to resolve perp to plank as well Correct	3
(iii)	Resolve parallel to plank $F = W\sin\theta$ $\mu = \frac{F}{R} = \frac{W\sin\theta}{\frac{1}{3}W\cos\theta} = 3\tan\theta$	 B1 M1 A1	 Use of $F = \mu R$ and their F and R Accept any form.	3
	total	19		