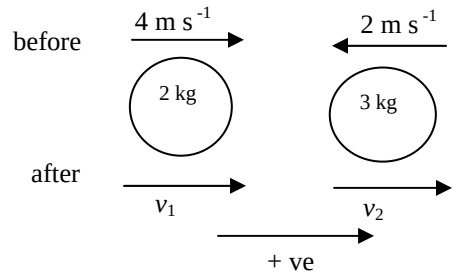
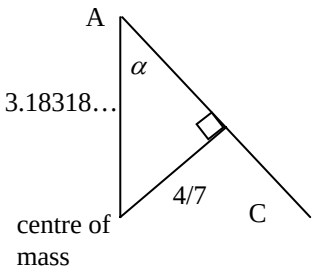
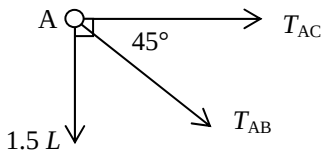
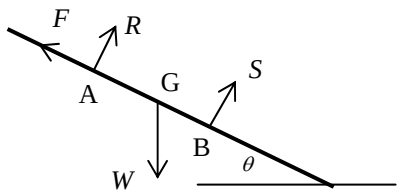
Q 1		mark		Sub
(a) (i)	240 **i** N s $\rightarrow$	B1		1
(ii)				
		M1	Equating to **their** 240 **i** in this part	
(A)	240 **i** = 70 **i** +50 **v** so **v** = 3.4 **i** m s^{-1}	A1	FT 240 **i**	
(B)	240 **i** = 70u **i** – 50u **i**	M1	Must have u in both RHS terms and opposite signs	
	u = 12 so **v** = – 12 **i** m s^{-1}	A1	FT 240 **i**	
(C)	240 **i** = 280(**i** + **j**) +50$\mathbf{v}_B$	M1	FT 240 **i** Must have all terms present	
	so $\mathbf{v}_B$ = (-0.8 **i** – 5.6 **j**) m s^{-1}	A1	cao	6
(b) (i)				
	NEL $\frac{v_2 - v_1}{-2-4} = -0.5$	M1	NEL	
	so $v_2 - v_1 = 3$	A1	Any form	
	PCLM $8 - 6 = 2v_1 + 3v_2$	M1	PCLM	
		A1	Any form	
	Solving v_2 = 1.6 so 1.6 m s^{-1} $\rightarrow$	A1	Direction must be clear (accept diagram)	
	v_1 = – 1.4 so 1.4 m s^{-1} $\leftarrow$	A1	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}	B1	FT **their** 1.6	
	at 60° to the wall (glancing angles both 60°)	B1		
	No change in the velocity component parallel to the wall as no impulse	E1	Must give reason	
	No change in the velocity component perpendicular to the wall as perfectly elastic	E1	Must give reason	4
	total	17		

Q 2		mark		Sub
(i)	We need $\frac{mgh}{t} = \frac{850\times 9.8\times 60}{20} = 24\,990$ so approx 25 kW	M1 E1	Use of $\frac{mgh}{t}$ Shown	2
(ii)	Driving force – resistance = 0 $25000 = 800v$ so v = 31.25 and speed is 31.25 m s^{-1}	B1 M1 A1	May be implied Use of $P = Fv$	3
(iii)	Force is $\frac{25000}{10} = 2500$ N N2L in direction of motion $2500 - 800 = 850a$ a = 2 so 2 m s^{-2}	B1 M1 A1	 Use of N2L with all terms	3
(iv)	$0.5\times 850\times 20^2 = 0.5\times 850\times 15^2$ $+25000\times 6.90$ $-800x$ x = 122.6562… so 123 m (3 s. f.)	M1 B1 B1 B1 A1 A1	W-E equation with KE and power term One KE term correct Use of Pt .Accept wrong sign WD against resistance. Accept wrong sign All correct cao	6
(v)	**either** $0.5\times 850\times v^2 = 0.5\times 850\times 20^2$ $-850\times 9.8\times \frac{105}{20}$ -800×105 $v^2 = 99.452...$ so 9.97 m s^{-1} **or** N2L + ve up plane $-(800 + 850g\times 0.05) = 850a$ a = -1.43117… $v^2 = 20^2 + 2\times(-1.43117...)\times 105$ $v^2 = 99.452...$ so 9.97 m s^{-1}	M1 M1 A1 B1 A1 M1 A1 M1 A1 A1	W-E equation inc KE, GPE and WD GPE term with attempt at resolution Correct. Accept expression. Condone wrong sign. WD term. Neglect sign. cao N2L. All terms present. Allow sign errors. Accept ± Appropriate *uvast*. Neglect signs. All correct including consistent signs. Need not follow sign of a above. 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)	$\bar{x} = \bar{y}$ $28\bar{x} = 16\times 2 + 6\times 4 + 2\times 0 + 2\times 1 + 2\times 2$ $\bar{x} = \frac{31}{14}$ (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		