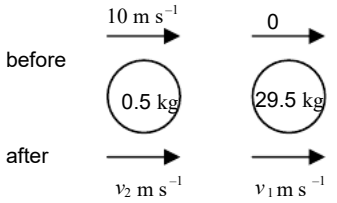
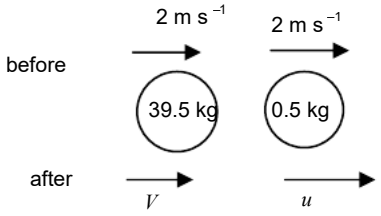
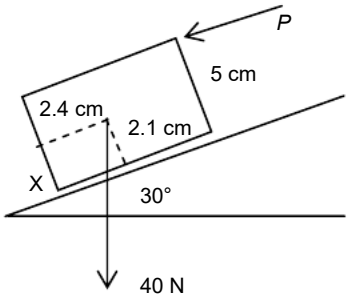
Q 1		mark		
(i)				
	$10\times0.5=0.5v_2+29.5v_1$	M1 A1	PCLM and two terms on RHS All correct. Any form.	
	$\frac{v_1-v_2}{0-10}=-0.8$	M1 A1	NEL Any form	
	$v_1=0.3$ so $V_1=0.3$ $v_2=-7.7$ so $V_2=7.7$ m s^{-1} in opposite to original direction	A1 A1 F1	Speed. Accept $\pm$. Must be correct interpretation of clear working	7
(ii) (A)	$10\times0.5=30V$ so $V=\frac{1}{6}$	M1 A1 A1	PCLM and coalescence All correct. Any form. Clearly shown. Accept decimal equivalence. Accept no direction.	3
(B)	Same velocity No force on sledge in direction of motion	E1 E1	Accept speed	2
(iii)		B1		
	$2\times40=0.5u+39.5V$ $u-V=10$ Hence $V=1.875$	M1 A1 B1 A1	PCLM, masses correct Any form May be seen on the diagram. Accept no reference to direction.	5
		17		

Q 2		mark	comment	sub
(i)	$X = R\cos 30$ (1) $Y + R\sin 30 = L$ (2)	B1 M1 A1	Attempt at resolution	3
(ii)	ac moments about A $R - 2L = 0$ Subst in (1) and (2) $X = 2L\frac{\sqrt{3}}{2}$ so $X = \sqrt{3}L$ $Y + 2L \times \frac{1}{2} = L$ so $Y + L = L$ and $Y = 0$	B1 M1 E1 E1	Subst **their** $R = 2L$ into **their** (1) or (2) Clearly shown Clearly shown	4
(iii)	(Below all are taken as tensions e. g. T_{AB} in AB)	B1 B1	Attempt at all forces (allow one omitted) Correct. Accept internal forces set as tensions or thrusts or a mix	2
(iv)	$\downarrow$ A $T_{AD}\cos 30\ (-Y) = 0$ so $T_{AD} = 0$	M1 E1	Vert equilibrium at A attempted. $Y = 0$ need not be explicit	2
(v)	Consider the equilibrium at pin-joints A $\rightarrow$ $T_{AB} - X = 0$ so $T_{AB} = \sqrt{3}L$ (T) C $\downarrow$ $L + T_{CE}\cos 30 = 0$ so $T_{CE} = \frac{-2L}{\sqrt{3}}$ so $\frac{2L}{\sqrt{3}}\left(= \frac{2L\sqrt{3}}{3}\right)$ (C) C $\leftarrow$ $T_{BC} + T_{CE}\cos 60 = 0$ so $T_{BC} = -\left(-\frac{2\sqrt{3}L}{3}\right) \times \frac{1}{2} = \frac{\sqrt{3}L}{3}$ (T)	M1 B1 B1 B1 B1 B1 F1	At least one relevant equilib attempted (T) not required Or equiv from **their** diagram Accept any form following from **their** equation. (C) not required. Or equiv from **their** diagram FT **their** T_{CE} or equiv but do not condone inconsistent signs even if right answer obtained. (T) not required. T and C consistent with **their** answers and **their** diagram	7
(vi)	$\downarrow$ B $T_{BD}\cos 30 + T_{BE}\cos 30 = 0$ so $T_{BD} = -T_{BE}$ so mag equal and opp sense	M1 E1	Resolve vert at B A statement required	2
		20		

Q 3		mark		sub
(i)	(10, 2, 2.5)	B1		1
(ii)	By symmetry $\bar{x} = 10$, $\bar{y} = 2$ $(240+80)\bar{z} = 80\times 0 + 240\times 2.5$ so $\bar{z} = 1.875$	B1 B1 B1 M1 A1	 Total mass correct Method for c.m. Clearly shown	5
(iii)	$\bar{x} = 10$ by symmetry $(320+80)\begin{pmatrix}\bar{x}\\ \bar{y}\\ \bar{z}\end{pmatrix} = 320\begin{pmatrix}10\\ 2\\ 1.875\end{pmatrix} + 80\begin{pmatrix}10\\ 4\\ 3\end{pmatrix}$ $\bar{y} = 2.4$ $\bar{z} = 2.1$	E1 M1 B1 B1 E1 E1	Could be derived Method for c.m. y coord c.m. of lid z coord c.m. of lid shown shown	6
(iv)	 c.w moments about X $40\times 0.024\cos 30 - 40\times 0.021\sin 30$ = 0.41138… so 0.411 N m (3 s. f.)	B1 B1 B1 E1	Award for correct use of dimensions 2.1 and 2.4 or equivalent 1st term o.e. (allow use of 2.4 and 2.1) 2nd term o.e. (allow use of 2.4 and 2.1) Shown [Perpendicular method: M1 Complete method: A1 Correct lengths and angles E1 Shown]	4
(v)	$0.41138\ldots - 0.05P = 0$ $P = 8.22768\ldots\ldots$ so 8.23 (3 s. f.)	M1 A1	Allow use of 5 Allow if cm used consistently	2
		18		

Q 4		mark		sub
(i)	$F_{max} = \mu R$ $R = 2g\cos 30$ so $F_{max} = 0.75\times 2\times 9.8\times\cos 30 = 12.730...$ so 12.7 N (3 s. f.) **either** Weight cpt down plane is $2g\sin 30 = 9.8$ N so no as $9.8 < 12.7$ **or** Slides if $\mu < \tan 30$ But $0.75 > 0.577\ldots$ so no	M1 B1 A1 B1 E1 B1 E1	Must have attempt at R with mg resolved [Award 2/3 retrospectively for limiting friction seen below] The inequality must be properly justified The inequality must be properly justified	5
(ii) (A)	Increase in GPE is $2\times 9.8\times(6+4\sin 30) = 156.8$ J	M1 B1 A1	Use of mgh $6 + 4\sin 30$	3
(B)	WD against friction is $4\times 0.75\times 2\times 9.8\times\cos 30 = 50.9222...$ J	M1 A1	Use of WD = Fd	2
(C)	Power is $10\times(156.8 + 50.9222\ldots)/60$ $= 34.620\ldots$ so 34.6 W (3 s. f.)	M1 A1	Use P = WD/t	2
(iii)	$0.5\times 2\times 9^2$ $= 2\times 9.8\times(6+x\sin 30)$ $+\ 0.5\times 2\times 4^2$ -90 so $x = 3.8163\ldots$ so 3.82 (3 s. f.)	M1 B1 A1 A1 A1	Equating KE to GPE and WD term. Allow sign errors and one KE term omitted. Allow 'old' friction as well. Both KE terms. Allow wrong signs. All correct but allow sign errors All correct, including signs. cao	5
		17		