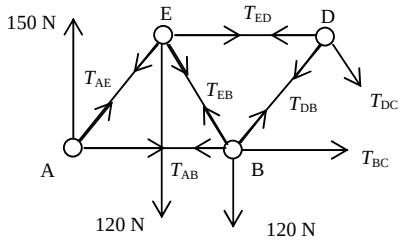
Q 1		mark		Sub
(i)	$16 = 0.4v$ so 40 m s^{-1}	M1 A1	Use of $I = \Delta mv$	2
(ii)	PCLM ↑ + ve $0.4\times32 - 0.6u = 0.4v_P + 0.6\times4$ NEL ↑ +ve $\frac{4 - v_P}{-u - 32} = -0.1$ Solving u = 18 $v_P = -1$ so 1 m s^{-1} downwards	M1 A1 M1 A1 E1 A1 A1	Use of PCLM Any form Use of NEL. Allow sign errors. Any form Must be obtained from a pair of correct equations. If given u = 18 used then v_P = -1 must be obtained from 1 equation and both values tested in the second equation cao. Accept use of given u = 18 cao	7
(iii)	Considering the momenta involved $0.5\begin{pmatrix}-3.6\\5.2\end{pmatrix} = 0.2\begin{pmatrix}3\\4\end{pmatrix} + 0.3\mathbf{v}_D$ $\mathbf{v}_D = \begin{pmatrix}-8\\6\end{pmatrix}$ so a = –8 and b = 6 Gradients of the lines are $\frac{4}{3}$ and $\frac{6}{-8}$ Since $\frac{4}{3}\times\frac{6}{-8} = -1$, they are at 90°	M1 B1 B1 A1 A1 A1 M1 E1	PCLM applied. May be implied. LHS momentum of C correct Complete equation. Accept sign error. cao cao Any method for the angle Clearly shown	8
				17

Q 2		mark		Sub
(i)	Moments about C $240 \times 2 = 3R_D$ $R_D = 160$ so 160 N Resolve vertically $R_C + R_D = 240$ $R_C = 80$ so 80 N	 M1 A1 M1 F1	 Moments about C or equivalent. Allow 1 force omitted Resolve vertically or moments about D or equivalent. All forces present. FT from **thei**r R_D only	4
(ii) (A)	Moments about D $240 \times 1 = 4T \sin 40$ T = 93.343… so 93.3 N (3 s. f.)	 M1 M1 A1 A1	 Moments about D or equivalent Attempt at resolution for RHS RHS correct	4
(ii) (B)	In equilibrium so horizontal force needed to balance cpt of T. This must be friction and cannot be at C.		Need reference to horizontal force that must come from friction at D.	1
(iii) (A)	Moments about B $3 \times 240 \times \cos 30 = 6P$ $P = 60\sqrt{3}$ (103.92…..) P inclined at 30° to vertical Resolve horizontally. Friction force F $F = P \sin 30$ so $F = 30\sqrt{3}$ (51.961…)	 M1 E1 B1 M1 A1	 All terms present, no extras. Any resolution required attempted. Accept decimal equivalent Seen or equivalent or implied in (iii) (A) or (B). Resolve horizontally. Any resolution required attempted Any form	5

(iii) (B)	Resolve vertically. Normal reaction R			
	$P\cos 30 + R = 240$	M1	Resolve vertically. All terms present.and resolution attempted	
		A1		
	Using $F = \mu R$	M1		
	$\mu = \dfrac{30\sqrt{3}}{240 - 60\sqrt{3} \times \dfrac{\sqrt{3}}{2}}$	A1	Substitute **their expressions** for F and R	
	$= \dfrac{30\sqrt{3}}{240 - 90} = \dfrac{\sqrt{3}}{5}$ = 0.34641 so 0.346 (3 s. f.)	A1	cao. Any form. Accept 2 s. f. or better	
				5
				19

Q 3		mark		**Sub**
(a) (i)	$80\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 48\begin{pmatrix}6\\2\end{pmatrix} + 12\begin{pmatrix}1\\-3\end{pmatrix} + 20\begin{pmatrix}11\\9\end{pmatrix}$	M1	Correct method for c.m.	
	$80\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = \begin{pmatrix}520\\240\end{pmatrix}$	B1	Total mass correct	
		B1	One c.m. on RHS correct [If separate components considered, B1 for 2 correct]	
	$\bar{x} = 6.5$	E1		
	$\bar{y} = 3$	A1	cao	5
(ii)	Consider x coordinate			
	$520 = 76\times 6.4 + 4x$	M1	Using additive principle o. e. on x cpts	
		B1	Areas correct. Allow FT from masses from (i)	
	so $x = 8.4$	A1	cao	3
(iii)				
	y coordinate is 1 so we need	B1	Position of centre of square	
	$240 = 76\bar{y} + 4\times 1$ and $\bar{y} = 3.10526...$	M1		
	so 3.11 (3 s. f.)	A1	cao	3
(b) (i)	Moments about C			
	$4R = 120\times 3 + 120\times 2$	M1	Moments equation. All terms present	
	so 4 R = 600 and R = 150	E1		2
(ii)		B1		
	A↑ $150 + T_{AE}\cos 30 = 0$	M1	Equilibrium at a pin-joint	
	$T_{AE} = -100\sqrt{3}$ so $100\sqrt{3}$ N (C)	A1	Any form. Sign correct. Neglect (C)	
	E↓ $120 + T_{AE}\cos 30 + T_{EB}\cos 30 = 0$	M1	Equilibrium at E, all terms present	
	$T_{EB} = 20\sqrt{3}$ so $20\sqrt{3}$ N (T)	F1	Any form. Sign follows working. Neglect (T).	
		F1	T/C consistent with answers	

				6
(iii)	Consider $\rightarrow$ at E, using (ii) gives ED as thrust	E1	Clearly explained. Accept 'thrust' correctly deduced from wrong answers to (ii).	1
				20

Q 4		mark		Sub
(i)	$\frac{0.5\times 20\times 8^2 - 0.5\times 20\times 5^2 + 510}{6}$	M1	Use of P = WD/t	
		B1	ΔKE. Accept ± 390 soi	
		A1	All correct including signs	
	= 150 W	A1		4
(ii) (A)	$20g\times\frac{3}{5}x - 5gx$	M1	Use of *mgh* on both terms	
		B1	Either term (neglecting signs)	
	$7gx$ (68.6x) gain	A1	$\pm 7gx$ in any form.	
		A1	cao	4
(B)	$11gx$	B1		1
(C)	$0.5\times 25\times 4^2 = 7gx + 11gx = 18gx$	M1	Use of work-energy equation. Allow 1 RHS term omitted.	
		B1	KE term correct	
	x = 1.13378… so 1.13 m (3 s. f.)	A1	cao. Except follow wrong sign for $7gx$ only.	3
(iii)	**either**			
	$0.5\times 35\times v^2 - 0.5\times 35\times 16$	M1	Use of work-energy. KE, GPE and WD against friction terms present.	
	$= 15g\times 0.5 - 11g\times 0.5 - 12g\times 0.5$	B1	ΔGPE correct inc sign (1.5g J loss)	
		A1	All correct	
	$v^2 = 13.76$ so v = 3.70944… so 3.71 m s^{-1} (3 s. f.)	A1	cao	
	or			
	$15g - T = 15a \qquad T - 12g - 11g = 20a$	M1	N2L in 1 or 2 equations. All terms present	
	so $a = -2.24$	A1	cao	
	$v^2 = 4^2 + 2\times(-2.24)\times 0.5$ so 3.71 m s^{-1} (3 s. f.)	M1	Use of appropriate (sequence of) *uvast*	
		A1	cao	4
				16