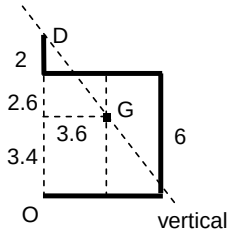
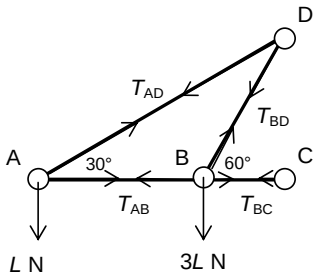
4762 Mechanics 2

Q 1		mark	comment	sub
(a) (i)	In **i** direction: $6u - 12 = 18$ so u = 5 i.e. 5**i** m s^{-1}	M1 E1	Use of I-M Accept $6u - 12 = 18$ as total working. Accept 5 instead of 5**i**.	
	either In **i** direction: $0.5v + 12 = 0.5 \times 11$ $v = -13$ so -13**i** m s^{-1} **or** 6 × 5 + 0.5 v = 6 × 3 + 0.5 × 11 v = – 13 so – 13**i** m s^{-1}	M1 B1 A1 M1 A1 A1	Use of I-M Use of + 12**i** or equivalent Accept direction indicated by any means PCLM Allow only sign errors Accept direction indicated by any means	5
(ii)	Using NEL: $\frac{11-3}{-13-5} = -e$ $e = \frac{4}{9}$ $(0.\dot{4})$	M1 F1 F1	Use of NEL. Condone sign errors but not reciprocal expression FT only **their** -13 (even if +ve) FT only **their** -13 and only if –ve (allow 1 s.f. accuracy)	3
(iii)	In **i** direction: $-2 \times 7 = 0.5v - 0.5 \times 11$ v = -17 so -17 **i** m s^{-1} **or** – 2 **i** = 0.5 a so a = – 4 **i** m s^{-2} v = 11**i** – 4**i** × 7 v = -17 so -17 **i** m s^{-1}	M1 M1 A1 A1 M1 A1 M1 A1	Use of **I** = **F***t* Use of **I** = *m*(**v** –**u**) For ± 17 cao. Direction (indicated by any means) Use of **F** = *m***a** For ± 4 Use of **uvas***t* cao. Direction (indicated by any means)	4
(b)	u **i** + ev **j** $\tan\alpha = \frac{v}{u}$, $\tan\beta = \frac{ev}{u}$ $\tan\beta = e\left(\frac{v}{u}\right) = e\tan\alpha$	B1 B1 M1 B1 E1	For u For ev Use of tan. Accept reciprocal argument. Accept use of **their** components Both correct. Ignore signs. Shown. Accept signs not clearly dealt with.	5
		17		

Q 2		mark	comment	sub
(i)	$(2+3\times6)\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=6\begin{pmatrix}3\\0\end{pmatrix}+6\begin{pmatrix}6\\3\end{pmatrix}+6\begin{pmatrix}3\\6\end{pmatrix}+2\begin{pmatrix}0\\7\end{pmatrix}$ $20\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=\begin{pmatrix}18+36+18\\18+36+14\end{pmatrix}=\begin{pmatrix}72\\68\end{pmatrix}$ $\bar{x}=3.6$ $\bar{y}=3.4$	M1 B1 B1 B1 E1 A1	Method for c.m. Total mass correct For any of the 1st 3 RHS terms For the 4th RHS term cao [If separate cpts, award the 2nd B1 for 2 *x*- terms correct and 3rd B1 for 2×7 in *y* term]	6
(ii)	 $\arctan\left(\frac{3.6}{2+(6-3.4)}\right)=\arctan\left(\frac{3.6}{4.6}\right)$ so 38.047… so 38.0° (3 s. f.)	B1 B1 M1 B1 A1	Diagram showing G vertically below D 3.6 and **their** 3.4 correctly placed (may be implied) Use of arctan on **their** lengths. Allow reciprocal of argument. Some attempt to calculate correct lengths needed 2 + (6 – **their** 3.4) seen cao	5
(iii)	moments about D $5\times3.6=6\times T_{BP}$ so tension in BP is 3 N Resolve vert: $3+T_{DQ}=5$ so tension in DQ is 2 N	M1 F1 M1 F1	moments about D. No extra forces FT **their** values if calc 2nd Resolve vertically or moments about B. FT **their** values if calc 2nd	4
(iv)	We require *x*-cpt of c.m. to be zero **either** $(20+L)\bar{x}=20\times3.6-\frac{1}{2}L^2$ **or** $2\times6\times(0.5\times6)+6\times6-0.5\times L^2=0$ *L* = 12	M1 B1 A1 A1	A method to achieve this with all cpts For the $0.5\times L^2$ All correct	4
		19		

Q 3		mark	comment	sub
(a) (i)		B1 B1	Internal forces all present and labelled All forces correct with labels and arrows (Allow the internal forces set as tensions, thrusts or a mixture)	2
(ii)	A ↑ T_{AD} sin 30 – L = 0 so T_{AD} = 2L so 2L N (T) A → T_{AB} + T_{AD} cos 30 = 0 so T_{AB} = $-\sqrt{3}L$ so $\sqrt{3}L$ N (C) B ↑ T_{BD} sin 60 – 3L = 0 so T_{BD} = $2\sqrt{3}L$ so $2\sqrt{3}L$ N (T) B → T_{BC} + T_{BD} cos 60 – T_{AB} = 0 so T_{BC} = $-2\sqrt{3}L$ so $2\sqrt{3}L$ N (C)	M1 A1 M1 F1 M1 A1 M1 F1 E1	Equilibrium equation at a pin-joint attempted 1st ans. Accept + or –. Second equation attempted 2nd ans. FT any previous answer(s) used. Third equation attempted 3rd ans. FT any previous answer(s) used. Fourth equation attempted 4th ans. FT any previous answer(s) used. All T/C consistent [SC 1 all T/C correct WWW]	9
(b)	Leg QR with frictional force F ← moments c.w. about R $U \times 2l\sin 60 - Wl\cos 60 = 0$ Horiz equilibrium for QR $F = U$ Hence $\frac{1}{2}W = \sqrt{3}F$ and so $F = \frac{\sqrt{3}}{6}W$	 M1 A1 A1 M1 E1 M1 E1	Accept only 1 leg considered (and without comment) Suitable moments equation. Allow 1 force omitted a.c. moments c.w. moments A second correct equation for horizontal or vertical equilibrium to eliminate a force (U or reaction at foot) [Award if correct moments equation containing only W and F] * This second equation explicitly derived Correct use of 2nd equation with the moments equation Shown. CWO but do not penalise * again.	7
		18		

Q 4		mark	comment	sub
(a) (i)	Tension is perp to the motion of the sphere (so WD, $Fd\cos\theta$ = 0)	E1		1
(ii)	Distance dropped is $2-2\cos 40$ = 0.467911..	M1	Attempt at distance with resolution used. Accept $\sin \leftrightarrow \cos$	
		E1	Accept seeing $2-2\cos 40$	
	GPE is *mgh* so	M1		
	$0.15\times 9.8\times 0.467911... = 0.687829...$ J	B1	Any reasonable accuracy	4
(iii)	$0.5\times 0.15\times v^2 = 0.687829...$ so v = 3.02837… so 3.03 m s^{-1} (3 s. f.)	M1	Using KE + GPE constant	
		F1	FT **their** GPE	2
(iv)	$\frac{1}{2}\times 0.15\left(v^2-2.5^2\right)$	M1	Use of W-E equation (allow 1 KE term or GPE term omitted)	
		B1	KE terms correct	
	$= 0.687829... - 0.6\times\frac{40}{360}\times 2\pi\times 2$	M1	WD against friction	
		A1	WD against friction correct (allow sign error)	
	v = 2.06178… so 2.06 m s^{-1} (3 s. f.)	A1	cao	5
(b)	N2L down slope: $3g\sin 30 - F = 3\times\frac{1}{8}g$	M1	Must have attempt at weight component	
		A1	Allow sign errors.	
	so $F = \frac{9g}{8}$ (= 11.025)	A1		
	$R = 3g\times\frac{\sqrt{3}}{2}$ (= 25.4611…)	B1		
	$\mu = \frac{F}{R} = \frac{\sqrt{3}}{4}$ (= 0.43301…)	M1	Use of $F = \mu R$	
		E1	Must be worked precisely	6
		18		