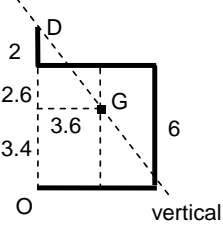
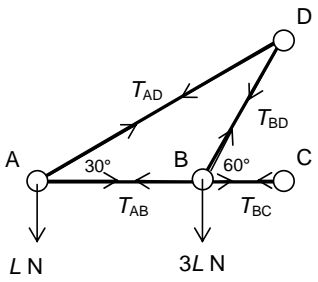


## 4762 Mechanics 2

Q 1	mark	comment	sub
(a) (i) In $i$ direction: $6u - 12 = 18$ so $u = 5$ i.e. $5i \text{ m s}^{-1}$  <b>either</b> In $i$ direction: $0.5v + 12 = 0.5 \times 11$  $v = -13$ so $-13i \text{ m s}^{-1}$ <b>or</b> $6 \times 5 + 0.5 v = 6 \times 3 + 0.5 \times 11$ $v = -13$ so $-13i \text{ m s}^{-1}$	M1 E1  M1 B1 A1  M1 A1 A1	Use of I-M Accept $6u - 12 = 18$ as total working. Accept 5 instead of $5i$ .  Use of I-M Use of $+ 12i$ or equivalent Accept direction indicated by any means  PCLM Allow only sign errors Accept direction indicated by any means	5
(ii) Using NEL: $\frac{11-3}{-13-5} = -e$  $e = \frac{4}{9}$ (0.4)	M1  F1 F1	Use of NEL. Condone sign errors but not reciprocal expression  FT only <b>their</b> $-13$ (even if +ve) FT only <b>their</b> $-13$ 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 $-17i \text{ m s}^{-1}$  <b>or</b> $-2i = 0.5a$ so $a = -4i \text{ m s}^{-2}$ $v = 11i - 4i \times 7$ $v = -17$ so $-17i \text{ m s}^{-1}$	M1 M1 A1 A1  M1 A1 M1 A1	Use of $I = Ft$ Use of $I = m(v - u)$ For $\pm 17$ cao. Direction (indicated by any means)  Use of $F = ma$ For $\pm 4$ 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 <b>their</b> components  Both correct. Ignore signs. Shown. Accept signs not clearly dealt with.	5
	17		

Q 2		mark	comment	sub
(i)	$(2+3\times 6)\left(\frac{\bar{x}}{\bar{y}}\right)=6\begin{pmatrix} 3 \\ 0 \end{pmatrix}+6\begin{pmatrix} 6 \\ 3 \end{pmatrix}+6\begin{pmatrix} 3 \\ 6 \end{pmatrix}+2\begin{pmatrix} 0 \\ 7 \end{pmatrix}$ $20\left(\frac{\bar{x}}{\bar{y}}\right)=\begin{pmatrix} 18+36+18 \\ 18+36+14 \end{pmatrix}=\begin{pmatrix} 72 \\ 68 \end{pmatrix}$ $\bar{x}=3.6$ $\bar{y}=3.4$	M1 B1 B1 B1 E1 A1	Method for c.m. Total mass correct For any of the 1 <sup>st</sup> 3 RHS terms For the 4 <sup>th</sup> RHS term cao [If separate cpts, award the 2 <sup>nd</sup> B1 for 2 x- terms correct and 3 <sup>rd</sup> B1 for 2×7 in y term]	6
(ii)	 $\arctan\left(\frac{3.6}{2+(6-3.4)}\right)=\arctan\left(\frac{3.6}{4.6}\right)$ <p>so 38.047... so 38.0° (3 s. f.)</p>	B1 B1 M1 B1 A1	Diagram showing G vertically below D 3.6 and <b>their</b> 3.4 correctly placed (may be implied) Use of arctan on <b>their</b> lengths. Allow reciprocal of argument. Some attempt to calculate correct lengths needed 2 + (6 – <b>their</b> 3.4) seen cao	5
(iii)	moments about D $5\times 3.6=6\times T_{BP}$ 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 <b>their</b> values if calc 2nd Resolve vertically or moments about B. FT <b>their</b> values if calc 2nd	4
(iv)	We require x-cpt of c.m. to be zero <b>either</b> $(20+L)\bar{x}=20\times 3.6-\frac{1}{2}L^2$ <b>or</b> $2\times 6\times(0.5\times 6)+6\times 6-0.5\times L^2=0$ $L=12$	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)	<p>A <math>\uparrow</math>  <math>T_{AD} \sin 30 - L = 0</math> so <math>T_{AD} = 2L</math> so <math>2L</math> N (T)</p> <p>A <math>\rightarrow</math> <math>T_{AB} + T_{AD} \cos 30 = 0</math>          so <math>T_{AB} = -\sqrt{3}L</math> so <math>\sqrt{3}L</math> N (C)</p> <p>B <math>\uparrow</math> <math>T_{BD} \sin 60 - 3L = 0</math>          so <math>T_{BD} = 2\sqrt{3}L</math> so <math>2\sqrt{3}L</math> N (T)</p> <p>B <math>\rightarrow</math>  <math>T_{BC} + T_{BD} \cos 60 - T_{AB} = 0</math>          so <math>T_{BC} = -2\sqrt{3}L</math> so <math>2\sqrt{3}L</math> N (C)</p>	M1 A1  M1 F1  M1 A1  M1 F1  E1	<p>Equilibrium equation at a pin-joint attempted 1<sup>st</sup> ans. Accept + or -.</p> <p>Second equation attempted 2<sup>nd</sup> ans. FT any previous answer(s) used.</p> <p>Third equation attempted 3<sup>rd</sup> ans. FT any previous answer(s) used.</p> <p>Fourth equation attempted 4<sup>th</sup> ans. FT any previous answer(s) used.</p> <p>All T/C consistent [SC 1 all T/C correct WWW]</p>	9
(b)	<p>Leg QR with frictional force <math>F \leftarrow</math>          moments c.w. about R  <math>U \times 2l \sin 60 - Wl \cos 60 = 0</math></p> <p>Horiz equilibrium for QR  <math>F = U</math></p> <p>Hence <math>\frac{1}{2}W = \sqrt{3}F</math>          and so <math>F = \frac{\sqrt{3}}{6}W</math></p>	M1 A1 A1  M1  E1 M1  E1	<p>Accept only 1 leg considered (and without comment)</p> <p>Suitable moments equation. Allow 1 force omitted a.c. moments c.w. moments</p> <p>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]</p> <p>* This second equation explicitly derived Correct use of 2<sup>nd</sup> equation with the moments equation</p> <p>Shown. CWO but do not penalise * again.</p>	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 $2 - 2 \cos 40 = 0.467911..$  GPE is $mgh$ so $0.15 \times 9.8 \times 0.467911... = 0.687829... \text{ J}$	M1 E1 M1 B1	Attempt at distance with resolution used. Accept $\sin \leftrightarrow \cos$ Accept seeing $2 - 2 \cos 40$  Any reasonable accuracy	4
(iii) $0.5 \times 0.15 \times v^2 = 0.687829...$ so $v = 3.02837... \text{ so } 3.03 \text{ m s}^{-1} \text{ (3 s. f.)}$	M1 F1	Using KE + GPE constant FT <b>their</b> GPE	2
(iv) $\frac{1}{2} \times 0.15 (v^2 - 2.5^2)$  $= 0.687829... - 0.6 \times \frac{40}{360} \times 2\pi \times 2$  $v = 2.06178... \text{ so } 2.06 \text{ m s}^{-1} \text{ (3 s. f.)}$	M1 B1 M1 A1 A1	Use of W-E equation (allow 1 KE term or GPE term omitted)  KE terms correct  WD against friction  WD against friction correct (allow sign error) cao	5
(b) N2L down slope: $3g \sin 30 - F = 3 \times \frac{1}{8} g$  so $F = \frac{9g}{8} (= 11.025)$  $R = 3g \times \frac{\sqrt{3}}{2} (= 25.4611...)$  $\mu = \frac{F}{R} = \frac{\sqrt{3}}{4} (= 0.43301...)$	M1 A1 A1 B1 M1 E1	Must have attempt at weight component  Allow sign errors.    Use of $F = \mu R$  Must be worked precisely	6
	18		