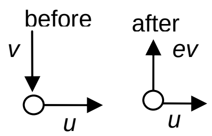
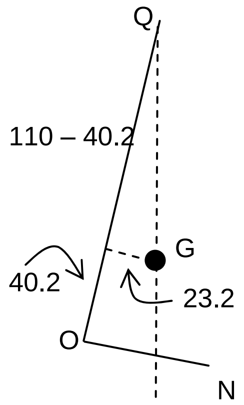
4762 Mechanics 2

1 (a) **(i)**	Let vel of Q be v $\rightarrow$ $6\times1=4v+2\times4$ $v = -0.5$ so 0.5 m s^{-1} in opposite direction to R	 M1 A1 A1 A1	 Use of PCLM Any form Direction must be made clear. Accept – 0.5 only if + ve direction clearly shown	4
(ii)	Let velocities after be R: v_R $\rightarrow$; S: v_S $\rightarrow$ PCLM +ve $\rightarrow$ $4\times2-1\times3=2v_R+3v_S$ $2v_R+3v_S=5$ NEL +ve $\rightarrow$ $\frac{v_S-v_R}{-1-4}=-0.1$ so $v_S - v_R = 0.5$ Solving gives $v_R = 0.7 \rightarrow$ $v_S = 1.2 \rightarrow$	 M1 A1 M1 A1 A1 A1	 PCLM Any form NEL Any form Direction not required Direction not required Award cao for 1 vel and FT second	6
(iii)	R and S separate at 0.5 m s^{-1} Time to drop T given by $0.5\times9.8T^2=0.4$ so $T=\frac{2}{7}$ (0.28571…) so distance is $\frac{2}{7}\times0.5=\frac{1}{7}$ m (0.142857…m)	M1 B1 A1	FT **their** result above. Either from NEL or from difference in final velocities cao	3
(b)	 $u \rightarrow u$ $v \rightarrow (-)ev$ KE loss is $\frac{1}{2}m(u^2+v^2)-\frac{1}{2}m(u^2+e^2v^2)$ $=\frac{1}{2}mu^2+\frac{1}{2}mv^2-\frac{1}{2}mu^2-\frac{1}{2}me^2v^2$ $=\frac{1}{2}mv^2(1-e^2)$	B1 B1 M1 E1	 Accept $v \rightarrow ev$ Attempt at difference of KEs Clear expansion and simplification of correct expression	
				4
				17

2(i)	GPE is 1200 × 9.8 × 60 = 705 600 Power is (705 600 + 1 800 000) ÷ 120 = 20 880 W = 20 900 W (3 s. f.)	B1 M1 B1 A1	Need not be evaluated power is WD ÷ time 120 s cao	4
(ii)	Using $P = Fv$. Let resistance be R N $13500 = 18F$ so $F = 750$ As v const, $a = 0$ so $F - R = 0$ Hence resistance is 750 N We require 750 × 200 = 150 000 J (= 150 kJ)	M1 A1 E1 M1 F1	Use of $P = Fv$. Needs some justification Use of WD = Fd or Pt FT **their** F	5
(iii)	$\frac{1}{2}\times 1200\times\left(9^2-18^2\right)$ $=1200\times 9.8\times x\sin 5-1500x$ Hence 145800 = 475.04846…x so x = 306.91… so 307 m (3 s, f,)	M1 B1 M1 A1 A1 A1	Use of W-E equation with ‘x’ 2 KE terms present GPE term with resolution GPE term correct All correct cao	6
(iv)	$P = Fv$ and N2L gives $F - R = 1200a$ Substituting gives $P = (R + 1200a)v$ If $a \neq 0$, v is not constant. But P and R are constant so a cannot be constant.	B1 B1 E1 E1	 Shown	
				4
				19
3 (i) (*A*)	Let force be P a.c. moments about C P × 0.125 – 340 × 0.5 = 0 P = 1360 so 1360 N	 M1 A1 A1	 Moments about C. All forces present. No extra forces. Distances correct cao	3
(i) (*B*)	Let force be P c.w. moments about E P × 2.125 – 340 × (2 – 0.5) = 0 P = 240 so 240 N	 M1 A1 A1	 Moments about E. All forces present. No extra forces. Distances correct cao	3

(ii)	$Q\sin\theta \times 2.125 + Q\cos\theta \times 0.9$ $= \frac{25.5Q}{13} + \frac{4.5Q}{13}$ $= \frac{30Q}{13}$ so $\frac{30Q}{13}$ N m	M1 B1 E1	Moments expression. Accept $s \leftrightarrow c$. Correct trig ratios **or** lengths Shown	3
(iii)	We need $\frac{30Q}{13} = 340 \times 1.5$ so $Q = 221$ Let friction be F and normal reaction R Resolve $\rightarrow$ $221\cos\theta - F = 0$ so $F = 85$ Resolve $\uparrow$ $221 \sin\theta + R = 340$ so $R = 136$ $F < \mu R$ as not on point of sliding so $85 < 136\mu$ so $\mu > \frac{5}{8}$	M1 E1 M1 A1 M1 A1 M1 A1 E1	Moments equn with all relevant forces Shown Accept $\le$ or = Accept $\le$. FT **their** F and R	
				9
				18
4 (i)	$4000\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 4800\begin{pmatrix}30\\ 40\end{pmatrix} - 800\begin{pmatrix}50\\ 20\end{pmatrix}$ so $\bar{x} = 26$ $\bar{y} = 44$	M1 A1 E1 A1	Any complete method for c.m. Either one RHS term correct or one component of both RHS terms correct [SC 2 for correct $\bar{y}$ seen if M 0]	4
(ii)	$250\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}$ $= 110\begin{pmatrix}0\\ 55\end{pmatrix} + 40\begin{pmatrix}20\\ 0\end{pmatrix} + 40\begin{pmatrix}40\\ 20\end{pmatrix} + 20\begin{pmatrix}50\\ 40\end{pmatrix} + 40\begin{pmatrix}60\\ 60\end{pmatrix}$ $\bar{x} = 23.2$ $\bar{y} = 40.2$	M1 B1 B1 E1 A1	Any complete method for c.m. Any 2 edges correct mass and c.m. **or** any 4 edges correct with mass and x or y c.m. coordinate correct. At most one consistent error	5

(iii)		B1	Indicating c.m. vertically below Q	
		B1	Clearly identifying correct angle (may be implied) and lengths	
	Angle is $\arctan\left(\frac{23.2}{110-40.2}\right)$	M1	Award for $\arctan\left(\frac{b}{a}\right)$ where b = 23.2 and a = 69.8 or 40.2 or where b = 69.8 or 40.2 and a = 23.2. Allow use of **their** value for y only.	
	= 18.3856…. so 18.4° (3 s. f.)	A1	cao	4
(iv)	$10\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 2\times1.5\times\begin{pmatrix}26\\44\end{pmatrix} + 7\begin{pmatrix}23.2\\40.2\end{pmatrix}$	M1	Combining the parts using masses	
		B1	Using both ends	
		A1	All correct	
	$\bar{x} = 24.04$ so 24.0 (3 s.f.)	A1	cao	
	$\bar{y} = 41.34$ so 41.3 (3 s.f.)	F1	FT **their** y values only.	5
				18