4762 Mechanics 2

Q 1		Mark		Sub
(i)	**either**			
		M1	Use of $I = Ft$	
	$m \times 2u = 5F$	A1		
	so $F = 0.4mu$ in direction of the velocity	A1	Must have reference to direction. Accept diagram.	
	or			
		M1	Use of *suvat* **and** N2L	
	$a = \frac{2u}{5}$	A1	May be implied	
	so $F = 0.4mu$ in direction of the velocity	A1	Must have reference to direction. Accept diagram.	3
(ii)				
		M1	For 2 equns considering PCLM, NEL or Energy	
	PCLM $\rightarrow$ $2um + 3um = mv_P + 3mv_Q$			
	NEL $\rightarrow$ $v_Q - v_P = 2u - u = u$			
	Energy $\frac{1}{2}m \times (2u)^2 + \frac{1}{2}(3m) \times u^2$			
	= $\frac{1}{2}m \times v_P^{\,2} + \frac{1}{2}(3m) \times v_Q^{\,2}$			
		A1	One correct equation	
		A1	Second correct equation	
	Solving to get both velocities	M1	Dep on 1st M1. Solving pair of equations.	
	$v_Q = \frac{3u}{2}$	E1	If Energy equation used, allow 2nd root discarded without comment.	
	$v_P = \frac{u}{2}$	A1		
			[If AG subst in one equation to find other velocity, and no more, max SC3]	6
(iii)	**either**			
	After collision with barrier $v_Q = \frac{3eu}{2}$ $\leftarrow$	B1	Accept no direction indicated	
	so $\rightarrow$ $m\frac{u}{2} - 3m\frac{3eu}{2} = -4m\frac{u}{4}$	M1	PCLM	
		A1	LHS Allow sign errors. Allow use of $3mv_Q$.	
		A1	RHS Allow sign errors	
	so $e = \frac{1}{3}$	A1		
	At the barrier the impulse on Q is given by			
	$\rightarrow$ $3m\left(-\frac{3u}{2} \times \frac{1}{3} - \frac{3u}{2}\right)$	M1	Impulse is $m(v - u)$	
		F1	$\pm\frac{3u}{2} \times \frac{1}{3}$	
	so impulse on Q is $-6mu$ $\rightarrow$	F1	Allow $\pm$ and direction not clear. FT only e.	
	so impulse on the barrier is $6mu$ $\rightarrow$	A1	cao. Direction must be clear. Units not required.	9
		18		

Q 1	continued	mark		sub
(iii)	**or**			
	After collision with barrier $v_Q = \frac{3eu}{2}$ $\leftarrow$	B1		
	Impulse – momentum overall for Q			
	$\rightarrow \quad 2mu + 3mu + I = -4m \times \frac{u}{4}$	M1	All terms present	
		A1	All correct except for sign errors	
	$I = -6mu$	A1		
	so impulse of $6mu$ on the barrier $\rightarrow$	A1	Direction must be clear. Units not required.	
	Consider impact of Q with the barrier to give speed v_Q after impact			
	$\rightarrow \quad \frac{3u}{2} \times 3m - 6mu = 3mv_Q$	M1	Attempt to use I - M	
		F1		
	so $v_Q = -\frac{u}{2}$	F1		
	$e = \frac{u}{2} \div \frac{3u}{2} = \frac{1}{3}$	A1	cao	
				9

Q 2		Mark		Sub
(i)	$R = 80g\cos\theta$ or $784\cos\theta$ $F_{max} = \mu R$ so $32g\cos\theta$ or $313.6\cos\theta$ N	B1 M1 A1	Seen	3
(ii)	Distance is $\frac{1.25}{\sin\theta}$ WD is $F_{max}\,d$ so $32g\cos\theta \times \frac{1.25}{\sin\theta}$ $= \frac{392}{\tan\theta}$	B1 M1 E1	Award for this or equivalent seen	3
(iii)	Δ GPE is mgh so $80\times 9.8\times 1.25 = 980$ J	M1 A1	Accept $100g$ J	2
(iv)	**either** $P = Fv$ so $(80g\sin 35 + 32g\cos 35)\times 1.5$ = 1059.85… so 1060 W (3 s. f.) **or** $P = \frac{\text{WD}}{\Delta t}$ so $\frac{980 + \frac{392}{\tan 35}}{\left(\frac{1.25}{\sin 35}\right)\div 1.5}$ = 1059.85… so 1060 W (3 s. f.)	M1 B1 A1 A1 M1 B1 B1 A1	 Weight term All correct cao Numerator FT **their** GPE Denominator cao	4
(v)	**either** Using the W-E equation $0.5\times 80\times v^2 - 0.5\times 80\times\left(\frac{1}{2}\right)^2 = 980 - \frac{392}{\tan 35}$ v = 3.2793.. so yes **or** N2L down slope a = 2.409973… distance slid, using *uvast* is 1.815372… vertical distance is 1.815372…× sin35 = 1.0412… < 1.25 so yes	M1 B1 B1 A1 A1 M1 A1 A1 M1 A1	Attempt speed at ground or dist to reach required speed. Allow only init KE omitted KE terms. Allow sign errors. FT from (iv). Both WD against friction and GPE terms. Allow sign errors. FT from parts above. All correct CWO All forces present valid comparison CWO	5
		17		

Q 3		Mark		Sub
(i)				
		M1	Correct method for $\bar{y}$ or $\bar{z}$	
		B1	Total mass correct	
		M1	$15\cos\alpha$ or $15\sin\alpha$ attempted either part	
	$\bar{y}$: $250\times 4+125\left(8+\frac{30}{2}\cos\alpha\right)=375\bar{y}$	B1	$\left(8+\frac{30}{2}\cos\alpha\right)$	
		B1	250×4	
	$\bar{y}=\frac{28}{3}=9\frac{1}{3}$	E1	Accept any form	
	$\bar{z}$: $(250\times 0+)\ 125\times\frac{30}{2}\sin\alpha=375\bar{z}$	B1	LHS	
	$\bar{z}=3$	E1		8
(ii)				
	Yes. Take moments about CD. c.w moment from weight; no a.c moment from	E1		
	table	E1	[Award E1 for $9\frac{1}{3}>8$ seen or 'the line of action of the weight is outside the base]	2
(iii)				
	c.m. new part is at (0, 8 + 20, 15)	M1	Either *y* or *z* coordinate correct	
		M1	Attempt to 'add' to (i) or start again. Allow mass error.	
	$375\times\frac{28}{3}+125\times 28=500\bar{y}$ so $\bar{y}=14$	E1		
	$375\times 3+125\times 15=500\bar{z}$ so $\bar{z}=6$	E1		4
(iv)				
	Diagram	B1	Roughly correct diagram	
		B1	Angle identified (may be implied)	
	Angle is $\arctan\frac{6}{14}$	M1	Use of tan. Allow use of 14/6 or equivalent.	
	= 23.1985… so 23.2° (3 s. f.)	A1	cao	4
		18		

Q 4		mark		sub
(a)	Let the ↑ forces at P and Q be R_P and R_Q			
(i)	c.w. moments about P $2\times600-3R_Q=0$ so force of 400 N ↑ at Q	M1 A1	Moments taken about a named point.	
	a.c. moments about Q or resolve $R_P=200$ so force of 200 N ↑ at P	M1 A1		4
(ii)	$R_P=0$	B1	Clearly recognised or used.	
	c.w. moments about Q	M1	Moments attempted with all forces. Dep on $R_P=0$ or R_P not evaluated.	
	$2L-1\times600=0$ so L = 300	A1		3
(b) (i)	$\cos\alpha=15/17$ or $\sin\alpha=8/17$ or $\tan\alpha=8/15$	B1	Seen here or below or implied by use.	
	c.w moments about A	M1	Moments. All forces must be present and appropriate resolution attempted.	
	$16\times340\cos\alpha-8R=0$	A1		
	so R = 600	E1	Evidence of evaluation.	4
(ii)	Diagram	B1	Must have 600 (or R) and 340 N and reactions at A.	
		B1	All internal forces clearly marked as tension or thrust. Allow mixture.	
	(Solution below assumes all internal forces set as tensions)		[Max of B1 if extra forces present]	2
(iii)		M1	Equilibrium at a pin-joint	
	B ↓ $340\cos\alpha+T_{BC}\cos\alpha=0$ so $T_{BC}=-340$ (Thrust of) 340 N in BC	A1		
	C → $T_{BC}\sin\alpha-T_{AC}\sin\alpha=0$ so $T_{AC}=-340$ (Thrust of) 340 N in AC	F1		
	B ← $T_{AB}+T_{BC}\sin\alpha-340\sin\alpha=0$	M1	Method for T_{AB}	
	so $T_{AB}=320$ (Tension of) 320 N in AB	A1		
	Tension/ Thrust all consistent with working	F1	[Award a max of 4/6 if working inconsistent with diagram]	6
		19		