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			
	$\rightarrow$ $2mu + 3mu + I = -4m \times \frac{u}{4}$	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			
	$\rightarrow$ $\frac{3u}{2} \times 3m - 6mu = 3mv_Q$	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 $784\cos\theta$	B1	Seen	
	$F_{max} = \mu R$	M1		
	so $32g\cos\theta$ or $313.6\cos\theta$ N	A1		3
(ii)	Distance is $\frac{1.25}{\sin\theta}$	B1		
	WD is $F_{max}\, d$	M1		
	so $32g\cos\theta \times \frac{1.25}{\sin\theta}$	E1	Award for this or equivalent seen	
	$= \frac{392}{\tan\theta}$			3
(iii)	Δ GPE is *mgh*	M1		
	so $80 \times 9.8 \times 1.25 = 980$ J	A1	Accept 100*g* J	2
(iv)	**either**			
	P = *Fv*	M1		
	so $(80g\sin 35 + 32g\cos 35) \times 1.5$	B1	Weight term	
		A1	All correct	
	= 1059.85… so 1060 W (3 s. f.)	A1	cao	
	or			
	$P = \frac{\text{WD}}{\Delta t}$	M1		
	so $\dfrac{980 + \frac{392}{\tan 35}}{\left(\frac{1.25}{\sin 35}\right) \div 1.5}$	B1	Numerator FT **their** GPE	
		B1	Denominator	
	= 1059.85… so 1060 W (3 s. f.)	A1	cao	4
(v)	**either**			
	Using the W-E equation	M1	Attempt speed at ground or dist to reach required speed. Allow only init KE omitted	
	$0.5 \times 80 \times v^2 - 0.5 \times 80 \times \left(\frac{1}{2}\right)^2 = 980 - \frac{392}{\tan 35}$	B1	KE terms. Allow sign errors. FT from (iv).	
		B1	Both WD against friction and GPE terms. Allow sign errors. FT from parts above.	
		A1	All correct	
	v = 3.2793.. so yes	A1	CWO	
	or			
	N2L down slope	M1	All forces present	
	a = 2.409973…	A1		
	distance slid, using *uvast* is 1.815372…	A1		
	vertical distance is 1.815372…× sin35	M1	valid comparison	
	= 1.0412… < 1.25 so yes	A1	CWO	5
		17		

Q 3		Mark		Sub
(i)		M1 B1 M1	Correct method for $\bar{y}$ or $\bar{z}$ Total mass correct $15\cos\alpha$ or $15\sin\alpha$ attempted either part	
	$\bar{y}$: $250\times4+125\left(8+\frac{30}{2}\cos\alpha\right)=375\bar{y}$	B1 B1	$\left(8+\frac{30}{2}\cos\alpha\right)$ 250×4	
	$\bar{y}=\frac{28}{3}=9\frac{1}{3}$	E1	Accept any form	
	$\bar{z}$: $(250\times0+)\ 125\times\frac{30}{2}\sin\alpha=375\bar{z}$	B1	LHS	
	$\bar{z}=3$	E1		8
(ii)	Yes. Take moments about CD. c.w moment from weight; no a.c moment from table	E1 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 M1	Either *y* or *z* coordinate correct Attempt to 'add' to (i) or start again. Allow mass error.	
	$375\times\frac{28}{3}+125\times28=500\bar{y}$ so $\bar{y}=14$	E1		
	$375\times3+125\times15=500\bar{z}$ so $\bar{z}=6$	E1		4
(iv)	Diagram	B1 B1	Roughly correct diagram 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) (i)	Let the ↑ forces at P and Q be R_P and R_Q c.w. moments about P $2\times600-3R_Q=0$ so force of 400 N ↑ at Q a.c. moments about Q or resolve $R_P=200$ so force of 200 N ↑ at P	 M1 A1 M1 A1	 Moments taken about a named point.	4
(ii)	$R_P=0$ c.w. moments about Q $2L-1\times600=0$ so L = 300	B1 M1 A1	Clearly recognised or used. Moments attempted with all forces. Dep on $R_P=0$ or R_P not evaluated.	3
(b) (i)	$\cos\alpha=15/17$ or $\sin\alpha=8/17$ or $\tan\alpha=8/15$ c.w moments about A $16\times340\cos\alpha-8R=0$ so R = 600	B1 M1 A1 E1	Seen here or below or implied by use. Moments. All forces must be present and appropriate resolution attempted. Evidence of evaluation.	4
(ii)	Diagram (Solution below assumes all internal forces set as tensions)	B1 B1	Must have 600 (or R) and 340 N and reactions at A. All internal forces clearly marked as tension or thrust. Allow mixture. [Max of B1 if extra forces present]	2
(iii)	B ↓ $340\cos\alpha+T_{BC}\cos\alpha=0$ so $T_{BC}=-340$ (Thrust of) 340 N in BC C → $T_{BC}\sin\alpha-T_{AC}\sin\alpha=0$ so $T_{AC}=-340$ (Thrust of) 340 N in AC B ← $T_{AB}+T_{BC}\sin\alpha-340\sin\alpha=0$ so $T_{AB}=320$ (Tension of) 320 N in AB Tension/ Thrust all consistent with working	M1 A1 F1 M1 A1 F1	Equilibrium at a pin-joint Method for T_{AB} [Award a max of 4/6 if working inconsistent with diagram]	6
		19		