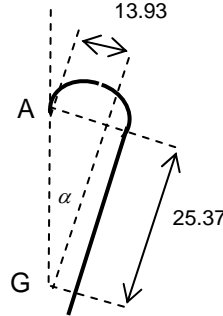


Q 1			
(a) (i)	Impulse has magnitude $2 \times 9 = 18 \text{ N s}$ speed is $\frac{18}{6} = 3 \text{ m s}^{-1}$.	B1 B1	2
(ii)	PCLM \rightarrow $3 \times 6 - 1 \times 2 = 8v$ $v = 2$ so 2 m s^{-1} in orig direction of A	M1 A1 E1	Use of PCLM + combined mass RHS All correct Must justify direction (diag etc)
(iii)	$\rightarrow 2 \times 2 - 2 \times -1 = 6 \text{ N s}$	M1 A1	Attempted use of $mv - mu$ for 6 N s dir specified (accept diag)
(iv) (A)	<p style="text-align: center;"> 2 m s^{-1} 1.8 m s^{-1} \rightarrow \rightarrow \rightarrow \rightarrow $v \text{ m s}^{-1}$ 1.9 m s^{-1} </p>	B1	Accept masses not shown
(B)	PCLM \rightarrow $2 \times 8 + 10 \times 1.8 = 8v + 10 \times 1.9$ $v = 1.875$	M1 A1 A1	PCLM. All terms present Allow sign errors only
(C)	NEL $\frac{1.9 - 1.875}{1.8 - 2} = -e$ so $e = 0.125$	M1 A1 F1	Use of NEL with their v Any form. FT their v FT their v (only for $0 < e \leq 1$)
(b)	Using $v^2 = u^2 + 2as$ $v = \sqrt{2 \times 10 \times 9.8} = 14$ rebounds at $14 \times \frac{4}{7}$ $= 8 \text{ m s}^{-1}$ No change to the horizontal component Since both horiz and vert components are 8 m s^{-1} the angle is 45°	B1 M1 F1 B1 A1	Allow ± 14 Using their vertical component FT from their 14. Allow \pm Need not be explicitly stated cao
		19	5

Q 2				
(i)	$\theta = \frac{\pi}{2}$ <p>gives CG = $\frac{8 \sin \frac{\pi}{2}}{\frac{\pi}{2}} = \frac{16}{\pi}$</p> $\left(-\frac{16}{\pi}, 8\right) \text{ justified}$	B1 E1 E1		3
(ii)	$(8\pi + 72) \begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} = 8\pi \begin{pmatrix} -\frac{16}{\pi} \\ 8 \end{pmatrix} + 72 \begin{pmatrix} 36 \\ 0 \end{pmatrix}$ $\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} = \begin{pmatrix} 25.3673\dots \\ 2.06997\dots \end{pmatrix} = \begin{pmatrix} 25.37 \\ 2.07 \end{pmatrix} \text{ (4 s. f.)}$	M1 B1 A1 A1 E1 E1	Method for c.m. Correct mass of 8 . or equivalent 1 st RHS term correct 2 nd RHS term correct [If separate cpts award the A1s for x- and y- cpts correct on RHS]	6
(iii)	 $\tan \alpha = \frac{13.93}{25.37}$ $\alpha = 28.7700\dots \text{ so } 28.8^\circ \text{ (3 s. f.)}$	B1 M1 M1 A1 A1	General position and angle (lengths need not be shown) Angle or complement attempted. arctan or equivalent. Attempt to get $16 - 2.0699\dots$ Obtaining $13.93\dots$ cao Accept use of $2.0699\dots$ but not 16. cao	5
(iv)	c. w. moments about A $12 \times 13.93 - 16F = 0$ so $F = 10.4475\dots$	M1 A1 A1	[FT use of $2.0699\dots$] Moments about any point, all forces present (1.5525... if $2.0699\dots$ used)	3
		17		

Q 3				
(i)	Moments c.w. about B $200 \times 0.6 - 0.8R_A = 0$ $R_A = 150$ so 150 N Resolve or moments $R_B = 50$ so 50 N	M1 A1 M1 F1	Accept about any point. Allow sign errors.	4
(ii)	Moments c.w. about D $-0.8R_C + 1.2 \times 200 = 0$ $R_C = 300$ ↑ Resolve or moments $R_D = 100$ ↓	M1 A1 M1 A1 E1	Or equiv. Accept about any point. All terms present. No extra terms. Allow sign errors. Neglect direction Or equiv. All terms present. No extra terms. Allow sign errors. Neglect direction Both directions clearly shown (on diag)	5
(iii)	Moments c.w. about P $0.4 \times 200 \cos \alpha - 0.8R_Q = 0$ $R_Q = 96$ so 96 N resolve perp to plank $R_P = 200 \cos \alpha + R_Q$ $R_P = 288$ so 288 N	M1 A1 A1 M1 A1 A1	Or equiv. Must have some resolution. All terms present. No extra terms. Allow sign errors. Correct [No direction required but no sign errors in working] Or equiv. Must have some resolution. All terms present. No extra terms. Allow sign errors. Correct [No direction required but no sign errors in working]	6
(iv)	Need one with greatest normal reaction So at P Resolve parallel to the plank $F = 200 \sin \alpha$ so $F = 56$ $\mu = \frac{F}{R}$ $= \frac{56}{288} = \frac{7}{36}$ (= 0.194 (3 s. f.))	B1 B1 M1 A1	FT their reactions Must use their F and R cao	4
		19		

Q 4				
(i)	<p>either</p> $0.5 \times 20 \times 0.5^2 + 20 \times 9.8 \times 4$ $= 786.5 \text{ J}$ <p>or</p> $a = \frac{1}{32}$ $T - 20g = 20 \times \frac{1}{32}$ $T = 196.625$ <p>WD is $4T = 786.5$ so 786.5 J</p>	<p>M1 B1 B1 A1</p> <p>B1</p> <p>M1 A1 A1</p>	<p>KE or GPE terms</p> <p>KE term</p> <p>GPE term</p> <p>cao</p> <p>N2L. All terms present.</p> <p>cao</p>	4
(ii)	$20g \times 0.5 = 10g \text{ so } 98 \text{ W}$	<p>M1 A1 A1</p>	<p>Use of $P = Fv$ or $\frac{\Delta \text{WD}}{\Delta t}$</p> <p>All correct</p>	3
(iii)	<p>GPE lost is $35 \times 9.8 \times 3 = 1029 \text{ J}$</p> <p>KE gained is $0.5 \times 35 \times (3^2 - 1^2) = 140 \text{ J}$</p> <p>so WE gives WD against friction is</p> $1029 - 140 = 889 \text{ J}$	<p>B1 M1 A1 M1 A1</p>	<p>ΔKE</p> <p>The 140 J need not be evaluated</p> <p>Use of WE equation</p> <p>cao</p>	5
(iv)	<p>either</p> $0.5 \times 35 \times 3^2 + 35 \times 9.8 \times 0.1x = 150x$ $x = 1.36127 \dots \text{ so } 1.36 \text{ m (3 S. F.)}$ <p>or</p> $35g \times 0.1 - 150 = 35a$ $a = -3.3057 \dots$ $0 = 9 - 2ax$ $x = 1.36127 \dots \text{ so } 1.36 \text{ m (3 S. F.)}$	<p>M1 B1 B1 A1 A1</p> <p>M1 A1 A1 M1 A1</p>	<p>WE equation. Allow 1 missing term. No extra terms.</p> <p>One term correct (neglect sign)</p> <p>Another term correct (neglect sign)</p> <p>All correct except allow sign errors</p> <p>cao</p> <p>Use of N2L. Must have attempt at weight component. No extra terms.</p> <p>Allow sign errors, otherwise correct</p> <p>cao</p> <p>Use of appropriate <i>uvast</i> or sequence</p> <p>cao</p>	5
		17		