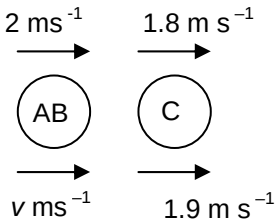
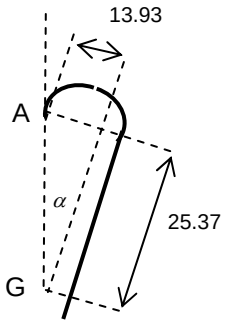
Q 1				
(a) (i)	Impulse has magnitude $2\times 9 = 18$ N s speed is $\frac{18}{6} = 3$ m s^{-1}.	B1 B1		2
(ii)	PCLM $\rightarrow$ $3\times 6 - 1\times 2 = 8v$ v = 2 so 2 m s^{-1} in orig direction of A	M1 A1 E1	Use of PCLM + combined mass RHS All correct Must justify direction (diag etc)	3
(iii)	$\rightarrow$ $2\times 2 - 2\times -1 = 6$ N s	M1 A1	Attempted use of m**v** - m**u** for 6 N s dir specified (accept diag)	2
(iv) (A)		B1	Accept masses not shown	1
(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	3
(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 $0 < e \leq 1$)	3
(b)	Using $v^2 = u^2 + 2as$ $v = \sqrt{2\times 10\times 9.8} = 14$ rebounds at $14\times\frac{4}{7}$ = 8 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 ± Need not be explicitly stated cao	5
		19		

Q 2				
(i)	$\theta = \frac{\pi}{2}$ gives CG $= \frac{8\sin\frac{\pi}{2}}{\frac{\pi}{2}} = \frac{16}{\pi}$ $\left(-\frac{16}{\pi}, 8\right)$ justified	B1 E1 E1		3
(ii)	$(8\pi + 72)\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = 8\pi\begin{pmatrix}-\frac{16}{\pi}\\ 8\end{pmatrix} + 72\begin{pmatrix}36\\ 0\end{pmatrix}$ $\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix} = \begin{pmatrix}25.3673...\\ 2.06997...\end{pmatrix} = \begin{pmatrix}25.37\\ 2.07\end{pmatrix}$ (4 s. f.)	M1 B1 A1 A1 E1 E1	Method for c.m. Correct mass of 8 . or equivalent 1st RHS term correct 2nd RHS term correct [If separate cpts award the A1s for *x*- and *y*- cpts correct on RHS]	6
(iii)	 $\tan\alpha = \frac{13.93}{25.37}$ α = 28.7700… so 28.8° (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… Obtaining 13.93… cao Accept use of 2.0699… but not 16. cao	5
(iv)	c. w. moments about A $12\times13.93 - 16F = 0$ so F = 10.4475…	M1 A1 A1	[FT use of 2.0699…] Moments about any point, all forces present (1.5525... if 2.0699… used)	3
		17		

Q 3				
(i)	Moments c.w. about B $200\times0.6-0.8R_A=0$ 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 $-0.8R_C+1.2\times200=0$ 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 $0.4\times200\cos\alpha-0.8R_Q=0$ 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)	**either**			
	$0.5\times20\times0.5^2+20\times9.8\times4$	M1	KE or GPE terms	
		B1	KE term	
		B1	GPE term	
	= 786.5 J	A1	cao	
	or			
	$a = 1/32$	B1		
	$T-20g=20\times 1/32$	M1	N2L. All terms present.	
	T = 196.625	A1		
	WD is $4T$ = 786.5 so 786.5 J	A1	cao	4
(ii)	$20g\times0.5=10g$ so 98 W	M1	Use of $P = Fv$ or $\Delta\text{WD}/\Delta t$	
		A1	All correct	
		A1		3
(iii)	GPE lost is $35\times9.8\times3=1029$ J	B1		
	KE gained is $0.5\times35\times(3^2-1^2)=140$ J	M1	Δ KE	
		A1	The 140 J need not be evaluated	
	so WE gives WD against friction is	M1	Use of WE equation	
	1029 – 140 = 889 J	A1	cao	5
(iv)	**either**			
	$0.5\times35\times3^2+35\times9.8\times0.1x=150x$	M1	WE equation. Allow 1 missing term. No extra terms.	
		B1	One term correct (neglect sign)	
		B1	Another term correct (neglect sign)	
		A1	All correct except allow sign errors	
	x = 1.36127… so 1.36 m (3 S. F.)	A1	cao	
	or			
	$35g\times0.1-150=35a$	M1	Use of N2L. Must have attempt at weight component. No extra terms.	
		A1	Allow sign errors, otherwise correct	
	a = – 3.3057…	A1	cao	
	$0 = 9 - 2ax$	M1	Use of appropriate *uvast* or sequence	
	x = 1.36127… so 1.36 m (3 S. F.)	A1	cao	5
		17		