1 (i)	$\left[s = 0.3 \times 5 + \frac{1}{2} \quad 0.5 \times 5^2\right]$ [$v = 0.3 + 0.5 \times 5 = 2.8$m] Complete method for finding s required	M1		For using $s = ut + \frac{1}{2}at^2$ **or** using $v = u + at$ followed by **either** $v^2 = u^2 + 2as$ **or** $s = \frac{(u+v)}{2}t$ **or** $s = vt - \frac{1}{2}at^2$
	Distance = 7.75 m	A1	2	
(ii)	[WD = 8 × 7.75 × 0.5]	M1		For using WD = $Td\cos60^{\circ}$
	Work done is 31 J	A1	2	
2 (i)	$\left[\frac{P}{5} = 80 \times 1.2\right]$	M1		For using DF = $\frac{P}{v}$ and Newton's 2nd law
	$P = 480$	A1	2	
(ii)	$\frac{450}{3.6} - 80g \times 0.035 = 80a$	M1 A1		For using $\frac{P}{v} - W\sin\alpha = ma$
	Acceleration is 1.21 ms^{-2}	A1	3	Allow $a = \frac{97}{80}$
3 (i)	KE gain $\left[= \frac{1}{2} \times 8 \times 4.5^2\right] = 81$ J	B1		
	$\left[\text{Decrease} = 8g \times 12 \times \left(\frac{1}{8}\right)\right]$	M1		For using PE = mgh and $h = d\sin\alpha$
	PE loss = 120 J	A1	3	
(ii)	[81 = 120 – 12R]	M1		For using KE gain = PE loss –WD by resistance
	Resisting force is 3.25 N	A1	2	Allow $R = \frac{13}{4}$

Alternative method for (ii)				
(ii)	$[4.5^2 = 2 \times a \times 12]$ ➔ $[a = \frac{27}{32} = 0.84375]$ $[8g\sin\alpha - R = 8 \times \frac{27}{32}]$ Resisting force is 3.25 N	M1 A1	 2	For using $v^2 = u^2 + 2as$ to find a **and** using Newton's 2nd law to find R
4 (i)	 $v(t) = 0.025t^3 - 0.75t^2 + 5t \quad (+0)$ $s(t) = 0.00625t^4 - 0.25t^3 + 2.5t^2$ (+0)	M1 A1 M1 A1	 4	For integrating to obtain $v(t)$. For integrating to obtain $s(t)$.
(ii)	 $[t^4 - 40t^3 + 400t^2 = 0$ ➔ $t^2(t - 20)^2 = 0]$ Time taken is 20 s	M1 M1 A1	 3	For setting $s = 0$ (t not zero) in their attempt at s which was obtained using integration only. For attempting to solve a quartic equation for $s = 0$ where s was obtained using integration only. $t = 20$ only
5 (i)	 $-20 = 20 - 10t$ ➔ time taken is 4s or $0 = 20 - 10t$ ➔ time taken is 2×2s = 4s $[30 = 0 + 4a]$ Acceleration of P is 7.5 ms^{-2}	M1 A1 M1 A1ft	 4	For using $v = u - gt$ to find the time taken by Q. Must be for a complete method for the total time taken to return to point A For using $v = u + at$ to find the acceleration of P ft on an incorrect positive value of the time taken

(ii)		M1		For using $v^2 = u^2 + 2as$ **or** $s = \frac{(u+v)}{2}t$ **or** $s = ut + \frac{1}{2}at^2$ **or** $s = vt - \frac{1}{2}at^2$ to find the distance *OA*
	Either $30^2 = 2 \times 7.5 \times OA$ **or** $OA = \frac{(0+30)}{2} \times 4$ **or** $OA = \frac{1}{2} \times 7.5 \times 4^2$ **or** $OA = 30 \times 4 - \frac{1}{2} \times 7.5 \times 4^2$ ➔ Distance *OA* is 60 m	A1	2	
6 (i)	$\left[h = \frac{1}{2} \times 0.5 \times 2\right]$	M1		For using area property of the graph or constant acceleration formulae
	$h = 0.5$	A1	2	
(ii)	$[a = 2 \div 0.5]$	B1		State the value of a using the gradient property of the graph
	$[T - mg = ma$ and $(1 - m)g - T = (1 - m)a$ or $a = \{(1 - 2m) \div (1 - m + m)\}g]$	M1		For applying both • Newton's 2nd law to P (while Q is moving) • Newton's 2nd law to Q (while Q is moving) or using $a = [(M - m) \div (M + m)]g$
		M1		For eliminating T or rearranging to find m
	$m = 0.3$	A1		
	$[T - 0.3 \times 10 = 4 \times 0.3$ or $0.7 \times 10 - T = 4 \times 0.7]$	M1		For substituting a and m into • Newton's 2nd law to P (while Q is moving) • Newton's 2nd law to Q (while Q is moving) to find T (tension)
	Tension is 4.2 N	A1	6	

(iii)		M1		For using the gradient property of the graph with acceleration $-g$
	$(-2-2) \div (t-0.5) = -10$	A1		
	$T = 0.9$	A1	3	
	First Alternative method for (iii)			
(iii)	$[-2 = 2 - 10t]$	M1		For using $v = u + at$ to find the total time that string is slack
	$t = 0.4$	A1		
	Required time = 0.5 + 0.4 = 0.9	A1	3	
	Second Alternative method for (iii)			
(iii)	$t = 0.2$ s	B1		Obtaining the time taken from $v = 0$ to $v = 2$ OR $v = 0$ to $v = -2$
	$t = 0.2 \times 2 = 0.4$ s	B1		Obtaining the total time that the string is slack.
	Total time = 0.9 s	B1	3	For completing the solution using 0.4 + 0.5 = 0.9 s
7 (i)		M1		For resolving forces at J horizontally **or** vertically
	$0.8T_A + 0.6T_R = 5.6$	A1		Allow $T_A \cos 36.9 + T_R \cos 53.1 = 5.6$ oe
	$0.6T_A = 0.8T_R$	A1		Allow $T_A \sin 36.9 = T_R \sin 53.1$ oe
		M1		For solving the simultaneous equations for T_A and T_R
	Tension in AJ is 4.48 N **and** tension in RJ is 3.36 N	A1	5	
	First Alternative Method for (i)			
(i)	$\frac{5.6}{\sin 90} = \frac{T_A}{\sin\alpha} = \frac{T_R}{\sin(270-\alpha)}$ m	M1		For applying Lami's theorem to two of the three forces T_A, T_R, and 5.6 where α is an obtuse angle
	$\frac{5.6}{\sin 90} = \frac{T_A}{0.8} = \frac{T_R}{0.6}$ m	A1 A1		Allow sin126.9 for 0.8 and sin143.1 for 0.6 here
		M1		Solve for T_A **and** T_R
	$T_A = 4.48$ **and** $T_R = 3.36$	A1	5	

Second Alternative Method for (i)

(i)	$\frac{5.6}{\sin 90} = \frac{T_A}{\sin\alpha} = \frac{T_R}{\sin(90-\alpha)}$ m	M1		For applying triangle of forces to two of the three forces T_A, T_R, and 5.6
	$\frac{5.6}{\sin 90} = \frac{T_A}{0.8} = \frac{T_R}{0.6}$ m	A1 A1		Allow sin 53.1 for 0.8 and sin 36.9 for 0.6 here
		M1		Solve for T_A **and** T_R
	$T_A = 4.48$ **and** $T_R = 3.36$	A1	5	
(ii)	$0.2g + F = T_R \times \cos 36.9$	B1√		ft on T_R and 36.9
	$N = T_R \times \sin 36.9$	B1√		ft on T_R and 36.9
	$[0.2g + \mu \times T_R \times 0.6 = T_R \times 0.8]$	M1		For using $\mu = F \div N$ and obtaining an equation in μ
	$\mu = 0.688 \div 2.016 = 0.341$	A1	4	AG
(iii)	$[0.2g + mg = \mu N + 0.8T_R]$	M1		For a four term equation from resolving forces acting on R vertically.
	$0.2g + mg = 0.341 \times 2.016 + 3.36 \times 0.8$	A1		
	$m = 0.137$ or 0.138	A1	3	