Question	Answer	Marks	Guidance
1(i)	$k = \frac{g}{2} = 5$	**B1**	Use the trajectory equation from the formula sheet
		1	
1(ii)	$V\sin 30 = 14$	**M1**	Use the trajectory equation from the formula sheet
	$V = 28$ ms^{-1} **AG**	**A1**	
		2	
1(iii)	$x = 28\cos 30 \times 3$	**M1**	Use horizontal motion. Allow *their* V for M1
	$x = 72.7$ m	**A1**	
		2	

Question	Answer	Marks	Guidance
2	Original square: Area $= 0.7^2$, CoM $= \sqrt{\left(0.35^2 + 0.35^2\right)}$ and Smaller square: Area $= 0.3^2$, CoM $= \sqrt{\left(0.15^2 + 0.15^2\right)}$	**B1**	0.49, 0.495 from A 0.09, 0.21213... from D or E
	$AX\left(0.49 - 0.09\right) + 0.09\left(\sqrt{0.98} - \sqrt{0.045}\right) = 0.49 \times 0.495$	**M1A1**	Attempt to take moments about A
	$AX = 0.431$ m	**A1**	
		4	
	Alternative method for question 2		
	$(0.49 \times 0.35) = (0.09 \times 0.55) + 0.4X \rightarrow X = 0.305$	**M1**	Take moments about AG or AB
	$X = Y = 0.305$	**B1**	

Question	Answer	Marks	Guidance
2	$AX = \sqrt{\left(0.305^2 + 0.305^2\right)}$	**M1**	Use Pythagoras's theorem
	$AX = 0.431$	**A1**	
		4	

Question	Answer	Marks	Guidance
3(i)	$r = 0.4$ m	**B1**	Use Pythagoras's theorem
	$T\cos\theta = 0.4 \times 5^2 \times 0.4$	**M1**	Use Newton's Second Law
	$T \times \frac{0.4}{0.5} = 4, T = 5N$	**A1**	
		3	
3(ii)	$R = 0.4g - T\sin\theta$	**M1**	Resolve vertically. Allow for their T for M1
	$R = 1N$	**A1**	
		2	

Question	Answer	Marks	Guidance
4(i)	$0.5v\frac{\mathrm{d}v}{\mathrm{d}x} = 0.5g - \frac{16x}{0.8} - 25x^2$	**M1**	Use Newton's Second Law vertically
	$v\frac{\mathrm{d}v}{\mathrm{d}x} = 10 - 40x - 50x^2$ **AG**	**A1**	
		2	

Question	Answer	Marks	Guidance
4(ii)	$\int v\mathrm{d}v = \int\left(10-40x-50x^2\right)\mathrm{d}x$	**M1**	Attempt to integrate
	$\frac{v^2}{2} = 10x - 20x^2 - \frac{50x^3}{3}(+c)$	**A1**	
	$0 = 10 - 40x - 50x^2$	**M1**	Put the acceleration equal to zero
	$x = 0.2$ (Ignore $x = -1$ if seen)	**A1**	
	$\frac{0.5v^2}{2} = \frac{8}{15} = 0.533\,\text{J}$	**B1**	Use $KE = \frac{mv^2}{2}$
	$16 \times \frac{0.2^2}{(2\times 0.8)} = 0.4\,\text{J}$	**B1**	Use $EE = \frac{\lambda x^2}{(2l)}$
		6	

Question	Answer	Marks	Guidance
5(i)	$4 = \frac{\lambda(1.6-a)}{a}$	**B1**	Use $T = \left(\frac{\lambda x}{l}\right)$ twice
	$6 = \frac{\lambda(2-a)}{a}$	**B1**	
	$1.5 = \frac{(2-a)}{(1.6-a)}$	**M1**	Attempt to solve the simultaneous equations

Question	Answer	Marks	Guidance
5(i)	$0.4 = 0.5(a)$, $a = 0.8$	**A1**	
	$\lambda = 4$	**A1**	
		5	
5(ii)	$T = 4 \times \frac{1.1}{0.8} (= 5.5)$	**B1**	**FT** Use $T = \frac{\lambda x}{L}$, ft candidates λ and a
	$5.5 = \frac{0.2v^2}{1.9}$	**M1**	Use Newton's Second Law horizontally
	$v = 7.23$ ms^{-1}	**A1**	
		3	

Question	Answer	Marks	Guidance
6(i)	$15\cos\theta = v_H$ and $15\sin\theta - 4g = v_V$	**B1**	Use horizontal and vertical motion
	$(15\cos\theta)^2 + (15\sin\theta - 4g)^2 = 30^2$	**M1**	Use Pythagoras's theorem
	$[225 - 1200\sin\theta + 1600 = 900]$	**M1**	Attempt to solve for θ
	$\theta = 50.4°$	**A1**	
		4	

Question	Answer	Marks	Guidance
6(i)	**Alternative Method**		
	$h = (15\sin\theta)\times 4 - \frac{g(4)^2}{2}$	**B1**	
	$\frac{m(15)^2}{2} = \frac{m(30)^2}{2} + mgh$	**M1**	Allow h not replaced
		M1	Attempt to eliminate h and attempt to solve for θ
	$\theta = 50.4°$	**A1**	
		4	
6(ii)	$s = 15\sin 50.4\times 4 - \frac{1}{2}\times g\times 4^2$	**M1**	Use vertical motion. Allow *their* θ for first M1
	$s = 33.75$ m **AG**	**A1**	
	$\cos\alpha = \frac{15\cos 50.4}{30}$	**M1**	Use trigonometry of a right angled triangle
	$\alpha = 71.4°$ below the horizontal	**A1**	
		4	If $g = 9.8$ or 9.81 used then M1A0M1A0

Question	Answer	Marks	Guidance
7(i)	$X = \frac{2r}{\pi}$	**B1**	X = distance of centre of mass of the arc from ABC
	$0.8 \times 0.1 = \pi r \times \frac{2r}{\pi}$	**M1**	Take moments about ABC
	$r = 0.2$	**A1**	
		3	
7(ii)	$AC = 0.8 + 2 \times 0.2 - 0.2\pi$ $(= 0.57168\ldots)$	**B1**	
	$0.1W = 7AC$	**M1**	AC must be a numerical value. Take moments about A
	$W = 40(0.)\,N$	**A1**	
		3	
7(iii)	$(0.8 - 0.2\pi + 0.2)$ $[= 0.37168\ldots]$	**B1**	
	$0.8Y = (0.8 - 0.2\pi) \times \frac{(0.8 - 0.2\pi)}{2} + (0.2\pi) \times (0.8 - 0.2\pi + 0.2)$	**M1A1**	
	$Y = 0.310(338)$	**A1**	
	$\tan\theta = \frac{0.1}{0.310338}$	**M1**	
	$\theta = 17.9$	**A1**	Allow 17.8