Question	Answer	Marks	Guidance
1	Conservation of momentum at $\frac{h}{4}$	**B1**	
	$\frac{5\times h}{4}=3\times 0.2$	**M1**	Take moments about A
	$(h=)$ 0.48 m	**A1**	
		3	

Question	Answer	Marks	Guidance
2(i)	$-15\sin\theta = 15\sin\theta - 2g$	**M1**	Use $v = u + at$ vertically
	$(\theta=)$ 41.8	**A1**	
		2	
2(ii)	Vertically: $\frac{v}{15\cos\theta}=\pm\tan 20$	**M1**	v = vertical velocity
	$v=(\pm)4.07$	**A1**	
	$-4.07 = 15\sin 41.8 - gt$	**M1**	Use $v = u + at$ vertically
	(t =) 1.41 s	**A1**	
		4	

Question	Answer	Marks	Guidance
3(i)	$0.25v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -kv^2x^{-2} \rightarrow v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -4kv^2x^{-2}$	**B1**	AG
		1	
3(ii)	$\int \dfrac{\mathrm{d}v}{v} = -4k\int x^{-2}\mathrm{d}x$	**M1**	Attempt to integrate
	$\ln v = \dfrac{4k}{x}(+c)$	**A1**	
	$x = 0.8, v = 3$ hence $c = \ln 3 - 5k$	**A1**	Finds c
	$\ln v = \dfrac{4k}{x} + \ln 3 - 5k$	**M1**	
	$v = 3^{\left(\frac{4k}{x} - 5k\right)}$	**A1**	
		5	

Question	Answer	Marks	Guidance
4(i)	$x = 30\cos 60t$	**B1**	Use horizontal motion
	$y = 30\sin 60t - \frac{gt^2}{2}$	**B1**	Use $s = ut + \frac{gt^2}{2}$ vertically
	$y = \frac{30\sin 60x}{30\cos 60} - \frac{5x^2}{(30\cos 60)^2}$	**M1**	Attempt to eliminate t
	$y = 1.73x - 0.0222x^2$ or $y = \sqrt{3}x - \frac{x^2}{45}$	**A1**	
		4	
4(ii)	$x = y$ or $\tan 45 = \frac{y}{x}$	**M1**	
	$1 = 1.73 - 0.0222x$ or $1 = \sqrt{3} - \frac{x}{45}$	**M1**	x common to all three terms
	$x = 32.9$	**A1**	
		3	

Question	Answer	Marks	Guidance
5(i)	$T = \frac{9\times(0.8-0.6)}{0.6}$	**M1**	Use $T = \frac{\lambda x}{l}$. Note $OP = \frac{0.4}{\sin 30}$
	$T = 3$ N	**A1**	
	$0.3a = 3 - 0.3g\sin 30$	**M1**	Use Newton's Second Law along the slope
	$a = 5\ \text{m}\,s^{-1}$	**A1**	
		4	
5(ii)	$0.3g\sin 30 = \frac{9e}{0.6}$	**M1**	Note the maximum speed is at the equilibrium position
	$e = 0.1$	**A1**	
	$\text{EPE} = \frac{9\times(0.8-0.6)^2}{2\times 0.6}$ or $\frac{9\times 0.1^2}{2\times 0.6}$	**B1**	
	$\frac{0.3v^2}{2} = \frac{9\times(0.8-0.6)^2}{2\times 0.6} - \frac{9\times 0.1^2}{2\times 0.6} - 0.3g\times 0.1\sin 30$	**M1**	Set up a 4 term energy equation
	$v = 0.707\ \text{m}\,\text{s}^{-1}$	**A1**	
		5	

Question	Answer	Marks	Guidance
6(i)	$0.3^2 + r^2 = 0.5^2$ hence $r = 0.4$	**B1**	Use Pythagoras's theorem
	$8 \times 0.4 = 3.2\ \text{m s}^{-1}$	**B1**	Use $v = r\omega$
		2	
6(ii)	$A \times \frac{3}{5} - B \times \frac{3}{5} = 0.3g$	**B1**	Resolve vertically
	$A \times \frac{4}{5} + B \times \frac{4}{5} = 0.3 \times 8^2 \times 0.4$ or $\frac{0.3 \times 3.2^2}{0.4}$	**M1A1**	Use Newton's Second Law horizontally
		M1	Attempt to solve for B
	$B = 2.3$ N	**A1**	
	$2.3 = \frac{46(0.5 - L)}{L}$	**M1**	Use $T = \frac{\lambda x}{l}$ and attempt to solve
	$L = 0.476$ m or $\frac{10}{21}$	**A1**	
		7	

Question	Answer	Marks	Guidance
7(i)	$BG = 0.3$ m	**B1**	G is the CoM vertically above B. M is the mid-point of AB and E is v the point vertically below C on AB extended.
	$ME = 3 \times 0.2 = 0.6$ and $\tan A = \frac{CE}{AE} = \frac{0.9}{0.8}$	**M1**	Use of similar triangles and trigonometry of a right angled triangle
	$A = 48.4°$	**A1**	AG
		3	
7(ii)	$AC = \frac{0.9}{\sin 48.4} = 1.20(41...)$	**B1**	Use trigonometry of a right angled triangle
	$18 \times 1.2041 = 0.4W$	**M1**	Moments about A
	$W = 54.2$ N	**A1**	
		3	
7(iii)	$H = 18\sin A = 18\sin 48.4$ (= 13.46)	**B1**	Resolve horizontally
	$V = 54.2 - 18\cos 48.4$ (= 42.25)	**B1ft**	Resolve vertically
	$\mu = \frac{13.46}{42.25}$	**M1**	Use $F = \mu R$
	$\mu = 0.319$	**A1**	Accept 0.32
		4	