

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 <i>A</i>
	$(h =) 0.48 \text{ m}$	A1	
		3	

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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
	$(t =) 1.41 \text{ s}$	A1	
		4	

Question	Answer	Marks	Guidance
3(i)	$0.25v \frac{dv}{dx} = -kv^2 x^{-2} \rightarrow v \frac{dv}{dx} = -4kv^2 x^{-2}$	B1	AG
		1	
3(ii)	$\int \frac{dv}{v} = -4k \int x^{-2} dx$	M1	Attempt to integrate
	$\ln v = \frac{4k}{x} (+c)$	A1	
	$x = 0.8, v = 3$ hence $c = \ln 3 - 5k$	A1	Finds c
	$\ln v = \frac{4k}{x} + \ln 3 - 5k$	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 $OP = \frac{0.4}{\sin 30}$
	$T = 3 \text{ N}$	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
	$v = 0.707 \text{ m s}^{-1}$	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
	$B = 2.3 \text{ N}$	A1	
	$2.3 = \frac{46(0.5 - L)}{L}$	M1	Use $T = \frac{\lambda x}{l}$ and attempt to solve
	$L = 0.476 \text{ m}$ or $\frac{10}{21}$	A1	
		7	

Question	Answer	Marks	Guidance
7(i)	$BG = 0.3 \text{ m}$	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
	$A = 48.4^\circ$	A1	AG
		3	
7(ii)	$AC = \frac{0.9}{\sin 48.4} = 1.20(41\dots)$	B1	Use trigonometry of a right angled triangle
	$18 \times 1.2041 = 0.4W$	M1	Moments about A
	$W = 54.2 \text{ N}$	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	