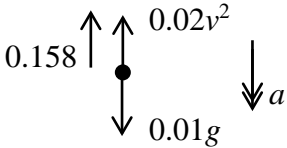
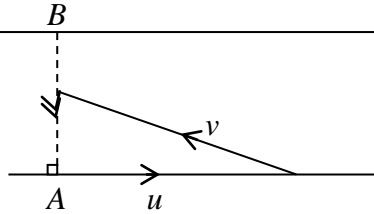
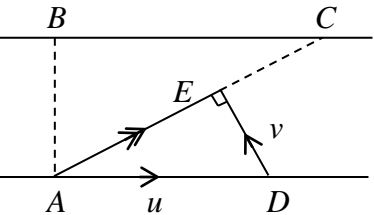
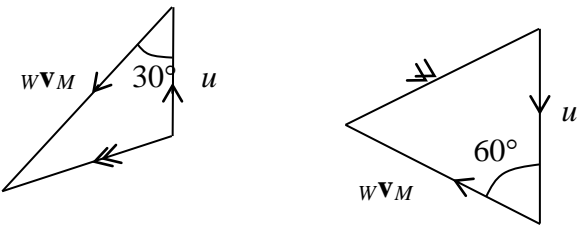
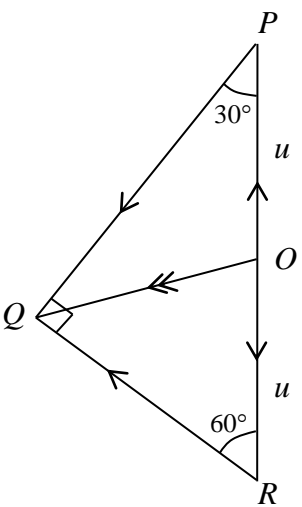


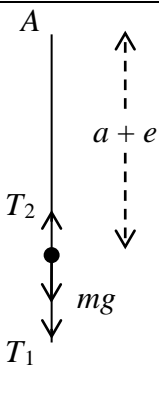
Question Number	Scheme	Marks
<p>1. (a)</p>  <p>(b)</p> $-\int \frac{v \, dv}{2v^2 + 6} = \int dx$ $x = \frac{1}{4} \ln(2v^2 + 6) + C$ $x = 0, v = 0 \Rightarrow C = \frac{1}{4} \ln 206$ $v = 0 \Rightarrow x = \frac{1}{4} \ln \frac{206}{6} \approx 0.884 \text{ m}$	$0.01a = 0.01g - 0.158 - 0.02v^2$ $a = v \frac{dv}{dx}$ $v \frac{dv}{dx} = -2v^2 - 6 (*)$	<p>M1</p> <p>M1</p> <p>A1 (3)</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>M1 A1 (5)</p> <p><b>(8 marks)</b></p>
<p>2. (a)</p>  <p>(b)</p> 	<p>vector triangle attempted</p> <p>vector triangle correct</p> <p>Explanation for <math>v &gt; u</math></p> <p>(e.g. 'hypotenuse &gt; other sides')</p> <p>vector triangle attempted</p> <p>right angle correctly placed</p> $\frac{BC}{AB} = \frac{AE}{ED} \quad \text{Use of similar triangles}$ $= \frac{\sqrt{(u^2 - v^2)}}{v}$	<p>M1</p> <p>A1</p> <p>A1 (3)</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>M1 A1 (5)</p> <p><b>(8 marks)</b></p>

((\*) indicates final line is given on the paper)

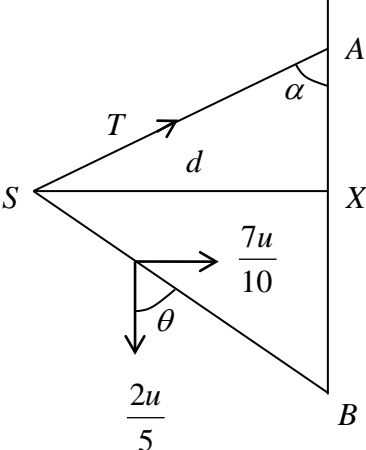
Question Number	Scheme	Marks
3.	<p><math>\mathbf{v}_W = w\mathbf{v}_M + \mathbf{v}_M</math> (used)</p>  <p>(one vector triangle)</p> <p>Combining</p>  <p> <math>P\hat{Q}R = 90^\circ</math>  <math>QR = 2u \sin 30^\circ = u</math>  <math>\Rightarrow</math> triangle <math>OQR</math> is equilateral  <math>\Rightarrow OQ = \mathbf{v}_W = u</math>                      also <math>\Rightarrow Q\hat{O}R = 60^\circ</math>                      Hence direction is from N <math>60^\circ</math> E                 </p>	<p>M1</p> <p>M1</p> <p>A1 A1</p> <p>M1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>A1 (9)</p> <p><b>(9 marks)</b></p>

Question Number	Scheme	Marks
4.	(a) Extension of string = $7a - 2a \cos \theta - a$ $= 2a(3 - \cos \theta)$	B1
	PE = $8mga \cos \theta + \frac{4mg}{5} \times \frac{4a^2}{2a} (3 - \cos \theta)^2$	B1, M1 A1
	$= 8mga \cos \theta + \frac{8mga}{5} (9 - 6 \cos \theta - \cos^2 \theta)$	M1
	$= \frac{8mga}{5} (\cos^2 \theta - \cos \theta) + C$ (*)	A1 (6)
	(b) $\frac{dV}{d\theta} = \frac{8mga}{5} (-2 \cos \theta \sin \theta + \sin \theta)$	M1 A1
	$= 0$	M1
	$\Rightarrow \sin \theta = 0$ or $\cos \theta = \frac{1}{2}$	
	$\Rightarrow \theta = 0$ or $\pi$ , or $\theta = \frac{\pi}{3}$	A1, A1 (5)
	(c) $\frac{d^2V}{d\theta^2} = \frac{8mga}{5} (\cos \theta + 2 \sin^2 \theta - 2 \cos^2 \theta)$	M1 A1
	$\theta = 0 \quad V'' < 0 \quad (= -\frac{8mga}{5})$ unstable	
$\theta = \pi \quad V'' < 0 \quad (= -3 \times \frac{8mga}{5})$ unstable	A1	
$\theta = \frac{\pi}{3} \quad V'' > 0 \quad (= 3 \times \frac{8mga}{5})$ stable	A1 (4)	
<b>(15 marks)</b>		

((\*) indicates final line is given on the paper)

Question Number	Scheme	Marks
5. (a)	 $T_2 = T_1 + mg$ $\frac{mge}{a} = \frac{mg}{a}(2a - e) + mg$ $e = \frac{3a}{2} \Rightarrow AE = \frac{5a}{2} \quad (*)$	M1 M1 A1 A1 A1 cso (5)
(b)	$mg + \frac{mg}{a} \left( \frac{1}{2}a - x \right) - \frac{mg}{a} \left( \frac{3}{2}a + x \right) - 2m \sqrt{\frac{g}{a}} \frac{dx}{dt} = m \frac{d^2x}{dt^2}$ $\Rightarrow \frac{d^2x}{dt^2} + 2k \frac{dx}{dt} + 2k^2x = 0 \quad (*)$	M1 A3 (-1eeoo) A1 (5)
(c)	<p>AE: <math>m^2 + 2km + 2k^2 = 0</math></p> <p><math>m = -k \pm ki</math></p> <p>GS: <math>x = e^{-kt}(A \cos kt + B \sin kt)</math></p> <p><math>t = 0, x = \frac{1}{2}a \Rightarrow A = \frac{1}{2}a</math></p> <p><math>\frac{dx}{dt} = ke^{-kt}(A \cos kt + B \sin kt) + e^{-kt}(-kA \sin kt + kB \cos kt)</math></p> <p><math>t = 0, \frac{dx}{dt} = 0 \Rightarrow -kA + kB = 0 \Rightarrow B = A = \frac{1}{2}a</math></p> <p><math>x = \frac{1}{2}a e^{-kt}(\cos kt + \sin kt)</math></p>	M1 A1 A1 ft B1 M1 M1 A1 (7) <b>(17 marks)</b>

(cso = correct solution only; ft = follow through mark; (\*) indicates final line is given on the paper; eeoo = each error or omission)

Question Number	Scheme	Marks
6.	(a) No impulse perpendicular to line of centres $\Rightarrow$ velocity perpendicular to line of centres unchanged = $U \cos \alpha$ (*) ( $\swarrow$ ): CLM $U \sin \alpha = v + w$ NLI $eU \sin \alpha = w - v$ $\Rightarrow v = \frac{1}{2} U \sin \alpha (1 - e)$	B1 M1 A1 M1 A1 M1 A1 (7)
	(b) Component perpendicular to wall = $v \sin \alpha + U \cos \alpha \cos \alpha$ $= \frac{1}{2} U \sin^2 \alpha (1 - e) + U \cos^2 \alpha$ $= \frac{1}{2} U (\sin^2 \alpha - e \sin^2 \alpha + 2 - 2 \sin^2 \alpha)$ $= \frac{1}{2} U [2 - \sin^2 \alpha (1 + e)]$ (*) Component parallel to wall = $U \cos \alpha \sin \alpha - v \cos \alpha$ $= U \cos \alpha \sin \alpha - \frac{1}{2} U \sin \alpha \cos \alpha (1 - e)$ $= \frac{1}{2} U \cos \alpha \sin \alpha (1 + e)$ (*)	M1 M1 A1 M1 A1 A1 (6)
	(c) $e = \frac{2}{3}, \tan \alpha = \frac{3}{4}$ Component perpendicular to wall = $\frac{1}{2} U (2 - \frac{9}{25} \times \frac{5}{3}) = \frac{7u}{10}$ Component parallel to wall = $\frac{1}{2} U \times \frac{4}{5} \times \frac{3}{12} \times \frac{5}{3} = \frac{2u}{5}$	B1 B1
		Distance of A from X = $d \cot \theta = \frac{4d}{3}$ B1 $BX = d \cot \theta$ M1 $\cot \theta = \frac{2u}{5} \times \frac{7u}{10} = \frac{4}{7}$ A1 $\therefore$ Total distance $AB = \frac{4d}{3} + \frac{4d}{7}$ $= \frac{40d}{21}$ A1 (5)
	<b>(18 marks)</b>	

((\*) indicates final line is given on the paper)