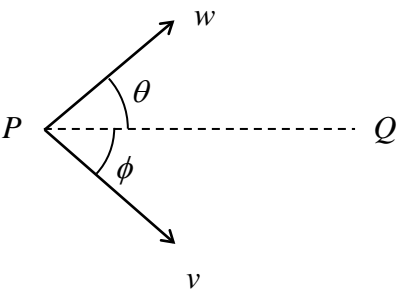
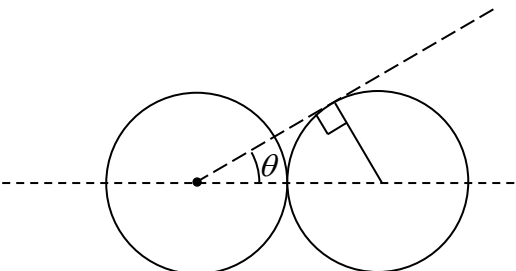
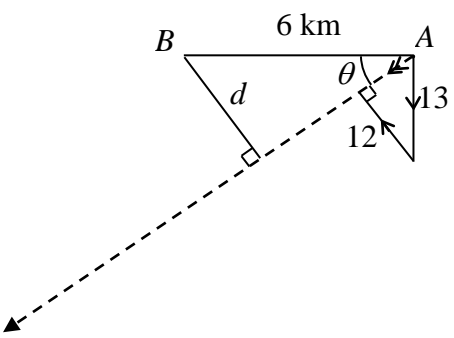
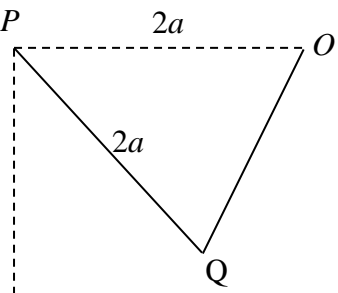
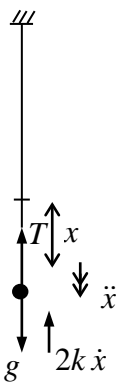
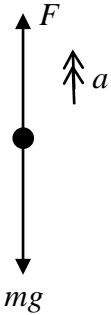


Question Number	Scheme	Marks
<p>1. (a)</p> <p>(b)</p>	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> $v_A = v_{AW} + v_W$ $\Rightarrow \begin{pmatrix} k \\ 0 \end{pmatrix} = \begin{pmatrix} v \cos \phi \\ -v \sin \phi \end{pmatrix} + \begin{pmatrix} w \cos \theta \\ w \sin \theta \end{pmatrix}$ $\Rightarrow v \sin \phi = w \sin \theta^*$ </div> </div> <p>(b)</p> $k = v \sin \phi + w \sin \theta$ $= \frac{v \sqrt{v^2 - w^2 \sin^2 \theta}}{v} + w \cos \theta$ $= \sqrt{v^2 - w^2 \sin^2 \theta} + w \cos \theta$	<p>M1</p> <p>A1 (2)</p> <p>M1 A1</p> <p>M1</p> <p>A1 (4)</p> <p>(6 marks)</p>
2.	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> $\sin \theta = \frac{a}{2a}$ $\Rightarrow \theta = 30^\circ$ $v_1 + v_2 = u \cos \theta$ $-v_1 + v_2 = eu \cos \theta$ $\frac{u \sin \theta}{v_1} = \tan (\theta + 30^\circ) \text{ (or equivalent)}$ Producing an equation in e only $e = \frac{1}{3}$ </div> </div>	<p>M1</p> <p>A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>A1 c.s.o</p> <p>(11 marks)</p>

Question Number	Scheme	Marks
3. (a)	 <p>Vector Δ</p> $\cos \theta = \frac{12}{13}$ $(\theta = 22.6^\circ)$ <p>Course is $360^\circ - 22.6^\circ$ $= 337^\circ$ (AWRT)</p>	M1 A1 M1 A1 (4)
	<p>(b)</p> $v = \sqrt{13^2 - 12^2} = 5$ $t = \frac{6 \cos \theta}{5} = 1.107$ <p>Time is 1.06 p.m.</p>	
	<p>(c)</p> $d = 6 \sin \theta = 6 \times \frac{5}{13} = 2.31 \text{ km}$ <p>(AWRT 2.3 km)</p>	M1 A1 (2) (11 marks)

Question Number	Scheme	Marks
4.	 <p> $OQ = 4a \sin \theta$ $V = (-) mga \sin 2\theta + \frac{mg}{2\sqrt{3}2a} (4a \sin \theta - a)^2 + C$ $= -mga \sin 2\theta + \frac{mga^2}{4a\sqrt{3}} (16 \sin^2 \theta - 8 \sin \theta + 1) + C$ $= -mga \sin 2\theta + \frac{mga}{4\sqrt{3}} (8(1 - \cos 2\theta) - 8 \sin \theta) + C$ </p> <p>i.e. $V = -\frac{mga}{\sqrt{3}} (2 \cos 2\theta + \sqrt{3} \sin 2\theta + 2 \sin \theta) + C$ *</p>	<p>B1</p> <p>B1; M1 A1</p> <p>M1</p> <p>M1</p> <p>A1 c.s.o (7)</p>
(b)	<p> $V'(\theta) = -\frac{mga}{\sqrt{3}} (-4 \sin 2\theta + 2\sqrt{3} \cos 2\theta + 2 \cos \theta)$ $V'\left(\frac{\pi}{6}\right) = -\frac{mga}{\sqrt{3}} (-2\sqrt{3} + 2\sqrt{3} \frac{1}{2} + 2 \frac{\sqrt{3}}{2}) = 0$ </p>	<p>M1 A1</p> <p>M1 A1 (4)</p>
(c)	<p> $V''(\theta) = \frac{mga}{\sqrt{3}} (+8 \cos 2\theta + 4\sqrt{3} \sin 2\theta + 2 \sin \theta)$ Hence, $V''\left(\frac{\pi}{6}\right) = \frac{11mga}{\sqrt{3}} > 0 \therefore \text{stable}$ </p>	<p>M1 A1</p> <p>M1 A1 c.s.o (4)</p> <p>(15 marks)</p>

Question Number	Scheme	Marks
5. (a)	 $R(\downarrow), mg - 2k\dot{x}m - T = m\ddot{x}$ $g - 2k\dot{x} - \frac{2ak^2x}{a} = \ddot{x}$ $\Rightarrow \ddot{x} + 2k\dot{x} + 2k^2x = g \quad *$	<p>M1</p> <p>A1 c.s.o (4)</p>
(b)	$t = 0, x = a: \quad a = D + \frac{g}{2k^2} \Rightarrow D = a - \frac{g}{2k^2}$ $\dot{x} = -ke^{-kt}(C \sin kt + D \cos kt) + -ke^{-kt}(C \cos kt - D \sin kt)$ $t = 0, \dot{x} = 0: \quad 0 = -kD + kC \Rightarrow C = D$ $\Rightarrow C = a - \frac{g}{2k^2}$	<p>M1 A1</p> <p>M1 A1</p> <p>A1 (5)</p>
(c)	$\dot{x} = 0 \Rightarrow C(\sin kt + \cos kt) + C(\cos kt - \sin kt)$ $\Rightarrow \sin kt = 0$ $\Rightarrow kt = \pi$ $\Rightarrow t = \frac{\pi}{k}$	<p>M1</p> <p>A1 ft</p> <p>A1 (3)</p>
(d)	<p>When $t = \frac{\pi}{k}, x = -De^{-\pi} + \frac{g}{2k^2}$</p> $\frac{g}{2k^2} - e^{-\pi} - \pi(a - \frac{g}{2k^2})$ $\Rightarrow xe^{\pi} = \frac{g}{2k^2}(e^{\pi} + 1) - a$ $> 0 \text{ (given)}$ $\Rightarrow g(e^{\pi} + 1) > 2k^2a \quad *$	<p>M1</p> <p>A1 ft</p> <p>M1</p> <p>A1 c.s.o (4)</p> <p>(16 marks)</p>

Question Number	Scheme	Marks
6. (a)	 $F = \frac{kmg}{v}$ $R(\uparrow), F - mg = ma$ $\frac{kmg}{v} - mg = mv \frac{dv}{dx}$ $g(k - v) = v^2 \frac{dv}{dx} \quad *$	B1 M1 M1 A1 (4)
	(b) $g \, dx = \frac{v^2}{k - v} \, dv$ $\int g \, dx = \int -v - k + \frac{k^2}{k - v} \, dv$ $gx = -\frac{v^2}{2} - kv - k^2 \ln(k - v) + (c)$ $x = 0, v = 0$ $0 = 0 - 0 - k^2 \ln k + c$ $c = k^2 \ln k$ $gx = -\frac{v^2}{2} - kv - k^2 \ln \left(\frac{k}{k - v} \right) \quad *$	M1 M1 A1 M1 A1 M1 A1 (7)
	(c) $\text{Work done by engine} = \text{Energy gain}$ $kmg t = \frac{1}{2} mv^2 + mgx$ $kmg t = mk^2 \ln \left(\frac{k}{k - v} \right) - mkv$ $\Rightarrow t = \frac{k}{g} \ln \left(\frac{k}{k - v} \right) - \frac{v}{g}$	M1 A1 M1 A1 (5)
		(16 marks)