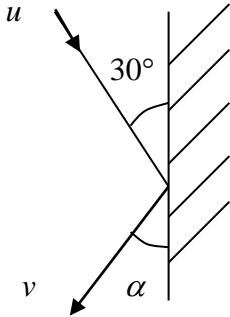
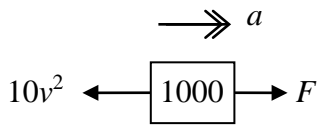


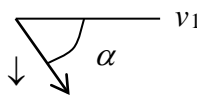
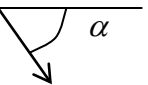
## Mock Paper Mark Scheme


### Advanced Subsidiary/Advanced GCE General Certificate of Education

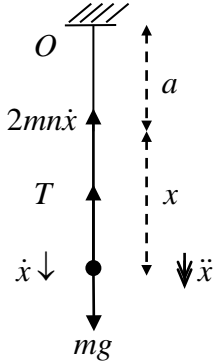
Subject **MECHANICS**

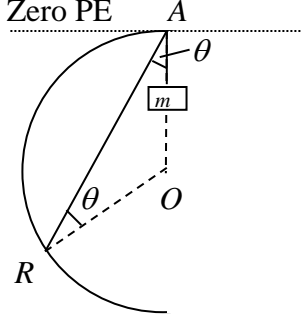
Paper No. **Mock M4**

Question number	Scheme	Marks
<b>1.</b>	<div style="display: flex; align-items: center; justify-content: center;">  <div style="margin-left: 20px;"> <math display="block">v \cos \alpha = u \cos 30^\circ</math> <math display="block">v \sin \alpha = \frac{1}{3} u \sin 30^\circ</math> <p>squaring and adding,</p> <math display="block">v^2 = u^2 \left( \frac{3}{4} + \frac{1}{36} \right)</math> <math display="block">v = \frac{u\sqrt{7}}{3}</math> </div> </div>	<p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p style="text-align: right;">A1 <b>(6)</b></p>
<b>2.</b>	<div style="display: flex; align-items: center; justify-content: center;">  <div style="margin-left: 20px;"> <math display="block">F = \frac{12000}{v}</math> <math display="block">\frac{12000}{v} - 10v^2 = 1000v \frac{dv}{dx}</math> <math display="block">\int dx = 100 \int \frac{v^2 dv}{1200 - v^3}</math> <math display="block">X = -\frac{100}{3} [\ln(1200 - v^3)]_5^{10}</math> <math display="block">= 56.1 \text{ m (3 s.f.)}</math> </div> </div>	<p>B1</p> <p>M1 A1</p> <p>M1</p> <p>M1 A1</p> <p style="text-align: right;">M1 A1 <b>(8)</b></p>

Question number	Scheme	Marks
3.	<div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <p><math>\rightarrow u \cos 30^\circ</math></p> <p><math>\downarrow A \text{ (m)}</math></p> <p><math>u \sin 30^\circ</math></p>  <p><math>v_1</math></p> <p><math>u \sin 30^\circ</math></p>  </div> <div style="text-align: center;"> <p><math>\rightarrow 0</math></p> <p><math>\downarrow B \text{ (m)}</math></p> <p>0</p> <p><math>\rightarrow v_2</math></p> <p><math>\downarrow</math></p> <p>0</p> </div> </div> <div style="margin-top: 20px;"> <p style="text-align: right;"><math>v_1 + v_2 = u \cos 30^\circ</math></p> <p style="text-align: right;"><math>-v_1 + v_2 = eu \cos 30^\circ</math></p> <p style="text-align: right;">subtracting, <math>v_1 = \frac{u\sqrt{3}}{4}(1 - e)</math></p> <p style="text-align: center;"><math>\tan \theta = \tan(\alpha - 30^\circ) = \frac{\tan \alpha - \tan 30^\circ}{1 + \tan \alpha \tan 30^\circ}</math></p> <p style="text-align: center;"><math>\tan \alpha = \frac{u \sin 30^\circ}{v_1} = \frac{2}{\sqrt{3}(1 - e)}</math></p> <p style="text-align: center;"><math>\tan \theta = \frac{\frac{2}{\sqrt{3}(1 - e)} - \frac{1}{\sqrt{3}}}{1 + \frac{2}{\sqrt{3}(1 - e)} \frac{1}{\sqrt{3}}}</math></p> <p style="text-align: center;"><math>= \frac{(1 + e)\sqrt{3}}{5 - 3e} \quad (*)</math></p> </div>	<p>M1 A1</p> <p>M1 A1</p> <p>A1</p> <p>M1</p> <p>M1 A1</p> <p>M1</p> <p>A1 <b>(10)</b></p>

Question number	Scheme	Marks
4.	 <p style="text-align: center;"><math>mg - 100k = 0</math> at terminal speed</p> $k = \frac{mg}{100}$ $mg - \frac{mg}{100}v = m \frac{dv}{dt}$ $\int dt = \frac{100}{g} \int \frac{dv}{100 - v}$ $T = \frac{100}{g} \left[ \ln(100 - v) \right]_{60}^0$ $= \frac{100}{g} \ln\left(\frac{100}{40}\right)$ $= 9.35 \text{ s (3 s.f.)}$	<p>M1</p> <p>A1</p> <p>M1 A1 A1</p> <p>M1</p> <p>A1 A1 (limits)</p> <p>M1</p> <p>A1</p>

Question number	Scheme	Marks
<p>5. (a)</p>  <p>(b)</p>	$mg - T - 2mn\dot{x} = m\ddot{x}$ $mg - \frac{2man^2x}{a} - 2mn\dot{x} = m\ddot{x}$ $\ddot{x} + 2n\dot{x} + 2n^2x = g \quad (*)$ <p>AE: <math>u^2 + 2nu + 2n^2 = 0</math></p> $(u + n)^2 = -n^2$ $u = -n \pm ni$ <p>CF: <math>x = e^{-nt} (A \cos nt + B \sin nt)</math>,    PI: <math>x = \frac{g}{2n^2}</math></p> <p>GS: <math>x = e^{-nt} (A \cos nt + B \sin nt) + \frac{g}{2n^2}</math></p> <p><math>t = 0, x = a, \dot{x} = 0: A = a - \frac{g}{2n^2}</math></p> $\dot{x} = e^{-nt} (-An \sin nt + Bn \cos nt) - ne^{-nt} (A \cos nt + B \sin nt)$ $x = e^{-nt} \left( a - \frac{g}{2n^2} \right) (\cos nt + \sin nt) + \frac{g}{2n^2}$	<p>M1 A1 A1</p> <p>M1</p> <p>A1 (5)</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>M1</p> <p>M1</p> <p>A1 (7)</p> <p><b>(12)</b></p>

Question number	Scheme	Marks
6.	<p>(a)</p> $(\mathbf{v}_P - \mathbf{v}_Q)^2 = \mathbf{v}_P^2 \quad \text{①}$ $(\mathbf{v}_P + \mathbf{v}_Q)^2 = 4\mathbf{v}_P^2 \quad \text{②}$ $4\mathbf{v}_P \cdot \mathbf{v}_Q = 3\mathbf{v}_P^2 \quad \text{②} - \text{①}$ <p>From ①: <math>2\mathbf{v}_P \cdot \mathbf{v}_Q = \mathbf{v}_Q^2 \quad \text{③}</math></p> $\therefore \frac{\sqrt{2}}{\sqrt{3}} = \frac{ \mathbf{v}_P }{ \mathbf{v}_Q }$ <p>(b) From ③ above, <math>2  \mathbf{v}_P   \mathbf{v}_Q  \cos \theta =  \mathbf{v}_Q ^2</math></p> $\cos \theta = \frac{1}{2} \sqrt{\frac{3}{2}} = \frac{\sqrt{6}}{4}$	<p>M1 A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1 A1</p> <p>A1 (9)</p> <p>M1 A1</p> <p>A1 (3)</p> <p><b>(12)</b></p>
7.	<p>(a)</p>  <p>Zero PE</p> <p><math>AR = 2r \cos \theta</math></p> <p>For P: <math>-mg(L - 2r \cos \theta)</math></p> <p>For R: <math>-mg 2r \cos^2 \theta</math></p> <p><math>V = 2mgr(\cos \theta - \cos^2 \theta) - mgL \quad (*)</math></p> <p>(b)</p> $\frac{dV}{d\theta} = 2mgr(-\sin \theta + 2 \cos \theta \sin \theta)$ $= 2mgr \sin \theta (2 \cos \theta - 1)$ $0 = 2mgr \sin \theta (2 \cos \theta - 1)$ <p><math>\sin \theta = 0</math> or <math>\cos \theta = \frac{1}{2}</math></p> <p><math>\theta = 0</math> or <math>\theta = \frac{\pi}{3}</math></p> <p>(c)</p> $\frac{d^2V}{d\theta^2} = 2mgr(-\cos \theta + 2 \cos 2\theta)$ <p><math>\theta = 0, \frac{d^2V}{d\theta^2} = 2mgr &gt; 0 \Rightarrow \text{STABLE}</math></p> <p><math>\theta = \frac{\pi}{3}, \frac{d^2V}{d\theta^2} = -3mgr &lt; 0 \Rightarrow \text{UNSTABLE}</math></p>	<p>B1</p> <p>B1</p> <p>M1 A1</p> <p>M1 A1 (6)</p> <p>M1 A1</p> <p>M1</p> <p>A1 A1 (6)</p> <p>M1 A1</p> <p>M1 A1</p> <p>A1 (5)</p> <p><b>(17)</b></p>

