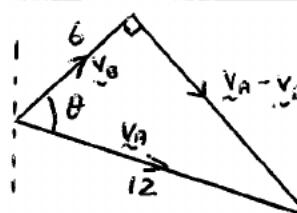
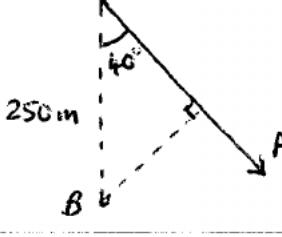
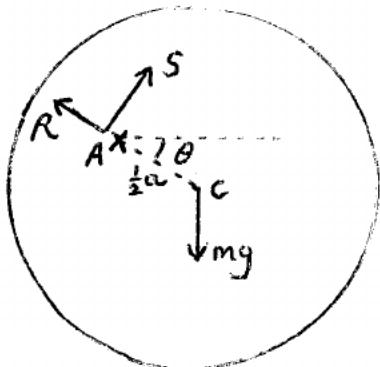


<b>1 (i)</b>	$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$ , $180 = 25 \times 5 + \frac{1}{2} \alpha \times 25$ $\alpha = 4.4 \text{ rad s}^{-2}$	M1 A1 2	
(ii)	Moment = $I\alpha = 0.65 \times 4.4$ = 2.86 N m	M1 A1 ft 2	
<b>2</b>	$\text{Area} = \int_0^9 \sqrt{x} dx = \left[ \frac{2}{3} x^{\frac{3}{2}} \right]_0^9 = 18$ $\int xy dx = \int_0^9 x^{\frac{3}{2}} dx = \left[ \frac{2}{5} x^{\frac{5}{2}} \right]_0^9 = 97.2$ $\bar{x} = \frac{97.2}{18} = \frac{27}{5} = 5.4$ $\int \frac{1}{2} y^2 dx = \int_0^9 \frac{1}{2} x dx = \left[ \frac{1}{4} x^2 \right]_0^9 = 20.25$ $\bar{y} = \frac{20.25}{18} = \frac{9}{8} = 1.125$	B1 B1 M1 A1 B1 M1 A1 7	For $\frac{2}{5} x^{\frac{5}{2}}$ For $\frac{1}{4} x^2$ (or $\frac{9}{2} y^2 - \frac{1}{4} y^4$ )
<b>3 (i)</b>	$I = 0.02 + 0.12 = 0.14$ Period is $2\pi \sqrt{\frac{I}{mgh}} = 2\pi \sqrt{\frac{0.14}{1.5 \times 9.8 \times 0.2}} = 1.37 \text{ s}$	B1 M1 A1 3	
(ii)	WD by couple is $3.2 \times \frac{1}{2}\pi$ $3.2 \times \frac{1}{2}\pi = 1.5 \times 9.8 \times 0.2 + \frac{1}{2}(0.14)\omega^2$ $\omega = 5.46 \text{ rad s}^{-1}$	B1 M1 A1 ft A1 4	For WD = PE + KE
<b>4 (i)</b>	 $\cos \theta = \frac{6}{12}$ $\theta = 60^\circ$ Bearing of B's velocity is $110 - 60 = 050^\circ$	M1 A1 M1 A1 4	Relative velocity perpendicular to $v_B$ Correct velocity triangle

(ii) As viewed from B:		M1  A1	Considering relative displacement  Relative velocity on bearing 140°
Shortest distance is $250 \sin 40^\circ$ $= 161 \text{ m}$		M1  A1	4

<b>5</b>	$m = \rho \int \pi y^2 dx = \rho \pi \int_0^{ka} a^2 e^{-\frac{2x}{a}} dx$ $= \rho \pi \left[ -\frac{1}{2} a^3 e^{-\frac{2x}{a}} \right]_0^{ka}$ $= \frac{1}{2} \rho \pi a^3 (1 - e^{-2k})$ $I = \int \frac{1}{2} \rho \pi y^4 dx$ $= \frac{1}{2} \rho \pi \int_0^{ka} a^4 e^{-\frac{4x}{a}} dx$ $= \frac{1}{2} \rho \pi \left[ -\frac{1}{4} a^5 e^{-\frac{4x}{a}} \right]_0^{ka} = \frac{1}{8} \rho \pi a^5 (1 - e^{-4k})$ $= \frac{\frac{1}{4} ma^2 (1 - e^{-4k})}{1 - e^{-2k}}$ $= \frac{\frac{1}{4} ma^2 (1 - e^{-2k})(1 + e^{-2k})}{1 - e^{-2k}} = \frac{1}{4} ma^2 (1 + e^{-2k})$	M1  A1  A1  M1  A1 ft  A1  M1  A1 (ag)	Integral of $\left( e^{-\frac{x}{a}} \right)^2$ (when finding mass or volume) For $\int e^{-\frac{2x}{a}} dx = -\frac{1}{2} a e^{-\frac{2x}{a}}$ For mass or volume Integral of $y^4$ Correct integral expression (in terms of $x$ )  <i>Dependent on previous MIMI</i>  <i>Intermediate step not required,          provided no wrong working seen</i>
		8	



6 (i)			
	$I = \frac{1}{2}ma^2 + m\left(\frac{1}{2}a\right)^2$ $= \frac{3}{4}ma^2$ $mg\left(\frac{1}{2}a \cos \theta\right) = I\alpha = \left(\frac{3}{4}ma^2\right)\alpha$ $\alpha = \frac{2g \cos \theta}{3a}$	M1 A1 M1 A1 (ag) <b>4</b>	Using parallel axes rule  Or differentiating the energy equation
(ii)	$\frac{1}{2}I\omega^2 = mg\left(\frac{1}{2}a \sin \theta\right)$ $\omega = \sqrt{\frac{4g \sin \theta}{3a}}$	M1 A1 A1 <b>3</b>	Using $\frac{1}{2}I\omega^2$
(iii)	$R - mg \sin \theta = m\left(\frac{1}{2}a\right)\omega^2$ $R = \frac{5}{3}mg \sin \theta$	B1 M1 A1	For radial acc'n of C is $(\frac{1}{2}a)\omega^2$ $\pm R \mp mg \sin \theta = mr\omega^2$ or $kma\omega^2$ (with numerical k)
	$mg \cos \theta - S = m\left(\frac{1}{2}a\right)\alpha$ $S = \frac{2}{3}mg \cos \theta$	B1 M1 A1 <b>6</b>	For transverse acc'n of C is $(\frac{1}{2}a)\alpha$ <i>as above</i> Direction must be clear  <i>Equations involving horizontal and vertical components can earn B1M1B1M1</i>
	OR $S\left(\frac{1}{2}a\right) = I_G \alpha$ $S\left(\frac{1}{2}a\right) = \left(\frac{1}{2}ma^2\right)\alpha$ $S = \frac{2}{3}mg \cos \theta$	M1 A1 A1	Must use $I_G$

7 (i)	$\begin{aligned} RB^2 &= a^2 + (2a)^2 - 2(a)(2a)\cos(\theta + \frac{1}{4}\pi) \\ &= 5a^2 - 4a^2(\cos\theta\cos\frac{1}{4}\pi - \sin\theta\sin\frac{1}{4}\pi) \\ &= a^2(5 - 2\sqrt{2}\cos\theta + 2\sqrt{2}\sin\theta) \end{aligned}$	M1 A1 (ag) <b>2</b>	
(ii)	$\begin{aligned} V &= -mg(2a\sin\theta) + \frac{mg\sqrt{2}}{2a} \times RB^2 \\ &= \frac{5}{2}\sqrt{2}mga - 2mga\cos\theta \\ \frac{dV}{d\theta} &= 2mga\sin\theta \\ \text{When } \theta = 0, \frac{dV}{d\theta} &= 0, \text{ hence equilibrium} \\ \frac{d^2V}{d\theta^2} &= 2mga\cos\theta \\ \text{When } \theta = 0, \frac{d^2V}{d\theta^2} &= 2mga > 0, \text{ hence stable} \end{aligned}$	M1 A1 M1 A1 M1 A1 <b>6</b>	<p>Considering PE and EE</p> <p>Correctly shown</p> <p>or other method for max / min</p> <p>Correctly shown</p>
(iii)	<p>KE is <math>\frac{1}{2}m(2a\dot{\theta})^2</math></p> $\frac{5}{2}\sqrt{2}mga - 2mga\cos\theta + 2ma^2\dot{\theta}^2 = E$ <p>Differentiating w.r.t. <math>t</math>,</p> $2mga\sin\theta\dot{\theta} + 4ma^2\dot{\theta}\ddot{\theta} = 0$ $\ddot{\theta} = -\frac{g}{2a}\sin\theta$	B1 M1 M1 A1	Requires fully correct working
	OR $(mg\cos\theta - T\sin\phi)(2a) = I\ddot{\theta}$ , where $T = \frac{mg\sqrt{2}(RB)}{a}$ and $\frac{\sin\phi}{a} = \frac{\sin(\theta + \frac{1}{4}\pi)}{RB}$		or $mg\cos\theta - T\sin\phi = m(2a\ddot{\theta})$
	$\ddot{\theta} = -\frac{g}{2a}\sin\theta$	A2	Give A1 if just one minor error
	Period is $2\pi\sqrt{\frac{2a}{g}}$	B1 ft <b>5</b>	ft provided that $k$ is in terms of $a$ and $g$ only