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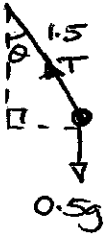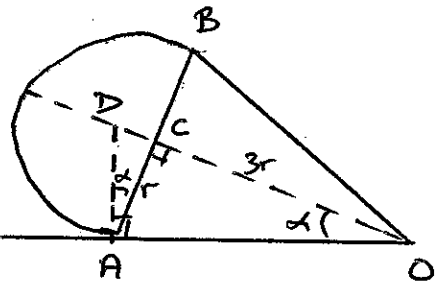### January 2005

Advanced Subsidiary/Advanced Level

General Certificate of Education

Subject: **Mechanics**   Paper: **M3**

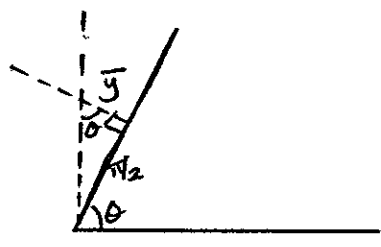| Question Number	Scheme	Marks
1.(a)	$r = 1.5 \sin \theta$ $T \sin \theta = mr\omega^2$ $T \sin \theta = 0.5 \times 1.5 \sin \theta \times 2.7^2$ $T = \underline{5.4675 \text{ N}}$	B1 M1 A1 A1 (4)
(b)	$T \cos \theta = 0.5g$ $\cos \theta = \dfrac{0.5g}{5.4675}$ $\underline{\theta = 26°}$ (nearest degree)	M1 A1 A1 (3) (7)
2.(a)	$\dfrac{3r}{4}$; $\dfrac{3r}{8}$ $-m \cdot \dfrac{3r}{4} + M \cdot \dfrac{3r}{8} = (m+M)\bar{x}$ $\dfrac{3r(M-2m)}{8(M+m)} = \bar{x}$ ✱	B1 ; B1 M1 A1 A1 (5)
(b)	$CD = r \tan \alpha$ $= r \times \left(\dfrac{r}{3r}\right)$ $= \dfrac{1}{3}r$ No equil^m $\Rightarrow$ $\bar{x} > CD$ $\dfrac{3r(M-2m)}{8(M+m)} > \dfrac{r}{3}$ $9(M-2m) > 8(M+m)$ $\underline{M > 26m}$ ✱	M1 A1 M1 A1 (4) (9)

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3.(c)	$\int_0^\pi \frac{1}{2}y^2\,dx = \int_0^\pi \frac{1}{2}\sin^2 x\,dx$	M1
	$= \frac{1}{4}\int_0^\pi (1-\cos 2x)\,dx$	M1
	$= \frac{1}{4}\left[x - \frac{1}{2}\sin 2x\right]_0^\pi$	A1
	$= \pi/4$	A1
	$\bar{y} = \dfrac{\pi/4}{\int_0^\pi \sin x\,dx} = \dfrac{\frac{\pi}{4}}{2}$	M1
	$= \pi/8$	A1　　(6)
(b)	$\tan\theta = \dfrac{\pi/2}{\bar{y}}$	M1
	$= 4$	A1 √
	$\theta = 75.96°$	A1　　(3)
		(9)

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4. (a)	$6 = 2\pi/\omega \quad \Rightarrow \quad \omega = \pi/3$ $a = 2L$ $x = 2L\cos\omega t$ $2L - b = 2L\cos\left(\frac{\pi}{3} \cdot \frac{3}{4}\right)$ $\underline{b = L(2-\sqrt{2})}$ ✱	M1 B1 M1 A1 ✓ A1 c.s.o. (5)
(b)	$\dot{x} = -2L\omega\sin\omega t$ $\quad = -2L\frac{\pi}{3}\sin\frac{\pi}{4}$ Speed $= \dfrac{\sqrt{2}\,L\pi}{3}$	M1 A1 (2)
(c)	$\frac{1}{2}(2-\sqrt{2})L = 2L\sin\omega t$ $t = 0.1469..$ $\therefore$ Total time $= 2 \times 0.14$ $\quad = \underline{0.28}$ (2dp)	M1 A1 A1 (3) ⑩
5. (a)	$\dfrac{dv}{dt} = -\dfrac{3}{\sqrt{t+4}}$ $v = -3\int (t+4)^{-\frac{1}{2}}\,dt$ $v = -6(t+4)^{\frac{1}{2}} + C$ $t=0, v=18: \quad 18 = -6\times2 + C \Rightarrow c = 30$ $\underline{v = 30 - 6\sqrt{t+4}}$ ✱	M1 M1 A1 M1 A1 c.s.o. (5)
(b)	$x = \int 30 - 6(t+4)^{\frac{1}{2}}\,dt$ $\quad = 30t - 4(t+4)^{\frac{3}{2}} + D$ $t=0, x=0: \; 0 = 0 - 4\times8 + D \Rightarrow D=32$ $v=0 \Rightarrow 30 - 6\sqrt{t+4} = 0 \Rightarrow t = 21$ When $t=21, \; x = 30\times21 - 4\times5^2 + 32$ $\quad = \underline{162(m)}$	M1 A1 M1 M1 A1 M1 A1 (7) ⑫

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6.(a)	$KE \text{ Loss} + PE \text{ Loss} = EPE \text{ Gain}$ $\frac{1}{2} \cdot m 2gL + mg 3L = \frac{\lambda (3L)^2}{2L}$ $* \quad \frac{8mg}{9} = \lambda$	M1 A2 (-1 e.e.) A1 (4)
(b)	$mg - T = m\ddot{x}$ $mg - \frac{8mg}{9L}(x + e) = m\ddot{x}$ $-\frac{8g}{9L}x = \ddot{x}$ Hence SHM about D	M1 A1 M1 A1 A1 c.s.o. (5)
(c)	(i) $\text{Period} = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{9L}{8g}} = 3\pi \sqrt{\frac{L}{2g}}$ (ii) $mg = \frac{8mg}{9L}e \Rightarrow e = 9L/8$ $a = 3L - 9L/8 = 15L/8$ $v_{max} = a\omega = \frac{15L}{8} \sqrt{\frac{8g}{9L}}$ $= \frac{5}{4}\sqrt{2gL}$	M1 A1 B1 M1 A1 (5) (14)

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7.(a)	$\frac{1}{2}m(v^2 - 15) = mg\,5(1 - \cos 60°)$ $\underline{v = 8\,ms^{-1}}$	M1 A1 A1 A1 (4)
(b)	$\frac{1}{2}mw^2 = mg\,5(1 - \cos 60°)$ $w = 7\,ms^{-1}$ CLM: $60 \times 8 - 3m = (60 + m)\,7$ $480 - 3m = 420 + 7m$ $60 = 10m$ $\underline{6 = m}$	M1 A1 A1 M1 A1✓ A1✓ A1 (7)
(c)	$T - 66g = \dfrac{66 \times 7^2}{5}$ $T = 132g$ $= \underline{1290\ (1294)\,N}$	M1 A1✓ A1 (3)
		④