Edexcel Maths M3

Mark Scheme Pack

2001-2015

EDEXCEL - LONDON EXAMINATIONS

Stewart House 32 Russell Square London WC1B 5DN

June 2001

Advanced Supplementary/Advanced Level

General Certificate of Education

Subject **MECHANICS 6679** | Paper No. **M3**

Question number	Scheme	Marks
1. (a)	$v = \int \frac{1}{2}e^{-\frac{1}{6}t}\,dt$	M1
	$= -3e^{-\frac{1}{6}t}\ (+c)$	A1
	use of limits or $t=0, v=10$	M1
	$v = 13 - 3e^{-\frac{1}{6}t}$	A1 (4)
(b)	$t = 3$, $v = 11.2\ \text{ms}^{-1}$	M1 A1 (2)
(c)	13 (ft. if $v = a \pm be^{-\frac{1}{6}t}$)	B1 ft (1) (7)
2. (a)	$\cos\theta = 3/4,\ 0.75,\ 6/8$	B1 (1)
(b)	$mg\cos\theta\ (-R) = \frac{mv^2}{0.8}$	M1 A1
	$v^2 = 5.88$ *	A1 (3)
(c)	$\frac{1}{2}m.5.88 - \frac{1}{2}mu^2 = mg \times 0.2$	M1 A1
	$u = 1.4$	A1 (3) (7)
3. (a)	$\frac{1}{2} \times 1.5v^2 = \frac{52 \times .05^2}{2 \times 0.25}$	M1 A1 A1
	$v = 0.589\ \text{ms}^{-1}$ (3SF)	M1 A1 (5)
(b)	$F = 0.6 \times 1.5g$	M1
	$\frac{52x}{0.25}$ or $\frac{52x}{25}$	B1
	$T = F \Rightarrow x = 0.0424\text{m}$ or 4.24cm	M1 A1
	Min distance $= 0.208\text{m}$ or 20.8cm	A1 ft (5) (10)

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4. (a)	$g = k/R^2 \Rightarrow k = R^2 g$	B1
	$a = -\dfrac{k}{x^2}$	M1
	$v\dfrac{dv}{dx} = -\dfrac{R^2 g}{x^2}$ *	M1 A1 c.s.o. (4)
(b)	$\int v\,dv = -\int \dfrac{R^2 g}{x^2}\,dx$	M1
	$\dfrac{v^2}{2} = \dfrac{R^2 g}{x}$ (+ c)	A1
	$x = R, v = u$ or correct use of correct limits	M1
	$\dfrac{v^2}{2} = \dfrac{R^2 g}{x} + \dfrac{u^2}{2} - Rg$	A1
	use of $v = 0$	M1
	$X = \dfrac{2gR^2}{2gR - u^2}$	A1 (6) (10)
5. (a)	$\pi r^2 h$ (6) $\frac{1}{6}\pi r^2 h$ (1) $\frac{5}{6}\pi r^2 h$ (5)	B2 −1 e.e.o.o.
	$\frac{1}{2}h$ $\frac{7h}{8}$ $\bar{x}$	B2 −1 e.e.o.o.
	$6.\frac{1}{2}h - \frac{7h}{8} = 5\bar{x}$	M1 A1
	$\bar{x} = \dfrac{17h}{40}$ *	A1 (7)
(b)	 $\tan\alpha = \dfrac{h - \bar{x}}{r}$	M1 A1
	use of $h = 4r$ to obtain expression in h or r only	M1
	$\alpha = 66.5°$ (1DP)	A1 (4) (11)

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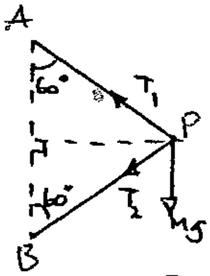
Question number	Scheme	Marks
6. (a)	$r = \frac{1}{2}h\tan 60° = \frac{\sqrt{3}h}{2}$ *	M1 A1 (2)
(b)		
	R(↑), $T_1\cos 60° - T_2\cos 60° = mg$	M1 A1
	R(←), $T_1\sin 60° + T_2\sin 60° = m\frac{\sqrt{3}}{2}h\omega^2$	M1 A1
	Use of $\cos 60° = \frac{1}{2}$ and $\sin 60° = \frac{\sqrt{3}}{2}$	B1
	solving for T_1 or T_2	M1
	$T_1 = \frac{1}{2}m(h\omega^2 + 2g)$; $T_2 = \frac{1}{2}m(h\omega^2 - 2g)$	A1; A1 (8)
(c)	$T_2 > 0 \Rightarrow \omega > \sqrt{\frac{2g}{h}}$	M1 A1√
	$T = \frac{2\pi}{\omega} \Rightarrow T < 2\pi\sqrt{\frac{h}{2g}} = \pi\sqrt{\frac{2h}{g}}$ *	M1 A1 c.s.o. (4) (14)
7. (a)	In equil^m, $T = mg\sin 30°$	B1
	$\lambda\frac{\frac{1}{8}a}{a} = mg\sin 30° \Rightarrow \lambda = 4mg$ *	M1 A1 (3)
(b)	$m\ddot{x} = mg\sin 30° - \frac{4mg}{a}(\frac{1}{8}a + x)$	M1 A2
	$\ddot{x} = -\frac{4g}{a}x \Rightarrow$ SHM	M1 A1
	Period $= 2\pi\sqrt{\frac{a}{4g}} = \pi\sqrt{\frac{a}{g}}$ *	A1 (6)
(c)	Max accel^n $= \omega^2 a = \frac{4g}{a}\cdot\frac{a}{4} = g$	M1 A1 (2)
(d)	$x = \frac{a}{4}\sin\omega t$; $(\pm)\frac{a}{8} = \frac{a}{4}\sin\omega t$	M1 A1
	$\omega t = \sin^{-1}\frac{1}{2} = \pi/6$	M1 A1
	$t = \frac{\pi}{12}\sqrt{\frac{a}{g}}$	A1√ (5)
OR:	Circle approach: $\theta = \frac{\pi}{2} - \cos^{-1}\frac{1}{2} = \frac{\pi}{2} - \frac{\pi}{3} = \frac{\pi}{6}$	OR M1 A1
	$\omega t = \pi/6$	M1 A1
	$t = \frac{\pi}{12}\sqrt{\frac{a}{g}}$	A1√ (5)
OR:	$\cos^{-1}(-\frac{1}{2}) - \cos^{-1}(0) = \frac{2\pi}{3} - \frac{\pi}{2} = \frac{\pi}{6}$	OR M1 A1
	$\omega t = \pi/6$	M1 A1
	$t = \frac{\pi}{12}\sqrt{\frac{a}{g}}$	A1√ (5) (16)

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Question	Solution	Markscheme
7.(d)	$\theta = \frac{\pi}{2} - \cos^{-1}\frac{1}{2} = \frac{\pi}{6}$	M1 A1
	$\omega t = \frac{\pi}{6}$	M1 A1
	$t = \frac{\pi}{6}\sqrt{\frac{a}{4g}} = \frac{\pi}{12}\sqrt{\frac{a}{g}}$	A1 f.t.
OR:	$\cos^{-1}\left(-\frac{1}{2}\right) - \cos^{-1}(0) = \frac{2\pi}{3} - \frac{\pi}{2} = \frac{\pi}{6}$	M1 A1
	$\omega t = \frac{\pi}{6}$	M1 A1
	$t = \frac{\pi}{6}\sqrt{\frac{a}{4g}} = \frac{\pi}{12}\sqrt{\frac{a}{g}}$	A1 f.t.

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* indicates printed answer

Question number	Scheme	Marks
1.	$0.2a = \frac{5}{x+1}$	M1
	$0.2v\frac{dv}{dx} = \frac{5}{x+1}$	M1
	$\int v\,dv = \int \frac{25}{x+1}\,dx$	M1
	$\frac{1}{2}v^2 = 25\ln(x+1)\ (+C)$	A1 A1
	$x=0,\ v=5 \Rightarrow C = 12.5$	A1
	$\frac{225}{2} = 25\ln(x+1) + 12.5$	M1
	$\underline{x = 53.6\ (3SF)}$	A1 (8)
2. (a)	PE Loss $= 0.5g(2+x)$; EPE at C $= \frac{19.6x^2}{4}$	B1; B1
	$0.5g(2+x) = \frac{19.6x^2}{4}$	M1
	$k(x^2 - x - 2) = 0$	A1
	solving	M1
	$\underline{AC = 4m}$	A1 ✓ (6)
(b)	$T_c = \frac{19.6 \times 2}{2} = 19.6$	B1 ✓
	$19.6 - 0.5g = 0.5a$	M1
	$\underline{a = 29.4\ ms^{-2}}$	A1 (3) (9)
3. (a)	Line of action of weight must pass through C which is not above centre of rod (or equivalent)	B1 (1)
(b)	Method A:	
	R(along AC): $T_1 = 2mg\sin\alpha = \underline{6mg/5}$	M1 M1 A1
	R(along BC): $T_2 = 2mg\cos\alpha = \underline{8mg/5}$ *	M1 A1
	[Equiv. to moments about A, B respectively]	
OR	Method B: R(↑), $T_1\sin\alpha + T_2\cos\alpha = 2mg$	M1
	R(→), $T_1\cos\alpha = T_2\sin\alpha$	M1
	solving to find T_1 or T_2	M1
	$T_1 = \underline{6mg/5}$; $T_2 = \underline{8mg/5}$ *	A1; A1 (5)
(c)	$\frac{8mg}{5} = \frac{kmg(BC - a)}{a}$	M1 A1
	$BC = 2a\sin\alpha$	B1
	$\underline{k = 8}$	A1 (4) (10)

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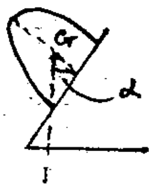
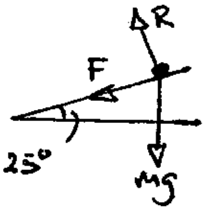
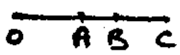
4.(a)	$\int_0^r (\pi) y^2 x \, dx = \bar{x} \int_0^r (\pi) y^2 dx$	M1 A1
	$\int_0^r r x^2 \, dx = \bar{x} \int_0^r r x \, dx$	M1
	$\left[(r)\frac{x^3}{3}\right]_0^r = \bar{x}\left[(r)\frac{x^2}{2}\right]_0^r$	A1 A1
	$\bar{x} = 2r/3$ *	A1 (6)
(b)	 vertical thro' CM and lowest point of plane face	M1
	$\tan\alpha = r / r/3$	M1 A1
	$\alpha = 72°$ (nearest degree)	A1 (4) (10)
5.	 $R(\uparrow)$, $R\cos 25° - F\sin 25° = mg$	M1 A2
	$R(\leftarrow)$, $R\sin 25° + F\cos 25° = \frac{mv^2}{40}$	M1 A2
	$F = 0.6R$ used	M1
	Eliminating R	M1
	Solving for v	M1
	$v = 24.1 \text{ ms}^{-1}$, 24 ms^{-1}	A1 (10)
6.(a)	 If S.H.M., $a = 1.2$	B1
	Using $v^2 = \omega^2(a^2 - x^2)$	M1
	$0.27 = \omega^2(1.2^2 - 0.6^2)$ or $0.2 = \omega^2(1.2^2 - 0.8^2)$	A1
	Solve for ω $(= 0.5)$ and use in other equ^n	M1
	Shown to be correct	A1 c.s.o. (5)
(b)	$v = a\omega = 1.2 \times 0.5 = 0.6$ *	M1 A1 (2)
(c)	$\lvert\ddot{x}\rvert = \omega^2 \times 0.6 = 0.15 \text{ ms}^{-2}$	M1 A1√ (2)
(d)	$0.6 = a\sin\omega t$ or $0.8 = a\sin\omega t$	M1
	$t = \frac{1}{\omega}\left(\sin^{-1}\frac{0.8}{a} - \sin^{-1}\frac{0.6}{a}\right)$	M1 A1√
	$= 0.412\text{s}$ (3SF)	A1 (4)
		(13)

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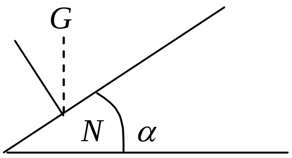
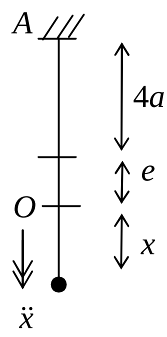
7. (a)	$\frac{1}{2}m\frac{7ag}{2} - \frac{1}{2}mv^2 = mga$	M1 A1
	$(\leftarrow)$, $R = \frac{mv^2}{a} = \frac{3mg}{2}$	M1 A1 (4)
(b)	$\frac{1}{2}m.\frac{7ag}{2} - \frac{1}{2}mv^2 = mga(1+\cos\theta)$	M1 A1
	R(↙), $mg\cos\theta = \frac{mv^2}{a}$	M1 A1
	Eliminating v^2	M1
	Solving to give $\cos\theta = k$, $\underline{\theta = 60°}$ *	M1 A1 (7)
(c)	$v\cos 60°\, t = a\sin 60°$	M1
	$v^2 = ag\cos 60°$	B1
	Making t explicit	M1
	$\underline{t = \sqrt{\frac{6a}{g}}}$	A1 (4)
		(15)

H.J.J. 17.1.02

Question Number	Scheme	Marks
1. (*a*)	$a = 0.25$	B1
	$\frac{2\pi}{\omega} = 2 \Rightarrow \omega = \pi$	B1
	$-0.125 = 0.25 \cos \omega t$	M1A1
(*b*)	$t = \frac{1}{\pi}\cos^{-1}(-0.5)$	M1
	$= \frac{2}{3}$	A1 **(6)**
		(6 marks)
2. (*a*)	$(\uparrow)$ $3mg \cos \alpha° = mg$	M1 A1
	$\alpha = \cos^{-1}(\tfrac{1}{3})$	M1
	$= 70.5$	A1 **(4)**
(*b*)	$(\leftarrow)$ $3mg \sin \alpha = mr \times 2gk$	M1 A1
	$l \sin \alpha = r$	B1
	$l = \tfrac{3}{2}k$	M1 A1 **(5)**
		(9 marks)
3. (*a*)	$2e^{-0.1x} = 2.5a$	M1 A1
	$\tfrac{4}{5}e^{-0.1x} = v\frac{dv}{dx}$	M1
	$-8e^{-0.1x} = \tfrac{1}{2}v^2 (+c)$	A1
	$x = 0, v = 2 \Rightarrow c = -10$	M1
	$v^2 = 20 - 16e^{-0.1x}$	A1 **(6)**
(*b*)	$16 = 20 - 16e - 0.1x \Rightarrow e^{-0.1x} = \tfrac{1}{4}$	M1
	$0.1x = \ln 4$	M1
	$x = 13.9$	A1 **(3)**
(*c*)	Appropriate comment.	B1 **(1)**
		(10 marks)

Question Number	Scheme	Marks
4. (*a*)	$\frac{1}{2} \times 0.2 \times 5^2 - \frac{1}{2} \times 0.2 \times u^2 = \frac{1}{2} \times \frac{20(0.5)^2}{1.5}$	M1 A1 A1
	$u^2 = \frac{25}{3}$	M1
	$u = 2.89 \text{ ms}^{-1}$	A1 **(5)**
(*b*)	$\frac{1}{2} \times 0.2 \times 5^2 - \frac{1}{2} \times 0.2 \times 1.5^2 = \frac{1}{2} \times \frac{20x^2}{1.5}$	M1 A1
	$x^2 = 0.34125$	M1
	$T = \frac{20x}{1.5} = 7.8 \text{ N}$	M1 A1 **(5)**
		(10 marks)
5. (*a*)	Cone: $\frac{1}{3}\pi(2r)^2h$; Cylinder: $\pi r^2 h$; Whole: $\frac{1}{3}\pi(2r)^2h + \pi r^2 h$	M1 A1
	(4) (3) (7)	
	$\frac{1}{4}h$ $\frac{1}{2}h$ $\bar{x}$	B1 B1
	$-4 \times \frac{1}{4}h + 3 \times \frac{1}{2}h = 7\bar{x}$	M1 A1
	$\bar{x} = \frac{1}{14}h$	M1 A1 cso **(8)**
(*b*)	 Use of G above N	M1
	$\tan\alpha = \frac{r}{h - \frac{1}{14}h} = \frac{7}{26}$	M1 A1
	$r = \frac{1}{4}h$	A1 **(4)**
		(12 marks)

Question Number	Scheme	Marks
6. (*a*)	$mg = \frac{8mge}{4a}$	M1
	$\frac{9}{2}a = AO$	A1 **(2)**
		
(*b*)	$mg - \frac{8mg}{4a}(e + x) = m\ddot{x}$	M1 M1 A1
	$\ddot{x} = -\frac{2g}{a}x$	M1 A1
	$T = 2\pi\sqrt{\frac{a}{2g}} = \pi\sqrt{\frac{2a}{g}}$ (✱)	M1 A1 **(7)**
	$v = d\omega$	M1
	$\frac{1}{2}\sqrt{ga} = d\sqrt{\frac{2g}{a}}$	A1 ft on ω
	$d = \frac{a}{2\sqrt{2}} = a\frac{\sqrt{2}}{4} = 0.35a$ (awrt)	A1 **(3)**
(*d*)	Partly under gravity, partly SHM	B1 B1 **(2)**
		(14 marks)
7. (*a*)	$\frac{1}{2}mu^2 = mgl(1 - \cos\theta)$	M1 A1 A1
	$u = \sqrt{\frac{2}{3}gl}$	A1 **(4)**
(*b*)	$T - mg\cos\theta = \frac{mv^2}{l}$	M1 A1
	$\frac{1}{2}mu^2 - \frac{1}{2}mv^2 = mgl(1 - \cos\theta)$	M1 A1
	eliminating v^2, $T = \frac{mg}{3}(9\cos\theta - 4)$ (✱)	M1, A1 cso **(6)**
(*c*)	max T, $\theta = 0$, $T_{MAX} = \frac{5mg}{3}$	M1
	min T, $\cos\theta = \frac{2}{3}$, $T_{MIN} = \frac{2mg}{3}$	M1 A1
	$\frac{2mg}{3} \le T \le \frac{5mg}{3}$	A1 **(4)**
		(14 marks)

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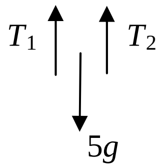
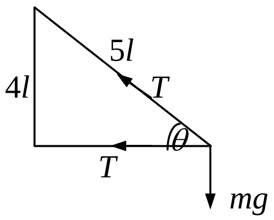
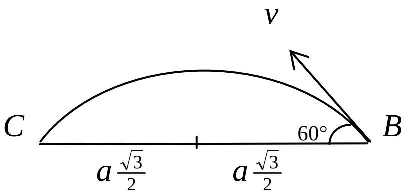
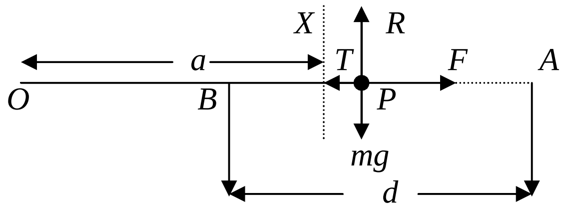
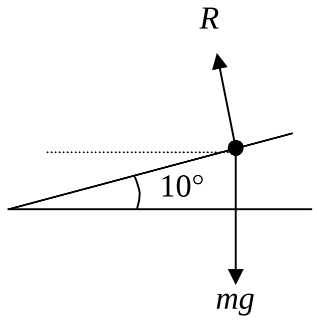
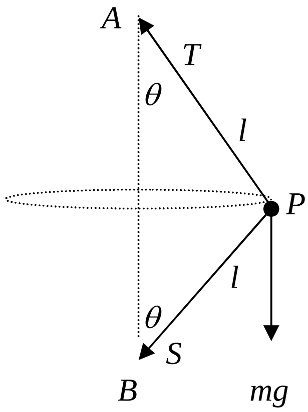
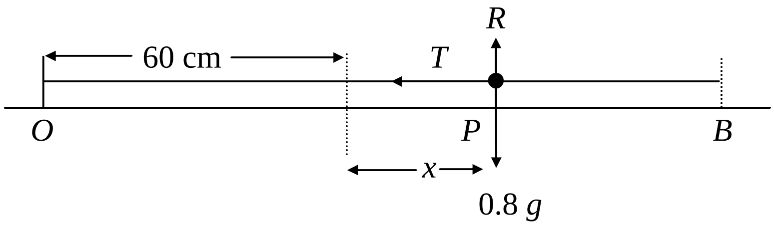
1.	 $T_1 = \frac{175 \times 0.2}{1}$	B1
	$\frac{175 \times 0.2}{1} + \frac{\lambda \times 0.3}{0.9} = 49$	M1 A 1
	$\Rightarrow \lambda = 42$	M1 A1 (5)
		(5 marks)
2. (*a*)	 3, 4, 5 Δ	B1
	R(↑) $T \sin \theta = mg$	M1
	$T = \frac{5mg}{4}$	A1 (3)
(*b*)	R (←) $T + T \cos \theta = \frac{mv^2}{3l}$	M1 A2
	$\frac{8}{5} \times \frac{5mg}{4} = \frac{mv^2}{3l}$	M1
	$v = \sqrt{6gl}$	A1 (5)
(*c*)	Could not assume tensions same	B1 (1)
		(9 marks)
3. (*a*)	Cylinder — half-sphere — toy	
	$\pi r^2 h\rho$ — $\frac{2}{3}\pi r^3 6\rho$ — $\pi r^2 h\rho + \frac{2}{3}\pi r^3 6\rho$	M1 A1
	$\frac{h}{2} + r$ — $\frac{5r}{8}$ — d	B1 B1
	$\pi r^2 h\rho(\frac{h}{2} + r) + 4\pi r^3 \rho \frac{5r}{8} = (\pi r^2 h\rho + 4\pi r^3 \rho)d$	M1 A1
	$\Rightarrow d = \frac{h^2 + 2rh + 5r^2}{2(h + 4r)}$ (*)	A1 (7)
(*b*)	$d = r, \Rightarrow$ $h^2 + 2rh + 5r^2 = 2r(h + 4r)$	M1, M1
	$h = \sqrt{3}r$	A1 (3)
		(10 marks)

Question Number	Scheme	Marks
4. (*a*)	$\frac{2\pi}{\omega} = \pi \Rightarrow\ = 2$	B1
	$2.4^2 = 4\,(a^2 - 0.5^2)$	M1 A1ft
	$a = 1.3$ m	A1 (4)
(*b*)	$v_{max} = a\omega = 2.6$ m s^{-1}	B1 (1)
(*c*)	$\text{arct}_{max} = a\omega^2 = 5.2$ m s^{-2}	B1ft (1)
(*d*)	$0.5 = 1.3 \sin 2t$	M1
	$t = \frac{1}{2} \sin^{-1}\left(\frac{0.5}{1.3}\right)$	M1 A1
	$\therefore$ Total time $= 4t = 0.79$ (2 dp)	M1 A1 (5)
		(11 marks)
5. (*a*)	$800\,\frac{dv}{dt} = \frac{48000}{(t+2)^2}$	M1
	$v = 60 \int \frac{dt}{(t+2)^2} = \frac{-60}{(t+2)}\ (+\,c)$	M1 A1
	$t = 0,\ v = 0 \Rightarrow c = 30$	M1 A1
	$v = 30 - \frac{60}{(t+2)} \Rightarrow v \to 30$ as $t \to \infty$	A1 (6)
(*b*)	$s = \int v\,dt = 30t - 60 \ln(t+2)\ (+\,c)$	M1 A1
	substitute in $t = 0$ and $t = 6$	M1
	$s = 180 - 60 \ln 8,\ - -60 \ln 2$	A1, A1
	≈ 96.8 m	A1 (6)
		(12 marks)

Question Number	Scheme	Marks
6. (*a*)	$\frac{1}{2} \times \frac{58.8}{4} x^2 = 0.5 \times 9.8\,(x + 4)$	M1 A1 A1
	$3x^2 - 2x - 8 = 0$	M1 A1
	$(3x + 4)(x - 2) = 0, \quad x = 2$	
	Distance fallen = 6 m	M1 A1 (7)
(b)	$\frac{1}{2} \times 0.5v^2 = \frac{1}{2} \times \frac{58.8}{4} \times 3^2 - 0.5 \times 9.8 \times 3$	M1 A1 A1
	$v = 14.3 \text{ m s}^{-1}$	M1 A1 (5)
		(12 marks)
7. (*a*)	$\frac{1}{2} mu^2 - \frac{1}{2} mv^2 = mga\,(1 + \cos 60°)$	M1 A1
	$v^2 = u^2 - 3ga$	A1 (3)
(*b*)	$R + mg \cos 60° = \frac{mv^2}{a}$	M1 A1
	$R = \frac{m}{a}(6ga - 3ga) - \frac{mg}{2}$	
	$= \frac{5mg}{2}$	A1 (3)
(*c*)	$R = 0$ at $B \Rightarrow \frac{mg}{2} = \frac{mv^2}{a} \Rightarrow v^2 = \frac{1}{2} ag$	M1
	$\Rightarrow u^2 = \frac{7ga}{2} \Rightarrow u = \sqrt{\frac{7ga}{2}}$	M1 A1 (3)
(*d*)	 (→) B to C: $v \cos 60° \times t = a\sqrt{3}$	M1 A1
	$t = \frac{2a\sqrt{3}}{v}$	
	(↑) B to C: $0 = v \sin 60t - \frac{1}{2} gt^2$	M1 A1
	$\Rightarrow t = \frac{2v \sin 60°}{g} = \frac{v\sqrt{3}}{g}$	
	$\therefore \frac{2a\sqrt{3}}{v} = \frac{v\sqrt{3}}{g} \Rightarrow v^2 = 2ga$	M1 A1
	$\Rightarrow u^2 = 5ga$	
	$\Rightarrow u = \sqrt{5ga}$	A1 (7)
		(16 marks)

Question Number	Scheme	Marks
1.		
	$R = mg$	B1
	$F = \mu R = \mu mg$	B1
	Attempt to relate Fd to EPE	M1
	$\frac{2}{3}\ mg\,d = \dfrac{4mg(\frac{a}{2})^2}{2a}$	M1 A1 ft
	Final answer: $d = \frac{3}{4}a$	A1 (6)
		(6 marks)
2.		
	($\updownarrow$) $R\cos 10° = mg$	M1 A1
	($\leftrightarrow$) $R\sin 10° = \dfrac{mv^2}{r}$	M1 A1ft
	Solving for r: $r = \left[\dfrac{18^2}{g\tan 10°}\right]$	M1
	$r = 190$ (m) [Accept 187, 188]	A1 (6)
		(6 marks)
3. (*a*)	$\frac{1}{10}x(4-3x) = 0.2\,a$	M1 A1
	$\frac{1}{10}x(4-3x) = 0.2v\dfrac{dv}{dx}$ or $\frac{1}{10}x(4-3x) = 0.2\dfrac{d(\frac{1}{2}v^2)}{dx}$	M1
	Integrating : $v^2 = 2x^2 - x^3$ (+ C) or equivalent	M1 A1
	Substituting $x = 6$, $v = 0$ to find candidate's C	M1
	$v^2 = 2x^2 - x^3 + 144$	A1 (7)
(*b*)	Substituting $x = 0$ and finding v; $v = 12$ (m s^{-1})	M1; A1 ft (2)
		(9 marks)

(ft = follow through mark)

Question Number	Scheme	Marks
4. (*a*)		
	(↕) $(T - S)\cos\theta = mg$	M1 A1
	(↔) $(T + S)\sin\theta = mr\omega^2$	M1 A1 ft
	$= m(l\sin\theta)\omega^2$	A1
	Finding T in terms of l, m, ω^2 and g	M1
	$T = \frac{1}{6}m(3l\omega^2 + 4g)$ (*)	A1 (7)
(*b*)	$S = \frac{1}{6}m(3l\omega^2 - 4g)$ any correct form	M1 A1 (2)
(*c*)	Setting $S \geq 0$; $\omega^2 \geq \frac{4g}{3l}$ (*) (no wrong working seen)	M1 A1 (2)
		(11 marks)
5. (*a*)	 $\lambda = 12$ N, $OB = 85$ cm	
	Hooke's Law: $T = \frac{12x}{0.6}$ [$= 20x$]	M1
	Equation of motion: $(-)T = 0.8\ddot{x}$	M1
	$-\frac{12x}{0.6} = 0.8\ddot{x}$ $\ddot{x} = -25x$	A1
	Finding ω from derived equation of form $\ddot{x} = -\omega^2 x$	M1
	Period $= \frac{2\pi}{\omega} = \frac{2\pi}{5}$ (*) no incorrect working seen	A1 (5)
(*b*)	Substituting (candidate's) ω and a in $\omega^2 a$; $= 25 \times 0.25 = 6.25$ (m s^{-2})	M1; A1 (2)
	(or finding $T_{max} = 0.8a \Rightarrow a = 5/0.8 = 6.25$)	
(*c*)	Complete method for x; $x = 0.25\cos 10°$ (–0.2098)	M1 A1
	Using $v^2 = \omega^2(a^2 - x^2) \Rightarrow v = (\pm)5\sqrt{[(0.25)^2 - (0.25\cos 10°)]}$	M1 A1 ft
	$v = (\pm)\ 0.68$ (m s^{-1})	A1 (5)
(*d*)	Direction $\overrightarrow{OB}$ or equivalent	B1 (1)
		(13 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

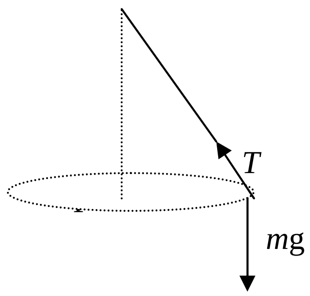
Question Number	Scheme	Marks
6. (*a*)	Energy: $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mga(1 - \cos\theta)$	M1 A1 A1
	Radial: $(\pm R) + mg\cos\theta = \frac{mv^2}{a}$	M1 A1
	Eliminating v and finding $\cos\theta =$, $\frac{u^2 + 2ga}{3ga}$	M1, A1 (7)
(*b*)	Energy (C and ground): $\frac{1}{2}m\left(\frac{9ag}{2}\right) - \frac{1}{2}mv^2 = mga(1 = \cos\theta)$	M1 A1
	Eliminating v: $\frac{1}{2}m\left(\frac{9ag}{2}\right) - \frac{1}{2}mag\cos\theta = mga(1 + \cos\theta)$	M1 A1
	$\cos\theta = \frac{5}{6}$	M1 A1 ft
	$\theta = 34°$	A1 (7)
		(14 marks)
Alt (*b*)	Or energy (A and ground): $\frac{1}{2}m\left(\frac{9ag}{2}\right) - \frac{1}{2}mu^2 = 2mga$	M1 A1
	$u^2 = \frac{1}{2}ga$	M1 A1
	Using with (*a*) to find $\cos\theta = \frac{5}{6}$; $\theta = 34°$	M1 A1; A1 (7)
Alt	Projectile approach: $V_x = v\cos\theta$; $V_y^2 = (v\sin\theta)^2 + 2ga(1 + \cos\theta)$	
	$\left(\frac{9ag}{2}\right) = V_x^2 + V_y^2 \Rightarrow \left(\frac{9ag}{2}\right) - v^2 = 2ga(1 + \cos\theta)$ – M1 A1, then scheme	

(ft = follow through mark)

Question Number	Scheme	Marks
7. (*a*)	$V = \pi\int y^2 \quad dx \ = \ \frac{1}{4}\pi\int (x-2)^4 dx$	M1
	$\int (x-2)^4 dx \ = \frac{1}{5}(x-2)^5$	M1 A1
	$V = \dfrac{8\pi}{5}$	A1 (4)
(*b*)	Using $\pi\int xy^2 \quad dx \ = \ \frac{1}{4}\pi\int x(x-2)^4 dx$	M1
	Correct strategy to integrate [e.g. substitution, expand, by parts]	M1
	[e.g. $\frac{1}{4}\pi\int (u-2)^4 du$; $\frac{1}{4}\pi\int (x^5 - 8x^4 + 24x^3 - 32x^2 + 16x)\, dx$]	
	$= \frac{1}{4}\pi\left[\dfrac{2u^5}{5} + \dfrac{u^6}{6}\right]$ or $\frac{1}{4}\pi\left[\dfrac{x^6}{6} - \dfrac{8x^5}{5} + 6x^4 - \dfrac{32x^3}{3} + 8x^2\right]$	M1 A1
	$= \dfrac{8\pi}{15}$ limits need to be used correctly	A1 (7)
	$V_c\,(\rho)\,\bar{x} \ = \ \pi(\rho)\int xy^2 \quad dx$ seen anywhere	M1
	$\bar{x} \ = \ \frac{1}{3}$ cm (*) no incorrect working seen	A1
(*c*)	Moments about *B*: $8A = 10W - 2W(\frac{1}{3})$	M1 A1 A1
	$A = \dfrac{59W}{12}$ $(4.9W)$	M1 A1 (5)
		(16 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

1.



(a) (↕) $T\cos 60° = mg \Rightarrow T = 2mg$ * B1 **(1)**

(b) (↔) $T\sin 60° = mr\omega^2$ M1A1
[Omission of m is M0]

Attempt at $r = L\sin 60°$ M1

$(T\sin 60° = m\,L\sin 60°\,\omega^2)$

$$\omega = \sqrt{\frac{2g}{L}}$$ A1 **(4)**

(c) Applying Hooke's Law: $2mg = \dfrac{\lambda}{(\frac{3}{5}L)}(L - \frac{2}{5}L)$; $\lambda = 3mg$ M1;A1 **(2)**

[L in denominator is M0]

[7]

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2. (a) Integration of $-4e^{-2t}$ w.r.t. t to give $v = 2e^{-2t}$ (+c) B1

Using initial conditions to find c (–1) or $v - 1 = \left[f(t)\right]_0^t$ M1

$v = 2e^{-2t} - 1$ ms^{-1} A1 **(3)**

(b) **Integrating** v w.r.t t ; $x = -e^{-2t} - t$ (+c) M1;A1√

Using $t = 0$, $x = 0$ **and** finding value for c ($c = 1$) M1

Finding t when $v = 0$; $t = ½ \ln 2$ or equiv., 0.347 M1;A1√

[both f.t. marks dependent on v of form $ae^{-2t} \pm b$]

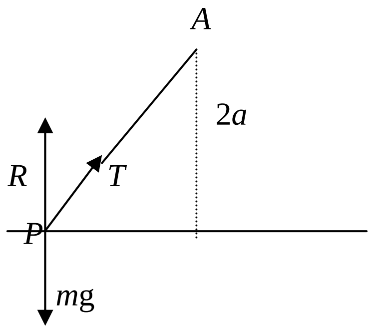
$x = ½\,(1 - \ln 2)$ m or 0.153 m(awrt) A1 **(6)**

[9]

[For A1, exact form must be two termed answer]

3. (a) $F = \dfrac{k}{x^2}$ [k may be seen as Gm_1m_2 , for example]	M1
Equating F to mg at $\boldsymbol{x = R}$, [$mg = \dfrac{k}{R^2}$]	M1
Convincing completion [$k = mgR^2$] to give $F = \dfrac{mgR^2}{x^2}$ *	A1 **(3)**
[Note: r may be used instead of x throughout, then $r \to x$ at end.]	
(b) Equation of motion: $(m)a = (-)\dfrac{(m)gR^2}{x^2}$; $(m)v\dfrac{dv}{dx} = -\dfrac{(m)gR^2}{x^2}$	M1;M1
Integrating: $\frac{1}{2}v^2 = \dfrac{gR^2}{x}$ (+ c) or equivalent	M1A1
[S.C: Allow A1√ if A0 earlier due to "+" only]	
Use of $v^2 = \dfrac{3gR}{2}$, $x = R$ to find c [$c = -\frac{1}{4}gR$] or use in def. int.	M1
[Using x = 0 is M0] [$v^2 = \dfrac{2gR^2}{x} - \dfrac{gR}{2}$]	
Substituting $x = 3R$ and finding V; $V = \sqrt{\dfrac{gR}{6}}$	M1;A1 **(7)**
[Using $x = 2R$ is M0]	
Alternative in (b)	**[10]**
Work/energy $(-)\displaystyle\int_R^a \frac{mgR^2}{x^2}dx$; = $\frac{1}{2}mv^2 - \frac{1}{2}mu^2$	M1;M1
Integrating: [$\dfrac{mgR^2}{x} - \dfrac{mgR^2}{R}$] = $\frac{1}{2}mv^2 - \frac{1}{2}m\frac{3gR}{2}$	M1A1M1
Final 2 marks as scheme	M1A1
[Conservation of energy scores 0]	

4.



(a) Length of string = $\frac{10}{3}a$ — B1

EPE = $\dfrac{\frac{1}{2}mg}{2a}(L - a)^2$ — M1

$= \frac{49}{36}mga$ — A1 **(3)**

(b) Energy equation: $\frac{1}{2}mv^2 + \dfrac{\frac{1}{2}mg}{2a}a^2 = (\frac{49}{36}mga)_C$ — M1A1✩

$v = \frac{2}{3}\sqrt{5ga}$ or equivalent — A1 **(3)**

(c) When string at angle θ to horizontal, length of string = $\dfrac{2a}{\sin\theta}$

$\Rightarrow$ Vert. Comp. of T, $T_{V,} = T\sin\theta = \dfrac{mg}{2a}\left(\dfrac{2a}{\sin\theta} - a\right)\sin\theta$ — M1A1

$= \dfrac{mg}{2}(2 - \sin\theta)$

(↕) $R + T_V = mg$ and find R = …. — M1

$R = mg - \dfrac{mg}{2}(2 - \sin\theta) = \dfrac{mg}{2}\sin\theta$ — A1

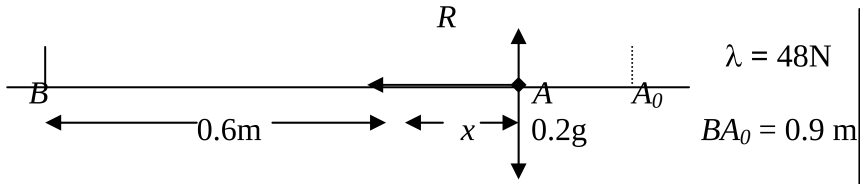
$\Rightarrow R > 0$ (as $\sin\theta > 0$), so stays on table — A1 **(5)**

[Alternative final 3 marks: As θ increases so T_V decreases M1

Initial T_V (string at β to hor.) = $\frac{7}{10}mg$ A1

$\Rightarrow T_V \leq \frac{7}{10}mg < mg$, so stays on table A1] **[11]**

5. (a)



Applying Hooke's Law correctly : e.g. $T = \frac{48x}{0.6}$	M1
Equation of motion: (–) T = 0.2 $\ddot{x}$	M1
Correct equation of motion: e.g. $-\frac{48x}{0.6} = 0.2\ \ddot{x}$	A1
Writing in form $\ddot{x} = -\ \omega^2\ x$, and stating motion is SHM	A1√
Period = $\frac{2\pi}{\omega} = \frac{2\pi}{20} = \frac{\pi}{10}$ * (no incorrect working seen)	A1 **(5)**
[If measure *x* from *B* or *A*, final 2 marks only available if equation of motion is reduced to $\ddot{X} = -\ \omega^2\ X$]	
(b) max *v* = *aw* with values substituted; = 0.3 x 20 = 6 ms^{-1}	M1A1**(2)**
(c) Using $x = 0.3\cos 20t$ or $x = 0.3\sin 20T$	M1
Using x = 0.15 to give either cos 20t = ½ or sin 20T = ½	M1
Either $t = \frac{\pi}{60}, \frac{5\pi}{60}$ or $T = \frac{\pi}{120}$	A1
Complete method for time:	
$t_2 - t_1$, or $\frac{\pi}{10} - 2t_1$, or $2(\frac{\pi}{40} + T)$	M1
Time = $\frac{\pi}{15}$ s (must be in terms of π)	A1 **(5)**
	[12]

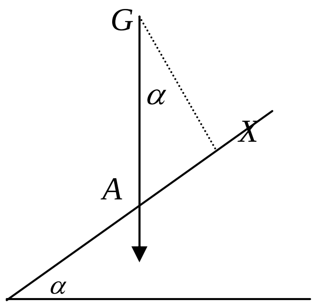
6. (a)

	Cylinder	Hemisphere	S	
Masses	$(\rho)\pi(2a)^2(\frac{3}{2}a)$	$(\rho)\frac{2}{3}\pi a^3$	$(\rho)(\frac{16}{3}\pi a^3)$	M1A1
	$[6\pi a^3]$ [18]	[2]	[16]	
Distance of CM from O	⅛ a	$\frac{3}{8}a$	$\bar{x}$	B1B1

Moments equation: $6\pi a^3(\frac{3}{4}a) - \frac{2}{3}\pi a^3(\frac{3}{8}a) = \frac{16}{3}\pi a^3\bar{x}$ M1

$\bar{x} = \frac{51}{64}a$ A1 **(6)**

(b)



G above "A" seen or implied M1

or $mg\sin\alpha(GX) = mg\cos\alpha(AX)$

$\tan\alpha = \frac{AX}{XG} = \frac{2a}{\frac{3}{2}a - \bar{x}}$ M1

$[GX = \frac{3}{2}a - \frac{51}{64}a = \frac{45}{64}a,\ \tan\alpha = \frac{128}{45}]$ $\alpha = 70.6°$ A1 **(3)**

(c) Finding F and R **:** $R = mg\cos\beta$, $F = mg\sin\beta$ M1

Using $F = \mu R$ and finding $\tan\beta$ [= 0.8] M1

$\beta = 38.7°$ A1 **(3)**

[12]

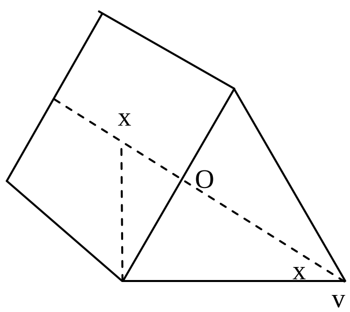
7. (a) Energy: $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mga\sin\theta$	M1	
$v^2 = \frac{3}{2}ga + 2ga\sin\theta$	A1	**(2)**
(b) Radial equation: $T - mg\sin\theta = m\frac{v^2}{a}$	M1A1	
$T = \frac{3mg}{2}(1 + 2\sin\theta)$ any form	A1✩	**(3)**
(c) Setting $T = 0$ and solving trig. equation; ($\sin\theta = -\frac{1}{2}$) $\Rightarrow \theta = 210°$ *	M1;A1	**(2)**
(d) Setting $\boldsymbol{v} = \mathbf{0}$ in (a) and solving for θ	M1	
$\sin\theta = -\frac{3}{4}$ so not complete circle	A1	**(2)**
OR Substituting $\theta = 270°$ in (a); $v^2 < 0$ so not possible to complete		
(e) No change in PE $\Rightarrow$ no change in KE (Cof E) so $v = u$	B1	**(1)**
(f) When string becomes slack, $V^2 = \frac{1}{2}ga$ [$\sin\theta = -\frac{1}{2}$ in (a)]	B1✩	
Using fact that horizontal component of velocity is unchanged	M1	
$\sqrt{\frac{ga}{2}}\cos 60° = \sqrt{\frac{3ga}{2}}\cos\phi$		
$\cos\phi = \sqrt{\frac{1}{12}} \Rightarrow \phi = 73.2°$	M1A1	**(4)**
		[14]

Question Number	Scheme	Marks
1.	1000 r.p.m = $\frac{1000 \times 2\pi}{60}$ rad/s	B1
	v = 0.035 × $\frac{1000 \times 2\pi}{60}$ = 3.67 ms^{-1} (3 SF) — M1 their r × their ω	M1 A1
		(3 marks)
2.	Extn at bottom = $\frac{a}{\cos\alpha} - a = \frac{2a}{3}$ (0.67a or better)	M1 A1
	Energy: $mga \tan\alpha = \frac{2\lambda\left(\frac{2a}{3}\right)^2}{2a}$	M1 A1 A1 ft
	$3mg = \lambda$ — Second M0 if treated as equilibrium; Third M1 for solving for λ	M1 A1
		(7 marks)
3. (*a*)	$mg \sin 30° - mx^2 = ma$	M1 A1
	$\frac{g}{2} - x^2 = v\frac{\text{d}v}{\text{d}x}$ or $\frac{\text{d}\left(\frac{1}{2}v^2\right)}{\text{d}x}$	M1
	$\frac{gx}{2} - \frac{x^3}{3} (+C) = \frac{v^2}{2}$	M1 A1
	$x = 2 : g - \frac{8}{3} = \frac{v^2}{2}$	M1
	$v = 3.8\text{ms}^{-1}$ (3.78) — Third M1 for attempting to integrate	A1 (7)
(b)	$v = 0$: $\frac{gx}{2} - \frac{x^3}{3} = 0$	M1
	$x^2 = \frac{3g}{2} \Rightarrow x = 3.8$, (3.83), $\sqrt{\frac{3g}{2}}$ — must have integrated for first M1	M1 A1 c.s.o (3)
		(10 marks)

(ft = follow through mark)

Question Number	Scheme	Marks
4. (*a*)	(↑), $R = mg$	B1
	$m\dfrac{4a}{3}\omega^2$ (seen and used)	B1
	$m\dfrac{4a}{3}\omega^2 \leq \dfrac{3}{5}\text{ mg}$	M1
	$\omega^2 \leq \dfrac{9g}{20a}$ *	A1 c.s.o (4)
(b)	$T = \dfrac{2mg}{a}\dfrac{a}{3} = \dfrac{2mg}{3}$	B1
	(→), $\dfrac{3}{5}mg + \dfrac{2mg}{3} \geq = m\dfrac{4a}{3}\omega_{max}^2$	M1 A1 f.t
	$\dfrac{19g}{20a} = \omega_{max}^2$	A1
	(→), $-\dfrac{3}{5}mg + \dfrac{2mg}{3} \leq = m\dfrac{4a}{3}\omega_{min}^2$	M1 A1 f.t
	$\dfrac{g}{20a} = \omega_{min}^2$	A1 (7)
	If only one answer, must be clear whether max or min for final A1	**(11 marks)**

(ft = follow through mark; (*) indicates final line is given on the paper)

Question Number	Scheme	Marks
5. (*a*)	Cylinder ($36\pi r^3$) Cone ($12\pi r^3$) Toy ($48\pi r^3$)	
	mass ratio: 3, 1, 4	B1
	dist. From *O*: $2r$, $(-)r$, $\bar{x}$	B1
	$(3 \times 2r) - r = 4\bar{x}$	M1 A1
	$\frac{5r}{4} = \bar{x}$	A1 (5)
	M1 for clear attempt at $\Sigma mx = \bar{x}\,\Sigma m$ – correct no. of terms.	
	If distances not measured from O, B1B1M1A1 available.	
(b)	*AG* vertical, seen or implied	M1
	$\tan\theta = \frac{3r}{4r - \bar{x}}$	M1 A1
	$\theta = 47\ 5°$ (1 d.p.) second M1 for use of tan	A1 (4)
(c)	 Sim Δ's: $\frac{OX}{3r} = \frac{3r}{4r}$ (= tan α)	M1
	$\Rightarrow OX = \frac{9r}{4}$	A1
	$\bar{x} < OX$	M1
	$\Rightarrow$ won't topple	A1 c.s.o (4)
	Note that second M1 is independent, for the general idea.	**(13 marks)**

(ft = follow through mark; (*) indicates final line is given on the paper)

Question Number	Scheme	Marks
	All M marks require correct number of terms with appropriate terms resolved	
6. (*a*)	B to C: $\frac{1}{2}mv^2 - \frac{1}{2}m20^2 = mg \times 50(1 - \sin 30°)$	M1 A1
	$v = 30 \text{ ms}^{-1}$ (29.8)	A1 (3)
(*b*)	$(\uparrow)$ at C, $R - mg = m\dfrac{890}{50}$	M1 A1 ft
	$R = 1900$ N (1930 N)	A1 (3)
(*c*)	C to D: $\frac{1}{2}\ m\ 890 - \frac{1}{2}mw^2 = mg \times 50\ (1 - \cos 30°)$	M1 A1 ft
	$w = 28 \text{ ms}^{-1}$ (27.5)	A1 (3)
(*d*)	Before: $R = mg\cos\theta$	B1
	After: $R = mg\cos\theta + m\ \dfrac{20^2}{50}$	M1 A1
	Change $= 70 \times \dfrac{20^2}{50} = 560$ N	A1 c.s.o (4)
(*e*)	Lower speed at $C \Rightarrow$ R reduced	M1 A1 (2)
		(15 marks)

(ft = follow through mark)

Question Number	Scheme	Marks
7. (*a*)	$(-)\ \dfrac{21.6x}{2} = 0.3\ddot{x}$	M1 A1
	$-36x = \ddot{x}$	M1
	S.H.M., period = $\dfrac{2\pi}{\sqrt{36}} = \dfrac{\pi}{3}$ *	A1 c.s.o. (4)
(*b*)	At *A*: $v = aw = 1.5 \times 6 = 9\ \text{ms}^{-1}$	M1 A1 (2)
(*c*)	$x = a\cos\omega t$	
	$0.75 = 1.5\cos 6t$	M1
	$\dfrac{\pi}{3} = 6t \Rightarrow t = \dfrac{\pi}{18}$ (no decimals)	M1 A1 (3)
(*d*)	$(-)\ \dfrac{21.6x}{2} = 0.5\ddot{x}$	M1 A1
	$-21.6x = \ddot{x} \Rightarrow$ S.H.M., $\omega = \sqrt{21.6}$	A1
	At collision: CLM: $0.3 \times 9 = 0.5v \Rightarrow v = 5.4$	M1 A1 ft
	$a \times \sqrt{21.6} = 5.4$	M1
	$a = 1.16$ m (3SF)	A1 (7)
		(16 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)

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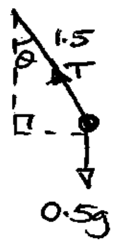
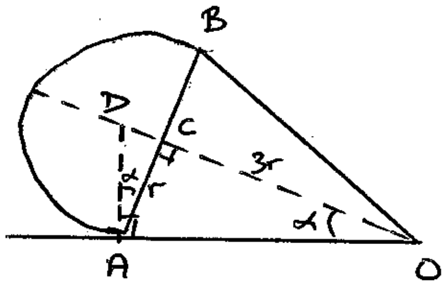
January 2005

Advanced Subsidiary/Advanced Level

General Certificate of Education

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

Question Number	Scheme	Marks
1.(a)		
	$r = 1.5\sin\theta$	B1
	$T\sin\theta = mr\omega^2$	M1 A1
	$T\sin\theta = 0.5\times1.5\sin\theta\times2.7^2$	
	$T = \underline{5.4675\text{ N}}$	A1 (4)
(b)	$T\cos\theta = 0.5g$	M1 A1
	$\cos\theta = \dfrac{0.5g}{5.4675}$	
	$\underline{\theta = 26°}$ (nearest degree)	A1 (3) (7)
2.(a)	$\frac{3r}{4}$; $\frac{3r}{8}$	B1 ; B1
	$-m\cdot\frac{3r}{4} + M\cdot\frac{3r}{8} = (m+M)\bar{x}$	M1 A1
	$\dfrac{3r(M-2m)}{8(M+m)} = \bar{x}$ *	A1 (5)
(b)		
	$CD = r\tan\alpha$	M1
	$= r\times\left(\frac{r}{3r}\right)$	
	$= \frac{1}{3}r$	A1
	No equil^{m} $\Rightarrow$ $\bar{x} > CD$	
	$\dfrac{3r(M-2m)}{8(M+m)} > \dfrac{r}{3}$	M1
	$9(M-2m) > 8(M+m)$	
	$M > 26m$ *	A1 (4) (9)

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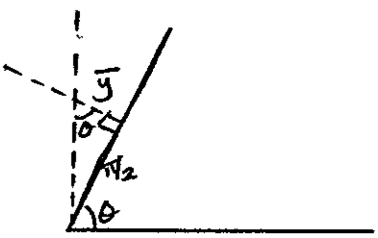
Advanced Subsidiary/Advanced Level

General Certificate of Education

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

Question Number	Scheme	Marks
3.(a)	$\int_0^{\pi} \frac{1}{2}y^2\,dx = \int_0^{\pi} \frac{1}{2}\sin^2 x\,dx$	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 ft
	$\underline{\theta = 75.96°}$	A1 (3)
		(9)

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

Question Number	Scheme	Marks
4. (a)	$6 = \frac{2\pi}{\omega} \Rightarrow \omega = \frac{\pi}{3}$	M1
	$a = 2L$	B1
	$x = 2L\cos\omega t$	M1
	$2L - b = 2L\cos\left(\frac{\pi}{3}\cdot\frac{3}{4}\right)$	A1 ✓
	$\underline{b = L(2-\sqrt{2})}$ *	A1 c.s.o. (5)
(b)	$\dot{x} = -2L\omega\sin\omega t$	M1
	$= -2L\frac{\pi}{3}\sin\frac{\pi}{4}$	
	Speed $= \frac{\sqrt{2}L\pi}{3}$	A1 (2)
(c)	$\frac{1}{2}(2-\sqrt{2})L = 2L\sin\omega t$	M1 A1
	$t = 0.1469..$	
	$\therefore$ Total time $= 2\times 0.14$	(3)
	$= \underline{0.28\ (2dp)}$	A1 (10)
5. (a)	$\frac{dv}{dt} = -\frac{3}{\sqrt{t+4}}$	M1
	$v = -3\int (t+4)^{-\frac{1}{2}}\,dt$	
	$v = -6(t+4)^{\frac{1}{2}} + C$	M1 A1
	$t=0, v=18$: $18 = -6\times 2 + C \Rightarrow C = 30$	M1
	$\underline{v = 30 - 6\sqrt{t+4}}$ *	A1 c.s.o. (5)
(b)	$x = \int 30 - 6(t+4)^{\frac{1}{2}}\,dt$	M1
	$= 30t - 4(t+4)^{3/2} + D$	A1
	$t=0, x=0$: $0 = 0 - 4\times 8 + D \Rightarrow D = 32$	M1
	$v=0 \Rightarrow 30 - 6\sqrt{t+4} = 0 \Rightarrow t = 21$	M1 A1
	When $t=21$, $x = 30\times 21 - 4\times 5^2 + 32$	M1
	$= \underline{\underline{162\ (m)}}$	A1 (7) (12)

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General Certificate of Education

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

Question Number	Scheme	Marks
6. (a)	KE Loss + PE Loss = EPE Gain $\frac{1}{2} \cdot m 2gL + mg3L = \frac{\lambda(3L)^2}{2L}$ $* \quad \frac{8mg}{9} = \lambda$	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) 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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Subject: **Mechanics** Paper: **M3**

Question Number	Scheme	Marks
7.(a)	$\frac{1}{2}m(v^2 - 15) = mg\,5(1 - \cos 60°)$	M1 A1 A1
	$v = 8\text{ ms}^{-1}$	A1 (4)
(b)	$\frac{1}{2}mw^2 = mg\,5(1-\cos 60°)$	M1 A1
	$w = 7\text{ ms}^{-1}$	A1
	CLM: $60\times 8 - 3m = (60+m)7$	M1 A1√ A1√
	$480 - 3m = 420 + 7m$	
	$60 = 10m$	
	$6 = m$	A1 (7)
(c)	$T - 66g = \frac{66\times 7^2}{5}$	M1 A1√
	$T = 132g$	
	$= 1290\ (1294)\text{ N}$	A1 (3)
		(14)

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June 2005 **Final Version**

6679 Mechanics M3
Mark Scheme

The following abbreviations are used in this scheme.

M	A method mark. These are awarded for 'knowing a method and attempting to apply it'.
A	An accuracy mark. Can only be awarded if the relevant method mark(s) have been earned.
B	These marks are independent of method marks.
cso	correct solution only. There must be no errors in this part of the question to obtain this mark.
cao	correct answer only.
ft	follow through. The scheme or marking guidance will specify what is to be followed through.
oe	or equivalent.
awrt	answers which round to

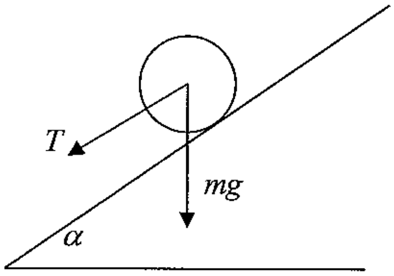
[The second mark is dependent on gaining the first mark.

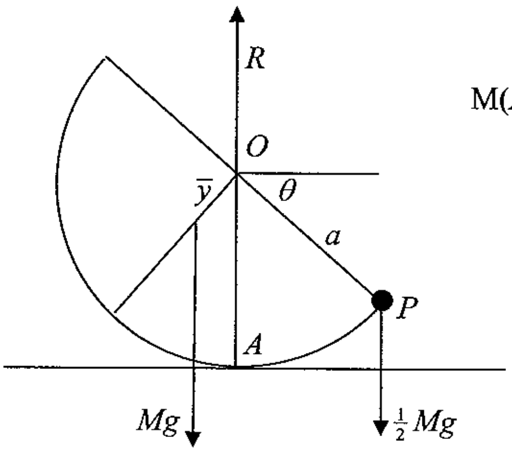
N2L	Newton's second law	LHS	Left hand side of an equation
LM	Linear momentum	RHS	Right hand side of an equation
HL	Hooke's Law.	EPE	Elastic potential energy

→, ↓ etc. Resolving in the appropriate direction

M(A) Taking moments about A.

* The answer is printed on the paper.

Question Number	Scheme	Marks
1.		
	HL $T = \frac{20 \times 0.4}{2}$ $(= 4)$ accept -4	M1 A1
	[$mg\sin\alpha + T = ma$	M1 A1
	$0.8g \times 0.6 + 4 = 0.8a$	M1
	$a = 10.88 \approx 10.9 \left(\text{m s}^{-2}\right)$ accept 11	A1
		[6]

Question Number	Scheme	Marks
2.	(a) Bowl, Lid, C	
	Mass ratio: 2, 1, 3 — anything in ratio 2 : 1 : 3	B1
	$\bar{y}$: $\frac{1}{2}a$, 0, $\bar{y}$	B1
	M(O) $2\times\frac{1}{2}a = 3\bar{y}$	M1
	$\bar{y} = \frac{1}{3}a$ * cso	A1
		(4)
	(b) 	
	M(A) $Mg\times\frac{1}{3}a\sin\theta = \frac{1}{2}Mg\times a\cos\theta$	M1 A1=A1
	$\tan\theta = \frac{3}{2}$	M1
	$\theta \approx 56°$ cao	A1 **(5)**
		[9]
	Methods involving the location of the combined centre of mass of C and P are considered on the next page.	

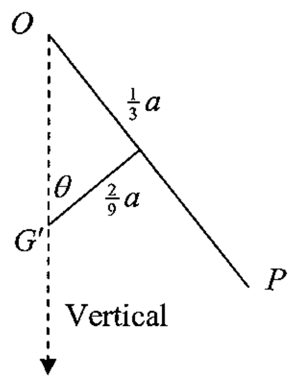
Question Number	Scheme	Marks
2.	(b) *Methods involving the location of the combined centre of mass of C and P.*	
	G is the centre of mass of C; G' is the combined centre of mass of C and P.	
	First Alternative	

	C	P	C and P
Mass ratios	2	1	3
$\bar{y}$	$\frac{1}{3}a$	0	$\bar{y}$
$\bar{x}$	0	a	$\bar{x}$

Finding both coordinates of G' — M1

$\frac{2}{3}a = 3\bar{y} \quad \Rightarrow \quad \bar{y} = \frac{2}{9}a$ — A1

$a = 3\bar{x} \quad \Rightarrow \quad \bar{x} = \frac{1}{3}a$ — A1

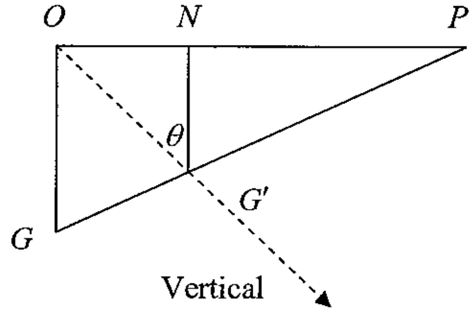


$\tan\theta = \dfrac{\frac{1}{3}a}{\frac{2}{9}a} = \dfrac{3}{2}$ — M1

$\theta \approx 56°$ cao — A1

(5)

Second Alternative



$GG' : G'P = \frac{1}{2}M : M = 1:2$

$OG = \frac{1}{3}a, \quad OP = a$

By similar triangles

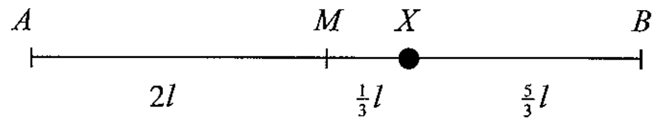
$ON = \frac{1}{3}OP = \frac{1}{3}a$ — M1 A1

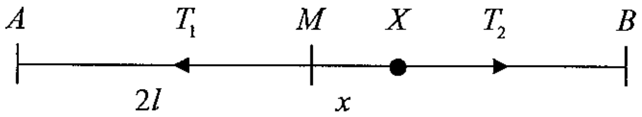
$NG' = \frac{2}{3}OG = \frac{2}{9}a$ — A1

$\tan\theta = \dfrac{ON}{NG'} = \dfrac{\frac{1}{3}a}{\frac{2}{9}a} = \dfrac{3}{2}$ — M1

$\theta \approx 56°$ cao — A1

(5)

Question Number	Scheme	Marks	
3.	(a)		
			
	Elastic energy when P is at X: $E = \frac{4mg\left(\frac{2}{3}l\right)^2}{2l} + \frac{4mg\left(\frac{4}{3}l\right)^2}{2l}$ $\left(= \frac{40mgl}{9}\right)$	M1 A1	
	$\frac{1}{2}mV^2 + 2\times\frac{4mgl^2}{2l} = \frac{4mg\left(\frac{2}{3}l\right)^2}{2l} + \frac{4mg\left(\frac{4}{3}l\right)^2}{2l}$	M1A1=A1ft	
	$\frac{1}{2}V^2 + 4gl = \frac{8}{9}gl + \frac{32}{9}gl$		
	$V^2 = \frac{8gl}{9}$ solving for V^2	M1	
	$V = \left(\frac{8gl}{9}\right)^{\frac{1}{2}}$ or exact equivalents	A1	**(7)**
	(b) The maximum speed occurs when $a = 0$	B1	
	At M the particle is in equilibrium (the sum of the forces is zero) $\Rightarrow a = 0$	B1	**(2)**
			[9]
	The alternative method using Newton's Second Law is considered on the next page.		

Question Number	Scheme	Marks
3.	*Alternative using Newton's second law.*	
	(a)	
		
	HL $\quad T_1 = \frac{4mg(l+x)}{l}, \quad T_2 = \frac{4mg(l-x)}{l}$	
	N2L $\quad m\ddot{x} = T_2 - T_1 = -\frac{8mg}{l}x$	M1 A1
	This is SHM, centre M	
	$a = \frac{l}{3}, \quad \omega^2 = \frac{8g}{l}$	A1, A1ft
	$v^2 = \omega^2(a^2 - x^2) \Rightarrow v^2 = \frac{8g}{l}\left(\frac{l^2}{9} - x^2\right)$ Depends on showing SHM	M1
	At M, $x = 0$, $\quad V^2 = \frac{8gl}{9}, \quad V = \left(\frac{8gl}{9}\right)^{\frac{1}{2}}$ or exact equivalents	M1, A1 **(7)**
	(b) The particle is performing SHM about the mid-point of AB.	B1
	The maximum speed occurs at the centre of the oscillation (when $x = 0$)	B1 **(2)**
		[9]

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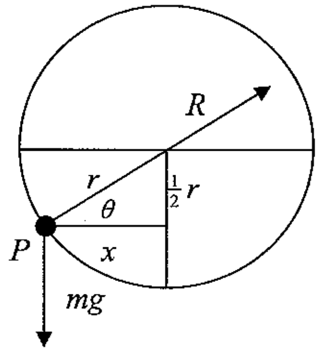
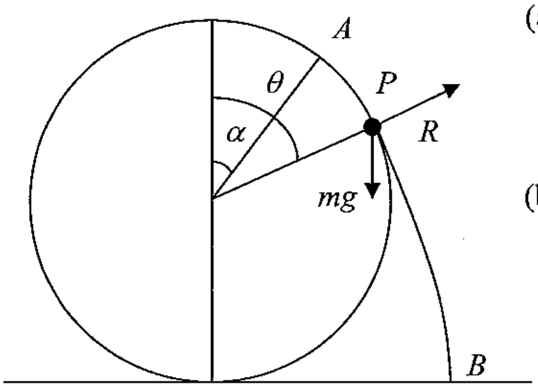
Question Number	Scheme	Marks	
4.	(a) $\sin\theta = \frac{\frac{1}{2}r}{r} = \frac{1}{2}$ $(\Rightarrow \theta = 30°)$	B1	
			
	$\uparrow$ $R\sin\theta = mg$	M1 A1	
	$R = 2mg$	A1	**(4)**
	(b) $\rightarrow$ $R\cos\theta = mx\omega^2$	M1 A1	
	$= m(r\cos\theta)\omega^2$	A1	
	$\omega = \left(\frac{2g}{r}\right)^{\frac{1}{2}}$	A1	
	$T = \frac{2\pi}{\omega} = 2\pi\left(\frac{r}{2g}\right)^{\frac{1}{2}}$ or exact equivalent	M1 A1	**(6)**
	Note: $x = \frac{\sqrt{3}}{2}r$		**[10]**

Question Number	Scheme	Marks
5.		
	(a) $\frac{1}{2}mv^2 = mg\left(\underline{a\cos\alpha - a\cos\theta}\right)$	M1 A1 $\underline{\text{A1}}$
	$v^2 = 2ga\left(\cos\alpha - \cos\theta\right)$ * cso	A1 **(4)**
	(b) [$mg\cos\theta\,(-R) = \frac{mv^2}{a}$ $(R=0)$	M1 A1=A1
	$g\cos\theta = 2g\left(\frac{3}{4} - \cos\theta\right)$	M1
	$\cos\theta = \frac{1}{2} \Rightarrow \theta = \frac{\pi}{3}$ (accept 60°)	A1 **(5)**
	(c) From A to B $\frac{1}{2}mw^2 = mg\left(\underline{a + a\cos\alpha}\right)$	M1 A1 $\underline{\text{A1}}$
	$w^2 = 2ga\left(1 + \frac{3}{4}\right) \Rightarrow w = \left(\frac{7ga}{2}\right)^{\frac{1}{2}}$	A1 **(4)**
		[13]
	Alternative solutions to 5(c) are considered on the next page.	

Question Number	Scheme	Marks
5.	*Alternatives to* 5(c)	
	From P to C	
	$v_P^2 = 2ga\left(\frac{3}{4}-\frac{1}{2}\right)=\frac{ga}{2}$	
	$\frac{1}{2}mw^2-\frac{1}{2}m\left(\frac{ga}{2}\right)=mg\left(\underline{a+a\cos\theta}\right)$	M1 A1 <u>A1</u>
	$w^2-\frac{ga}{2}=2mga\left(1+\frac{1}{2}\right) \Rightarrow w=\left(\frac{7ga}{2}\right)^{\frac{1}{2}}$	A1 **(4)**
	Alternatives using projectile motion from P	
	$v_P=\left(\frac{ga}{2}\right)^{\frac{1}{2}}$, as above	
	$\downarrow \quad u_y=\left(\frac{ga}{2}\right)^{\frac{1}{2}}\sin 60°=\left(\frac{3ga}{8}\right)^{\frac{1}{2}}$	
	$\downarrow \quad v_y^2=u_y^2+2g\times\frac{3a}{2},=\frac{27ga}{8}$	M1, A1
	$\rightarrow \quad u_x=\left(\frac{ga}{2}\right)^{\frac{1}{2}}\cos 60°=\left(\frac{ga}{8}\right)^{\frac{1}{2}}$	A1
	$w^2=u_x^2+v_y^2=\frac{ga}{8}+\frac{27ga}{8}=\frac{7ga}{2} \Rightarrow w=\left(\frac{7ga}{2}\right)^{\frac{1}{2}}$	A1 **(4)**
	There are also longer projectile methods using time of flight	
	In outline, solving $\frac{3a}{2}=\left(\frac{3ga}{8}\right)^{\frac{1}{2}}t+\frac{1}{2}gt^2$ gives $t=\left(\frac{3a}{2g}\right)^{\frac{1}{2}}$,	
	then, using $v=u+at$ gives $v_y=\left(\frac{3ga}{8}\right)^{\frac{1}{2}}+g\left(\frac{3a}{2g}\right)^{\frac{1}{2}}=\left(\frac{27ga}{8}\right)^{\frac{1}{2}}$, then as before.	M1 A1

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Question Number	Scheme	Marks
6.	(a) $a=3,\quad T=12\ \left(\text{or } \tfrac{1}{2}T=6\right)$	B1, B1
	$T=\dfrac{2\pi}{\omega}=12 \quad\Rightarrow\quad \omega=\dfrac{\pi}{6}$ (□ 0.52)	M1 A1
	In the scheme below, when a and/or ω appear in a line, accept the symbols or the candidates' values of a and/or ω for the marks in that line.	
	(Taking $x=a$ when $t=0$) $\quad x=a\cos\omega t$	M1
	$\dot{x}=-a\omega\sin\omega t$	M1 A1
	When $t=5$ $\quad \dot{x}=-3\times\dfrac{\pi}{6}\sin\dfrac{5\pi}{6}$	M1
	$\lvert\dot{x}\rvert=\dfrac{\pi}{4}\ \left(\text{m h}^{-1}\right)$ awrt 0.79	A1 **(9)**
	(b) Depth of 5.5 m $\Rightarrow x=-1.5$	
	$-1.5=a\cos\omega t$	M1
	$\cos\omega t=-\dfrac{1}{2}$	A1ft
	$\dfrac{\pi}{6}t=\dfrac{2\pi}{3},\ \left(\dfrac{4\pi}{3}\right)$	M1
	$t=4, 8$	A1
	Required time is $\quad t_2-t_1=8-4=4$ (h)	A1 **(5)**
		[14]
	In 6(b), the following should be accepted	
	$1.5=a\cos\omega t$	M1
	$\cos\omega t=\dfrac{1}{2}$	A1ft
	$\dfrac{\pi}{6}t=\dfrac{\pi}{3}$	M1
	$t=2$	A1
	Required time is $\quad 2t=4$ (h)	A1 **(5)**
	Further alternatives are given over the page.	

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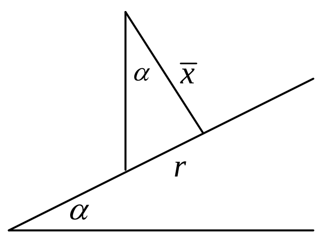
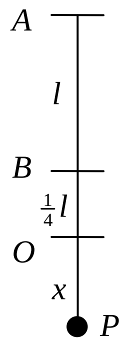
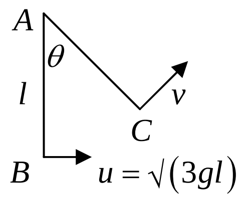
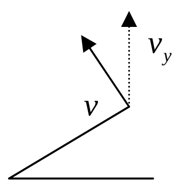
Question Number	Scheme	Marks
6.	*Alternative to* 6(a) The last 5 marks of 6(a) can be gained as follows. The first 4 marks are as above.	
	When $t=5$ $\quad x = 3\cos\frac{5\pi}{6} = -\frac{3\sqrt{3}}{2}$ $\quad (\square -2.60)$	M1
	$v^2 = \omega^2(a^2 - x^2)$	M1
	$= \frac{\pi^2}{6^2}\left(9 - \frac{9\times 3}{4}\right) \quad \left(= \frac{\pi^2}{16}\right)$	M1 A1
	$\lvert v \rvert = \frac{\pi}{4} \quad (\mathrm{m\,h^{-1}})$ $\quad$ awrt 0.79	A1
	Alternatives measuring x from the centre of oscillation	
	(a) (Using 1400 as $t = 0$) The first 4 marks are as above	B1 B1 M1 A1
	$x = a\sin\omega t$	M1
	$\dot{x} = a\omega\cos\omega t$	M1 A1
	When $t = 2$ $\quad \dot{x} = 3\times\frac{\pi}{6}\cos\frac{2\pi}{6}$ $\quad$ $t=2$ oe is essential for this M	M1
	$= \frac{\pi}{4} \quad (\mathrm{m\,h^{-1}})$	A1 **(9)**
	(b) $\quad 1.5 = 3\sin\omega t$	M1
	$\sin\omega t = \frac{1}{2}$	A1ft
	$\frac{\pi}{6}t = \frac{\pi}{6}, \left(\frac{5\pi}{6}\right)$	M1
	$t = 1, 5$	A1
	Required time is $\quad t_2 - t_1 = 5 - 1 = 4 \quad$ (h)	A1 **(5)** **[14]**

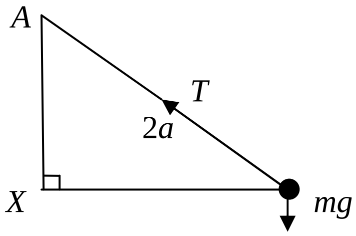
Question Number	Scheme	Marks
7.	(a) $\frac{1}{3}\ddot{x} = -\frac{k}{(x+1)^2}$	M1
	$\frac{1}{3}v\frac{dv}{dx} = -\frac{k}{(x+1)^2}$	M1
	$\int v\,dv = \int -\frac{3k}{(x+1)^2}\,dx$ Separating variables &	
	$\frac{1}{2}v^2 = \frac{3k}{x+1}$ $(+C)$ attempting integration of both sides	M1 A1=A1
	$v^2 = \frac{6k}{x+1} + A$	
	Using boundary values to obtain two simultaneous equations.	M1
	$(1, 4)$ $16 = 3k + A$	A1
	$(8, \sqrt{2})$ $2 = \frac{2k}{3} + A$	A1
	$14 = \frac{7}{3}k \Rightarrow k = 6$	M1 A1 **(10)**
	(b) $A = -2$	B1
	$v^2 = \frac{36}{x+1} - 2 = 0$	M1
	$x = 17$ (m)	M1 A1 **(4)**
		[14]

Question Number	Scheme	Marks
1.	(a) $\rightarrow \quad F = T\sin 60°$ $\quad \uparrow \quad T\cos 60° = 0.8g$ both	M1
	[or Z $\quad F\cos 60° = 0.8g\cos 30°$]	(M2)
	$F = 0.8g\tan 60° \approx 14$ (N) accept 13.6	M1 A1
		(3)
	(b) $T = \dfrac{0.8g}{\sin 30°}(=15.68)$ allow in (a)	M1
	HL $\quad 15.68 = \dfrac{24\times x}{1.2} \quad \Rightarrow \quad x \approx 0.78$ (cm) accept 0.784	M1 A1
		(3)
	(c) $E = \dfrac{24\times x^2}{2\times 1.2} \approx 6.1\,(\text{J})$ accept 6.15	M1 A1ft
		(2)
		Total 8 marks
2.	(a) $\dfrac{dv}{dt} = 2\sin\frac{1}{2}t \quad \Rightarrow \quad v = A - 4\cos\frac{1}{2}t$	M1 A1
	$v = 4, t = 0 \quad \Rightarrow \quad 4 = A - 4 \quad \Rightarrow \quad A = 8$	M1
	$v = 8 - 4\cos\frac{1}{2}t$	A1
		(4)
	(b) $\int_{\ldots}^{\ldots}\left(8 - 4\cos\frac{1}{2}t\right)dt = 8t - 8\sin\frac{1}{2}t$ ft constants	M1 A1ft
	$[\ldots]_0^{\pi/2} = 4\left(\pi - \sqrt{2}\right)$ awrt 6.9	M1 A1
		(4)
		Total 8 marks

Question Number	Scheme	Marks
3.	(a) N2L $ma = -\frac{cm}{x^2}$	B1
	$\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{2}v^2\right) = -\frac{c}{x^2} \Rightarrow \frac{1}{2}v^2 = A + \frac{c}{m}$ ignore A	M1 A1
	$v^2 = B + \frac{2c}{m}$	
	$x = R, v = U \Rightarrow B = U^2 - \frac{2c}{R}$	M1
	Leading to $v^2 = U^2 + 2c\left(\frac{1}{x} - \frac{1}{R}\right)$ ∗ cso	A1
		(5)
	(b) $\frac{1}{2}\left[\frac{1}{2}mU^2\right] = \frac{1}{2}m\left[U^2 + 2c\left(\frac{1}{2R} - \frac{1}{R}\right)\right]$	M1 A1
	Leading to $c = \frac{1}{2}RU^2$	A1
		(3)
		Total 8 marks
4.	(a) $5M\bar{x} = 3M \times \frac{h}{2} + 2M\left(h + \frac{3}{8}r\right)$	M1 A2(1,0)
	$5\bar{x} = \frac{3h}{2} + 2h + \frac{3}{4}r = \frac{7h}{2} + \frac{3}{4}r$	
	$\bar{x} = \frac{14h + 3r}{20}$ ∗ cso	M1 A1
		(5)
	(b) 	
	$\tan\alpha = \frac{20r}{14h + 3r} = \frac{4}{3}$	M1 A1
	Leading to $h = \frac{6}{7}r$	M1 A1
		(4)
		Total 9 marks

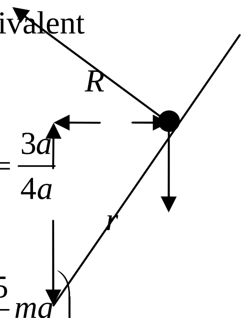
Question Number	Scheme	Marks
5.		
	(a) HL $T = mg = \frac{\lambda \times \frac{1}{4}l}{l} \Rightarrow \lambda = 4mg$	M1 A1
		(2)
	(b) N2L $mg - T = m\ddot{x}$	M1
	$mg - \frac{4mg\left(\frac{1}{4}l + x\right)}{l} = m\ddot{x}$	M1 A1
	$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\frac{4g}{l}x$ * cso	M1 A1
		(5)
	(c) $v^2 = \omega^2\left(a^2 - x^2\right) = \frac{4g}{l}\left(\frac{l^2}{4} - \frac{l^2}{16}\right)$	M1 A1
	Leading to $v = \frac{1}{2}\sqrt{(3gl)}$	M1 A1
		(4)
	or energy, $\frac{1}{2}\frac{4mg.gl^2/16}{l} = \frac{1}{2}mv^2 + mg.\frac{3l}{4}$ for the first M1 A1 in (c)	
	(d) *P* first moves freely under gravity, then (part) SHM.	B1 B1
		(2)
		Total 13 marks

Question Number	Scheme	Marks
6.	(a) 	
	Energy $\frac{1}{2}m\left(u^2-v^2\right)=mgl\left(1-\cos\theta\right)$	M1 A1
	$\left[v^2=gl+2gl\cos\theta\right]$	
	N2L $T-mg\cos\theta=\frac{mv^2}{l}$	M1 A1
	$=\frac{mgl\left(1+2\cos\theta\right)}{l}$	M1
	$T=mg\left(1+3\cos\theta\right)$ * cso	A1
		(6)
	(b) $T=0 \Rightarrow \cos\theta=-\frac{1}{3}$	B1
	$v^2=gl-\frac{2}{3}gl \Rightarrow v=\left(\frac{gl}{3}\right)^{\frac{1}{2}}$	M1 A1
		(3)
	(c) $\uparrow\ v_y=\left(\frac{gl}{3}\right)^{\frac{1}{2}}\sin\theta \quad \left[=\left(\frac{gl}{3}\right)^{\frac{1}{2}}.\frac{2\sqrt{2}}{3}\right]$	M1
	 $v^2=u^2-2gh \Rightarrow 2gh=\frac{gl}{3}.\frac{8}{9} \Rightarrow h=\frac{4l}{27}$	M1 A1
	$H=l\left(1-\cos\theta\right)+\frac{4l}{27}=\frac{40l}{27}$	M1 A1
		(5)
		Total 14 marks

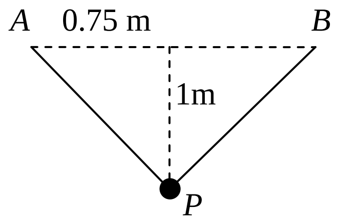
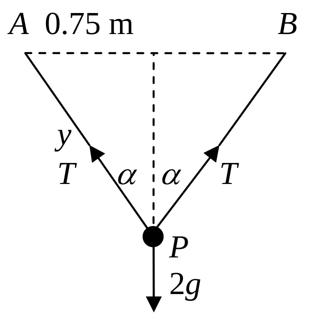
Question Number	Scheme	Marks
7.	(a) N2L $\leftarrow$ $T\cos 30° = m(2a\cos 30°)\left(\frac{kg}{3a}\right)$	M1 A1
	$T = \frac{2kmg}{3}$ ✱ cso	A1
		(3)
	(b) $\uparrow$ $R = mg - T\sin 30°$	M1 A1
	$= mg\left(1 - \frac{k}{3}\right)$	A1
		(3)
	(c) $(R$ □ $0)$ $\Rightarrow$ k □ 3 ignore $k > 0$, accept $k < 3$	M1 A1
		(2)
	(d) 	
	N2L $\leftarrow$ $T\cos\theta = m(2a\cos\theta)\left(\frac{2g}{a}\right)$	M1 A1
	$(T = 4mg)$	
	$\uparrow$ $T\sin\theta = mg$	M1
	Eliminating T	M1
	$AX = 2a\sin\theta = \frac{1}{2}a$	A1
	$AO = 2a\sin 30° = a$ $\Rightarrow$ $AX = \frac{1}{2}AO$, as required ✱ cso	B1, A1
		(7)
		Total 15 marks

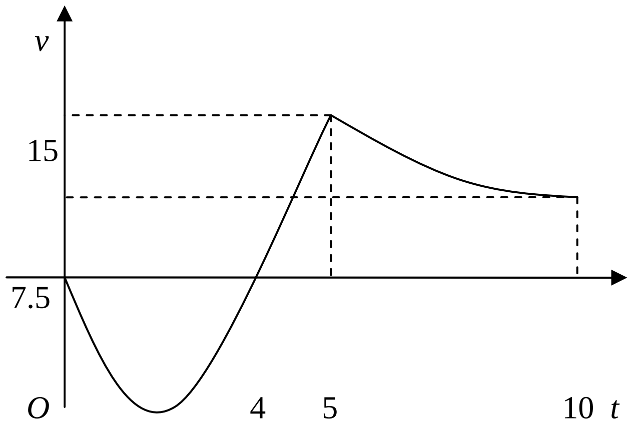
June 2006
6679 Mechanics M3
Mark Scheme

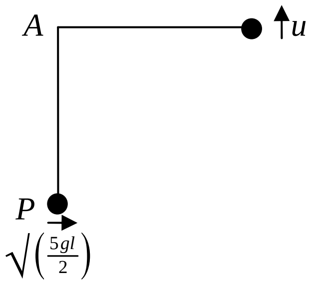
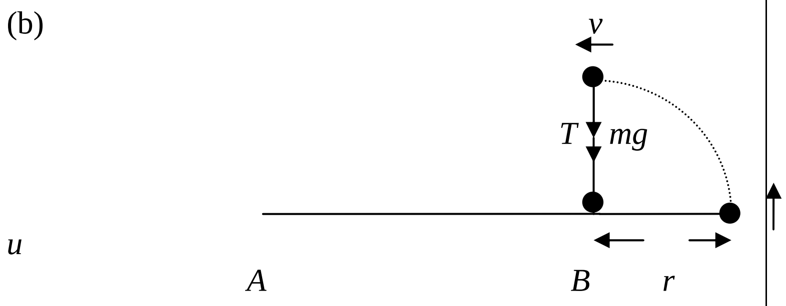
Question Number	Scheme	Marks
1.	Use of $(\pi)\int y^2\,dx \times \bar{x} = (\pi)\int xy^2\,dx$	M1
	$\int x\,dx \times \bar{x} = \int x^2\,dx$	
	$\left[\frac{1}{2}x^2\right]_{\ldots}^{\ldots} \times \bar{x} = \left[\frac{1}{3}x^3\right]_{\ldots}^{\ldots}$	A1 = A1
	Using limits 0 and 4 $\quad \frac{16}{2} \times \bar{x} = \frac{64}{3}$	M1
	$\bar{x} = \frac{8}{3}$	A1 **(5)**
		[5]
2.	(a) Small Hemisphere, Bowl, Large Hemisphere	
	Mass ratios: $\frac{2}{3}\pi\left(\frac{a}{2}\right)^3$, $\frac{2}{3}\pi\frac{7a^3}{8}$, $\frac{2}{3}\pi a^3$	B1
	Anything in the ratio 1 : 7 : 8	
	$\bar{x}$: $\frac{3}{16}a$, $\bar{x}$, $\frac{3}{8}a$	B1
	$1 \times \frac{3}{16}a + 7 \times \bar{x} = 8 \times \frac{3}{8}a$	M1 A1
	Leading to $\quad \bar{x} = \frac{45}{112}a$ * $\quad$ cso	A1 **(5)**
	(b) Bowl, Liquid, Bowl and Liquid	
	Mass Ratios: M, kM, $(k+1)M$	B1
	$\bar{x}$: $\frac{45}{112}a$, $\frac{3}{16}a$, $\frac{17}{48}a$	B1
	$M \times \frac{45}{112}a + kM \times \frac{3}{16}a = (k+1)M \times \frac{17}{48}a$	M1 A1
	Leading to $\quad k = \frac{2}{7}$	A1 **(5)**
		[10]

Question Number	Scheme	Marks
3.	(a) $a = 0.1$	B1
	$\frac{2\pi}{\omega} = \frac{1}{5} \quad \Rightarrow \quad \omega = 10\pi$	M1 A1
	$F_{\max} = ma\omega^2$	M1
	$= 0.2 \times 0.1 \times (10\pi)^2$	M1
	$\approx 19.7 \quad (\text{N})$ cao	A1 **(6)**
	(b) $a' = 0.2, \quad \omega' = 10\pi$	B1ft, B1ft
	$v^2 = \omega^2(a^2 - x^2) = 100\pi^2(0.2^2 - 0.1^2) \quad (= 3\pi^2 \approx 29.6\ ...)$	M1 A1
	$v \approx 5.44 \quad (\text{m s}^{-1})$ cao	A1 **(5)**
	If answers are given to more than 3 significant figures a maximum of one A mark is lost in the question.	**[11]**
4.	$\tan\alpha = \frac{3}{4}$ or equivalent	B1
		
	$\tan\alpha = \frac{r}{h}$ or $\frac{r}{h} = \frac{3a}{4a}$	B1
	$R(\uparrow) \quad R\sin\alpha = mg$ $\left(R = \frac{5}{3}mg\right)$	M1 A1
	$R(\leftarrow) \quad R\cos\alpha = mr\omega^2$	M1 A1
	$= mr \times \frac{8g}{9a} \quad \left(R = \frac{10mrg}{9a}\right)$	A1
	$\tan\alpha = \frac{9a}{8r} \quad \left(\frac{5}{3}mg = \frac{10mrg}{9a}\right)$ Eliminating R	M1 A1
	$\left(\frac{3}{4} = \frac{9a}{8r} \quad \Rightarrow \quad r = \frac{3}{2}a\right)$	
	$h = \frac{r}{\tan\alpha} = \frac{3a}{2} \times \frac{4}{3} = 2a$	M1 A1 **(11)**

		[11]

Question Number	Scheme	Marks
5.	(a) 	
	$AP = \sqrt{(0.75^2 + 1^2)} = 1.25$	M1 A1
	Conservation of energy $\frac{1}{2}\times 2\times v^2 + 2\times\frac{49\times 0.5^2}{2\times 0.75} = 2g\times 1$ −1 for each incorrect term	M1 A2 (1, 0)
	Leading to $v \approx 1.8 \quad (\text{m s}^{-1})$ accept 1.81	A1 **(6)**
	(b) 	
	$R(\uparrow) \quad 2T\cos\alpha = 2g$	M1 A1
	$y = \frac{0.75}{\sin\alpha}$	
	Hooke's Law $T = \frac{49}{0.75}\left(\frac{0.75}{\sin\alpha} - 0.75\right)$ $= 49\left(\frac{1}{\sin\alpha} - 1\right)$	M1 A1
	$\frac{9.8}{\cos\alpha} = 49\left(\frac{1}{\sin\alpha} - 1\right)$ Eliminating T	M1
	$\tan\alpha = 5(1 - \sin\alpha)$ $5 = \tan\alpha + 5\sin\alpha$ * cso	A1 **(6)**
		[12]

Question Number	Scheme	Marks
6.	(a)	
	Parabola 	B1
	Hyperbola	B1
	Points	B1 **(3)**
	(b) Identifying the minimum point of the parabola and 5 as the end points.	M1
	$2 < t < 5$	A1 **(2)**
	(c) Splitting the integral into two part, with limits 0 and 4, and 4 and 5, and evaluating both integrals.	M1
	$\int_0^4 3t(t-4)\,dt = \left[t^3 - 6t^2\right]_0^4 = -32$ and $\int_4^5 3t(t-4)\,dt = \left[t^3 - 6t^2\right]_4^5 = 7$ Both	A1
	Total distance $= 39$ (m) ∗ cso	A1 **(3)**
	(d) $\int_5^{t_1} \frac{75}{t}\,dt = 32 - 7$	M1 A1
	$75\left[\ln t\right]_5^{t_1} = 25$	A1
	$\ln\frac{t_1}{5} = \frac{1}{3} \Rightarrow t_1 = 5e^{\frac{1}{3}}$	M1
	≈ 6.98 cao	A1 **(5)**
		[13]

Question Number	Scheme	Marks
7.	(a)	
		
	Conservation of Energy	
	$\frac{1}{2}m\left(\frac{5gl}{2}-u^2\right)=mgl$	M1 A1= A1
	Leading to $u=\sqrt{\left(\frac{gl}{2}\right)}$	A1 **(4)**
	(b)	
		
	Conservation of Energy	
	$\frac{1}{2}m\left(u^2-v^2\right)=mgr$	M1 A1
	$v^2=u^2-2gr$	
	$R(\downarrow)$ $T+mg=\frac{mv^2}{r}$	M1 A1
	$T=\frac{m}{r}\left(u^2-2gr\right)-mg$	M1
	$=\frac{mu^2}{r}-3mg$	A1
	$=\frac{mgl}{2r}-3mg$	M1
	$T\geq 0\Rightarrow\frac{mgl}{2r}\geq 3mg$	M1
	$\Rightarrow\frac{1}{6}\geq r$	
	$AB_{\text{MIN}}=\frac{5l}{6}$	A1 **(9)**
		[13]

Mark Scheme (Results)

January 2007

GCE

GCE Mathematics

Mechanics M3 (6679)

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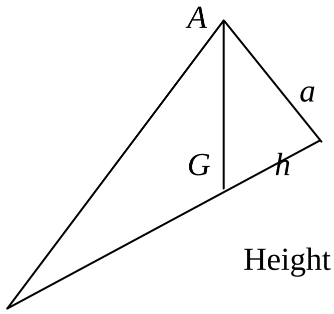
January 2007
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
1.	(a) Maximum speed when accel. = 0 (o.e.)	B1 (1)
	(b) $\frac{1}{12}(30 - x) = v\frac{dv}{dx}$ (acceln = … + attempt to integrate)	M1 ↓
	Use of $v\frac{dv}{dx}$: $\frac{v^2}{2} = \frac{1}{12}\left(30x - \frac{x^2}{2}\right)$ $(+c)$	M1 A1 ↓
	Substituting $x = 30$, $v = 10$ and finding c (= 12.5), or limits	M1
	$\underline{v^2 = 25 + 5x - \frac{1}{12}x^2}$ (o.e.)	A1 (5)
	(a) Allow "acceln > 0 for $x < 30$, acceln < 0 for $x > 30$" Also "accelerating for $x < 30$, decelerating for $x > 30$" But "acceln < 0 for $x > 30$" only is B0	
	(b) 1st M1 will be generous for wrong form of acceln (e.g. dv/dx)! 3rd M1 If use limits, they must use them in correct way with correct values Final A1. Have to accept any expression, but it must be for v^2 explicitly (not $1/2v^2$), and if in separate terms, one can expect like terms to be collected. Hence answer in form as above, or e.g. $\frac{1}{12}\left(300 + 60x - x^2\right)$; also $100 - \frac{1}{12}(30 - x)^2$	

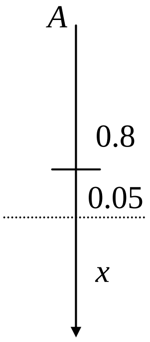
2.	 Height of cone = $\dfrac{a}{\tan\alpha} = 3a$ Hence $h = \frac{3}{4}a$ $\tan\theta = \dfrac{a}{\frac{3}{4}a} = \dfrac{4}{3} \Rightarrow \theta = 53.1°$ 1st M1 (generous) allow any trig ratio to get height of cone (e.g. using sin) 3rd M1 For correct trig ratio on a suitable triangle to get θ or complement (even if they call the angle by another name – hence if they are aware or not that they are getting the required angle)	M1 A1 ↓ M1 ↓ M1 A1 (5)

3.	(a) E.P.E. $= \frac{1}{2}\frac{3.6mg}{a}x^2 = \frac{1}{2}\frac{3.6mg}{a}\left(\frac{a}{3}\right)^2$ $= \underline{0.2\ mga}$	M1 A1 A1 (3)
	(b) Friction = $\mu mg \Rightarrow$ work done by friction = $\mu mg\left(\frac{4a}{3}\right)$ Work-energy: $\frac{1}{2}m.2ga = \mu mgd + 0.2\ mga$ (3 relevant terms) Solving to find μ: $\underline{\mu = 0.6}$ (b) 1st M1: allow for attempt to find work done by frictional force (i.e. not just finding friction). 2nd M1: "relevant" terms, i.e. energy or work terms! A1 f.t. on their work done by friction	M1 A1 M1 A1√ ↓ M1 A1 (6)

4.	(a) Energy: $\frac{1}{2}m.3ag - \frac{1}{2}mv^2 = mga(1+\cos\theta)$	M1 A1
	$\underline{v^2 = ag(1-2\cos\theta)}$ **(o.e.)**	A1 (3)
	(b) $T + mg\cos\theta = m\dfrac{v^2}{a}$	M1 A1
	Hence $\underline{T = (1-3\cos\theta)mg}$ (*)	A1 cso (3)
	(c) Using $T = 0$ to find $\cos\theta$	M1
	Hence height above A = $\underline{\frac{4}{3}a}$ Accept 1.33a (but must have 3+ s.f.)	A1 (2)
	(d) $v^2 = \frac{1}{3}ag$ **(o.e.)** f.t. using $\cos\theta = \frac{1}{3}$ in v^2	B1√
	consider vert motion: $(v\sin\theta)^2 = 2gh$ (with v resolved)	M1 A1 ↓
	$\sin^2\theta = \frac{8}{9}$ (or θ = 70.53, sin θ = 0.943) and solve for h (as ka)	M1
	h = $\underline{\frac{4}{27}a}$ or 0.148a (awrt)	A1
	OR consider energy: $\frac{1}{2}m(v\cos\theta)^2 + mgh = \frac{1}{2}mv^2$ (3 non-zero terms)	M1 A1 ↓
	Sub for v, θ and solve for h	M1
	h = $\underline{\frac{4}{27}a}$ or 0.148a (awrt)	A1

Question Number	Scheme	Marks
5.	(a) $\updownarrow\ T\cos\theta = mg$	B1
	$\leftrightarrow\ T + T\sin\theta = mr\omega^2$ (3 terms)	M1 A1
	$r = h\tan\theta$	B1
	$\dfrac{mg}{\cos\theta}(1+\sin\theta) = \dfrac{m\omega^2 h\sin\theta}{\cos\theta}$ (eliminate *r*)	↓ M1
	$\underline{\omega^2 = \dfrac{g}{h}\left(\dfrac{1+\sin\theta}{\sin\theta}\right)}$ (*) (solve for ω^2)	↓ M1 A1 (7)
	(b) $\omega^2 = \dfrac{g}{h}\left(\dfrac{1}{\sin\theta}+1\right) > \dfrac{2g}{h}\ (\sin\theta < 1) \Rightarrow \omega > \sqrt{\dfrac{2g}{h}}$ (*)	M1 A1 (2)
	(c) $\dfrac{3g}{h} = \dfrac{g}{h}\left(\dfrac{1+\sin\theta}{\sin\theta}\right) \Rightarrow \sin\theta = \tfrac{1}{2}$	M1 A1
	$T\cos\theta = mg \Rightarrow \underline{T = \dfrac{2\sqrt{3}}{3}mg}$ or $\underline{1.15mg}$ (awrt)	↓ M1 A1 (4)
	(a) Allow first B1 M1 A1 if assume different tensions (so next M1 is effectively for eliminating *r* **and** *T*. (b) M1 requires a *valid* attempt to derive an *in*equality for ω. (Hence putting sin θ = 1 immediately into expression of ω^2 [assuming this is the critical value] is M0.)	

6.	(a) Moments: $\pi \int_1^2 xy^2 \mathrm{d}x = V\bar{x}$ or $\int_1^2 xy^2 \mathrm{d}x = \bar{x}\int_1^2 y^2 \mathrm{d}x$	M1
	$\int_1^2 y^2 \,\mathrm{d}x = \int_1^2 \frac{1}{4x^4}\mathrm{d}x = \left[-\frac{1}{12x^3}\right]_1^2 \quad (= \frac{7}{96})$ (either)	M1 A1
	$\int_1^2 xy^2 \,\mathrm{d}x = \int_1^2 \frac{1}{4x^3}\mathrm{d}x = \left[-\frac{1}{8x^2}\right]_1^2 \quad (= \frac{3}{32})$ (both)	A1
	Solving to find $\bar{x}$ $(= \frac{9}{7})$ $\Rightarrow$ required dist $= \frac{9}{7} - 1 = \frac{2}{7}$ m (*)	↓ M1 A1 cso (6)
	(b) H, S, T Mass: H: $(\rho)\frac{2}{3}\pi\left(\frac{1}{2}\right)^3$ $\left[= \frac{1}{12}(\rho)\pi\right]$, S: $(\rho)\frac{7\pi}{96}$, T: $H + S$ $\left[= \frac{5}{32}(\rho)\pi\right]$	B1, M1
	Dist of CM from base: H: $\frac{19}{16}$ m, S: $\frac{5}{7}$ m, T: $\bar{x}$	B1 B1
	Moments: $\left[= \frac{1}{12}(\rho)\pi\right]\left(\frac{19}{16}\right) + (\rho)\frac{7\pi}{96}\left(\frac{5}{7}\right) = \left[\frac{5}{32}(\rho)\pi\right]\bar{x}$	M1 A1
	$\bar{x} = \frac{29}{30}$ m or 0.967 m (awrt)	A1 (7)
	Allow distances to be found from different base line if necessary	

7.	(a)  $T = \dfrac{\lambda}{0.8}(0.05) = 0.25g$	M1
	$\lambda = \dfrac{(0.8)(0.25g)}{0.05} = 39.2$ (*)	A1 (2)
	(b) $T = \dfrac{39.2}{0.8}(x + 0.05)$	M1
	$mg - T = ma$ (3 term equn)	M1
	$0.25g - \dfrac{39.2}{0.8}(x + 0.05) = 0.25\ddot{x}$ (or equivalent)	A1
	$\ddot{x} = -196x$	A1
	SHM with period $\dfrac{2\pi}{\omega} = \dfrac{2\pi}{14} = \dfrac{\pi}{7}$ s (*)	↓ M1 A1 cso (6)
	(c) $v = 14\sqrt{\{(0.1)^2 - (0.05)^2\}}$	M1 A1√
	$= 1.21(24\ldots) \approx$ <u>1.21 m s^{-1}</u> (3 s.f.) Accept $7\sqrt{3}/10$	A1 (3)
	(d) Time T under gravity $= \dfrac{1.21..}{g}$ $(= 0.1237s)$	B1√
	Complete method for time T' from B to slack. [↑ e.g. $\dfrac{\pi}{28} + t$, where $0.05 = 0.1\sin 14t$ OR T', where $-0.05 = 0.1\cos 14T'$]	M1 A1
	$T'' = 0.1496$s	A1
	Total time = $T + T'$ = <u>0.273 s</u>	A1 (5)
	(b) 1st M1 must have extn as $x + k$ with $k \neq 0$ (but allow M1 if e.g. $x + 0.15$), or must justify later For last four marks, *must* be using $\ddot{x}$ (not a) (c) Using $x = 0$ is M0 (d) M1 – must be using distance for when string goes slack. Using $x = -0.1$ (i.e. assumed end of the oscillation) is M0	

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Mark Scheme (Results)

Summer 2007

GCE

GCE Mathematics

Mechanics M3 (6679)

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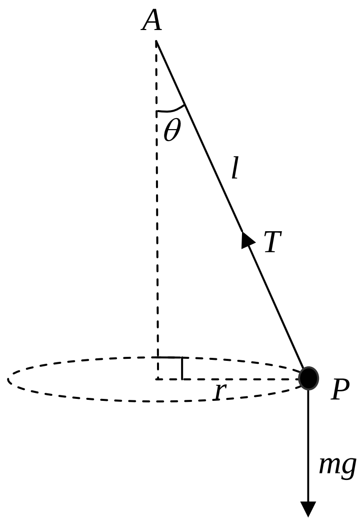
June 2007
6679 Mechanics M3
Mark Scheme

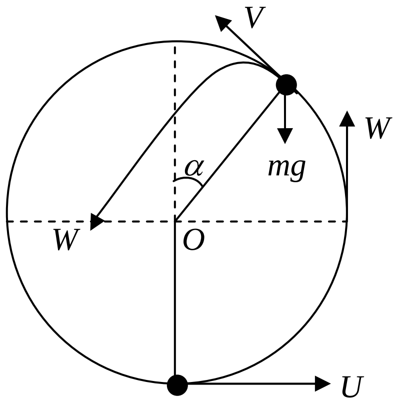
Question Number	Scheme	Marks
1.	(a) $A = \int_0^2 \left(2x - x^2\right) \mathrm{d}x$	M1 A1
	$= \left[x^2 - \frac{x^3}{3}\right]_{\dots}^{\dots}$	A1
	$A = \left[x^2 - \frac{x^3}{3}\right]_0^2 = 4 - \frac{8}{3} = \frac{4}{3}$ * cso	A1 **(4)**
	(b) $\bar{x} = 1$ (by symmetry)	B1
	$\frac{4}{3}\bar{y} = \frac{1}{2}\int y^2 \,\mathrm{d}x = \frac{1}{2}\int \left(2x - x^2\right)^2 \mathrm{d}x$	M1
	$= \frac{1}{2}\int \left(4x^2 - 4x^3 + x^4\right) \mathrm{d}x$	A1
	$= \frac{1}{2}\left[\frac{4x^3}{3} - x^4 + \frac{x^5}{5}\right]$	A1
	$\frac{4}{3}\bar{y} = \frac{1}{2}\left[\frac{4x^3}{3} - x^4 + \frac{x^5}{5}\right]_0^2 = \frac{8}{15}$	
	$\bar{y} = \frac{8}{15} \times \frac{3}{4} = \frac{2}{5}$ accept exact equivalents	A1 **(5)**
		[9]

Question Number	Scheme	Marks
2.	(a) Base, Cylinder, Container Mass ratios: πh^2, $2\pi h^2$, $3\pi h^2$ — Ratio of 1 : 2 : 3	B1
	$\bar{y}$: 0, $\frac{h}{2}$, $\bar{y}$	B1
	$3\pi h^2 \times \bar{y} = 2\pi h^2 \times \frac{h}{2}$	M1 A1
	Leading to $\bar{y} = \frac{1}{3}h$ * — cso	A1 **(5)**
	(b) Liquid, Container, Total Mass ratios: M, M, $2M$ — Ratio of 1 : 1 : 2	B1
	$\bar{y}$: $\frac{h}{2}$, $\frac{h}{3}$, $\bar{y}$	B1
	$2M \times \bar{y} = M \times \frac{h}{2} + M \times \frac{h}{3}$	M1 A1
	$\bar{y} = \frac{5}{12}h$	A1 **(5)**
		[10]

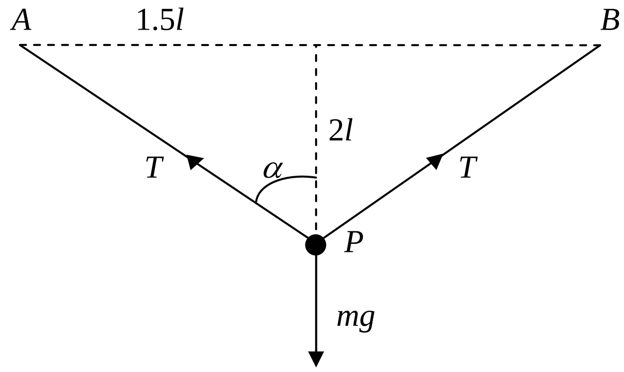
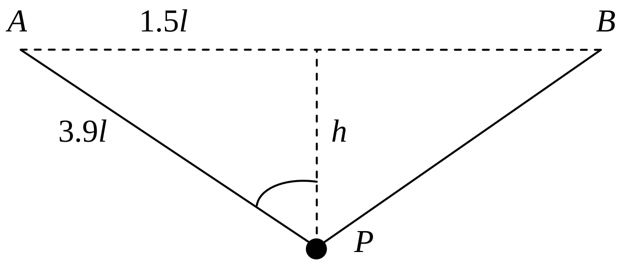
Question Number	Scheme	Marks
3.	(a) At surface	
	$\frac{k}{R^2} = mg \quad \Rightarrow \quad k = mgR^2$ * cso	M1 A1 **(2)**
	(b) N2L $\quad m\ddot{x} = -\frac{mgR^2}{x^2}$	
	$v\frac{\mathrm{d}v}{\mathrm{d}x} = -\frac{gR^2}{x^2}$ or $\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{2}v^2\right) = -\frac{gR^2}{x^2}$	M1
	$\int v\,\mathrm{d}v = -gR^2\int\frac{1}{x^2}\mathrm{d}x$ or $\frac{1}{2}v^2 = -gR^2\int\frac{1}{x^2}\mathrm{d}x$	M1
	$\frac{1}{2}v^2 = \frac{gR^2}{x}\ (+C)$	A1
	$x = 2R, v = 0 \quad \Rightarrow \quad C = -\frac{gR}{2}$	M1 A1
	$v^2 = \frac{2gR^2}{x} - gR$	
	At $x = R$, $\quad v^2 = \frac{2gR^2}{R} - gR$	M1
	$v = \sqrt{(gR)}$	A1 **(7)**
		[9]

Question Number	Scheme		Marks
4.			
	↑ $T\cos\theta = mg$		M1 A1
	← $T\sin\theta = \frac{mv^2}{r}$		M1 A1
	$\tan\theta = \frac{r}{\sqrt{(l^2 - r^2)}}$	or equivalent	M1 A1
	$\tan\theta = \frac{v^2}{rg}$	Eliminating T	M1
	$\frac{r}{\sqrt{(l^2 - r^2)}} = \frac{v^2}{rg}$	Eliminating θ	M1
	$gr^2 = v^2\sqrt{(l^2 - r^2)}$ ✱	cso	A1 **(9)**
			[9]

Question Number	Scheme	Marks
5.	(a) $\ddot{x} = -\omega^2 x \quad \Rightarrow \quad 1 = \omega^2 \times 0.04 \quad (\Rightarrow \quad \omega = 5)$	M1 A1
	$T = \dfrac{2\pi}{5}$ awrt 1.3	A1 **(3)**
	(b) $v^2 = \omega^2\left(a^2 - x^2\right) \quad \Rightarrow \quad 0.2^2 = 5^2\left(a^2 - 0.04^2\right)$ ft their ω	M1 A1ft
	$a = \dfrac{\sqrt{2}}{25}$ accept exact equivalents or awrt 0.057	A1 **(3)**
	(c) Using $x = a\cos\omega t$	
	$\dfrac{1}{2}a = a\cos\omega t$ ft their ω	M1 A1ft
	$5t = \dfrac{\pi}{3}$	
	$t = \dfrac{\pi}{15}$	A1
	$T' = 4t = \dfrac{4\pi}{15}$ awrt 0.84	M1 A1 **(5)**
		[11]
	Alternative to (c)	
	Using $x = a\sin\omega t$	
	$\dfrac{1}{2}a = a\sin\omega t$ ft their ω	M1 A1ft
	$5t = \dfrac{\pi}{6}$	
	$t = \dfrac{\pi}{30}$	A1
	$T' = T - 4t = \dfrac{4\pi}{15}$ awrt 0.84	M1 A1 **(5)**

Question Number	Scheme	Marks
6.		
	(a) Energy $\frac{1}{2}m\left(U^2 - v^2\right) = mga\left(1+\cos\alpha\right)$	M1 A1=A1
	$\left(T+\right)\ mg\cos\alpha = \frac{mv^2}{a}$	M1 A1
	Leaves circle when $T = 0$	
	$g\cos\alpha = \frac{U^2 - 2ga - 2ga\cos\alpha}{a}$ Eliminating v	M1
	Leading to $U^2 = ag\left(2+3\cos\alpha\right)$ ✱ cso	A1 **(7)**
	(b) Using conservation of energy from the lowest point of the surface	
	$\frac{1}{2}m\left(U^2 - W^2\right) = mga$	M1 A1=A1
	$W^2 = U^2 - 2ag$	
	Using $\cos\alpha = \frac{1}{\sqrt{3}}$, $W^2 = ag\left(2+\frac{3}{\sqrt{3}}\right) - 2ag$	M1
	$= ag\sqrt{3}$ ✱ cso	A1 **(5)**
		[12]
	Alternatives for (b) *are given on the next page.*	

Question Number	Scheme	Marks
6.	*Alternative to part* (b) *using conservation of energy from the point where P loses contact with surface.*	
	$\left(V^2 = ag\cos\alpha = \dfrac{ga}{\sqrt{3}}\right)$	
	Energy $\quad \dfrac{1}{2}m\left(W^2 - V^2\right) = mga\cos\alpha$	M1 A1
	$\dfrac{1}{2}m\left(W^2 - \dfrac{1}{\sqrt{3}}ag\right) = mga \times \dfrac{1}{\sqrt{3}}$	A1
	Leading to $\quad W^2 = ag\sqrt{3}$ ∗ $\quad$ cso	M1 A1 **(5)**
	Alternative to part (b) *using projectile motion from the point where P loses contact with surface.*	
	$V^2 = ag\cos\alpha = \dfrac{ga}{\sqrt{3}}$	
	↓ $\quad W_y^2 = V^2\sin^2\alpha + 2ga\cos\alpha$	
	$= \dfrac{1}{\sqrt{3}}ag\left(1 - \dfrac{1}{3}\right) + 2ga \times \dfrac{1}{\sqrt{3}} = \dfrac{8\sqrt{3}}{9}ag$	M1 A1
	← $\quad V_x = V\cos\alpha$	A1
	$W^2 = W_y^2 + V_x^2 = \dfrac{8\sqrt{3}}{9}ag + \dfrac{1}{3}ag\sqrt{3} \times \dfrac{1}{3} = ag\sqrt{3}$ ∗ $\quad$ cso	M1 A1 **(5)**

Question Number	Scheme		Marks	
7.	(a) 			
	$AP = \sqrt{\left((1.5l)^2 + (2l)^2\right)} = 2.5l$		M1 A1	
	$\cos\alpha = \frac{4}{5}$		B1	
	Hooke's Law $T = \frac{\lambda(2.5l - 1.5l)}{1.5l} \left(= \frac{2\lambda}{3}\right)$		M1 A1	
	$\uparrow$ $2T\cos\alpha = mg$ $\left(T = \frac{5mg}{8}\right)$		M1 A1	
	$2 \times \frac{2\lambda}{3} \times \frac{4}{5} = mg$ $\left(\frac{2\lambda}{3} = \frac{5mg}{8}\right)$		M1	
	$\lambda = \frac{15mg}{16}$ *	cso	A1	**(9)**
	(b) 			
	$h = \sqrt{\left((3.9l)^2 - (1.5l)^2\right)} = 3.6l$		M1 A1	
	Energy $\frac{1}{2}mv^2 + mg \times h = 2 \times \frac{15mg}{16} \times \frac{(2.4l)^2}{2 \times 1.5l}$	ft their h	M1 A1ft = A1	
	Leading to $v = 0$ *	cso	A1	**(6)** **[15]**

Mark Scheme (Results)

January 2008

GCE

GCE Mathematics (6679/01)

Edexcel Limited. Registered in England and Wales No. 4496750
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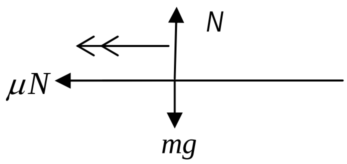
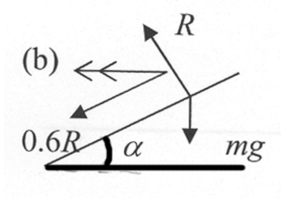
January 2008
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
1.(a)	T or $\frac{\lambda \times e}{l} = mg$ (even T=m is M1, A0, A0 sp case)	M1
	$\frac{\lambda \times 0.16}{0.4} = 2g$	A1
	$\Rightarrow \lambda = \underline{49\text{ N}}$ or 5g	A1 (3)
(b)	Special case $T\sin\theta = mg$ giving θ = 30 is M1 A0 A0 unless there is evidence that they think θ is with horizontal – then M1 A1 A0	
	R(↑) $T\cos\theta = mg$ or $\cos\theta = \frac{mg}{T}$	M1
	$49.\frac{0.32}{0.4}.\cos\theta = 19.6$ or $4g.\cos\theta = 2g$ or $2mg.\cos\theta = mg$ (ft on their λ)	A1ft
	$\Rightarrow \cos\theta = \frac{1}{2} \Rightarrow \theta = 60°$ (or $\frac{\pi}{3}$ radians)	A1 (3)
		6
2.	m ‘a’ = $\pm\frac{16}{5x^2}$, with acceleration in any form (e.g. $\frac{d^2x}{dt^2}$, $v\frac{dv}{dx}$, $\frac{dv}{dt}$ or a)	B1
	Uses $a = v\frac{dv}{dx}$ to obtain $kv\frac{dv}{dx} = \pm k'\frac{32}{x^2}$	M1
	Separates variables, $k\int v\,dv = k'\int \frac{32}{x^2}dx$	dM1
	Obtains $\frac{1}{2}v^2 = \mp\frac{32}{x}$ (+ C) or equivalent e.g. $\frac{0.1}{2}v^2 = -\frac{16}{5x}$ (+ C)	A1
	Substituting x = 2 if + used earlier or – 2 if – used in d.e. $x = 2$, $v = \pm 8 \Rightarrow 32 = -16 + C \Rightarrow C = 48$ (or value appropriate to their correct equation)	M1 A1
	$v = 0 \Rightarrow \frac{32}{x} = 48 \Rightarrow x = \frac{2}{3}$ m (N.B. $-\frac{2}{3}$ is not acceptable for final answer)	M1 A1 cao
		8
	N.B $\frac{d}{dx}(\frac{1}{2}mv^2) = \frac{16}{5x^2}$, is also a valid approach. Last two method marks are independent of earlier marks and of each other	

Question Number	Scheme	Marks
3.(a)		
	Large cone small cone S	
	Vol. $\frac{1}{3}\pi(2r)^2(2h)$ $\frac{1}{3}\pi r^2 h$ $\frac{7}{3}\pi r^2 h$ (accept ratios 8 : 1 : 7)	B1
	C of M $\frac{1}{2}h$, $\frac{5}{4}h$ $\bar{x}$ (or equivalent)	B1, B1
	$\frac{8}{3}\pi r^2 h.\frac{1}{2}h - \frac{1}{3}\pi r^2 h.\frac{5}{4}h = \frac{7}{3}\pi r^2 h.\bar{x}$ or equivalent	M1
	$\rightarrow \bar{x} = \frac{11}{28}h$ *	A1 (5)
(b)	$\tan\theta = \frac{2r}{\bar{x}} = \frac{2r}{\frac{11}{28}h}, = \frac{2r}{\frac{11}{14}r} = \frac{28}{11}$	M1, A1
	$\theta \approx 68.6°$ or 1.20 radians	A1 (3) **8**
	(Special case – obtains complement by using $\tan\theta = \frac{2r}{\bar{x}}$ giving 21.4° or .374 radians M1A0A0)	
	Centres of mass may be measured from another point (e.g. centre of small circle, or vertex) The Method mark will then require a complete method (Moments and subtraction) to give required value for $\bar{x}$). However B marks can be awarded for correct values if the candidate makes the working clear.	

4. (a)	Energy equation with at least three terms, including K.E term $\frac{1}{2}mV^2 + ..$ $+ .. \frac{1}{2}.\frac{2mg}{a}.\frac{a^2}{16}, + mg.\frac{1}{2}a.\sin 30, = \frac{1}{2}.\frac{2mg}{a}.\frac{9a^2}{16}$ $\Rightarrow V = \sqrt{\frac{ga}{2}}$	M1 A1, A1, A1 dM1 A1 (6)
(b)	Using point where velocity is zero and point where string becomes slack: $\frac{1}{2}mw^2 =$ $\frac{1}{2}.\frac{2mg}{a}.\frac{9a^2}{16}, -mg.\frac{3a}{4}.\sin 30$ $\Rightarrow w = \sqrt{\frac{3ag}{8}}$ Alternative (using point of projection and point where string becomes slack): $\frac{1}{2}mw^2 - \frac{1}{2}mV_1^2, = \frac{mga}{16} - \frac{mga}{8}$ So $w = \sqrt{\frac{3ag}{8}}$	M1 A1, A1 A1 (4) M1,A1 A1 A1 **10**
	In part (a) DM1 requires EE, PE and KE to have been included in the energy equation. If sign errors lead to $V^2 = -\frac{ga}{2}$, the last two marks are M0 A0 In parts (a) and (b) A marks need to have the correct signs In part (b) for M1 need **one** KE term in energy equation of at least **3 terms** with distance $\frac{3a}{4}$ to indicate first method, and **two** KE terms in energy equation of at least **4 terms** with distance $\frac{a}{4}$ to indicate second method. SHM approach in part (b). (**Condone this method only if SHM is proved**) Using $v^2 = \omega^2(a^2 - x^2)$ with $\omega^2 = \frac{2g}{a}$ and $x = \pm\frac{a}{4}$. Using 'a' = $\frac{a}{2}$ to give $w = \sqrt{\frac{3ag}{8}}$.	M1 A1 A1 A1

5.(a)	 $\frac{mv^2}{r} = \mu N, = \mu mg$	M1, A1
	$\mu = \frac{v^2}{rg} = \frac{21^2}{75 \times 9.8} = 0.6$ *	A1 (3)
(b)	 R(↑) $R\cos\alpha, \mp 0.6R\sin\alpha = mg$	M1, A1, A1
	$\Rightarrow R\left(\frac{4}{5} - \frac{3}{5}.\frac{3}{5}\right) = mg \Rightarrow R = \frac{25mg}{11}$	A1 (4)
(c)	R(←) $R\sin\alpha, \pm 0.6R\cos\alpha = \frac{mv^2}{r}$	M1, A1, A1
	$v \approx$ 32.5 m s^{-1}	dM1 A1cao (5) **12**
	In part (b) M1 needs three terms of which one is mg If cos α and sin α are interchanged in equation this is awarded M1 A0 A1 In part (c) M1 needs three terms of which one is $\frac{mv^2}{r}$ or $mr\omega^2$ If cos α and sin α are interchanged in equation this is also awarded M1 A0 A1	
	If they resolve along the plane and perpendicular to the plane in part (b), then attempt at $R - mg\cos\alpha = \frac{mv^2}{r}\sin\alpha$, and $0.6R + mg\sin\alpha = \frac{mv^2}{r}\cos\alpha$ and attempt to eliminate v	M1
	Two correct equations	A1
	Correct work to solve simultaneous equations	A1
	Answer	A1 (4)
	In part (c) Substitute R into one of the equations	M1
	Substitutes into a correct equation (earning accuracy marks in part (b))	A1
	Uses $R = \frac{25mg}{11}$ (or $\frac{25mg}{29}$)	A1
	Obtain v = 32.5	M1A1 (5)

6.(a)	Energy equation with two terms on RHS, $\frac{1}{2}mv^2 = \frac{1}{2}m.\frac{5ga}{2} + mga\sin\theta$	M1, A1
	$\Rightarrow v^2 = \frac{ga}{2}(5+4\sin\theta)$ *	A1 cso (3)
(b)	R(\\ string) $T - mg\sin\theta = \frac{mv^2}{a}$ (3 terms)	M1 A1
	$\Rightarrow T = \frac{mg}{2}(5+6\sin\theta)$ o.e.	A1 (3)
(c)	$T = 0 \Rightarrow \sin\theta, = -\frac{5}{6}$	M1, A1
	Has a solution, so string slack when $\alpha \approx 236(.4)°$ or 4.13 radians	A1 (3)
(d)	At top of small circle, $\frac{1}{2}mv^2 = \frac{1}{2}m.\frac{5ga}{2} - \frac{mga}{2}$ (M1 for energy equation with 3 terms)	M1 A1
	$\Rightarrow v^2 = \frac{3}{2}ga = 14.7a$	A1
	Resolving and using Force = $\frac{mv^2}{r}$, $T + mg = m.\frac{\frac{3}{2}ga}{\frac{1}{2}a}$ (M1 needs three terms, but any v)	M1 A1
	$\Rightarrow T = 2mg$	A1 (6)
		15
	Use of $v^2 = u^2 + 2gh$ is M0 in part (a)	

7.(a)	(Measuring x from E) $2\ddot{x} = 2g - 98(x + 0.2)$, and so $\ddot{x} = -49x$ SHM period with $\omega^2 = 49$ so $T = \frac{2\pi}{7}$	M1 A1, A1 d M1 A1cso (5)
(b)	Max. acceleration = 49 × max. x = 49 x 0.4 = 19.6 m s^{-2}	B1 (1)
(c)	String slack when x = –0.2: $v^2 = 49(0.4^2 - 0.2^2)$ $\Rightarrow v \approx 2.42$ m s^{-1} $= \frac{7\sqrt{3}}{5}$	M1 A1 A1 (3)
(d)	Uses $x = a\cos\omega t$ or use $x = a\sin\omega t$ but not with x = 0 or $\pm a$ Attempt complete method for finding time when string goes slack –0.2 = 0.4 cos 7t $\Rightarrow$ cos 7t $= -\frac{1}{2}$ $t = \frac{2\pi}{21} \approx 0.299$ s Time when string is slack $= \frac{(2)\times 2.42}{g} = \frac{2\sqrt{3}}{7} \approx 0.495\,\text{s}$ (2 needed for A) Total time = 2 x 0.299 + 0.495 ≈ 1.09 s	M1 dM1 A1 A1 M1 A1ft A1 (7) **16**
(a) (b) (c) (d)	DM1 requires the minus sign. Special case $2\ddot{x} = 2g - 98x$ is M1A1A0M0A0 $2\ddot{x} = -98x$ is M0A0A0M0A0 No use of $\ddot{x}$, just a is M1 A0,A0 then M1 A0 if otherwise correct. Quoted results are not acceptable. Answer must be positive and evaluated for B1 M1 – Use correct formula with their ω, a and x but **not** x = 0. A1 Correct values but allow x = +0.2 **Alternative** It is possible to use energy instead to do this part $\frac{1}{2}mv^2 + mg \times 0.6 = \frac{\lambda \times 0.6^2}{2l}$ M1 A1 If they use $x = a\sin\omega t$ with $x = \pm 0.2$ and add $\frac{\pi}{7}$ or $\frac{\pi}{14}$ this is dM1, A1 if done correctly If they use $x = a\cos\omega t$ with x = -0.2 this is dM1, then A1 (as in scheme) If they use $x = a\cos\omega t$ with x = +0.2 this needs *their* $\frac{\pi}{7}$ minus answer to reach dM1, then A1	

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Mechanics 3 M3 (6679

June 2008

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Mark Scheme (Final)

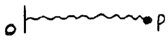
Edexcel GCE

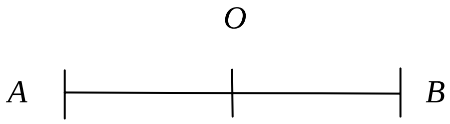
Mathematics

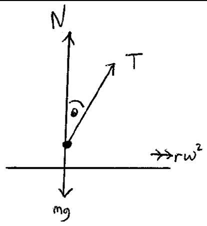
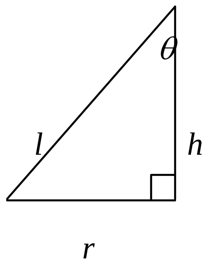
General Marking Guidance

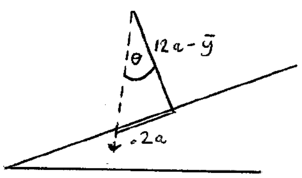
- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

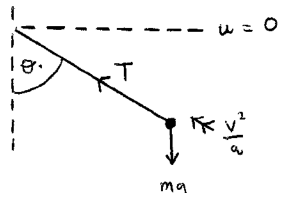
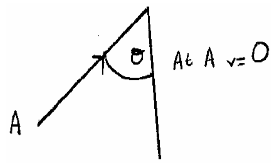
June 2008
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
Q1(a)	 EPE stored $= \frac{1}{2}\frac{\lambda}{L}\left(\frac{1}{2}L\right)^2 \quad \left(=\frac{\lambda L}{8}\right)$	B1
	KE gained $= \frac{1}{2}m\,2gL \quad (= mgL)$	B1
	EPE = KE $\Rightarrow \frac{\lambda L}{8} = \text{mg}\,L$ i.e. $\lambda = 8mg$*	M1A1cso
		(4)
(b)	EPE = GPE + KE	M1
	 $\frac{1}{2}\frac{8mg}{L}\left(\frac{1}{2}L\right)^2 = \frac{8mgL}{8} = mg\frac{L}{2} + \frac{1}{2}mu^2$	A1A1
	$\frac{mgL}{2} = \frac{m}{2}u^2 \quad \therefore\ u = \sqrt{gL}$	M1A1 **(5)**
		9 Marks

Question Number	Scheme	Marks
Q2 (a)		
	$T = 3 = \frac{2\pi}{\omega} \quad \therefore \ \omega = \frac{2\pi}{3}$	M1A1
	$u^2 = \omega^2 \left(a^2 - x^2\right)$; $a = 0.12$, $u^2 = a^2\omega^2, u = 0.12 \times \omega$	M1
	$= 0.251 \text{ ms}^{-1}$ (0.25 m s^{-1})	A1 **(4)**
(b)	Time from $O \to A \to O = 1.5\text{s}$ $\therefore t = 0.5$	B1
	$x = a \sin \omega t \quad \Rightarrow OP = 0.12 \sin\left(\frac{\pi}{3}\right)$	M1A1
	Distance from B is $0.12 - OP = 0.12 - 0.104\ldots = 0.016\text{m}$	M1A1 **(5)**
(c)	$v^2 = \omega^2 \left(a^2 - x^2\right)$	M1
	$v = \frac{2\pi}{3} \sqrt{0.12^2 - 0.104....^2} = \frac{2\pi}{3} \times 0.0598 = 0.13 \text{ ms}^{-1}$	A1 **(2)**
		11 Marks

Question Number	Scheme	Marks
Q3 (a)		
	↑ $T\cos\theta + N = Mg$ **(1)**	M1A1
	→ $T\sin\theta = mr\omega^2$ **(2)**	M1A1
	 $\sin\theta = \frac{r}{l}$ from **(2)** $T = ml\omega^2$	
	sub into **(1)** $ml\cos\theta\,\omega^2 + N = mg$	M1
	$N = mg - mh\omega^2$	A1
	Since in contact with table $N \geq 0$ $\therefore \omega^2 \leq \frac{g}{h}$ *	M1A1 cso
		(8)
(b)	$r:h:l = 3:4:5$ $\therefore$ extension $= \frac{h}{4}$	B1
	$T = \frac{2mg}{h} \times \frac{h}{4} = \frac{mg}{2}$	M1A1
	$T = ml\omega^2 = \frac{5mh}{4}\omega^2$ $\omega = \sqrt{\frac{2g}{5h}}$	M1A1
		(5)
		13 marks

Question Number	Scheme	Marks
Q4 (a)		
	Mass $a^3 \frac{2}{3}\pi \times$: 216 8 208	M1A1
	27 1 26	
	C of M from O: $\frac{3}{8}\times 6a$ $\frac{3}{8}\times 2a$ $\bar{x}$ Use of $\frac{3}{8}r$	M1
	Moment : $216\times\frac{6a\times 3}{8} = 8\times\frac{2a\times 3}{8} + 208\bar{x}$	M1
	$\bar{x} = \frac{480a}{208} = \frac{30a}{13}$ *	A1 cso **(5)**
(b)	 + □ = S	
	Mass $\pi a^3 \times$: $\frac{416}{3}$ + 24 = $\frac{488}{3}$	B1
	C of M: $\frac{30}{13}a$ + $9a$ = $\bar{y}$	B1
	Moments : $320a + 216a = \frac{488}{3}\bar{y}$	M1
	$\bar{y} = \frac{201}{61}a$ *	A1 cso **(4)**
(c)		
	$12a - \frac{201}{61}a$	M1
	$\tan\theta = \frac{2a}{12a - \frac{201}{61}a}$ $\tan\theta = \frac{2a}{....}$	M1
	$\theta = 12.93.....$	A1
	so critical angle = 12.93… $\therefore$ if $\theta = 12°$ it will <u>NOT</u> topple.	A1√ **(4)**
		13 marks

Question Number	Scheme	Marks
Q5(a)		
	Energy $\frac{1}{2}mv^2 = mga\cos\theta$	M1A1
	$v^2 = 2ga\cos\theta$	
	$F = ma$ ↖ $T - mg\cos\theta = \frac{mv^2}{a}$	M1A1
	Sub for $\frac{v^2}{a}$: $T = mg\cos\theta + 2mg\cos\theta$: $\theta = 60$ $\therefore T = \frac{3}{2}mg$	M1A1
		(6)
(b)	Speed of P before impact = $\sqrt{2ga}$	B1
	$\rightarrow \sqrt{2ga}$ $\rightarrow 0$ $\rightarrow u$	
	PCLM : • • → • $\therefore u = \frac{\sqrt{2ga}}{4} = \sqrt{\frac{ga}{8}}$ *	M1A1cso
	m 3m 4m	**(3)**
(c) (i)		
	At A $v = 0$ so conservation of energy gives:	
	$\frac{1}{2}$ ~~4m~~u^2 = ~~4m~~ $ga(1-\cos\theta)$	M1A1
	$\frac{ga}{16} = ga(1-\cos\theta)$	M1
	$\cos\theta = \frac{15}{16}$, $\theta = 20°$	A1
(ii)	↗ At A $T = 4mg\cos\theta = \frac{15mg}{4}$ (accept 3.75mg)	M1A1 **(6)**
		15 Marks

Question Number	Scheme	Marks
Q6 (a)	$F = ma\ (\rightarrow)\quad \dfrac{3}{(x+1)^3} = 0.5a = 0.5\ v\dfrac{dv}{dx}$	M1A1
	$\int \dfrac{3}{(x+1)^3}dx = 0.5\int v\ dv$ Separate and ∫	M1
	$-\dfrac{3}{2(x+1)^2} = \dfrac{1}{4}v^2\ (+\ c)$	A1
	$x = 0,\ v = 0 \Rightarrow c' = -\dfrac{3}{2} \quad \therefore \quad v^2 = 6\left(1 - \dfrac{1}{(x+1)^2}\right)$ *	M1A1 cso **(6)**
(b)	$\forall x \quad v^2 < 6 \quad \therefore \quad v < \sqrt{6} \quad (\because (x+1)^2 \text{ always} > 0)$	B1 **(1)**
(c)	$v = \dfrac{dx}{dt} = \dfrac{\sqrt{6}\sqrt{(x+1)^2 - 1}}{x+1}$	M1
	$\int \dfrac{x+1}{\sqrt{(x+1)^2 - 1}}\ dx = \sqrt{6}\int dt$	M1
	$\sqrt{(x+1)^2 - 1} = \sqrt{6}\,t + c'$	M1 A1
	$t = 0,\ x = 0 \Rightarrow c' = 0$	M1
	$t = 2 \Rightarrow (x+1)^2 - 1 = (2\sqrt{6})^2$	M1
	$(x+1)^2 = 25 \Rightarrow x = 4$ (c' need not have been found)	A1 cao
		(7)
		14 Marks

Mark Scheme (Results)

January 2009

GCE

GCE Mathematics (6679/01)

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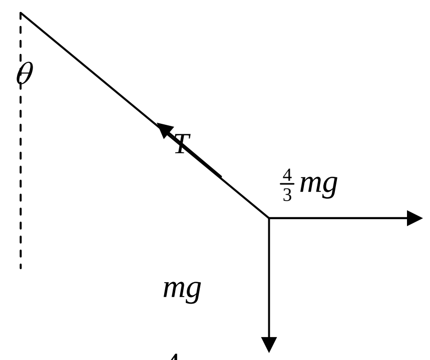
January 2009
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
1	N2L $\quad 3a = -\left(9 + \frac{15}{(t+1)^2}\right)$	B1
	$3v = -9t + \frac{15}{t+1}(+A)$	M1 A1ft
	$v = 0, t = 4 \quad \Rightarrow \quad 0 = -36 + 3 + A \quad \Rightarrow \quad A = 33$	M1 A1
	$v = -3t + \frac{5}{t+1} + 11$	
	$t = 0 \quad \Rightarrow \quad v = 16$	M1 A1 (7) **[7]**
2		
(a)	$(\leftarrow) \qquad T\sin\theta = \frac{4}{3}mg$	M1 A1
	$(\uparrow) \qquad T\cos\theta = mg$	A1
	$T^2 = \left(\frac{4}{3}mg\right)^2 + (mg)^2$	M1
	Leading to $\quad T = \frac{5}{3}mg$	A1 (5)
(b)	HL $\quad T = \frac{\lambda x}{a} \quad \Rightarrow \quad \frac{5}{3}mg = \frac{3mge}{a} \qquad$ ft their T	M1 A1ft
	$e = \frac{5}{9}a$	
	$E = \frac{\lambda x^2}{2a} = \frac{3mg}{2a} \times \left(\frac{5}{9}a\right)^2 = \frac{25}{54}mga$	M1 A1 (4)
		[9]

Question Number	Scheme	Marks
3	$\omega = \frac{80 \times 2\pi}{60}$ rad s^{-1} $\left(= \frac{8\pi}{3} \approx 8.377...\right)$	B1
	Accept $v = \frac{16\pi}{75} \approx 0.67\,\text{ms}^{-1}$ as equivalent	
	$(\uparrow)$ $R = mg$	B1
	For least value of μ $(\leftarrow)$ $\mu mg = mr\omega^2$	M1 A1=A1
	$\mu = \frac{0.08}{9.8} \times \left(\frac{8\pi}{3}\right)^2 \approx 0.57$ accept 0.573	M1 A1 (7)
		[7]
4 (a)	$a = 8$	B1
	$T = \frac{25}{2} = \frac{2\pi}{\omega} \Rightarrow \omega = \frac{4\pi}{25}\ (\approx 0.502\ ...)$	M1 A1
	$v^2 = \omega^2\left(a^2 - x^2\right) \Rightarrow v^2 = \left(\frac{4\pi}{25}\right)^2\left(8^2 - 3^2\right)$ ft their $a,\ \omega$	M1 A1ft
	$v = \frac{4\pi}{25}\sqrt{55} \approx 3.7\ \left(\text{m h}^{-1}\right)$ awrt 3.7	M1 A1 (7)
(b)	$x = a\cos\omega t \Rightarrow 3 = 8\cos\left(\frac{4\pi}{25}t\right)$ ft their $a,\ \omega$	M1 A1ft
	$t \approx 2.3602\ \ldots$	M1
	time is 12 22	A1 (4)
		[11]

Question Number	Scheme	Marks
5 (a)	Let x be the distance from the initial position of B to C GPE lost = EPE gained	
	$mgx\sin 30° = \dfrac{6mgx^2}{2a}$	M1 A1=A1
	Leading to $x = \dfrac{a}{6}$	M1
	$AC = \dfrac{7a}{6}$	A1 (5)
(b)	The greatest speed is attained when the acceleration of B is zero, that is where the forces on B are equal.	
	$(\nwarrow)$ $T = mg\sin 30° = \dfrac{6mge}{a}$	M1
	$e = \dfrac{a}{12}$	A1
	CE $\dfrac{1}{2}mv^2 + \dfrac{6mg}{2a}\left(\dfrac{a}{12}\right)^2 = mg\dfrac{a}{12}\sin 30°$	M1 A1=A1
	Leading to $v = \sqrt{\left(\dfrac{ga}{24}\right)} = \dfrac{\sqrt{6ga}}{12}$	M1 A1 (7)
		[12]
	Alternative approaches to (b) *are considered on the next page.*	

Question Number	Scheme	Marks
5	*Alternative approach to* (b) *using calculus with energy.*	
	Let distance moved by B be x	
	CE $\quad \frac{1}{2}mv^2 + \frac{6mg}{2a}x^2 = mgx\sin 30°$	M1 A1=A1
	$v^2 = gx - \frac{6g}{a}x^2$	
	For maximum v $\quad \frac{\mathrm{d}}{\mathrm{d}x}\left(v^2\right) = 2v\frac{\mathrm{d}v}{\mathrm{d}x} = g - \frac{12g}{a}x = 0$	M1 A1
	$x = \frac{a}{12}$	
	$v^2 = g\left(\frac{a}{12}\right) - \frac{6g}{a}\left(\frac{a}{12}\right)^2 = \frac{ga}{24}$	M1
	$v = \sqrt{\left(\frac{ga}{24}\right)}$	A1 (7)
	Alternative approach to (b) *using calculus with Newton's second law.*	
	As before, the centre of the oscillation is when extension is $\frac{a}{12}$	M1 A1
	N2L $\quad mg\sin 30° - T = m\ddot{x}$	
	$\frac{1}{2}mg - \frac{6mg\left(\frac{a}{12} + x\right)}{a} = m\ddot{x}$	M1 A1
	$\ddot{x} = -\frac{6g}{a}x \quad \Rightarrow \quad \omega^2 = \frac{6g}{a}$	A1
	$v_{\max} = \omega a = \sqrt{\left(\frac{6g}{a}\right)} \times \frac{a}{12} = \sqrt{\left(\frac{ga}{24}\right)}$	M1 A1 (7)

Question Number	Scheme	Marks
6 (a)	$\int y^2\,\mathrm{d}x = \int (4-x^2)^2\,\mathrm{d}x = \int (16 - 8x^2 + x^4)\,\mathrm{d}x$	
	$= 16x - \frac{8x^3}{3} + \frac{x^5}{5}$	M1 A1
	$\left[16x - \frac{8x^3}{3} + \frac{x^5}{5}\right]_0^2 = \frac{256}{15}$	M1 A1
	$\int xy^2\,\mathrm{d}x = \int x(4-x^2)^2\,\mathrm{d}x = \int (16x - 8x^3 + x^5)\,\mathrm{d}x$	
	$= 8x^2 - 2x^4 + \frac{x^6}{6}$	M1 A1
	$\left[8x^2 - 2x^4 + \frac{x^6}{6}\right]_0^2 = \frac{32}{3}$	M1A1
	$\bar{x} = \frac{\int xy^2\,\mathrm{d}x}{\int y^2\,\mathrm{d}x} = \frac{32}{3} \times \frac{15}{216} = \frac{5}{8}$ *	M1 A1 (10)
(b)	$A \times \bar{x} = (\pi r^2 l) \times \frac{l}{2}$	M1
	$\frac{256}{15}\pi \times \frac{5}{8} = \pi \times 16l \times \frac{l}{2}$	A1 ft
	Leading to $l = \frac{2\sqrt{3}}{3}$ accept exact equivalents or awrt 1.15	M1 A1 (4)
		[14]

Question Number	Scheme	Marks
7 (a)	Let speed at C be u	
	CE $\frac{1}{2}mu^2 - \frac{1}{2}m\left(\frac{ag}{4}\right) = mga(1-\cos\theta)$	M1 A1
	$u^2 = \frac{9ga}{4} - 2ga\cos\theta$	
	$mg\cos\theta \ (+R) = \frac{mu^2}{a}$	M1 A1
	$mg\cos\theta = \frac{9mg}{4} - 2mg\cos\theta$ eliminating u	M1
	Leading to $\cos\theta = \frac{3}{4}$ ✱	M1 A1 (7)
(b)	At C $u^2 = \frac{9ga}{4} - 2ga \times \frac{3}{4} = \frac{3}{4}ga$	B1
	$(\rightarrow)$ $u_x = u\cos\theta = \sqrt{\left(\frac{3ga}{4}\right)} \times \frac{3}{4} = \sqrt{\left(\frac{27ga}{64}\right)} = 2.033\sqrt{a}$	M1 A1ft
	$(\downarrow)$ $u_y = u\sin\theta = \sqrt{\left(\frac{3ga}{4}\right)} \times \frac{\sqrt{7}}{4} = \sqrt{\left(\frac{21ga}{64}\right)} = 1.792\sqrt{a}$	M1
	$v_y^2 = u_y^2 + 2gh \ \Rightarrow \ v_y^2 = \frac{21}{64}ga + 2g \times \frac{7}{4}a = \frac{245}{64}ga$	M1 A1
	$\tan\psi = \frac{v_y}{u_x} = \sqrt{\left(\frac{245}{27}\right)} \approx 3.012 \ldots$	M1
	$\psi \approx 72°$ awrt $72°$	A1 (8)
	Or 1.3^c (1.2502^c) awrt 1.3^c	**[15]**
	Alternative for the last five marks	
	Let speed at P be v.	
	CE $\frac{1}{2}mv^2 - \frac{1}{2}m\left(\frac{ag}{4}\right) = mg \times 2a$ or equivalent	M1
	$v^2 = \frac{17mga}{4}$	M1 A1
	$\cos\psi = \frac{u_x}{v} = \sqrt{\left(\frac{27}{64} \times \frac{4}{17}\right)} = \sqrt{\left(\frac{27}{272}\right)} \approx 0.315$	M1
	$\psi \approx 72°$ awrt $72°$	A1
	Note: The time of flight from C to P is $\frac{\sqrt{235} - \sqrt{21}}{8}\sqrt{\left(\frac{a}{g}\right)} \approx 1.38373\sqrt{\left(\frac{a}{g}\right)}$	

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Mark Scheme (Results)

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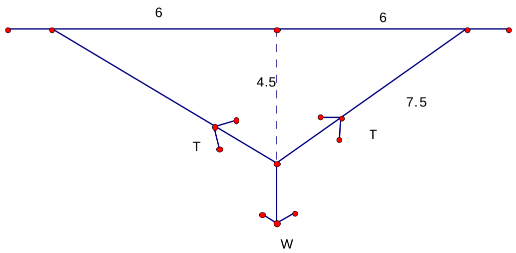
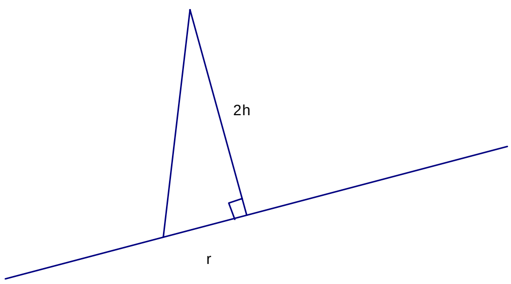
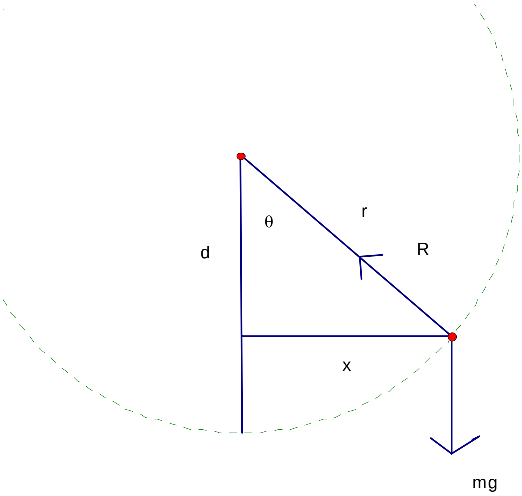
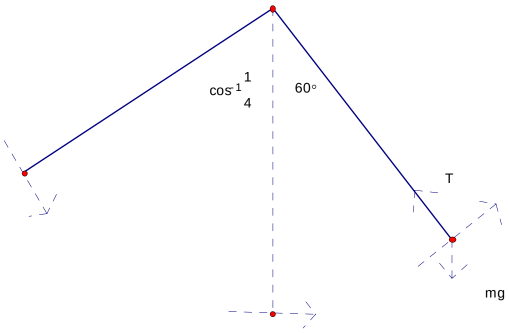
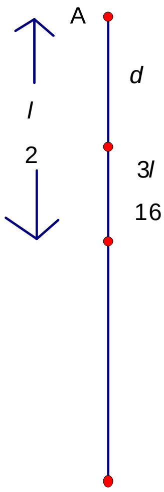
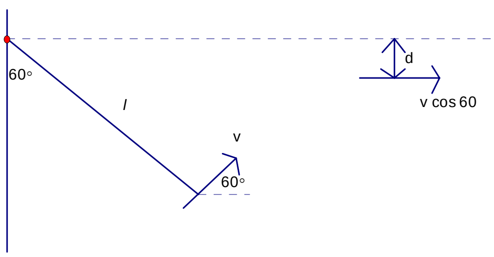
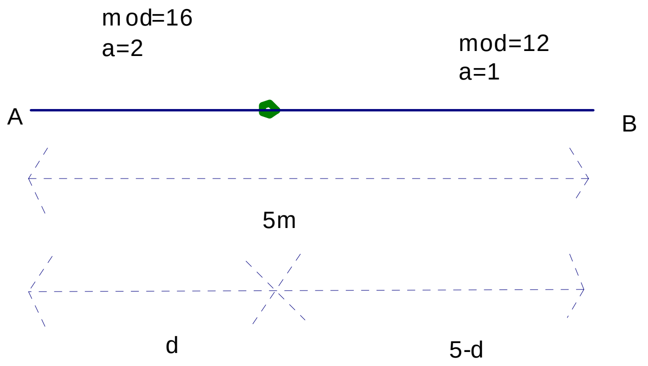
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
Q1 (a)	 Resolving vertically: $2T\cos\theta = W$ Hooke's Law: $T = \frac{80\times 3.5}{4}$ $W = 84\text{N}$	M1A2,1,0 M1A1 A1
(b)	EPE = $2\times\frac{80\times 3.5^2}{2\times 4}, = 245$ (or awrt 245) (alternative $\frac{80\times 7^2}{16} = 245$)	M1A1ft,A1 **[9]**
Q2 (a)	Object Mass c of m above base Cone m $2h+3h$ Base $3m$ h Marker $4m$ d m x $5h$ +$3m$ x h = $4m$ x d $d = 2h$	B1(ratio masses) B1(distances) M1A1ft A1
(b)	 $\frac{r}{d} = \frac{1}{12}$ $6r = h$	M1A1ft A1 **[8]**

Question Number	Scheme	Marks
Q3 (a)	 $\leftrightarrow \quad R\sin\theta = mx\omega^2$	M1 A1
	$R\times\frac{x}{r} = mx\times\frac{3g}{2r}$	M1
	$R = \frac{3mg}{2}$	A1
(b)	$\updownarrow \quad R\cos\theta = mg$	M1 A1
	$\frac{3mg}{2}\times\frac{d}{r} = mg$	M1
	$d = \frac{2}{3}r$	A1
		[8]
Q4 (a)	Volume = $\int_{\frac{1}{4}}^{1}\pi y^2 dx = \int_{\frac{1}{4}}^{1}\pi\frac{1}{x^4}dx$	M1A1
	$= \left[\pi\times\frac{-1}{3x^3}\right]_{\frac{1}{4}}^{1}$	A1ft
	$= \pi(\frac{-1}{3}+\frac{64}{3}) = 21\pi$ *	A1
(b)	$21\pi\rho\bar{x} = \rho\int\pi y^2 x dx = \rho\int\pi\frac{1}{x^4}xdx$	M1A1
	$21\pi\bar{x} = \pi\left[\frac{-1}{2x^2}\right]_{\frac{1}{4}}^{1}$	A1ft
	$\bar{x} = \frac{1}{21}(\frac{-1}{2}+\frac{16}{2}) = \frac{5}{14}$ or awrt 0.36	A1
	$\bar{y} = 0$ by symmetry	B1
		[9]

Question Number	Scheme	Marks
Q5 (a)		
	Energy:	
	$(\frac{1}{2}mu^2 +)mgl(\cos\theta - \frac{1}{4}) = \frac{1}{2}mv^2$	M1A1
	Resolving:	
	$T - mg\cos\theta = \frac{mv^2}{l}$	M1A1
	Eliminate v^2:	
	$T = mg\cos\theta + \frac{1}{l}(2mgl(\cos\theta - \frac{1}{4}))$	M1
	$T = 3mg\cos\theta - \frac{mg}{2}$ *	A1
(b)		
	$\theta = 60° \Rightarrow mv^2 = 2mgl(\frac{1}{2} - \frac{1}{4})$	M1
	$\Rightarrow v^2 = \frac{gl}{2}$	
	vertical motion under gravity:	
	$\updownarrow \; 0 = (v\cos 30°)^2 - 2gs$	M1
	$0 = \frac{gl}{2} \times \frac{3}{4} - 2gs \Rightarrow s = \frac{3l}{16}$	A1
	Distance below A $= \frac{l}{2} - \frac{3l}{16} = \frac{5l}{16}$	M1A1
		[11]
Alternative for end of (b) using energy		
	$\frac{1}{2}mv^2 - mgl\cos 60 = \frac{1}{2}m(v\cos 60)^2 - mgd$	M1A1
	$\frac{gl}{4} - \frac{gl}{2} = \frac{gl}{4} \times \frac{1}{4} - gd$	M1
	$d = \frac{1-4+8}{16}l = \frac{5l}{16}$	A1

Question Number	Scheme	Marks
Q6 (a)	At max v, driving force = resistance	
	Driving force = $\frac{80}{v}$	B1
	$\Rightarrow \frac{80}{20} = k \times 20^2 \Rightarrow k = \frac{1}{100}$	M1A1
	F = ma $\Rightarrow 100a = \frac{80}{v} - kv^2 \quad (= \frac{8000 - v^3}{100v})$	M1
	* $\Rightarrow v\frac{\mathrm{d}v}{\mathrm{d}x} = \frac{8000 - v^3}{10000v}$ *	A1
(b)	$\int_4^8 \frac{10000v^2}{8000 - v^3}\mathrm{d}v = \int_0^D 1\mathrm{d}x$	M1A1
	$D = \left[-\frac{10000}{3}\ln\lvert 8000 - v^3\rvert\right]_4^8$	A1
	$= (-\frac{10000}{3}\ln\frac{7488}{7936}) = 193.7..... \approx 194\,\mathrm{m} \quad$ (accept 190)	M1 A1
(c)	$\frac{\mathrm{d}v}{\mathrm{d}t} = \frac{8000 - v^3}{10000v} \Rightarrow \int_0^T 1\mathrm{d}t = \int_4^8 \frac{10000v}{8000 - v^3}\mathrm{d}v$	M1A1
	$\Rightarrow T \approx \frac{1}{2} \times 2 \times 10000 \times \left\{\frac{4}{7936} + \frac{2 \times 6}{7784} + \frac{8}{7488}\right\}$	M1 A1
	$\Rightarrow T(= 31.1409....) \approx 31$	
		[14]

Question Number	Scheme	Marks
Q7 (a)		
	Hooke's law: Equilibrium $\Rightarrow \frac{16(d-2)}{2} = \frac{12(4-d)}{1}$	M1A1A1
	$\Rightarrow d = 3.2$	A1
	so extensions are 1.2m and 0.8m.	A1
(b)	If the particle is displaced distance x towards ***B*** then	
	$-m\ddot{x} = \frac{16(1.2+x)}{2} - \frac{12(0.8-x)}{1} (= 20x)$	M1A1ft A1ft
	$\Rightarrow \ddot{x} = -40x$ or $\ddot{x} = -\frac{20}{m} (\Rightarrow \text{SHM})$	A1
(c)	$T = \frac{2\pi}{\sqrt{40}}$	B1ft
	$a = \frac{\sqrt{10}}{\text{their } \omega}$	B1ft
	$x = a\sin\omega t$ their a, their ω	M1
	$\frac{1}{4} = \frac{1}{2}\sin\sqrt{40}t$	A1
	$\sqrt{40}t = \frac{\pi}{6} (\Rightarrow t = \frac{\pi}{6\sqrt{40}})$	M1
	Proportion $\frac{4t}{T} = \frac{4\pi}{6\sqrt{40}} \times \frac{\sqrt{40}}{2\pi} = \frac{1}{3}$	M1A1
		[16]

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GCE

Mechanics M3 (6679)

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January 2010

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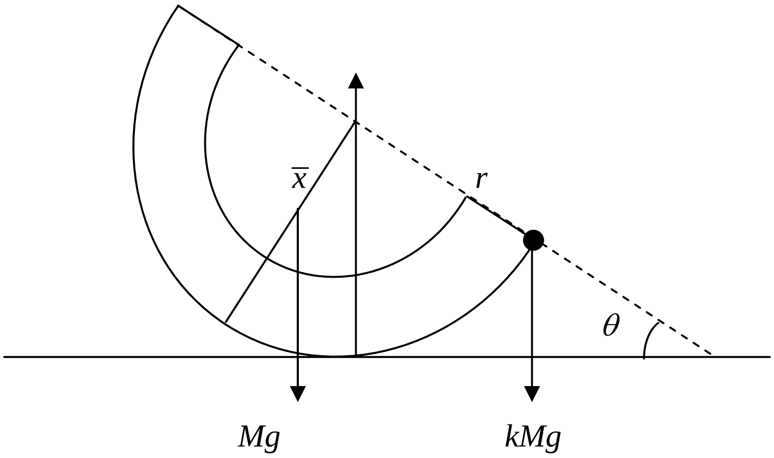
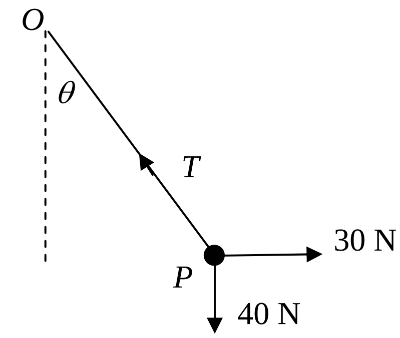
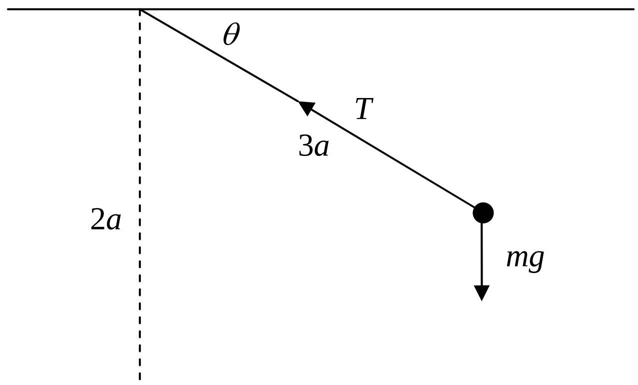
January 2010
6679 Mechanics M3
Mark Scheme

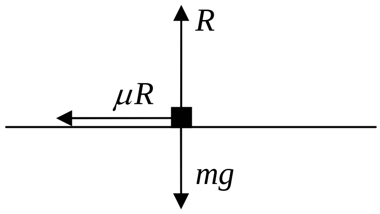
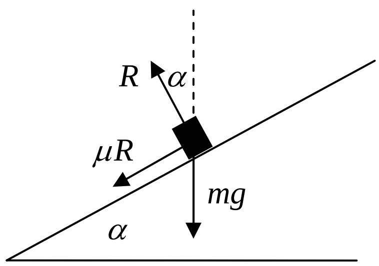
Question Number	Scheme	Marks
Q1.	$0.5a = 4 + \cos(\pi t)$	B1
	Integrating $\quad 0.5v = 4t + \dfrac{\sin(\pi t)}{\pi} \; (+C)$	M1 A1
	Using boundary values $3 = 4 + C \Rightarrow C = -1$	M1 A1
	When $t = 1.5$ $0.5v = 6 - \dfrac{1}{\pi} - 1$	M1
	$v \approx 9.36 \; (\mathrm{m\,s^{-1}})$ cao	A1 (7)
		[7]

Question Number	Scheme	Marks
Q2.	(a) $\frac{2\pi}{\omega} = 2.4 \quad \Rightarrow \omega = \frac{5\pi}{6} \left(\approx 2.62\right)$	M1 A1
	$x = 0, t = 0 \quad \Rightarrow \quad x = a\sin\omega t$	
	when $t = 0.4$, $x = a\sin\left(\frac{5\pi}{6} \times 0.4\right) \qquad \left(= \frac{\sqrt{3}}{2}a\right)$	M1
	$v^2 = \omega^2\left(a^2 - x^2\right) \quad \Rightarrow \quad 16 = \frac{25\pi^2}{36}\left(a^2 - \frac{3a^2}{4}\right) \quad \Rightarrow \quad a = \frac{48}{5\pi}\left(\approx 3.06\right)$	M1 A1
	$v_{max} = a\omega = 8$ (or awrt 8.0 if decimals used earlier) cao	M1 A1 (7)
	(b) $\ddot{x}_{max} = a\omega^2 = \frac{20\pi}{3}$ awrt 21	M1 A1 (2)
		[9]
	Alternative in (a)	
	(a) $\frac{2\pi}{\omega} = 2.4 \Rightarrow \omega = \frac{5\pi}{6}$	M1 A1
	$x = 0, t = 0 \quad \Rightarrow \quad x = a\sin\omega t$	
	$\dot{x} = a\omega\cos\omega t$	M1
	$4 = a\omega\cos\left(\frac{5\pi}{6} \times 0.4\right)$	M1
	$a = \frac{48}{5\pi}\left(\approx 3.06\right)$ or $a\omega = 8$	A1
	$v_{max} = a\omega = 8$	M1 A1 (7)

Question Number	Scheme	Marks
Q3.	(a) Mass ratios: s 8, B 19, S 27 — anything in correct ratio	B1
	$\bar{x}$: $\frac{3}{8}\times\frac{2}{3}r$, $\bar{x}$, $\frac{3}{8}r$	B1
	$$8\times\frac{1}{4}r+19\bar{x}=27\times\frac{3}{8}r$$	M1 A1ft
	$$\bar{x}=\frac{65}{152}r \quad *$$	A1 (5)
	(b) 	
	$$Mg\times\bar{x}\sin\theta=kMg\times r\cos\theta$$	M1 A1=A1
	leading to $k=\frac{13}{38}$	M1 A1 (5)
		[10]

Question Number	Scheme	Marks	
Q4.			
	$\uparrow \quad T\cos\theta = 40$ M1 attempt at both equations	M1 A1	
	$\rightarrow \quad T\sin\theta = 30$	A1	
	leading to $\quad T = 50$	M1 A1	
	$E = \dfrac{\lambda x^2}{2a} = 10$	B1	
	HL $\quad T = \dfrac{\lambda x}{a} = 50$	M1	
	leading to $\quad x = 0.4$	M1 A1	
	$OP = 0.5 + 0.4 = 0.9\,(\text{m})$	A1ft	(10)
			[10]

Question Number	Scheme	Marks
Q5.	(a) 	
	$\frac{1}{2}m\times 2ag-\frac{1}{2}mv^2=mg\left(2a-3a\sin\theta\right)$	M1 A1=A1
	leading to $v^2=2ga\left(3\sin\theta-1\right)$ ∗ cso	M1 A1 (5)
	(b) minimum value of T is when v = 0 $\Rightarrow$ $\sin\theta=\frac{1}{3}$	B1
	$T=mg\sin\theta=\frac{mg}{3}$	M1 A1
	maximum value of T is when $\theta=\frac{\pi}{2}$ $\left(v^2=4ag\right)$	
	$\uparrow$ $T=\frac{mv^2}{3a}+mg$	M1 A1
	$=\frac{7mg}{3}$	A1 (6)
	$\left(\frac{mg}{3}\le T\le\frac{7mg}{3}\right)$	**[11]**

Question Number	Scheme	Marks
Q6.	(a) 	
	↑ $R = mg$	B1
	Use of limiting friction, $F_r = \mu R$	B1
	← $\mu R = \frac{m28^2}{120}$	M1 A1
	$\mu = \frac{28^2}{120 \times 9.8} = \frac{2}{3}$ ✱ cao	M1 A1 (6)
	(b) 	
	↑ $R\cos\alpha - \mu R\sin\alpha = mg$	M1 A1
	← $\mu R\cos\alpha + R\sin\alpha = \frac{mv^2}{r}$	M1 A1
	$\frac{\mu\cos\alpha + \sin\alpha}{\cos\alpha - \mu\sin\alpha} = \frac{v^2}{rg}$ Eliminating R	M1
	$\frac{2\cos\alpha + 3\sin\alpha}{3\cos\alpha - 2\sin\alpha} = \frac{25}{24}$ Substituting values	M1
	leading to $\tan\alpha = \frac{27}{122}$ awrt 0.22	M1 A1 (8)
		[14]

Question Number	Scheme	Marks
Q7.	(a)	
	$\frac{1}{2}mv^2 + \frac{3mgx^2}{4a} = mg(a+x)$	M1 A2 (1, 0)
	leading to $v^2 = 2g(a+x) - \frac{3gx^2}{2a}$ ∗ cso	A1 (4)
	(b) Greatest speed is when the acceleration is zero	
	$T = \frac{\lambda x}{a} = \frac{3mgx}{2a} = mg \quad \Rightarrow \quad x = \frac{2a}{3}$	M1 A1
	$v^2 = 2g\left(a + \frac{2a}{3}\right) - \frac{3g}{2a} \times \left(\frac{2a}{3}\right)^2 \left(= \frac{8ag}{3}\right)$	M1
	$v = \frac{2}{3}\sqrt{(6ag)}$ accept exact equivalents	A1 (4)
	(c) $v = 0 \quad \Rightarrow \quad 2g(a+x) - \frac{3gx^2}{2a} = 0$	M1
	$3x^2 - 4ax - 4a^2 = (x-2a)(3x+2a) = 0$	
	$x = 2a$	M1 A1
	At D, $m\ddot{x} = mg - \frac{\lambda \times 2a}{a}$ ft their $2a$	M1 A1ft
	$\lvert\ddot{x}\rvert = 2g$	A1 (6)
		[14]
	Alternative to (b)	
	$v^2 = 2g(a+x) - \frac{3gx^2}{2a}$	
	Differentiating with respect to x	
	$2v\frac{\mathrm{d}v}{\mathrm{d}x} = 2g - \frac{3gx}{a}$	
	$\frac{\mathrm{d}v}{\mathrm{d}x} = 0 \Rightarrow x = \frac{2a}{3}$	M1 A1
	$v^2 = 2g\left(a + \frac{2a}{3}\right) - \frac{3g}{2a} \times \left(\frac{2a}{3}\right)^2 \left(= \frac{8ag}{3}\right)$	M1
	$v = \frac{2}{3}\sqrt{(6ag)}$ accept exact equivalents	A1 (4)

Question Number	Scheme	Marks
Q7.	*Alternative approach using SHM for* (b) *and* (c) If SHM is used mark (b) and (c) together placing the marks in the gird as shown. Establishment of equilibrium position $T = \frac{\lambda x}{a} = \frac{3mge}{2a} = mg \quad \Rightarrow \quad e = \frac{2a}{3}$	bM1 bA1
	N2L , using y for displacement from equilibrium position $m\ddot{y} = mg - \frac{\frac{3}{2}mg\left(y+e\right)}{a} = -\frac{3g}{2a}y$	bM1 bA1
	$\omega^2 = \frac{3g}{2a}$	
	Speed at end of free fall $\quad u^2 = 2ga$	cM1
	Using A for amplitude and $v^2 = \omega^2\left(a^2 - x^2\right)$	
	$u^2 = 2ga$ when $y = -\frac{2}{3}a \quad \Rightarrow \quad 2ga = \frac{3g}{2a}\left(A^2 - \frac{4a^2}{9}\right)$	cM1
	$A = \frac{4a}{3}$	cA1
	Maximum speed $\quad A\omega = \frac{4a}{3} \times \sqrt{\left(\frac{3g}{2a}\right)} = \frac{2}{3}\sqrt{\left(6ag\right)}$	cM1 cA1
	Maximum acceleration $\quad A\omega^2 = \frac{4a}{3} \times \frac{3g}{2a} = 2g$	cA1

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GCE

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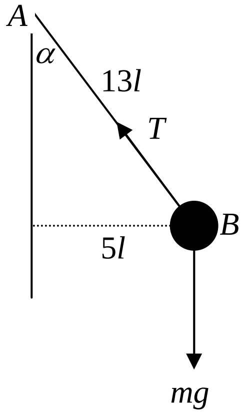
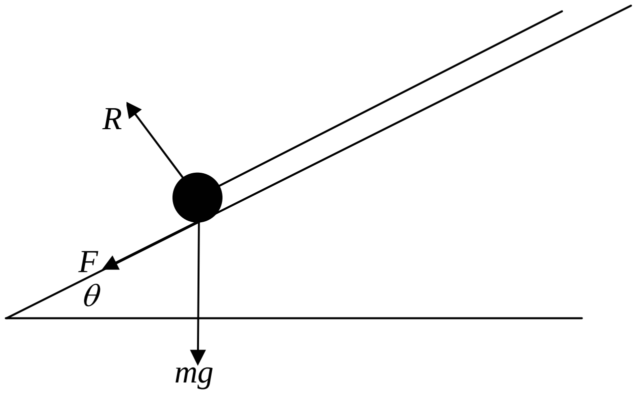
Summer 2010

Publications Code UA024475

Summer 2010
Mechanics M3 6679
Mark Scheme

Question Number	Scheme	Marks
Q1		
(a)	$\cos\alpha = \frac{12}{13}$	B1
	R$(\uparrow)$ $T\cos\alpha = mg$	M1
	$T \times \frac{12}{13} = mg$	
	$T = \frac{13}{12}mg$ oe	A1 (3)
(b)	Eqn of motion $T\sin\alpha = m\frac{v^2}{5l}$	M1 A1
	$\frac{13mg}{12} \times \frac{5}{13} = m\frac{v^2}{5l}$	M1 dep
	$v^2 = \frac{25gl}{12}$	
	$v = \frac{5}{2}\sqrt{\frac{gl}{3}}$ $\left(\text{accept } 5\sqrt{\frac{gl}{12}} \text{ or } \sqrt{\frac{25gl}{12}} \text{ or any other equiv}\right)$	A1 (4)
		[7]

Question Number	Scheme	Marks
Q2 (a)	$F = (-)\dfrac{k}{x^2}$	M1
	$mg = (-)\dfrac{k}{R^2}$	M1
	$F = \dfrac{mgR^2}{x^2}$ *	A1 (3)
(b)	$m\ddot{x} = -\dfrac{mgR^2}{x^2}$	M1
	$v\dfrac{dv}{dx} = -\dfrac{gR^2}{x^2}$	M1
	$\dfrac{1}{2}v^2 = \int\left(-\dfrac{gR^2}{x^2}\right)dx$	M1 dep on 1st M mark
	$\dfrac{1}{2}v^2 = \dfrac{gR^2}{x} \quad (+c)$	A1
	$x = R,\ v = 3U \qquad \dfrac{9U^2}{2} = gR + c$	M1 dep on 3rd M mark
	$\dfrac{1}{2}v^2 = \dfrac{gR^2}{x} + \dfrac{9U^2}{2} - gR$	
	$x = 2R,\ v = U \qquad \dfrac{1}{2}U^2 = \dfrac{gR^2}{2R} + \dfrac{9U^2}{2} - gR$	M1 dep on 3rd M mark
	$U^2 = \dfrac{gR}{8}$	
	$U = \sqrt{\dfrac{gR}{8}}$	A1 (7)
		[10]

Question Number	Scheme	Marks
Q3		
	EPE lost $=\dfrac{\lambda\times0.6^2}{2\times0.9}-\dfrac{\lambda\times0.1^2}{2\times0.9}\left(=\dfrac{7}{36}\lambda\right)$	M1 A1
	R$(\uparrow)$ $R=mg\cos\theta$	M1
	$=0.5g\times\dfrac{4}{5}=0.4g$	
	$F=\mu R=0.15\times0.4g$	M1 A1
	P.E. gained = E.P.E. lost − work done against friction	
	$0.5\text{g}\times0.7\sin\theta=\dfrac{\lambda\times0.6^2}{2\times0.9}-\dfrac{\lambda\times0.1^2}{2\times0.9}-0.15\times0.4g\times0.7$	M1 A1 A1
	$0.1944\lambda=0.5\times9.8\times0.7\times\dfrac{3}{5}+0.15\times0.4\times9.8\times0.7$	
	$\lambda=12.70......$	
	$\lambda=13$ N or 12.7	A1
		[9]

Question Number	Scheme	Marks
Q4 (a)		

	cone	container	cylinder
mass ratio	$\frac{4\pi l^3}{3}$	$\frac{68\pi l^3}{3}$	$24\pi l^3$
	4	68	72
dist from O	l	$\bar{x}$	$3l$

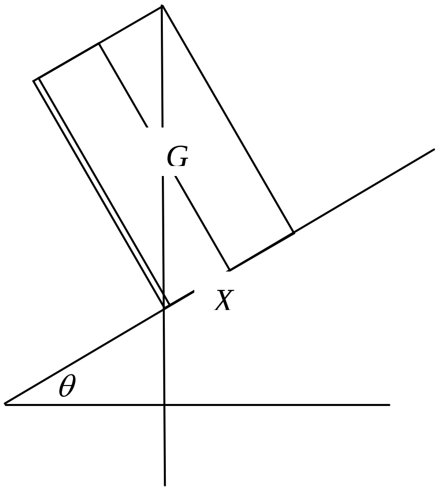
M1 A1

B1

Moments: $4l + 68\bar{x} = 72 \times 3l$ — M1 A1ft

$\bar{x} = \frac{212l}{68} = \frac{53}{17}l$ accept $3.12l$ — A1 (6)

(b)



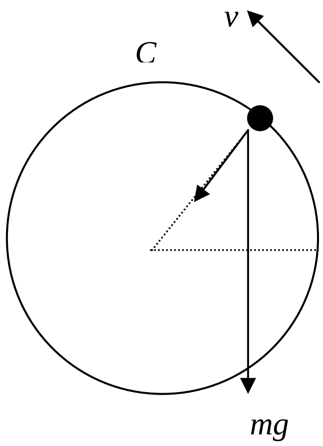
$GX = 6l - \bar{x}$ seen — M1

$\tan\theta = \frac{2l}{6l - \bar{x}}$ — M1 A1

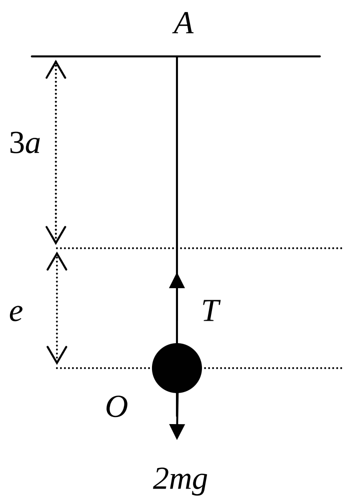
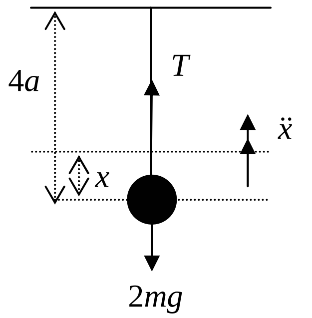
$= \frac{2 \times 17}{49}$

$\theta = 34.75... = 34.8$ or 35 — A1 (4)

[10]

Question Number	Scheme	Marks
Q5		
(a)	Energy: $mga\sin\theta = \frac{1}{2}m\times 5ag - \frac{1}{2}mv^2$ $v^2 = 5ag - 2ag\sin\theta$	M1 A1 A1 (3)
(b)	Eqn of motion along radius: $T + mg\sin\theta = \frac{mv^2}{a}$ $T = \frac{m}{a}(5ag - 2ag\sin\theta) - mg\sin\theta$ $T = mg(5 - 3\sin\theta)$	M1 A1 M1 A1 (4)
(c)	At C, $\theta = 90°$ $T = mg(5-3) = 2mg$ $T > 0 \quad \therefore P$ reaches C	M1 A1 A1 (3)
(d)	Max speed at lowest point ($\theta = 270°$; $v^2 = 5ag - 2ag\sin 270$) $v^2 = 5ag + 2ag$ $v = \sqrt{(7ag)}$	M1 A1 (2) **[12]**

Question Number	Scheme	Marks
Q6 (a)	$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = -\frac{3}{(t+1)^2}$	M1
	$\frac{\mathrm{d}x}{\mathrm{d}t} = \int -3(t+1)^{-2}\,\mathrm{d}t$	
	$= 3(t+1)^{-1}\ (+c)$	M1 A1
	$t=0,\ v=2 \quad 2=3+c \quad c=-1$	M1
	$\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{3}{t+1} - 1$ *	A1 (5)
(b)	$x = \int\left(\frac{3}{t+1} - 1\right)\mathrm{d}t$	M1
	$= 3\ln(t+1) - t \quad (+c')$	A1
	$t=0,\ x=0 \quad \Rightarrow c'=0$	B1
	$x = 3\ln(t+1) - t$	
	$v=0 \Rightarrow \frac{3}{t+1} = 1$	M1
	$t=2$	A1
	$x = 3\ln 3 - 2$	M1
	$= 1.295...$	
	$= 1.30$ m (Allow 1.3)	A1 (7) **[12]**

Question Number	Scheme	Marks
Q7		
(a)	R$(\uparrow)$ $T = 2mg$	B1
	Hooke's law: $T = \dfrac{6mge}{3a}$	
	$2mg = \dfrac{6mge}{3a}$	M!
	$e = a$	
	$AO = 4a$	A1 (3)
(b)		
	H.L. $T = \dfrac{6mg(a-x)}{3a} = \dfrac{2mg(a-x)}{a}$	B1ft
	Eqn. of motion $-2mg + T = 2m\ddot{x}$	M1
	$-2mg + \dfrac{2mg(a-x)}{a} = 2m\ddot{x}$	M1
	$-\dfrac{2mgx}{a} = 2m\ddot{x}$	
	$\ddot{x} = -\dfrac{g}{a}x$	A1
	period $2\pi\sqrt{\dfrac{a}{g}}$ *	A1 (5)

Question Number	Scheme	Marks
(c)	$v^2 = \omega^2\left(a^2 - x^2\right)$	
	$v_{\max}{}^2 = \frac{g}{a}\left(\left(\frac{a}{4}\right)^2 - 0\right)$	M1 A1
	$v_{\max} = \frac{1}{4}\sqrt{(ga)}$	A1 (3)
(d)	$x = -\frac{a}{8}$ $\quad v^2 = \frac{g}{a}\left(\frac{a^2}{16} - \frac{a^2}{64}\right)$	M1
	$= \frac{3ag}{64}$	
	$v^2 = u^2 + 2as$	M1
	$0 = \frac{3ag}{64} - 2gh$	A1
	$h = \frac{3a}{128}$	
	Total height above $O = \frac{a}{8} + \frac{3a}{128} = \frac{19a}{128}$	A1 (4)
		[15]

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GCE

GCE Mechanics M3 (6679) Paper 1

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   - **B** marks are unconditional accuracy marks (independent of M marks)
   - Marks should not be subdivided.

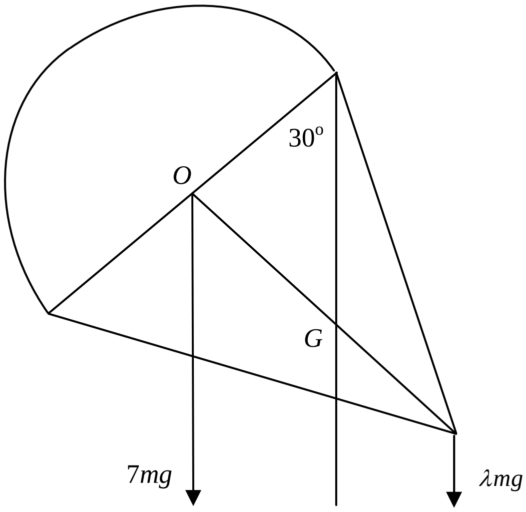
3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\sqrt{}$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper
   - ⎿ The second mark is dependent on gaining the first mark

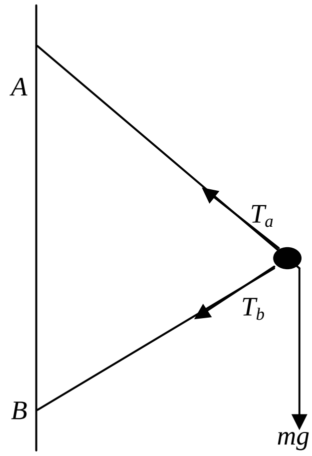
January 2011
Mechanics M3 6679
Mark Scheme

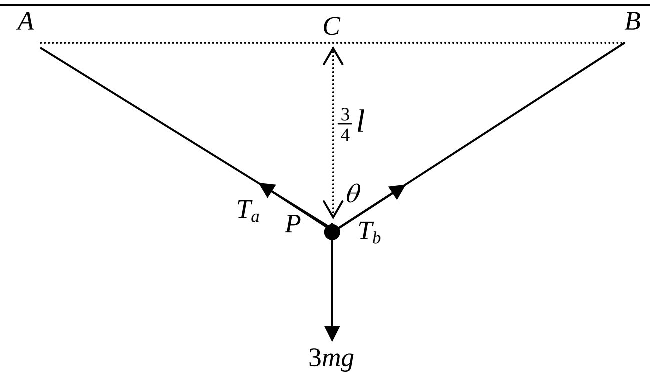
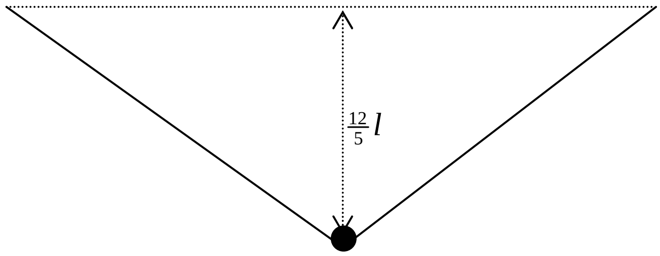
Question Number	Scheme	Marks
1.	$v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 7 - 2x$	M1
	$\frac{1}{2}v^2 = 7x - x^2 \quad (+c)$	M1A1
	$x = 0 \quad v = 6 \quad \Rightarrow \quad c = 18$	A1
	$v = 0 \quad x^2 - 7x - 18 = 0$	
	$(x+2)(x-9) = 0$	M1
	$\therefore x = 9$	A1
		[6]

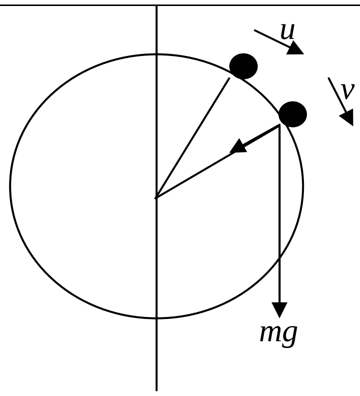
Question Number	Scheme	Marks
2. **(a)**	Mass ratio $4m$ km ‖ $(4+k)m$	B1
	Dist from O $\frac{3}{8}r$ $-\frac{1}{2}r$ ‖ 0	B1
	Moments about O: $\frac{3}{8}r\times 4m=\frac{1}{2}r\times km$	M1
	$k=3$	A1
		(4)
(b)		
	$\tan 30=\frac{OG}{r}$	B1
	$OG=\frac{\lambda}{(7+\lambda)}\times 2r$	M1
	$\frac{1}{\sqrt{3}}=\frac{\lambda}{(7+\lambda)}\times 2r\times\frac{1}{r}$	A1
	$7+\lambda=2\sqrt{3}\lambda$	
	$\lambda=\frac{7}{(2\sqrt{3}-1)}$ (o.e.) or 2.84	A1
		(4) **[8]**

Question Number	Scheme	Marks
3. (a)	Vol $= \pi\int_1^2 y^2\,dx = \pi\int_1^2 e^{2x}\,dx$	M1
	$= \frac{1}{2}\pi\left[e^{2x}\right]_1^2$	M1 A1
	$= \frac{1}{2}\pi\left[e^4 - e^2\right]$	A1
		(4)
(b)	C of M $= \dfrac{\int_1^2 \pi y^2 x\,dx}{\text{vol}}$	
	$\int_1^2 e^{2x}x\,dx = \left[\frac{1}{2}xe^{2x}\right]_1^2 - \int_1^2 \frac{1}{2}e^{2x}\,dx$	M1 A1
	$= \left[\frac{1}{2}xe^{2x}\right]_1^2 - \left[\frac{1}{4}e^{2x}\right]_1^2$	M1
	$= \frac{1}{2}\times 2e^4 - \frac{1}{2}\times 1e^2 - \left(\frac{1}{4}e^4 - \frac{1}{4}e^2\right)$	
	$= \left(\frac{3}{4}e^4 - \frac{1}{4}e^2\right)$	A1
	C of M $= \dfrac{\pi\left(\frac{3}{4}e^4 - \frac{1}{4}e^2\right)}{\frac{1}{2}\pi\left(e^4 - e^2\right)} = 1.656...$	M1 A1
	$= 1.66$	
	(3 sf)	
		(6)
		[10]

Question Number	Scheme	Marks
4. **(a)**	$x = 5\sin\left(\frac{\pi t}{3}\right)$ $\dot{x} = 5 \times \frac{\pi}{3}\cos\left(\frac{\pi t}{3}\right)$ $\ddot{x} = -5 \times \left(\frac{\pi}{3}\right)^2 \sin\left(\frac{\pi t}{3}\right)$ $\ddot{x} = -\frac{\pi^2}{9}x \qquad (\therefore \text{S.H.M.})$	 M1A1 A1 (3)
(b)	period = $\frac{2\pi}{\frac{\pi}{3}} = 6$ amplitude = 5	B1 B1 (2)
(c)	$... = 5 \times \frac{\pi}{3}\cos\left(\frac{\pi t}{3}\right) \qquad \text{or} \quad \lvert v_{\max} \rvert = a\omega$ max. $v = \frac{5\pi}{3}$	M1 A1 (2)
(d)	At A $x = 2 \qquad 2 = 5\sin\left(\frac{\pi t}{3}\right)$ $\sin\frac{\pi}{3}t = 0.4$ $t_A = \frac{3}{\pi} \times \sin^{-1} 0.4$ At B $x = 3 \qquad t_B = \frac{3}{\pi} \times \sin^{-1} 0.6$ time $A \to B \quad = \frac{3}{\pi} \times \sin^{-1} 0.6 - \frac{3}{\pi} \times \sin^{-1} 0.4$ $= 0.2215... = 0.22$ s accept awrt 0.22	M1 A1 A1 A1 (4) **[11]**

Question Number	Scheme	Marks
5.		
(a)	$r = \frac{l}{\sqrt{2}}$	B1
	$\mathrm{R}(\uparrow)$ $\quad T_a \cos 45 = T_b \cos 45 + mg$	M1A1
	$T_a - T_b = mg\sqrt{2}$ $\qquad$ (1)	
	$\mathrm{R}(\rightarrow)$ $\quad T_a \cos 45 + T_b \cos 45 = mr\omega^2$	M1A1
	$T_a \times \frac{1}{\sqrt{2}} + T_b \times \frac{1}{\sqrt{2}} = m\frac{l}{\sqrt{2}}\omega^2$	
	$T_a + T_b = ml\omega^2$ $\qquad$ (2)	
	$T_a - T_b = mg\sqrt{2}$ $\qquad$ (1)	
	$2T_a = m\left(l\omega^2 + g\sqrt{2}\right)$	M1
	$T_a = \frac{1}{2}m\left(l\omega^2 + g\sqrt{2}\right)$	A1
	$T_b = ml\omega^2 - T_a$	
	$= \frac{1}{2}m\left(l\omega^2 - g\sqrt{2}\right)$	A1
		(8)
(b)	$T_b > 0 \qquad \frac{1}{2}m\left(l\omega^2 - g\sqrt{2}\right) > 0$	M1
	$\omega^2 > \frac{g\sqrt{2}}{l}$ $\quad$ *	A1
		(2) **[10]**

Question Number	Scheme	Marks
6. **(a)**		
	length AP = length $BP = \frac{5}{4}l$	B1
	$T_a = T_b = \frac{kmg\left(\frac{1}{4}l\right)}{l} = \frac{1}{4}kmg$ $\quad$ (or $T = ...$)	M1A1
	R$(\uparrow)$ $\quad T_a \cos\theta + T_b \cos\theta = 3mg$ $\quad$ (or $2T\cos\theta = 3mg$)	M1A1
	$\frac{1}{4}kmg \times \frac{3}{5} + \frac{1}{4}kmg \times \frac{3}{5} = 3mg$ $\quad$ $\left(\text{or } \frac{1}{2}kmg \times \frac{3}{5} = 3mg\right)$	A1
	$\frac{3}{10}kmg = 3mg$	
	$k = 10$ $\quad$ *	A1
		(7)
(b)		
	initial extn $= \frac{13}{5}l - l = \frac{8}{5}l$	B1
	E.P.E. lost $= 2 \times \frac{\lambda x^2}{2l} = 2 \times \frac{10mg}{2l}\left(\frac{8l}{5}\right)^2 = \frac{128mgl}{5}$	M1A1
	P.E. gained $= 3mg \times \frac{12l}{5} = \frac{36mgl}{5}$	
	$\frac{1}{2} \times 3mv^2 + \frac{36mgl}{5} = \frac{128mgl}{5}$	M1A1
	$v^2 = \frac{256gl}{15} - \frac{72gl}{15}$	
	$v = \sqrt{\left(\frac{184}{15}gl\right)}$	A1
		(6)
		[13]

Question Number	Scheme	Marks
7.		
(a)	$mgl(\cos\alpha - \cos\theta) = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$	M1A1=A1
	$v^2 = u^2 + 2gl(\cos\alpha - \cos\theta)$ *	A1
		(4)
(b)	$\cos\alpha = \frac{3}{5}$ $\quad v^2 = 2gl\left(\frac{3}{5} - \cos\theta\right) + u^2$	
	At top $\theta = 360°$ $\quad v^2 = 2gl\left(\frac{3}{5} - 1\right) + u^2$	M1A1
	$v^2 > 0 \quad -2gl \times \frac{2}{5} + u^2 > 0$	M1
	$u^2 > \frac{4gl}{5}$	
	$u > 2\sqrt{\frac{gl}{5}}$ *	A1
		(4)

Question Number	Scheme	Marks
(c)	Equation of motion along radius at lowest point:	
	$T_1 - mg = \frac{mv^2}{l}$	M1A1
	$\theta = 180 \qquad v^2 = 2gl\left(\frac{3}{5}+1\right)+u^2$	M1
	$v^2 = \frac{16gl}{5}+u^2$	
	$T_1 = \frac{m}{l}\left(\frac{16gl}{5}+u^2\right)+mg$	
	$= \frac{21mg}{5}+\frac{mu^2}{l}$	A1
	At highest point:	
	$T_2 + mg = \frac{mv^2}{l}$	M1
	$\theta = 360 \qquad T_2 = 2mg\left(-\frac{2}{5}\right)+\frac{mu^2}{l}-mg$	M1
	$T_2 = \frac{mu^2}{l}-\frac{9mg}{5}$	A1
	$T_1 = 5T_2$	
	$\frac{21mg}{5}+\frac{mu^2}{l} = 5\left(\frac{mu^2}{l}-\frac{9mg}{5}\right)$	M1
	$\frac{66mg}{5} = \frac{4mu^2}{l}$	
	$u^2 = \frac{33gl}{10} \qquad *$	A1
		(9) **[17]**

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Mark Scheme (Results)

June 2011

GCE Mechanics M3 (6679) Paper 1

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June 2011
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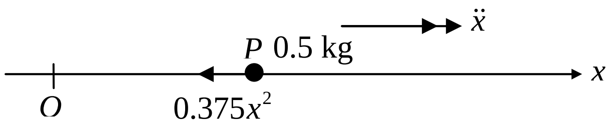
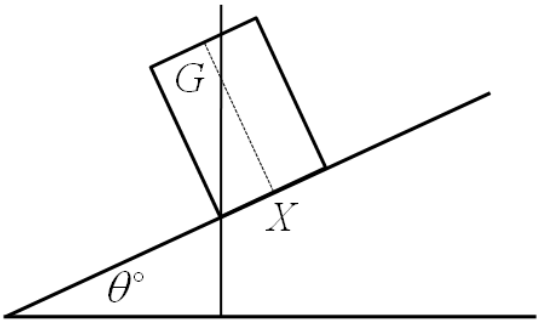
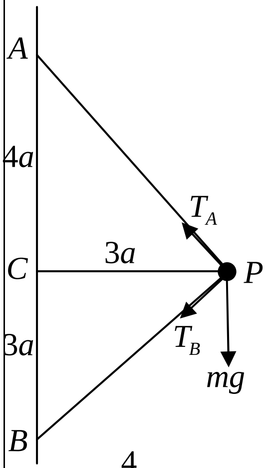
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper
   - □ The second mark is dependent on gaining the first mark

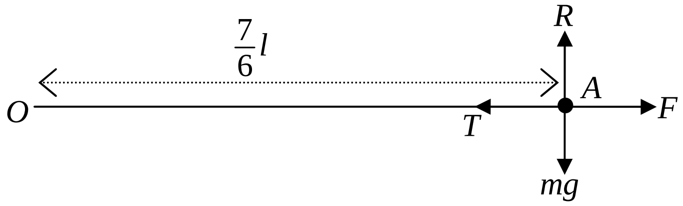
June 2011
Mechanics M3 6679
Mark Scheme

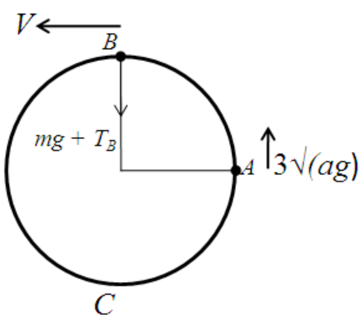
Question Number	Scheme	Marks
1. **(a)**		
	$0.5v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -0.375x^2$	M1
	$\dfrac{1}{2}v^2 = -0.25x^3 + c$	M1 A1
	$t = 0, v = 2, x = 8$	
	$\dfrac{1}{2}\times 2^2 = -0.25\times 8^3 + c$	
	$c = 130$	
	$\therefore v^2 = -\dfrac{1}{2}x^3 + 260$ *	A1
		(4)
(b)	$v = 5 \quad x^3 = 520 - 50$	M1
	$x = 7.77$	A1
		(2)
		6

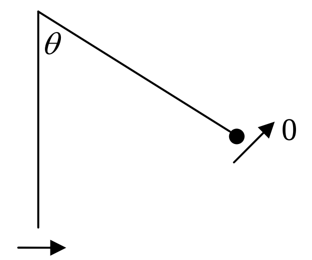
Question Number	Scheme	Marks
2.	$V=\pi\int_0^3 (9-x^2)^2\,dx=\pi\int_0^3 (81-18x^2+x^4)\,dx$	M1
	$=\pi\left[81x-6x^3+\frac{x^5}{5}\right]_0^3=\frac{648}{5}\pi$	M1 A1
	$\int_0^3 \pi(9-x^2)^2\,x\,dx$ OR: $\pi\int_0^3 (81x-18x^3+x^5)\,dx$	
	$=\frac{\pi}{6}\left[-(9-x^2)^3\right]_0^3$; $=\pi\left[\frac{81}{2}x^2-\frac{9}{2}x^4+\frac{1}{6}x^6\right]_0^3$	M1 A1
	$=\frac{\pi}{6}\left[0+(9)^3\right]$	
	$=\pi\left[\frac{81}{2}\times 3^2-\frac{9}{2}\times 3^4+\frac{1}{6}\times 3^6\right]$	M1
	$=\frac{243}{2}\pi$; $=\frac{243}{2}\pi$	A1
	$\bar{x}=\frac{\frac{243}{2}}{\frac{648}{5}}=\frac{15}{16}$ (accept 0.94)	M1 A1
		(9) **9**
3. (a)	Mass ratio: $\pi(3l)^2\times 5l\rho$; $\frac{2}{3}\pi(3l)^3\times 2\rho$; $81\pi l^3\rho$	
	5 ; 4 ; 9	B1
	Dist. from *O*: $\frac{5}{2}l$; $-\frac{3}{8}\times 3l$; $\bar{x}$	B1
	Moments equation:	
	$5\times\frac{5}{2}l-4\times\frac{9}{8}l=9\bar{x}$	M1 A1 ft
	$\bar{x}=\frac{8}{9}l$	A1
		(5)

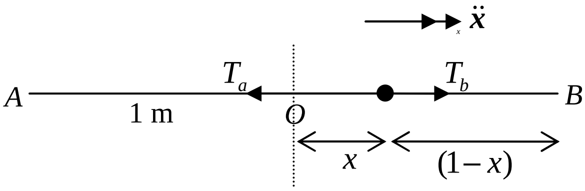
Question Number	Scheme	Marks
(b)		
	$GX = 5l - \frac{8}{9}l = \frac{37}{9}l$	B1ft
	$\tan\theta° = \frac{3l}{\frac{37}{9}l} = \frac{27}{37}$	M1 A1 ft
	$\theta° = 36.1°$ accept $36°$, 0.63 or 0.630 rad or better	A1
		(4)
		9

Question Number	Scheme	Marks
4. **(a)**		
	$\cos\theta = \frac{4}{5}$ or $\sin\theta = \frac{3}{5}$	B1
	R(vert) $T_B \cos 45 + mg = T_A \cos\theta$	M1 A1
	$\frac{1}{\sqrt{2}}T_B + mg = \frac{4}{5}T_A$	
	R(horiz) $T_A \sin\theta + T_B \cos 45 = m \times 3a\omega^2$	M1 A1=A1
	$\frac{3}{5}T_A + \frac{1}{\sqrt{2}}T_B = 3ma\omega^2$	
	$\frac{3}{5}T_A - mg = 3ma\omega^2 - \frac{4}{5}T_a$	M1
	$\frac{7}{5}T_A = 3ma\omega^2 + mg$	
	$T_A = \frac{5}{7}m\left(3a\omega^2 + g\right)$ *	A1 (8)
(b)	$T_b = \sqrt{2}\left(\frac{4}{5}T_a - mg\right)$	M1
	$= \sqrt{2}\left(\frac{4}{7}m\left(3a\omega^2 + g\right) - mg\right)$	
	$= \frac{3\sqrt{2}}{7}m\left(4a\omega^2 - g\right)$ oe	A1
		(2)

Question Number	Scheme	Marks
(c)	$T_b \geqslant 0 \Rightarrow 4a\omega^2 \geqslant g$	M1
	$\omega^2 \geqslant \frac{g}{4a}$	
	$\omega \geqslant \frac{1}{2}\sqrt{\frac{g}{a}}$ *	A1
	(Allow strict inequalities in (c).)	
		(2)
		12
5. (a)		
	$T = \frac{3mg}{l}\left(\frac{1}{6}l\right) = \frac{1}{2}mg$	B1
	R$(\uparrow)$ $R = mg$ R$(\rightarrow)$ $F = T = \frac{1}{2}mg$	M1
	$F \leqslant \mu R$	
	$\frac{1}{2}mg \leqslant \mu mg$	M1
	$\mu \geqslant \frac{1}{2}$ *	A1
		(4)
(b)	E.P.E. lost = $\frac{1}{2} \times \frac{3mg}{l}\left(\frac{1}{2}l\right)^2 = \frac{3mgl}{8}$	B1
	Work done by friction $= \frac{1}{2}mg\left(\frac{l}{2}\right)$	B1
	$\frac{3mgl}{8} = \frac{1}{2}mv^2 + \frac{1}{2}mg\left(\frac{l}{2}\right)$	M1 A1ft
	$v^2 = \frac{gl}{4}$	
	$v = \frac{1}{2}\sqrt{gl}$	A1
		(5)

Question Number	Scheme	Marks
(c)	$\frac{3mgl}{8} = \frac{1}{2}mgx$	M1 A1 ft
	$x = \frac{3l}{4}$	A1
		(3)
		12
6.	 	
(a)	Energy to B:	
	$\frac{1}{2}m\left(3\sqrt{ag}\right)^2 - \frac{1}{2}\times mV^2 = mag$	M1 A1
	$9ag - V^2 = 2ag$	
	$V^2 = 7ag$	
	NL2 along radius at B:	
	$T_B + mg = m\frac{V^2}{a}$	M1 A1
	$T_B + mg = 7mg$	M1
	$T_B = 6mg$	
	$T_B > 0 \Rightarrow$ particle reaches B	A1
		(6)

Question Number	Scheme	Marks
(b)	Energy to C:	
	$\frac{1}{2}\times mU^2 - \frac{1}{2}m\left(3\sqrt{ag}\right)^2 = mag$	M1
	$U^2 = 2ag + 9ag$	
	$U = \sqrt{11ga}$	A1
		(2)
(c)		
	$\frac{5}{12}\sqrt{11ag}$	
	Energy from C to rest:	
	$\frac{1}{2}\times m\times\left(\frac{5}{12}\sqrt{11ag}\right)^2 = mga\left(1-\cos\theta\right)$	M1 A1
	$\frac{25}{144}\times 11ag = 2ga\left(1-\cos\theta\right)$	
	$\cos\theta = \frac{1}{2}\left(2 - \frac{25\times 11}{144}\right)$	M1
	$\theta = 87.4...$	
	$\theta = 87°$ (or 1.5 rad) or better	A1
		(4)
		12

Question Number	Scheme	Marks
7.	 	
(a)	Total extn. = 0.6 $T_b = \dfrac{\lambda \times \text{ext}}{l} = \dfrac{2(0.3-x)}{0.7} = \dfrac{2}{7}(3-10x) \quad *$	M1 A1 (2)
(b)	$T_a = \dfrac{2(x+0.3)}{0.7} \quad \left(= \dfrac{2}{7}(10x+3) \right)$	B1 (1)
(c)	$T_b - T_a = 0.5\ddot{x}$ $\dfrac{2}{7}(3-10x) - \dfrac{2}{7}(10x+3) = 0.5\ddot{x}$ $2 \times \left(-\dfrac{20x}{7} \right) = 0.5\ddot{x}$ $\ddot{x} = -\dfrac{40}{7 \times 0.5}x$ $(\therefore \text{ S.H.M.})$ Period $= \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{7 \times 0.5}{40}} = 2\pi\sqrt{\dfrac{7}{80}} \quad *$	M1 A1 ft M1 A1 M1 A1 (6)
(d)	$v_{\max} = a\omega = 0.2\sqrt{\dfrac{80}{7}}$ o.e. or a.w.r.t. 0.68 m s^{-1}	M1 A1 (2)
(e)	$x = a\cos\omega t = 0.2\cos\left(\sqrt{\dfrac{80}{7}}t\right)$ $x = -0.1 \qquad -\dfrac{0.1}{0.2} = \cos\left(\sqrt{\dfrac{80}{7}}t\right)$ $t = \sqrt{\dfrac{7}{80}}\cos^{-1}(-0.5)$ $t = \sqrt{\dfrac{7}{80}} \times \dfrac{2\pi}{3} = \dfrac{\pi}{3}\sqrt{\dfrac{7}{20}}$ o.e. (accept a.w.r.t. 0.62) s	M1 A1 M1 A1 (4) **15**

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Mark Scheme (Results)

January 2012

GCE Mechanics M3 (6679) Paper 1

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January 2012
Publications Code UA030776

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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- dp decimal places
- sf significant figures
- * The answer is printed on the paper
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4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

General Principals for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to x = ...

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to x = …

2. Formula

Attempt to use correct formula (with values for a, b and c), leading to x = …

3. Completing the square

Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c, \quad q \neq 0$, leading to x = …

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \rightarrow x^{n-1}$)

2. Integration

Power of at least one term increased by 1. ($x^n \rightarrow x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are mistakes in the substitution of values.

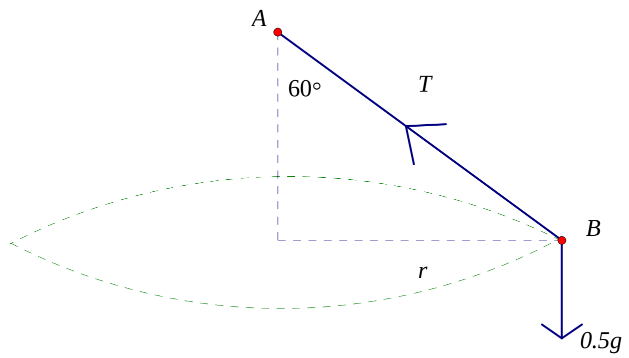
Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

January 2012
6679 Mechanics M3
Mark Scheme

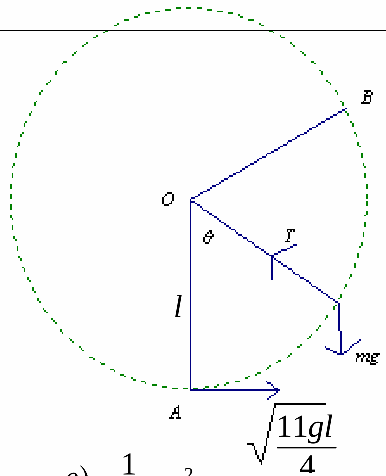
Question Number	Scheme	Marks
1.	EPE = $\dfrac{\lambda \times 0.5^2}{1.2}$	B1
	GPE lost = EPE gained	M1 (used)
	$0.8 \times 9.8 \times 1.1 = \dfrac{\lambda \times 0.5^2}{1.2}$	A1ft
	λ = 41.4 N or 41 N	A1
		4

Question Number	Scheme	Marks
2.		
(a)	$T = \frac{2\pi}{\omega} = \frac{2\pi}{3}, \quad \omega = 3$	B1
	$\lvert a \rvert = \omega^2 x = 9 \times 0.2 = 1.8\ \text{ms}^{-2}$ towards C	M1 A1
		(3)
(b)	$v^2 = \omega^2\left(a^2 - x^2\right) = 9(0.25 - 0.04) = 1.89$	M1
	$v = 1.37\ \text{ms}^{-1}$	A1
		(2)
(c)	$x = 0.5 \sin 3t = 0.2$	M1 A1ft
	$t = \frac{1}{3}\sin^{-1} 0.4 \approx 0.137\ \text{s}$	A1
		(3)
		8

Question Number	Scheme	Marks
3.		
(a)	$a = v\frac{dv}{dx} = \frac{10}{x+6} \times \frac{-10}{(x+6)^2}, \; = \frac{-100}{(x+6)^3}$	M1 M1, A1
	$= \frac{-100}{(14+6)^3} = -\frac{1}{80}\text{ ms}^{-2}$	A1
		(4)
(b)	$\frac{dx}{dt} = \frac{10}{x+6} \Rightarrow \int x+6dx = \int 10dt$	M1 M1
	$\left[\frac{x^2}{2}+6x\right]_2^{14} = [10t]_1^T$	M1 A1
	$\frac{196}{2} + 6\times14 - 2 - 12 = 10T - 10$	M1
	$178 = T \qquad T = 17.8\text{(s)}$	A1
		(6) **10**

Question Number	Scheme	Marks
4. **(a)**		
	$\uparrow$ $T\cos 60° = 0.5g$, $T = g$ (1)	M1, A1
	Extension in the string = x, $T = \dfrac{\lambda x}{a} = \dfrac{19.6x}{0.8}$	B1
	Using (1) , $g = 24.5x$, $x = 0.4$ m *	M1, A1
		(5)
(b)	$\rightarrow T\sin 60° = 0.5\times r\times \omega^2$ (2)	M1 A1
	Using (2) $g\sin 60° = 0.5\times(0.8+0.4)\sin 60°\omega^2$	M1 A1
	$\omega^2 = \dfrac{2g}{1.2}$, $\omega = \sqrt{\dfrac{5g}{3}}$ (4.04 or 4.0)	A1
		(5)
		10

Question Number	Scheme	Marks
5.		
(a)	Distance of P from the centre of the Earth = $R + x$	
	$F = \dfrac{k}{(R+x)^2}$	
	$x = 0$, $F = mg$, $k = mg(R)^2$	M1 A1
	$F = \dfrac{mgR^2}{(R+x)^2}$ *	A1
		(3)
(b)	$F = ma$, $-\dfrac{gR^2}{(R+x)^2} = v\dfrac{\mathrm{d}v}{\mathrm{d}x}$	M1 A1
	$\displaystyle\int_V^{\sqrt{\frac{gR}{2}}} v\,\mathrm{d}v = \int_R^{2R} -\frac{gR^2}{(R+x)^2}\mathrm{d}x$	M1 A1
	$\left[\dfrac{1}{2}v^2\right]_V^{\sqrt{\frac{gR}{2}}} = \left[\dfrac{gR^2}{R+x}\right]_R^{2R}$	M1 A1
	$\dfrac{1}{2}\times\dfrac{gR}{2} - \dfrac{1}{2}V^2 = \dfrac{gR^2}{3R} - \dfrac{gR^2}{2R} = -\dfrac{gR}{6}$	M1
	$\dfrac{V^2}{2} = \dfrac{gR}{4} + \dfrac{gR}{6} = \dfrac{5gR}{12}$ $V^2 = \dfrac{5gR}{6}$, $V = \sqrt{\dfrac{5gR}{6}}$	A1, A1
		(9) **12**

Question Number	Scheme	Marks
6. **(a)**		
	GPE gained = $mgl(1-\cos\theta)$	
	Conservation of energy: $\frac{1}{2}m\frac{11gl}{4} = mgl(1-\cos\theta)+\frac{1}{2}mv^2$	M1A1 A1
	$v^2 = gl\left(\frac{11}{4}-2+2\cos\theta\right) = gl\left(\frac{3}{4}+2\cos\theta\right)$	
	Resolving towards the centre of the circle:	M1
	$T - mg\cos\theta = \frac{mv^2}{l}$	A1 A1
	$T - mg\cos\theta = mg\left(\frac{3}{4}+2\cos\theta\right)$	M1
	$T = mg\left(\frac{3}{4}+3\cos\theta\right) = 3mg\left(\cos\theta+\frac{1}{4}\right)$ *	A1
		(8)
(b)	$T = 0 \Rightarrow \cos\theta = -\frac{1}{4}$	M1
	$v^2 = gl\left(\frac{3}{4}+2\cos\theta\right) = \frac{gl}{4}$, $v = \sqrt{\frac{gl}{4}}$	M1, A1
		(3)
(c)	Horizontal component of velocity at B	
	$= \sqrt{\frac{gl}{4}} \times \cos(180-\theta) = \frac{1}{4}\sqrt{\frac{gl}{4}}$	B1ft
	Extra height $h \Rightarrow mgh + \frac{1}{2}m\frac{gl}{64} = \frac{1}{2}m\frac{gl}{4}$	M1 A1
	$h = \left(\frac{1}{8}-\frac{1}{128}\right)l = \frac{15l}{128}$ $(0.117l)$	A1
	OR: Using $h = \frac{v^2\sin^2\theta}{2g} = \frac{\frac{gl}{4}\times\frac{15}{16}}{2g} = \frac{15l}{128}$	(4)
	OR: Using $v^2 = u^2 + 2as$, $0 = \frac{15gl}{64} - 2gh$, $h = \frac{15l}{128}$	
		15

Question Number	Scheme	Marks
7.		
(a)	$\int \pi y^2 \mathrm{d}x = \frac{\pi}{4}\int x^2(6-x)^2 \mathrm{d}x = \frac{\pi}{4}\int 36x^2 - 12x^3 + x^4 \mathrm{d}x$	M1 A1
	$= \frac{\pi}{4}\left[12x^3 - 3x^4 + \frac{x^5}{5}\right]_2^6 = \frac{\pi}{4}\times\frac{1024}{5}$	M1
	(160.8….)	
	$\int \pi y^2 x \mathrm{d}x = \frac{\pi}{4}\int x^3(6-x)^2 \mathrm{d}x = \frac{\pi}{4}\int 36x^3 - 12x^4 + x^5 \mathrm{d}x$	M1 A1
	$= \frac{\pi}{4}\left[9x^4 - \frac{12}{5}x^5 + \frac{1}{6}x^6\right]_2^6 = \frac{\pi}{4}\times\frac{10496}{15}$	M1
	(549.5……)	
	$\Rightarrow \bar{x} = \frac{10496}{15}\times\frac{5}{1024} = 3.416......$	M1 A1
	Required distance $\approx 3.42 - 2 = 1.42$(cm) *	A1
		(9)
(b)	Base has radius $\frac{1}{2}\times 2\times 4 = 4$ cm	B1
	About to topple $\Rightarrow \tan\alpha = \frac{4}{1.42}$	M1 A1
	$\alpha \approx 70.5°$	A1
		(4)
(c)	Parallel to slope: $F = mg\sin\beta$	
	Perpendicular to the slope: $R = mg\cos\beta$	M1 A1
	About to slip: $F = \mu R$	
	$\tan\beta = \mu = 0.3, \quad \beta \approx 16.7°$	A1
		(3)
		16

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Mark Scheme (Results)

Summer 2012

GCE Mechanics M3
(6679) Paper 1

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Summer 2012
Publications Code UA032681

Summer 2012
6679 Mechanics 3
Mark Scheme

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso – correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌈ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

General Principles for Mechanics Marking

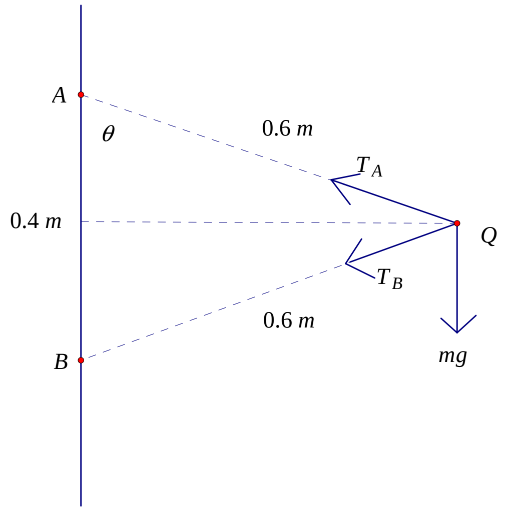
Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
Omission or extra g in a resolution is accuracy error not method error.
Omission of mass from a resolution is method error.
Omission of a length from a moments equation is a method error.
Omission of units or incorrect units is not (usually) counted as an accuracy error.
DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
Use of g = 9.81 should be penalised once per (complete) question.
N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.
However, premature approximation should be penalised every time it occurs.
MARKS MUST BE ENTERED IN THE SAME ORDER AS THEY APPEAR ON THE MARK SCHEME.

In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

Accept column vectors in all cases.

Summer 2012
6679 Mechanics M3
Mark Scheme

Question Number	Scheme	Marks
1(a)	Use of $a = v\frac{\mathrm{d}v}{\mathrm{d}x}$ or $a = \frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{1}{2}v^2\right)$	M1
	$a = 2e^{-x}.-2e^{-x}$ or $v^2 = 4e^{-2x}$	A1
	$a = -4e^{-2x}$	A1
		(3)
(b)	Separate the variables and attempt to integrate:	M1
	$\int 2\mathrm{d}t = \int e^x \mathrm{d}x$	
	$2t = e^x + C$	A1A1
	t=0, x=0 $\Rightarrow C$=-1, $2t = e^x - 1$	M1A1
	$x = \ln(2t+1)$	A1
		(6)
		9
2(a)	$T = \frac{2\pi}{\omega} \Rightarrow \omega = 4$	B1
	Use of $v^2 = \omega^2(v^2 - x^2)$, or $v = a\omega$	M1
	a = 1.5 (m)	A1
		(3)
(b)	Use of max. accn. = $\omega^2 a$	M1
	24 ms^{-2}	A1
		(2)
(c)	$x = a\sin\omega t$ with their values for a & ω	B1
	$1 = 1.5\sin 4t$ (with their 1.5 & 4) and attempt to solve for t	M1
	t = 0.18 (or awrt)	A1
		(3)
		8

Question Number	Scheme	Marks
3		
	$\cos\theta = \frac{0.2}{0.6}\left(=\frac{1}{3}\right)$	B1
	Resolve vertically: $T_A\cos\theta = T_B\cos\theta + mg \quad (T_A = T_B + 3mg)$	M1 A2,1,0
	Acceleration towards the centre: $T_A\sin\theta + T_B\sin\theta = m\times 0.6\sin\theta\times\omega^2 \quad \left(T_A + T_B = 5\times\frac{3}{5}\times 100 = 300\right)$	M1 A2,1,0
	Substitute values for ω and trig functions and solve to find T_A or T_B $T_B + 147 + T_B = 300, \quad 2T_B = 300 - 147 = 153$ $T_A = 223.5(\text{N})$, $T_B = 76.5(\text{N})$ $T_A = 224$ or 220 $T_B = 76$ $T_B = 76.5$ or 77 $T_A = 223$	M1 A1,A1
		(10) **10**

Question Number	Scheme	Marks
4 (a)		

	volume	Mass ratio	C of M from V
Large cone	$\frac{1}{3}\pi a^2.2a = \frac{2}{3}\pi a^3$	2	$\frac{3}{4}\times 2a = \frac{3}{2}a$
Small cone	$\frac{1}{3}\pi a^2.a = \frac{1}{3}\pi a^3$	1	$a + \frac{3}{4}a = \frac{7}{4}a$
S	$\frac{1}{3}\pi a^2.a = \frac{1}{3}\pi a^3$	1	D

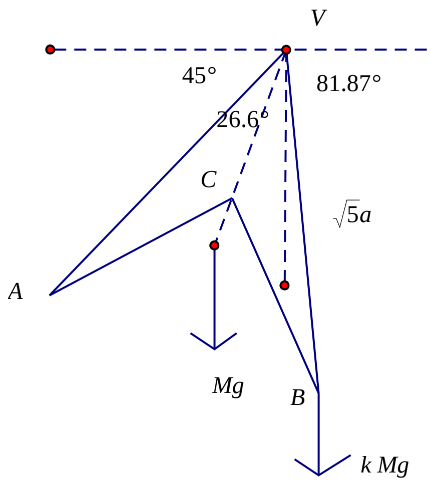
B1, B1

$1\times D = 2\times\frac{3}{2}a - 1\times\frac{7}{4}a$ M1A1

$= \frac{12-7}{4}a = \frac{5}{4}a$ ** A1

(5)

(b)



$45° + 26.6°(= 71.6°)$, $(81.8698...... =)81.9°$

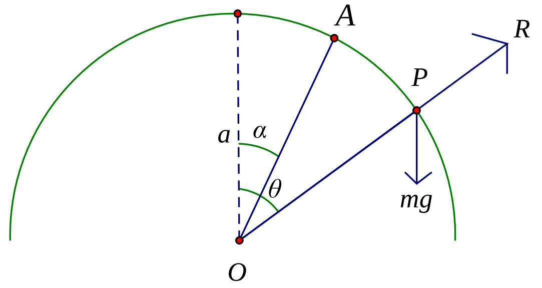
Take moments about V: M1

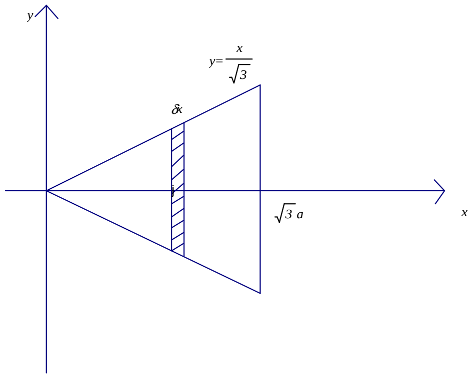
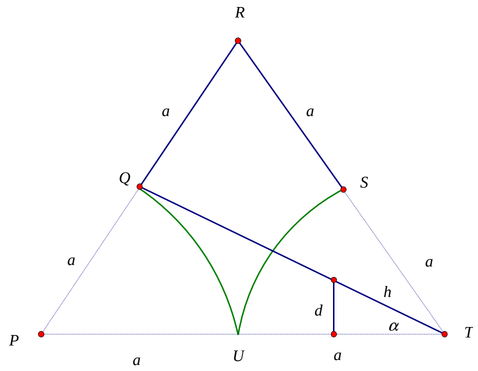
$$Mg\times\frac{5}{4}a\times\cos 71.6 = kMg\times\sqrt{5}a\times\cos 81.9$$ A2

$$k = \frac{5\cos 71.6}{4\sqrt{5}\cos 81.9} = 1.25$$ M1A1

(5)

10

Question Number	Scheme	Marks
5(a)		
	Conservation of energy : Loss in GPE = gain in KE	M1
	$mga(\cos\alpha - \cos\theta) = \frac{1}{2}mv^2$	A2,1,0
	Substitute for $\cos\alpha$ and rearrange to **given answer**:	A1
	$v^2 = \frac{2mga}{m}\left(\frac{3}{5} - \cos\theta\right) = \frac{2ga}{5}(3 - 5\cos\theta)$ *	
		(4)
(b)	Considering the acceleration towards the centre of the hemisphere:	M1
	$mg\cos\theta - R = \frac{mv^2}{a}$	A2,1,0
	Substitute for v^2 to form expression for R:	DM1
	$R = mg\cos\theta - \frac{mv^2}{a} = mg(3\cos\theta - 2\cos\alpha)\left(= mg\left(3\cos\theta - \frac{6}{5}\right)\right)$	A1
	Loses contact with the surface when $R = 0$	M1
	$\cos\theta = \frac{2}{5}$	A1
	$v^2 = \frac{2ga}{5}, \quad v = \sqrt{\frac{2ga}{5}}$	A1
		(8) **12**
Alt:	$R = 0 \Rightarrow mg\cos\theta = \frac{mv^2}{a}$	DM1
	$\cos\theta = \frac{v^2}{ga}$	A1
	Substitute in given (a) $v^2 = \frac{2ga}{5}\left(3 - 5\frac{v^2}{ga}\right)$	M1
	$v^2 = \frac{6ga}{5} - 2v^2, \quad 3v^2 = \frac{6ga}{5}$	A1
	$v = \sqrt{\frac{2ga}{5}}$	A1

Question Number	Scheme	Marks
6(a)		
	Mass of lamina = $\rho\frac{1}{2}\times 2a\times\sqrt{3}a=\sqrt{3}\rho a^2$	B1
	$\sum \rho x\times\frac{2x}{\sqrt{3}}\times\delta x=\rho\int_0^{\sqrt{3}a}\frac{2x^2}{\sqrt{3}}\mathrm{d}x$	M1
	$=\rho\left[\frac{2x^3}{3\sqrt{3}}\right]_0^{\sqrt{3}a}$	A1
	$=\rho\frac{2\times3\sqrt{3}a^3}{3\sqrt{3}}=2\rho a^3$	A1
	Distance from vertex = $\frac{2\rho a^3}{\sqrt{3}\rho a^2}=\frac{2}{3}a\sqrt{3}$ **	M1A1
		(6)
(b)		
	Area of each sector $=\frac{1}{6}\pi a^2$	B1
	Using sector formula, $d=h\sin\alpha=\frac{2a\sin\alpha}{3\alpha}\sin\alpha=\frac{a}{3\frac{\pi}{6}}\times\frac{1}{2}=\frac{a}{\pi}$	B2,1,0
	Taking moments: $\left(\sqrt{3}a^2-2\times\frac{\pi a^2}{6}\right)D=\sqrt{3}a^2\times\frac{\sqrt{3}a}{3}-2\times\frac{\pi a^2}{6}\times\frac{a}{\pi}$	M1A1

Question Number	Scheme	Marks
	$D=\dfrac{\frac{2a^3}{3}}{\left(\sqrt{3}-\frac{\pi}{3}\right)a^2}=\dfrac{2a}{3\sqrt{3}-\pi}$ **	A1 (6) **12**

Question Number	Scheme	Marks
7(a)	Use of $T = \frac{\lambda x}{a} = mg$	M1
	$T = \frac{24.5x}{0.75} = 0.5g$	A1
	$x = \frac{0.75 \times 0.5g}{24.5} = 0.15, \quad AE = 0.75 + 0.15 = 0.9$ (m) **(**)**	A1
		(3)
(b)	Using gain in EPE = loss in GPE	M1
	$\frac{\lambda x^2}{2a} = \frac{24.5x^2}{1.5} = ...$	A1
	….. $= 0.5g(0.75 + x)$	A1
	Form quadratic in x and attempt to solve for x :	DM1
	$24.5x^2 = 5.5125 + 7.35x, \quad 24.5x^2 - 7.35x - 5.5125 = 0,$	
	$x = \frac{7.35 \pm \sqrt{7.35^2 + 4 \times 24.5 \times 5.5125}}{49}$	
	(or $40x^2 - 12x - 9 = 0, \quad x = \frac{12 \pm \sqrt{144 + 3600}}{80}$)	
	$x = 0.647...$ (m) $\quad AC \approx 1.4$ (m)	A1
		(5)
(c)	Using $F = ma$ and displacement x from E:	M1
	$0.5g - \frac{24.5(x + 0.15)}{0.75} = 0.5\ddot{x}$	A2,1,0
	$\ddot{x} = -\frac{196}{3}x$, so SHM	A1
		(4)
(d)	Max speed = their a x their ω	M1
	$= (0.647 - 0.15) \times \sqrt{\frac{196}{3}}$	
	$\approx 4.0 \text{ ms}^{-1}$ (4.02)	A1
		(2)
		14

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Mark Scheme (Results)

January 2013

GCE Mechanics – M3 (6679/01)

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January 2013
Publications Code UA034768

General Marking Guidance

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- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Unless indicated in the mark scheme a correct answer with no working should gain full marks for that part of the question.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
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- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

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These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark.
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ or AG: The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but incorrect answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of ‘0’ or ‘1’ for each mark, or “trait”, as shown:

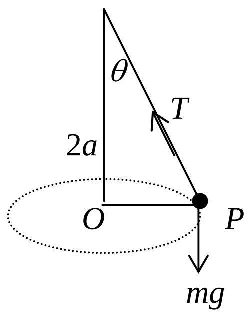
	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

January 2013
6679 M3
Mark Scheme

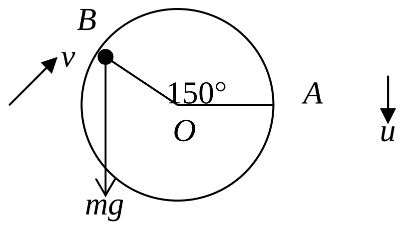
Question Number	Scheme	Marks
1.	$v\dfrac{\mathrm{d}v}{\mathrm{d}x} = 9x$	M1
	$\dfrac{1}{2}v^2 = 9x \quad (+c)$	A1
	$v^2 = 9x^2 + c$	M1dep
	$x = 2 \;\; v = 6 \quad 36 = 9\times 4 + c \Rightarrow c = 0$	
	$v^2 = 9x^2$	A1

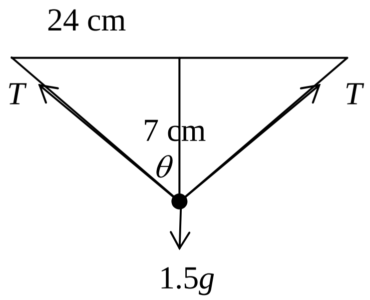
Question Number	Scheme	Marks
2 (a)		
	Mass: $\frac{2}{3}\pi r^3$ $\quad \frac{1}{3}k\pi r^3$	
	$2 \quad k \quad \| \quad 2+k$	B1
	Dist from *O*: $-\frac{3}{8}r \quad \frac{1}{4}kr \quad \| \quad \bar{x}$	B1
	$-\frac{3}{4}r+\frac{k^2r}{4}=\bar{x}(2+k)$	M1A1ft
	$\bar{x}=\frac{(k^2-3)r}{4(k+2)}$ *	A1
(b)		
	$\tan\theta=\frac{(k^2-3)r}{4(k+2)}\div r$	M1A1
	$\frac{(k^2-3)}{4(k+2)}=\frac{11}{14}$	
	$14k^2-42=44k+88$	
	$7k^2-22k-65=0$	
	$(7k+13)(k-5)=0$	
	$k=5$	M1depA1

Question Number	Scheme	Marks
3		
(a)	$0.6a = -\frac{12}{(t+2)^2}$	M1
	$0.6\int \mathrm{d}v = -\int \frac{12}{(t+2)^2}\,\mathrm{d}t$	
	$0.6v = \frac{12}{(t+2)} \quad (+c)$	M1depA1
	$t = 0 \quad v = 15 \qquad 0.6\times 15 = 6 + c \Rightarrow \quad c = 3$	M1dep
	$0.6v = \frac{12}{(t+2)} + 3 \qquad v = \frac{20}{(t+2)} + 5 = 5\left(\frac{4}{t+2} + 1\right)$ *	A1
(b)	$\frac{\mathrm{d}x}{\mathrm{d}t} = 5\left(\frac{4}{t+2} + 1\right)$	M1
	$x = \int 5\left(\frac{4}{t+2} + 1\right)\mathrm{d}t$	
	$x = 5\left(4\ln(t+2) + t\right) \quad (+c')$	M1depA1
	$t = 0,\ x = 0 \quad c' = -20\ln 2$	
	$t = 5 \quad x = 5\left(4\ln 7 + 5\right) - 20\ln 2$ $= 50.05... \ = 50.1$ or better	M1dep
	or $20\ln\left(\frac{7}{2}\right) + 25$	A1

Question Number	Scheme	Marks
4		
(a)	R$(\uparrow)$ $\quad T\cos\theta = mg$	M1
	$T\times\frac{2a}{(2a+x)} = mg$	A1
	Hooke's Law: $\quad T = \frac{6mgx}{2a} = \frac{3mgx}{a}$	M1A1
	$\frac{3mgx}{a}\times\frac{2a}{(2a+x)} = mg$	M1dep
	$6x = 2a + x$	
	$x = \frac{2}{5}a \qquad *$	A1
(b)	$T\sin\theta = \frac{mv^2}{r}$	M1A1
	$3mg\times\frac{2}{5}\sin\theta = \frac{mv^2}{\left(\frac{12a}{5}\right)\sin\theta}$	M1dep
	$v^2 = \frac{6}{5}g\times\frac{12a}{5}\sin^2\theta$	
	$\sin^2\theta = 1-\left(\frac{4a^2}{\left(\frac{12a}{5}\right)^2}\right) = \frac{11}{36}$	
	$v^2 = \frac{72ag}{25}\times\frac{11}{36} = \frac{22ag}{25}$	M1depA1

Question Number	Scheme	Marks
5		
(a)	$x = a\sin\omega t$	
	$0.125 = 0.25\sin 0.1\omega$	M1A1
	$\sin 0.1\omega = \frac{1}{2}$	
	$0.1\omega = \frac{\pi}{6}$	
	$\omega = \frac{\pi}{0.6} = \frac{10\pi}{6}$	M1depA1
	Period $= \frac{2\pi}{\omega} = \frac{6}{5} \quad (=1.2)$	A1 (B1 on e-pen)
(b)	$x = 0.25\sin\frac{5}{3}\pi t$	
	$t = 2 \quad x = 0.25\sin\left(2\times\frac{5}{3}\pi\right)$	M1
	$x = -0.2165...$	A1
	Dist from $B = 0.25 + x = 0.033$ m	A1 ft
(c)	Max accel $= a\omega^2 = 0.25\times\left(\frac{5\pi}{3}\right)^2 = 6.853... = 6.85$	M1A1
(d)	Max speed $a\omega = 0.25\times\left(\frac{5\pi}{3}\right) = 1.308... = 1.31$	M1A1

Question Number	Scheme	Marks
6		
(a)	At B $\quad mg\cos 60 \;(+R) = \dfrac{mv^2}{a}$	M1A1
	$\dfrac{1}{2}g = \dfrac{v^2}{a} \qquad v = \sqrt{\dfrac{ag}{2}}$ *	A1
(b)	Energy A to B: $\dfrac{1}{2}mu^2 - \dfrac{1}{2}m\left(\dfrac{ag}{2}\right) = mga\sin 30$	M1A1A1
	$u^2 = \dfrac{ag}{2} + 2ag \times \dfrac{1}{2}$	
	$u = \sqrt{\dfrac{3ag}{2}}$	A1
(c)	Horiz speed = $\sqrt{\dfrac{ag}{2}}\cos 60 \quad \left(= \dfrac{1}{2}\sqrt{\dfrac{ag}{2}}\right)$	M1A1
	Initial vert speed = $(-)\sqrt{\dfrac{ag}{2}}\sin 60 \quad \left(= (-)\dfrac{1}{2}\sqrt{\dfrac{3ag}{2}}\right)$	M1
	$v^2 = \dfrac{1}{4} \times \dfrac{3ag}{2} + 2g \times \dfrac{a}{2}$	M1A1
	$v^2 = \dfrac{11ag}{8}$	
	$\tan\theta = \dfrac{\text{vert}}{\text{horiz}} = \sqrt{\dfrac{11ag}{8} \times \dfrac{8}{ag}} = \sqrt{11}$	M1
	$\theta = 73.22... = 73$	A1

Question Number	Scheme	Marks
7 (a)	$T = \frac{\lambda x}{l} \Rightarrow 240 = \frac{\lambda \times 18}{30}$	M1A1
	$\lambda = 400$	A1
(b)		
	Extension = 10 cm or 20 cm (used in (b) or (c))	B1
	$T = \frac{400 \times 10}{15} = \left(\frac{800}{3}\right)$	M1A1ft
	R$(\uparrow)$ $2T\cos\theta - 1.5g = (\pm)1.5a$	M1A1
	$\frac{1600}{3} \times \frac{7}{25} - 1.5 \times 9.8 = (\pm)1.5a$	
	$a = 89.75...$ $a = 90$ m s^{-2} or 89.8 (positive)	A1
(c)	E.P.E. $= \frac{1}{2} \times 400 \times \frac{0.2^2}{0.3}$	B1ft (any correct EPE)
	$1.5g \times 0.07 + \frac{1}{2} \times 1.5v^2 = 200 \times \frac{0.2^2}{0.3} - \frac{200 \times 0.18^2}{0.3}$	M1A1A1
	$v^2 = \frac{1}{0.75}\left(200 \times \frac{0.2^2}{0.3} - \frac{200 \times 0.18^2}{0.3} - 1.5g \times 0.07\right)$	M1dep
	$v = 2.32... = 2.3$ m s^{-1}	A1

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Summer 2013

GCE Mechanics 3 (6679/01R)

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Summer 2013
Publications Code UA036430

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
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- sf significant figures
- * The answer is printed on the paper
- ⌜ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

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6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
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7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme

General Rules for Marking Mechanics

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is accuracy error not method error.

- Omission of mass from a resolution is method error.

- Omission of a length from a moments equation is a method error.

- Omission of units or incorrect units is not (usually) counted as an accuracy error.

- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

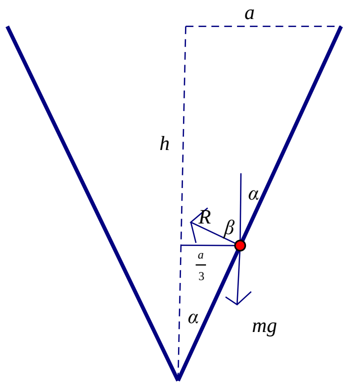
- Use of g = 9.81 should be penalised once per (complete) question.

- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.

- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- Accept column vectors in all cases.

- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Question Number	Scheme	Marks
1.		
	Vertical: $R\cos\beta = mg$	M1A1
	Horizontal: $R\sin\beta = \dfrac{mv^2}{r} = \dfrac{3mv^2}{a}$	M1A1
	Divide: $\tan\beta = \dfrac{3mv^2}{amg}$	M1dep
	$\tan\beta = \dfrac{h}{a}$	B1
	$\dfrac{3mv^2}{amg} = \dfrac{h}{a}$, $\dfrac{3v^2}{g} = h$, $v = \sqrt{\dfrac{hg}{3}}$ *AG*	A1
		(7)
		[7]

Question Number	Scheme	Marks
2.	$F = 1 + 3t^{\frac{1}{2}} = m\frac{\mathrm{d}v}{\mathrm{d}t} = 4\frac{\mathrm{d}v}{\mathrm{d}t}$	B1
	$4v = \int 1 + 3t^{\frac{1}{2}}\mathrm{d}t = t + 2t^{\frac{3}{2}}\left(+C\right)$	M1A1
	$v = \frac{1}{4}\left(t + 2t^{1.5}\right) + 2$	A1
	$t = 4, v = \frac{1}{4}\left(4 + 16\right) + 2 = 7$ (m s^{-1})	A1ft
	Work done = gain in KE = $\frac{1}{2}mv^2 - \frac{1}{2}mu^2$ their v	M1
	$= \frac{1}{2} \times 4 \times 7^2 - \frac{1}{2} \times 4 \times 2^2 = 90$ (J)	A1 **(7)** **[7]**

Question Number	Scheme	Marks
3. **(a)**	Weight + thrust = mass x accn. $0.5\times g+\dfrac{20\times 1}{2}=0.5a$ $a = g + 20 = 29.8 \approx 30$ (m s^{-2})	M1 B1(thrust) A1ft A1 **(4)**
(b)	Change in GPE = $mg(x+1)$ EPE at B $=\dfrac{20\times 1^2}{2\times 2}$ or EPE at C $=\dfrac{20\times x^2}{2\times 2}$ Conservation of energy: $\dfrac{20\times 1^2}{2\times 2}+mgh=\dfrac{20\times x^2}{2\times 2}$ $h=x+1$ $5+0.5g(x+1)=5x^2$ $5x^2-0.5gx-(5+.5g)=0$ $x=\dfrac{0.5g+\sqrt{(0.5g)^2+20(5+0.5g)}}{10}=1.98$ Distance BC = 1 + 1.98 = 2.98 (m)	B1 B1 M1A1 M1dep A1 **(6)** **[10]**

Question Number	Scheme	Marks
4. **(a)**	$v=\frac{4}{(x+2)}=\frac{\mathrm{d}x}{\mathrm{d}t}$	B1
	$\frac{\mathrm{d}t}{\mathrm{d}x}=\frac{x+2}{4}$; $\int_{t=0}^{t=2}1\mathrm{d}t=\frac{1}{4}\int_{x=0}^{x=X}(x+2)\mathrm{d}x$, $[t]_0^2=\frac{1}{4}\left[\frac{x^2}{2}+2x\right]_0^X$	M1,A1
	$2=\frac{X^2}{8}+\frac{X}{2}$,	
	$0=X^2+4X-16$, $X=\frac{-4+\sqrt{80}}{2}=2.47$ (m)	M1depA1
		(5)
(b)	$a\left(=\frac{\mathrm{d}v}{\mathrm{d}t}\right)=v\frac{\mathrm{d}v}{\mathrm{d}x}$	B1
	$=\frac{4}{(x+2)}\times\frac{-4}{(x+2)^2}$	M1A1
	$=\frac{-16}{(2.47+2)^3}=-0.1788...$ their X	M1dep
	0.18 (m s^{-2}) towards O.	A1
		(5) **[10]**

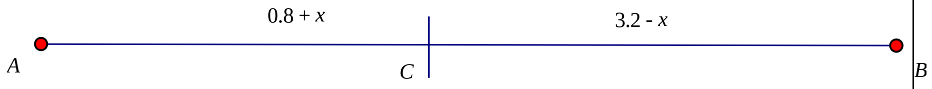
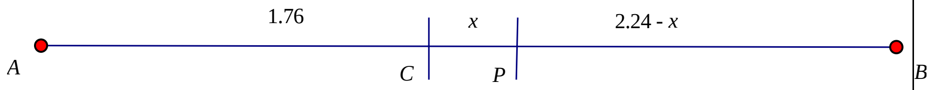
Question Number	Scheme	Marks
5. **(a)**	Use of Energy at A = energy at B	
	$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mgh$, $\frac{1}{2}mgr = \frac{1}{2}mv^2 + mg \times r(1-\cos\alpha)$	M1 A1A1
	$= \frac{1}{2}mv^2 + mg \times r \times \frac{1}{5}$	
	$v^2 = gr - \frac{2gr}{5} = \frac{3gr}{5}$	
	$v = \sqrt{\frac{3gr}{5}}$ *AG*	A1
		(4)
(b) **v1**	Horizontal component of speed at *B* and at *C* = their $v\cos\theta$	M1
	Vertical component of speed at B = their $v\sin\theta$	M1
	Conservation of energy gives speed at C = $\sqrt{\frac{2g}{5}}$	
	Vertical component of speed at C = $\sqrt{\frac{2g}{5} - \frac{16 \times 6g}{25^2}} \approx 1.5539..$	M1A1
	$v = u + at \Rightarrow$ $t = \frac{1.5539... + 0.92017...}{g} \approx 0.252..\text{seconds}$	M1A1
	Horizontal distance = $\frac{3}{5} \times 0.4 + 1.22689.. \times 0.252... = 0.55\,(\text{m})$	M1A1
		(8)
(b) **v2**	Horizontal component of speed at *B* and at *C* = their $v\cos\theta$	M1
	Vertical component of speed at B = their $v\sin\theta$	M1
	$s = ut + \frac{1}{2}at^2$: $-\frac{1}{5} \times 0.4 = -\frac{2}{25} = \sqrt{\frac{6g}{25}} \times \frac{3}{5}t - \frac{1}{2}gt^2$	M1A1
	$4.9t^2 - .92017..t - 0.08 = 0$	
	$t = \frac{0.920 + \sqrt{0.920^2 + 0.32 \times 4.9}}{9.8} = 0.252......$	M1A1
	Horizontal distance = $\frac{3}{5} \times 0.4 + 1.22689.. \times 0.252... = 0.55\,(\text{m})$	M1A1
		(8)

Question Number	Scheme	Marks
(b) **v3**	Horizontal component of speed at *B* and at *C* = their $v\cos\theta$	M1
	Vertical component of speed at B = their $v\sin\theta$	M1
	$s = ut + \frac{1}{2}at^2 \;:\; -\frac{1}{5}\times 0.4 = -\frac{2}{25} = \sqrt{\frac{6g}{25}}\times\frac{3}{5}t - \frac{1}{2}gt^2$	M1A1
	$4.9t^2 - .92017t - 0.08 = 0$	
	Horizontal distance from B $= 1.22689\ldots\times t = x$	
	Form quadratic in x by substituting for *t* above	M1
	$3.255x^2 - 0.75x - 0.08 = 0$	
	$x = \frac{0.75 + \sqrt{0.75^2 + 4\times 3.255\times 0.08}}{2\times 3.255} = 0.3097\ldots$	M1A1
	Horizontal distance = $\frac{3}{5}\times 0.4 + 0.3097\ldots = 0.55\,(\text{m})$	A1
		(8) **[12]**

Question Number	Scheme	Marks
6 (a) **v1**	Mass of quadrant = $\rho\dfrac{\pi a^2}{4}$	B1
	$\int_0^a \rho x\sqrt{a^2-x^2}\,\mathrm{d}x = \rho\left[-\frac{1}{3}\left(a^2-x^2\right)^{\frac{3}{2}}\right]_0^a$	M1A1 A1
	$= \rho\left[0+\frac{1}{3}a^3\right]$	A1
	$\rho\dfrac{\pi a^2}{4}\bar{x} = \rho\dfrac{a^3}{3}$	M1
	$\bar{x} = \dfrac{4a}{3\pi}$, $\bar{y} = \dfrac{4a}{3\pi}$ by symmetry *AG*	A1,A1
		(7)
(b)	(table below)	B1
	Moments about AE: $2a^2\bar{x} = 2a^2\dfrac{a}{2} + \dfrac{\pi a^2}{4}(a+\dfrac{4a}{3\pi}) - \dfrac{\pi a^2}{4}(a-\dfrac{4a}{3\pi})$	M1A2
	$= a^3 + \dfrac{2a^3}{3} = \dfrac{5a^3}{3}$	
	$\bar{x} = \dfrac{5a^3}{3}\times\dfrac{1}{2a^2} = \dfrac{5a}{6}$	A1
		(5)
(c)	Taking moments about E: $2aX = \dfrac{5a}{6}W$ their $\bar{x}$	M1A1ft
	$X = \dfrac{5}{12}W$	A1
		(3)
6 (a) **v2**	Mass of quadrant = $\rho\dfrac{\pi a^2}{4}$	B1
	$\int_0^{\frac{\pi}{2}} \rho\cdot\frac{1}{2}a^2\cdot\frac{2}{3}a\cos\theta\,\mathrm{d}\theta = \left[\dfrac{a^3}{3}\sin\theta\right]_0^{\frac{\pi}{2}} = \rho\dfrac{a^3}{3}$	M1A1,=A1
	$\rho\dfrac{\pi a^2}{4}\bar{x} = \rho\dfrac{a^3}{3}$	M1
	$\bar{x} = \dfrac{4a}{3\pi}$, $\bar{y} = \dfrac{4a}{3\pi}$ by symmetry *AG*	A1A1
		(7) **[15]**

Table for (b):

Area	$2a^2$	$\dfrac{\pi a^2}{4}$	$-\dfrac{\pi a^2}{4}$
Distance to AE	$\dfrac{a}{2}$	$a+\dfrac{4a}{3\pi}$	$a-\dfrac{4a}{3\pi}$

Question Number	Scheme	Marks
7 (a)		
	Tensions equal when *P* in equilibrium: $\frac{15\times x}{0.8}=\frac{10\times(2.4-x)}{0.8}$	M1A2
	$25x=24\,,\quad x=\frac{24}{25}=0.96$	
	AC = 1.76 (m) *AG*	A1
		(4)
(b)		
	When *P* is distance *x* from *C*, restoring force	M1A2
	$\frac{15\times(0.96+x)}{0.8}-\frac{10\times(1.44-x)}{0.8}=\frac{25}{0.8}x=-m\ddot{x}=-0.2\ddot{x}$	
	$\ddot{x}=-156.25x\left(=-12.5^2x\right)\quad\Rightarrow\quad$ SHM	A1
		(4)
(c)	Speed at *C* = max speed = $a\omega=0.4\times12.5=5\,(\text{m s}^{-1})$ 0.4 x their ω	M1A1ft
		(2)
(d)	$x=a\cos\omega t$ their ω	B1ft
	$\dot{x}=-a\omega\sin\omega t$ their ω	M1
	$(-)2=(-)5\sin12.5t$ their ω	A1ft
	$12.5t=0.4115.....,\quad t=0.0329.....\approx0.033\,(\text{s})$	A1
		(4) **[14]**

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Mark Scheme (Results)

Summer 2013

GCE Mechanics 3 (6679/01)

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Summer 2013
Publications Code UA036427

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes:

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme

General Rules for Marking Mechanics

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is accuracy error not method error.
- Omission of mass from a resolution is method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.
- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Question Number	Scheme	Marks
1.	$\text{R}(\uparrow)\quad R = mg$	
	$F = \mu mg$	B1
	20 revs per min $= \dfrac{20}{60} \times 2\pi$ rad s^{-1}	M1A1
	$\left(= \dfrac{2}{3}\pi \text{ rad s}^{-1}\right)$	
	$\text{R}(\rightarrow)\quad \mu mg = m \times 0.4 \times \left(\dfrac{2}{3}\pi\right)^2$	M1A1ft
	$\mu = \dfrac{0.4 \times 4\pi^2}{9g}$	
	$\mu = 0.18$ or 0.179	A1
		[6]

Notes for Question 1

B1 for resolving vertically and using $F = \mu R$ to obtain $F = \mu mg$. This may not be seen explicitly, but give B1 when seen used in an equation.

M1 for attempting to change revs per minute to rad s^{-1}, must see $(2)\pi$. (Can use 60 or 60^2)

A1 for $\dfrac{20}{60} \times 2\pi$ (rad s^{-1}) oe

M1 for NL2 horizontally along the radius - acceleration in either form for this mark, F or μmg or μm all allowed. r to be 0.4 now or later. This is not dependent on the previous M mark.

A1ft for $\mu mg = m \times 0.4 \times \left(\dfrac{2}{3}\pi\right)^2$ follow through on their ω

A1cso for $\mu = 0.18$ or 0.179, **must be 2 or 3 sf.**

NB: Use of $\leqslant$: is allowed, provided used correctly, until the final statement, which must be $\mu = \ldots$.

Question Number	Scheme	Marks
2		
(a)	$\left(2t+\frac{1}{2}\right)=0.5\frac{\mathrm{d}v}{\mathrm{d}t}$	M1
	$\int(4t+1)\,\mathrm{d}t=\int \mathrm{d}v$	
	$2t^2+t=v+c$	M1dep *c* not needed
	$t=0\ v=0 \qquad c=0$	
	$v=2t^2+t\ \ \mathrm{m\ s^{-1}}$	A1 inc the value for *c* (3)
(b)	$\frac{\mathrm{d}x}{\mathrm{d}t}=2t^2+t$	
	$x=\frac{2}{3}t^3+\frac{1}{2}t^2+k$	M1
	$t=0\ x=0 \qquad k=0$	
	$x=\frac{2}{3}t^3+\frac{1}{2}t^2$	A1
	$v=6 \quad 6=2t^2+t \quad 2t^2+t-6=0$	
	$(2t-3)(t+2)=0 \quad t=\frac{3}{2}$	M1A1
	$x=\frac{2}{3}\times\left(\frac{3}{2}\right)^3+\frac{1}{2}\left(\frac{3}{2}\right)^2$	M1dep
	$x=\frac{27}{8}$ (oe 3.4, 3.375, 3.38) m	A1 cso (6) **[9]**

Notes for Question 2

(a)

M1 for NL2 with acceleration in the form $\frac{dv}{dt}$, seen explicitly or implied by the integration mass can be 0.5 or m

M1dep for integrating with respect to t - constant not needed

A1cso for **showing** that $c = 0$ and giving the final result $v = 2t^2 + t$ Must see $t = 0, v = 0$ as a minimum

By definite integration:

M1 as above

M1dep for integrating, ignore limits

A1 for substituting the limits 0 and v and 0 and t and obtaining $v = 2t^2 + t$

(b)

M1 for integrating their v with respect to t constant not needed

A1 for **showing** that $k = 0$ If no constant shown this mark is lost.

M1 for setting $v = 6$ using their answer from (a) **and** attempting to solve the resulting quadratic equation, any valid method. If solved by calculator, **both** solutions must be shown.

A1 for $t = \frac{3}{2}$ negative solution need not be shown with an algebraic solution

M1dep for using **their** (positive) value for t to obtain x = ... If two positive values were obtained, then allow M1 for substituting either value. Dependent on the first M1 of (b) but not the second.

A1cso for $x = \frac{27}{8}$ (oe eg 3.375, 3.38) (All marks for (b) must have been awarded)

By definite integration:

M1 for integrating their v with respect to t limits not needed

A1 for correct integration with lower limits 0.

M1 for setting $v = 6$ using their answer from (a) **and** attempting to solve the resulting quadratic equation, any valid method. If solved by calculator, **both** solutions must be shown.

A1 for $t = \frac{3}{2}$ negative solution need not be shown with an algebraic solution

M1dep for substituting **their** limits into **their** integrated v (sub should be shown). Dependent on the first M1 of (b) but not the second

A1cso for $x = \frac{27}{8}$ (oe eg 3.375, 3.38)

Question Number	Scheme	Marks
3 (i)	For Q $T = 2mg$	B1
	For P $T\cos\theta = mg$	M1
	$\cos\theta = \frac{1}{2}$ $\theta = 60°$ *	A1cso
(ii)	For P $\rightarrow$ $T\sin\theta = mr\omega^2$	M1A1
	$2mg\sin\theta = m \times 5l\sin\theta \times \omega^2$	M1depA1
	$\omega^2 = \frac{2g}{5l}$ $\omega = \sqrt{\frac{2g}{5l}}$ *	A1cso
		[8]

Notes for Question 3

In this question, award marks as though the question is not divided into two parts - ie give marks for equations wherever seen.

(i)

B1 for using *Q* (no need to state Q being used) to state that $T = 2mg$ or $T_Q = 2mg$ with $T_P = T_Q$ seen or implied later.

M1 for attempting to resolve vertically for *P* *T* must be resolved but sin/cos interchange or omission of *g* are accuracy errors.
$mg + 2mg = T + T\cos\theta$ gets M0

A1cso for combining the two equations to obtain $\theta = 60°$ *

NB: This is a "show" question, so if no expression is seen for *T* and just $2mg\cos\theta = mg$ shown, award 0/3 as this equation could have been produced from the required result, so insufficient working.

(ii)

M1 for attempting NL2 for *P* along the radius. The mass used must be *m* if the particle is not stated to be *P*; a mass of 2*m* would imply use of *Q*. *T* must be resolved. Acceleration can be in either form.

A1 for $T\sin\theta = mr\omega^2$ or $T\frac{\sqrt{3}}{2} = mr\omega^2$

M1 dep for eliminating *T* between the two equations for *P* and substituting for *r* in terms of *l* and θ dependent on the second but not the first M mark.

A1 for $2mg\sin\theta = m \times 5l\sin\theta \times \omega^2$ or $\frac{T\sin\theta}{T\cos\theta} = \tan\theta = 5l\sin\theta\left(\frac{\omega^2}{g}\right)$ θ or 60°

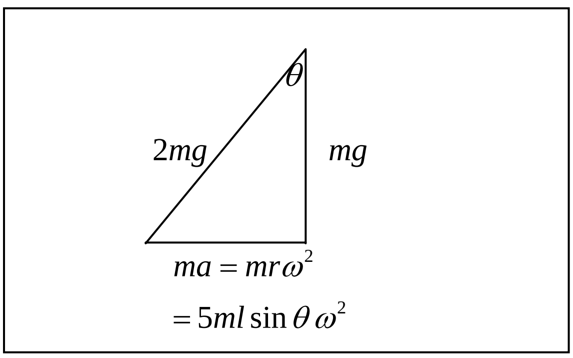
A1cso for re-arranging to obtain $\omega = \sqrt{\frac{2g}{5l}}$ * ensure the square root is correctly placed

Alternatives: Some candidates "cancel" the $\sin\theta$ without ever showing it.

M1A1 for $T = m \times 5l\omega^2$
M1A1 for $2mg = 5ml\omega^2$
A1cso as above

Vector Triangle method: **Triangle must be seen**

$T = 2mg$	B1
$\cos\theta = \frac{mg}{2mg}$	M1
$\theta = 60°$	A1
Correct triangle	M1A1
$\sin\theta = \frac{5ml\sin\theta\omega^2}{2mg}$	M1A1
$\omega = ...$	A1cso (as above)



Question Number	Scheme	Marks
4 **(a)**	$T = \dfrac{\lambda x}{l}$	
	$20 = \dfrac{\lambda \times 0.3}{1.2}$	M1A1
	$\lambda = 80$ N	A1
	Initial EPE = $\dfrac{\lambda x^2}{2l} = \dfrac{80 \times 0.3^2}{2.4}$ (= 3 J)	B1
	$\dfrac{80 \times 0.3^2}{2.4} - 0.4 \times 2g \times 0.3 = \dfrac{1}{2} \times 2v^2$	M1A1ft
	$v^2 = 0.648$	
	$v = 0.80$ or 0.805 m s^{-1}	A1 (7)
(b)	Comes to rest $0.4 \times 2g \times y = 3$	M1
	$y = \dfrac{3}{0.4 \times 2 \times 9.8} = 0.38$ or 0.383 m	A1 (2)
		[9]
	Alternatives: Energy from string going slack to rest:	
	$\dfrac{1}{2} \times 2 \times 0.648 = 0.4 \times 2g \times x$	
	$x = 0.8265...$	
	$y = 0.3 + 0.08265... = 0.38$ or 0.383	M1 Complete method A1
	NL2 to obtain the accel when string is slack $\left(-\dfrac{2g}{5}\right)$ and $v^2 = u^2 + 2as$	
	$0 = 0.648 + 2 \times \left(-\frac{2g}{5}\right)s$	
	$BC = \dfrac{0.648 \times 5}{4g} + 0.3 = 0.38$ or 0.383	M1A1

Notes for Question 4

(a)

M1 for attempting Hooke's Law, formula must be correct, either explicitly or by correct substitution.

A1 for $20 = \frac{\lambda \times 0.3}{1.2}$

A1 for obtaining $\lambda = 80$

B1 for the initial EPE $\frac{"\lambda" \times 0.3^2}{2.4}$ $(= 3 \text{ J})$ their value for λ allowed. May only be seen in the eqaution.

M1 for a work-energy equation with one EPE term, one KE term and work done against friction (Award if second EPE/KE terms included **provided** these become 0). The EPE must be dimensionally correct, but need not be fully correct (eg denominator 1.2 instead of 2.4)

A1ft for a completely correct equation follow through their EPE

A1 cao for $v = 0.80$ or 0.805 must be 2 or 3 sf

NB: This is damped harmonic motion (due to friction) so all SHM attempts lose the last 4 marks.

(b)

M1 for any **complete** method leading to a value for either *BC*. If the distance travelled after the string becomes slack is found the work must be completed by adding 0.3 Their EPE found in (a) used in energy methods.

MS method is energy from *B* to *C* ie work done against friction = loss of EPE.

OR Energy from point where the string becomes slack to *C* ie work done against friction = loss of KE and completed for the required distance

OR NL2 to obtain the acceleration $\left(-\frac{2g}{5}\right)$ while the string is slack **and** $v^2 = u^2 + 2as$ to find the distance and completed for the required distance

A1cso for $BC = 0.38$ or 0.383 (m) **must be 2 or 3 sf**

Question Number	Scheme	Marks
5(a)	$V=\int_0^2 \pi y^2\,\mathrm{d}x=\pi\int_0^2 (x+1)^4\,\mathrm{d}x$	M1
	$=\pi\left[\frac{1}{5}(x+1)^5\right]_0^2$	A1
	$=\frac{1}{5}\pi\left[3^5-1\right]\quad\left(=\frac{242\pi}{5}\right)$	M1
	$\int_0^2 \pi y^2 x\,\mathrm{d}x=\pi\int_0^2 x(x+1)^4\,\mathrm{d}x$	M1
	$=\pi\left[\frac{x(x+1)^5}{5}\right]_0^2-\pi\int_0^2\frac{(x+1)^5}{5}\mathrm{d}x,\ =\frac{2\times3^5\pi}{5}-\pi\left[\frac{(x+1)^6}{30}\right]_0^2$	A1
	$\left[\frac{2\times3^5}{5}-\frac{3^6}{30}+\frac{1}{30}\right]\pi\quad(=72.933...\pi)$	M1
	ALT: by expanding $=\pi\int_0^2\left(x^5+4x^4+6x^3+4x^2+x\right)\mathrm{d}x$	
	$=\pi\left[\frac{x^6}{6}+\frac{4}{5}x^5+\frac{6}{4}x^4+\frac{4}{3}x^3+\frac{1}{2}x^2\right]_0^2$	M1A1
	$=\pi\left[\frac{2^6}{6}+\frac{4}{5}\times2^5+\frac{6}{4}\times2^4+\frac{4}{3}\times2^3+\frac{1}{2}\times2^2\right]$	M1
	OR by subst: $\pi\int_1^3(u-1)u^4\mathrm{d}u,\ =\pi\left[\frac{u^6}{6}-\frac{u^5}{5}\right]_1^3,\ =\pi\left[\frac{3^6}{6}-\frac{3^5}{5}-\left(\frac{1}{6}-\frac{1}{5}\right)\right]$	M1A1M1
	$\bar{x}=\dfrac{\pi\left[\frac{2\times3^5}{5}-\frac{3^6-1}{30}\right]}{\frac{242\pi}{5}}$ OR $\dfrac{\pi\left[\frac{2^6}{6}+\frac{4\times2^5}{5}+\frac{6\times2^4}{4}+\frac{4\times2^3}{3}+\frac{2^2}{2}\right]}{\frac{242\pi}{5}},\ =1.5068$	M1, A1 (8)
(b)	hemisphere $\quad S \quad T$	
	Mass ratio $\quad 10\times\frac{2\pi}{3}\times1 \quad \frac{242\pi}{5} \quad \left(\frac{20}{3}+\frac{242}{5}\right)\pi=\frac{826}{15}\pi$	B1ft on S
	Dist from A $\quad 2+\frac{3\times1}{8} \quad 0.493 \quad \bar{x}$	B1ft on S
	$\frac{20}{3}\times\frac{19}{8}+\frac{242}{5}\times0.493=\left(\frac{20}{3}+\frac{242}{5}\right)\bar{x}$	M1A1ft
	$\bar{x}=0.7208...$ cm (awrt 0.72)	A1 (5) **[13]**

Notes for Question 5

NB: Some candidates will omit π throughout (as they know it cancels). In such cases award all marks if earned. If π is omitted from one integration only but then appears in the result of that integration at the last stage or is then omitted from the second integration, all marks can be gained. But if omitted from one integration, including the last stage, and included with the other mark strictly according to the MS.

(a)

M1 for using $V=\int_0^2 \pi y^2 \, dx=\pi\int_0^2 (x+1)^4 \, dx$ - limits not needed and attempting the integration by inspection or expansion (algebra **must** be seen)

A1 for correct integration - limits not needed

M1 for substituting the correct limits into **their** integrated function - no need to simplify

M1 for attempting to integrate $\int_0^2 \pi y^2 x \, dx=\pi\int_0^2 x(x+1)^4 \, dx$ - limits not needed - by parts. This mark can be awarded once the integral has been expressed as the difference of an appropriate integrated function and an integral

A1 for correct, complete integration $\pi\left[\frac{x(x+1)^5}{5}\right]_0^2-\pi\left[\frac{(x+1)^6}{30}\right]_0^2$ or $\frac{2\times 3^5\pi}{5}-\pi\left[\frac{(x+1)^6}{30}\right]_0^2$ Limits not needed

M1 for substituting the correct limits into **their** integrated function - no need to simplify

Alternative methods for $\int_0^2 \pi y^2 x \, dx=\pi\int_0^2 x(x+1)^4 \, dx$

M1 for expanding and integrating or making a suitable substitution and attempting the integration - limits not needed

A1 for correct integration - limits not needed

M1 for substituting the correct limits into **their** integrated function - no need to simplify

M1 for using $\bar{x}=\dfrac{\int \pi y^2 x dx}{\int \pi y^2 dx}$ Their integrals need not be correct.

A1cao for $\bar{x}=1.5068...$ Accept 1.5, 1.51 or better or $\frac{547}{363}$

(b)

B1ft for correct mass ratio, follow through their volume for *S* need π now

B1ft for correct distances, follow through their distance for *S*, but remember it must be 2 - answer from (a) if working from *A*. Distances from the common face are $-\frac{3}{8}$, ans from (a), $\bar{x}$ Distances from other end are $\frac{5}{8}$, $1+$ans from (a), $\bar{x}$

M1 for a dimensionally correct moments equation

A1ft for a fully correct moments equation, follow through their distances and mass ratio

A1cao for 0.7208...Accept 0.72 or better (Exact is $\frac{1191}{1652}$)

Question Number	Scheme	Marks
6(a)	$\frac{24e}{1.5}=\frac{18(1.5-e)}{0.75}$	M1A1
	$16e=36-24e$	
	$e=0.9$	A1
	$AO=2.4\text{ m}$*	A1ft (4)
(b)	$\frac{18(0.6-x)}{0.75}-\frac{24(0.9+x)}{1.5}=m\ddot{x}$ or $0.8\ddot{x}$	M1A1A1
	$14.4-24x-14.4-16x=m\ddot{x}$ or $0.8\ddot{x}$	
	$\ddot{x}=-\frac{40x}{0.8\text{ or }m}$ $(=-50x)$ $\therefore$ SHM	M1depA1 (5)
(c)	$\ddot{x}=-50x\Rightarrow\omega=\sqrt{50}$ or $5\sqrt{2}$	B1
	max. speed = $\sqrt{2}$ $\Rightarrow$ $a\times5\sqrt{2}=\sqrt{2}$	M1
	$a=\frac{1}{5}$	A1
	$-0.1=0.2\cos\left(5\sqrt{2}\right)t$	M1
	$t=\frac{1}{5\sqrt{2}}\cos^{-1}\left(-\frac{1}{2}\right)$	
	$t=\frac{1}{5\sqrt{2}}\times\frac{2\pi}{3}=\frac{\pi\sqrt{2}}{15}$ or 0.296s $(0.2961...)$ Accept 0.30, or better	A1 (5)
		[14]

Notes for Question 6

(a)

M1 for using Hooke's Law for each string, equating the two tensions and solving to find the extension in either string. The extensions should add to 1.5. The formula for Hooke's law must be correct, either shown explicitly in its general form or implicitly by the substitution.

A1 for a correct equation

A1 for $e = 0.9$

A1cso for 2.4 (m) *

Alternative: Find the ratio of the two extensions and divide 1.5 m in that ratio.
M1 complete method A1 correct ratio A1 extension in *AO*
A1 2.4 (m)

(b)

M1 for an equation of motion for *P*. There must be a difference of two tensions. The acceleration can be *a* or $\ddot{x}$ here and *x* should be measured from the equilibrium position (*O*) unless a suitable substitution is made later. Mass can be *m* or 0.8

A1,A1 for $\frac{18(0.6-x)}{0.75}-\frac{24(0.9+x)}{1.5}=m\ddot{x}$ or $0.8\ddot{x}$ or *a* instead of $\ddot{x}$ Give A1A1 if the equation is completely correct and A1 if only one error. Note that if the difference of the tensions is the wrong way round, this is *one* error

M1dep for simplifying to $\ddot{x}=\mathrm{f}(x)$ Must be $\ddot{x}$ now.

A1 for $\ddot{x}=-\frac{40x}{0.8 \text{ or } m}$ $(=-50x)$ **and the conclusion** (ie $\therefore$ SHM)

(c)

B1 for $\omega=\sqrt{50}$ or $5\sqrt{2}$ need not be shown explicitly

M1 for using max speed $= a\omega=\sqrt{2}$ with **their** ω

A1 for $a=\frac{1}{5}$

M1 for using $x=a\cos\omega t$ with **their** ω and *a* and $x=\pm(0.3-a)$ **or** $x=a\sin\omega t$ provided the work is completed by adding a quarter of their period is added to the time to complete the method.

A1cao for $t=\frac{\pi\sqrt{2}}{15}$ or 0.296 s $(0.2961...)$ Accept 0.30 or better

Question Number	Scheme	Marks
7 **(a)**	$T - 5mg\cos\theta = \dfrac{5mv^2}{a}$	M1A1
	$\dfrac{1}{2}\times 5mv^2 - \dfrac{1}{2}\times 5m\times\dfrac{9ag}{5} = 5mga\cos\theta$	M1A1
	$5mv^2 = 10mga\cos\theta + 9mga$	
	$T = 5mg\cos\theta + 10mg\cos\theta + 9mg$	M1dep
	$T = 3mg\left(5\cos\theta + 3\right)$ *	A1 (6)
(b)	$T = 0 \quad \cos\theta = -\dfrac{3}{5}$	B1
	$v^2 = \dfrac{9ag}{5} - \dfrac{6ag}{5} = \dfrac{3ag}{5}$	M1
	$v = \sqrt{\dfrac{3ag}{5}}$	A1 (3)
(c)	horiz comp of vel at $B = \sqrt{\dfrac{3ag}{5}}\times\dfrac{3}{5}$	M1
	vert comp = $\sqrt{\dfrac{3ag}{5}}\times\dfrac{4}{5}$	M1
(i)	$x = -\dfrac{4a}{5} + \dfrac{3}{5}\sqrt{\dfrac{3ag}{5}}t$	M1depA1
	$y - \dfrac{3a}{5} = \dfrac{4}{5}\sqrt{\dfrac{3ag}{5}}t - \dfrac{1}{2}gt^2$	M1depA1ft
(ii)	$y = \dfrac{4}{5}\sqrt{\dfrac{3ag}{5}}t - \dfrac{1}{2}gt^2 + \dfrac{3a}{5}$	A1 (7) **[16]**

Notes for Question 7

(a)

M1 for attempting NL2 along the radius when the string makes an angle θ with the downward vertical. The acceleration can be in either form, the weight must be resolved and T must be included (not resolved). Sin/cos interchange or omission of g are accuracy errors as is omission of 5 in one or both terms. Radius can be a or r.

A1 for a correct equation $T - 5mg\cos\theta = \frac{5mv^2}{a}$ Acceleration must be in the $\frac{v^2}{r}$ form now.

M1 for a conservation of energy equation from the horizontal to the same point. There must be a difference of 2 KE terms and a loss of PE term (which may be indicated by a difference of 2 PE terms). The initial KE can be $\frac{1}{2}\times mass \times \left(\sqrt{\frac{9ag}{3}}\right)^2$ or $\frac{1}{2}\times mass \times u^2$ for this mark. Omission of g and sin/cos interchange are accuracy errosr. Mass can be m or $5m$ here or just "mass". Use of $v^2 = u^2 + 2as$ gets M0

A1 for a fully correct equation $\frac{1}{2}\times(5m)v^2 - \frac{1}{2}\times(5m)\times\frac{9ag}{5} = (5m)ga\cos\theta$

M1dep for eliminating v^2 between the 2 equations. Dependent on both previous M marks.

A1cso for $T = 3mg(5\cos\theta + 3)$ *

(b)

B1 for obtaining $\cos\theta = -\frac{3}{5}$

M1 for using **their** value for $\cos\theta$ - must be numerical - in the energy equation to get $v^2 = ...$ (no need to simplify) Accept with $5m$ or m.

OR making $T = 0$ and $\cos\theta = -\frac{3}{5}$ (their value) in $T - 5mg\cos\theta = \frac{5mv^2}{a}$

A1cao for $v = \sqrt{\frac{3ag}{5}}$ oe Check square root is applied correctly.

(c)

M1 for resolving **their** v to get the horizontal component of the speed at B. May not be seen explicitly, but seen in their attempt at x.

M1 for resolving **their** v to get the vertical component of the speed at B

Both of these M marks can be given if sin and cos are interchanged or numerical substitutions not made.

M1dep for attempting to obtain x by using the distance from B to the y-axis with the horizontal distance travelled (found using their horizontal component, so dependent on the first M1 of (c))

A1cso for $x = -\frac{4a}{5} + \frac{3}{5}\sqrt{\frac{3ag}{5}}t$

Notes for Question 7 Continued
M1dep for attempting to obtain *y* by using $s = ut + \frac{1}{2}at^2$ with **their** vertical component and using the initial vertical distance above the *x*-axis. Dependent on the second M mark of (c) A1ft for $y - \frac{3a}{5} = \frac{4}{5}\sqrt{\frac{3ag}{5}}t - \frac{1}{2}gt^2$ Follow through their initial vertical component A1cao for $y = \frac{4}{5}\sqrt{\frac{3ag}{5}}t - \frac{1}{2}gt^2 + \frac{3a}{5}$

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Rewarding Learning

Mark Scheme (Results)

January 2014

Pearson Edexcel International Advanced Level

Mechanics 3 (WME03/01)

Edexcel and BTEC Qualifications

January 2014
Publications Code IA037823

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
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- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⌈ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

General Notes From Chief Examiner

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is accuracy error not method error.
- Omission of mass from a resolution is method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.
- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

Question Number	Scheme	Marks
1.	$v=\sqrt{\left(8x^{\frac{3}{2}}-4\right)}$ $v^2=\left(8x^{\frac{3}{2}}-4\right)$ $2v\frac{\mathrm{d}v}{\mathrm{d}x}=12x^{\frac{1}{2}}$ $F=0.5\times 6x^{\frac{1}{2}}=3x^{\frac{1}{2}}$ $x=4\Rightarrow F=6$	M1 A1 A1 M1dep A1 **5**

Notes

M1	for attempting to differentiate the expression for v^2 - chain rule must be used on lhs.
A1	for correct $x^{\frac{1}{2}}$
A1	for 6 Award both only if work fully correct
M1dep	for using NL2 with $m=0.5$ to obtain an expression for F in terms of x
A1cso	for $F=6$

Alternatives: for the first 3 marks

$\frac{\mathrm{d}v}{\mathrm{d}x}=\frac{1}{2}\left(8x^{\frac{3}{2}}-4\right)^{-\frac{1}{2}}\times 12x^{\frac{1}{2}}$ $\frac{\mathrm{d}v}{\mathrm{d}x}=\frac{1}{2v}\times 12x^{\frac{1}{2}}$ $\quad v\frac{\mathrm{d}v}{\mathrm{d}x}=6x^{\frac{1}{2}}$	M1 Must be a complete method to obtain accel in terms of x A1rhs A1lhs
$\frac{\mathrm{d}v}{\mathrm{d}t}=\frac{1}{2}\left(8x^{\frac{3}{2}}-4\right)^{-\frac{1}{2}}\times 12x^{\frac{1}{2}}\times\frac{\mathrm{d}x}{\mathrm{d}t}$ $\frac{\mathrm{d}v}{\mathrm{d}t}=\frac{1}{2}\left(8x^{\frac{3}{2}}-4\right)^{-\frac{1}{2}}\times 12x^{\frac{1}{2}}\times\left(8x^{\frac{3}{2}}-4\right)^{\frac{1}{2}}=6x^{\frac{1}{2}}$	M1A1A1 Award as above

Question Number	Scheme	Marks
2	$\frac{2mg}{2l}\left(\left(\frac{1}{2}l\right)^2 - x^2\right) = \frac{1}{4}mg\left(\frac{1}{2}l + x\right)$	M1A1;M1 A 1
	$8x^2 + 2lx - l^2 = 0$	M1 A1
	$(4x-l)(2x+l) = 0$	M1dep
	$x = \frac{1}{4}l$ or $-\frac{1}{2}l$	A1
	distance $= \frac{1}{2}l + \frac{1}{4}l = \frac{3}{4}l$	A1
		9

Notes

M1 for the difference of 2 elastic energy terms, not nec in a complete energy equation.

A1 for a correct difference

M1 for a work energy equation, loss of EPE = work done against friction(not dep on previous mark)

A1 for a fully correct equation

M1dep for re-arranging to a three term quadratic, dependent on the second M mark, or use the difference of 2 squares to get a linear equation

A1 for a correct 3 term quadratic, terms in any order

M1dep for solving the resulting quadratic, usual rules. Dependent on all second and third M marks

A1 for $x = \frac{1}{4}l$ $\quad x = -\frac{1}{2}l$ need not be shown

A1cao and cso distance $= \frac{3}{4}l$

Question Number	Scheme	Marks
3	$\frac{9}{8}mg - mg = \frac{mu^2}{2a}$	M1 A1
	$u^2 = \frac{ag}{4}$	A1
	$\frac{1}{2}m\left(\frac{ag}{4}\right) - \frac{1}{2}m\left(\frac{ag}{20}\right) = mg2a\left(1-\cos\theta\right)$	M1 A1 A1
	$\theta = 18°$ nearest degree	M1dep A1 **8**

Notes

M1 for NL2 along the radius at the bottom or top. Must have 2 forces and an acceleration

A1 for a fully correct equation ie $\frac{9}{8}mg - mg = \frac{mu^2}{2a}$ oe Must be at the bottom

A1 for obtaining $u^2 = \frac{ag}{4}$

M1 for an energy equation from the bottom or top to the point where the speed is $\sqrt{\frac{ag}{20}}$ (this may be v here and for the 2A marks). Must have a difference of KE terms and a GPE term.

A1ft for correct difference of KE terms or correct PE term (from bottom) Follow through their u.

A1 for a completely correct equation

M1dep for substituting $v = \sqrt{\frac{ag}{20}}$ and solving for θ Dependent on both previous M marks

A1cao $\theta = 18°$ **must be nearest degree.**

If candidates do the energy equation first, give those 3 marks for an equation with u (speed at bottom) and $\sqrt{\frac{ag}{20}}$. The final M mark will then be for substituting $u^2 = \frac{ag}{4}$ and solving for θ.

If the radius is a throughout, treat as mis-read. If sometimes a and sometimes $2a$ mark each equation on it own merit.

Question Number	Scheme	Marks
4(a)	$\pi\int_0^1 \mathrm{e}^{-2x}\mathrm{d}x = \frac{\pi}{-2}\left[\mathrm{e}^{-2x}\right]_0^1$	M1 A1
	$= \frac{\pi}{2}\left(1-\mathrm{e}^{-2}\right)$ PRINTED ANSWER	A1cso 3
(b)		
	$\pi\int_0^1 x\mathrm{e}^{-2x}\mathrm{d}x = \pi\left[\frac{-1}{2}x\mathrm{e}^{-2x}\right]_0^1 - \pi\int_0^1 \frac{-1}{2}\mathrm{e}^{-2x}\mathrm{d}x$	M1 A1
	$= \pi\left(-\frac{1}{2}\mathrm{e}^{-2} + \frac{1}{2}\left[-\frac{1}{2}\mathrm{e}^{-2x}\right]_0^1\right)$	M1dep A1ft
	$= \pi\left(-\frac{1}{2}\mathrm{e}^{-2} - \frac{1}{4}\left(\mathrm{e}^{-2}-1\right)\right)$	
	$= \pi\left(\frac{1}{4} - \frac{3}{4}\mathrm{e}^{-2}\right)$	A1cao
	$\bar{x} = \frac{\pi\left(\frac{1}{4}-\frac{3}{4}\mathrm{e}^{-2}\right)}{\frac{\pi}{2}\left(1-\mathrm{e}^{-2}\right)} = \frac{1}{2}\frac{\left(\mathrm{e}^{2}-3\right)}{\left(\mathrm{e}^{2}-1\right)}$	M1 A1
		(7) **10**

Notes for Question 4

A note about π: (a) is a "show that" so π must be included throughout (unless a put in at the end of (a), with a convincing argument for doing so). No answer given in (b), so allow the first 5 marks (as earned) without π **provided** either no π s or both π s appear for the final 2 marks. If the final fraction has the denominator π only, the last 3 marks will be lost

(a)

M1 for using $V = \pi\int y^2\mathrm{d}x = \pi\int \mathrm{e}^{-2x}\mathrm{d}x$ and attempting the integration. limits not needed for this mark

A1 for correct integration, correct limits must be shown

A1cso for $V = \frac{\pi}{2}\left(1-\mathrm{e}^{-2}\right)$ * Must be seen in this form

(b)

M1 for attempting the integration of $\pi\int x\mathrm{e}^{-2x}\mathrm{d}x$ by parts - limits not needed yet. Allow if intention to integrate $\pi\int xy^2\mathrm{d}x$ is shown.

A1 for a correct result with or w/o limits (check signs carefully)

M1dep for attempting the next integral, limits not needed

A1 ft for substituting the correct limits in their integral

A1cao for $\pi\left(\frac{1}{4}-\frac{3}{4}\mathrm{e}^{-2}\right)$ oe

M1 for using $\bar{x} = \frac{(\pi)\int xy^2\mathrm{d}x}{(\pi)\int y^2\mathrm{d}x}$ with their integrals, must be the correct way up.

A1 for $\bar{x} = \frac{\left(\mathrm{e}^2-3\right)}{2\left(\mathrm{e}^2-1\right)}$ oe **must be in terms of e**. Must have only 2 terms in each of the numerator and denominator and no fractions in either.

Question Number	Scheme	Marks
5(a)	$3k\frac{2}{3}\pi r^3 \quad k\pi r^2 3r \quad 3k\frac{2}{3}\pi r^3 + k\pi r^2 3r$	B1
	$(2) \quad (3) \quad (5)$	
	$\left(\frac{3r}{8}+3r\right) \quad \frac{3r}{2} \quad \bar{x}$	B1
	$\left(\frac{3r}{8}+3r\right).2 + \frac{3r}{2}.3 = 5\bar{x}$	M1 A1ft
	$\frac{9r}{4} = \bar{x}$ PRINTED ANSWER	A1 (5)
(b)	$R = W\ ;\ F = P$	B1
	$P.2r\sin\alpha = W(\frac{9r}{4}\sin\alpha - r\cos\alpha)$	M1 A1 A1
	$P = W(\frac{9}{8} - \frac{1}{2}\cot\alpha)$	A1
	$F = \mu R$	
	$\frac{1}{8}(9-4\cot\alpha) = \mu$ PRINTED ANSWER	M1depA1cso (7) **12**

Notes

(a) B1 for a correct ratio of masses

B1 for correct distances of the c of ms of the two components, hopefully from *O*, but can be from another point

M1 for a moments equation about *O* or their chosen point. Must have three terms and be dimensionally correct

A1ft for a correct equation, follow through their ratio of masses and distances, but **not** 1:3:4 (from mass/unit vol)

A1cso for $\bar{x} = \frac{9r}{4}$ *

Special case: Using volumes: max B0B1M1A1A1

(b)B1 for the two shown equations

M1 for a moments equation about the point of contact

A1A1 Award A2 if eqn fully correct; A1A0 if one error

A1 for re-arranging to obtain $P = W\left(\frac{9}{8} - \frac{1}{2}\cot\alpha\right)$

M1dep for using $F = \mu R$ together with the expression for *P* and the first two equations to obtain an expression for μ

A1cso for $\mu = \frac{1}{8}(9 - 4\cot\alpha)$ * must be this form

Question Number	Scheme	Marks
6(a)	$(6a)^2 + (8a)^2 = (10a)^2$	M1
	by Pythag (converse), APB = 90 ^{o} PRINTED ANSWER	A1 (2)
(b)	$T_1 \sin\alpha + T_2 \cos\alpha = mr\omega^2$	M1 A2
	$T_1 \cos\alpha - T_2 \sin\alpha = mg$	M1 A1
	$r = 8a\sin\alpha$	M1 A1
	$\sin\alpha = \frac{3}{5}$ or $\cos\alpha = \frac{4}{5}$	B1
	solving, $T_2 = \dfrac{3m}{25}(32a\omega^2 - 5g)$	M1
	$T_2 \geq 0 \Rightarrow \omega = \sqrt{\dfrac{5g}{32a}}$	M1 A1
	max time $= \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{32a}{5g}}$ PRINTED ANSWER	M1A1 (13) **15**

Notes for Question 6
(a) M1 for squaring the sides and showing they fit Pythagoras' theorem or ratio of sides 3:4:5 or use the cosine rule A1cso for stating that (the converse of) Pythagoras' theorem shows that $APB = 90°$ * or appropriate conclusion for their method **(b)** M1 for NL2 horizontally. There must be two tensions, both resolved, but may be the same, and an acceleration (either form accepted here) Sine/cos interchange is an accuracy error. A1 for any two correct terms A1 for the third correct term. Acceleration must be in the form $mr\omega^2$ and tensions must be different for both these marks to be awarded M1 for resolving vertically. Again, two tensions, both resolved but may be the same, and sine/cos interchange is an accuracy error. A1 for a fully correct equation with different tensions. M1 for finding the radius as $r = 8a\sin\alpha$ or $8a\cos\alpha$ A1 for $r = 8a\sin\alpha$ May not be shown explicitly B1 for a correct value for $\sin\alpha$ or $\cos\alpha$ M1dep for solving to obtain an expression for T_2 in terms of m, g, a, ω. Dependent on all M marks above **and** two different tensions. Or making $T_2 = 0$ in the above equations and solving for ω M1dep for using $T_2 \geqslant 0$ in *their* expression for T_1 to obtain an expression for ω in terms of g and a Dependent on the previous M mark $T_2 < 0$ gets M0 A1 for $\omega_{\min} = \sqrt{\frac{5g}{32a}}$ oe M1 for using $\frac{2\pi}{\omega}$ with their ω to obtain the maximum time A1cso for max time = $2\pi\sqrt{\frac{32a}{5g}}$

Question Number	Scheme	Marks
7 (a)	$\frac{8mge}{l} = mg$	M1
	$e = \frac{1}{8}l$	A1 (2)
(b)	$-mg - T = m\ddot{x}$	M1 A1
	$-mg - \frac{8mg}{l}(x - \frac{1}{8}l) = m\ddot{x}$	M1dep A1
	$-\frac{8g}{l}x = \ddot{x}$	A1
	SHM, period $2\pi\sqrt{\frac{l}{8g}}$ PRINTED ANSWER	A1cso (6)
(c)	$a = \frac{1}{2}l - \frac{1}{8}l = \frac{3}{8}l$	B1
	$u^2 = \frac{8g}{l}((\frac{3}{8}l)^2 - (\frac{-1}{8}l)^2)$	M1 A1
	$u = \sqrt{gl}$	A1 (4)
(d)	$x = -a\cos\omega t$	
	$\dot{x} = a\omega\sin\omega t$	
	$\sqrt{\frac{9gl}{32}} = \frac{3l}{8}\sqrt{\frac{8g}{l}}\sin\sqrt{\frac{8g}{l}}t$	M1 A1
	$\frac{1}{2} = \sin\sqrt{\frac{8g}{l}}t$	
	$t = \frac{\pi}{6}\sqrt{\frac{l}{8g}}$	M1dep A1 (4)
		16

Notes for Question 7
(a) M1 for Hooke's law and equating tension to weight A1cao for $e = \frac{1}{8}l$ **(b)** M1 for NL2 vertically, weight and tension needed, $\ddot{x}$ or a for acceleration here A1 for a correct equation with $\ddot{x}$ or a M1dep for using HL to replace the tension with an expression in terms of x Dependent on the previous M mark Must have $\ddot{x}$ now A1 for this equation correct A1 for re-arranging to get $-\frac{8g}{l}x = \ddot{x}$ oe A1cso for the conclusion SHM and the period $2\pi\sqrt{\frac{l}{8g}}$ * **(c)** B1 for using the information in the question to obtain amp $= \frac{3}{8}l$ M1 for using $v^2 = \omega^2\left(a^2 - x^2\right)$ with *their* ω and a A1 for a correct, unsimplified expression for u^2 in terms of l and g A1cao for $u = \sqrt{gl}$ By energy: B1 for EPE, M1 equation, A1 correct equation, A1 answer **(d)** M1 for using $\dot{x} = a\omega\sin\omega t$ (or v instead of $\dot{x}$) with *their* a and ω and the given speed A1 for a fully correct equation M1dep for solving *their* equation **must use radians** A1cao for $t = \frac{\pi}{6}\sqrt{\frac{l}{8g}}$ or 0.5235... $\sqrt{\frac{l}{8g}}$ oe. (if sub for g seen, must be 2 or 3 sf) *Alternative for* (d): Use $v^2 = \omega^2\left(a^2 - x^2\right)$ with *their* ω and a and the given speed M1 $x = \frac{3l}{16}\sqrt{3}$ or $x^2 = \frac{27l^2}{256}$ oe A1 Use $x = a\cos\omega t$ with *their* x, ω and a and solve in radians M1dep $t = \frac{\pi}{6}\sqrt{\frac{l}{8g}}$ or 0.5235... $\sqrt{\frac{l}{8g}}$ oe. (if sub for g seen, must be 2 or 3 sf) A1cao

Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Mechanics 3R (6679/01R)

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Summer 2014
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- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

<u>'M' marks</u>
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

<u>'A' marks</u>
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

<u>'B' marks</u>
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

6. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is an accuracy error not method error.

- Omission of mass from a resolution is a method error.

- Omission of a length from a moments equation is a method error.

- Omission of units or incorrect units is not (usually) counted as an accuracy error.

- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.

- Marks must be entered in the same order as they appear on the mark scheme.

- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- Accept column vectors in all cases.

- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1 (a)	$\frac{dv}{dx} = 3 \Rightarrow v = 3x - 3$ $a = 3(3x - 3)$ When $x = 5$, $F = 0.25 \times 3(15 - 3) = 9$ N	M1 A1 DM1 A1 (4)
(b)	$\frac{dx}{dt} = 3(x-1)$ $\int_2^5 \frac{dx}{(x-1)} = \int_0^t 3dt$ $\left[\ln(x-1)\right]_2^5 = 3t$ $t = \frac{1}{3}\ln 4 = 0.4620....$	M1 A1 DM1 A1 (4) **8**
Notes		
(a)	M1 Integration A1 correct integration DM1 using $a = v\,dv/dx$ with their v A1 correct integration	
(b)	M1 using $\frac{dx}{dt} = 3(x-1)$ A1 correct integrals with correct limits DM1 Substitute the limits A1 correct final answer	

Question Number	Scheme	Marks
2(a)	$T\sin 60^\circ + R\sin 60^\circ = mg$	M1 A1
	$T\cos 60^\circ - R\cos 60^\circ = ml\cos 60^\circ \omega^2$	M1 A1 A1
	$T = \frac{1}{2}m(l\omega^2 + \frac{2}{\sqrt{3}}g)$	DM1 A1 (7)
(b)	$R = \frac{1}{2}m(\frac{2}{\sqrt{3}}g - l\omega^2)$	M1 A1
	$\frac{1}{2}m(\frac{2}{\sqrt{3}}g - l\omega^2) > 0$	DM1
	$\omega < \sqrt{\frac{2g}{l\sqrt{3}}}$	A1
	$t > 2\pi\sqrt{\frac{l\sqrt{3}}{2g}}$ **	DM1 A1 (6)
		13

Notes

(a)	M1 vertical equation A1 correct vertical equation M1 horizontal equation, acceleration in either form A1 correct lhs A1 correct rhs DM1 solve for *T* A1 correct *T*
(b)	M1 obtain an expression for *R* A1 correct expression DM1 setting *R*> 0 A1 correct inequality for *w* DM1 obtaining an inequality for *t* A1 correct inequality

Question Number	Scheme	Marks
3 (a)	$R = mg\cos\theta$	B1
	WD against friction$=\mu xmg\cos\theta$	B1
	$\mu xmg\cos\theta = mgx\sin\theta - \frac{mgx^2}{2a}$	M1 A2
	$x = 2a(\sin\theta - \mu\cos\theta)$ **	A1 (6)
(b)	$T = \frac{mg2a(\sin\theta - \mu\cos\theta)}{a} = 2mg(\sin\theta - \mu\cos\theta)$	B1
	No motion if $T \le mg\sin\theta + \mu mg\cos\theta$	M1 A1
	$2mg(\sin\theta - \mu\cos\theta) \le mg\sin\theta + \mu mg\cos\theta$	DM1
	$\frac{1}{3}\tan\theta \le \mu$ **	A1 (5)
		11

Notes

(a)	B1 correct equation perpendicular to the plane B1 correct expression for work done against friction M1 work-energy equation A2 fully correct; A1 one error; A1 correct expression for x no errors in the working
(b)	B1 use Hooke's law to obtain a correct expression for T M1 using NL2 parallel to the plane to set up an inequality for situation where no motion A1 correct inequality DM1 solving to get an inequality for μ A1 correct inequality and no errors in the working If only error is use of < instead of $\leqslant$, deduct final A mark only

Question Number	Scheme	Marks
4(a)	$\frac{1}{2}mV^2 - \frac{1}{2}m\frac{2ag}{5} = mga(1-\cos\theta)$	M1 A1 A1
	$mg\cos\theta = m\frac{V^2}{a}$	M1 A1
	$V = \sqrt{\frac{4ag}{5}}$	DM1 A1 (7)
(b)	$\cos\theta = \frac{4}{5}$	B1
	$t = \frac{a - a\sin\theta}{V\cos\theta} \quad \left(= \sqrt{\frac{5a}{16g}}\right)$	M1 A1
	$s = Vt\sin\theta + \frac{1}{2}gt^2$	M1
	$= \sqrt{\frac{4ag}{5}}\sqrt{\frac{5a}{16g}}\frac{3}{5} + \frac{1}{2}g(\frac{5a}{16g})$	M1 A1
	$= \frac{73a}{160}$	A1
	$AX = a\cos\theta - \frac{73a}{160}$	M1
	$= \frac{11a}{32}$	A1 (9)
		16

Notes

(a)	M1 energy equation A1 correct difference of KEs A1 fully correct equation M1 NL2 towards the centre. May include R A1 correct equation May include R DM1 set $R = 0$ and solve for V or V^2 A1 correct final answer with no errors in working
(b)	B1 for correct trig function for θ M1 using the horizontal distance and speed to obtain an expression for the time A1 correct expression M1 using $s = ut + \frac{1}{2}at^2$ to get the vertical distance M1 attempt at initial vertical velocity A1 correct initial vertical velocity A1 correct vertical distance M1 attempt distance AX A1 correct final answer

Question Number	Scheme	Marks
5. (a)	$\pi r^2 h \quad \pi(\frac{1}{4}r)^2(\frac{1}{4}h) \quad \pi r^2 - \pi(\frac{1}{4}r)^2(\frac{1}{4}h)$ $\frac{1}{2}h \quad \frac{1}{8}h \quad \bar{y}$	B2 B2
	$\pi r^2 h \frac{1}{2}h - \pi(\frac{1}{4}r)^2(\frac{1}{4}h)\frac{1}{8}h = \left[\pi r^2 - \pi(\frac{1}{4}r)^2(\frac{1}{4}h)\right]\bar{y}$	M1 A1ft
	$\bar{y} = \frac{85h}{168}$ **	A1 (7)
(b)	$0 - \pi(\frac{1}{4}r)^2(\frac{1}{4}h)\frac{1}{4}r = \left[\pi r^2 - \pi(\frac{1}{4}r)^2(\frac{1}{4}h)\right]\bar{x}$	M1 A1
	$\bar{x} = -\frac{r}{252}$	A1
	$\tan\alpha = \dfrac{\frac{85h}{168}}{\frac{r}{252}} = 17$	DM1 A1ft
	$r = 7.5h$	A1 (6) **13**

Notes	
(a)	B2 masses or volumes B2 all correct; B1 two correct B2 distances B2 all correct; B1 one of the known ones correct M1A1ft form a moments equation using their volumes and distances A1 correct result with no errors in the working
(b)	M1A1 form an equation to find the distance of the centre of mass from the axis of the cylinder A1 correct distance DM1 using their two distances to find the tan of the required angle (may be inverted) A1ft ratio is correct(inc correct way up) with their distances A1 correct answer

Question Number	Scheme	Marks
6(a)	$\frac{4mge}{l} = mg$	M1
	$e = \frac{1}{4}l$	A1 (2)
(b)	$mg - T = m\ddot{x}$	M1 A1
	$mg - \frac{4mg}{l}(x + \frac{1}{4}l) = m\ddot{x}$	M1
	$-\frac{4g}{l}x = \ddot{x}$	A1
	SHM, $\left(\text{with } \omega = \sqrt{\frac{4g}{l}}\right)$	A1 (5)
(c)	$\sqrt{gl} = a\sqrt{\frac{4g}{l}}$	M1 A1
	$a = \frac{1}{2}l$	A1 (3)
(d)	$-\frac{1}{4}l = \frac{1}{2}l \sin\sqrt{\frac{4g}{l}}t$	M1 A1
	$t = \frac{7\pi}{12}\sqrt{\frac{l}{g}}$	M1 A1 (4)
		14

Notes

(a)	M1 using Hooke's law to obtain an equation for *e* A1 correct answer
(b)	M1 using NL2 vertically A1 correct equation M1 using Hooke’s law to replace *T* with an expression for *x*. These 3 marks can be gained with *a* instead of $\ddot{x}$ A1 fully correct, simplified equation A1 conclusion with all work correct
(c)	M1 using $v = aw$ A1 correct equation A1 correct amplitude
(d)	M1 for an equation to find required time A1 correct equation M1 solving their equation must be in radians and must give a positive value A1 correct time decimal equivalent acceptable.

Mark Scheme (Results)

Summer 2014

Pearson Edexcel International A Level in Mechanics 3 (WME03/01)

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Summer 2014
Publications Code IA039521

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

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1(a)	$\omega = \dfrac{2\pi}{\frac{\pi}{4}} = 8$	M1
	$\ddot{x} = -\omega^2 x$	
	$20 = \lvert -8^2 a \rvert = 64a$	M1
	$a = \dfrac{20}{64} = \dfrac{5}{16}$ (m) oe (Accept 0.31, 0.313, 0.3125)	A1 (3)
(b)	$v_{max} = a\omega = 2.5$ (m s^{-1})	B1ft (1)
(c)	Dist from A $= 1.5 - \dfrac{20}{16} = 0.25$	B1
	$x = a\cos\omega t = \dfrac{5}{16}\cos 8t$	
	$\dfrac{1}{16} = \dfrac{5}{16}\cos 8t$	M1
	$t = \dfrac{1}{8}\cos^{-1} 0.2$	A1
	Total time = $\dfrac{\pi}{4} + \dfrac{1}{8}\cos^{-1} 0.2 = 0.95657...$ 0.96 or better	A1ft (4) [8]
	Notes for Question 1	
	(a)M1 for attempting to obtain ω no need to simplify M1 using max mag of $\ddot{x} = \lvert -\omega^2 x \rvert$ with max mag accel = 20 and their ω A1 $a = \dfrac{5}{16}$ m oe fraction or 0.3125 m (b)B1ft $v_{max} = a\omega = 2.5$ follow through their values for ω and a (c)B1 finding the distance from A when P has travelled 1.5 m = 0.25 m OR the distance from the centre = $\dfrac{1}{16}$ M1 using $x = a\cos\omega t$ with $x = \dfrac{1}{16}$ (their value), their ω and their a OR for using $x = a\sin\omega t$ with $x = \dfrac{1}{16}$ (their value), their ω and their a A1 for $t = \dfrac{1}{8}\cos^{-1} 0.2$ OR $t = \dfrac{1}{8}\sin^{-1} 0.2$ A1ft for $\dfrac{\pi}{4} + \dfrac{1}{8}\cos^{-1} 0.2 = 0.95657...$ 0.96 or better ft their time or equivalent using sine	

Question Number	Scheme	Marks
2.	Mass/area of half of lamina = $(\rho)\times\frac{1}{2}\times a\times\sqrt{3}a=(\rho)\frac{\sqrt{3}a^2}{2}$	B1
	$\int_0^{a\sqrt{3}} yx\,dx=\int_0^{a\sqrt{3}}\frac{x^2}{\sqrt{3}}dx$	M1
	$=\left[\frac{x^3}{3\sqrt{3}}\right]_0^{a\sqrt{3}}$	A1
	$=a^3$	A1
	For the half lamina in the first quadrant $\bar{x}=\frac{\int yx\,dx}{\text{area}}=a^3\div\frac{a^2\sqrt{3}}{2}$	M1
	By symmetry, c of m of complete triangle is $\frac{2a}{\sqrt{3}}$ oe eg 1.15a, 1.2a	A1 [6]
	Alternative Work with the whole lamina by multiplying by 2 in lines 1 - 4. No mention of symmetry needed for final answer.	
	Notes for Question 2	
	B1 for the mass or area of half of the lamina M1 for attempting to integrate $\int_0^{a\sqrt{3}}\frac{x^2}{\sqrt{3}}dx$ limits not needed here A1 for $\left[\frac{x^3}{3\sqrt{3}}\right]_0^{a\sqrt{3}}$ limits must be shown and correct but can be implied if result of sub is correct. A1 for sub limits to get a^3 M1 for using $\bar{x}=\frac{\int yx\,dx}{\text{area}}$ with their previous answers A1cso for $\frac{2a}{\sqrt{3}}$ oe eg 1.15a, 1.2a "Symmetry" or "2 x " <u>must</u> be seen for all marks to be awarded. If missing, deduct final A mark. If no a in the integrals deduct final A mark unless similar triangles are mentioned. Use of a solid scores 0/6	

Question Number	Scheme	Marks
3	$T_a\cos 30+T_b\cos 60=3g$	M1A1A1
	$T_a\sin 30+T_b\sin 60=3r\omega^2$	M1A1
	$=3\times 0.4\cos 30\omega^2$	A1
	Solve: $T_a\frac{\sqrt{3}}{2}+\frac{1}{2}T_b=3g$ $\frac{1}{2}T_a+T_b\frac{\sqrt{3}}{2}=3\times 0.4\times\frac{\sqrt{3}}{2}\times 36$ $T_b=1.2\times 36\times\frac{3}{2}-3g$	
	$T_b=35.4$ (N)	DM1A1
	$T_a=13.5$ (N) must be 2 or 3 sf	A1 [9]
	Notes for Question 3	
	M1 for resolving vertically. Two tensions (resolved) and a weight must be seen. A1 for two correct terms A1 for all terms (inc signs) correct M1 for NL2 horizontally. Two tensions (resolved) and mass x acceleration needed. The acceleration can be in either form A1 for the two tensions, correctly resolved and added A1 for $3\times 0.4\cos 30\omega^2$ M1 dep for solving the equations to obtain either tension. Dependent on both previous M marks A1 for either tension correct A1 for the second tension correct. Both tensions must be given to 2 or 3 sf to gain the marks. (Penalise once for more than 3 sf)	

Question Number	Scheme	Marks
4(a)	$0.4\frac{\mathrm{d}v}{\mathrm{d}t}=\frac{4}{(t+5)^2}$	B1
	$v=-\frac{10}{(t+5)}+c$	M1A1
	$t=0,\ v=4\ \Rightarrow 4=-\frac{10}{5}+c,\ \ c=6$	DM1
	$v=6-\frac{10}{(t+5)}\qquad t\geqslant 0\quad \frac{10}{t+5}\geqslant 0\Rightarrow v\leqslant 6$	A1 (5)
(b)	$s=\int_2^7\left(6-\frac{10}{(t+5)}\right)\mathrm{d}t$	
	$=\left[6t-10\ln(t+5)\right]_2^7$	M1A1ft
	$=42-10\ln 12-(12-10\ln 7)$	M1
	$=30+10\ln\left(\frac{7}{12}\right)$ oe eg 24.6100.... 25 or better	A1 (4)
(c)	KE = $\frac{1}{2}\times 0.4\times\left(6-\frac{10}{12}\right)^2-\frac{1}{2}\times 0.4\times\left(6-\frac{10}{7}\right)^2$	M1A1ft
	$=1.1592....\mathrm{J}$ Accept 1.2 or better	A1 (3) [12]
	Notes for Question 4	
	(a)B1 for a correct equation of motion with acceleration = $\frac{\mathrm{d}v}{\mathrm{d}t}$. Can be awarded by implication if work correct at next stage M1 for attempting the integration wrt *t* to obtain an expression for *v* A1 for correct result, constant not needed M1dep for using $t=0,\ v=4$ to obtain a value for *c* Dependent on the previous M mark A1cso for a correct concluding statement. Can have $\geqslant$ or > **(b)** M1 for attempting the integration of *their* expression for *v* Limits need not be seen for this mark A1ft for correct integration M1 for substituting the limits 2 and 7 A1cao a correct result, exact or decimal (min 2 sf) (c)M1 for attempting the difference of KE between the points *A* and *B* (either way round). Velocities to be calculated using *their* expression for *v*. Award for a gain or a loss. A1ft for KE at *B* - KE at *A*, with *their* expression for *v*. Need not be simplified, may be reversed. A1cso for $=1.1592....\mathrm{J}$ Accept 1.2 or better Must be positive.	

Question Number	Scheme	Marks
5(a)	Energy A to B $\frac{1}{2}\times 2mv^2-\frac{1}{2}\times 2mu^2=2mga\left(1-\cos 60°\right)$	M1A1 A1
	$v^2=u^2+ga$	
	C of M: $2mv=3mV$	B1
	$V=\frac{2}{3}\sqrt{u^2+ag}$ *	DM1A1 (6)
(b)	NL2 at bottom: $3m\frac{V^2}{a}=T-3mg$	M1A1
	$T=3m\left(\frac{V^2}{a}+g\right)=m\left(\frac{4u^2}{3a}+\frac{13g}{3}\right)$ (N) oe	A1 (3)
(c)	Energy from B to top: $\frac{1}{2}\times 3m\times\frac{4}{9}\left(u^2+ag\right)-\frac{1}{2}\times 3mX^2=3mg\times 2a$	M1A1
	At top $T+3mg=3m\frac{X^2}{a}$	M1A1
	$T\geqslant 0 \quad \Rightarrow X^2\geqslant ag$	DM1
	$\frac{4}{18}\left(u^2+ag\right)-2ag\geqslant\frac{ag}{2}$	
	$u^2\geqslant\frac{41ag}{4}$ *	A1 (6) [15]

	Notes for Question 5	
	(a) M1 for an energy equation from *A* to *B*. Two KE terms and 2 PE terms (or a loss of PE) needed. A1 for correct KE terms (difference either way round) A1 for a correct loss of PE and all signs correct throughout the equation mass can be *m* or 2*m* for these two A marks, provided consistent B1 for a correct conservation of momentum equation M1dep for using the two equations to obtain the speed of the combined particle. Dep on the first M mark and using the C of M equation even if B0 has been given for it. A1cso for $V = \frac{2}{3}\sqrt{u^2 + ag}$ * (b) M1 for using NL2 at the bottom, tension, weight and mass x accel terms required. Accel can be in either form. A1 for a fully correct equation, no need to substitute for the speed. A1 for substituting the speed (as given in (a)) to obtain a correct expression for the tension in terms of *a*, *g*, *m* and *u*. Must be simplified. Any equivalent expression scores A1 eg $\frac{m}{3a}\left(12u^2 + 13ag\right)$ (c)M1 An energy equation from the bottom to the top. Must have a difference of KE terms and a gain of PE. A1 for a fully correct equation M1 for NL2 along the radius at the top. Must have a tension, weight and mass x acceleration (in either form). A1 for a fully correct equation acceleration in either form. M1dep for using $T \geqslant 0$ at the top to obtain an inequality for the speed at the top and completing to an inequality for u^2. Dependent on both previous M marks in (c). OR: Eliminate X^2 between the two equations and then use the inequality $T \geqslant 0$ A1cso for $u^2 \geqslant \frac{41ag}{4}$ *	

Question Number	Scheme	Marks
6(a)	$T = \dfrac{9mgpa}{6a} = mg$	M1
	$p = \dfrac{2}{3}$ *	A1 (2)
(b)	$T = \dfrac{9mg\left(\frac{2}{3}a + x\right)}{6a}$	
	$mg - \dfrac{9mg\left(\frac{2}{3}a + x\right)}{6a} = m\ddot{x}$	M1A1
	$-\dfrac{9gx}{6a} = -\dfrac{3gx}{2a} = \ddot{x}$	DM1
	Of form $\ddot{x} = -\omega^2 x$ $\therefore$ SHM	A1 (4)
(c)	Period $= \dfrac{2\pi}{\omega} = \dfrac{2\pi}{\sqrt{\frac{3g}{2a}}}$, $= 2\pi\sqrt{\dfrac{2a}{3g}}$	M1,A1ft (2)
(d)	The string never becomes slack or the SHM is complete	B1 (1)
(e)	Loss of EPE = $\dfrac{9mg \times (2a)^2}{2 \times 6a} = 3mga$	B1
	$mgh = 3mga$, $h = 3a$	M1,A1
	$AE = AD - h = 8a - 3a = 5a$	A1ft (4) [13]
	Notes for Question 6	
	(a)M1 for using Hooke's Law resolving vertically. A1cso for $p = \dfrac{2}{3}$ * (b)M1 for an equation of motion vertically. Must have a tension, a weight and a mass x acceleration. Allow with *a* for acceleration. Must be dimensionally correct, but allow for misuse of brackets. A1 for a correct equation, can still have *a* M1dep for rearranging to the form $\ddot{x} = -\omega^2 x$ Acceleration *a* scores M0 A1 for a correct equation and a conclusion eg $\therefore$ SHM Accept "shown" (c)M1 for using period $= \dfrac{2\pi}{\omega}$ with *their* ω to obtain the period. A1ft for $2\pi\sqrt{\dfrac{2a}{3g}}$ (d)B1 for any statement equivalent to those shown (e)B1 for the EPE lost or initial EPE. Need not be simplified. M1 for an energy equation equating their EPE to the PE gained A1 for a correct vertical distance risen A1ft for $AE = 8a -$ *their* distance risen	

Question Number	Scheme	Marks
7(a)	Cylinder cone S	
	Mass $18\pi a^3$ $\frac{1}{3}\pi\times 4\times\frac{3}{2}a^3 = 2\pi a^3$ $16\pi a^3$	B1
	Dist from O a $\frac{3a}{8}$ $\overline{x}$	B1
	$18a - 2\times\frac{3}{8}a = 16\overline{x}$	M1A1ft
	$\overline{x} = \frac{69}{64}a$ *	A1 (5)
(b)	$\tan\theta = \frac{3a}{\overline{x}}$	M1
	$\theta = \tan^{-1}\left(\frac{64}{23}\right)$, $\theta = 70.23...° = 70°$ or 1.2257...rad	A1,A1 (3)
(c)	$R = mg\cos\phi$ $F = mg\sin\phi$ (or $F\cos\phi = R\sin\phi$ M1A1)	B1 B1
	$\frac{F}{R} = \tan\phi = \mu = 0.6$	M1
	$\phi_{max} = 30.96... = 31$ *	A1 (4) [12]
	Notes for Question 7	
	(a) B1 for a correct mass ratio B1 for correct distances, probably from O but can be from another point, eg vertex of cone or centre of base. M1 for a moments equation with 3 terms A1ft for a correct equation, follow through *their* mass ratio and distances. A1cso for $\overline{x} = \frac{69}{64}a$ * **(b)** M1 for $\tan\theta = \frac{3a}{\overline{x}}$ with the given $\overline{x}$. Can be either way up. A1 for $\theta = \tan^{-1}\left(\frac{64}{23}\right)$ A1cao for $\theta = 70.23...°$ Accept 70° or better. Or $1.2257...^c$ Accept 1.2^c or better. (c) B1 for $R = mg\cos\phi$ B1 for $F = mg\sin\phi$ M1 for using $F = \mu R$ with $\mu = 0.6$ to obtain an equation for $\tan\varphi$ A1cso for $\phi_{max} = 31°$ *	

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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Mechanics 3 (6679_01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

‘M’ marks
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a ‘force x distance’ term or ‘mass x distance’, if we allow them to cancel ‘g’ s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

‘A’ marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

‘B’ marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⎣ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

6. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- dM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

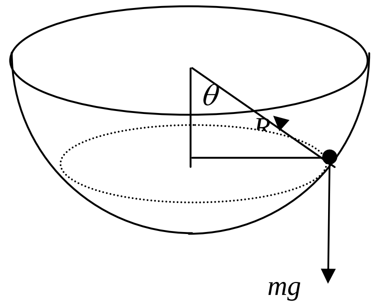
  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1.		
	$R\sin\theta = m \times 4r\sin\theta \times \frac{3g}{8r}$	M1A1A1
	$R = \frac{3}{2}mg$	
	$R\cos\theta = mg$	M1A1
	$\frac{3}{2}mg\cos\theta = mg$	M1(dep)
	$\cos\theta = \frac{2}{3}$	A1
	$OC = 4r\cos\theta = 4r \times \frac{2}{3} = \frac{8}{3}r$ oe	M1A1
		[9]

	Notes for Question 1
M1	for NL2 towards *C* - Accept use of $v = \sqrt{\frac{3g}{8r}}$ and $a = \frac{v^2}{r}$ as a mis-read
A1	for LHS fully correct
A1	for RHS fully correct
ALT:	Work in the direction of *R* and obtain the same equation with $\sin\theta$ "cancelled". Give M1A1A1 if fully correct, M0 otherwise.
M1	for resolving vertically
A1	for the equation fully correct
M1 dep	for eliminating *R* between the two equations Dependent on both above M marks
A1	for $\cos\theta = \frac{2}{3}$
M1	for attempting to use trig or Pythagoras to obtain *OC*
A1 cso	for $OC = \frac{8}{3}r$

Alternative for Question 1	
M1A1A1	$R\sin\theta = m \times a \times \frac{3g}{8r}$
M1 A1	$R\cos\theta = mg$
M1 A1	$\tan\theta = \frac{3a}{8r}$
M1	$\frac{a}{OC} = \frac{3a}{8r}$
A1	$OC = \frac{8r}{3}$

Question Number	Scheme	Marks
2.		
(a)	(At surface) $\frac{k}{R^2} = mg \Rightarrow k = mgR^2$	M1A1 (2)
(b)	$m\ddot{x} = -\frac{mgR^2}{x^2}$	
	$v\frac{dv}{dx} = -\frac{gR^2}{x^2}$	M1
	$\int v\frac{dv}{dx}dx = -gR^2\int\frac{1}{x^2}dx$ or $\int\frac{d\left(\frac{1}{2}v^2\right)}{dx}dx$	
	$\frac{1}{2}v^2 = \frac{gR^2}{x}$ $(+c)$	DM1A1
	$x = \frac{5R}{4},\ v = \sqrt{\frac{gR}{2}} \Rightarrow c = -\frac{11gR}{20}$	DM1A1
	$v = 0$ $0 = \frac{gR^2}{x} - \frac{11gR}{20}$	DM1
	$x = \frac{20R}{11}$	A1 (7) **[9]**

	Notes for Question 2
(a)	
M1	for $\frac{k}{R^2} = mg$. If not made clear that this applies at the surface of the Earth award M0 **or** $\frac{k}{x^2} = mg$ **and** $x = R$.
A1 cso	for $k = mgR^2$ *
(b)	
M1	for using accel = $v\frac{dv}{dx}$ oe in NL2 with or w/o m Minus sign not required.
M1 dep	for attempting to integrate both sides - minus not needed
A1	for fully correct integration, with or w/o the constant. Must have included the minus sign from the start.
M1 dep	for using $x = \frac{5R}{4}$, $v = \sqrt{\frac{gR}{2}}$ to obtain a value for the constant. Use of $x = \frac{R}{4}$ scores M0 Depends on both previous M marks
A1	for $c = -\frac{11gR}{20}$
M1 dep	for setting $v = 0$ and solving for x Depends on 1st and 2nd M marks, but not 3rd
A1 cso	for $x = \frac{20R}{11}$
ALT:	By definite integration First 3 marks as above, then
DM1	Using limits $x = \frac{5R}{4}$, $v = \sqrt{\frac{gR}{2}}$
DM1	Using limit $v = 0$
A1	Correct substitution
A1 cso	for $x = \frac{20R}{11}$
	NB: The penultimate A mark has changed position, but must be entered on e-pen in its original position.

Alternative for Question 2

Qu 2 (a):

Using $F = \dfrac{GM_1M_2}{x^2}$ with $x = R$ and one mass as mass of Earth:

$$mg = \frac{GmM_E}{R^2}$$

$$GM_E = gR^2 \Rightarrow F = \frac{mgR^2}{x^2} \Rightarrow F = \frac{k}{x^2} \text{ with } k = mgR^2 \ *$$

M1 Complete method A1 Correct answer

Qu 2 (b):

By conservation of energy:

Work done against gravity $= \int_{\frac{5r}{4}}^{z} \dfrac{mgR^2}{x^2}\,\mathrm{d}x = \int_{\frac{5r}{4}}^{z} mgR^2 x^{-2}\,\mathrm{d}x$ M1

$= \dfrac{4mgR}{5} - \dfrac{mgR^2}{z}$ DM1(integration)A1(correct)

Work-energy equation: $\dfrac{mgR}{4} = \dfrac{4mgR}{5} - \dfrac{mgR^2}{z}$ DM1A1

$z = \dfrac{20R}{11}$ DM1A1

Question Number	Scheme	Marks
3. **(a)**	Shell / wax / filled shell Mass ratio: m, $3m$, $4m$ Dist. above vertex: $\frac{2}{3}\times 6r$, $\frac{3}{4}\times 2r$, $\overline{x}$	B1
	$4mr+\frac{9}{2}mr=4m\overline{x}$	M1A1ft
	$\overline{x}=\frac{17}{8}r$	A1 (4)
(b)	$\tan\theta=\frac{r}{6r-\overline{x}}=\frac{r}{31r/8}$	M1A1ft
	$\tan\theta=\frac{8}{31}$	
	$\theta=14.47...^\circ$	A1 (3) **[7]**

Notes for Question 3

(a)	
B1	for correct distances from the vertex or any other point
M1	for a dimensionally correct moments equation with their distances and masses
A1 ft	for a correct moments equation, follow through their distances but must have correct masses
A1 cso	for $\overline{x}=\frac{17}{8}r$
	NB: If $\frac{2}{3}$ and $\frac{3}{4}$ are interchanged in the distances, the correct answer is obtained but the solution is incorrect. Score: B0M1A1A0
(b)	
M1	for $\tan\theta=\frac{r}{6r-\overline{x}}$. Can be either way up, but must include $6r-\overline{x}$. Substitution for $\overline{x}$ not required
A1 ft	for $\tan\theta=\frac{r}{31r/8}$ oe ft their $\overline{x}$
A1 cso	for $\theta=14.47...^\circ$ Accept 14°, 14.5° or better or $\theta=0.2525...$ rad Accept 0.25 or better Obtuse angle accepted.

Question Number	Scheme	Marks
4		
(a)	$\dfrac{3mgx^2}{2l} = 2mgx\sin\alpha$	M1A1 B1(A1 on e-pen)
	$3x^2 = 4xl \times \dfrac{3}{5}$	
	$5x^2 = 4xl$	
	$x = \dfrac{4}{5}l$	DM1A1 (5)
(b)	$R = 2mg\cos\alpha \quad \left(= \dfrac{8}{5}mg\right)$	B1
	$\dfrac{3mg}{2l} \times \dfrac{4}{25}l^2 = 2mg \times \dfrac{2}{5}l \times \dfrac{3}{5} -, \quad \mu\dfrac{8}{5}mg \times \dfrac{2}{5}l$	M1A1ft, B1ft (A1 on e-pen)
	$6 = 12 - 16\mu$	
	$16\mu = 6 \qquad \mu = \dfrac{3}{8}$	DM1A1 (6) **[11]**

	Notes for Question 4
(a)	
M1	for an energy equation with an EPE term of the form $\frac{kmgx^2}{l}$ and a GPE term. If a KE term is included it must become 0 later.
A1	for a correct EPE term
B1	for a correct GPE term. This can be in terms of the distance moved down the plane or the vertical distance fallen
M1 dep	for solving their equation to obtain the distance moved or using the vertical distance and obtaining the distance moved along the plane.
A1	for $x = \frac{4}{5}l$ oe eg $x = \frac{12}{15}l$
(b)	
B1	for resolving perpendicular to the plane to obtain $R = 2mg\cos\alpha$. May only be seen in an equation.
M1	for an work-energy equation with an EPE term of the form $\frac{kmgx^2}{l}$, a GPE term and the work done against friction. The work term must include a distance along the plane.
A1	for EPE and GPE terms correct and work subtracted from the GPE
B1 ft	for the work term ft their *R*
M1 dep	for solving to obtain a value for μ
A1 cso	for $\mu = \frac{3}{8}$ oe inc 0.375 but not 0.38
	If *m* used instead of 2*m*, assuming correct otherwise:
(a)	M1A1B0M1A0 (so 2 penalties for mis-read)
(b)	
B1	$R = mg\cos\alpha$
M1, A1	Equation, with EPE correct and $mg \times \frac{2}{5}l \times \frac{3}{5}$
B1 ft	$\mu \frac{4mg}{5} \times \frac{2}{5}l$
DM1, A1	$\mu = 0$

Alternative for Question 4

Qu 4: Using NL2:

(a)

$2ma = 2mg\sin\alpha - \dfrac{3mgx}{l}$	
$2v\dfrac{dv}{dx} = \dfrac{6g}{5} - \dfrac{3gx}{l}$	M1(equation and attempt integration)
$v^2 = \dfrac{6gx}{5} - \dfrac{3gx^2}{2l},\ +c$	A1, A1 (show $c = 0$)
$v = 0\ \ 3gx\left(\dfrac{2}{5} - \dfrac{x}{2l}\right) = 0$	M1 (set $v = 0$ and solve)
$x = \dfrac{4l}{5}$	A1

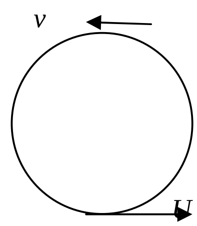
(b)

$R = 2mg\cos\alpha$	B1
$2v\dfrac{dv}{dx} = \dfrac{6g}{5} - \dfrac{3gx}{l} - \mu\dfrac{8g}{5}$	
$v^2 = \dfrac{6gx}{5} - \dfrac{3gx^2}{2l} - \mu\dfrac{8gx}{5},\ +c$	M1(eqn and int)A1, A1 (show $c = 0$)
$v = 0\ \ x = \dfrac{2l}{5}\quad \mu\dfrac{8}{5} = \dfrac{6}{5} - \dfrac{3}{2l}\times\dfrac{2l}{5}$	M1 (set $v = 0$ and solve)
$\mu = \dfrac{3}{8}$	A1

If SHM methods are used, SHM must be proved first.

Question Number	Scheme	Marks
5.		
(a)	Vol = $\pi\int_0^{\frac{\pi}{2}} y^2 \mathrm{d}x = \pi\int_0^{\frac{\pi}{2}} \cos^2 x \mathrm{d}x$	M1
	$= \pi\int_0^{\frac{\pi}{2}} \frac{1}{2}(\cos 2x + 1)\,\mathrm{d}x$	M1
	$= \frac{\pi}{2}\left[\frac{1}{2}\sin 2x + x\right]_0^{\frac{\pi}{2}} = \frac{\pi^2}{4}$	DM1A1 (4)
(b)	$\pi\int_0^{\frac{\pi}{2}} y^2 x\,\mathrm{d}x = \pi\int_0^{\frac{\pi}{2}} x\cos^2 x\,\mathrm{d}x$	M1
	$= \pi\int_0^{\frac{\pi}{2}} \frac{1}{2}x(\cos 2x + 1)\,\mathrm{d}x$	
	$= \frac{\pi}{2}\int_0^{\frac{\pi}{2}} x\cos 2x\,\mathrm{d}x + \frac{\pi}{2}\left[\frac{x^2}{2}\right]_0^{\frac{\pi}{2}}$	
	$\frac{\pi}{2}\left[x \times \frac{1}{2}\sin 2x\right]_0^{\frac{\pi}{2}} - \frac{\pi}{2}\int_0^{\frac{\pi}{2}} \frac{1}{2}\sin 2x\,\mathrm{d}x, + \frac{\pi^3}{16}$	M1,B1
	$= 0 + \frac{\pi}{2}\left[\frac{1}{4}\cos 2x\right]_0^{\frac{\pi}{2}} + \frac{\pi^3}{16}$	DM1
	$= \frac{\pi}{8}[-1-1] + \frac{\pi^3}{16} = \frac{\pi^3}{16} - \frac{\pi}{4}$	A1ft
	$\bar{x} = \frac{\pi^3 - 4\pi}{16} \div \frac{\pi^2}{4} = \frac{\pi^2 - 4}{4\pi}$ or 0.467088....	M1A1 (7) **[11]**

	Notes for Question 5
(a)	
M1	for using Vol = $\pi\int_0^{\frac{\pi}{2}}\cos^2 x\,dx$. If π is missing here it must be included later to earn this mark. Limits not needed
M1	for using the double angle formula (correct) to prepare for integration. Formula must be correct. π and limits not needed for this mark.
M1 dep	for attempting to integrate and substitute the correct limits (only sub of non-zero limit needed be to seen) dependent on both M marks.
A1 cso	for $\frac{\pi^2}{4}$ * (check integration is correct, answer can be obtained by luck due to the limits)
(b)	**NB**: The first 5 marks can be earned with or without π
M1	for using $\pi\int_0^{\frac{\pi}{2}} x\cos^2 x\,dx$ π not needed; limits not needed.
M1	for using the double angle formula (correct) and attempting the first stage of integration by parts
B1	for $\frac{\pi^3}{16}$ or $\frac{\pi^2}{16}$ if π not included. NB integration by parts not needed for this mark
M1 dep	for completing the integration by parts, limits not needed yet
A1 ft	for $=\frac{\pi}{8}\left[-1-1\right]+\frac{\pi^3}{16}=\frac{\pi^3}{16}-\frac{\pi}{4}$ or $=\frac{1}{8}\left[-1-1\right]+\frac{\pi^2}{16}=\frac{\pi^2}{16}-\frac{1}{4}$ ft on $\frac{\pi^3}{16}$
M1	for using $\bar{x}=\dfrac{\int \pi y^2 x\mathrm{d}x}{\int \pi y^2\mathrm{d}x}$ The numerator integral need not be correct. π should be seen in both or neither integral
A1 cso	for $\bar{x}=\frac{\pi^2-4}{4\pi}$ oe eg $\frac{\pi}{4}-\frac{1}{\pi}$ or 0.467088.... Accept 0.47 or better but no fractions within fractions. (a) has a given answer, so the cso applies to the solution of (b) only.

Question Number	Scheme	Marks
6.		
(a)	$\frac{1}{2}mU^2 - \frac{1}{2}mv^2 = 2mga$	M1A1
	$T + mg = m\frac{v^2}{a}$	M1A1
	$T = \frac{(mU^2 - 4mga)}{a} - mg$	DM1
	$T = \frac{mU^2 - 5mga}{a}$	A1
	$T \geqslant 0 \Rightarrow U^2 \geqslant 5ga$	DM1
	$U \geqslant \sqrt{5ag}$ *	A1 (8)
(b)	At top: $T = \frac{9mga - 5mga}{a} = 4mg$	M1(either tension)A1
	At bottom: $T' - mg = \frac{mU^2}{a}$	A1
	$kT = mg + \frac{9mag}{a} = 10mg$	DM1
	$k = \frac{10mg}{4mg} = \frac{5}{2}$	A1 (5)
		[13]

	Notes for Question 6
(a)	
M1	for an energy equation, from the bottom to the top. A difference of KE terms and a PE term needed. From bottom to a general point gets M0 until a value for θ at the top is used. $v^2 = u^2 + 2as$ scores M0
A1	for all terms correct (inc signs)
M1	for NL2 along the radius at the top. Two forces and mass x acceleration needed. Accel can be in either form here. **But see NB at end of (a)**
A1	for a fully correct equation. Acceleration should be $\frac{v^2}{a}$ now.
M1 dep	for eliminating v (vel at top) between the two equations. Dependent on both previous M marks. If v is set = 0, award M0
A1	for a correct expression for T
M1 dep	for using $T \geqslant 0$ to obtain an inequality for U^2 or U. Allow with > Dependent on all previous M marks.
A1 cso	for $U \geqslant \sqrt{5ag}$ * Watch square root! Give A0 if > seen on previous line.
	NB: The second and fourth M marks (and their As if earned) can be given together if $mg \leq m\frac{v^2}{a}$ is seen
(b)	
M1	for obtaining an expression for the tension at the top or at the bottom, no need to substitute for U yet.
A1	Substitute for U and obtain one correct tension ($4mg$ at top or $10mg$ at bottom)
A1	for the other tension correct
M1 dep	for using tension at bottom = k x tension at the top and solving for k
A1 cso	for $k = \frac{5}{2}$ oe

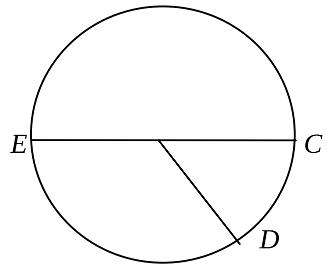
Question Number	Scheme	Marks
7.		
(a)	$T = \frac{\lambda x}{l} = \frac{\lambda \times 0.5l}{l}$	M1A1
	$\lambda = 2mg$ *	A1 (3)
(b)	$mg - T = m\ddot{x}$	M1
	$mg - \frac{2mg(0.5l + x)}{l} = m\ddot{x}$	DM1A1A1
	$\ddot{x} = -\frac{2gx}{l}$	A1
	$\therefore$ SHM	A1cso(B1 on e-pen) (6)
(c)	$a = 0.3l$	
	$\lvert\ddot{x}\rvert_{max} = 2g \times \frac{0.3l}{l} = 0.6g \quad (= 5.88 \text{ or } 5.9 \text{ m s}^{-2})$	M1A1ft (2)
(d)	$x = a\cos\omega t = 0.3l\cos\left(\sqrt{\frac{2g}{l}}\right)t$	
	Time C to D: $0.15 = 0.3\cos\left(\sqrt{\frac{2g}{l}}\right)t$	M1
	$t = \sqrt{\frac{l}{2g}}\cos^{-1}0.5$	
	Time C to E: $t' =$ half period $= \pi\sqrt{\frac{l}{2g}}$	B1
	Time D to E: $= \left(\pi - \cos^{-1}0.5\right)\sqrt{\frac{l}{2g}} = \frac{2\pi}{3}\sqrt{\frac{l}{2g}}$	M1A1 (4)
		[15]

	Notes for Question 7
(a)	
M1	for using Hooke's Law
A1	for a correct equation
A1	for solving to get $\lambda = 2mg$ *
(b)	
M1	for using NL2. Weight and tension must be seen. Acceleration can be *a* here, but must be an equation at a general position
M1 dep	for using Hooke's Law for the tension. Acceleration can be *a*
A1 A1	for a fully correct equation inc acceleration as $\ddot{x}$ (-1 ee)
A1	for simplifying to $\ddot{x} = -\frac{2gx}{l}$ oe
A1 cso	for the conclusion
(c)	
M1	for using $\lvert\ddot{x}\rvert_{\max} = \omega^2 a$ with their ω and $a = 0.3l$. ω must be dimensionally correct
A1 ft	for obtaining the max magnitude of the accel, accept 0.6*g*, 5.9 or 5.88 only. ft their ω
(d)	
M1	for using $x = a\cos\omega t$ with $x = \pm 0.15l$, $a = 0.3l$ and their ω to obtain an expression for the time from *C* to *D*
B1	for time *C* to *E* = half period = $\pi\sqrt{\frac{l}{2g}}$
M1	For any correct method for obtaining the time from *D* to *E*
A1 cao	for $\frac{2\pi}{3}\sqrt{\frac{l}{2g}}$ oe inc $0.473\sqrt{l}$ $0.47\sqrt{l}$
ALT for (d): (i)	
M1	Use $x = a\sin\omega t$ with $x = 0.15l$, $a = 0.3l$ and their ω to obtain an expression for the time from *B* to *D*
M1, A1	as above
(ii)	Using $x = a\cos\omega t$ with $x = \pm 0.15l$, $a = 0.3l$ and their ω This gives the required time in one step. Award M2 A1 for correct substitution A1 correct answer **However do not isw if further work shown. Mark according to mark scheme method and give max M1B1M0A0.**

Alternative for Question 7

Qu 7 (d)

By reference circle:



Centre of circle is O

Angle $COD = \theta$ Angle $EOD = \alpha$

$\cos\theta = \frac{0.15l}{0.3l} \quad \theta = \frac{\pi}{3}$	M1
$\alpha = \pi - \frac{\pi}{3} = \frac{2\pi}{3}$	B1
$\omega = \sqrt{\frac{2g}{l}}$	
$\text{time} = \frac{\alpha}{\omega} = \frac{2\pi/3}{\sqrt{\frac{2g}{l}}} = \frac{2\pi}{3}\sqrt{\frac{l}{2g}}$	M1A1

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Mark Scheme (Results)

January 2015

Pearson Edexcel International A Level in
Mechanics 3
(WME03/01)

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January 2015
Publications Code IA040633

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These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
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e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
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A few of the A and B marks may be f.t. – follow through – marks.

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- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
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4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

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   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

6. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Jan 2015
WME03/01 M3 (IAL)
Mark Scheme

Question Number	Scheme	Marks
1.	$3v\frac{\mathrm{d}v}{\mathrm{d}x}=\frac{9}{2}(26-x)$	M1
	$\frac{\mathrm{d}\left(\frac{1}{2}v^2\right)}{\mathrm{d}x}=\frac{3}{2}(26-x)$	
	$\frac{1}{2}v^2=\frac{3}{2}\left(26x-\frac{1}{2}x^2\right)\quad(+\,c)$	M1A1
	Max speed when accel is zero ie when $x=26$	B1
	$\frac{1}{2}\times32^2=\frac{3}{2}\times\frac{1}{2}\times26^2+c\quad\Rightarrow c=5$	A1
	$v^2=3\left(26x-\frac{1}{2}x^2\right)+10$	A1 (6)
	M1 NL2 with accel in a correct form- can be implied by subsequent working M1 integrate the equation wrt x A1 correct result after integrating - constant not needed B1 deduce max speed occurs when $x=26$ A1 a correct value for the constant A1 a correct expression for v^2 - can be in any form ALT for last 3 marks: M1 (B1 on e-pen) Complete square and equate constant part to 32^2 or use max of quadratic $=\frac{4ac-b^2}{4a}$ A1 correct c A1 correct expression for v^2	

Question Number	Scheme	Marks
2	Area = $\int_1^3 y\,\mathrm{d}x = \int_1^3 \frac{3}{x^2}\,\mathrm{d}x$	
	$= \left[-3x^{-1}\right]_1^3 = -1-(-3) = 2$	B1
(i)	$\int_1^3 xy\,\mathrm{d}x = \int_1^3 x \times \frac{3}{x^2}\,\mathrm{d}x = \int_1^3 \frac{3}{x}\,\mathrm{d}x$	
	$\left[3\ln x\right]_1^3 \quad (= 3\ln 3)$	M1A1
	$\bar{x} = \frac{3\ln 3}{2} \quad (= 1.647....)$	M1A1
(ii)	$\int_1^3 \frac{1}{2} y^2\,\mathrm{d}x = \int_1^3 \frac{1}{2} \times \frac{9}{x^4}\,\mathrm{d}x$	
	$\frac{9}{2}\left[-\frac{x^{-3}}{3}\right]_1^3 = \frac{9}{2}\left[-\frac{1}{81}+\frac{1}{3}\right] = 1\frac{4}{9}$	M1A1
	$\bar{y} = \frac{1\frac{4}{9}}{2} = \frac{13}{18} \quad (= 0.722.....)$	DM1A1 (9)
	B1 for a correct area of R (may be embedded in the working) M1 attempting the integral $\int_1^3 xy\,\mathrm{d}x$ (integration to be seen) A1 correct integration and limits (substitution not needed) M1 divide by their area - denominator **must** be an area A1 correct value for $\bar{x}$ - can be exact or decimal 1.6 or better M1 attempting the integral $\int_1^3 \frac{1}{2} y^2\,\mathrm{d}x$ or $\int_1^3 y^2\,\mathrm{d}x$ (integration to be seen) A1 correct integration (of their integral) and limits shown DM1 divide by their area **must** have used $\int \frac{1}{2} y^2\,\mathrm{d}x$ A1 correct value for $\bar{y}$ - can be exact or decimal 0.72 or better	

Question Number	Scheme	Marks
3	$2T\cos 30 = T\cos 30 + mg$	M1A1
	$\frac{T\sqrt{3}}{2} = mg$	A1
	$3T\cos 60 = mr\omega^2$	M1A1
	$\frac{3}{2}\times\frac{2mg}{\sqrt{3}} = mr\omega^2$	A1
	$AB = 4a \quad \frac{r}{2a} = \tan 30 = \frac{1}{\sqrt{3}}$	
	$r = \frac{2a}{\sqrt{3}}$	
	$\frac{3g}{\sqrt{3}} = \frac{2a}{\sqrt{3}}\omega^2$	DM1 Dep on both prev M marks
	$\omega^2 = \frac{3g}{2a} \quad \omega = \sqrt{\frac{3g}{2a}}$	A1
		[8]
	M1 resolve vertically - both tensions resolved A1 fully correct equation A1 substitute for trig function M1 NL2 horizontally - tensions resolved, acceleration in either form A1 correct equation, r still present, acceleration $r\omega^2$ A1 correct equation with no trig function DM1 eliminate r and T to obtain an equation with ω, a, g and no other letters r need not be correct but do not allow $r = a$ A1 correct result For first 6 marks the equations can have T and $2T$ or two different tensions	

Question Number	Scheme	Marks
4 **(a)**	Length of string/half string = 10 m / 5 m (or extn = 5 m)	B1
	$T = \frac{\lambda x}{l} = \frac{20\times 5}{5}, \quad = 20$	M1, A1
	$2T\cos\alpha = mg$	M1
	$2\times 20\times\frac{4}{5} = mg$	A1ft
	Weight = 32 N (Accept mg = 32)	A1 (6)
(b)	PE lost $= "mg"\times 4$	
	EPE gained $= \frac{20\times 5^2}{2\times 5} - \frac{20\times 1^2}{2\times 5}$	
	$\frac{1}{2}mv^2 = "mg"\times 4 - \left(\frac{20\times 5^2}{2\times 5} - \frac{20\times 1^2}{2\times 5}\right)$	M1A1A1
	$\frac{16}{g}v^2 = 32\times 4 - \left(\frac{20\times 5^2}{2\times 5} - \frac{20\times 1^2}{2\times 5}\right)$	DM1
	$v^2 = 5g$	
	$v = 7$, 7.0 or 7.00	A1 (5) [11]
(a)	B1 correct length of complete or half string or correct extension(need not be shown explicitly) M1 apply Hooke's law $x \neq 1$ A1 correct tension obtained M1 resolving vertically, both tensions resolved A1ft substitute their tension and $\cos\alpha = \frac{4}{5}$ A1 correct weight obtained (no ft)	
(b)	M1 energy equation with KE, PE and two EPE terms - all calculated with correct formulae A1A1 Deduct one A mark per error (if *m* is substituted early, ft their *m*) M1 Substitute their mass (not weight) A1 correct value for v 7, 7.0 or 7.00 only acceptable	

Question Number	Scheme	Marks
5 (a)	Small cone — Large cone — S Mass: $\frac{4}{3}\pi r^3\rho$ — $\frac{1}{3}k\pi r^3\rho$ — $\frac{1}{3}\pi r^3\rho(4+k)$ Ratio: 4 — k — $4 + k$ Disp from O: $-r$ — $\frac{kr}{4}$ — $\overline{x}$	
	$-4r+\frac{k^2r}{4}=(4+k)\overline{x}$	M1A1A1
	$\overline{x}=\frac{(k^2-16)r}{4(4+k)}=\frac{1}{4}(k-4)r$	A1 (4)
(b)	k greatest when $\frac{\overline{x}}{r}=\frac{r}{4r}$	M1
	$\frac{1}{4}(k-4)=\frac{1}{4}$	A1ft
	Greatest $k=5$	A1 (3)
(c)	$\tan 12°=\frac{\overline{x}}{r}=\frac{1}{4}(k-4)$	M1A1ft
	$k=4.85 \quad 4.9 \quad (4.8502...)$	A1 (3) [10]
(a) **(b)** **(c)**	M1 moments equation about any (suitable) point. Volumes or ratio of volumes used. A1 LHS correct A1 RHS side A1 correct distance from O, inc use of $k > 4$ Single fraction only in the expression M1 using vertical through c of m passes through A to obtain a connection between $\overline{x}$ and r or a numerical value for $\overline{x}$ or any other complete valid method A1ft obtain a correct equation for k with their $\overline{x}$ A1 cao $k=5$ (inequality gets A0) M1 $\tan 12°=\frac{\overline{x}}{r}$ either way up A1ft substitute for $\overline{x}$ correct way up now A1 Final answer 4.9, 4.85 or better	

Question Number	Scheme	Marks
6		
(a)	$\frac{1}{2}mv^2 - \frac{1}{2}m\left(\frac{ag}{5}\right) = mga(1-\cos\theta)$	M1A1A1
	$v^2 = 2ag + \frac{ag}{5} - 2ag\cos\theta = \frac{ag}{5}(11-10\cos\theta)$ *	A1 (4)
(b)	$mg\cos\alpha \ (-R) = m\frac{v^2}{a}$	M1A1
	$g\cos\alpha = \frac{g}{5}(11-10\cos\alpha)$ or sub $\cos\alpha = \frac{v^2}{ag}$ in energy equation	M1 A1
	$\cos\alpha = \frac{11}{15}$	
	P leaves the sphere with speed $\sqrt{\frac{ag}{5}\left(11-\frac{22}{3}\right)} = \sqrt{\frac{11ag}{15}}$	DM1A1 (6)
(c)	Horiz comp = $\sqrt{\frac{11ag}{15}} \times \cos\alpha = \sqrt{\frac{11ag}{15}} \times \frac{11}{15}$	M1
	By cons of energy from top: $2mag = \frac{1}{2}mV^2 - \frac{1}{2}m\frac{ag}{5}$	M1
	$V^2 = \frac{21ag}{5}$	A1
	$\cos\theta = \sqrt{\frac{11ag}{15}} \times \frac{11}{15} \times \sqrt{\frac{5}{21ag}} = \sqrt{\frac{11}{63}} \times \frac{11}{15} = 0.30642...$	M1
	$\theta = 72.155...$ Accept 72^{o} or better	A1 (5)
		[15]
(a)	M1 **Energy** equation from start to general position - must have 2 KE terms and a loss of PE A1 LHS correct A1 RHS correct A1cso re-arrange to the given result	

Question Number	Scheme	Marks
(b)	M1 NL2 along radius, acceleration in either form, R need not be shown, weight must be resolved A1 fully correct equation with or w/o R, accel now $\frac{v^2}{a}$ M1 elimination of v^2 or $\cos\alpha$ A1 correct equation after elimination DM1 substitute their $\cos\alpha$ to obtain an expression for v^2 Dep on both previous M marks A1 correct expression for v	
(c)	M1 obtaining an expression for the horiz comp of speed at P M1 use energy to obtain the speed when particle hits the floor A1 correct speed at floor M1 use horizontal speed and resultant speed to find the angle A1 correct angle 2 sf or more figures (g cancels) ALT: By SUVAT: M1 Horiz component M1 Vert component and complete attempt for speed at the floor (including the vertical height) A1 correct vert speed at floor M1 attempt angle using tan (either way up) A1 correct angle 2 sf or more figures (g cancels)	

Question Number	Scheme	Marks
7		
(a)	$T = \dfrac{\lambda a/5}{a}$	M1A1
	$T = mg\cos 60 = \dfrac{1}{2}mg$	
	$\dfrac{1}{2}mg = \dfrac{\lambda}{5} \quad \lambda = \dfrac{5}{2}mg$ *	M1A1 (4)
(b)	When string has length $\left(\dfrac{6a}{5} + x\right)$:	
	$\dfrac{1}{2}mg - \dfrac{5}{2}mg\left(\dfrac{a/5 + x}{a}\right) = m\ddot{x}$	M1A1A1
	$-\dfrac{5g}{2a}x = \ddot{x}, \Rightarrow$ SHM	DM1,A1
	Period = $2\pi\sqrt{\dfrac{2a}{5g}}$ *	A1 (6)
(c)	Max accel = $\omega^2 \times \text{amp} = \omega^2 \dfrac{a}{5} = \dfrac{5g}{2a} \times \dfrac{a}{5} = \dfrac{g}{2}$	M1A1 (2)
(d)	$x = \dfrac{a}{5}\sin \omega t$	
	$\dfrac{a}{10} = \dfrac{a}{5}\sin \omega t$	M1
	$\omega t = \sin^{-1} 0.5 = \dfrac{\pi}{6}$	
	$t = \dfrac{\pi}{6\omega} = \dfrac{\pi}{6}\sqrt{\dfrac{2a}{5g}}$	A1
	Total time = $t = \dfrac{\pi}{6}\sqrt{\dfrac{2a}{5g}} + \dfrac{\pi}{2}\sqrt{\dfrac{2a}{5g}} = \dfrac{2\pi}{3}\sqrt{\dfrac{2a}{5g}}$	M1A1 (4)
		[16]

Question Number	Scheme	Marks
(a)	M1 Hooke's Law used to find T at B A1 correct equation M1 eliminating T by use of resolving along the plane A1cso correct value for λ	
(b)	M1 NL2 along the plane when extension is $\frac{a}{5}+x$ - must have a tension and a component of the weight. Allow with $\ddot{x}$ or f (acceleration). A1A1 deduct one per error. (difference of forces wrong way round is one error only) mass x acceleration (not $\ddot{x}$) is also an error DM1 simplify to the correct form acceleration must be $\ddot{x}$ now A1cso correct final equation AND conclusion A1 correct period	
(c)	M1 obtaining the max acceleration, amp $\neq a$ A1 correct max acceleration (no ft)	
(d)	M1 using equation for x - sin or cos form and solving for t - must use radians and $\omega = \sqrt{\frac{5g}{2a}}$ amp $\neq a$ A1 correct value for t from their equation M1 complete to obtain the required time A1 correct total time If time from end point to $x = -\frac{a}{10}$ is found mark M1M1A1A1	

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Mark Scheme (Results)

Summer 2015

Pearson Edexcel International A Level in Mechanics 3 (WME03/01)

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Summer 2015
Publications Code IA042169

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   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is an accuracy error not method error.

- Omission of mass from a resolution is a method error.

- Omission of a length from a moments equation is a method error.

- Omission of units or incorrect units is not (usually) counted as an accuracy error.

- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.

  Marks must be entered in the same order as they appear on the mark scheme.

- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- Accept column vectors in all cases.

- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

June 2015
WME03 M3
Mark Scheme

Question Number	Scheme	Marks
1	(30^o or θ for the first 3 lines)	
	$R\sin 30° = mg$	M1A1
	$R\cos 30° = m\left(r\cos 30°\right)\omega^2$	M1A1A1
	$\omega^2 = \frac{R}{mr} = \frac{g}{r\sin 30}$	DM1
	$\omega = \sqrt{\frac{2g}{r}}$	A1
	Time = $\frac{2\pi}{\omega} = 2\pi\sqrt{\frac{r}{2g}} = \pi\sqrt{\frac{2r}{g}}$ *	A1cso [8]

M1 Resolving vertically 30^o or θ
A1 Correct equation 30^o or θ
M1 Attempting an equation of motion along the radius, acceleration in either form 30^o or θ
Allow with *r* for radius
A1 LHS correct 30^o or θ
A1 RHS correct, 30^o or θ but not *r* for radius
DM1 Obtaining an expression for ω^2 or for v^2 **and** the length of the path 30^o or θ Dependent on both previous M marks
A1 Correct expression for ω Must have the numerical value for the trig function now
A1cso Deducing the GIVEN answer

ALT: Resolve perpendicular to the reaction:

$mg\cos 30 = m \times rad \times \omega^2 \cos 60$	M2A1(LHS) A1(RHS)
$= mr\cos 30\omega^2 \cos 60$	A1
Obtain ω	M1A1
Correct time	A1

Question Number	Scheme	Marks
2 (a)	$F = \frac{K}{x^2}$	
	$x = R \Rightarrow F = mg \qquad \therefore mg = \frac{K}{R^2}$	M1
	$K = mgR^2$ *	A1 (2)
(b)	$\frac{mgR^2}{x^2} = -mv\frac{dv}{dx}$	M1
	$g\int \frac{R^2}{x^2}dx = -\int v\,dv$	
	$-g\frac{R^2}{x} = -\frac{1}{2}v^2 \quad (+c)$	DM1A1ft
	$x = 3R,\ v = V \Rightarrow -g\frac{R^2}{3R} = -\frac{1}{2}V^2 + c$	M1
	$c = -\frac{Rg}{3} + \frac{1}{2}V^2$	A1
	$x = R \Rightarrow \frac{1}{2}v^2 = -\frac{Rg}{3} + \frac{1}{2}V^2 + g\frac{R^2}{R}$	M1
	$v^2 = V^2 + \frac{4Rg}{3}$	
	$v = \sqrt{V^2 + \frac{4Rg}{3}}$	A1 cso (7)
		[9]

(a) M1 Setting $F = mg$ **and** $x = R$
A1 Deducing the GIVEN answer

(b) M1 Attempting an equation of motion with acceleration in the form $v\frac{dv}{dx}$. The minus sign may be missing.
DM1 Attempting the integration
A1ft Correct integration, follow through on a missing minus sign from line 1, constant of integration may be missing
M1 Substituting $x = 3R, v = V$ to obtain an equation for c
A1 Correct expression for c
M1 Substituting $x = R$ and their expression for c
A1 Correct expression for v, any equivalent form

Question Number	Scheme	Marks
3 (a)	$\frac{dv}{dt} = -2(t+4)^{-\frac{1}{2}}$	M1
	$v = -\int 2(t+4)^{-\frac{1}{2}}\,dt$	
	$v = -4(t+4)^{\frac{1}{2}} \quad (+c)$	DM1A1
	$t = 0, v = 8 \Rightarrow c = 16$	M1
	$v = 16 - 4(t+4)^{\frac{1}{2}} \quad (\text{m s}^{-1})$ *	A1cso (5)
(b)	$v = 0 \quad 16 = 4(t+4)^{\frac{1}{2}}$	M1
	$16 = t + 4 \quad t = 12$	A1
	$x = 4\int\left(4 - (t+4)^{\frac{1}{2}}\right)dt$	
	$x = 4\left(4t - \frac{2}{3}(t+4)^{\frac{3}{2}}\right) \quad (+d)$	M1A1
	$t = 0,\ x = 0 \quad d = 4 \times \frac{2}{3} \times 4^{\frac{3}{2}} = \frac{64}{3}$ oe	A1
	$t = 12 \quad x = 4\left(4 \times 12 - \frac{2}{3} \times 16^{\frac{3}{2}}\right) + \frac{64}{3} = 42\frac{2}{3}$ (m) oe eg 43 or better	DM1A1 (7)
		[12]

(a) M1 Attempting an expression for the acceleration in the form $\frac{dv}{dt}$; minus may be omitted.

DM1 Attempting the integration

A1 Correct integration, constant of integration may be omitted (no ft)

M1 Using the initial conditions to obtain a value for the constant of integration

A1cso Substitute the value of c and obtain the final GIVEN answer

(b) M1 Setting the **given** expression for v equal to 0

A1 Solving to get $t = 12$

M1 Setting $v = \frac{dx}{dt}$ and attempting the integration wrt t At least one term must clearly be Integrated.

A1 Correct integration, constant may be omitted

A1 Substituting $t = 0,\ x = 0$ and obtaining the correct value of d. Any equivalent number, inc decimals.

DM1 Substituting their value for t and obtaining a value for the required distance. Dependent on The second M mark.

A1 Correct final answer, any equivalent form.

Question Number	Scheme	Marks
4(a)	Energy to top: $\frac{1}{2}\times 3m\times u^2-\frac{1}{2}\times 3mv^2=3mga$	M1A1
	NL2 at top: $T+3mg=3m\frac{v^2}{a}$	M1A1
	$T=3m\frac{u^2}{a}-6mg-3mg$	DM1
	$T\geqslant 0\ \Rightarrow \frac{u^2}{a}\geqslant 3g$	M1
	$u^2\geqslant 3ag$ *	A1 cso (7)
(b)	Tension at bottom:	
	$\frac{1}{2}\times 3m\times V^2-\frac{1}{2}\times 3mu^2=3mga$	M1
	$T_{\max}-3mg=3m\frac{V^2}{a}$	M1
	$T_{\max}=3mg+6mg+3m\frac{u^2}{a}$	A1
	$T_{\min}=3m\frac{u^2}{a}-9mg$	
	$9mg+3m\frac{u^2}{a}=3\left(3m\frac{u^2}{a}-9mg\right)$	DM1
	$u^2=6ag$ *	A1 cso (5)
		[12]

(a) M1 Attempting an energy equation, can be to a general point for this mark. Mass can be missing but use of $v^2=u^2+2as$ scores M0

A1 Correct equation from *A* to the top

M1 Attempting an equation of motion along the radius at the top, acceleration in either form

A1 Correct equation, acceleration in form $\frac{v^2}{r}$

DM1 Eliminate v^2 to obtain an expression for T Dependent on both previous M marks

M1 Use $T\geqslant 0$ at top to obtain an inequality connecting *a*, *g* and *u*

A1cso Re-arrange to obtain the GIVEN answer

(b) M1 Attempting an energy equation to the bottom, maybe from *A* or from the top

M1 Attempting an equation of motion along the radius at the bottom

A1 Correct expression for the max tension

DM1 Forming an equation connecting *their* tension at the top with *their* tension at the bottom. If the 3 is multiplying the wrong tension this mark can still be gained. Dependent on both previous M marks

A1cso Obtaining the GIVEN answer.

Question Number	Scheme	Marks
5 (a)	$T=\frac{20e}{2}=\frac{15(1.8-e)}{1.2}$	M1A1
	$10e\times1.2=15(1.8-e)$	
	$e=1$	A1
	$AO=3\text{m}$ *	A1cso (4)
(b)	$0.5\ddot{x}=\frac{20(1-x)}{2}-\frac{15(0.8+x)}{1.2}$	M1A1A1
	$\ddot{x}=-45x \quad \therefore \text{SHM}$	A1cso (4)
(c)	String becomes slack when $x=(-)0.8$ (allow wo sign due to symmetry)	B1
	$v^2=\omega^2(a^2-x^2)$	
	$v^2=45(1-0.8^2) \quad (=16.2)$	M1A1ft
	$v=4.024...$ m s^{-1} (4.0 or better)	A1ft (4)
(d)	$\frac{1}{2}\times\frac{20y^2}{2}-\frac{1}{2}\times\frac{20\times1.8^2}{2}=\frac{1}{2}\times0.5\times16.2$ ft on v	M1A1A1ft
	$20y^2-64.8=16.2$	
	$y^2=4.05 \quad y=2.012....$	A1
	Distance $DB=\lvert 5-4.012...\rvert=0.988...\text{m}$ (accept 0.99 or better)	A1ft (5) [17]
Alt for d:	Prove SHM with only one string M1A1 (equation) Value ω A1 Use $v=a\omega$ to find a A1ft (ft on v) Dist A1ft	

(a) M1 Attempting to obtain and equate the tensions in the two parts of the string.
A1 Correct equation, extension in *AP* or *BP* can be used or use *OA* as the unknown
A1 Obtaining the correct extension in either string (ext in *BP* =0.8 m) or another useful distance
A1cso Obtaining the correct GIVEN answer
(b) M1 Forming an equation of motion at a general point. There must be a difference of tensions, both with the variable. May have *m* instead of 0.5 Accel can be *a*
A1 A1 Deduct 1 for each error, *m* or 0.5 allowed, acceleration to be $\ddot{x}$ now
A1cso Correct equation in the required form, with a concluding statement; *m* or 0.5 allowed
(c) B1 For $x=\pm0.8$ Need not be shown explicitly
M1 Using $v^2=\omega^2(a^2-x^2)$ with *their* (numerical) ω and their x
A1ft Equation with correct numbers ft their ω
A1ft Correct value for v 2sf or better or exact
(d) M1 Attempting an energy equation with 2 EPE terms and a KE term
A1 2 correct terms may have $(1.8+x)$ instead of y
A1ft Completely correct equation, follow through their v from (c)
A1 Correct value for distance travelled after *PB* became slack. $x=0.21$
A1ft Complete to the distance *DB*. Follow through their distance travelled after *PB* became slack.
Alternatives at end of mark scheme

Question Number	Scheme	Marks
6(a)	Vol = $\pi\int_0^2 \left(x^2+3\right)^2 \mathrm{d}x$	M1
	$=\pi\int_0^2 \left(x^4+6x^2+9\right)\mathrm{d}x$	
	$=\pi\left[\frac{1}{5}x^5+2x^3+9x\right]_0^2$	DM1A1
	$=\frac{202}{5}\pi$ cm^3 *	A1 (4)
(b)	$\pi\int_0^2 x\left(x^2+3\right)^2 \mathrm{d}x=\pi\int_0^2\left(x^5+6x^3+9x\right)\mathrm{d}x$	M1
	$=\pi\left[\frac{1}{6}x^6+\frac{3}{2}x^4+\frac{9}{2}x^2\right]_0^2$	A1
	$=\frac{158}{3}\pi$ (Or by chain rule or substitution)	A1
	C of m $=\frac{158}{3}\times\frac{5}{202}$, $=1.3036...=1.30$ cm	M1A1 (5)
(c)	Mass ratio $\quad 2\times\frac{202}{5}\pi \quad \frac{1}{3}\pi\times7^2\times6 \quad \left(\frac{404}{5}+98\right)\pi$	B1
	Dist from *V* $\quad 6.7 \quad 4.5 \quad \overline{x}$	B1
	$\frac{404}{5}\times6.7+98\times4.5=\left(\frac{404}{5}+98\right)\overline{x}$	M1A1ft
	$\overline{x}=\dfrac{\frac{404}{5}\times6.7+98\times4.5}{\left(\frac{404}{5}+98\right)}=5.494....=5.5$ cm Accept 5.49 or better	A1 (5)
(d)	$\tan\theta=\frac{6-\overline{x}}{7}=\frac{0.5058...}{7}$	M1
	$\alpha=\tan^{-1}\left(\frac{6}{7}\right)-\tan^{-1}\left(\frac{0.5058...}{7}\right)=36.468...°=36°$ or better	M1A1 (3) [17]

Question Number	Scheme	Marks

(a) M1 Using $\pi\int y^2 \mathrm{d}x$ with the equation of the curve, no limits needed

DM1 Integrating their expression for the volume

A1 Correct integration inc limits now

A1 Substituting the limits to obtain the GIVEN answer

(b) M1 Using $(\pi)\int xy^2 \mathrm{d}x$ with the equation of the curve, no limits needed, π can be omitted

A1 Correct integration, including limits; no substitution needed for this mark

A1 Correct substitution of limits

M1 Use of $\dfrac{\pi\int xy^2\mathrm{d}x}{\pi\int y^2\mathrm{d}x}$ with their $\pi\int xy^2\mathrm{d}x$. π must be seen in both numerator and denominator or in neither.

A1cao Correct answer. Must be 1.30

(c) B1 Correct mass ratio

B1 Correct distances, from V or any other point, provided consistent

M1 Attempting a moments equation

A1ft Correct equation, follow through their distances and mass ratio

A1 Correct distance from V

(d) M1 Attempting the tan of an appropriate angle, numbers either way up

M1 Attempting to obtain the required angle

A1 Correct final answer 2sf or more

	Alternatives for 5(d)	
1	EPE in BP (at release) transferred to EPE in AP (same as MS, except 1 term for first A1)	
2	$0.5a = -10(1.8 + x)$	
	$v\dfrac{dv}{dx} = -36 - 10x$	
	$\int v dv = -\int(36 + 10x)dx$	
	$\dfrac{v^2}{2} = -36x + 5x^2 + c$	M1A1
	$x = 0, v = \dfrac{9\sqrt{5}}{5} \therefore c = 8.1$	A1
	Then $v = 0$ etc	M1A1

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Mark Scheme (Results)

Summer 2015

Pearson Edexcel GCE in Mechanics 3 (6679/01)

Summer 2015
Publications Code UA042154

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

<u>‘M’ marks</u>
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a ‘force x distance’ term or ‘mass x distance’, if we allow them to cancel ‘g’ s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

<u>‘A’ marks</u>
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

<u>‘B’ marks</u>
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⎿ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5 For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6 If a candidate makes more than one attempt at any question:
   a. If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   b. If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7 Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- dM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

edexcel

June 2015
6679 M3
Mark Scheme

Question Number	Scheme	Marks
1		
(a)	$0.5g = T = \frac{\lambda \times 0.3}{1.2}$	M1A1
	$\lambda = 2g = 19.6$	A1 (3)
(b)	$\frac{1}{2}\times\frac{19.6\times x^2}{1.2} - \frac{1}{2}\times\frac{19.6\times 0.4^2}{1.2} = 0.5\times g\times(x+0.4)$	M1A1ftA1
	$5x^2 - 3x - 2 = 0$	
	$(5x+2)(x-1) = 0$ or use of diff of 2 squares to obtain and then solve a linear equation	
	$x = 1$ $(x = -0.4$ need not be seen$)$	
	$AC = 2.2$ m	A1 (4) [7]

(a) M1 Use Hooke's law to obtain the tension and equate to the weight
A1 Correct equation
A1 Solve to get $\lambda = 19.6$ Accept 20 or $2g$

(b) M1 Attempt an energy equation with the difference of 2 EPE terms and a loss of GPE
EPE formula must be of the form $k\frac{\lambda x^2}{l}$
A1ft EPE terms correct follow through their λ
A1 GPE term correct, including all signs in the equation correct If x used for EPE and GPE A0 here
A1 Correct length AC If $\lambda = 20$ is used, this is p.a. and so scores A0

ALT: Find BC first: $\frac{1}{2}\times\frac{19.6\times(h-0.4)^2}{1.2} - \frac{1}{2}\times\frac{19.6\times 0.4^2}{1.2} = 0.5gh$ M1A1A1
$BC = 1.4$ $AC = 2.2$ A1

Methods depending on SHM must prove SHM first, but if correct answer only is given award B1 (M1 on e-PEN)
By integration: Integrating and substituting yields an equation equivalent to the one shown - mark from here M1A1A1ft -1 each error ft on λ

Question Number	Scheme	Marks
2 (a)	$\text{Vol} = \pi\int_0^1 4e^{2x}dx$	M1
	$= \pi\left[2e^{2x}\right]_0^1$	DM1A1
	$= 2\pi\left(e^2 - 1\right)$ *	A1cso (4)
(b)	$\pi\int_0^1 4xe^{2x}\,dx$	M1
	$= 4\pi\left\{\left[x\times\frac{1}{2}e^{2x}\right]_0^1 - \int_0^1 \frac{1}{2}e^{2x}dx\right\}$	DM1
	$= 4\pi\left[\frac{1}{2}e^2 - 0\right] - 4\pi\left[\frac{1}{4}e^{2x}\right]_0^1$	A1
	$= \pi\left(e^2 + 1\right)$	A1
	x coord $= \dfrac{\pi\left(e^2+1\right)}{2\pi\left(e^2-1\right)}, \quad = \dfrac{e^2+1}{2\left(e^2-1\right)}$ oe	M1A1 (6)
		[10]

(a) M1 Using $\pi\int y^2dx$ with the equation of the curve, no limits needed

DM1 Integrating their expression for the volume

A1 Correct integration inc limits now

A1 Substituting the limits to obtain the GIVEN answer

(b) M1 Using $(\pi)\int xy^2dx$ with the equation of the curve, no limits needed, π can be omitted

DM1 Attempting to use integration by parts; allow $\pm$ between the two parts. No limits needed

A1 Correct integration, including limits; no substitution needed for this mark

A1 Correct after limits substituted

M1 Use of $\dfrac{\pi\int xy^2dx}{\pi\int y^2dx}$ with their $\pi\int xy^2dx$. π must be seen in both numerator and denominator or in neither. This mark is not dependent on the previous M marks

A1cao Correct answer.

Question Number	Scheme	Marks
3(a)	R$(\uparrow)$ $T_A \cos 30 = mg + T_B \cos 30$	M1A1
	NL2 $T_A \cos 60 + T_B \cos 60 = mr\omega^2$	M1A1
	$= m \times 2l \cos 60 \omega^2$ or $ml\omega^2$	A1
	$T_A + T_B = 2ml\omega^2$	
	$T_A - T_B = \dfrac{2mg}{\sqrt{3}}$	
(i)	$T_A = \dfrac{m}{3}\left(3l\omega^2 + g\sqrt{3}\right)$ oe	DM1A1
(ii)	$T_B = \dfrac{m}{3}\left(3l\omega^2 - g\sqrt{3}\right)$ oe	A1 (8)
(b)	$T_B \geqslant 0 \Rightarrow 3l\omega^2 \geqslant g\sqrt{3}$	M1
	$\omega^2 \geqslant \dfrac{g\sqrt{3}}{3l}$ *	A1cso (2)
		[10]

(a) M1 Resolving vertically
A1 Correct equation
M1 NL2 along radius, acceleration in either form
A1 LHS correct
A1 Correct radius substituted and accel in $r\omega^2$. Can be awarded later by implication if work implies correct radius used.
DM1 Solving the two equations to obtain an expression for either tension. Depenent on both previous M marks
A1 Tension in *AP* correct – simplified to two terms
A1 Tension in *BP* correct – simplified to two terms

(b) M1 Using their tension in *BP* $\geqslant 0$ **must be** $\geqslant$ for this mark
A1cso Obtaining the GIVEN answer. Only error allowed is the expression for the tension in *AP*

Question Number	Scheme	Marks
4(a)	$\frac{63000}{kt^2} = 900\frac{\mathrm{d}v}{\mathrm{d}t}$	M1
	$-\frac{70}{kt}\ (+c) = v$	DM1A1ft
	$t=1\ \ v=0\ \Rightarrow c = \frac{70}{k}$	M1(either)
	$t=4\ \ v=10.5\ \Rightarrow -\frac{70}{4k} + c = 10.5$	A1(both)
	$-\frac{70}{4k} + \frac{70}{k} = 10.5$	
	$k=5,\quad c=14$	A1
	$v = 14 - \frac{14}{t}$ *	A1 cso (7)
(b)	$\frac{14}{t} > 0\quad \Rightarrow v < 14$ or v never reaches 14	B1 (1)
(c)	$7 = 14 - \frac{14}{t}$	
	$\frac{14}{t} = 7\quad t = 2$	B1
	t 1 1.25 1.5 1.75 (2) v 0 2.8 4.666.. 6 7	
	$x = \frac{0.25}{2}\left(0 + 2\times 2.8 + 2\times 4.666... + 2\times 6 + 7\right)$	M1A1
	$X = 4.24175$ Accept 4.2 or 4.24	A1 (4) [12]

(a) M1 Forming an equation of motion with acceleration as $\frac{\mathrm{d}v}{\mathrm{d}t}$ 900 or m

DM1 Attempting the integration

A1 Correct equation. Constant of integration not needed

M1 Substituting either pair of given values

A1 Obtaining correct equations using each pair of values

A1 Obtaining correct values for c **and** k or use $k=5,\quad c=\frac{70}{k}$

A1 Substituting these values to obtain the GIVEN answer
Misread eg 6300 for 63000: M1DM1A1M1A0A0A0

(b) B1 Must be clear that $v < 14$ not just never = 14 $\frac{14}{t} > 0$ essential

(c) B1 Showing that $t = 2$ when $v = 7$ Award if seen as upper limit for t in trapezium rule or values 1.25, 1.5, 1.75 seen for t

M1 Using the trapezium rule. Must have 4 intervals and values of t shown in the table.

A1 Correct numbers in the trapezium rule statement.
Values of v can be in the form $14 - \frac{14}{1.25}$ etc

A1 Correct final answer. It is an estimate, so 2 or 3 sf only.

Question Number	Scheme	Marks
5	Dist of c of m from $O = r\tan 30 = \dfrac{r}{\sqrt{3}}$	M1A1
	Ratio of masses: M, kM, $(1+k)M$; 1, k, $1+k$	
	Dist from O: $-\dfrac{1}{4}h$, $\dfrac{kh}{4}$, $\dfrac{r}{\sqrt{3}}$	
	M(O) $\quad -\dfrac{1}{4}h + \dfrac{k^2h}{4} = (1+k)\dfrac{r}{\sqrt{3}}$	M1A1A1ft
	$\dfrac{h}{4}(k^2-1) = (k+1)\dfrac{r}{\sqrt{3}}$	
	$k = \dfrac{4r}{h\sqrt{3}} + 1 \quad *$	A1 [6]
Alt 1	By moments about A	
	$kMg\left(\dfrac{1}{4}kh\cos 30 - r\sin 30\right), \quad Mg\left(\dfrac{1}{4}h\cos 30 + r\sin 30\right)$	M1A1,M1A1
	$h\cos 30(k^2-1) = 4r\sin 30(k+1)$	A1ft
	$(k-1) = \dfrac{4r}{h}\tan 30$	
	$k = \dfrac{4r}{h\sqrt{3}} + 1 \quad *$	A1

Question Number	Scheme	Marks
Alt 2	Find $\bar{x}$ first	
	M(0) $-\frac{1}{4}h+\frac{k^2h}{4}=(1+k)\bar{x}$	M1 A1
	$\bar{x}=\frac{h(k-1)}{4}$ oe	A1
	Then suspend: $\frac{\bar{x}}{r}=\tan 30$	M1
	$\frac{h(k-1)}{4r}=\frac{1}{\sqrt{3}}$ $(or \tan 30)$	A1ft
	$k=\frac{4r}{h\sqrt{3}}+1$ *	A1

M1 Finding the distance of the c of m from *O* by using the angle given. Must use tan.
A1 Obtaining $\frac{r}{\sqrt{3}}$ (no approx allowed)
M1 Forming a moments equation using the three known distances; mass ratio only needed – do not penalise use of incorrect formulae
A1 LHS correct
A1ft RHS correct for their distance
A1cao Obtaining the GIVEN answer

ALT 1 Taking moments about *A*
M1 Attempting the LHS – must have two appropriate terms inc the necessary resolution
A1 Correct LHS
M1 Attempting the RHS – must have two appropriate terms inc the necessary resolution
A1 Correct RHS
A1ft Collecting the terms and cancelling *M*g
A1cao Completing to the GIVEN answer

ALT 2 Find $\bar{x}$ first
M1 First M mark on e-PEN: Attempting an equation to find $\bar{x}$ in terms of *h* and *k* - mass ratio as above
A1 First A mark on e-PEN: Correct equation
A1 Second A mark on e-PEN: Correct expression for $\bar{x}$ (as shown or equivalent)
M1 Second M mark on e-PEN: Using $\frac{\bar{x}}{r}=\tan 30$ (LHS either way up)
A1ft Third A mark on e-PEN: Substitute their $\bar{x}$; LHS must be the correct way up
A1cao Final A mark on e-PEN: Obtaining the GIVEN answer

Question Number	Scheme	Marks
6 (a)	$T_A = \frac{20x}{2.5}\ (=8x) \qquad T_B = \frac{18(2-x)}{1.5}\ (=12(2-x))$	
	$\frac{20x}{2.5} = \frac{18(2-x)}{1.5}$	M1A1
	$x = \frac{12}{10} = 1.2$	A1
	$AO = 3.7$ m	A1ft (4)
(b)	$\frac{18(0.8-y)}{1.5} - \frac{20(1.2+y)}{2.5} = 0.5\ddot{y}$	M1A1A1
	$-40y = \ddot{y}\ \therefore$ SHM (or $\ddot{y} = (-20/m)y$	A1cso (4)
(c)	(Max) speed $= \frac{6}{0.5} = 12$ m s^{-1}	B1
	$\omega = \sqrt{40} = 2\sqrt{10}$	B1ft
	$12 = a \times 2\sqrt{10}$	M1
	$a = \frac{6}{\sqrt{10}}$ or $\frac{3\sqrt{10}}{5}$ m (accept 1.897... ie 1.9, 1.90 or better)	A1ft (4)
(d)	$1.2 = a\sin\omega t$	M1(their a, ω)
	$t = \frac{1}{2\sqrt{10}}\sin^{-1}\left(\frac{1.2\sqrt{10}}{6}\right)$	M1(must use radians)
	$t = 0.1082...$ s (Accept 0.11 or better)	A1cso (3) [15]

(a) M1 Using Hooke's law to find **both** tensions and equating them. The extension in *BP* can be used instead of the extension in *AP*. ALT: Use both extensions and use $e_a+e_b=2$ later
A1 Correct equation
A1 Correct value found for either extension
A1ft Correct length for *AO*; follow through their extension

(b) M1 Forming an equation of motion at a general point. Difference of 2 tensions, both including. the variable. Use of *a* instead of $\ddot{x}$ can score M1A1A0A0 max (ie an A error)
A1 A1 A1A1 fully correct; A1A0 one error May have *m* instead of 0.5 Extensions measured from *O*
A1cso A correct simplified equation. Any equivalent form, including having *m* instead of 0.5. There must be a concluding statement.

(c) B1 Correct speed following impulse Can be awarded if seen in (b) or (d)
B1ft Correct value of ω; must be numerical. FT from (b) Can be awarded if seen in (b) or (d)
M1 Using $v_{\max} = a\omega$ (their values). By energy – equation must have all terms
A1ft Correct value of a any equivalent form including decimals. Follow through their ω

(d) M1 Using $y = a\sin\omega t$ with their a and ω If $y = a\cos\omega t$ is used there must be some indication of moving from the time obtained to the required time.
M1 Solving their equation to find a time. **Must** use radians
A1cso Correct time, min 2 sf. ω and a must have been obtained from correct work.

Question Number	Scheme	Marks
7 (a)	$\frac{1}{2}mv^2 - \frac{1}{2}m\frac{rg}{4} = mgr\left(1-\cos\theta\right)$	M1A1A1
	$v^2 = \frac{rg}{4}\left(9-8\cos\theta\right)$ *	A1 (4)
(b)	$\left(R\right) + mg\cos\theta = \frac{mv^2}{r}$	M1A1
	$R = 0 \quad mg\cos\alpha = \frac{mg}{4}\left(9-8\cos\alpha\right)$	DM1
	$12\cos\alpha = 9$	
	$\cos\alpha = \frac{3}{4}$ or 0.75	A1 (4)
(c)	Initial vert comp of speed $= \sqrt{\frac{3g}{8}}\sin\alpha = \sqrt{\frac{3g}{8}}\times\frac{\sqrt{7}}{4}\ \left(=1.2679...\right)$	M1A1
	$\frac{7}{8} = 1.2679...t + \frac{1}{2}gt^2$	M1
	$7 = 10.143...t + 39.2t^2$	
	$39.2t^2 + 10.143...t - 7 = 0$	
	$t = \frac{-10.143 \pm \sqrt{10.143^2 + 4\times7\times39.2}}{2\times39.2}$	DM1
	$t = 0.3125...$	A1
	Horiz speed $= \sqrt{\frac{3g}{8}}\cos\alpha = \frac{1}{4}\sqrt{\frac{27g}{8}}$	
	$AC = \frac{1}{4}\sqrt{\frac{27g}{8}}\times0.3125 + r\sin\alpha = 0.4493 + 0.3307 = 0.78$ m	M1A1cso (7) [15]

(a) M1 Attempting an energy equation. 2KE terms needed and a PE term.
Award if mass missing throughout, but **not** for use of $v^2 = u^2 + 2as$

A1 KE terms correct (and subtracted) Mass not needed if M mark earned

A1 PE correct Again, mass not needed if M mark earned

A1cso Obtaining the GIVEN answer

(b) M1 Attempting an equation of motion along the radius. Accel in either form, $\left(\pm\right)R$ may be included.

A1 Correct equation, with or without $\left(\pm\right)R$

DM1 Set $R = 0$ and substitute for v

A1 $\cos\alpha = 3/4$ obtained

(c) M1	Attempting the initial vertical component of the speed
A1	Correct vertical component - decimal or exact
M1	Using $s = ut + \frac{1}{2}at^2$ to form a quadratic in t, with *their* vertical speed and attempt at the vertical distance **Must** satisfy $0.5 < \text{distance} < 1$
DM1	Solving their quadratic; formula must be shown (and correct) if answer is incorrect, but allow with $+\sqrt{....}$ instead of $\pm\sqrt{....}$
A1	Correct t. Give by implication if stored on a calculator and final answer correct Second solution need not be shown; ignore any shown
M1	Using the horizontal speed and completing to obtain the required distance.
A1	$AC = 0.78$ **must** be 2 sf.
	ALT for (c):
M1A1	As main method above
M1	Use the horizontal speed and distance travelled as a projectile to get an expression for t and substitute in $s = ut + \frac{1}{2}at^2$ Vertical distance must be between 0.5 and 1
DM1	Solve their quadratic - see above
A1	Correct (projectile) distance
M1A1	As main method above

7(c) Using energy etc:

M1	Using energy to get the speed at the floor. Can be from the top or the point of leaving the surface
A1	Correct speed at floor
M1	Using the horizontal component of the speed and Pythagoras to obtain the vertical component at the floor
M1	Using $v = u + at$ vertically to get t
A1	Correct t
M1A1	Complete as main method

Other alternative Methods

Question 4(a) **by definite integration**

$900\frac{dv}{dt} = \frac{63000}{kt^2}$	M1
$\int_0^{10.5} dv = \int_1^4 \frac{70}{kt^2} dt$	
$[v]_0^{10.5} = \left[-\frac{70}{kt}\right]_1^4$	DM1A1 Integration, limits not needed
$10.5\ (-0) = -\frac{70}{4k} + \frac{70}{k}$	M1 Substitute limits
$k = 5$	A1 Correct value
$\int_0^v dv = \int_1^t \frac{14}{t^2} dt$	A1 Integrate again with limits as shown
$v = 14 - \frac{14}{t}$ *	A1 Obtain GIVEN answer

OR:

$900\frac{dv}{dt} = \frac{63000}{kt^2}$	M1
$\int_0^v dv = \int_1^t \frac{70}{kt^2} dt$	
$[v]_0^v = \left[-\frac{70}{kt}\right]_1^t$	DM1A1 Integration, limits not needed
$v = \frac{70}{k}\left[-\frac{1}{t}\right]_1^t = \frac{70}{k}\left(1 - \frac{1}{t}\right)$	M1 Substitute limits and $v = 10.5,\ t = 4$
$k = 5$	A1 Correct value
$v = \frac{70}{5}\left(1 - \frac{1}{t}\right)$	A1 substitute
$v = 14 - \frac{14}{t}$ *	A1 Obtain GIVEN answer

Question 6(c) **by reference circle**

M1 Finding the required angle in radians.

M1 Using the period $\left(\frac{2\pi}{\omega}\right)$ and their angle to find the required time.

A1 Correct time.

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