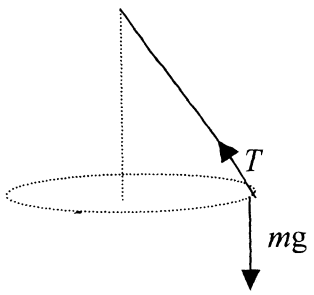
EDEXCEL FOUNDATION

Stewart House 32 Russell Square London WC1B 5DN

January 2004

Advanced Subsidiary / Advanced Level
General Certificate of Education

SUBJECT: **MECHANICS 6679** PAPER NO: **M3**

1. 	(a) ($\updownarrow$) $T\cos 60° = mg \Rightarrow T = 2mg$ *	B1 (1)
	(b) ($\leftrightarrow$) $T\sin 60° = mr\omega^2$	M1A1
	$r = L\sin 60°$	B1
	$\omega = \sqrt{\dfrac{\mathbf{2g}}{\boldsymbol{L}}}$	A1 (4)
	(c) Applying Hooke's Law: $2mg = \dfrac{\lambda}{(\frac{3}{5}L)}(L - \frac{3}{5}L)$; $\lambda = \mathbf{3}\boldsymbol{m}\mathbf{g}$	M1;A1 (2) [7]
2.	(a) Integrating to find expression for v $[v = 2e^{-2t}$ (+c)]	M1
	Using initial conditions to find c (–1) or $v - 1 = [f(t)]_0^t$	M1
	$\mathbf{v = 2e^{-2t} - 1}$ ms^{-1}	A1 (3)
	(b) Finding t when $v = 0$; $[T = ½ \ln 2,\ 0.347]$	M1
	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
	Substituting T in equation for x and finding value for x	M1
	[Def. integral: $x = \left[-e^{-2t} - t\right]_0^T$ M1; correct use of limits M1]	
	$\boldsymbol{x} = \mathbf{½\,(1 - \ln 2)}$ **m** (or equiv. **two** terms) or **0.15** or **0.153** m (awrt)	A1 (6) [9]

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3. (a)	$F = \dfrac{k}{x^2}$ [k may be seen as Gm_1m_2, for example]	M1
	Equating F to mg at $\boldsymbol{x = R}$,	M1
	Convincing completion [$k = mgR^2$] to give $F = \dfrac{mgR^2}{x^2}$ *	A1 **(3)**
(b)	Equation of motion: $(m)a = (-)\dfrac{(m)gR^2}{x^2}$; using $a = v\dfrac{\mathrm{d}v}{\mathrm{d}x}$	B1;M1
	Integrating: $\tfrac{1}{2}v^2 = \dfrac{gR^2}{x}$ (+ c) or equivalent	M1A1
	Use of $v^2 = \dfrac{3gR}{2}$, $x = R$ to find c [$c = -\tfrac{1}{4}gR$] or use in def. int.	M1
	Substituting $x = 3R$ and finding V ; $V = \sqrt{\dfrac{\boldsymbol{gR}}{\boldsymbol{6}}}$	M1;A1 **(7)**
		[10]
	Alternative in (b)	
	Work/energy $(-)\displaystyle\int_R^a \dfrac{mgR^2}{x^2}\mathrm{d}x$; $= \tfrac{1}{2}mv^2 - \tfrac{1}{2}mu^2$	B1;M1
	Integrating: $\left[\dfrac{mgR^2}{x} - \dfrac{mgR^2}{R}\right] = \tfrac{1}{2}mv^2 - \tfrac{1}{2}m\dfrac{3gR}{2}$	M1A1M1
	Final 2 marks as scheme	M1A1

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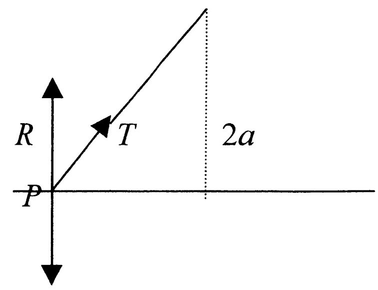
4.



(a) Length of string $(L) = \frac{10}{3}a$	B1
$\text{EPE} = \dfrac{\frac{1}{2}mg}{2a}(L-a)^2$	M1
$= \frac{49}{36}mga$	A1 **(3)**
$(1.36mga,\ 13ma \text{ or } 13.3ma)$	
(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 [allow $1.49\sqrt{ga}$, $\frac{14}{3}\sqrt{a}$]	A1 **(3)**
(c) $T_V = T\sin\theta$ [implied by $R + T\sin\theta = mg$]	B1
T_V in terms of θ [$\frac{mg}{2a}(\frac{2a}{\sin\theta} - a)\sin\theta$]	M1
or in terms of x or AP [or $\frac{mg(AP-a)}{2}.\frac{2a}{AP}$ or $\frac{mg}{2}\frac{x}{a}\frac{2a}{(a+x)}$]	
(i) $T = \frac{1}{2}mg(2-\sin\theta)$ or $R = \frac{1}{2}mg\sin\theta$	A1
Complete method to show $R > 0$	M1A1
OR	OR
(ii) $T = \frac{1}{2}mg(2-\sin\theta)$; $mg(1-\frac{a}{AP})$; $\frac{mgx}{a+x}$	A1
Complete method to show $T_V < mg$ or that $T_V \geq mg$ not poss	M1A1
OR	OR
(iii) $T = \frac{1}{2}mg(2-\sin\theta)$	A1
asθ increases T_V decreases; $T_V < T_{V\max} = \frac{7}{10}mg < mg$	M1A1 **(5)**
[In all cases: For A1 all working correct and arg. convincing]	**[11]**

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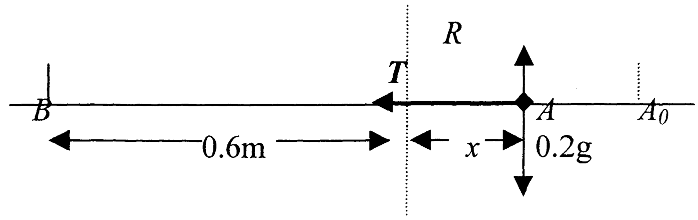
5. (a)



$\lambda = 48\text{N}$

$BA_0 = 0.9$ m

Applying Hooke's Law in general position [$T = \dfrac{48x}{0.6}$ (=80x)]	M1
[*Note*: x may be other forms e.g.("x" – 0.6) or "(0.3 – "x")	
Equation of motion: $T = (–)0.2\ \ddot{x}$ (or a)	M1
Correct equation: e.g.: $\dfrac{48x}{0.6} = –0.2\ \ddot{x}$, 0.2 "$\ddot{x}$" $= \dfrac{48x}{0.6}(0.3 –$ "x")	A1
Equation of the form $\ddot{x} = – \omega^2 x$, so SHM	M1
Period $(= \dfrac{2\pi}{\omega_C}) = \dfrac{2\pi}{20} = \dfrac{\pi}{10}$ * (no incorrect working seen)	A1 **(5)**
(b) max $v = a\omega$; $= 0.3 \times 20 = 6\ \text{ms}^{-1}$	M1;A1**(2)**
[	
(c) Using $x = a\cos 20t$ or $x = a\sin 20T$ or $\cos\alpha = \dfrac{x}{a}$	M1
Using $x = 0.15$: $\cos 20t = \dfrac{0.15}{a}$ or $\sin 20T = \dfrac{0.15}{a}$ or $\cos\alpha = \dfrac{0.15}{a}$	M1
Either $t = \dfrac{\pi}{60}, (\dfrac{5\pi}{60})$ or $T = \dfrac{\pi}{120}$ or $\alpha = \dfrac{\pi}{3}$	A1
Complete method for time:	
$t_2 – t_1$, or $\dfrac{\pi}{10} – 2t_1$, or $\dfrac{\pi}{20} + 2T$ or $\dfrac{2\pi - 2\alpha}{2\pi} = \dfrac{t}{(\pi/10)}$	M1
Time = $\dfrac{\pi}{\mathbf{15}}$ s (must be in terms of π)	A1 **(5) [12]**

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6. (a)

	Cylinder	Hemisphere	S	
Masses	$(\rho)\pi(2a)^2(\frac{3}{2}a)$ [$6\pi a^3$] [18]	$(\rho)\frac{2}{3}\pi a^3$ [2]	$(\rho)(\frac{16}{3}\pi a^3)$ [16]	M1A1

[M1 for attempt at C, H and $S = C - H$ masses]

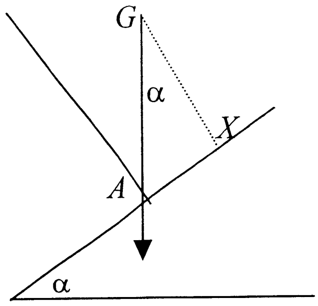
Distances of CM from

O	$\frac{3}{4}a$	$\frac{3}{8}a$	$\bar{x}$	B1B1
or lower face	$\frac{3}{4}a$	$\frac{a}{2}+\frac{5a}{8}$	$\bar{x}'$	

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

$\boldsymbol{\bar{x} = \frac{51}{64}a}$ (0.797a) A1 (6)

(b)



G above "A" seen or implied or $mg\sin\alpha\,(GX) = mg\cos\alpha\,(AX)$ M1

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

$[GX = \frac{3}{2}a - \frac{51}{64}a = \frac{45}{64}a,\ \tan\alpha = \dfrac{128}{45}]$ $\boldsymbol{\alpha = 70.6°}$ 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

β **= 38.7°** A1 (3) [12]

7. (a) Attempt at conservation of 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 $v = 0$ in (a) and (i) solving for θ	M1
$\sin\theta = -\frac{3}{4}$ so not complete circle	A1 **(2)**
or (ii) looking at energy at top (mga) and at start ($\frac{3}{4}mga$) so not possible	
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√
Working horizontally : $\sqrt{\frac{ga}{2}}\cos 60° = \sqrt{\frac{3ga}{2}}\cos\phi$	M1A1√
or vertically : $\frac{3}{2}ag\sin^2\phi = \frac{1}{2}ag.\sin^2 60° + ag$ $(= \frac{11ag}{8})$	
or finding V_V **and** V_H and using to find $\tan\phi$	
ϕ **= 73° or 73.2°**	A1 **(4) [14]**