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Mark Scheme (Results)

Summer 2012

GCE Mechanics M5
(6681) Paper 1

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6681 Mechanics M5
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Question Number	Scheme	Marks
1.	$\frac{d\mathbf{r}}{dt} - \frac{2}{t}\mathbf{r} = 4\mathbf{i}$	
	IF= $e^{\int -\frac{2}{t}dt} = \frac{1}{t^2}$	M1 A1
	$\frac{d}{dt}(\frac{\mathbf{r}}{t^2}) = \frac{1}{t^2}4\mathbf{i}$	M1 A1
	$\frac{\mathbf{r}}{t^2} = \int \frac{1}{t^2}4\mathbf{i}\ dt$	M1
	$= \frac{-1}{t}4\mathbf{i} + \mathbf{C}$ (**C** not needed for A1)	A1
	$\mathbf{r} = -4t\mathbf{i} + \mathbf{C}t^2$	
	$t = 1, \mathbf{r} = \mathbf{i} + \mathbf{j} \Rightarrow \mathbf{i} + \mathbf{j} = -4\mathbf{i} + \mathbf{C} \Rightarrow 5\mathbf{i} + \mathbf{j} = \mathbf{C}$	M1 A1
	$\mathbf{r} = -4t\mathbf{i} + (5\mathbf{i} + \mathbf{j})t^2$	A1
		9

Question Number	Scheme	Marks
2. **(a)**	$(m+\delta m)(v+\delta v)-(-\delta m)(1000-v)-mv=-mg\delta t$	M1 A2
	$\delta v+\dfrac{1000}{m}\delta m=-g\delta t$	
	$\dfrac{\mathrm{d}v}{\mathrm{d}t}+\dfrac{1000}{m}\dfrac{\mathrm{d}m}{\mathrm{d}t}=-9.8$ PRINTED ANSWER	DM1 A1
		(5)
(b)	$\dfrac{\mathrm{d}v}{\mathrm{d}t}-\dfrac{15000}{1500-15t}=-9.8$	M1
	$\dfrac{\mathrm{d}v}{\mathrm{d}t}-\dfrac{1000}{100-t}=-9.8$	
	$v=\int_0^t \dfrac{1000}{100-t}-9.8\ \mathrm{d}t$	M1
	$=\left[-1000\ln(100-t)-9.8t\right]_0^t$	A1
	$v=1000\ln\dfrac{100}{(100-t)}-9.8t$	DM1 A1
		(5)
		10

Question Number	Scheme	Marks
3.		
(a)	$I_P \; = \frac{4}{3}m(\frac{3a}{2})^2 + 3m(2a)^2 = 15ma^2$ PRINTED ANSWER OR $= \frac{1}{3}m(\frac{3a}{2})^2 + m(\frac{3a}{2})^2 + 3m(2a)^2 = 15ma^2$	M1 A1
		(2)
(b)	KE gain = PE loss	
	$\frac{1}{2}3mv^2 = 3mg.2a$ **OR** $\frac{1}{2}(12ma^2)\Omega^2 = 3mg.2a$	M1
	$v = 2\sqrt{ag}$ $\Omega = \sqrt{\frac{g}{a}}$	A1
	CAM: $3mv.2a = 15ma^2\omega$ **OR** CAM: $(12ma^2)\Omega = 15ma^2\omega$	M1 A1
	$\omega = \frac{2av}{5a^2} = \frac{4}{5}\sqrt{\frac{g}{a}}$	A1
	KE loss = PE gain	
	$\frac{1}{2}15ma^2\omega^2 = mg\frac{3a}{2}(1-\cos\theta) + 3mg.2a(1-\cos\theta)$	M1 A1 A1
	$\cos\theta = \frac{9}{25}$ i.e. $\theta = \cos^{-1}(\frac{9}{25})$ PRINTED ANSWER	M1 A1
		(10)
		12
	OR	
	$\frac{1}{2}15ma^2\omega^2 = 4mg\frac{15a}{8}(1-\cos\theta)$	M1 A1 A1
	$\cos\theta = \frac{9}{25}$ i.e. $\theta = \cos^{-1}(\frac{9}{25})$ PRINTED ANSWER	M1 A1

Question Number	Scheme	Marks
4.	$M(Q)$, $2mgr\sin\beta + 3mg2r\sin\beta = 15mr^2\ddot{\theta}$	M1 A1
	OR $M(Q)$, $5mg\frac{8r}{5}\sin\beta = 15mr^2\ddot{\theta}$	M1 A1
	(□) $2mg\sin\beta + 3mg\sin\beta - X = 2mr\ddot{\theta} + 3m2r\ddot{\theta}$	M1 A1
	OR (□) $5mg\sin\beta - X = 5m\frac{8r}{5}\ddot{\theta}$	M1 A1
	solving for X,	M1
	$X = \dfrac{11mg}{60}$	A1
		6

Question Number	Scheme	Marks
5.		
(a)	$\mathbf{F}_1 = 7.\frac{1}{\sqrt{4^2+(-6)^2+(-12)^2}}\begin{pmatrix}4\\-6\\-12\end{pmatrix} = \begin{pmatrix}2\\-3\\-6\end{pmatrix}$	B1
	$\mathbf{F}_2 = 3.\frac{1}{\sqrt{2^2+4^2+4^2}}\begin{pmatrix}-2\\-4\\-4\end{pmatrix} = \begin{pmatrix}-1\\-2\\-2\end{pmatrix}$	B1
	$\mathbf{F}_3 = 3\sqrt{10}.\frac{1}{\sqrt{2^2+(-10)^2+(-16)^2}}\begin{pmatrix}2\\-10\\-16\end{pmatrix} = \begin{pmatrix}1\\-5\\-8\end{pmatrix}$	B1
		(3)
(b)	$\sum \mathbf{F}_i = \begin{pmatrix}2\\-3\\-6\end{pmatrix} + \begin{pmatrix}-1\\-2\\-2\end{pmatrix} + \begin{pmatrix}1\\-5\\-8\end{pmatrix} = \begin{pmatrix}2\\-10\\-16\end{pmatrix}$ PRINTED ANSWER	M1 A1
		(2)
(c)	Taking moments about O,	
	$\begin{pmatrix}4\\-6\\-12\end{pmatrix} \text{x} \begin{pmatrix}1\\-5\\-8\end{pmatrix} = \begin{pmatrix}x\\y\\z\end{pmatrix} \text{x} \begin{pmatrix}2\\-10\\-16\end{pmatrix}$	M1
	$\begin{pmatrix}-12\\20\\-14\end{pmatrix} = \begin{pmatrix}-16y+10z\\2z+16x\\-10x-2y\end{pmatrix}$ put $x=0 \Rightarrow z=10 \Rightarrow y=7$	A1 A1 M1
	so, $\mathbf{r} = \begin{pmatrix}0\\7\\10\end{pmatrix} + \lambda\begin{pmatrix}1\\-5\\-8\end{pmatrix}$ is a vector equation.	A1
		(5) **10**

Question Number	Scheme	Marks
6.		
(a)	$3mg - T_1 = 3mr\alpha$	M1 A1
	$T_2 - 2mg = 2mr\alpha$	M1 A1
	$r(T_1 - T_2) = \frac{1}{2}4mr^2\alpha$	M1 A1
	adding, $mg = 7mr\alpha$	DM1
	$\alpha = \dfrac{g}{7r}$	A1
		(8)
(b)	$G = 2mr^2\beta$	M1 A1
	$0^2 = \Omega^2 - 2\beta\theta$	M1
	$\theta = \dfrac{mr^2\Omega^2}{G}$	A1
		(4) **12**
	OR , using Work-Energy	
	$G\theta = \frac{1}{2}2mr^2\Omega^2$	M1 A1
	$\theta = \dfrac{mr^2\Omega^2}{G}$	M1 A1

Question Number	Scheme	Marks
7.		
(a)	$\rho = \dfrac{2m}{bh}$	B1
	$\delta m = \rho \dfrac{b(h-x)}{h}\delta x$	M1
	$= \dfrac{2m}{h^2}(h-x)\delta x$	
	$\delta I = \dfrac{2m}{h^2}(h-x)x^2\delta x$	A1
	$I = \int_0^h \dfrac{2m}{h^2}(h-x)x^2 \mathrm{d}x = = \dfrac{2m}{h^2}\left[\dfrac{hx^3}{3} - \dfrac{x^4}{4}\right]_0^h$	M1 A1
	$= \dfrac{1}{6}mh^2$ PRINTED ANSWER	DM1 A1
		(7)
(b)	$I = 2 \text{ x } \dfrac{1}{6}m(a\sqrt{2})^2 = \dfrac{2}{3}ma^2$	B1
	$k = \sqrt{\dfrac{I}{M}} = \sqrt{\dfrac{\frac{2}{3}ma^2}{2m}} = \dfrac{a}{\sqrt{3}}$	M1 A1
		(3)
(c)	MI of square about QS = $\dfrac{1}{3}\dfrac{8M}{7}a^2 = \dfrac{8M}{21}a^2$	M1 A1
	MI of square about XY = $\dfrac{8M}{21}a^2 + \dfrac{8M}{7}(\dfrac{a\sqrt{2}}{2})^2$	M1 A1
	$= \dfrac{20Ma^2}{21}$	
	Hence, $I_{PQXYS} = \dfrac{20Ma^2}{21} - \dfrac{1}{6}\dfrac{M}{7}(\dfrac{a}{\sqrt{2}})^2 = \dfrac{79Ma^2}{84}$ PRINTED	M1 A1
		(6) **16**

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