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Mark Scheme (Results)
Summer 2010

GCE

GCE Mechanics M4 (6680/01)

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Publications Code UA024478

Mechanic guidance:

- For M marks, correct number of terms, dimensionally correct, all terms that need resolving are resolved.
- Omission of *g* from a resolution is an accuracy error, not a method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Where there is only one method mark for a question or part of a question, this is for a *complete* method.
- Omission of units is not (usually) counted as an error.
- Use of 9.81 for g is a rubric error. Deduct the final A1 from the first part of any question affected.
- More than 3 sf in an answer using an approximation for g is an accuracy error. Deduct the final A1 from the first part of any question affected.
- A dimensionally incorrect equation is a method error unless a correct equation was quoted and the error arises from a slip in substitution of values.
- For a misread which does not alter the character of a question or materially simplify it, all marks in that part of the question affected become ft. Deduct the first 2 A or B marks gained as a result and give the rest.

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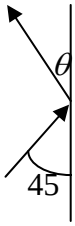
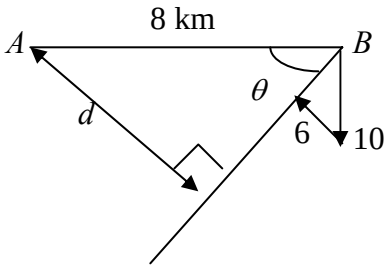
Mechanics M4 6680
Mark Scheme

Question Number	Scheme	Marks
Q1	$v(3\mathbf{i}-4\mathbf{j}) = \mathbf{v}_W - u\mathbf{j}$	M1A1
	$\mathbf{v}_W = 3v\mathbf{i} + (u-4v)\mathbf{j}$	
	$w\mathbf{i} = \mathbf{v}_W - \frac{u}{5}(-3\mathbf{i}+4\mathbf{j})$	M1A1
	$\mathbf{v}_W = (w-\frac{3u}{5})\mathbf{i} + \frac{4u}{5}\mathbf{j}$	
	$(u-4v) = \frac{4u}{5}$	M1
	$v = \frac{u}{20}$	A1
	$\mathbf{v}_W = \frac{3u}{20}\mathbf{i} + \frac{4u}{5}\mathbf{j}$	A1
		7

Question Number	Scheme	Marks
Q2 (a)	$\uparrow 2$ $\quad$ $\uparrow 1$ $1 \leftarrow$ $\quad$ $\rightarrow 1$ S 0.3kg $\quad$ T 0.6 kg $2 \uparrow$ $\quad$ $\uparrow 1$ $\rightarrow v$ $\quad$ $w \leftarrow$ $0.3v - 0.6w = 0.3$ $v - 2w = 1$ $\frac{1}{2}(v+w) = 2$ $v + w = 4$ $w = 1, v = 3$ (i) $\mathbf{u}_1 = 3\mathbf{i} + 2\mathbf{j}$ (ii) $\mathbf{u}_2 = -\mathbf{i} + \mathbf{j}$	M1 A1 M1 A1 A1 A1 (6)
(b)	$\uparrow 1$ $v \leftarrow$ $v = 0.5$ $1 \uparrow$ $\rightarrow 1$  $\tan\theta = 0.5$ $\quad$ $\tan\theta$ = their v $\theta = 26.6$ their $\theta + 45^\circ$ Defln angle $= 45 + 26.6 = 71.6^\circ$	B1 M1 A1 M1 A1 (5)
(c)	KE Loss = $\frac{1}{2}$ x 0.6 x $\left\{(1^2+1^2)-(1^2+v^2)\right\}$ $= 0.225$ J	M1 A1 A1 (3) **14**

Question Number	Scheme	Marks
Q3 (a)		M1
	$\cos\theta = \frac{6}{10} \Rightarrow \theta = 53.1^{o}$	M1 A1
	Bearing is 307^{o}	A1 (4)
(b)	$d = 8\sin\theta$ (=8×0.8) = 6.4 km	M1 A1 A1 (3)
(c)	$T = \frac{8\cos\theta}{\sqrt{10^2 - 6^2}}$ = 0.6 hrs i.e. the time is 12:36 pm	M1 A1 A1 (3) **10**

Question Number	Scheme	Marks
Q4		
(a)	$-mg(1+\frac{v^2}{k^2}) = m\frac{\mathrm{d}v}{\mathrm{d}t}$	M1 A1
	$g\int_0^T \mathrm{d}t = \int_U^0 \frac{-k^2\mathrm{d}v}{(k^2+v^2)}$	DM1
	$T = \frac{k}{g}\left[\tan^{-1}\frac{v}{k}\right]_0^U$	A1
	$= \frac{k}{g}\tan^{-1}\frac{U}{k}$	DM1A1
		(6)
(b)	$-mg(1+\frac{v^2}{k^2}) = mv\frac{\mathrm{d}v}{\mathrm{d}x}$	M1 A1
	$g\int_0^H \mathrm{d}x = \int_U^0 \frac{-k^2 v\mathrm{d}v}{(k^2+v^2)}$	DM1
	$H = \frac{k^2}{2g}\left[\ln(k^2+v^2)\right]_0^U$	A1
	$H = \frac{k^2}{2g}\ln\frac{(k^2+U^2)}{k^2}$	DM1A1
		(6)
		12

Question Number	Scheme	Marks
Q5 (a)	$\sqrt{4a^2+16a^2-16a^2\sin\theta}$	M1 A1
	Let length of string be L.	
	$V=-4mga\cos\theta-mg(L-\sqrt{4a^2+16a^2-16a^2\sin\theta}$	M1 A1
	$=-4mga\cos\theta-mgL+2mga\sqrt{5-4\sin\theta}$	
	$=2mga\left\{\sqrt{5-4\sin\theta}-2\cos\theta\right\}+\text{constant}$ **	A1
		(5)
(b)	$V'(\theta)=2mga\left\{\frac{-2\cos\theta}{\sqrt{5-4\sin\theta}}+2\sin\theta\right\}$	M1 A1
	For equilibrium, $V'(\theta)=0$	
	$\left\{\frac{-2\cos\theta}{\sqrt{5-4\sin\theta}}+2\sin\theta\right\}=0$	M1
	$\frac{\cos^2\theta}{5-4\sin\theta}=\sin^2\theta$	
	$1-\sin^2\theta=\sin^2\theta(5-4\sin\theta)$	DM1
	$4\sin^3\theta-6\sin^2\theta+1=0$ **	A1
		(5)
(c)	$V''(\theta)=2mga\left(\frac{\left\{\sqrt{5-4\sin\theta}.2\sin\theta-\frac{-2\cos\theta.(-4\cos\theta)}{2\sqrt{5-4\sin\theta}}\right\}}{(5-4\sin\theta)}+2\cos\theta\right)$	M1 A1 A1
	$V''(\frac{\pi}{6})=2mga\left\{\frac{\sqrt{3}-\frac{8x\frac{3}{4}}{2\sqrt{3}}}{3}+\sqrt{3}\right\}=2mga\sqrt{3}>0$ so stable	DM1 A1
		(5)
		15

Question Number	Scheme	Marks
Q6		
(a)	$T_1 = \dfrac{2mge}{a}\ ;\ T_2 = \dfrac{mg(2a-e)}{a}$	B1 (either)
	$T_1 = T_2$	
	$2e = (2a-e)$	M1 A1
	$e = \dfrac{2a}{3}$	
	$AP = a + \dfrac{2a}{3} = \dfrac{5a}{3}$ **	A1
		(4)
(b)	$T_2 - T_1 - 4m\omega\dot{x} = m\ddot{x}$	
	$\dfrac{mg}{a}\left(\dfrac{4a}{3} - x\right) - \dfrac{2mg}{a}\left(\dfrac{2a}{3} + x\right) - 4m\omega\dot{x} = m\ddot{x}$	M1 A3
	$\ddot{x} + 4\omega\dot{x} + \dfrac{3g}{a}x = 0$	
	$\ddot{x} + 4\omega\dot{x} + 3\omega^2 x = 0$ **	A1
		(5)
(c)	$\lambda^2 + 4\omega\lambda + 3\omega^2 = 0$	
	$(\lambda + 3\omega)(\lambda + \omega) = 0$	M1
	$\lambda = -3\omega$ or $\lambda = -\omega$	
	$x = Ae^{-\omega t} + Be^{-3\omega t}$	A1
	$\dot{x} = -\omega Ae^{-\omega t} - 3\omega Be^{-3\omega t}$	M1 A1
	$t = 0,\ x = \frac{1}{2}a,\ \dot{x} = 0$	M1
	$\frac{1}{2}a = A + B$	
	$0 = -\omega A - 3\omega B$	A1
	$A = \frac{3}{4}a,\ B = -\frac{1}{4}a$	A1
	$\dot{x} = v = \frac{3}{4}a\omega\left(e^{-3\omega t} - e^{-\omega t}\right)$	A1
		(8)
		17

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