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# Mark Scheme (Results)
# Summer 2010

GCE

## GCE Mechanics M4 (6680/01)

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**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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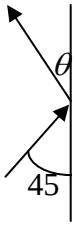
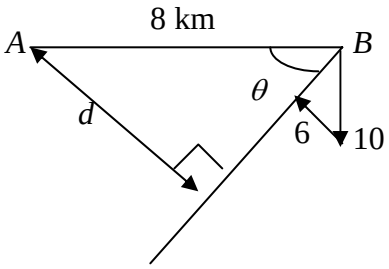
# Summer 2010
# Mechanics M4 6680
# Mark Scheme

| 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) | $\uparrow 2$ $\quad$ $\uparrow 1$<br>$1 \leftarrow$ $\quad$ $\rightarrow 1$<br>$S$ 0.3kg $\quad$ $T$ 0.6 kg<br>$2 \uparrow$ $\quad$ $\uparrow 1$<br>$\rightarrow v$ $\quad$ $w \leftarrow$ | |
| | $0.3v - 0.6w = 0.3$ | M1 A1 |
| | $v - 2w = 1$ | |
| | $\frac{1}{2}(v + w) = 2$ | M1 A1 |
| | $v + w = 4$ | |
| | $w = 1, v = 3$ | |
| | (i) $\mathbf{u}_1 = 3\mathbf{i} + 2\mathbf{j}$ (ii) $\mathbf{u}_2 = -\mathbf{i} + \mathbf{j}$ | A1 A1 |
| | | (6) |
| (b) | $\uparrow 1$<br>$v \leftarrow$ | |
| | $v = 0.5$ | B1 |
| | $1 \uparrow$<br>$\rightarrow 1$ | |
| |  | |
| | $\tan\theta = 0.5$ $\quad$ $\tan\theta$ = their $v$ | M1 |
| | $\theta = 26.6$ | A1 |
| | their $\theta + 45^\circ$ | M1 |
| | Defln angle $= 45 + 26.6 = 71.6^\circ$ | A1 |
| | | (5) |
| (c) | KE Loss = $\frac{1}{2}$ x 0.6 x $\left\{(1^2 + 1^2) - (1^2 + v^2)\right\}$ | M1 A1 |
| | $= 0.225$ J | 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)<br>$= 6.4$ km | M1 A1<br>A1 (3) |
| (c) | $T = \frac{8\cos\theta}{\sqrt{10^2 - 6^2}}$<br>$= 0.6$ hrs<br>i.e. the time is 12:36 pm | M1 A1<br>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 |
| | $g\int_0^H \mathrm{d}x=\int_U^0 \frac{-k^2v\mathrm{d}v}{(k^2+v^2)}$ | 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 |
| | $\dot{x} = v = \frac{3}{4}a\omega\,(\mathrm{e}^{-3\omega t} - \mathrm{e}^{-\omega t})$ | A1 |
| | | (8) |
| | | **17** |

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