



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.	$\frac{d\mathbf{r}}{dt} - \frac{2}{t}\mathbf{r} = 4\mathbf{i}$ $\text{IF} = e^{\int \frac{-2}{t} dt} = \frac{1}{t^2}$ $\frac{d}{dt} \left(\frac{\mathbf{r}}{t^2} \right) = \frac{1}{t^2} 4\mathbf{i}$ $\frac{\mathbf{r}}{t^2} = \int \frac{1}{t^2} 4\mathbf{i} dt$ $= \frac{-1}{t} 4\mathbf{i} + \mathbf{C} \quad (\mathbf{C} \text{ not needed for A1})$ $\mathbf{r} = -4t\mathbf{i} + \mathbf{C}t^2$ $t = 1, \mathbf{r} = \mathbf{i} + \mathbf{j} \Rightarrow \mathbf{i} + \mathbf{j} = -4\mathbf{i} + \mathbf{C} \Rightarrow 5\mathbf{i} + \mathbf{j} = \mathbf{C}$ $\mathbf{r} = -4t\mathbf{i} + (5\mathbf{i} + \mathbf{j})t^2$	<p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>A1</p> <p>M1 A1</p> <p>A1</p> <p style="text-align: right;">9</p>

Question Number	Scheme	Marks
<p>2. (a)</p>	$(m + \delta m)(v + \delta v) - (-\delta m)(1000 - v) - mv = -mg \delta t$ $\delta v + \frac{1000}{m} \delta m = -g \delta t$ $\frac{dv}{dt} + \frac{1000}{m} \frac{dm}{dt} = -9.8$	<p>M1 A2</p> <p>DM1 A1</p> <p>(5)</p>
<p>(b)</p>	<p>PRINTED ANSWER</p> $\frac{dv}{dt} - \frac{15000}{1500 - 15t} = -9.8$ $\frac{dv}{dt} - \frac{1000}{100 - t} = -9.8$ $v = \int_0^t \frac{1000}{100 - t} - 9.8 dt$ $= [-1000 \ln(100 - t) - 9.8t]_0^t$ $v = 1000 \ln \frac{100}{(100 - t)} - 9.8t$	<p>M1</p> <p>M1</p> <p>A1</p> <p>DM1 A1</p> <p>(5)</p> <p>10</p>

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

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

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

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

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

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