

Mark Scheme (Results) Summer 2010

GCE

GCE Mechanics M5 (6681/01)

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Summer 2010

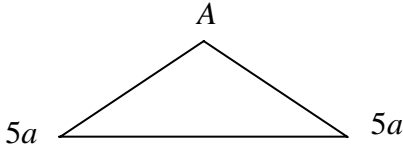
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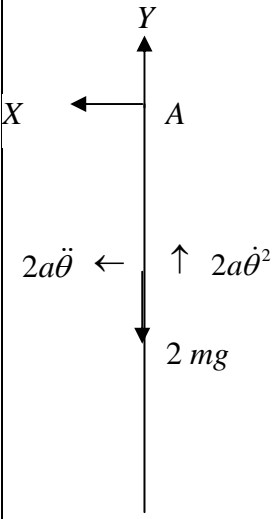
June 2010
6681 Mechanics M5
Mark Scheme

Question Number	Scheme	Marks
1	$\frac{d\mathbf{r}}{dt} - 2\mathbf{r} = 4e^t \mathbf{j}$ $\text{IF} = e^{-2t}$ $e^{-2t} \left(\frac{d\mathbf{r}}{dt} - 2\mathbf{r} \right) = e^{-2t} \cdot 4e^t \mathbf{j}$ $\frac{d(\mathbf{r}e^{-2t})}{dt} = 4e^{-t} \mathbf{j}$ $\mathbf{r}e^{-2t} = \int 4e^{-t} \mathbf{j} dt$ $= -4e^{-t} \mathbf{j} (+ \mathbf{C})$ $t = 0, \mathbf{r} = -3\mathbf{j} \Rightarrow \mathbf{C} = \mathbf{j}$ $e^{-2t} \mathbf{r} = (1 - 4e^{-t}) \mathbf{j} \quad \text{or} \quad \mathbf{r} = (e^{2t} - 4e^t) \mathbf{j}$ $(1 - 4e^{-t}) = 0 \quad \text{or} \quad (e^{2t} - 4e^t) = 0$ $t = \ln 4, 1.4 \text{ or better}$	M1 DM1 A1 DM1 A1 DM1 A1
2 (a)	Mass of disc removed = m $\frac{1}{2} 4m(4a)^2 + 4m(4a)^2$ $\frac{1}{2} m(2a)^2 + m(5a)^2$ $I = \frac{1}{2} 4m(4a)^2 + 4m(4a)^2 - \left(\frac{1}{2} m(2a)^2 + m(5a)^2 \right)$ $= 69ma^2 \quad *$	B1 M1 A1 M1 A1 DM1 A1
(b)	$4m \cdot 0 = 3m\bar{x} - ma$ $\bar{x} = \frac{1}{3} a \quad (\text{from } O)$ $\frac{1}{2} 69ma^2 \Omega^2 = 3mg \left(4a - \frac{1}{3} a \right) \left(1 - \cos \frac{2\pi}{3} \right)$ $\Omega = \sqrt{\frac{11g}{23a}}$	M1 A1 M1 A2 A1
		<p style="text-align: right;">7</p> <p style="text-align: right;">(7)</p> <p style="text-align: right;">(6)</p> <p style="text-align: right;">13</p>

Question Number	Scheme	Marks
<p>3</p> <p>(a)</p>	<div style="text-align: center;">  </div> $\delta A = \frac{8x}{3} \delta x$ $\delta m = \frac{8x}{3} \delta x \cdot \frac{m}{12a^2} \text{ or } \delta m = \frac{8x}{3} \delta x \cdot \rho$ $\delta I = \frac{8x}{3} \delta x \cdot \frac{m}{12a^2} x^2 \quad (= \frac{2m}{9a^2} x^3 \delta x)$ $I = \int_0^{3a} \frac{2m}{9a^2} x^3 dx$ $= \frac{2m}{9a^2} \left[\frac{x^4}{4} \right]_0^{3a}$ $= \frac{9ma^2}{2} *$	<p>M1 A1</p> <p>DM1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>(6)</p>
	<p>(b)</p> $I_A = \frac{9ma^2}{2} + \frac{8ma^2}{3} = \frac{43ma^2}{6} \text{ (perp axes rule)}$ $I_A = I_G + m(2a)^2 \text{ (parallel axes rule)}$ $I_D = I_G + ma^2 \text{ (parallel axes rule)}$ $I_D = \frac{43ma^2}{6} - 3ma^2 = \frac{25ma^2}{6}$	<p>M1 A1</p> <p>DM1 A1</p> <p>A1</p> <p>A1</p>
	<p>(c)</p> <p>For small θ,</p> $\ddot{\theta} = -\frac{6g}{25a} \theta \text{ SHM}$ $T = 2\pi \sqrt{\frac{25a}{6g}} = 5\pi \sqrt{\frac{2a}{3g}}$	<p>M1</p> <p>A1</p> <p>(8)</p> <p>(2)</p> <p>16</p>

Question Number	Scheme	Marks
<p>4 (a) (i)</p>	$\mathbf{R} = (\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}) + (3\mathbf{i} + \mathbf{j} + 2\mathbf{k})$ $= (4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k})$	<p>M1 A1 (2)</p>
<p>(a) (ii)</p>	$(\mathbf{x}\mathbf{i} + \mathbf{y}\mathbf{j} + \mathbf{z}\mathbf{k}) \times (4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k}) = (2\mathbf{i} + \mathbf{k}) \times (\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}) + (\mathbf{j} + 2\mathbf{k}) \times (3\mathbf{i} + \mathbf{j} + 2\mathbf{k})$ $(5y - 3z)\mathbf{i} + (4z - 5x)\mathbf{j} + (3x - 4y)\mathbf{k} = (-2\mathbf{i} - 5\mathbf{j} + 4\mathbf{k}) + (6\mathbf{j} - 3\mathbf{k})$ $(5y - 3z)\mathbf{i} + (4z - 5x)\mathbf{j} + (3x - 4y)\mathbf{k} = (-2\mathbf{i} + \mathbf{j} + \mathbf{k})$ <p>a solution is $x = 0, y = -\frac{1}{4}, z = \frac{1}{4}; x = \frac{1}{3}, y = 0, z = \frac{2}{3}; x = -\frac{1}{5}, y = -\frac{2}{5}, z = 0$</p> $\mathbf{r} = -\frac{1}{4}\mathbf{j} + \frac{1}{4}\mathbf{k} + \lambda(4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k})$	<p>M1 A2 B1 M1 A1 ft (6)</p>
<p>(b)</p>	$(\mathbf{i} + 2\mathbf{j} + \mathbf{k}) \times (4\mathbf{i} + 3\mathbf{j} + 5\mathbf{k}) + \mathbf{G} = (-2\mathbf{i} + \mathbf{j} + \mathbf{k})$ $(7\mathbf{i} - \mathbf{j} - 5\mathbf{k}) + \mathbf{G} = (-2\mathbf{i} + \mathbf{j} + \mathbf{k})$ $\mathbf{G} = (-9\mathbf{i} + 2\mathbf{j} + 6\mathbf{k})$ $ \mathbf{G} = \sqrt{(-9)^2 + 2^2 + 6^2}$ $= 11 \text{ (Nm)}$	<p>M1 A1 A1 M1 A1 ft (5) 13</p>

Question Number	Scheme	Marks
<p>5</p> <p>(a)</p>	$\frac{dr}{dt} = \lambda \Rightarrow r = \lambda t + a$ $(m + \delta m)(v + \delta v) - mv = mg \delta t$ $\frac{dv}{dt} + \frac{v}{m} \frac{dm}{dt} = g$ $\frac{dm}{dt} = 4\pi r^2(\rho)\lambda$ $\frac{dv}{dt} + \frac{3v}{4\pi r^3 \rho} 4\pi r^2 \rho \lambda = g \Rightarrow \frac{dv}{dt} + \frac{3v\lambda}{r} = g$ $\frac{dv}{dt} + \frac{3v\lambda}{\lambda t + a} = g \quad *$	<p>B1</p> <p>M1 A1</p> <p>DM1 A1</p> <p>A1 (B1)</p> <p>DM1</p> <p>A1</p> <p>(8)</p>
<p>(b)</p>	$R = e^{\int \frac{3\lambda}{\lambda t + a} dt} = e^{3\ln(\lambda t + a)} = e^{\ln(\lambda t + a)^3} = (\lambda t + a)^3$ $v(\lambda t + a)^3 = g \int (\lambda t + a)^3 dt$ $v(\lambda t + a)^3 = \frac{1}{4\lambda} g (\lambda t + a)^4$ $t = 0, v = 0 \Rightarrow C = -\frac{1}{4\lambda} g a^4$ $\lambda t + a = 3a$ $v = \frac{1}{4\lambda} g (3a) - \frac{1}{4\lambda} \frac{g a^4}{27 a^3} = \frac{20ag}{27\lambda}$	<p>M1 A1</p> <p>DM1</p> <p>A1</p> <p>DM1</p> <p>DM1</p> <p>A1</p> <p>(7)</p> <p>15</p>

Question Number	Scheme	Marks
<p>6</p> <p>(a)</p>	$\text{MI of disc about } L = \frac{1}{4}m(2a)^2 + m(2a)^2 = 5ma^2$ $\text{CAM: } m3\sqrt{ag}.2a = (5ma^2 + m(2a)^2)\omega$ $\omega = \frac{2}{3}\sqrt{\frac{g}{a}}$	<p>M1 A1</p> <p>M1 A1 ft</p> <p>A1</p> <p>(5)</p>
<p>(b)</p>	 <p style="margin-left: 20px;">$M(A), 0 = I\ddot{\theta}$</p> <p style="margin-left: 20px;">$\ddot{\theta} = 0$</p> <p style="margin-left: 20px;">$R(\leftarrow), X = 2m2a\ddot{\theta} = 0$</p> <p style="margin-left: 20px;">$R(\uparrow), Y - 2mg = 2m2a\dot{\theta}^2$</p> <p style="margin-left: 20px;">$Y = 2mg + 4ma\frac{4g}{9a}$</p> <p style="margin-left: 20px;">$= \frac{34mg}{9}$</p>	<p>B1</p> <p>B1</p> <p>M1 A1</p> <p>DM1</p> <p>A1</p> <p>(6)</p> <p>11</p>

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