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Mark Scheme (Results)
Summer 2010

GCE

GCE Mechanics M5 (6681/01)

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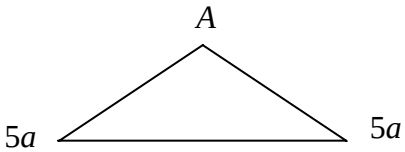
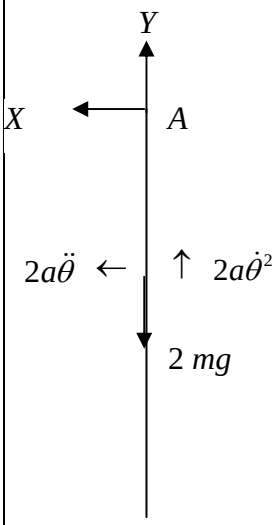
Question Number	Scheme	Marks
1	$\frac{d\mathbf{r}}{dt} - 2\mathbf{r} = 4e^{t}\,\mathbf{j}$	
	IF $= e^{-2t}$	
	$e^{-2t}(\frac{d\mathbf{r}}{dt} - 2\mathbf{r}) = e^{-2t}.4e^{t}\,\mathbf{j}$	M1
	$\frac{d(\mathbf{r}e^{-2t})}{dt} = 4e^{-t}\,\mathbf{j}$	
	$\mathbf{r}e^{-2t} = \int 4e^{-t}\,\mathbf{j}\,dt$	DM1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

Question Number	Scheme	Marks
3		
(a)	$\delta A = \frac{8x}{3}\delta x$	M1 A1
	$\delta m = \frac{8x}{3}\delta x.\frac{m}{12a^2}$ or $\delta m = \frac{8x}{3}\delta x.\rho$	DM1
	$\delta I = \frac{8x}{3}\delta x.\frac{m}{12a^2}x^2 \quad (=\frac{2m}{9a^2}x^3\delta x)$	A1
	$I = \int_0^{3a} \frac{2m}{9a^2}x^3 \, \mathrm{d}x$	M1
	$= \frac{2m}{9a^2}\left[\frac{x^4}{4}\right]_0^{3a}$	
	$= \frac{9ma^2}{2}*$	A1
		(6)
(b)	$I_A = \frac{9ma^2}{2} + \frac{8ma^2}{3} = \frac{43ma^2}{6}$ (perp axes rule)	M1 A1
	$I_A = I_G + m(2a)^2$ (parallel axes rule)	DM1 A1
	$I_D = I_G + ma^2$ (parallel axes rule)	A1
	$I_D = \frac{43ma^2}{6} - 3ma^2 = \frac{25ma^2}{6}$	A1
	$mga\sin\theta = -\frac{25ma^2}{6}\ddot{\theta}$	M1
	$\ddot{\theta} = -\frac{6g}{25a}\sin\theta$	A1
		(8)
(c)	For small θ, $\ddot{\theta} = -\frac{6g}{25a}\theta$ SHM	M1
	$T = 2\pi\sqrt{\frac{25a}{6g}} = 5\pi\sqrt{\frac{2a}{3g}}$	A1
		(2)
		16

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

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

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

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