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Mark Scheme (Results)

June 2011

GCE Mechanics M5 (6681) Paper 1

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June 2011
Publications Code UA028449
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EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

   - **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
   - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
   - **B** marks are unconditional accuracy marks (independent of M marks)
   - Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

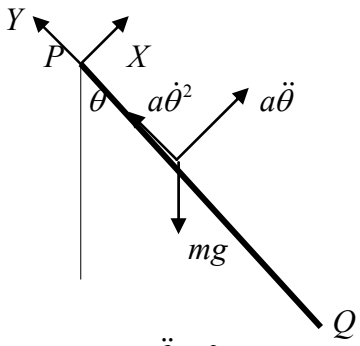
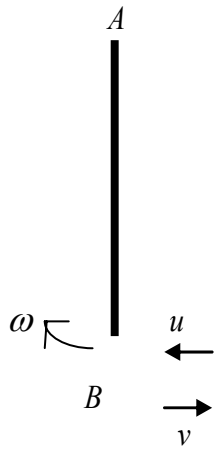
   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\hat{}$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper
   - ⌊ The second mark is dependent on gaining the first mark

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June 2011
Mechanics M5 6681
Mark Scheme

Question Number	Scheme	Marks
1.	$\mathbf{AB} = (\mathbf{i} - 2\mathbf{j} - 4\mathbf{k}) - (3\mathbf{i} - \mathbf{j} + 3\mathbf{k}) = (-2\mathbf{i} - \mathbf{j} - 7\mathbf{k})$ $(2\mathbf{i} - 3\mathbf{j} - \mathbf{k}).(-2\mathbf{i} - \mathbf{j} - 7\mathbf{k}) = -4 + 3 + 7 = 6$ J	M1 A1 M1 A1 **4**
2.	$m^2 - 4 = 0 \Rightarrow m = 2 or -2$ CF is $\mathbf{r} = \mathbf{A}e^{2t} + \mathbf{B}e^{-2t}$ PI try $\mathbf{r} = \mathbf{C}e^{t}$ $\dot{\mathbf{r}} = \mathbf{C}e^{t}$ $\ddot{\mathbf{r}} = \mathbf{C}e^{t}$ $\mathbf{C}e^{t} - 4\mathbf{C}e^{t} = -3e^{t}\mathbf{j}$ $\mathbf{C} = \mathbf{j}$ GS is $\mathbf{r} = \mathbf{A}e^{2t} + \mathbf{B}e^{-2t} + \mathbf{j}e^{t}$ $\mathbf{v} = 2\mathbf{A}e^{2t} - 2\mathbf{B}e^{-2t} + \mathbf{j}e^{t}$ $t = 0, \mathbf{r} = \mathbf{0}, \mathbf{v} = 2\mathbf{i} + \mathbf{j}$ $\mathbf{0} = \mathbf{A} + \mathbf{B} + \mathbf{j}$ $2\mathbf{i} + \mathbf{j} = 2\mathbf{A} - 2\mathbf{B} + \mathbf{j}$ $\mathbf{i} = \mathbf{A} - \mathbf{B}$ $\mathbf{A} = \frac{1}{2}(\mathbf{i} - \mathbf{j}); \mathbf{B} = -\frac{1}{2}(\mathbf{i} + \mathbf{j})$ $\mathbf{r} = \frac{1}{2}(\mathbf{i} - \mathbf{j})e^{2t} - \frac{1}{2}(\mathbf{i} + \mathbf{j})e^{-2t} + \mathbf{j}e^{t}$	M1 A1 B1 M1 A1 A1 M1 M1 A1 A1 **10**

Question Number	Scheme	Marks
3.	$(m+\delta m)(v+\delta v)+(-\delta m)(v-c)=mv$ $m\delta v+c\delta m=0$ $\int_0^V \mathrm{d}v=-c\int_M^{M(1-k)}\frac{\mathrm{d}m}{m}$ $V=c[\ln m]_{M(1-k)}^{M}$ $V=c\ln\left(\frac{1}{1-k}\right)$	M1A2 M1A1 A1 A1 **7**
4. **(a)**	$\mathbf{R}=(3\mathbf{j}+\mathbf{k})+(4\mathbf{i}+\mathbf{j}-\mathbf{k})$ $=(4\mathbf{i}+4\mathbf{j})$ (N)	M1 A1 (2)
(b)	$(\mathbf{i}+2\mathbf{j}+\mathbf{k})\times(4\mathbf{i}+4\mathbf{j})+\mathbf{G}=(2\mathbf{i}-\mathbf{j}+3\mathbf{k})\times(3\mathbf{j}+\mathbf{k})+(-3\mathbf{i}+2\mathbf{k})\times(4\mathbf{i}+\mathbf{j}-\mathbf{k})$ $(-4\mathbf{i}+4\mathbf{j}-4\mathbf{k})+\mathbf{G}=(-10\mathbf{i}-2\mathbf{j}+6\mathbf{k})+(-2\mathbf{i}+5\mathbf{j}-3\mathbf{k})$ $\mathbf{G}=(-8\mathbf{i}-\mathbf{j}+7\mathbf{k})$ (N m)	M1 A2 A1 (4)
(c)	$\mathbf{F}_3=-\mathbf{R}=(-4\mathbf{i}-4\mathbf{j})$ $\mathbf{G}=(2\mathbf{i}-\mathbf{k})\times(-4\mathbf{i}-4\mathbf{j})+(-12\mathbf{i}+3\mathbf{j}+3\mathbf{k})$ $=(-16\mathbf{i}+7\mathbf{j}-5\mathbf{k})$ $\lvert\mathbf{G}\rvert=\sqrt{(-16)^2+7^2+(-5)^2}$ $=\sqrt{330}$ (N m)	B1 M1 A1 A1 M1 A1 (6) **12**

Question Number	Scheme	Marks
5.		
	$\ddot{\theta} = 0$	B1
	$X - mg\sin\theta = ma\ddot{\theta}(=0)$	M1 A1
	$X = mg\sin\theta$	
	$Y - mg\cos\theta = ma\dot{\theta}^2 = ma\dfrac{g}{a} = mg$	M1 A1
	$Y = mg(1+\cos\theta)$	
	$R = mg\sqrt{(1+\cos\theta)^2 + \sin^2\theta}$	M1
	$= mg\sqrt{2(1+\cos\theta)}$	
	$= mg\sqrt{2.2\cos^2(\frac{1}{2}\theta)}$	DM1
	$= 2mg\left\|\cos(\frac{1}{2}\theta)\right\|$*	A1
		8
6.		
	$I_A = \dfrac{1}{3}4ml^2$	B1
	CAM: $mul = \dfrac{1}{3}4ml^2\omega - mvl$	M1 A1
	$3u = 4l\omega - 3v$	
	NIL: $u = \omega l + v$	M1 A1
	eliminating ωl	DM1
	$u = 7v$*	A1
		7

Question Number	Scheme	Marks
7.	$r_x = \frac{rx}{h}$	M1A1
	$\delta m = \pi r_x^{\,2}\delta x.\rho$	M1
	$= \pi(\frac{rx}{h})^2 \delta x.\frac{3M}{\pi r^2 h}$	
	$= \frac{3M}{h^3}x^2\delta x$	A1
	$\delta I = \frac{1}{2}\delta m\ r_x^{\,2}$	M1A1
	$= \frac{1}{2}\frac{3M}{h^3}x^2\delta x(\frac{rx}{h})^2$	
	$= \frac{3Mr^2}{2h^5}x^4\delta x$	A1 (DM1)
	$I = \frac{3Mr^2}{2h^5}\int_0^h x^4\ dx$	M1
	$= \frac{3Mr^2}{2h^5}\left[\frac{x^5}{5}\right]_0^h$	A1
	$= \frac{3Mr^2}{10}$	A1
		10

Question Number	Scheme	Marks
8. **(a)**	$I_{DISC} = \frac{ma^2}{4} + m(2a)^2 = \frac{17ma^2}{4}$ $I_{ROD} = \frac{3m(2a)^2}{3} = 4ma^2$ $I_{PENDULUM} = \frac{17ma^2}{4} + 4ma^2 = \frac{33ma^2}{4}$	M1A1 B1 M1 A1 (5)
(b)	$3mga(\cos\theta - \cos\alpha) + mg.2a(\cos\theta - \cos\alpha) = \frac{1}{2}\frac{33ma^2}{4}\dot{\theta}^2$ $\frac{40g(\cos\theta - \cos\alpha)}{33a} = \dot{\theta}^2 *$	M1A2 A1 (4)
(c)	$2\dot{\theta}\ddot{\theta} = -\frac{40g}{33a}\sin\theta.\dot{\theta}$ $\ddot{\theta} = -\frac{20g}{33a}\sin\theta$	M1A1 A1 (3)
(d)	For small θ, $\ddot{\theta} = -\frac{20g}{33a}\theta$ i.e. SHM $\omega = \sqrt{\frac{20g}{33a}} = \sqrt{\frac{20g}{33x\frac{4}{33}}} = 7$ $\theta = \alpha\cos\omega t$ $\dot{\theta} = -\alpha\omega\sin\omega t$ $= -7\frac{\pi}{20}\sin 1.4$ $\lvert\dot{\theta}\rvert = 1.08$ rad s^{-1} (3SF)	M1 A1 M1 M1 A1 (5) **17**

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Order Code UA028449 June 2011

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