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Mark Scheme (Results)

Summer 2009

GCE

GCE Mathematics (6680/01)

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June 2009
6680 Mechanics M4
Mark Scheme

Question Number	Scheme	Marks
Q1	CLM along plane: $v\cos 30^o = u\cos 45^o$	M1 A1
	$v = u\sqrt{\frac{2}{3}}$	A1
	Fraction of KE Lost = $\dfrac{\frac{1}{2}mu^2 - \frac{1}{2}mv^2}{\frac{1}{2}mu^2} = \dfrac{\frac{1}{2}mu^2 - \frac{1}{2}m\frac{2}{3}u^2}{\frac{1}{2}mu^2} = \dfrac{1}{3}$	M1 M1 A1
		[6]
Q2	$-mg - mkv^2 = ma$	M1 A1
	$-(g + kv^2) = v\dfrac{dv}{dx}$	M1
	$\pm\int_0^X dx = \int_{\sqrt{\frac{g}{k}}}^{\frac{1}{2}\sqrt{\frac{g}{k}}} \dfrac{-v\,dv}{(g + kv^2)}$	DM1 A1 (both previous)
	$X = \dfrac{1}{2k}\left[\ln(g + kv^2)\right]_{\frac{1}{2}\sqrt{\frac{g}{k}}}^{\sqrt{\frac{g}{k}}}$	M1 A1
	$= \dfrac{1}{2k}\left(\ln 2g - \ln\dfrac{5g}{4}\right)$	M1
	$= \dfrac{1}{2k}\ln\dfrac{8}{5}$	A1
		[9]

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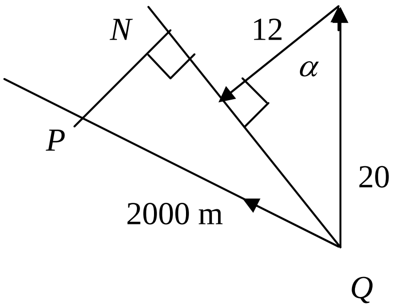
Question Number	Scheme	Marks
Q3 (a)		M1
	$\cos\alpha = \frac{12}{20}$	M1 A1
	Bearing is $180^\circ + \alpha = 233^o$ (nearest degree)	A1
		(4)
(b)	$PN = 2000\cos(135^\circ - \alpha) = 200\sqrt{2}$ m or decimal equivalent	M1A1ft A1
		(3)
(c)	$\sqrt{20^2 - 12^2}$	B1
	Time to closest approach = $\dfrac{QN}{\sqrt{20^2 - 12^2}}$	M1
	$= \dfrac{2000\sin(135^\circ - \alpha)}{16}$	A1
	Distance moved by Q = their t x 12	DM1
	$= 1050\sqrt{2}$ m or decimal equivalent	A1
		(5)
		[12]

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Question Number	Scheme	Marks
Q4 (a)	$V = -mg2a\sin 2\theta - \frac{7}{20}mg(L - 4a\sin\theta)$	M1 B1 A1
	$= \frac{1}{5}mga(7\sin\theta - 10\sin 2\theta) - \frac{7}{20}mgL$	A1
		(4)
(b)	$\frac{dV}{d\theta} = \frac{1}{5}mga(7\cos\theta - 20\cos 2\theta)$	M1 A1
	$\frac{1}{5}mga(7\cos\theta - 20\cos 2\theta) = 0$	DM1
	$7\cos\theta - 20(2\cos^2\theta - 1) = 0$	DM1
	$40\cos^2\theta - 7\cos\theta - 20 = 0$	A1
	$(5\cos\theta - 4)(8\cos\theta + 5) = 0$	
	$\cos\theta = \frac{4}{5}$ or ($\cos\theta = -\frac{5}{8} \Rightarrow 2\theta > 180^\circ$)	DM1 A1 DM1
		(8)
(c)	$\frac{d^2V}{d\theta^2} = \frac{1}{5}mga(-7\sin\theta + 40\sin 2\theta)$	M1 A1
	$= \frac{1}{5}mga(-7\sin\theta + 80\sin\theta\cos\theta)$	
	When $\cos\theta = \frac{4}{5}$,	
	$\frac{d^2V}{d\theta^2} = \frac{1}{5}mga(\frac{-21}{5} + 80 \text{x} \frac{3}{5} \text{x} \frac{4}{5}) = \frac{171}{25}mga$	M1
	> 0 therefore stable	A1 cso
		(4) **[16]**

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Question Number	Scheme	Marks
Q5 (a)	CLM: $2(\mathbf{i} + 2\mathbf{j}) + -2\mathbf{i} = \mathbf{2\,j} + \mathbf{v}$	M1 A1
	$\mathbf{v} = 2\mathbf{j}$ m s^{-1}	A1
		(3)
(b)	$\mathbf{I} = 2(\mathbf{j} - (\mathbf{i} + 2\mathbf{j}))$	M1 A1
	$= (-2\mathbf{i} - 2\mathbf{j})$ Ns	A1
	Since **I** acts along l.o.c.c. **,** l.o.c.c is parallel to $\mathbf{i} + \mathbf{j}$	B1
		(4)
(c)	Before *A*: $(\mathbf{i} + 2\mathbf{j}).\frac{1}{\sqrt{2}}(\mathbf{i} + \mathbf{j}) = \frac{3}{\sqrt{2}}$	
	B: $-2\mathbf{j}.\frac{1}{\sqrt{2}}(\mathbf{i} + \mathbf{j}) = \frac{-2}{\sqrt{2}}$	
	After *A*: $\mathbf{j}.\frac{1}{\sqrt{2}}(\mathbf{i} + \mathbf{j}) = \frac{1}{\sqrt{2}}$	M1 A3
	B: $2\mathbf{j}.\frac{1}{\sqrt{2}}(\mathbf{i} + \mathbf{j}) = \frac{2}{\sqrt{2}}$	
	NIL:	
	$e = \dfrac{\frac{2}{\sqrt{2}} - \frac{1}{\sqrt{2}}}{\frac{3}{\sqrt{2}} - \frac{-2}{\sqrt{2}}} = \frac{1}{5}$	DM1 A1
		(6)
		[13]

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Question Number	Scheme	Marks
Q6 (a)	$(\rightarrow),\ T = m\ddot{y}$	M1
	Hooke's Law: $T = \dfrac{2mn^2ax}{2a} = mn^2x$	B1
	$x + y = \frac{1}{2}ft^2$, $\dot{x} + \dot{y} = ft$, $\ddot{x} + \ddot{y} = f$	B2
	so, $(\rightarrow),\ mn^2x = m\ddot{y} = m(f - \ddot{x})$	DM1
	$\ddot{x} + n^2x = f$ **	A1
		(6)
(b)	C.F. : $x = A\cos nt + B\sin nt$	B1
	P.I. : $x = \dfrac{f}{n^2}$	B1
	Gen solution: $x = A\cos nt + B\sin nt + \dfrac{f}{n^2}$	M1
	$\dot{x} = -An\sin nt + Bn\cos nt$ follow their PI	M1 A1ft
	$t = 0, x = 0 \Rightarrow A = -\dfrac{f}{n^2}$; $t = 0, \dot{x} = 0 \Rightarrow B = 0$	M1 A1
	$x = \dfrac{f}{n^2}(1 - \cos nt)$	A1
		(8)
(c)	$\dot{x} = 0 \Rightarrow \quad nt = \pi$	M1
	$x_{\max} = \dfrac{f}{n^2}(1 - -1) = \dfrac{2f}{n^2}$	M1 A1
		(3)
(d)	$\dot{y} = ft - \dot{x}$	M1
	$= f\dfrac{\pi}{n} - 0 = \dfrac{f\pi}{n}$	A1
		(2)
		[19]