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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MM03 Mechanics 3

Mark Scheme

2008 examination - June series

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Key to mark scheme and abbreviations used in marking

M	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation

√ or ft or F	follow through from previous incorrect result	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

MM03

Q	Solution	Marks	Total	Comments
1	$LT^{-1} = L^{\alpha} \times (ML^{-3})^{\beta}(LT^{-2})^{\gamma}$	M1		
	There is no M on the left hand side, so $\beta = 0$.	E1		
	$LT^{-1} = L^{\alpha+\gamma}T^{-2\gamma}$	m1		Dependent on M1
	$\alpha + \gamma = 1$ $-2\gamma = -1$	m1		Equating corresponding indices
	$\gamma = \frac{1}{2}$	A1		
	$\alpha = \frac{1}{2}$	A1	6	
	Total		**6**	
2(a)	${}_A v_B = v_B - v_A$ $= (3i + 4j) - (5i - j)$ $= -2i + 5j$	M1 A1	2	
(b)	${}_A r_{0B} = (40i - 90j) - (-60i + 160j)$ $= 100i - 250j$	M1		Simplification not necessary
	${}_A r_B = (100i - 250j) + (-2i + 5j)\text{t}$	m1 A1F	3	**ALTERNATIVE:** $r_A = (60i + 160j) + (5i - j)\text{t}$ M1 $r_B = (40i - 90j) + (3i + 4j)\text{t}$ ${}_A r_B = \left[(40i - 90j) + (3i + 4j)\text{t}\right] -$ $\left[(60i + 160j) + (5i - j)\text{t}\right]$ m1A1
(c)	${}_A r_B = (100 - 2\text{t})i + (-250 + 5t)\text{j}$	M1		Collecting i and j terms
	$(100 - 2\text{t}) = 0 \Leftrightarrow \text{t} = 50$ $(-250 + 5\text{t}) = 0 \Leftrightarrow \text{t} = 50$	A1F		
	$\therefore$ A and B would collide.	E1	3	
		ALTERNATIVE: $\left[(100 - 2\text{t})i + (-250 + 5\text{t})j\right].(-2i + 5j) = 0$ M1 $-200 + 4\text{t} - 1250 + 25\text{t} = 0 \Rightarrow \text{t} = 50$ A1 $\lvert {}_A r_B \rvert \sqrt{(100 - 2\times 50)^2 + (-250 + 5\times 50)^2} = 0$ $\therefore$ A and B would collide E1		
	Total		**8**	

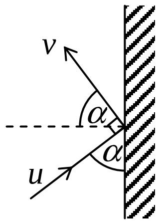
MM03 (cont)

Q	Solution	Marks	Total	Comments
3	$\int_0^t 5\times10^3 t^2\,\mathrm{d}t = 0.2(2) - 0.2(0)$	M1A1		Impulse-Momentum principle
	$\frac{5\times10^3}{3}t^3 = 0.4$	A1F		
	$t = 0.0621$	A1F	4	At least 3 sig. fig. required
	Total		**4**	
4(a)	C.L.M.			
	$m(4\mathbf{i} + 3\mathbf{j}) + 2m(-2\mathbf{i} + 2\mathbf{j}) = mv + 2m(\mathbf{i} + \mathbf{j})$	M1		
	$7\mathbf{j} = v + (2\mathbf{i} + 2\mathbf{j})$			
	$v = -2\mathbf{i} + 5\mathbf{j}$	A2,1,0	3	A1 for one slip
(b)	The angle with **j** direction :			OE. in **i** direction
	$A: \quad \tan^{-1}\frac{2}{5} = 21.8^\circ$			
	$B: \quad \tan^{-1}\frac{1}{1} = 45^\circ$	M1		M1 for two inverse tan and addition of angles
	The angle $= 21.8^\circ + 45^\circ = 67^\circ$	A1F	3	AWRT. **Alternative (not in the specification)** $(-2\mathbf{i}+5\mathbf{j}).(\mathbf{i}+\mathbf{j}) = \sqrt{29}\times\sqrt{2}\cos\theta$ (M1) $\cos\theta = \frac{3}{\sqrt{58}}$ (A1) $\theta = 67^\circ$ (A1F) awrt
(c)	The impulse = Gain in momentum of A	M1		
	$= m(-2\mathbf{i} + 5\mathbf{j}) - m(4\mathbf{i} + 3\mathbf{j})$	A1F		
	$= -6m\mathbf{i} + 2m\mathbf{j}$	A1F	3	
(d)	$-3\mathbf{i} + \mathbf{j}$ or any scalar multiple of $-3\mathbf{i} + \mathbf{j}$	B1	1	
	Total		**10**	

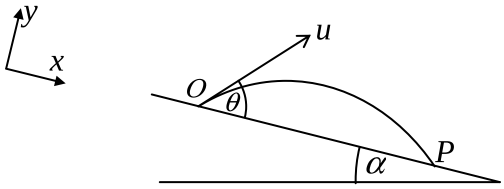
MM03 (cont)

Q	Solution	Marks	Total	Comments
5(a)	$5 = 10\cos\alpha.t$	M1		
	$t = \dfrac{5}{10\cos\alpha}$	A1		
	$1 = -\dfrac{1}{2}(9.8)t^2 + 10\sin\alpha.t$	M1A1		
	$1 = -\dfrac{1}{2}(9.8)\dfrac{25}{100\cos^2\alpha} + 10\sin\alpha\dfrac{5}{10\cos\alpha}$	m1		Dependent on both M1s
	$1 = -\dfrac{1}{2}(9.8)\dfrac{25}{100}(1+\tan^2\alpha) + 10\sin\alpha\dfrac{5}{10\cos\alpha}$	A1		
	$49\tan^2\alpha - 200\tan\alpha + 89 = 0$	A1	7	Answer given
(b)	$\tan\alpha = \dfrac{200 \pm \sqrt{40000 - 4(49)(89)}}{2\times 49}$	M1		
	$= 3.57, 0.508$	A1		AWRT
	$\alpha = 74.4^\circ, 26.9^\circ$	A1F	3	
(c)(i)	$10\cos 26.9^\circ = 8.92$ (or 8.91) > 8			
	$\Rightarrow$ The can will be knocked off the wall	M1		Both values checked
	$10\cos 74.4^\circ = 2.69 < 8$	A1F		Acc. of both results
	$\Rightarrow$ The can will not be knocked off the wall	E1	3	Correct conclusions
		ALTERNATIVE The can will be knocked off the wall if $10\cos\alpha > 8$ $\cos\alpha > 0.8$ $\alpha < 36.9^\circ$ M1A1 So, for $\alpha = 26.9^\circ$ the can will be knocked off and for $\alpha = 74.4^\circ$, the can will not be knocked off E1		
5(c)(ii)	$x = ut$			
	$t = \dfrac{5}{10\cos 26.9^\circ}$			
	$v = 10\sin 26.9^\circ - 9.8(\dfrac{5}{10\cos 26.9^\circ})$	M1		Any correct use of equations
	$v = -0.970$	A1F		
	$\tan\theta = \dfrac{-0.970}{8.92}$	M1		
	$\theta = -6.2^\circ$			
	At an angle of depression of 6.2°	A1F	4	AWRT 6°
	Total		**17**	

MM03 (cont)

Q	Solution	Marks	Total	Comments
6(a)				
	Parallel to the wall : velocity is unchanged $u\cos\alpha = v\sin\alpha$	M1		
	Perpendicular to the wall : Law of Restitution $\frac{v\cos\alpha}{u\sin\alpha} = \frac{3}{4}$	M1		
	$\frac{v\cos\alpha}{v\tan\alpha\sin\alpha} = \frac{3}{4}$	m1		Dependent on both M1s
	$\frac{\cos^2\alpha}{\sin^2\alpha} = \frac{3}{4}$	m1		Dependent on both M1s
	$\tan^2\alpha = \frac{4}{3}$			
	$\tan\alpha = \frac{2}{\sqrt{3}}$	A1	5	Answer given
(b)	$v = \frac{u}{\tan\alpha}$	M1		
	$v = \frac{\sqrt{3}}{2}u$ or $0.866u$	A1	2	
(c)	Magnitude of Impulse = Change in momentum perpendicular to the wall	M1		
	$= 0.2\times v\cos\alpha - (-0.2\times 4\sin\alpha)$	A1 A1		
	$= 0.2\times\frac{\sqrt{3}}{2}\times 4\cos\alpha + 0.2\times 4\sin\alpha$	m1		
	$= 1.06$ Ns	A1F		
	Average Force = $\frac{1.06}{0.1} = 10.6$ N	A1F	6	
	Total		**13**	

MM03 (cont)

Q	Solution	Marks	Total	Comments
7				
(a)	$v_y{}^2 = u^2\sin^2\theta - 2g\cos\alpha . y$	M1 A1		
	$0 = u^2\sin^2\theta - 2g\cos\alpha . y_{\max}$	m1		
	$y_{\max} = \dfrac{u^2\sin^2\theta}{2g\cos\alpha}$	A1F	4	
(b)(i)	$u\sin\theta\, t - \dfrac{1}{2}g\cos(\alpha)t^2 = 0$	M1		
	$t = \dfrac{2u\sin\theta}{g\cos\alpha}$	A1	2	
(ii)	$x = u\cos\theta t - \dfrac{1}{2}g\sin(-\alpha)t^2$	M1 A1		
	$R = u\cos\theta\left(\dfrac{2u\sin\theta}{g\cos\alpha}\right) + \dfrac{1}{2}g\sin\alpha\left(\dfrac{2u\sin\theta}{g\cos\alpha}\right)^2$	M1		
	$= \dfrac{2u^2\cos\theta\sin\theta\cos\alpha + 2u^2\sin\alpha\sin^2\theta}{g\cos^2\alpha}$	m1		Dependent on both M1s
	$= \dfrac{2u^2\sin\theta(\cos\theta\cos\alpha + \sin\theta\sin\alpha)}{g\cos^2\alpha}$	A1F		
	$= \dfrac{2u^2\sin\theta\cos(\theta-\alpha)}{g\cos^2\alpha}$	A1	6	Answer given
(iii)	$\overline{OP} = \dfrac{2u^2\sin\theta\cos(\theta-\alpha)}{g\cos^2\alpha}$			
	$= \dfrac{2u^2\frac{1}{2}\left[\sin(2\theta-\alpha)+\sin\alpha\right]}{g\cos^2\alpha}$	M1A1		
	$\overline{OP}$ is max when $\sin(2\theta-\alpha) = 1$	M1		
	$\overline{OP}_{\max} = \dfrac{u^2(1+\sin\alpha)}{g\cos^2\alpha}$	A1F		
	$\overline{OP}_{\max} = \dfrac{u^2(1+\sin\alpha)}{g(1-\sin^2\alpha)}$			
	$\overline{OP}_{\max} = \dfrac{u^2}{g(1-\sin\alpha)}$	A1	5	Answer given
	Total		**17**	

MM03 (cont)

Q	Solution	Marks	Total	Comments
7(a)	**ALTERNATIVE**			
	$0 = u\sin\theta - g\cos a\ t$	M1		
	$t = \dfrac{u\sin\theta}{g\cos a}$	A1		
	$y_{max} = u\sin\theta\left(\dfrac{u\sin\theta}{g\cos a}\right) - \dfrac{1}{2}g\cos a\left(\dfrac{u\sin\theta}{g\cos a}\right)^2$	m1		
	$y_{max} = \dfrac{u^2\sin^2\theta}{2g\cos a}$	A1F	4	
	Total		**4**	