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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MM03 Mechanics 3

Mark Scheme

2005 examination – June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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	OE	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)

Application of Mark Scheme

No method shown:	
Correct answer without working	mark as in scheme
Incorrect answer without working	zero marks unless specified otherwise
More than one method / choice of solution:	
2 or more complete attempts, neither/none crossed out	mark both/all fully and award the mean mark rounded down
1 complete and 1 partial attempt, neither crossed out	award credit for the complete solution only
Crossed out work	do not mark unless it has not been replaced
Alternative solution using a correct or partially correct method	award method and accuracy marks as appropriate

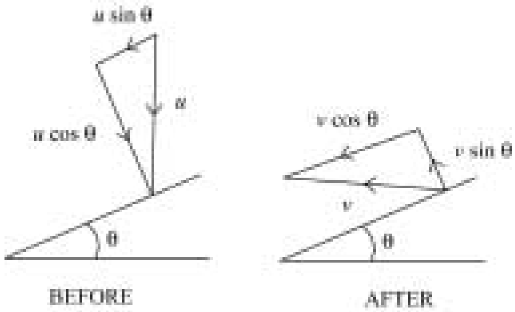
MM03

Q	Solution	Mark	Total	Comments
1(a)(i)	$ML^{-1}T^{-1}$	B1	1	
(ii)	$MLT^{-2}L^{-2}=ML^{-1}T^{-2}$	B2,1	2	B2 for simplified form
(b)	$L^3\times T^{-1}=L^{-1}\times L^a\times\left(MLT^{-2}L^{-2}\right)^b\times\left(ML^{-1}T^{-1}\right)^c$	M1 A1F		
	$=L^{-1}\times L^a\times M^b\times L^b\times T^{-2b}\times L^{-2b}\times M^c\times L^{-c}\times T^{-c}$			
	$=L^{-1+a-b-c}\times M^{b+c}\times T^{-2b-c}$	m1		PI
	$\begin{cases}-1+a-b-c=3\\ b+c=0\\ -2b-c=-1\end{cases}$	m1 M1		Getting 3 equations Solution (finding at least one of a,b,c)
	$a=4,\ b=1,\ c=-1$	A1F	6	
	Total		**9**	
2(a)	$\mathbf{r}_A=(3\mathbf{i}+2\mathbf{j})+(-5\mathbf{i}+8\mathbf{j})t$ $\mathbf{r}_B=(-4\mathbf{i}+7\mathbf{j})+(2\mathbf{i}+3\mathbf{j})t$	B1 B1	2	Or equivalent Or equivalent
(b)	When t = 1, $\mathbf{r}_A=\mathbf{r}_B=-2\mathbf{i}+10\mathbf{j}$ $\Rightarrow$ *Collision*	M1 A1	2	Substitution Simplification
	Alternative: $\mathbf{r}_A=\mathbf{r}_B$ $\Rightarrow 3-5t=-4+2t\Rightarrow t=1$ and $2+8t=7+3t\Rightarrow t=1$	(M1) (A1)		Equate **i** or **j** Complete solution
(c)(i)	At time T after 1:45 am $\mathbf{r}_A=(3\mathbf{i}+2\mathbf{j})+(-5\mathbf{i}+8\mathbf{j})\left(T+\frac{3}{4}\right)$ $\mathbf{r}_B=(-4\mathbf{i}+7\mathbf{j})+(2\mathbf{i}+3\mathbf{j})\frac{3}{4}+(2\mathbf{i}+10\mathbf{j})T$	M1A1 M1A1		
	${}_A\mathbf{r}_B=(7T-1.75)\mathbf{i}+(2T+1.25)\mathbf{j}$	m1 A1	6	For $\mathbf{r}_B$ - $\mathbf{r}_A$ Answer given
(ii)	At 2:00 am ${}_A\mathbf{r}_B=\left(7\times\frac{1}{4}-1.75\right)\mathbf{i}+\left(2\times\frac{1}{4}+1.25\right)\mathbf{j}$ $=1.75\mathbf{j}$ The distance = 1.75 km	M1 A1	2	
	Total		**12**	

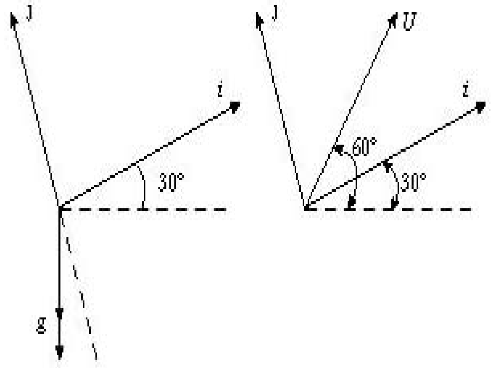
MM03 (cont)

Q	Solution	Mark	Total	Comments
3(a)	By P.C.L.M.:			
	$4mu = 4mv_1 + 2mv_2$	M1		
	$2u = 2v_1 + v_2$ ....(1)			
	Law of restitution: $e = \dfrac{v_2 - v_1}{u}$ ....(2)	M1A1		A1 for both correct
	Solving (1) and (2) $\rightarrow$	m1		Dependent on both Ms
	$v_1 = \dfrac{2u - eu}{3}$			
	$v_2 = \dfrac{2u + 2eu}{3}$	A1F	5	A1F for both v_1 and v_2
(b)	$\dfrac{12mu}{5} = 4mu - 4m\left(\dfrac{2u - eu}{3}\right)$	M1A1 F		Impulse/Momentum
	$\left[\text{or} = 2m\left(\dfrac{2u + 2eu}{3}\right)\right]$			
	$20meu = 16mu$			
	$e = \dfrac{4}{5}$	A1	3	Solution to get the right answer Answer given
(c)	$2mv_2 = 2mv_3 + mv_4$	M1		
	$\dfrac{v_4 - v_3}{v_2} = \dfrac{4}{5}$	M1		
	$v_3 = \dfrac{12u}{25}$	m1 A1F	4	Dependent on both Ms
(d)	$v_1 = \dfrac{2u - \frac{4}{5}u}{3} = \dfrac{2u}{5}$	M1		
	$v_3 \succ v_1 \Rightarrow$ A and B will not collide again	E1F	2	
	Total		**14**	

MM03 (cont)

Q	Solution	Marks	Total	Comments
4(a)	Ball and plane are smooth $\Rightarrow$ Mutual reaction acts along the normal to the plane at the point of impact $\Rightarrow$ No change in momentum parallel to plane	E2,1	2	1 mark per implication
(b)	$\frac{3}{4}=\frac{v\sin\theta}{u\cos\theta}$ or $v\sin\theta=\frac{3}{4}u\cos\theta$	M1		
	$3u\cos\theta=4v\sin\theta$	A1	2	Answer given
(c)				
	$v\cos\theta=u\sin\theta$	M1		
	$3u\cos\theta=4u\tan\theta\sin\theta$	m1		
	$\frac{3}{4}=\tan^2\theta$	M1		
	$\theta=40.9^\circ$	A1	4	Answer given
(d)	$I=mu\cos\theta-(mv\sin\theta)$	M1A1		Impulse momentum
	$I=mu\cos\theta+mu\tan\theta\sin\theta$	m1		Elimination of *v*
	$I=\frac{mu}{\cos\theta}$	A1F		
	$I=1.32mu$	A1	5	Answer given
	Total		**13**	

MM03 (cont)

Q	Solution	Marks	Total	Comments
5				
(a)	<u>In **j** direction</u>			
	$a = -g\cos 30$	M1		
	$0 = 90\sin 30t - 4.9\cos 30t^2$	M1 A1		
	$t = \frac{90\sin 30}{4.9\cos 30}$	m1		
	$t = 10.6\text{s}$	A1	5	Answer given
(b)	<u>In **i** direction</u>			
	$a = -g\sin 30$	M1A1		
	$OA = 90\cos 30(10.6) - 4.9\sin 30(10.6)^2$	M1A1		
	$= 551$ m	A1F	5	Must be >0.
(c)	The missile is at its max. perpend. distance from the slope when vel.is zero.			
	$0 = 90\sin 30 - 9.8\cos 30t$	M1		Use of special results
	$t = 5.3$	A1F		gains 3 out of 4 marks
	$y = -\frac{\sqrt{3}}{4} \times 9.8(5.3)^2 + 45(5.3)$	M1		
	$y = 119$ metres	A1F	4	
	Total		**14**	

MM03 (cont)

Q	Solution	Marks	Total	Comments
6(a)	$x = 40t\cos\alpha$	M1		
	$y = 40t\sin\alpha - \frac{1}{2}gt^2$	M1 A1		
	$t = \frac{x}{40\cos\alpha}$			
	$y = 40\left(\frac{x}{40\cos\alpha}\right)\sin\alpha - \frac{1}{2}g\left(\frac{x}{40\cos\alpha}\right)^2$	m1		
	$y = x\tan\alpha - \frac{gx^2}{3200\cos^2\alpha}$			
	$y = x\tan\alpha - \frac{gx^2}{3200}\left(1+\tan^2\alpha\right)$	A1	5	Answer given
(b)	$4 = 100\tan\alpha - \frac{9.8\times100^2}{3200}\left(1+\tan^2\alpha\right)$	M1		
	$245\tan^2\alpha - 800\tan\alpha + 277 = 0$	M1A1		
	$\tan\alpha = \frac{400 \pm \sqrt{(-400)^2 - (245)(277)}}{245}$	M1 A1F		Or equivalent
	$\alpha = 71^\circ, 21^\circ$ $\left(22^\circ \text{ acceptable}\right)$ $\left(\text{or } 1.24 \text{ rad.}, 0.375 \text{rad.}\right)$	A1F	6	AWRT (or equivalent in radians) Must be positive
(c)	The ball is a particle, No air resistance, etc	E1 E1	2	
	Total		**13**	
	Total		**75**	