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General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2009 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.

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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.

MM1B

Q	Solution	Marks	Total	Comments
1(a)	$3\begin{bmatrix}6\\-2\end{bmatrix}+7\begin{bmatrix}-1\\4\end{bmatrix}=10\mathbf{v}$	M1		M1: Forming three term equation for conservation of momentum, but condone incorrect signs. Must see combined mass of 10.
		A1		A1: Correct equation with correct signs. Accept $3\begin{bmatrix}6\\-2\end{bmatrix}+7\begin{bmatrix}-1\\4\end{bmatrix}=3\mathbf{v}+7\mathbf{v}$ oe
	$\mathbf{v}=\frac{1}{10}\begin{bmatrix}11\\22\end{bmatrix}=\begin{bmatrix}1.1\\2.2\end{bmatrix}$	A1	3	A1: Correct velocity Consistent use of *mg* instead of *m* throughout deduct 1 mark
(b)	$v=\sqrt{1.1^2+2.2^2}$	M1		M1: Finding speed. Must be + inside square root.
	$v=2.46$ ms^{-1}	A1F	2	A1F: Correct speed for their velocity Accept $1.1\sqrt{5}$ or $\frac{11\sqrt{5}}{10}$ or 2.45 or AWRT 2.46
	Total		**5**	
2(a)	$16=\frac{1}{2}(u+4.2)\times5$ $32=5u+21$ $5u=11$	M1A1		M1: Using a constant acceleration equation to find u with $v=4.2$ and $a\neq9.8$. Could be derived from a velocity–time graph. A1: Correct equation
	$u=\frac{11}{5}=2.2$ ms^{-1}	A1		A1: Correct value for u
	OR First solution from (b) to find acceleration followed by any constant acceleration equation to find u: eg. $4.2=u+0.4\times5$ $u=2.2$	(M1) (A1) (A1)	3	Eg $s=\frac{1}{2}(u+v)t$ followed by $16=(u+4.2)\times5$ or similar scores M1A0

MM1B (cont)

Q	Solution	Marks	Total	Comments
2(b)	$4.2 = 2.2 + 5a$ $5a = 2$ $a = \frac{2}{5} = 0.4 \text{ ms}^{-2}$ OR $16 = 2.2 \times 5 + \frac{1}{2} \times a \times 5^2$ $16 = 11 + 12.5a$ $a = \frac{5}{12.5} = 0.4 \text{ ms}^{-2}$ OR $16 = 4.2 \times 5 - \frac{1}{2} \times a \times 5^2$ $16 = 21 - 12.5a$ $a = \frac{5}{12.5} = 0.4 \text{ ms}^{-2}$ OR $4.2^2 = 2.2^2 + 2a \times 16$ $a = \frac{17.64 - 4.84}{32} = 0.4 \text{ ms}^{-2}$	M1 A1F A1F (M1) (A1F) (A1F) (M1) (A1F) (A1F) (M1) (A1F) (A1F)	3	M1: Using a constant acceleration equation to find a with $u \neq 0$. A1F: Correct equation. Follow through for their incorrect u. A1F: Correct value for a, which must be > 0. Follow through for their incorrect u. (If acceleration found correctly in part (a) and simply quoted as answer to (b) give full marks).
	Total		**6**	
3(a)	Resultant Force = 3000 – 600 = 2400 N	M1 A1	2	M1: Difference between the two forces. A1: Correct magnitude of resultant force. Must be a positive answer. (600 – 3000 = –2400 scores M1A0)
(b)	$2400 = 1200a$ $a = \frac{2400}{1200} = 2 \text{ ms}^{-2}$	M1 A1	2	M1: Use of Newton's second Law to find acceleration. A1: Correct acceleration ($a = \frac{-2400}{1200} = -2 \text{ ms}^{-2}$ scores M1A0)
	Total		**4**	
4(a)	$v = \frac{16}{10} = 1.6 \text{ ms}^{-1}$ AG	B1	1	B1: Printed result obtained from correct division. Must see 16 divided by 10.
(b)	$V^2 = 1.6^2 + 1.2^2$ $V = \sqrt{4} = 2 \text{ ms}^{-1}$	M1A1 A1	3	M1: Equation to find V based on Pythagoras. Must involve addition of the squares of two components. A1: Correct equation A1: Correct V

MM1B (cont)

Q	Solution	Marks	Total	Comments
4(c)	$\sin\alpha = \frac{1.6}{2}$ or $\frac{1.2}{2}$	M1		M1: Trigonometric equation to find α.
	$\alpha = 53.1°$	A1F		A1F: Correct α. Follow through incorrect answer to (b).
	OR			
	$\cos\alpha = \frac{1.2}{2}$ or $\frac{1.6}{2}$	(M1)		Ignore diagrams
	$\alpha = 53.1°$	(A1F)		
	OR			
	$\tan\alpha = \frac{1.6}{1.2}$ or $\frac{1.2}{1.6}$	(M1)		
	$\alpha = 53.1°$	(A1F)	2	
(d)	The boat is a particle	B1	1	B1: Statement of particle assumption. Ignore any other assumptions.
	Total		**7**	
5(a)	$R = 14\times 9.8 = (137.2)$	M1		M1: Finding the normal reaction. Accept $14g$.
	$F = 0.25\times 137.2$ OR $F = 0.25\times 14\times 9.8$	M1		M1: Use of $F = \mu R$
	$F = 34.3$ N	A1	3	A1: Correct friction Use of $g = 9.81$ gives $R = 137.3$ and $F = 34.3$ so in this case do not penalise use of $g = 9.81$.
(b)	$6g - T = 6a$	M1A1		M1: Equation of motion for the particle, containing T, $6g$ or 58.8 and $6a$. A1: Correct equation with correct signs.
	$T - 34.3 = 14a$	M1A1		M1: Equation of motion for the block, containing T, 34.3 or their F and $14a$. A1: Correct equation with correct signs.
	$6g - 34.3 = 20a$			A1: Correct acceleration from correct working.
	$a = \frac{6g - 34.3}{20} = 1.225$ ms^{-2} AG	A1	5	If –1.225 is obtained from consistent working award 4 marks and if changed to +1.225 with an explanation, award full marks. Special Case: Whole string method $6g - 34.3 = 20a$ OE $a = 1.225$ award M1A1A1 Use of $g = 9.81$ gives $a = 1.228$ penalise use of $g = 9.81$ by deducting 1 mark, but don't penalise again on the same script.

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(c)	$T-34.3=14\times1.225$ $T=17.15+34.3=51.5$ N	M1 A1		M1: Use of either of candidates equations of motion to find tension, with $a=\pm1.225$ and their F (Method 1). A1: Correct tension Accept 51.45 or 51.4. Don't penalise use of g = 9.81 if already done in part (b).
	OR $6g-T=6\times1.225$ $T=6\times9.8-6\times1.225=51.5$	 (M1) (A1)	 2	
(d)	$v^2=0^2+2\times1.225\times0.8$ $v=\sqrt{1.96}=1.4$ ms^{-1}	M1A1 A1		M1: Use of constant acceleration equation to find speed with $u=0$. A1: Correct equation A1: Correct speed AWRT 1.4
	OR $0.8=\frac{1}{2}\times1.225t^2$ $t=(1.1428)$ $v=1.225\times1.1428$ $=1.40$	 (M1) (A1) (A1)	 3	In method 2, no marks awarded for just finding t.
(e)	$v^2=1.4^2+2\times9.8\times0.5$ $v=3.43$ ms^{-1}	M1 A1F A1F		M1: Use of constant acceleration equation to find speed with u = 1.4 or their answer to part (d), a = ±9.8 and s = 0.5. A1F: Correct equation. Follow through their answer to part (d). A1F: Correct speed. Don't penalise use of g = 9.81 if already done earlier in question.
	OR $0.5=1.4t+4.9t^2$ $t=0.2071$ $v=1.4+9.8\times0.2071$ $=3.43$ ms^{-1}	 (M1) (A1F) (A1F)	 3	In method 2, no marks awarded for just finding t.
	Total		**16**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	$20\sin 50°t - 4.9t^2 = 0$ $t = \frac{20\sin 50°}{4.9}$ or $3.126... = 3.13$ s AG	M1A1 dM1 A1		M1: Equation to find time, with $y = 0$, $u = 20\sin 50°$ or $u = 20\cos 50°$ and ± 9.8 or $\pm g$. A1: Correct equation dM1: Solving for t. A1: Correct time from correct working. Must see division by 4.9 oe or more than 3sf Verification methods can only gain first 2 marks Special case $t = \frac{15.3}{4.9} = 3.12$ or 3.13 scores M1A1dM1A0
	OR $0 = 20\sin 50° - 9.8t$ $t = \frac{20\sin 50°}{9.8} = 1.563$ $T = 2 \times 1.563$ $= 3.13$	(M2) (A2)	4	M2: doubling time to max height (could use cos instead of sin) but must use ± 9.8 or $\pm g$. A2: Correct time from correct working. Don't penalise use of $g = 9.81$ if already done earlier on script. Would obtain time as 3.12 seconds. Note: If using a memorised formula either 4 marks if final answer correct, 3 marks if substituted correctly, otherwise zero. Special case $T = 2 \times 1.56 = 3.12$ or 3.13 scores M2A1
(b)	$PQ = 20\cos 50° \times 3.127 = 40.2$ m	M1 A1	2	M1: Calculation of range, could use sin instead of cos. A1: Correct range Accept 40.1
(c)	No change because a greater mass would not change the acceleration. OR Mass is not used in the equations.	B1 B1	2	B1: No change B1: Explanation following a correct statement.

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(d)	$0=(20\sin 50°)^2+2\times(-9.8)s$ $s=\dfrac{(20\sin 50°)^2}{2\times 9.8}=12.0$ m OR $t=\dfrac{3.13}{2}=1.565$ $h=20\sin 50°\times 1.565-4.9\times 1.565^2$ $=12.0$	M1 A1 A1 (M1) (A1) (A1)	3	M1: Equation to find height, with $u=20\sin 50°$ or $u=20\cos 50°$ and ± 9.8 or $\pm g$ (and t between 1.56 and 1.57 if method 2 used). A1: Correct equation A1: Correct height. Accept 12 or 11.9 or AWRT 12.0 In method 2, no marks awarded for just finding t. Don't penalise use of g = 9.81 if already done earlier on script. Should still get 12. Note: If using a memorised formula either 3 marks if final answer correct, 2 marks if substituted correctly, otherwise zero.
(e)	20 ms^{-1} at 50° below the horizontal.	B1 B1	2	B1: Speed AWRT 20 B1: Direction AWRT 50°. Must indicate below, or down. Could be implied by a diagram.
	Total		**13**	
7(a)	$\mathbf{v}=(-2\mathbf{i}+2\mathbf{j})+(0.25\mathbf{i}+0.3\mathbf{j})\times 20$ $\mathbf{v}=3\mathbf{i}+8\mathbf{j}$	M1 A1 A1	3	M1: Finding velocity using $\mathbf{v}=\mathbf{u}+\mathbf{a}t$. A1: Correct expression. A1: Correct velocity in simplest form.
(b)	$-2+0.25t=0$ $t=8$ s $\mathbf{v}=(2+0.3\times 8)\mathbf{j}=4.4\mathbf{j}$	M1A1 A1 A1	4	M1: One component equal to zero (either **i** or **j** component). A1: Correct equation A1: Correct time A1: Correct velocity
(c)	$\mathbf{r}=(-2\mathbf{i}+2\mathbf{j})\times 20+\dfrac{1}{2}(0.25\mathbf{i}+0.3\mathbf{j})\times 20^2+(9\mathbf{i}+7\mathbf{j})$ **OR** $\mathbf{r}=\dfrac{1}{2}\big((-2\mathbf{i}+2\mathbf{j})+(3\mathbf{i}+8\mathbf{j})\big)\times 20+(9\mathbf{i}+7\mathbf{j})$ $\mathbf{r}=19\mathbf{i}+107\mathbf{j}$	M1 A1 A1	3	M1: Finding position vector using a constant acceleration equation with or without the initial position with $t=20$. A1: Correct expression for position vector including initial position. A1: Correct position vector in simplest form.
(d)	$\mathbf{v}_{AVERAGE}=\dfrac{(19\mathbf{i}+107\mathbf{j})-(9\mathbf{i}+7\mathbf{j})}{20}$ $=\dfrac{10\mathbf{i}+100\mathbf{j}}{20}$ $=0.5\mathbf{i}+5\mathbf{j}$	M1 A1F	2	M1: Finding average velocity based on change of position. Subtraction of initial position must be seen or implied. Division by 8 scores M0 A1F: Correct average velocity. Follow through incorrect answers from part (c). Allow $\dfrac{\mathbf{u}+\mathbf{v}}{2}$
	Total		**12**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)(i)	$20\times9.8=R+60\sin30°$	M1		M1: Equation or expression for normal reaction with *mg* or 20*g* or 196 and 60sin30° or 60cos30°.
		A1		A1: Correct equation or expression with correct signs.
	$(R=)20\times9.8-60\sin30°=166$ N AG	A1	3	A1: Correct value from correct working. Must be positive.
				Don't penalise use of g = 9.81 if already done earlier on script. Should still get 166, but from 166.2.
(ii)	$166\mu=60\cos30°$	M1		M1: Use of $F=\mu R$, with R = 166 or 166.2. Do not allow inequalities here.
		M1A1		M1: Resolving horizontally with cos30° or sin30° oe.
	$\mu=\dfrac{60\cos30°}{166}$			A1: Correct equation
	$=0.313$	A1	4	Examples:
				$166\mu=60$ M1M0A0
				$166\mu=-60\cos30°$ M1M1A0
				A1: Correct coefficient of friction.
(b)	$20\times0.8=T\cos30°-0.313(20\times9.8-T\sin30°)$	B1		B1: $20g-T\sin30°$ oe seen.
		M1		M1: Three term equation of motion, where normal reaction is dependent on T.
		A1F		A1F: Correct equation
	$T=\dfrac{20\times0.8+0.313\times20\times9.8}{\cos30°+0.313\sin30°}=75.6$ N	dM1		dM1: Solving for T including factorisation.
		A1F	5	A1F: Correct tension.
				AWRT 75.6
				Follow through incorrect values of μ from part (a).
				Don't penalise use of g = 9.81 if already done earlier on script. Should get 75.7. Allow 75.8 if intermediate values rounded.
	Total		**12**	
	TOTAL		**75**	