

## **General Certificate of Education**

# **Mathematics 6360**

MM2A/W Mechanics 2A

# **Mark Scheme**

2008 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					
В	mark is independent of M or m marks and is	for method and	accuracy			
E	mark is for explanation	mark is for explanation				
$\sqrt{\text{or ft or F}}$	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.

#### MM2A

1(a) $a = \frac{dv}{dt} = 12t + 4$	Q	Solution	Marks	Total	Comments
(b) Using $\mathbf{F} = m\mathbf{a}$ , Force $= 3 \times (12t + 4)$ When $t = 4$ , force $= 3(12 \times 4 + 4)$ Force $= 156$ N    2 $\overline{X} = \frac{25 \times 1 + 12 \times 4 + 4 \times 5}{1 + 4 + 5}$ M1 $= \frac{93}{10} \text{ or } 9.3$ A1 $\overline{Y} = \frac{10 \times 1 + 7 \times 4 + 18 \times 5}{10}$ M1 $= \frac{128}{10} \text{ or } 12.8$ A1  4   3(a) Conservation of energy from B to A: $\frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2$ A1 $v^2 = 2ag + u^2$ A1 $= \frac{17mu^2}{2} + mga = \frac{1}{2}mv^2$ A1 $v^2 = 2ag + u^2$ A1 $= \frac{17mu^2}{2} + mga = \frac{1}{2}mv^2$ A1 $v^2 = \frac{17mu^2}{2} + \frac{17mu^2}{2} + \frac{17mu^2}{2}$ A1 $v^2 = \frac{17mu^2}{2} + \frac{17mu^2}{2} + 17m$	<b>1</b> (a)	$a = \frac{\mathrm{d}v}{} = 12t + 4$	M1 A1	2	
Force = $3 \times (12t + 4)$ When $t = 4$ , force = $3(12 \times 4 + 4)$ Force = $156$ N  Al 2  Total  2 $\overline{X} = \frac{25 \times 1 + 12 \times 4 + 4 \times 5}{1 + 4 + 5}$ M1 $= \frac{93}{10}$ or $9.3$ A1 $\overline{Y} = \frac{10 \times 1 + 7 \times 4 + 18 \times 5}{10}$ M1 $= \frac{128}{10}$ or $12.8$ SC3 interchange $\overline{X}$ and $\overline{Y}$ Total  3(a) Conservation of energy from B to A: $\frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2$ A1 $v^2 = 2ag + u^2$ A1 $v = \sqrt{27}ag$ A1  (b) At A, speed of particle is $\sqrt{27}ag$ Resolving vertically at A: $T = \frac{mv^2}{a} + mg$ A1 $T = m\frac{28ag}{a}$ A1 $T = 28mg$ A1F 3 ft from (a)		$\mathrm{d}t$			
Force = $3 \times (12t + 4)$ When $t = 4$ , force = $3(12 \times 4 + 4)$ Force = $156$ N  Al 2  Total  2 $\overline{X} = \frac{25 \times 1 + 12 \times 4 + 4 \times 5}{1 + 4 + 5}$ M1 $= \frac{93}{10}$ or $9.3$ A1 $\overline{Y} = \frac{10 \times 1 + 7 \times 4 + 18 \times 5}{10}$ M1 $= \frac{128}{10}$ or $12.8$ SC3 interchange $\overline{X}$ and $\overline{Y}$ Total  3(a) Conservation of energy from B to A: $\frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2$ A1 $v^2 = 2ag + u^2$ A1 $v = \sqrt{27}ag$ A1  (b) At A, speed of particle is $\sqrt{27}ag$ Resolving vertically at A: $T = \frac{mv^2}{a} + mg$ A1 $T = m\frac{28ag}{a}$ A1 $T = 28mg$ A1F 3 ft from (a)					
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			Al		
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$ \begin{array}{c} = \frac{93}{10} \text{ or } 9.3 \\ \hline \overline{Y} = \frac{10 \times 1 + 7 \times 4 + 18 \times 5}{10} \\ = \frac{128}{10} \text{ or } 12.8 \\ \hline \vdots \text{ Centre of mass is at } (9.3, 12.8) \\ \hline \\ \textbf{3(a)}  \begin{array}{c} \textbf{Conservation of energy from B to A:} \\ \frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2 \\ v^2 = 2ag + u^2 \\ = 27ag \\ v = \sqrt{27ag} \\ \hline \end{array}  \begin{array}{c} \textbf{A1} \\ \textbf{A1} \\ \textbf{A1} \\ \textbf{A2} \\ \hline \end{array}  \begin{array}{c} \textbf{A1} \\ \textbf{A1} \\ \textbf{A1} \\ \textbf{A2} \\ \hline \end{array}  \begin{array}{c} \textbf{A1} \\ \textbf{A1} \\ \textbf{A2} \\ \textbf{A3} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A5} \\ \textbf{A5} \\ \textbf{A6} \\ \textbf{A7} \\ \textbf{A7} \\ \textbf{A8} \\ \textbf{A9} \\ \textbf{A1} \\ \textbf{A1} \\ \textbf{A1} \\ \textbf{A1} \\ \textbf{A1} \\ \textbf{A2} \\ \textbf{A3} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A5} \\ \textbf{A6} \\ \textbf{A7} \\ \textbf{A7} \\ \textbf{A8} \\ \textbf{A8} \\ \textbf{A1} \\ \textbf{A2} \\ \textbf{A3} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A1} \\ \textbf{A4} \\ \textbf{A1} \\ \textbf{A2} \\ \textbf{A3} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A5} \\ \textbf{A6} \\ \textbf{A7} \\ \textbf{A8} \\ \textbf{A8} \\ \textbf{A8} \\ \textbf{A8} \\ \textbf{A1} \\ \textbf{A2} \\ \textbf{A3} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A4} \\ \textbf{A5} \\ \textbf{A6} \\ \textbf{A7} \\ \textbf{A7} \\ \textbf{A7} \\ \textbf{A8} \\ $	2	$\bar{X} = \frac{25 \times 1 + 12 \times 4 + 4 \times 5}{25 \times 1 + 12 \times 4 + 4 \times 5}$	M1		
$\overline{Y} = \frac{10 \times 1 + 7 \times 4 + 18 \times 5}{10}$ $= \frac{128}{10} \text{ or } 12.8$ $\therefore \text{ Centre of mass is at } (9.3, 12.8)$ $\begin{array}{r} \textbf{Total} \\ \textbf{3(a)} \\ \textbf{Conservation of energy from B to A} : \\ \frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2 \\ v^2 = 2ag + u^2 \\ = 27ag \\ v = \sqrt{27ag} \\ \textbf{Resolving vertically at } A: \\ \textbf{T} = \frac{mv^2}{a} + mg \\ \textbf{T} = \frac{m}{28ag} \\ \textbf{T} = 28mg \\ \textbf{M1} \\ \textbf{A1F} \\$		1+4+5			denominator correct
$\overline{Y} = \frac{10 \times 1 + 7 \times 4 + 18 \times 5}{10}$ $= \frac{128}{10} \text{ or } 12.8$ $\therefore \text{ Centre of mass is at } (9.3, 12.8)$ $\begin{array}{r} \textbf{Total} \\ \textbf{3(a)} \\ \textbf{Conservation of energy from B to A} : \\ \frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2 \\ v^2 = 2ag + u^2 \\ = 27ag \\ v = \sqrt{27ag} \\ \textbf{Resolving vertically at } A: \\ \textbf{T} = \frac{mv^2}{a} + mg \\ \textbf{T} = \frac{m}{28ag} \\ \textbf{T} = 28mg \\ \textbf{M1} \\ \textbf{A1F} \\$		$=\frac{93}{10}$ or 9.3	A1		
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$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		-		4	
Total43(a)Conservation of energy from B to A: $             \frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2             $ $             v^2 = 2ag + u^2             $ $             = 27ag             v = \sqrt{27ag}             $ A13 terms, 2 KE and PE(b)At A, speed of particle is $\sqrt{27ag}$ Resolving vertically at A: $             T = \frac{mv^2}{a} + mg             $ A1FM1 A1FCorrect 3 terms Signs all correct $T = m\frac{28ag}{a}$ $T = 28mg$ A1F3ft from (a)		$=\frac{128}{10}$ or 12.8	Al	4	
Total43(a)Conservation of energy from B to A: $             \frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2             $ $             v^2 = 2ag + u^2             $ $             = 27ag             v = \sqrt{27ag}             $ A13 terms, 2 KE and PE(b)At A, speed of particle is $\sqrt{27ag}$ Resolving vertically at A: $             T = \frac{mv^2}{a} + mg             $ A1FM1 A1FCorrect 3 terms Signs all correct $T = m\frac{28ag}{a}$ $T = 28mg$ A1F3ft from (a)		∴ Centre of mass is at (9.3, 12.8)			SC3 interchange $\overline{X}$ and $\overline{Y}$
$\frac{1}{2}mu^2 + mga = \frac{1}{2}mv^2$ $v^2 = 2ag + u^2$ $= 27ag$ $v = \sqrt{27ag}$ A1  (b) At A, speed of particle is $\sqrt{27ag}$ Resolving vertically at A: $T = \frac{mv^2}{a} + mg$ $T = 28ag$ $T = 28mg$ A1  M1 A1				4	
$\frac{-mu^2 + mga = -mv^2}{2}$ $v^2 = 2ag + u^2$ $= 27ag$ $v = \sqrt{27ag}$ A1	3(a)	Conservation of energy from B to A:			
$v^{2} = 2ag + u^{2}$ $= 27ag$ $v = \sqrt{27ag}$ A1		$\frac{1}{mu^2 + mag} = \frac{1}{mu^2}$			3 terms, 2 KE and PE
		$\frac{-mu}{2} + mgu - \frac{-mv}{2}$	A1		
		$v^2 = 2ag + u^2$	A1		
(b) At A, speed of particle is $\sqrt{27ag}$ Resolving vertically at A: $T = \frac{mv^2}{a} + mg$ M1 A1F Signs all correct $T = m\frac{28ag}{a}$ $T = 28mg$ A1F 3 ft from (a)		= 27ag			
(b) At A, speed of particle is $\sqrt{27ag}$ Resolving vertically at A: $T = \frac{mv^2}{a} + mg$ M1 A1F Signs all correct $T = m\frac{28ag}{a}$ $T = 28mg$ A1F 3 ft from (a)		$v = \sqrt{27ag}$	A1	4	
Resolving vertically at $A$ : $T = \frac{mv^2}{a} + mg$ $T = m\frac{28ag}{a}$ $T = 28mg$ A1F  M1 A1F  Correct 3 terms Signs all correct		$\gamma = \sqrt{2} / u_{\delta}$			
Resolving vertically at $A$ : $T = \frac{mv^2}{a} + mg$ $T = m\frac{28ag}{a}$ $T = 28mg$ A1F  M1 A1F  Correct 3 terms Signs all correct	(b)	At A speed of particle is $\sqrt{27ag}$			
$T = \frac{mv^2}{a} + mg$ $T = m\frac{28ag}{a}$ $T = 28mg$ A1F  M1 A1F  Correct 3 terms Signs all correct  A1F  3 ft from (a)					
$T = \frac{hW}{a} + mg$ $T = m\frac{28ag}{a}$ $T = 28mg$ A1F Signs all correct A1F Signs all correct			M1		Correct 3 terms
$T = m\frac{28ag}{a}$ $T = 28mg$ A1F 3 ft from (a)		$T = \frac{mv}{a} + mg$			
T = 28mg A1F 3 ft from (a)			7 1 1 1		2.5 dir contect
		$T = m \frac{200g}{g}$			
		T = 28mg	A1F	3	ft from (a)
10001   /		Total		7	\

Q	Solution	Marks	Total	Comments
4(a)	$\mathbf{v} = \frac{\mathbf{dr}}{\mathbf{d}t}$ $\mathbf{v} = -2\sin\frac{1}{4}t\mathbf{i} - 2\cos\frac{1}{4}t\mathbf{j}$	M1 A1	2	No <b>i</b> , <b>j</b> : no marks
(b)	Speed is $\{(-2\sin\frac{1}{4}t)^2 + (-2\cos\frac{1}{4}t)^2\}^{\frac{1}{2}}$ = $2\left(\sin^2\frac{1}{4}t + \cos^2\frac{1}{4}t\right)^{\frac{1}{2}}$	M1 M1		clear use of $\sin^2 \theta + \cos^2 \theta = 1$
	= 2 which is a constant	A1	3	Use of 2 values SC1
(c)	Magnitude of <b>r</b> is $\{(8\cos\frac{1}{4}t)^2 + (8\sin\frac{1}{4}t)^2\}^{\frac{1}{2}}$	M1		
	<ul><li>= 8 which is a constant</li><li>∴ Particle is moving in a circle</li></ul>	A1	2	$\mathbf{a} = -k\mathbf{r} \Rightarrow \text{circle}$ SC2
(d)	Using $v = a\omega$	M1		M1 for their $\frac{b}{c}$ if both found
	Angular speed is 0.25	A1	2	
(e)	$\boldsymbol{a} = -\frac{1}{2}\cos\frac{1}{4}t\mathbf{i} + \frac{1}{2}\sin\frac{1}{4}t\mathbf{j}$	M1 A1	2	
( <b>f</b> )	Magnitude of acceleration is $\frac{1}{2}$	B1	1	
	Total		12	

Q	Solution	Marks	Total	Comments
5(a)	Using $F = ma$			
	$-0.05mv = m\frac{dv}{dt}$ $\therefore \frac{dv}{dt} = -0.05v$ $\int \frac{dv}{v} = -\int 0.05 dt$	В1	1	Need to see <i>m</i> terms
(b)	$\int \frac{\mathrm{d}v}{v} = -\int 0.05 \mathrm{d}t$	B1		
	$\ln v = -0.05 t + c$ $v = Ce^{-0.05t}$	M1		Need first 2 terms
	When $t = 0$ , $v = 20$ ,			
	∴ <i>C</i> = 20	M1		anly for fully compate solutions
	$v = 20e^{-0.05t}$	A1	4	only for fully correct solutions
(c)	When $v = 10$ , $10 = 20e^{-0.05t}$	M1		
	$e^{0.05t} = 2$	A1		
	$\therefore t = \frac{1}{0.05} \ln 2$			
	= 13.9 or 20ln2	A1	3	
(d)	Work done by force is change in KE of car	M1		
	$= \frac{1}{2}m(20)^2 - \frac{1}{2}m(10)^2$	A1		
	= 150 m	A1	3	
	Total		11	

Q	Solution	Marks	Total	Comments
<b>6(a)</b>	Using power = force $\times$ velocity			
	Power = $(40 \times 50) \times 50$	M1		
	∴= $100,000$ watts	A1	2	
<b>(b)</b>	When speed is 25,			
	max force exerted is $\frac{100000}{25} = 4000$ N	B1		
	∴ Accelerating force is 3000N			
	Using $F = ma$			
	$3000 = 1500 \ a$	M1		
	$a = 2 \text{ ms}^{-2}$	A1	3	
(c)	When van is at maximum speed	M1		
	force against gravity is mg sin6			
	Force against gravity and resistance is			
	$mg\sin6 + 40 v$	M1		
	= 1536.6+ 40 v	A1		
	Speed is maximum	M1		
	when $1536.6 + 40v = \frac{100000}{v}$			
	$40 v^2 + 1536.6 v - 100 000 = 0$	A1		
	Speed is 34.4 ms <sup>-1</sup>	A1	6	
	Total		11	

Q	Solution	Marks	Total	Comments
7(a)	$\mathcal{C}^{e} \lambda x$	M1		
	Work done = $\int_{0}^{e} \frac{\lambda x}{l} dx$			
	U			
	$= \left[\frac{\lambda x^2}{2l}\right]_0^e$	A1		Needs limit of 0
	$\lfloor 2l \rfloor_0$			
	$=rac{\lambda e^2}{2l}$	A1	3	
	$=\frac{1}{2l}$			
	Or			
	area under a straight line			
	$=$ average force $\times$ distance			
	$=\frac{\lambda e^2}{2l}$			
	21			
/1 \ /2\	2			
(b)(i)	Using $T = \frac{\lambda x}{l}$			
		M1		
	$5g = \frac{150 \times x}{0.6}$	1411		
	Extension is 0.196 m	A1	2	
(ii)	$EPE = \frac{\lambda x^2}{2I}$			
	<del></del>			
	$= \frac{150 \times (1.4)^2}{2 \times 0.6}$	M1		
	= 245 J	A1	2	
(:::)	When at point O			
(iii)	When at point $O$ , EPE = 0			
	$PE[relative to P] = 5 \times g \times 2$	M1		
	KE [at $O$ ] = EPE [at $P$ ] – gain in PE[at $O$ ]	M1		
	$\frac{1}{2}mv^2 = 245 - 10g$			
	2 2.13 108	A1		
	$\frac{1}{2}.5.v^2 = 147$			
	$v^2 = 58.8$ Speed is 7.67 ms <sup>-1</sup>	A1	4	
	V = 38.8 Speed is 7.07 iiis  Total	AI	11	
	TOTAL		60	