



**General Certificate of Education**

**Mathematics 6360**

**MM2B      Mechanics 2B**

**Mark Scheme**

*2009 examination - January 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.

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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
A <sub>2,1</sub>	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.**

## MM2B

Q	Solution	Marks	Total	Comments
1	$r = \int v dt$ $= t^4 + 4 \cos 2t + 5t (+c)$ <p>When <math>t = 0, r = 0 \Rightarrow c = -4</math>  <math>\therefore r = t^4 + 4 \cos 2t + 5t - 4</math></p>	M1 A1 M1 A1ft	4	Finding $c$ correctly
<b>Total</b>			<b>4</b>	
2(a)	<p>Initial KE = <math>\frac{1}{2}mv^2</math>  <math>= \frac{1}{2} \times 6 \times 12^2</math>  <math>= 432 \text{ J}</math></p>	M1 A1	2	Allow one of $m$ and $v$ incorrect
(b)(i)	<p>When it hits the ground, conservation of energy gives  KE = Initial KE + loss in PE  <math>= 432 + 6 \times g \times 4</math>  <math>= 667.2</math>  <math>= 667 \text{ J (3sf)}</math></p>	M1 A1	2	Need $6 \times g \times 4$ or 235.2 AG
(ii)	$667.2 = \frac{1}{2} \times 6 \times v^2$ <p>Speed is <math>14.9 \text{ m s}^{-1}</math></p>	M1A1 A1	3	
(iii)	<p>Stone is a particle  No air resistance</p>	B1 B1	2	Not $g$ constant No other forces acting
<b>Total</b>			<b>9</b>	

## MM2B (cont)

Q	Solution	Marks	Total	Comments
3(a)	$\mathbf{v} = \frac{d\mathbf{r}}{dt}$ $\mathbf{v} = (e^{\frac{1}{2}t} - 8)\mathbf{i} + (2t - 6)\mathbf{j}$	M1 A1 A1	3	<b>i</b> terms <b>j</b> terms
(b)(i)	When $t = 3$ , $\mathbf{v} = -3.52\mathbf{i}$ Speed is $3.52 \text{ m s}^{-1}$	B1 B1	2	Accept $(e^{\frac{3}{2}} - 8)\mathbf{i}$ 3.5 does not give 2 <sup>nd</sup> B mark
(ii)	West	B1	1	
(c)	$\mathbf{a} = \frac{1}{2}e^{\frac{1}{2}t}\mathbf{i} + 2\mathbf{j}$ When $t = 3$ , $\mathbf{a} = \frac{1}{2}e^{\frac{3}{2}}\mathbf{i} + 2\mathbf{j}$ or $2.24\mathbf{i} + 2\mathbf{j}$	M1A1 A1	3	
(d)	Using $\mathbf{F} = m\mathbf{a}$ : $\mathbf{F} = 7(\frac{1}{2}e^{\frac{3}{2}}\mathbf{i} + 2\mathbf{j})$ $\therefore$ Magnitude of force is $7\left(\left(\frac{1}{2}e^{\frac{3}{2}}\right)^2 + 2^2\right)^{\frac{1}{2}}$ $\mathbf{F} = 21.025$ $\mathbf{F} = 21.0$	M1 M1 A1	3	Accept $\mathbf{F} = 7\mathbf{a}$  Accept 21
<b>Total</b>			<b>12</b>	
4(a)	Taking moments about $AD$ : $8 \times 10 + 2 \times 15 = 10\bar{x}$ $\bar{x} = \frac{110}{10}$ $= 11 \text{ cm}$	M1A1 A1	3	M1 for moments and 1 term on left correct and 1 term on right
(b)	5 cm	B1	1	
(c)	$(\tan)\theta = \frac{1}{5}$ ie $\frac{(a)-10}{(b)}$ $= 0.2$ Angle is $\tan^{-1}(0.2)$ $= 11.3^\circ$	M1 A1ft M1 A1ft	4	From areas; $\frac{1.4}{5} \Rightarrow \theta = 15.6$ or $15.7$
(d)	Centre of mass is at middle of lamina	E1	1	
<b>Total</b>			<b>9</b>	

## MM2B (cont)

Q	Solution	Marks	Total	Comments
5(a)	40 revolutions per minute	B1	2	or $\frac{2}{3}$ rev per second
	= $80\pi$ radians per minute	B1		AG
	= $\frac{4\pi}{3}$ radians per second			
	(b) Resolve vertically: $T \cos 30 = 6g$ $T = 67.9 \text{ N}$	M1A1 A1	3	M1 1 term each side, 1 correct AG
(c) Resolve horizontally: $T \sin 30 = m\omega^2 r$ $67.9 \sin 30 = 6 \times r \times \left(\frac{4\pi}{3}\right)^2$ $r = 0.322 \text{ m}$	M1 A1	4	M1 1 term each side, 1 correct A1 $T \sin 30$	
	A1		A1 RHS	
	A1	Condone 0.323 (using $\pi$ as 3.14)		
	<b>Total</b>		<b>9</b>	
6(a)	At maximum speed, tractive force = resistance force Using power = force $\times$ velocity: $800\,000 = F \times 40$ $F = 20\,000 \text{ N}$	M1 M1 A1	3	
	(b) Using force $\times$ distance = work done = change in energy: $20\,000 s = \frac{1}{2} \times 60\,000 \times (40^2 - 36^2)$	M1 A1 A1	4	M1 $Fs = \text{change of KE}$ A1 2 of 3 terms correct A1 all 3 terms correct
	Distance = 456 m	A1		
<b>Total</b>		<b>7</b>		
7(a)	$\frac{1}{2}mv^2 = \frac{1}{2}m \times 8^2 - mg2$  $v^2 = 64 - 39.2$ $= 24.8$ $v = 4.98$	M1 A1  A1	3	M1 3 terms, 2 KE and 1 PE  Accept $\sqrt{24.8}$
	(b) Using $F = ma$ radially: $R = mg \cos 60 + \frac{mv^2}{r}$  $= 6g \cos 60 + \frac{6 \times 24.8}{4}$ $= 66.6 \text{ N}$	M1 A1 B1  A1	4	M1 3 correct terms (not necessarily correct signs) B1 for $60^\circ$
	<b>Total</b>		<b>7</b>	

## MM2B (cont)

Q	Solution	Marks	Total	Comments
8(a)	Using $F = ma$ : $-0.08v^2 = 0.05a$ $\therefore \frac{dv}{dt} = -1.6v^2$	B1 B1	2	AG; condone sign error in first B1
(b)	$\int \frac{dv}{v^2} = -1.6 \int dt$ $-\frac{1}{v} = -1.6t (+ c)$ When $t = 0, v = 3 \Rightarrow c = -\frac{1}{3}$ $\frac{1}{v} = \frac{1}{3} + 1.6t$ * $\frac{1}{v} = \frac{1}{3} + \frac{8}{5}t$ $\frac{1}{v} = \frac{5 + 24t}{15}$ $v = \frac{15}{5 + 24t}$	M1 A1 M1 A1	5	Condone $-\frac{1}{v} = -1.6t + c \Rightarrow \frac{1}{v} = 1.6t + c$ AG; all working lines correct from *
<b>Total</b>			<b>7</b>	
9(a)	When acceleration is zero, tension = gravitational force $\frac{784x}{16} = 80g$ $x = 16, x + 16 = 32\text{ m}$ Length of cord is 32 m	M1 A1 A1	3	Both terms correct A1 for $x=16$
(b)(i)	When bungee jumper comes to rest, $EPE = \frac{784 \times x^2}{2 \times 16}$ $= \frac{49x^2}{2}$ Change in PE = $80 \times g \times (16 + x)$ $\frac{49x^2}{2} = 80 \times 9.8 \times (16 + x)$ $x^2 = 32x + 512$ $x^2 - 32x - 512 = 0$	M1 M1 A1 A1	4	Or $80 \times g \times 65 - (80g[16 + x])$ (or $80g(49 - x)$ ) AG
(ii)	$x = \frac{32 \pm \sqrt{32^2 + 2048}}{2}$ $x = 43.7128$ Distance below point of jump is $43.7 + 16 = 59.7\text{ m}$ Distance between jumper and ground is $65 - 59.7$ $= 5.29\text{ m}$	M1 A1 M1 A1	4	Accept 5.287, 5.3
<b>Total</b>			<b>11</b>	
<b>TOTAL</b>			<b>75</b>	