



**General Certificate of Education**

**Mathematics 6360**

**MM2B      Mechanics 2B**

**Mark Scheme**

*2008 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
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.**

## MM2B

Q	Solution	Marks	Total	Comments
1(a)	Kinetic energy = $\frac{1}{2} \times 0.6 \times 15^2$ = 67.5 J	M1 A1	2	
(b)	Using $mgh = \frac{1}{2}mv^2$ : $67.5 = 0.6 \times g \times h$ $\Rightarrow h = \frac{67.5}{0.6g}$ = 11.5 m	M1 A1 A1	3	
(c)	When 3 m above ground level: Change in PE is $0.6 \times g \times 3$ = 17.64 J $\therefore$ KE of ball is $67.5 - 17.64$ = 49.86 J Speed of ball is $\sqrt{\frac{49.86}{\frac{1}{2} \times 0.6}}$ = $12.9 \text{ m s}^{-1}$	M1 A1 m1 A1	4	Dep on M1 No KE given: speed = 12.9 SC3
(d)	eg ball is a particle, no air resistance, weight is the only force acting etc	E1	1	Accept no spin, no wind
<b>Total</b>			<b>10</b>	
2(a)(i)	$a = \frac{dv}{dt} = 6t - 6\cos 3t$	M1A1	2	M1 for at least one term correct
(ii)	When $t = \frac{\pi}{3}$ , $a = 6 \times \frac{\pi}{3} - 6\cos(3 \cdot \frac{\pi}{3})$ = $2\pi + 6$	M1 A1	2	AG
(b)	$r = t^3 + \frac{2}{3}\cos 3t + 6t + c$ When $t = 0$ , $r = 0 \therefore c = -\frac{2}{3}$ $\therefore r = t^3 + \frac{2}{3}\cos 3t + 6t - \frac{2}{3}$	M1A1 M1 A1	4	M1 for 3 terms including $\cos 3t$ term Condone no '+ c'
<b>Total</b>			<b>8</b>	

## MM2B (cont)

Q	Solution	Marks	Total	Comments
3(a)		B2	2	B1 for any 4 correct
(b)	Resolve vertically: $R = 20g + 80g$ $= 100g$ Using $F = \mu R$ : $F = 0.4 \times 100g$ $= 40g$ or 392 N	B1 m1 A1	3	Must see $20g + 80g$ or $100g$ to obtain any marks in (b) Dep on B1 AG
(c)	Resolve horizontally: $S = 40g$ Moments about A: $80gx \cos 60 + 20g \cdot 2 \cos 60$ $= S \cdot 4 \cos 30$ $40gx + 20g = 138.56g$ $x = \frac{118.56}{40}$ $= 2.96 \text{ m}$	B1 M1A1 A1 m1 A1	6	M1 for 3 terms, all moments Dep on M1 Accept $2\sqrt{3} - \frac{1}{2}$
<b>Total</b>			<b>11</b>	
4(a)	$\mathbf{v} = \frac{dr}{dt}$ $\mathbf{v} = (3t^2 - 6t)\mathbf{i} + (4 + 2t)\mathbf{j}$	M1A1	2	
(b)(i)	$\mathbf{a} = (6t - 6)\mathbf{i} + 2\mathbf{j}$ Using $\mathbf{F} = m\mathbf{a}$ : $\mathbf{F} = (18t - 18)\mathbf{i} + 6\mathbf{j}$	M1 A1ft A1ft	3	
(ii)	When $t = 3$ , $\mathbf{F} = 36\mathbf{i} + 6\mathbf{j}$ Magnitude is $\sqrt{36^2 + 6^2}$ $= 36.5$	M1 A1ft	2	Accept $6\sqrt{37}$ ; ft from (b)(i)
(c)	When $\mathbf{F}$ acts due north: Component of $\mathbf{F}$ in the $\mathbf{i}$ direction is 0 $18t - 18 = 0$ $t = 1$	M1 A1ft	2	ft from (b)(i)
<b>Total</b>			<b>9</b>	

## MM2B (cont)

Q	Solution	Marks	Total	Comments
5(a)	Acceleration is $\frac{v^2}{r}$ $= \frac{2^2}{0.2}$ $= 20 \text{ m s}^{-2}$	M1 A1	2	
(b)	$\theta = 30^\circ$ Resolve vertically: $T_1 \cos \theta = mg$ $T_1 \cos \theta = 4g$ $T_1 = 45.3 \text{ N}$	B1 M1 A1 A1	4	AG
(c)	Resolve horizontally: $T_1 \sin \theta + T_2 = \frac{mv^2}{r}$ $45.3 \sin \theta + T_2 = 4 \times 20$ $T_2 = 57.4 \text{ N}$	M1A1 A1	3	M1 for 3 terms, 2 correct Condone 57.3 N
<b>Total</b>			<b>9</b>	
6(a)	EPE = $\frac{\lambda x^2}{2l}$ $= \frac{300 \times (1.5)^2}{2 \times 4}$ $= 84.375$ $= 84.4 \text{ J}$	M1 A1	2	
(b)	When string is slack, gain in PE is $mgh$ $= 6 \times g \times 1.5 \sin 30$ $= 44.1 \text{ J}$ KE = EPE – gain in PE $= 84.375 - 44.1$ $= 40.275$ $\frac{1}{2} \cdot 6 \cdot v^2 = 40.275$ $v = 3.66$	M1 A1 m1 A1 A1	5	AG
(c)	At A, PE gained above initial position is $6 \times g \times 5.5 \sin 30$ $= 161.7 \text{ J}$ This is more than initial elastic potential energy $\therefore$ particle will not reach A	B1 B1 E1	3	Or PE above position string slack is 117.6 KE at A is -77.3  <b>Or</b> Using $v^2 = u^2 + 2as$ $a = 0.5g$ B1 $s = 1.37$ or $1.366$ B1 [or 2.87 above starting point] Hence stops before A E1 Vertical height above sling slack is 0.683 Vertical height above starting point is 1.435
<b>Total</b>			<b>10</b>	

## MM2B (cont)

Q	Solution	Marks	Total	Comments
7(a)	Conservation of energy: $\frac{1}{2}m(3\sqrt{ag})^2 + mg2a = \frac{1}{2}mv^2$ $\frac{9}{2}mga + 2mga = \frac{1}{2}mv^2$ $v = \sqrt{13ag}$	M1A1 A1 A1	4	M1 for 3 terms: 2 KE and PE
(b)	At A, consider vertical forces: $T - mg = \frac{mv^2}{a}$ $T = mg + 13mg$ $T = 14mg$	M1A1 m1 A1ft	4	M1 for 3 terms, 2 correct ft from (a)
<b>Total</b>			<b>8</b>	
8(a)	Power of engine is 8kW $\therefore \text{Force exerted by engine} = \frac{8000}{v}$ Using $F = ma$ : $\frac{8000}{v} - kv^2 = 600 \frac{dv}{dt}$ $600 \frac{dv}{dt} - \frac{8000}{v} + kv^2 = 0$	M1A1 m1 A1	4	M1 for Power = $Fv$ AG
(b)(i)	When engine is turned off, power is zero: $-kv^2 = 600 \frac{dv}{dt}$	B1	1	AG
(ii)	$\int 600 \frac{dv}{v^2} = -\int k dt$ $-\frac{600}{v} = -kt + c$ When $t = 0, v = 20$ : $\therefore c = -\frac{600}{20} = -30$ $\therefore \frac{600}{v} = kt + 30$ When $v = 10, kt = 30$ : $\therefore t = \frac{30}{k}$	M1 A1 A1 M1 A1	5	Need '+ c'  $-\frac{30}{k}$ SC3
<b>Total</b>			<b>10</b>	
<b>TOTAL</b>			<b>75</b>	