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General Certificate of Education

Mathematics 6360

MM2B Mechanics 2B

Mark Scheme

2007 examination - June series

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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 = $\frac{1}{2} \times 5 \times 10^2$	M1		Full method
	= 250 J	A1	2	
(b)	Using conservation of energy: KE when box hits ground = Initial KE + Change in potential energy	M1		Could have sign errors
	$= 250 + 5 \times 30 \times g$	A1ft		
	= 1720 J	A1	3	AG; SC2 $5 \times 35.1 \times g = 1720$. ...
(c)	$\frac{1}{2}mV^2 = 1720$	M1		
	$V^2 = 688$	A1		
	∴ Speed is 26.2 m s^{-1}	A1	3	CAO; accept $\sqrt{688}$ or $4\sqrt{43}$; SC2 26.3
(d)	No air resistance	E1		Or no resistance forces
	Box is a particle	E1	2	Deduct 1 mark for unacceptable third reason
	Total		**10**	
2(a)	Symmetry of the lamina about *PQ*	E1	1	Accept 'mirror line'
(b)	Taking moments about *AB*:			
	$600\rho \times 15 + 100\rho \times 35$	M1A1		Condone lack of ρ
	$= 700\rho\bar{x}$	A1		
	$\bar{x} = 17.857 = 17.9$ cm	A1	4	SC3 17.8
(c)	$\tan\theta = \frac{10}{17.857}$	M1A1		M1 for use of $\tan\theta$
	$= 0.56$			
	Angle is 29.2488…	M1		
	$= 29°$	A1	4	
	Total		**9**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
3(a)	Using $F = ma$:			
	$2400\mathbf{i} - 4800t\mathbf{j} = 800\mathbf{a}$	M1		
	$\mathbf{a} = 3\mathbf{i} - 6t\mathbf{j}$	A1	2	
(b)	$\mathbf{v} = \int \mathbf{a}\, dt$	M1		
	$= 3t\mathbf{i} - 3t^2\mathbf{j} + \mathbf{c}$	A1		Condone no '+ **c**'
	When $t = 0$, $\mathbf{v} = 6\mathbf{i} + 30\mathbf{j}$			
	$\therefore\ \mathbf{c} = 6\mathbf{i} + 30\mathbf{j}$	M1		Needs '+ **c**' above
	$\therefore\ \mathbf{v} = (3t + 6)\mathbf{i} + (30 - 3t^2)\mathbf{j}$	A1	4	AG
(c)	$\mathbf{r} = \int \mathbf{v}\, dt$	M1		
	$= (\frac{3}{2}t^2 + 6t)\mathbf{i} + (30t - t^3)\mathbf{j} + \mathbf{d}$	A1,A1		A1 **i** term, A1 **j** term; condone no '+ **d**'
	When $t = 0$, $\mathbf{r} = 2\mathbf{i} + 5\mathbf{j}$			
	$\therefore\ \mathbf{d} = 2\mathbf{i} + 5\mathbf{j}$	M1		
	$\therefore\ \mathbf{r} = (\frac{3}{2}t^2 + 6t + 2)\mathbf{i} + (30t - t^3 + 5)\mathbf{j}$	A1	5	
	Total		**11**	
4(a)	Centre of mass of rod is 3 m from river bank	B1		Use of centre of mass is centre of rod
	Taking moments about A, edge of bank:			Or resolve $R = 65g$ B1
	$3 \times 15 = 50x$	M1		Moments about any point (correct) M1
	$x = 0.9$	A1	3	0.9 A1
(b)	Taking moments about A:			
	$50 \times 2 = 15 \times 3 + m \times 8$	M1A1		M1 3 terms, 2 correct
	$55 = 8m$	A1		
	$m = 6\frac{7}{8}$			
	Mass is $6\frac{7}{8}$ kg	A1	4	Accept 6.88 and 6.87
(c)	Centre of mass of rod is 3 m from river bank	E1	1	Centre of mass is at centre of rod
(d)	eg Woman is a particle The mass is a particle The plank is a rigid rod	E1	1	
	Total		**9**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
5(a)	Using conservation of energy (lowest and highest points):	M1		
	$\frac{1}{2}m(7v)^2 = \frac{1}{2}mv^2 + 2mga$	A1A1		A1 for $7v$ and v
	$\frac{48}{2}v^2 = 2ga$	M1		Needs 48 or 24
	$\therefore v = \sqrt{\frac{ag}{12}}$	A1	5	AG
(b)	Velocity at A is $\sqrt{\frac{ag}{12}}$			
	Resolving vertically at A:	M1		3 terms
	$m\frac{v^2}{a} + R = mg$	A1,A1		A1 correct 3 terms, A1 correct signs
	$R = mg - \frac{m}{a}\times\frac{ag}{12}$			$\left(1-\frac{1}{12}\right)mg$ M1A2
	$= \frac{11}{12}mg$	A1	4	Condone $-\frac{11}{12}mg$
	Total		**9**	
6(a)	EPE is $\frac{\lambda x^2}{2l}$			
	$= \frac{200(0.5)^2}{2\times 2}$	M1		
	= 12.5 J	A1	2	
(b)	When string becomes slack,			
	using $\frac{1}{2}mv^2$ = loss in EPE:	M1		NB Using $\sqrt{5}$ to answer (a) and thus (b) $\Rightarrow$ no marks
	$\frac{1}{2}\times 5 \times v^2 = 12.5$	A1		
	Speed is $\sqrt{5}$ m s^{-1}	A1	3	AG
(c)	Resolving vertically, $R = 5g$	B1		
	$F = \mu R$	M1		
	$0.4 \times 5g = 2g$	M1		
	Using change in energy = work done:			
	$2g \times 0.5 =$	M1		M1 for force × distance
	$\frac{1}{2}\times 5\times\left(\sqrt{5}^2\right) - \frac{1}{2}\times 5\times v^2$	A1,A1		A1 first term (or 12.5) A1 second term (inc $-$)
	$9.8 = 12.5 - \frac{5}{2}v^2$			
	$v^2 = 1.08$			
	Speed is 1.04 m s^{-1}	A1	7	
	Total		**12**	

MM2B (cont)

Q	Solution	Marks	Total	Comments
7(a)	Using $F = ma$:			
	$-\lambda mv = ma = m\frac{dv}{dt}$	M1		Condone no ' – '
	$\therefore \frac{dv}{dt} = -\lambda v$	A1	2	AG Note: no use of $m \Rightarrow$ no marks in (a)
(b)	$\int \frac{dv}{v} = -\lambda \int dt$	M1		
	$\ln v = -\lambda t + c$ $v = Ce^{-\lambda t}$	A1		Needs '+ c'
	When $t = 0$, $v = U \Rightarrow C = U$	M1		Needs correct working
	$v = Ue^{-\lambda t}$	A1	4	AG
	Total		**6**	
8(a)	Q is in equilibrium	E1		Q at rest, or not moving
	$T = 5g = 49$ N	B1	2	AG
(b)	Resolving vertically for P:			
	$T\cos\theta = 3g$	M1A1		
	$\cos\theta = \frac{3}{5}$			
	$\theta = \cos^{-1}\frac{3}{5} = 53.1°$	A1	3	Do not condone 53°
(c)	$\therefore \sin\theta = \frac{4}{5}$	B1		
	Resolving horizontally for P:			
	$\frac{mv^2}{r} = T\sin\theta$	M1A1		M1 2 terms: 1 term correct, other term includes sin or cos
	$\frac{3v^2}{r} = \frac{4}{5} \times 5g$			
	$\frac{3\times 4^2}{r} = 4g$			
	$r = \frac{48}{4g}$			
	$= 1.22$	A1	4	SC3 1·23
	Total		**9**	
	TOTAL		**75**	