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General Certificate of Education (A-level)
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Mathematics MM2B

(Specification 6360)

Mechanics 2B

Final

Mark Scheme

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Key to mark scheme abbreviations

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
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
–*x* EE	deduct *x* marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
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.

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.

Q	Solution	Marks	Total	Comments
1(a)	$v = \frac{ds}{dt}$	M1		
	$= 24t^2$	A1	2	
(b)	$a = \frac{dv}{dt}$			
	$= 48t$	B1		
	When $t = 2$, $a = 96$	B1		
	Using $F = ma$			
	$F = 3 \times 96$	M1		
	$= 288$ N	A1	4	
	Total		**6**	
2(a)	$\text{KE} = \frac{1}{2} \times 52 \times 7^2$	M1		
	$= 1274$ J	A1	2	
	$= 1270$ J			
(b)	Change in PE: $mgh = 52 \times 9.8 \times 8$	M1		
	$= 4076.8$	A1		
	Carol's KE when she reaches the net			
	$= 1274 + 4076.8$ J $= 5350.8$ J			
	$= 5350$ J	A1	3	
(c)	Speed of Carol is $\sqrt{\frac{5350.8}{\frac{1}{2} \times 52}}$	M1A1		
	$= 14.3457$ m s^{-1}			
	$= 14.3$ m s^{-1}	A1	3	
	Total		**8**	
3(a)	$v = \int a \, dt$			
	$= (20t^2 + t^3)\mathbf{i} - 5e^{-4t}\mathbf{j} + \mathbf{c}$	M1A1		M1 for either term correct Condone no '+ **c**'
	When $t = 1$,			
	$6\mathbf{i} - 5e^{-4}\mathbf{j} = 21\mathbf{i} - 5e^{-4}\mathbf{j} + \mathbf{c}$	M1		Finding '+ **c**'; not using $\mathbf{c} = 6\mathbf{i} - 5e^{-4}\mathbf{j}$
	$\mathbf{c} = -15\mathbf{i}$	A1		
	$\mathbf{v} = (20t^2 + t^3 - 15)\mathbf{i} - 5e^{-4t}\mathbf{j}$	A1	5	
(b)	When $t = 0$, $\mathbf{v} = -15\mathbf{i} - 5\mathbf{j}$	M1		
	Speed is $\sqrt{15^2 + 5^2}$	M1		
	$= 15.8$ m s^{-1}	A1	3	Accept $5\sqrt{10}$
	Total		**8**	

Q	Solution	Mark	Total	Comments
4(a)(i)	Moments about Q	M1		**Or**
	$2.2 \times 25g = T_P \times 4.2$	A1		Moments about any point M1A1
	$T_P = 13.095 \times g$			Moments about any other point M1
	$T_P = 128$ N	A1		T_P A1 ; T_Q A1
	Resolving vertically			
	$T_P + T_Q = 25g$ or 245	M1		
	$T_Q = 117$ N	A1	5	
(ii)	Weight of plank acts through its centre	E1	1	
(b)	Resolve vertically	M1		Could use T rather than T_P , T_Q
	$T_P + T_Q = (25 + m)g = 2T_P$	A1		**Or**
	Moments about B	M1		Moments about Q
	$T_P \times 5 + T_Q \times 0.8 = 25g \times 3$	A1		$T_P \times 4.2 = 25g \times 2.2 - mg \times 0.8$
	$(25 + m)g \times 2.9 = 25g \times 3$			$\frac{1}{2} \times (25 + m)g \times 4.2$
				$= 25g \times 2.2 - mg \times 0.8$
	$2.9mg = 25g \times 0.1$	M1		$2.9mg = 25g \times 0.1$
	$29m = 25$			$29m = 25$
				OR
				Moments about any point M1A1
				Moments about any other point M1A1
				Solution M1A1
	$m = 0.862$ or $\frac{25}{29}$	A1	6	
	Total		**12**	
5	In limiting equilibrium, using $F = \mu R$			
	Frictional force is $0.2 \times mg$	M1A1		
	Resolve horizontally			
	$\frac{m \times 15^2}{r} = 0.2 \times mg$	M1		
	$r = \frac{15^2}{0.2 \times g}$			
	$= 114.79$	A1	4	
	$= 115$			
	Total		**4**	

Q	Solution	Marks	Total	Comments
6(a)	Using $F = ma$			
	$1600\dfrac{\mathrm{d}v}{\mathrm{d}t} = 4000 - 40v$	M1		
	$\dfrac{\mathrm{d}v}{\mathrm{d}t} = \dfrac{4000 - 40v}{1600}$			
	$\dfrac{\mathrm{d}v}{\mathrm{d}t} = \dfrac{100 - v}{40}$	A1	2	
(b)	$40\dfrac{\mathrm{d}v}{100 - v} = \mathrm{d}t$	B1		
	$40\int\dfrac{\mathrm{d}v}{100 - v} = \int\mathrm{d}t$	M1		
	$-40\ln(100 - v) = t + c$	A1		Condone lack of '+ c'
	When $t = 0$, $v = 0 \Rightarrow c = -40\ln 100$	M1A1		
	$-40\ln(100 - v) = t - 40\ln 100$			
	$t = 40\ln\dfrac{100}{100 - v}$			
	$\mathrm{e}^{\frac{t}{40}} = \dfrac{100}{100 - v}$			
	$v = 100 - 100\mathrm{e}^{-\frac{t}{40}}$ or $100(1 - \mathrm{e}^{-\frac{t}{40}})$	A1	6	
	Total		**8**	
7	Using power = force × velocity			
	$240\,000 = F \times 20$	M1A1		
	$F = 12\,000$	A1		
	Accelerating force is $12\,000 - 5000$			
	$= 7000$ N	B1		
	Using $F = ma$	M1		
	$22\,000a = 7000$			
	$a = 0.318$ or $\dfrac{7}{22}\ \mathrm{m\,s^{-2}}$	A1	6	
	Total		**6**	

Q	Solution	Marks	Total	Comments
8(a)	Using conservation of energy:			
	$\frac{1}{2}m(5u)^2 = \frac{1}{2}m(2u)^2 + 2amg$	M1A1		M1 for 3 [or 4] terms: 2 KE and 1[or 2] PE
	$\frac{1}{2}\times 21\times u^2 = 2ag$	M1		M1A1 for finding h
	$u = \sqrt{\frac{4ag}{21}}$	A1	4	
(b)	Using conservation of energy with speed at point S to be V:			**Or**
	$\frac{1}{2}m(5u)^2 = \frac{1}{2}m(V)^2 + amg(1+\cos 60)$	M1		$\frac{1}{2}m(V)^2 = amg(1-\cos 60°) + \frac{1}{2}m\left(2\sqrt{\frac{4ag}{21}}\right)^2$
	$\frac{1}{2}mV^2 = \frac{1}{2}m(5u)^2 - 1\frac{1}{2}amg$			
	$V^2 = 25\times\left(\frac{4ag}{21}\right) - 3ag$			
	$V^2 = \frac{37ag}{21}$	A1		
	Resolving radially at point S:			
	$R = -mg\cos 60 + \frac{m(V)^2}{a}$	M1A1		
	$= -\frac{1}{2}mg + \frac{37mg}{21}$			
	$= \frac{53}{42}mg$ or $1.26mg$	A1	5	
	Total		**9**	

Q	Solution	Marks	Total	Comments
9(a)(i)	Using $T = \frac{\lambda x}{l}$			
	Tension in string is $\frac{60 \times 2.5}{3}$			
	$= 50$ N	B1		
	Frictional force on A [using $F = \mu R$] is $0.4 \times 8 \times g$			
	$= 31.36$ N	B1		
	which is less than tension in string			
	Thus particle A moves towards the hole	B1	3	
(ii)	Gravitational force on B is $3g = 29.4$	B1		
	which is less than tension in string			
	Thus particle B moves towards the hole	B1	2	
(b)	$\text{EPE} = \frac{\lambda x^2}{2l}$			
	$= \frac{60 \times (2.5)^2}{2 \times 3}$	M1		
	$= 62.5$ J	A1	2	
(c)	Let x be the distance B has moved upwards			
	Work done by friction [on A] is 31.36×0.46	M1		
	$= 14.4256$			
	$= 14.43$ J	A1		
	When B is at rest, extension is $2.04 - x$			
	$\text{EPE} = \frac{\lambda x^2}{2l}$			
	$= \frac{60 \times (2.04 - x)^2}{2 \times 3}$			
	$= 10(2.04 - x)^2$ J	B1		
	C of Energy, when particle B is at rest, gives			
	$3 \times g \times x + 10(2.04 - x)^2 + 14.4256$	M1A1		
	$= 62.5$	A1		
	$10x^2 - 11.4x - 6.4584 = 0$			Or $10x^2 - 11.4x - 6.454 = 0$
	$x = 1.555$ and -0.415			
	Particle B is first at rest when it has moved upwards 1.56 m	A1	7	Accept 1.55
	Total		**14**	
	TOTAL		**75**	