

A-LEVEL **Mathematics**

MM2B Mechanics 2B Mark scheme

6360

June 2018

Version/Stage: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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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Annotations key

Annotation	Use
?	Unclear
٨	Omission
BOD	Benefit of doubt
Cross	Incorrect
FT	Follow through
H wavy	Highlight relevant working
ISW	Ignore subsequent working
On page comment	Clarifies issue
SEEN	Only used on blank pages
Tick	Correct

Q	Solution	Mark	Total	Comment
1 (a)(i)	Total weight is 20kg.	B1		B1: Total weight CAO
	Taking moments about y axis $7 \times 60 + 6 \times 20 + 3 \times 60 + 4 \times 80 = 20x$	M1		M1: At least three correct multiplications on LHS.
	$x = \frac{1040}{20}$ = 52 Distance from AD is 52 cm	A 1	3	A1: Correct distance CAO.
(ii)				
	Taking moments about x axis $7 \times 40 + 6 \times 60 + 3 \times 30 + 4 \times 20 = 20y$ $y = \frac{810}{20}$ $= 40.5$ Distance from AB is 40.5 cm	M1	2	M1: At least three correct multiplications on LHS. A1: Correct distance CAO.
(b)	If lamina hangs in equilibrium, C of G must be vertically below X Hence distance of C of G from y axis is 60 cm. Moments about AD; $1040 + m \times 120 = (20 + m) 60$ $60 \text{ m} = 160$	M1 M1A1		M1: Uses 60 or other appropriate distance in their calculations. No need to see this explicitly stated. M1: At least two terms correct in a 3/4 term moment equation correct. A1: Correct moment equation.
	Mass is $\frac{8}{3}$ kg	A1	4	A1: Correct mass. CAO Accept 2.67.
	Total		9	

Q	Solution	Mark	Total	Comment
2 (a)	Initial KE is $\frac{1}{2} \times 21 \times 2^2$	M1		M1: Correct expression for KE.
	= 42 J	A 1	2	A1: Correct value for KE
(b)(i)	Energy gained by moving to point B is	M1		M1: For height change 8.
	mgh			
	$= 21 \times 8 \times g$			
	= 1646.4	A 1		A1: Correct change in PE.
	Total KE at B is 1646.4 + 42			
	= 1688.4			
	= 1690 J	A1F	3	A1F: Correct sum of their energies.
(ii)	KE at point B is 1688.4			
	$\frac{1}{2} \times m \times v^2 = 1688.4$	М1		M1: Seeing $\frac{1}{2}mv^2$ equated to their
				answer to (b)(i).
	$v^2 = \frac{1688.4}{10.5}$			
	= 12.68			
	Speed is 12.7 ms ⁻¹	A1F	2	A1: Correct speed for their answer to
				(b)(i).
(c)	Work done = $F \times s$ = change in KE			
	$21g\mu s = 1688.4$	M1		M1: For Fs = Change in KE using their
	$\mu = \frac{1688.4}{21 \times g \times 18}$	A1F		answer to (b)(i).
	= 0.45578			A1: Correct equation (using bi).
	= 0.456			A4. Compart on officient of frieties. CAO
	01100	A1	3	A1: Correct coefficient of friction. CAO
	OR			
	a = -4.4666	(M1)		M1: Correct acceleration (Accept -4.48 from 12.7)
	$-21g\mu = 21 \times (-4.4666)$	(A1)		A1: Correct equation.
	$\mu = \frac{4.4666}{g} = 0.456$	(A1)		A1: Correct coefficient of friction. CAO
	Total		10	

Q 3	Solution	Mark	Total	Comment
(a)	$\mathbf{a} = (12 - 3t^2)\mathbf{i} + 12 e^{-2t}\mathbf{j}$	M1A1	2	M1: Either term correct.
				A1: All correct
(b)(i)	$\mathbf{F} = \mathbf{ma}$	M1		M1: Use of $F = ma$
	$= (24 - 6t^2)\mathbf{i} + 24 e^{-2t}\mathbf{j}$	A1	2	A1: Correct expression for force.
(ii)	When $t = 0$, F = $24i + 24j$			
				M1: Finding magnitude and substituting
	Magnitude is $\sqrt{24^2 + 24^2}$	M1		t=0.
	$= 24\sqrt{2}$ or 33.9	A1	2	A1: Correct magnitude. Do not only 34.
(c)	When F acts north, i component is zero			
	$24 - 6t^2 = 0$	M1		M1: Setting i component equal to zero.
	t=2	A 1	2	A1: Correct time.
(d)	$\mathbf{r} = \int \boldsymbol{v} dt$			
	$= (6t^2 - \frac{1}{4}t^4)\mathbf{i} + 3e^{-2t}\mathbf{j} + \mathbf{c}$	M1A1		M1: Either component correct.
	4 0 10 1 3 0 1 1 0			A1: Both components correct. Condone
				missing c .
	When $t = 0$, $\mathbf{r} = 4\mathbf{i} - 2\mathbf{j}$, $\mathbf{c} = 4\mathbf{i} - 5\mathbf{j}$	m1A1		m1: Must use t=0. Either component of c
				correct.
				A1: Correct c .
	$\mathbf{r} = (6t^2 - \frac{1}{4}t^4 + 4)\mathbf{i} + (3e^{-2t} - 5)\mathbf{j}$	A 1	5	A1: Correct position vector.
				Tit. Contest position vector.
			_	
	Total		13	

Q	Solution	Mark	Total	Comment
4 (a)	Using $F = \frac{mv^2}{r}$	M1		M1: Using $F = \frac{mv^2}{r}$
	$F = \frac{900 \times 12^2}{80}$			
	= 1620 N	A 1	2	A1: Correct force.
(b)	Using $F = \mu R$			
	$1620 = \mu \times 900g$	M1		M1: Use of $F = \mu R$ Condone use of inequality.
	$\mu = 0.18367$			mequanty.
	$\mu = 0.184$	A 1	2	A1: Correct coefficient of friction.
	Total		4	

$32000 = (k \times 40) \times 40$ $= 1600k$ $k = 20$ A1: Using an equation that leads to AG (b)(i) Accelerating forces $= 600g \times \frac{1}{10} - 20v$ M1: Resolving to find component or weight in equation. Must see $\sin\theta$ of weight in equation. Must see $\sin\theta$ of A1: Use of $F = ma$ A1: Correct answer from correct weight in equation of variables. A1: Correct LHS. $-\ln(3g - v) = \frac{1}{30}t + c$ $-\ln(3g - v) = \frac{1}{30} = \frac{1}{3g - v}$ A1A1 A1A1 B1: Correct Answer from correct weight in equation of variables. A1: Correct LHS. A1: Correct Instance of the AWRT -2.4 or -ln(11.4) or $e^c = \frac{5}{5}$, $e^{-c} = \frac{57}{5}$ A1: Correct final answer. Accept $t = 30\ln(\frac{3g - v}{3g - v})$ or $t = -30\ln(\frac{3g - v}{3g - v})$ A1 5 M1 M1: Substituting $v = 22$ (must be a exp term)	Q	Solution	Mark	Total	Comment
$k = 20$ A1 2 Al: Using an equation that leads to AG (b)(i) Accelerating forces $= 600g \times \frac{1}{10} - 20v$ $\Rightarrow 600\frac{dv}{dt} = 60g - 20v$ $\frac{dv}{dt} = \frac{3}{30} - \frac{v}{30}$ $\frac{dv}{dt} = \frac{3}{30} - \frac{v}{30}$ A1 3 Al: Correct answer from correct we AG (ii) $\int \frac{dv}{3x^2 - v} = \frac{1}{30} \int dt$ $-\ln(3g - v) = \frac{1}{30}t + c$ When $t = 0$, $v = 18 \Rightarrow c = -\ln(3g - 18)$ $\frac{1}{30}t = \ln\frac{3g - 18}{3g - v}$ $t = 30 \ln\frac{3g - 18}{3g - v}$ A1 4 5 A1 5 $\frac{1}{5} = \frac{5}{5}$ A1: Correct answer from correct we AG A1A1 B1 Correct RHS. Condone missing constant. B1: Correct constant. (-2.4336 or AWRT -2.4 or -ln(11.4) or $e^c = \frac{5}{57}$ A1: Correct final answer. Accept $t = 30 \ln\left(\frac{11.4}{3g - v}\right)$ or $t = -30 \ln\left(\frac{3g - 18}{11.0}\right)$ $t = 30 \ln\left(\frac{57}{5(3g - v)}\right)$ oe Do not accept $t = 73.008 - 30 \ln(3g - v)$ (iii) When $v = 22 \Rightarrow t = 30 \ln\frac{3g - 18}{3g - 22}$ M1 M1: Substituting $v = 22$ (must be a exp term)	a) P	$Power = F \times v$	M1		M1: Use of $P = Fv$
A1 2 A1: Using an equation that leads to AG		$32000 = (k \times 40) \times 40$			
(ii) Accelerating forces $= 600g \times \frac{1}{10} - 20v$ $\Rightarrow 600 \frac{dv}{dt} = 60g - 20v$ $\Rightarrow \frac{dv}{dt} = \frac{g}{10} - \frac{v}{30}$ $\Rightarrow \frac{dv}{dt} = \frac{3g - v}{30}$ $\Rightarrow -\ln (3g - v) = \frac{1}{30}t + c$ $\Rightarrow t = 30 \ln \frac{3g - 18}{3g - v}$ $t = 30 \ln \frac{3g - 18}{3g - v}$ $\Rightarrow t = 30 \ln \frac{3g - 18}{3g - v}$ (iii) Accelerating forces $\Rightarrow -\ln (3g - 18) = \frac{1}{30} \int dt$ A1 A		= 1600k			
(ii) Accelerating forces $= 600g \times \frac{1}{10} - 20v$ $\Rightarrow 600 \frac{dv}{dt} = 60g - 20v$ $\Rightarrow \frac{dv}{dt} = \frac{g}{10} - \frac{v}{30}$ $\Rightarrow \frac{dv}{dt} = \frac{3g - v}{30}$ $\Rightarrow -\ln (3g - v) = \frac{1}{30}t + c$ $\Rightarrow t = 30 \ln \frac{3g - 18}{3g - v}$ $\Rightarrow t = 30 \ln \frac{3g - 18}{3g - v}$ $\Rightarrow t = 30 \ln \frac{3g - 18}{3g - v}$ (iii) Accelerating forces $\Rightarrow \frac{dv}{dt} = \frac{3g - v}{30}$ $\Rightarrow \frac{dv}{dt} = \frac{dv}{dt} = \frac{dv}{dt}$ $\Rightarrow \frac{dv}{dt} = \frac{dv}{dt}$	k	<i>z</i> = 20	A1	2	A1: Using an equation that leads to $k = 20$.
$ = 600g \times \frac{1}{10} - 20v $ $ \Rightarrow 600 \frac{dv}{dt} = 60g - 20v $ $ \Rightarrow \frac{dv}{dt} = \frac{g}{10} - \frac{v}{30} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{30} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{4i} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{30} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{4i} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{30} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{4i} $ $ \Rightarrow \frac{dv}{dt} = \frac{3g - v}{4$					AG
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weight in equation. Must see $\sin\theta$ of $\frac{dv}{dt} = 60g - 20v$ $\frac{dv}{dt} = \frac{g}{10} - \frac{v}{30}$ $\frac{dv}{dt} = \frac{3g-v}{30}$ A1: Use of $F = ma$ A1: Correct answer from correct we AG A2: Correct AHS. A1: Correct LHS. A1: Correct CHS. A1: Correct CHS. A1: Correct RHS. Condone missing constant. B1: Correct constant. (-2.4336 or AWRT -2.4 or -ln(11.4) or $e^c = \frac{5}{57}$; A1: Correct final answer. Accept $t = 30 \ln \frac{3g-18}{3g-v}$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$ A1: $t = 30 \ln \left(\frac{3g-18}{3g-v}\right)$	=	$= 600g \times \frac{1}{100} - 20v$	M1		M1: Resolving to find component of
$\frac{dv}{dt} = \frac{g}{10} - \frac{v}{30}$ $\frac{dv}{dt} = \frac{3g-v}{30}$ A1 3 A1: Correct answer from correct wo AG (ii) $\int \frac{dv}{3g-v} = \frac{1}{30} \int dt$ $-\ln (3g-v) = \frac{1}{30} t + c$ When $t = 0$, $v = 18 \Rightarrow c = -\ln (3g-18)$ $\frac{1}{30} t = \ln \frac{3g-18}{3g-v}$ $t = 30 \ln \frac{3g-18}{3g-v}$ A1 5 $\frac{1}{5} t = 30 \ln \left(\frac{57}{5(3g-v)}\right) \text{ or } t = -30 \ln \left(\frac{3g-18}{11.5}\right)$ (iii) When $v = 22 \Rightarrow t = 30 \ln \frac{3g-18}{3g-22}$ M1 M1: Substituting $v = 22$ (must be a exp term)		10			weight in equation. Must see $\sin \theta$ or $\times \frac{1}{10}$.
(ii) $\frac{dv}{dt} = \frac{3g-v}{30}$ A1 3 A1: Correct answer from correct work AG (iii) $\int \frac{dv}{3g-v} = \frac{1}{30} \int dt$ A1 A1: Correct answer from correct work AG M1: Separation of variables. A1: Correct LHS. A1: Correct LHS. A1: Correct LHS. A1: Correct RHS. Condone missing constant. B1: Correct constant. (-2.4336 or AWRT -2.4 or -ln(11.4) or $e^c = \frac{5}{57}$ and		$\rightarrow 600 \frac{dv}{dt} = 60g - 20v$	A 1		A1: Use of $F = ma$
(ii) $\int \frac{dv}{3g-v} = \frac{1}{30} \int dt$ $-\ln (3g-v) = \frac{1}{30} t + c$ When $t = 0$, $v = 18 \Rightarrow c = -\ln (3g-18)$ $t = 30 \ln \frac{3g-18}{3g-v}$ A1		$\frac{dv}{dt} = \frac{g}{10} - \frac{v}{30}$			
(ii) $\int \frac{dv}{3g-v} = \frac{1}{30} \int dt$ $-\ln (3g-v) = \frac{1}{30} t + c$ When $t = 0$, $v = 18 \Rightarrow c = -\ln (3g-18)$ $t = 30 \ln \frac{3g-18}{3g-v}$ $t = 30 \ln \frac{3g-18}{3g-v}$ A1 A1 A1 A1 A1 A1 A1 A1 A1: Correct LHS. A1: Correct RHS. Condone missing constant. B1: Correct constant. (-2.4336 or AWRT -2.4 or -\ln(11.4) or $e^c = \frac{5}{57}$) $e^{-c} = \frac{57}{5}$ A1: Correct final answer. Accept the angle of the constant that the con		$\frac{dv}{dt} = \frac{3g - v}{30}$	A 1	3	A1: Correct answer from correct working.
A1: Correct LHS. A1: Correct LHS. A1: Correct LHS. A1: Correct RHS. Condone missing constant. B1: Correct constant. (-2.4336 or AWRT -2.4 or -ln(11.4) or $e^c = \frac{5}{57}$) $e^{-c} = \frac{57}{5}$ A1: Correct final answer. Accept $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ $t = 30 \ln \left(\frac{57}{5(3g-v)}\right)$ $t = 30 \ln \left(\frac{57}{5(3g-v)}\right)$ $t = 73.008 - 30 \ln (3g-v)$ (iii) When $v = 22 \Rightarrow t = 30 \ln \frac{3g-18}{3g-22}$ M1 M1: Substituting $v = 22$ (must be a exp term)					
A1A1 When $t = 0$, $v = 18 \Rightarrow c = -\ln (3g - 18)$ B1 B1 B1 B1 B1 B1 B1 B		$\int \frac{dv}{3g-v} = \frac{1}{30} \int dt$	M1		
When $t = 0$, $v = 18 \Rightarrow c = -\ln (3g - 18)$ B1 Solution When $t = 0$, $v = 18 \Rightarrow c = -\ln (3g - 18)$ B1: Correct constant. (-2.4336 or AWRT -2.4 or -\ln(11.4) or $e^c = \frac{5}{57}$) $e^{-c} = \frac{57}{5}$ A1: Correct final answer. Accept $t = 30 \ln \left(\frac{11.4}{3g - v}\right)$ or $t = -30 \ln \left(\frac{3g - 18}{11.4}\right)$ A1 Solution When $v = 22 \Rightarrow t = 30 \ln \frac{3g - 18}{3g - 22}$ M1 M1: Substituting $v = 22$ (must be a exp term)		1. (2			
$\frac{1}{30}t = \ln \frac{3g-18}{3g-v}$ $t = 30 \ln \frac{3g-18}{3g-v}$ A1 5 $\frac{1}{5} = \ln \frac{3g-18}{3g-v}$ A1: Correct final answer. Accept the end of the end		$-\ln(3g - V) = \frac{1}{30}t + C$	A1A1		
A1 Substituting $v = 22 \Rightarrow t = 30 \ln \frac{3g-18}{3g-22}$ A1: Correct final answer. Accept $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-1}{11.4}\right)$ $t = 30 \ln \left(\frac{57}{5(3g-v)}\right)$ Oe Do not accept $t = 73.008 - 30 \ln (3g-v)$ M1: Substituting $v = 22$ (must be a exp term)	,	When $t = 0$, $v = 18 \implies c = -\ln (3g - 18)$	B1		_
t = 30 ln $\frac{3g-18}{3g-v}$ A1 $t = 30 \ln \frac{3g-18}{3g-v}$ A1: Correct final answer. Accept $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-11.4}{3g-v}\right)$ oe Do not accept $t = 73.008 - 30 \ln (3g-v)$ (iii) When $v = 22 \Rightarrow t = 30 \ln \frac{3g-18}{3g-22}$ M1 M1: Substituting $v = 22$ (must be a exp term)	-	$\frac{1}{30}t = \ln \frac{3g-18}{3g-n}$			
A1 5 $t = 30 \ln \left(\frac{11.4}{3g-v}\right)$ or $t = -30 \ln \left(\frac{3g-v}{11.4}\right)$ or $t = 30 \ln \left(\frac{57}{5(3g-v)}\right)$ oe Do not accept $t = 73.008 - 30 \ln (3g-v)$ (iii) M1: Substituting $v = 22$ (must be a exp term)					$e^{-c} = \frac{37}{5}$
(iii) $t = 30\ln\left(\frac{57}{5(3g-v)}\right) \text{ oe}$ $t = 73.008 - 30\ln(3g-v)$ $t = 73.008 - 30\ln(3g-v)$ $M1: \text{ Substituting } v = 22 \text{ (must be a exp term)}$	1	$t = 30 \ln \frac{s}{3g - v}$			
$t = 30\ln\left(\frac{57}{5(3g-v)}\right) \text{ oe}$ Do not accept $t = 73.008 - 30\ln(3g-v)$ (iii) When $v = 22 \Rightarrow t = 30 \ln\frac{3g-18}{3g-22}$ M1 M1: Substituting $v = 22$ (must be a exp term)			۸1	5	$t = 30\ln\left(\frac{11.4}{3g-v}\right) \text{ or } t = -30\ln\left(\frac{3g-v}{11.4}\right) \text{ or }$
(iii) $t = 73.008 - 30 \ln(3g - v)$ When $v = 22 \Rightarrow t = 30 \ln \frac{3g - 18}{3g - 22}$ M1 M1: Substituting $v = 22$ (must be a exp term)			AI	5	$t = 30\ln\left(\frac{57}{5(3g-v)}\right)$ oe
(iii) When $v = 22 \Rightarrow t = 30 \ln \frac{3g-18}{3g-22}$ M1 M1: Substituting $v = 22$ (must be a exp term)					Do not accept
When $v = 22 \Rightarrow t = 30 \ln \frac{3g-18}{3g-22}$ M1 M1: Substituting $v = 22$ (must be a exp term)					$t = 73.008 - 30\ln(3g - v)$
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$)				
	,	When $v = 22 \implies t = 30 \ln \frac{3g - 18}{3g - 22}$	M1		M1: Substituting $v = 22$ (must be a log or exp term)
		When <i>v</i> = 18 <i>t</i> =0	B1		B1: Using <i>v</i> = 18 when <i>t</i> =0. PI
Time taken is = 30 ln $\frac{3g-18}{3g-22}$	-	Time taken is = 30 ln $\frac{3g-18}{3g-22}$			
= 12.964 sec		= 12.964 sec			
= 13.0 sec A1 3 Condone 13	:	= 13.0 sec	A 1	3	Condone 13
Total 13		Total		13	

Q	Solution	Mark	Total	Comment
6 (a)	$T_A = \frac{mu^2}{a} - mg$	M1		M1: Resolving correctly at A or B.
	u u			
	$T_B = \frac{mv^2}{a} + mg$	A 1		A1: Correct T_A and T_B
	2			THE CONTOUT IA MILE IB
	$\frac{mu^2 - mag}{mv^2 + mag} = \frac{T_A}{T_B} = \frac{5}{7}$			
	$5v^2 + 5ag = 7u^2 - 7ag $ [1]			
	G . f F . 1 2 1 2 . 2	M1A1		M1: Use of conservation of energy.
	C of E; $\frac{1}{2}mv^2 = \frac{1}{2}mu^2 + 2mag$			Accept any height.
	$v^2 = u^2 + 4ag$			A1: Correct equation.
	Hence from [1]			n an action equation.
	$5u^2 + 25ag = 7u^2 - 7ag$			
		M1		M1: Any correct equation linking ag and u^2
	$32ag = 2u^2$			
	$u = 4\sqrt{ag}$	A 1	6	A1: Correct u . Accept $\sqrt{16ag}$
(b)	$v^2 = 20 \ ag$			
	$v = 2\sqrt{5ag}$	M1		M1: Correct v.
	, -	A1		A1: Any correct ratio in any correct form.
	Ratio u : v = 2: $\sqrt{5}$ or $2\sqrt{5}$: 5	A1	2	Do not accept decimals.
			-	
	Total		8	

Q	Solution	Mark	Total	Comment
7(a)	EPE in AC is zero.	B1		B1: Zero EPE implied for one string. Must
	EPE in BC is $\frac{240 \times 2^2}{6}$			be stated. B1: Shows how to obtain 160.
	= 160J		_	AG
	Total EPE is 160 J	B1	2	
(b)	$\frac{1}{2} \times 8v^2 + \text{EPE [of AC]} + \text{EPE [of BC]}$	M1		M1: Energy equation with correct KE and including 160 and at least one EPE.
	+ work done by friction = 160			
	Work done by friction = $8g\mu x$	B1		B1: Correct friction term.
	EPE of AC = $\frac{160 \times x^2}{4}$			
	$EPE \text{ of BC} = \frac{240 \times (2-x)^2}{6}$	B1		B1: Both EPEs correct.
	$4v^2 + \frac{160 \times x^2}{4} + \frac{240 \times (2-x)^2}{6} + 8g\mu x = 160$	A 1		A1: All terms correct with correct signs.
	$\begin{vmatrix} 4v^2 + 40x^2 + 40(4 - 4x + x^2) + \\ 8g\mu x = 160 \end{vmatrix}$			
	$v^2 = 40 \ x - 20x^2 - 2g\mu x$			
	$v = (40 x - 20x^2 - 2g\mu x)^{0.5}$	A1	5	A1: Correct expression for v .
(c)	Differentiation of any quadratic [wrt t or wrt x]	M1		M1: Derivative equated to zero.
	$2v\frac{dv}{dt} = \frac{dx}{dt}(40-40x-2g\mu)$ At max speed 40-40x-2g\mu = 0			A1: Correct expression.
	$x = 1 - \frac{g\mu}{20}$	A1		
	OR 20			
	Max speed of v is when $x = -\frac{b}{2a}$	(M1)		M1: Uses equal roots of a quadratic.
	$x = \frac{40 - 2g\mu}{2 \times 20} = 1 - \frac{g\mu}{20}$	(A1)		A1: Correct expression.
	OR (using forces) $160x 240(2-x)$	(M1)		M1: Correct equation for zero resultant
	$\frac{160x}{2} + 8g\mu = \frac{240(2-x)}{3}$ $x = 1 - \frac{g\mu}{20}$	(A1)		force. A1: Correct expression.
	T-1-1	0		
	Total	9	9	

Q	Solution	Mark	Total	Comment
8	7 / 5			
	D 30 R	B1		B1 for S clearly through the centre of hemisphere
	30 mg	B1		B1 for force at R clearly perpendicular to rod
	$PR = 2r\cos 30^{\circ} = \sqrt{3}r$	B1		B1: Correct length of PR.
	Resolving along the rod	М1		M1: Resolving to find <i>S</i> or <i>T</i> .
	$S\cos 30 = mg\sin 30$ $S = \frac{mg}{\sqrt{3}}$	A1		A1: Correct expression for <i>S</i> or <i>T</i> .
	Moments about <i>R</i> S. 2rcos30.sin30	M 1		M1: Taking moments about <i>P</i> or <i>R</i> . in terms of l, r or PR
	$= mg(2r\cos 30 - \frac{1}{2}l)\cos 30$	A 1		Note moments about <i>P</i> gives:
	$4rS\sin 30 = mg(4r\cos 30 - l)$			$T \times 2r\cos 30^{\circ} = mg \times \frac{l}{2}\cos 30^{\circ}$
				A1: Correct moment equation.
	$4r.\frac{mg}{\sqrt{3}}.\sin 30 = mg(4r\cos 30 - l)$			
	$\frac{2r}{\sqrt{3}} = 2\sqrt{3} \ r - l$	A 1		A1: Correct equation containing only <i>r</i> and <i>l</i> .
	$\frac{4r}{\sqrt{3}} = l$ $r = \frac{\sqrt{3}}{4}l$			
	$\left \begin{array}{ccc} I & -\frac{1}{4}l \end{array} \right $	A 1	9	A1: Correct expression for <i>r</i> .
	Total		9	