Version



General Certificate of Education (A-level) January 2013

Mathematics

MM2B

(Specification 6360)

Mechanics 2B

Final



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Key to mark scheme abbreviations

М	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
А	mark is dependent on M or m marks and is for accuracy
В	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
\sqrt{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 <i>x</i> 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)	$\mathrm{KE} = \frac{1}{2} \times 0.16 \times 11^2$	M1		
	= 9.68 J	A1	2	
(b)	Change in PE: $mgh = 0.16 \times 9.8 \times 5$ = 7.84 J	M1 41	2	
	- /.04 J	AI	2	
(c)(i)	KE when reached point <i>B</i>			
	= 9.68 - 7.84 J	M1	2	(a) (b)
	- 1.64 J	AI	2	cau
	Speed of ball is 1.84	M1		If added in $(c)(i)$ 0 marks for $(c)(i)$
(11)	$\sqrt{\frac{1}{2}} \times 0.16$	111		14.8 MTATIOI C(II)
	$= 4.7958 \text{ m s}^{-1}$			
	$= 4.80 \text{ m s}^{-1}$	A1	2	Condone 4.8,4.79
	Total		8	
2(a)	$\mathbf{a} = \frac{\mathbf{d}\mathbf{v}}{\mathbf{d}t}$	M1		
	$= 4 - \sin\left(\frac{\pi}{4}\right); 184;$			M1 for either term correct
	$-4\pi \sin\left(\frac{-1}{3}\right)^{1-18l}$	A 1	2	Accept $-12 \times \frac{\pi}{2} \sin\left(\frac{\pi}{2}t\right) \mathbf{i} - 18t\mathbf{j}$ condone
		AI	2	3 (3)
(b)(i)	Using $\mathbf{F} = \mathbf{w} \mathbf{e}$:			
(D)(I)	Using $\mathbf{r} - m\mathbf{a}$.			
	$\mathbf{F} = 4 \times \left[-4\pi \sin\left(\frac{\pi}{3}t\right)\mathbf{i} - 18t\mathbf{j} \right]$	M1		Or either term correct
	$\mathbf{F} = -16\pi \sin\left(\frac{\pi}{2}t\right)\mathbf{i} - 72t\mathbf{i}$	A 1	n	
	$\mathbf{F} = -100.5 \operatorname{m} \left(\frac{3}{3}t\right)\mathbf{F} = 72t\mathbf{j}$	AI	L	
(ii)	When $t = 3$ $\mathbf{F} = 4 \times [-4\pi \sin(\pi)\mathbf{i} - 54\mathbf{i}]$			
(11)	= -216j	B1		
	Magnitude is 216	B1ft	2	ft finding magnitude of their F
	$\mathbf{r} = \int \mathbf{v} dt$	M1		either term correct
(C)	$\mathbf{I} = \int \mathbf{V} \mathrm{d}t$	MII		
	$=\frac{36}{\sin}\sin\left(\frac{\pi}{t}\right)\mathbf{i}-3t^{3}\mathbf{j}+\mathbf{c}$. 1		No need for \mathbf{c} (otherwise cao)
	π (3)	AI		Condone $\frac{1}{(\pi/2)}$
	When $t = 3$, $\mathbf{r} = 4\mathbf{i} - 2\mathbf{j}$	M1		(73)
	$\rightarrow -81\mathbf{j} + \mathbf{c} = 4\mathbf{i} - 2\mathbf{j}$			
	$\begin{vmatrix} \mathbf{c} &= 4\mathbf{i} + \frac{1}{9}\mathbf{j} \\ (2\mathbf{c} & (\mathbf{c}) \end{pmatrix}$	Al		
	$ \mathbf{r} = \left\{ \frac{36}{-} \sin\left(\frac{\pi}{2}t\right) + 4 \right\} \mathbf{i} + \{79 - 3t^3\} \mathbf{j}$	A1	5	cao
			11	
	Total		11	

Q	Solution	Marks	Total	Comments
3	Force acting against gravity is $mg\sin\theta$ Force acting against gravity and resistance			Condone $\cos\theta$ or -1 for M marks
	is $mg\sin\theta + 8000$	M1		
	$= 1500 \times g \times \sin\theta + 8000$			
	= 8588 N or 8590 N	Al		
	Using power = force \times velocity			
	$= 8588 \times 22$	M1		
		dep		
	= 188 936 W	AÌ		
	= 189 kW	A1	5	Accept 188.9 or 188
	Total		5	
4 (a)	Symmetry	E1	1	
(b)	Moments about <i>AB</i> :			
	$300\sigma.15 + 100\sigma.5 + 300\sigma.15 = 700\sigma.x$	M1A1		(condone lack of σ)
	$r = \frac{9500}{1000}$			M1 needs correct total marks
	x - 700			
	95			
	$=\frac{1}{7}$ or 13.6 cm	A1	3	
	7			
(c)	Distance from HG is 16.4 cm	B 1		
(0)	15	DI		
	$\tan \theta = \frac{15}{16.42957}$	M1		Seeing both 15,16.4 and tan
	16.42857			
	= 0.913043			
	$\theta = 42.3974^{\circ}$	A1		
	$\theta = 42^{\circ}$			[48° probably B1, M1]
		A1	4	NB $\frac{13.6}{2}$ etc $\rightarrow 42^{\circ}$ no marks
	Total		8	

Q	Solution		Marks	Total	Comments
5(a)	Using F = ma:				
	$-4v^{\frac{1}{3}} = 12\frac{\mathrm{d}v}{\mathrm{d}t}$		B1		
	$\therefore \frac{\mathrm{d}v}{\mathrm{d}t} = -\frac{1}{3}v^{\frac{1}{3}}$				
	$-3\int \frac{\mathrm{d}v}{v^{\frac{1}{3}}} = \int \mathrm{d}t$		M1		condone –, 3 incorrect side
	$-3 \times \frac{v^{\frac{2}{3}}}{\frac{2}{3}} = t + c$		A1		condone lack of $+ c$
	$-\frac{9}{2}v^{\frac{2}{3}} = t + c$ When $t = 0, v = 8 \implies c = -18$ $-\frac{9}{2}v^{\frac{2}{3}} = t - 18$		M1A1		
	$v^{\frac{2}{3}} = 4 - \frac{2}{9}t$ $v = \left(4 - \frac{2}{9}t\right)^{\frac{3}{2}}$		A1	6	
(b)	Particle is at rest when $4 - \frac{2}{9}t = 0$				
	The value of <i>t</i> is 18	F ()	B1	1	
6(a)	Resolve vertically:	lotal		1	
U(a)	$T \cos \theta = mg$ $34 \cos \theta = 2 \times 9.8$ $\cos \theta = \frac{19.6}{24}$		M1 A1		M1 for $T\cos\theta$ or $T\sin\theta$ and mg
	$\theta = 54.8^{\circ}$		A1	3	
(b)	Resolve horizontally for particle:				
	$\frac{mv^2}{r} = T\sin\theta$		M1		M1 for $T\cos\theta$ or $T\sin\theta$
	$v^2 = \frac{34\sin 54.8 \times 0.8}{2}$		A1 ft from (a)		
	$v^2 = 11.113$ Speed is 3.33 m s ⁻¹		A1	3	Accept 3.34
(c)	Time taken is $2\pi r / v$		M1		Or find ω and use $\frac{2\pi}{\omega}$
	= 1.51 sec		A1ft	2	
]	Fotal		8	

Q	Solution	Marks	Total	Comments
7(a)	Using conservation of energy:			
	$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 - mgh$	M1		for 3 terms, 2 KE and 1 PE
	$\frac{1}{2} \times 3 \times v^{2} = \frac{1}{2} \times 3 \times 4^{2} - 3 \times g \times 1.2 (1 - \cos 25)$	M1 A1		M1A1 for finding h [M1 for 1.2(1 - cos 25 or sin 25)]
	$v^2 = 4^2 - 2.4 \times g(1 - \cos 25)$			
	$v^2 = 16 - 2.2036$			
	$v = 3.71 \mathrm{ms^{-1}}$	A1	4	Accept 3.7, 3.70, 3.72
(b)	Resolving radially:			
	$T = mg \cos 25 + \frac{mv^2}{a}$	M1A1		M1 accept $\cos 25 \text{ or } \sin 25$, + or - sign and $\neq 2$
	= 26.645 + 34.491			A1 fully correct and substituted
	= 61.1 N	A1	3	Accept 61.0 or 61
	Total		7	

$ \begin{aligned} \mathbf{S}(\mathbf{a}) & \text{Work done} = \int_{0}^{L} \frac{\lambda x}{l} d\mathbf{x} & \text{MI} \\ & = \left[\frac{\lambda x^2}{2l} \right]_{0}^{T} & \text{AI} \\ & = \frac{\lambda x^2}{2l} & \text{AI} & \text{SCI} \int_{0}^{L} \frac{\lambda x}{l} d\mathbf{x} & \text{with no limits} \\ & = \frac{\lambda x^2}{2l} & \text{AI} & \text{3} \\ \end{aligned} $ $ \begin{aligned} \mathbf{(b)(i)} & \text{Using } T = \frac{\lambda x}{l} : & \text{SGI} & \frac{1}{2} \frac{\lambda x}{r} d\mathbf{x} & \text{with no limits} \\ & = \frac{\lambda x^2}{l} & \text{AI} & \text{3} \\ & \text{Sg} = \frac{392x}{16} & \text{MI} \\ & x = \frac{5g \times 1.6}{332} & \text{AI} & 2 \\ & \text{Extension is 0.2 m} & \text{AI} & 2 \\ & \text{(ii)} & \text{When extension is 0.6 m, EPE} = \frac{\lambda x^2}{2l} & \text{BI} \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} & \text{MI} \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} & \text{MI} \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} & \text{AI} & 3 \\ \end{aligned} $ $ \begin{aligned} \text{MI AI terms, 2 correct} \\ & \text{MIAI 4 terms, 3 correct} \\ & \text{MIAI 4 terms correct} \\ & \text{Ftanswer to (b)(ii)} \\ \end{aligned} $ $ \begin{aligned} \text{MI 4 terms correct} \\ & \text{Ftanswer to (b)(ii)} \\ \end{aligned} $	Q	Solution	Marks	Total	Comments
$ \begin{vmatrix} x^{2} \\ z \\ $	8 (a)	Work done = $\int_{0}^{e} \frac{\lambda x}{l} dx$	M1		SC1 $\int_{0}^{e} \frac{\lambda e}{l} de$
$ \begin{array}{ c c c c c c c c } & = \frac{\lambda e^2}{2l} & & A1 & 3 \\ \hline & & & \\ & $		$= \left[\frac{\lambda x^2}{2l}\right]_0^e$	A1		SC1 $\int \frac{\lambda x}{l} dx$ with no limits
(b)(i) Using $T = \frac{\lambda x}{l}$; $5g = \frac{392x}{1.6}$ $x = \frac{5g \times 1.6}{392}$ = 0.2 Extension is 0.6 m, EPE $= \frac{\lambda x^2}{2l}$ B1 $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ M1 = 44.1 J A1 3 (ii) Let y metres be distance particle is above A. C of energy, when particle has speed 0.8 m s^3 , gives $5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2}$ M1A1 $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ A1F $49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2$ $49y - 147y + 122.5y^2 + 1.6 = 0$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 12.5}$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{243}$ A1 Speed first becomes 0.8 when $y = 0.0167$ E1 5 Total Total Table A1 A1		$= \frac{\lambda e^2}{2l}$	A1	3	
$\begin{aligned} & 5g = \frac{392.6}{392} \\ & x = \frac{5g \times 1.6}{392} \\ & = 0.2 \\ & Extension is 0.2 m \end{aligned} \qquad M1 \\ & & A1 \qquad 2 \end{aligned}$ (ii) When extension is 0.6 m, EPE = $\frac{2x^2}{2I}$ B1 $& = \frac{392 \times (0.6)^2}{2 \times 1.6} \\ & = 44.1 J \end{aligned} \qquad M1 \\ & A1 \qquad 3 \end{aligned}$ (iii) Let y metres be distance particle is above $\frac{A}{A}$. C of energy, when particle has speed 0.8 m s^{-1} , gives $5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2 \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} \end{aligned} \qquad M1A1 \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} \end{aligned} \qquad M1A1 \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} \\ & = \frac{392 \times (0.6)^2}{2 \times 1.6} \\ & y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5 \times 1.6} \\ & y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5} \\ & y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5} \\ & y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5} \\ & y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5} \\ & x = 0.016674 \text{ and } 0.7833 \\ & A1 \end{aligned} \qquad \text{if } x \text{ used instead of } 0.6 - y, \text{ A1 here for } x = 0.5833 \end{aligned}$	(b)(i)	Using $T = \frac{\lambda x}{l}$:			
$\begin{aligned} x &= \frac{28 \pm 100}{392} \\ &= 0.2 \\ \text{Extension is } 0.2 \text{ m} \\ \text{(ii)} \end{aligned} \qquad $		$5g = \frac{392x}{1.6}$	M1		
Extension is 0.2 m A1 2 (ii) When extension is 0.6 m , $EPE = \frac{\lambda x^2}{2l}$ B1 B1 B1 for 0.6 = $\frac{392 \times (0.6)^2}{2 \times 1.6}$ M1 A1 3 (iii) Let y metres be distance particle is above A. C of energy, when particle has speed 0.8 m s^- , gives M1A1 3 5 × g × y $\frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$ M1A1 A1F M1A1 4 terms, 2 correct M1A2 4 terms correct Ft answer to (b)(ii) 49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2 M1A1 A1F M1A2 4 terms correct Ft answer to (b)(ii) $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 if x used instead of $0.6 - y$, A1 here for $x = 0.5833$ Speed first becomes 0.8 when $y = 0.0167$ E1 5 Total 13		$x = \frac{38 \times 1.0}{392}$ $= 0.2$			
(ii) When extension is 0.6 m, EPE = $\frac{Ax^2}{2I}$ B1 = $\frac{392 \times (0.6)^2}{2 \times 1.6}$ M1 = 44.1 J A1 3 (iii) Let y metres be distance particle is above A. C of energy, when particle has speed 0.8 m s ⁻¹ , gives $5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$ M1A1 = $\frac{392 \times (0.6)^2}{2 \times 1.6}$ A1F $\frac{392 \times (0.6 - y)^2}{2 \times 1.6} + 1.6 = 122.5 \times 0.6^2$ A1F $\frac{49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2}{122.5y^2 - 98y + 1.6 = 0}$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ A1 $y = \frac{12}{2 \times 12.5}$ A1 $y = \frac{12}{2 \times 12$		Extension is 0.2 m	A1	2	
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	(ii)	When extension is 0.6 m, EPE = $\frac{\lambda x^2}{2l}$	B1		B1 for 0.6
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$		$= \frac{392 \times (0.6)^2}{2 \times 1.6}$	M1	2	
(iii) Let y metres be distance particle is above A. C of energy, when particle has speed 0.8 m s^{-1} , gives $5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$ $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ 414 terms, 2 correct M1A1 4 terms, 3 correct M1A2 4 terms correct Ft answer to (b)(ii) $49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2$ $49y - 147y + 122.5y^2 + 1.6 = 0$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ g = 0.016674 and 0.7833 A1 if x used instead of 0.6 - y, A1 here for x = 0.5833 Speed first becomes 0.8 when $y = 0.0167$ E1 5		= 44.1 J	Al	3	
C of energy, when particle has speed 0.8 m s^{-1} , gives $5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$ $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ M1A1 $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ A1F $49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2$ $49y - 147y + 122.5y^2 + 1.6 = 0$ $122.5y^2 - 98y + 1.6 = 0$ A1F $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm 93.9148}{245}$ = 0.016674 and 0.7833 A1 if x used instead of $0.6 - y$, A1 here for x = 0.5833 Speed first becomes 0.8 when $y = 0.0167$ E1 5 5	(iii)	Let y metres be distance particle is above A .			
$5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$ $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ $41F$ $= \frac{392 \times (0.6)^2}{2 \times 1.6}$ $A1F$ $A1F$ $A1F$ $A1F$ $A1F$ $y = \frac{98 \pm (0.6)^2 + 1.6 = 122.5 \times 0.6^2}{49y - 147y + 122.5y^2 + 1.6 = 0}$ $122.5y^2 - 98y + 1.6 = 0$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm 93.9148}{245}$ $= 0.016674 \text{ and } 0.7833$ $A1$ $if x used instead of 0.6 - y, A1 here for x = 0.5833$ $Speed first becomes 0.8 \text{ when } y = 0.0167$ $E1$ 5		C of energy, when particle has speed 0.8 m s^{-1} , gives			
$= \frac{392 \times (0.6)^2}{2 \times 1.6}$ A1F $49y + 122.5(0.6 - y)^2 + 1.6 = 122.5 \times 0.6^2$ A1F $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm 93.9148}{245}$ $= 0.016674 \text{ and } 0.7833$ A1 if x used instead of $0.6 - y$, A1 here for $x = 0.5833$ Speed first becomes 0.8 when $y = 0.0167$ E1 5		$5 \times g \times y + \frac{392 \times (0.6 - y)^2}{2 \times 1.6} + \frac{1}{2} \times 5 \times 0.8^2$	M1A1		M1 4 terms, 2 correct M1A1 4 terms, 3 correct M1A2 4 terms correct
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		$=\frac{392\times(0.6)^2}{2\times1.6}$	A1F		Ft answer to (b)(ii)
$y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$ $y = \frac{98 \pm 93.9148}{245}$ $= 0.016674 \text{ and } 0.7833$ A1 if x used instead of $0.6 - y$, A1 here for $x = 0.5833$ Speed first becomes 0.8 when $y = 0.0167$ E1 5 Total 13		$49y + 122.5(0.6 - y)^{2} + 1.6 = 122.5 \times 0.6^{2}$ $49y - 147y + 122.5y^{2} + 1.6 = 0$ $122.5y^{2} - 98y + 1.6 = 0$			
$y = \frac{98 \pm 93.9148}{245}$ = 0.016674 and 0.7833 Speed first becomes 0.8 when y = 0.0167 E1 5 Total 13		$y = \frac{98 \pm \sqrt{98^2 - 4 \times 122.5 \times 1.6}}{2 \times 122.5}$			
245 = 0.016674 and 0.7833 A1 if x used instead of $0.6 - y$, A1 here for $x = 0.5833$ Speed first becomes 0.8 when $y = 0.0167$ E1 5 Total 13		$y = \frac{98 \pm 93.9148}{2}$			
Speed first becomes 0.8 when $y = 0.0167$ E15Total13		245 = 0.016674 and 0.7833	A1		if x used instead of $0.6 - y$, A1 here for $x = 0.5833$
Speed first becomes 0.8 when $y = 0.0167$ E15Total13		Smood first has a second secon	D 1	E	
		Speed first becomes 0.8 when $y = 0.0167$ Total	El	3 13	

Q	Solution	Marks	Total	Comments
9(a)	Smooth, hence reaction is perpendicular	E1	1	
	to possible movement			
(b)				
	h			
	R	\backslash /	a	
		\mathbf{V}	S	
		/ `	\backslash	
	/		\backslash	В
			X	
	θ	- /	,	
	A			
		∎ mg		
		B2	2	B1 for 2 forces correct
(c)	Resolving along the rod:			Or geometrically:
	resorving along the rod.			
	$S\cos\theta = mg\sin\theta$	M1A1		three forces act through a point B1 M1 is for 2 or 3 terms: 1 term correct
				(could be horizontal force at C used)
	Moment about C: $S 2a\cos\theta .\sin\theta$			[forces act through point D]
	$= mg(2a\cos\theta - \frac{1}{2}l)\cos\theta$	MIAI		$4D\cos 2\theta = \frac{l}{\cos \theta}$ M1A1
		WIIAI		$\frac{1000320}{2}$
	$4a.S\sin\theta = mg(4a\cos\theta - l)$			$AD\cos\theta = 2a\cos\theta$ M1
	Dividing: $4a \tan \theta = \frac{4a \cos \theta - l}{\sin \theta}$			$l = \frac{4a\cos 2\theta}{\cos \theta} \text{A1}$
	$l = 4a\cos\theta - 4a\sin\theta\tan\theta$			0.50
	$l = \frac{4a\cos 2\theta}{2}$	A1	5	
	$\cos heta$			

Q	Solution	Marks	Total	Comments
9 cont	or			
	Resolving perpendicular to S: $R \cos\theta = mg \cos 2\theta$	(M1A1)		
	Moments about A:			
	$R \ 2a\cos\theta = mg \pm l \cos\theta$	(MIAI)		
	$4a R = mgl$ $4amg \cos 2\theta = mgl \cos \theta$ $l = \frac{4a \cos 2\theta}{\cos \theta}$ or	(A1)		
	01			
	Resolving horizontally: $R \sin \theta = S \cos 2\theta$ Resolving vertically: $R \cos \theta + S \sin 2\theta = mg$	(M1A1)		Both attempted for M1 Both correct for A1
	Moments about 4:			
	$R \ 2a\cos\theta = mg \frac{1}{2} \ l \cos\theta$	(M1A1)		
	4a R = mgl			
	$R\cos\theta + R\frac{\sin\theta}{\cos 2\theta}\sin 2\theta = 4a\frac{R}{l}$			
	$l = \frac{4a\cos 2\theta}{\cos \theta}$	(A1)		
	Total		8	
	TOTAL		75	