A-Level

Mathematics

MM2B Mechanics 2B

Final Mark scheme

6360

June 2017

Version/Stage: v1.0

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.

Further copies of this mark scheme are available from aqa.org.uk

Copyright © 2017 AQA and its licensors. All rights reserved.
AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Annotations

Annotation	Description
^	Omission mark
A1	Accuracy mark awarded one
B1	Independent mark one
BOD	Benefit of the doubt
Cross	Incorrect point
FT	Follow through
H Wavy	Dynamic, Horizontal Wavy line that can be expanded
Highlight	Highlight
ISW	Ignore subsequent work
M1	Method mark awarded one
Not Relevant	Not Relevant
Text Box	On Page Comment
SC	Special case
SEEN	Indicates that the point has been noted, but no credit has been given.
Tick	Correct point
?	Unclear
FIW	From Incorrect Work

Q	Solution	Mark	Total	Comment
1 (a)	Initial KE is $\frac{1}{2} \times 3 \times 12^2$	M1		Correct terms
	= 216 J	A1	2	CAO
(b)	KE = Initial KE + loss in PE	M1		Sum of (a) and a PE term
	= 216 + 3 × g × 50	B1		Correct PE
	= 1686			
	= 1690 J	A1	3	CAO (Accept 1686 or 1690) Do not award for 1687 or 1687.5 or 1688 These are from g = 9.81
(c)	Speed of stone is $\sqrt{\frac{1686}{\frac{1}{2}\times 3}}$	M1		Their b or 1690 used Correct expression for speed
	= 33.526.. ms $^{-1}$			
	= 33.5 ms $^{-1}$	A1ft	2	AWFW [33.5 and 33.6]
	Total		**7**	

Q	Solution	Mark	Total	Comment
2				
(a) (i)	a = $12t^2 - 12\cos 4t$	M1A1	2	M1 one term correct A1 all correct
(ii)	a = $12\left(\frac{\pi}{4}\right)^2 - 12\cos\pi$	M1		Substitution of $\frac{\pi}{4}$ for t with at least one term correct
	= $\frac{3\pi^2}{4} + 12$			
	= 19.4 ms^{-2}	A1	2	CAO [Accept exact form]
(b)	r = $\int v\, dt$			
	= $t^4 + \frac{3}{4}cos4t + 8t + c$	M1A1		M1 two [non c] terms correct A1 does not need c; other 3 terms correct
	When t =0, r = 0, $\therefore c = -\frac{3}{4}$	m1m1		m1 for any use of t=0, r=0 m1 for any value of c found [not 0]
	r = $t^4 + \frac{3}{4}\cos 4t + 8t - \frac{3}{4}$	A1	5	CAO
	Total		**9**	

Q	Solution	Mark	Total	Comment
3	Resolving horizontally $F = S$	B1		
	Resolving vertically $R = 15g + 70g$ $= 85g$	B1		
	$S = \mu R = 25.5$ g	B1		
	Moments about A $3.5\times15g\times\cos\theta + 4\times70g\times\cos\theta = S\times7\sin\theta$	M1A1		M1 3 terms, at least 2 correct If 4 terms at least 3 correct
	$\text{Tan}\ \theta = \frac{332.5}{178.5}$			
	$\theta = 61.77..$			
	$= 61.8^\circ$	A1		
				If no g included 4 marks awarded If reaction at the wall is perp to the ladder could get M1 A1 only
			6	
	Total		**6**	

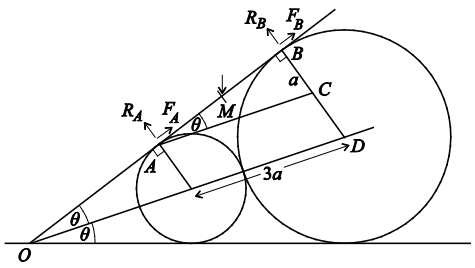
Q	Solution	Mark	Total	Comment
4 (a)	Resolve vertically at P $T_{BP}\cos 20 + T_{AP}\cos 40 = 6g$	M1 A1		M1 for 3 terms 2 correct A1 fully correct equation
	$T_{AP}\cos 40 = 6g - 28.19$ $T_{AP} = 39.957..$ $= 40.0$ N	A1	3	
(b)	Resolve horizontally at P $\frac{mv^2}{r} = T_{BP}\sin 20 + T_{AP}\sin 40$	M1A1		M1 for 3 terms 2 correct A1 fully correct equation
	$\frac{6\times64}{r} = 30\sin20 + 39.958\sin40$	A1ft		
	$r = \frac{384}{35.945}$ $= 10.68..$ $= 10.7$	A1	4	
	Total		**7**	

Q	Solution	Mark	Total	Comment
5 (a)	Power = F × v = (40 × 45) × 45 = 81 000 watts	M1 A1	 2	
(b)	Accelerating force = $\frac{81000}{30}$ – 40 × 30 = 1500 F = ma → 1600a = 1500 a = $\frac{15}{16} ms^{-2}$ [or 0.9375]	M1 A1	 2	If only one term on RHS 0 marks for (b)
(c)	At 55ms^{-1}, Resistance force = engine force + gravitational force 40 × 55 = $\frac{81000}{55}$ + 1600 g sin θ 1600 g sin θ = 2200 – 1472.7.. Sin θ = $\frac{727.27}{1600g}$ θ = 2.66°	 M1 A1A1 A1	 4	 Must be correct 3 terms with correct signs A1 for 2 correct terms; A1 for all correct Accept 0.0464 radians
	Total		**8**	

Q	Solution	Mark	Total	Comment
6	At A, $\frac{1}{2}mv^2 = \frac{1}{2}mU^2 + mg4\,(1-\cos\theta)$	M1A1		M1 for at least 3terms correct [seen] A1 for all correct
	When particle leaves the surface, Resolving in direction OA			
	$\frac{mv^2}{4} = mg\cos\theta$ $v^2 = 4g\cos\theta$	M1		Do not accept $\sin\theta$
	$\frac{1}{2}U^2 + 4g\,(1-\cos\theta) = \frac{1}{2}.\,4g\cos\theta$	m1A1		M1 for substituting their v^2 into their energy equation A1 for all correct
	$U^2 = -8g + 12g\cos\theta$ $= 12g\cos 35 - 8g$ $= 1.8298g$	A1		
	$U = 4.2346$ $= 4.23\ ms^{-1}$	A1	7	
	Total		**7**	

Q	Solution	Mark	Total	Comment
7 (a)	$450\frac{dv}{dt} = 600 - 90v$ $-15\frac{dv}{dt} = 3v - 20$ $\frac{dv}{dt} = -\frac{3v-20}{15}$	B1	1	Needs mass being considered
(b)	$\int \frac{dv}{3v-20} = -\int \frac{dt}{15}$	M1		
	$\frac{1}{3}\ln(3v\text{-}20) = -\frac{1}{15}t + c$	A1A1		A1 for each side correct [do not need c]
	$\ln(3v\text{-}20) = -\frac{1}{5}t + c_1$	M1		M1 for using exponentials
	$3v - 20 = Ce^{-\frac{1}{5}t}$ $v = 15$ when $t = 0$, $C = 25$	m1		M1 for attempting to find c or c_1 or C
	$v = \frac{1}{3}(20 + 25\,e^{-\frac{1}{5}t})$	A1	6	
(c)	When $v = 10$, $10 = 25\,e^{-\frac{1}{5}t}$	M1		Attempt at substitution v = 10
	$e^{-\frac{1}{5}t} = 0.4$ $t = 4.58$	A1	2	Accept 5 ln2.5 or -5ln0.4 oe
	Total		**9**	

Q	Solution	Mark	Total	Comment
8 (a)	Word done in stretching string is $\int T\mathrm{d}x$ $= \int_0^e \frac{\lambda x}{l} dx$	M1		
	$= [\ \lambda \frac{x^2}{2l}\ ]$	A1		Correct integral could be in e
	$= \frac{\lambda e^2}{2l} - 0$ $= \frac{\lambda e^2}{2l}$	A1	3	A1 not given unless limits and dx on line 2 and use of dx not de
(b)(i)	Using $T = \frac{\lambda x}{l} = mg$ $10g = \frac{250x}{0.8}$	M1		
	$x = \frac{8g}{250}$ $= 0.3136$	A1	2	Accept 0.314 or 0.3136
(ii)	EPE at $P = \frac{250\times0.6^2}{1.6}$	M1	2	
	$= 56.25$	A1		Accept 56.3
(iii)	Let particle be at Q when it is x m above P EPE at P = change in PE + KE[at Q] + EPE[at Q]	B1 B1 B1		B1 for PE B1 for KE B1 for correct EPE
	$= mgx + \frac{1}{2}mv^2 + \frac{250\times(0.6-x)^2}{1.6}$ $56.25 = 10gx + 5v^2 + 156.25(0.6-x)^2$ $225 = 40gx + 20v^2 + 625(0.6-x)^2$ $225 = 40gx + 20v^2 + 225 - 750x + 625x^2$ $20v^2 = 358x - 625x^2$	M1 A1	5	M1 for correct equation Correct equation from correct working
(iv)	When particle comes to rest v = 0 in $20v^2 = 358x - 625x^2$	M1		
	$x = 0.5728$	A1	2	Accept 0.573
	Total		**14**	

Q	Solution	Mark	Total	Comment
9				
(a)	Using triangle *OBD*; this is similar to triangle *ABC*; Thus $\sin\theta = \frac{a}{3a} \rightarrow \sin\theta = \frac{1}{3}$ $\cos\theta = \frac{2\sqrt{2}}{3}$ $\sin 2\theta = 2\,sin\theta cos\theta$ $= 2 \times \frac{1}{3} \times \frac{2\sqrt{2}}{3}$ $= \frac{4\sqrt{2}}{9}$	M1 A1	2	

(b)	Moments about centre of rod gives $R_A . \frac{1}{2} AB = R_B . \frac{1}{2} AB$ $R_A = R_B$ Or moments about A $W \cos 2\theta . \frac{1}{2} AB = R_B . AB$ $R_B = \frac{1}{2} W \cos 2\theta$ Moments about B gives $R_A = \frac{1}{2} W \cos 2\theta$ Resolving horizontally $R_A \sin 2\theta + R_B \sin 2\theta = F_A \cos 2\theta + F_B \cos 2\theta$ Using $F = \mu R$ $R_A \sin 2\theta + R_B \sin 2\theta = 2\mu R_A \cos 2\theta + \mu R_B \cos 2\theta$ [or $2R \sin 2\theta = 3\mu R \cos 2\theta$ if seen the reactions are the same] $3\mu R = 2R \tan 2\theta$ $\mu = \frac{2}{3} \tan 2\theta$ $= \frac{2}{3} \times \frac{4\sqrt{2}}{7}$ $= \frac{8\sqrt{2}}{21}$	M1 A1 (M1) (A1) M1 A1 B1 A1	6	Could omit lengths Resolve along rod $F_A + F_B = mg\sin 2\theta$ Resolve perp to rod $R_A + R_B = mg \cos 2\theta$ **Summary** Moments give M1A1 [no more marks for second moments] Resolving correct M1A1 [no more marks however many times resolved] Using $F = \mu R$ B1 Answer A1
	Total	**8**	**8**	