A-LEVEL
MATHEMATICS

Mechanics 2B – MM2B
Mark scheme

6360
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Version/Stage: Final 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

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	Mark	Total	Comment
1 (a)	KE = $\frac{1}{2}\times 3\times 8^2$	M1		
	= 96 J	A1	2	
(b)	Change in PE;			
	mgh = 3 × 9.8 × 13	M1		
	= 382.2 J	A1	2	
	= 382 J			SC1 380
(c)(i)	Salmon's KE when it reaches the sea			(a) + (b)
	= 96 + 382.2J	M1		[both non zero]
	= 478 J	A1	2	Ft [one correct]
(ii)	Speed of salmon is $\sqrt{\frac{478.2}{\frac{1}{2}\times 3}}$	M1		
	= 17.8549 ms^{-1}			
	= 17.9 ms^{-1}	A1	2	Accept 17.8,17.85,17.855, 17.86
	Total		**8**	

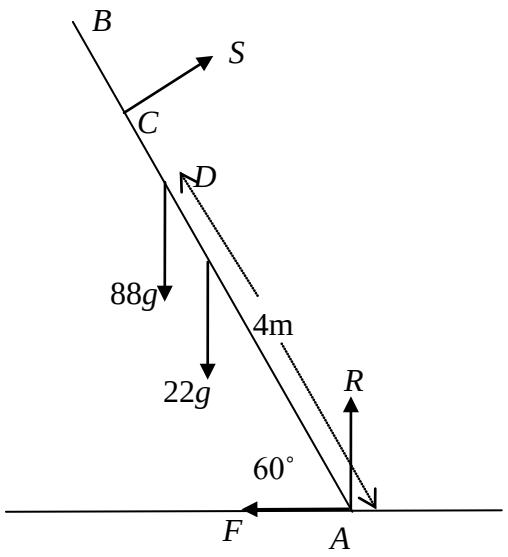
Q	Solution	Mark	Total	Comment
2 (a)	Using $F = ma$	M1		M1 either term correct oe
	$\boldsymbol{a} = 4e^{-2t}\,\mathbf{i} - 2t^3\mathbf{j}$	A1	2	
(b)	$v = \int a\,dt$	M1		M1 for either term correct
	$= -2\,e^{-2t}\,\mathbf{i} - \frac{1}{2}t^4\mathbf{j} + \mathbf{c}$	A1		Ft from (a) oe Condone no + **c**
	When t = 0, $-7\mathbf{i} - 4\mathbf{j} = -2\,\mathbf{i} + \mathbf{c}$	m1		
	$\mathbf{c} = -5\,\mathbf{i} - 4\,\mathbf{j}$			
	$\mathbf{v} = -(2\,e^{-2t} + 5)\mathbf{i} - (\frac{1}{2}t^4 + 4)\mathbf{j}$	A1	4	CAO
(c)	When $t = 0.5$,			
	$\mathbf{v} = -(2\,e^{-1} + 5)\mathbf{i} - (\frac{1}{2} \times 0.5^4 + 4)\mathbf{j}$	M1A1		
	$= -5.7357\mathbf{i} - 4.03125\,\mathbf{j}$			
	Speed is $\sqrt{5.736^2 + 4.031^2}$	M1		
	= 7.0106...	A1	4	
	or 7.01 ms^{-1}			MR A0 in (a) and last part of (c) Do not accept 7
	Total		**10**	

Q	Solution	Mark	Total	Comment
3	$\overline{X} = \frac{4\times11+3\times3+7\times5+1\times1+5\times7}{4+3+7+1+5}$	M1		M1 for at least 4 correct
	$= \frac{124}{20}$ or 6.2	A1		Accept $\frac{124}{20}$
	$\overline{Y} = \frac{4\times2+3\times6+7\times9+1\times4+5\times6}{20}$	M1		
	$= \frac{123}{20}$ or 6.15	A1		
	∴ Centre of mass is at (6.2, 6.15)	A1ft	5	Do not accept $\frac{124}{20}$ etc (6.15,6.2)M2A2 If lamina not used SC2; ie M1,M1
	Total		**5**	

Q	Solution	Mark	Total	Comment
4 (a)	20 revolutions per minute = 40π radians per minute	B1		or $\frac{1}{3}$ revolutions per second
	= $\frac{2\pi}{3}$ radians per second	B1	2	Accept 2.09
(b)	Resolve vertically $T\cos 35 = 0.8g$	M1 A1		M1 if Tsin35 used; need g
	T= 9.5708… = 9.57 N	A1	3	
(c)	Resolve horizontally $T \sin 35 = m\omega^2 r$	M1		M1 condone Tcos35 and $m\frac{v^2}{r}$
	$9.57 \sin 35 = 0.8 \times r \times \left(\frac{2\pi}{3}\right)^2$	A1 A1		A1 for either side
	r = 1.564… Radius is 1.56 m	A1	4	Condone 1.57
	Total		**9**	

Q	Solution	Mark	Total	Comment
5 (a)	Using conservation of energy :			
	$\frac{1}{2}mv_P^2 = \frac{1}{2}mv_Q^2 + 2amg$	M1 A1		M1 for 3 [or 4] terms 2 KE and 1[or 2] PE
	$v_Q^2 = 49ag - 4ag$	M1		
	$v_Q^2 = 45ag$			
	$v_Q = \sqrt{45ag}$	A1	4	$v_Q = 3\sqrt{5ag}$
(b)	At Q, T + mg = $\frac{mv_Q^2}{a}$	M1A1		M1 for correct 3 terms
	T = m. 45 g – mg = 44mg	A1	3	
	Total		**7**	

Q	Solution	Mark	Total	Comment
6 (a)	Using F = ma			
	$-0.3mv^{\frac{1}{3}} = m\frac{dv}{dt}$			
	$\therefore \frac{dv}{dt} = -0.3v^{\frac{1}{3}}$	B1		Need substitution for a
	$\int v^{-\frac{1}{3}}dv = -\int 0.3dt$	M1		
	$\frac{3}{2}v^{\frac{2}{3}} = -0.3\,t + c$	A1A1		A1 for each side no – sign [B0] could get M1A1
	When $t = 0$, $v = 8$,			
	$\therefore c = 6$	A1		
	$\frac{3}{2}v^{\frac{2}{3}} = -0.3\,t + 6$			
	$v^{\frac{2}{3}} = -0.2\,t + 4$			
	$v = (4-0.2t)^{\frac{3}{2}}$	A1	6	
(b)	When $v = 0$, $4 - 0.2\,t = 0$	M1		
	$t = 20$	A1	2	
(c)				
	Integrating $v = (4-0.2t)^{\frac{3}{2}}$,			
	$x = -2(4-0.2t)^{\frac{5}{2}} + d$	M1A1		M1 for power of 5/2 A1 correct [condone no d]
	When t = 0 , x = 0, $\Rightarrow d = 64$			
	$x = -2(4-0.2t)^{\frac{5}{2}} + 64$	A1		
	When speed is 0 ms^{-1}, $t = 20$	M1		
	$x = 64$	A1	5	
	Total		**13**	

Q	Solution	Mark	Total	Comment
7(a)		B2	2	Need 5 forces correct ignore labels B1 for 4 forces correct
(b)	Resolve horizontally F = S cos 30	B1		
	Resolve vertically R = 88g + 22g – S sin 30	B1		
	Moments about A 22g . 3 cos 60 + 88g. 4 cos 60 = 5 S 5S = 209g	M1		M1 for correct moments about any point Resolve once B1 moments twice is M1A1, B1
	S = 41.8g [409.64]	A1		
	Using F = μR; S cos 30 = μ(110g – S sin 30)	M1		R =873.18 F =354.758
	$\mu = \frac{S\sqrt{3}}{220g-S}$ $= \frac{41.8\sqrt{3}}{220-41.8}$ $= \frac{41.8\sqrt{3}}{178.2}$ $= \frac{19\sqrt{3}}{81} = 0.406$	A1	6	Accept 0.407, 0.4063..,0.41 not 0.4
	If S is horizontal, B1 in (a) In (b) M1 [moments], M1 for friction,B1 [2 resolve] 0.439 SC3			
	Total		**8**	

Q	Solution	Mark	Total	Comment
8 (a)	Resolve perpendicular to plane			
	$R = mg\cos 20$	M1		
	$F = \mu R = \mu mg\cos 20$	m1		
	$= 0.8 \times 4 \times g\cos 20$			or 0.8 x 36.8359
	$= 29.468..$	A1	3	
	$= 29.5$ N			
(b)(i)	As particle moves from C to B; Constant friction acts.			
	Work done by friction is $(x + 2) \times 29.468$	B1		
	Change in PE is $mg(x+2)\sin 20$	B1		
	Initial EPE $= \frac{\lambda x^2}{2l}$			
	$= \frac{120\times(x-1.5)^2}{2\times1.5}$			
	$= 40\,(x - 1.5)^2$	B1		
	Final EPE $= \frac{120\times(0.5)^2}{2\times1.5} = 10$	B1		
	$(x + 2) \times 29.468 + mg(x+2)\sin 20$	M1A1		M1 for 4 of these terms at least 2 correct
	$= 40\,(x - 1.5)^2 - 10$	A1		A1for 3 terms correct with correct signs A1 for equation totally correct
	$40x^2 - 162.875x - 5.75 = 0$			
	$x = 4.1069$ or -0.035			
	$\therefore\ x = 4.11$	A1	8	condone 4.10, 4.12, and anything in between,
(ii)	Using $T = \frac{\lambda x}{l}$			
	Tension when particle is at B is $\frac{120\times0.5}{1.5}$			
	$= 40$	B1		
	Frictional force is 29.468			
	Gravitational force is $mg\sin 20$			
	$= 13.407$	B1		For both 29.4. and 13.4.
	Using $F = ma$			
	$4a = 40 + 13.407 - 29.468$	M1		Need all terms & correct
	$= 23.938$			
	Acceleration is 5.984			
	$= 5.98\ ms^{-2}$	A1	4	condone 5.99,5.984..,5.985
	Total		**15**	
	TOTAL		**75**	