AQA

AS
FURTHER MATHEMATICS
7366/2M

Paper 2 Mechanics

Mark scheme

June 2019

Version: 1.0 Final

I96A7366/2m/MS

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 Examiner.

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

Mark scheme instructions to examiners

General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- marking instructions that indicate when marks should be awarded or withheld including the principle on which each mark is awarded. Information is included to help the examiner make his or her judgement and to delineate what is creditworthy from that not worthy of credit
- a typical solution. This response is one we expect to see frequently. However credit must be given on the basis of the marking instructions.

If a student uses a method which is not explicitly covered by the marking instructions the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

Key to mark types

M	mark is for method
R	mark is for reasoning
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
F	follow through from previous incorrect result

Key to mark scheme abbreviations

CAO	correct answer only
CSO	correct solution only
ft	follow through from previous incorrect result
'their'	indicates that credit can be given from previous incorrect result
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
sf	significant figure(s)
dp	decimal place(s)

Examiners should consistently apply the following general marking principles

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.

Diagrams

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

Work erased or crossed out

Erased or crossed out work that is still legible and has not been replaced should be marked. Erased or crossed out work that has been replaced can be ignored.

Choice

When a choice of answers and/or methods is given and the student has not clearly indicated which answer they want to be marked, mark positively, awarding marks for all of the student's best attempts. Withhold marks for final accuracy and conclusions if there are conflicting complete answers or when an incorrect solution (or part thereof) is referred to in the final answer.

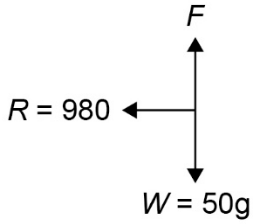
AS/A-level Maths/Further Maths assessment objectives

AO		Description
AO1	AO1.1a	Select routine procedures
	AO1.1b	Correctly carry out routine procedures
	AO1.2	Accurately recall facts, terminology and definitions
AO2	AO2.1	Construct rigorous mathematical arguments (including proofs)
	AO2.2a	Make deductions
	AO2.2b	Make inferences
	AO2.3	Assess the validity of mathematical arguments
	AO2.4	Explain their reasoning
	AO2.5	Use mathematical language and notation correctly
AO3	AO3.1a	Translate problems in mathematical contexts into mathematical processes
	AO3.1b	Translate problems in non-mathematical contexts into mathematical processes
	AO3.2a	Interpret solutions to problems in their original context
	AO3.2b	Where appropriate, evaluate the accuracy and limitations of solutions to problems
	AO3.3	Translate situations in context into mathematical models
	AO3.4	Use mathematical models
	AO3.5a	Evaluate the outcomes of modelling in context
	AO3.5b	Recognise the limitations of models
	AO3.5c	Where appropriate, explain how to refine models

Q	Marking Instructions	AO	Marks	Typical Solution
1	Circles correct answer	1.1b	B1	$\frac{10\pi}{9}$
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
2	Circles correct answer	1.1b	B1	3200 J
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
3	Recalls the correct dimensions for energy	1.2	B1	$[E] = \mathrm{ML^2T^{-2}}$ $[k](\mathrm{L})^2 = \mathrm{ML^2T^{-2}}$ $[k] = \mathrm{MT^{-2}}$
	Forms an equation to find the dimensions of k using their expression for energy and L for the extension of the spring – the L does not need to be squared Their expression must contain M, L and T Condone use of units for this mark only	1.1a	M1	
	Completes a rigorous argument using correct dimensions for energy, the extension of the spring and the dimensionless constant to obtain $\mathrm{MT^{-2}}$ for the dimensions of k	2.1	R1	
	Total		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
4(a)	Draws an accurate force diagram with vertical forces of weight and friction identified Condone omission of normal reaction	3.3	B1	
	Explains that friction and Stephi's weight must be equal to remain in equilibrium and deduces that $F = 50g = 490$ N	2.4	E1	To stop sliding down the wall friction must equal the weight of Stephi $F = 50g = 490$ N
4(b)	Uses correct formula with either v or ω to obtain an expression for the magnitude of the resultant force or the acceleration	3.4	B1	Force towards centre of circle = $mr\omega^2$ $980 = 50(4.6)\omega^2$
	Forms a correct equation in v or ω involving the normal reaction Must use 980 for the reaction	1.1a	M1	$\omega = \sqrt{\dfrac{980}{50 \times 4.6}}$
	Obtain the correct value of ω AWRT 2.1	1.1b	A1	$\omega = 2.064.....$ $\omega = 2.1$
4(c)	States one appropriate modelling assumption Accept No air resistance or The radius is exactly 4.6 metres	3.5a	M1	Stephi is modelled as particle. This means that 4.6 metres can be used as the radius of the circle, which would not be the case otherwise.
	Provides correct reasoning about their modelling assumption Accept Without air resistance there is no horizontal frictional force or There is no need to consider variations in the value of the radius	2.4	A1	
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
5	Translates problem into equations by modelling power as Fv and resistance as kv	3.3	M1	At 40 m s^{-1} Power 48000 = 40F Resistance R = 40k
	Explains that at maximum speed (or when acceleration is zero) the driving force equals the resistance	2.4	E1	At maximum speed the driving force equals the resistance $R = F$
	Obtains or uses a correct value for k PI by use in an expression for the resistance	1.1b	A1	F = 1200 N k = 30
	Finds the resistance when travelling at 25 m s^{-1} using 'their' value of k	1.1a	M1	Resistance = 30(25) = 750
	Finds the correct driving force needed when travelling with maximum power at 25 m s^{-1} May be embedded in an equation	1.1a	M1	At 25 m s^{-1} Power 48000 = 25D D = 1920
	Forms a correct equation to find a	1.1b	A1	Equation of motion 1920 – 750 = 1000a
	Finds the correct value of a **stating correct units** AWRT 1.2	3.2a	A1	a = 1.2 m s^{-2}
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
6(a)	Forms an expression for PE and at least one expression for KE Must include $15\sin/\cos(40°/50°)$	3.1b	M1	PE at A $mgh = 40g(15\sin 50^0) = 4504$
	Obtains three fully correct energy expressions	1.1b	A1	KE at A $\frac{1}{2}mv^2 = \frac{1}{2}(40)(1)^2 = 20$ KE at B $\frac{1}{2}mv^2 = \frac{1}{2}(40)(5)^2 = 500$
	Evaluates 'their' change in energy using three energy terms with appropriate signs	1.1a	M1	Loss in energy 4504 + 20 – 500 = 4000 J (to 2 sf)
	Obtains the correct change in energy AWRT 4000 J	1.1b	A1	
6(b)(i)	Translates problem into an equation to find F	3.1b	M1	Change in energy = force x distance 4024 = 15F
	Obtains F = 270 when rounded to two significant figures AG Must use their rounded or unrounded energy value from part **(a)** Must show F to more than two sig figs before rounding	1.1b	A1	F = 268.2…. N F = 270 N (to 2 sf)
6(b)(ii)	Translates problem into an equation and finds distance travelled along BC Or Calculates total energy needed to move from B to C	3.4	M1	KE at B = force x distance travelled 500 = 270d d = 1.85 1.85 < 2 If Martin's size is negligible then he does not reach the end of the slide If Martin's size is not negligible then he might reach the end of the slide
	Compares their value of d with distance BC Or Compares their energy with the KE at B	1.1b	A1F	
	Infers correctly whether Martin reaches the point C or not CSO	2.2b	E1	
	Total		**9**	

Q	Marking Instructions	AO	Marks	Typical Solution
7(a)(i)	Forms an equation using conservation of momentum	1.1a	M1	CoM $3mu = 3mv + mw$ $3u = 3v + w$ NLR $w - v = ue$ Subtracting equations gives $4v = 3u - ue$ $v = \frac{u(3-e)}{4}$
	Obtains a correct momentum equation – can be unsimplified	1.1b	A1	
	Forms a correct equation using Newton's law of restitution	1.1b	B1	
	Completes a rigorous argument using both conservation of momentum and the coefficient of restitution to verify the correct speed of *P*	2.1	R1	
7(a)(ii)	Substitutes the speed of *P* back into either of their equations Or Eliminates v from their pair of equations	1.1a	M1	$w = \frac{u(3-e)}{4} + ue$ $w = \frac{3u(1+e)}{4}$
	Obtains the correct speed for *Q* - must be fully simplified	1.1b	A1	
7(b)	Substitutes either $e = 0$ or $e = 1$ into the expression for v	1.1a	M1	When $e = 0$ $v = \frac{u(3-0)}{4} = \frac{3u}{4}$ When $e = 1$ $v = \frac{u(3-1)}{4} = \frac{u}{2}$ Hence $\frac{u}{2} \le v \le \frac{3u}{4}$
	Completes a rigorous argument by correctly substituting both $e = 0$ and $e = 1$ into the expression for v to confirm the corresponding stated maximum and minimum values of v If maximum and minimum values are clearly identified then there is no need to state inequality at the end	2.1	R1	

7(c)(i)	Uses the formula for impulse and substitutes a pair of corresponding velocities and consistent masses into the impulse formula	1.1a	M1	$I = 3m\left(\frac{u}{2}\right) - 3mu$ $I = -\frac{3mu}{2}$ Magnitude = $\frac{3mu}{2}$
	Deduces that e = 1 will result in the maximum magnitude of the impulse and uses this to find the impulse	2.2a	R1	
	Obtains $\frac{3mu}{2}$	3.2a	A1	
7(c)(ii)	Deduces that the impulse *Q* exerts on *P* is equal in magnitude but opposite in direction Accept Impulse will be the negative of the impulse *P* exerts on *Q* (opposite) or Equal and opposite FT any reference to their specific value obtained in part **(c)(i)**	2.2a	E1F	The impulse *Q* exerts on *P* is equal in magnitude but opposite in direction
	Total		**12**	