AS
FURTHER MATHEMATICS
7366/2M

Paper 2 Mechanics

Mark scheme

June 2022

Version: 1.0 Final Mark Scheme

226A7366/2M/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 marks and is for accuracy
B	mark is independent of 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
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	50 J
	Question total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
2	Circles correct answer.	1.1b	B1	$\begin{bmatrix}4\\1\end{bmatrix}$ ms^{-1}
	Question total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3(a)	Recalls the formula for kinetic energy and calculates the initial kinetic energy. Condone missing units.	1.1b	B1	$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2}(0.75)(12)^2 = 54\text{ J}$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3(b)	Uses conservation of energy to form an equation with PE and their KE from part (a).	3.3	M1	mgh = 54 $h = \frac{54}{(0.75)(9.8)}$ = 7.34..
	Solves the equation to obtain h = 7.3 AWRT 7.3 Must have clearly rearranged the equation to find h **or** obtains correct value (7.3469..) to at least 3 sf. AG	1.1b	A1	Jeff has assumed no air resistance to obtain h = 7.3 Gurjas includes air resistance and so knows the ball will not reach 7. 3 metres
	Makes an inference about one or more assumptions for both Jeff and Gurjas. For example: • Jeff has assumed no air resistance, Gurjas has taken this into account • Jeff assumes that all energy is conserved, Gurjas does not.	2.2b	E1	
	Subtotal		**3**	

	Question total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
4(a)	Substitutes dimensions for length, time and acceleration due to gravity into both sides of any correct version of the formula. Do not condone use of units.	1.1a	M1	$[t] = T$ $[g] = LT^{-2}$ $[w] = L$ $[k] = \frac{[gt^2]}{[w]} = \frac{LT^{-2}T^2}{L} = 1$ Therefore, k is a dimensionless constant
	Completes a rigorous argument using dimensions to verify that k is a dimensionless constant.	2.1	R1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
4(b)	Uses dimensions to form a correct expression for the dimensions of $[(gd)^{\alpha}t^{\beta}]$ Need not be simplified. Do not condone use of units.	1.1b	B1	$[(gd)^{\alpha}t^{\beta}] = (LT^{-2}L)^{\alpha}(T)^{\beta}$ $= (L)^{2\alpha}(T)^{-2\alpha+\beta}$ $2\alpha = 1$ $-2\alpha + \beta = 0$ $\alpha = \frac{1}{2}$ $\beta = 1$
	Forms two simultaneous equations in α and β consistent with their simplified $[(gd)^{\alpha}t^{\beta}]$ PI by a correct value of α or β	1.1a	M1	
	Obtains correct values for α and β	1.1b	A1	
	Subtotal		**3**	

	Question total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
5	Explains that at maximum speed the driving force equals the resistance or that the acceleration is zero. OE	2.4	E1	For maximum power the car travels at maximum speed when the driving force equals the resistance $R = F$ $v = \frac{72 \times 1000}{60 \times 60} = 20$ ms^{-1} $R = 25v = 25(20) = 500$ $P = Fv$ $P = 500 \times 20 = 10000$ Max $P = 10$ *kW*
	Converts km h^{-1} to m s^{-1} to obtain 20 m s^{-1}	1.1b	B1	
	Obtains their correct driving force or resistive force using their value for speed.	3.4	M1	
	Forms an equation by modelling power as Fv with both their F and v substituted.	3.3	M1	
	Finds the correct maximum power of 10 kW OE Must state units.	3.2a	A1	
	Question total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
6(a)	Forms a correct definite integral for impulse.	3.4	B1	Impulse = $\int_0^T (2t+3)dt$
	Integrates with at least one term correct.	1.1a	M1	= $[t^2+3t]_0^T$
	Obtains $T^2 + 3T$ or $a = 1$ and $b = 3$	1.1b	A1	= $T^2 + 3T$ $a = 1$ and $b = 3$
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
6(b)	Uses $mv - mu$	1.1a	M1	$I = mv - mu$ $I = 0.2(4) - 0.2(1) = 0.6$
	Obtains 0.6	1.1b	A1	$T^2 + 3T = 0.6$
	Equates their answer to part **(a)** to their change in momentum and solves their quadratic equation.	1.1a	M1	$T = 0.188$ or -3.19 As $0 \le t \le T$, $T = 0.188$
	Obtains $T = 0.188$ and clearly rejects the negative value.	3.2a	A1	
	Subtotal		**4**	

	Question total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
7(a)	Forms a term using *mv* for either particle.	1.1a	M1	Momentum for *A* = 4(0.4) = 1.6 Momentum for *B* = -2(0.2) = - 0.4 Total momentum = 1.2 Ns
	Obtains 1.2 kg ms^{-1} or 1.2 Ns Condone missing units.	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
7(b)(i)	Forms a conservation of momentum equation using their answer from **(a)**.	3.1b	M1	Speed of *A* = u Speed of *B* = v C of M $1.2 = 0.4u + 0.2v$ $12 = 4u + 2v$ NLR $v - u = 6e$ $12 = 4(v - 6e) + 2v$ $12 = 6v - 24e$ $2 = v - 4e$ $v = 4e + 2$
	Forms a correct equation using Newton's law of restitution.	1.1b	B1	
	Completes a rigorous argument using both conservation of momentum and the Newton's law of restitution to verify the correct speed of *B*	2.1	R1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
7(b)(ii)	Substitutes the speed of *B* back into either of their equations.	1.1a	M1	$4e + 2 - u = 6e$ $u = 2 - 2e$
	Rearranges their equation to obtain the correct speed of *A*	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
7(c)	States that $e = 1$	1.1a	M1	Perfectly elastic collision so $e = 1$ $u = 2 - 2(1) = 0$ Hence particle *A* comes to rest
	Deduces that *A* comes to rest.	2.2a	R1	
	Subtotal		**2**	

	Question total		**9**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)	Demonstrates the use of Hooke's law to obtain the result stated.	3.3	B1	$T = \frac{\lambda x}{l} = \frac{200x}{1} = 200x$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
8(b)	Uses $a = \frac{v^2}{r}$ or $T = \frac{mv^2}{r}$	3.4	M1	$T = \frac{mv^2}{r}$ $T = \frac{3(4)^2}{1+x}$ $\frac{48}{1+x} = 200x$ $48 = 200x(1+x)$ $200x^2 + 200x - 48 = 0$ $25x^2 + 25x - 6 = 0$
	Identifies $r = 1 + x$	1.1b	B1	
	Forms an equation in x using their expression for r Must not use $r = 1$	1.1a	M1	
	Completes a reasoned argument to obtain $25x^2 + 25x - 6 = 0$	2.1	R1	
	Subtotal		**4**	

Q	Marking instructions	AO	Marks	Typical solution
8(c)	Solves $25x^2 + 25x - 6 = 0$ to obtain either $x = 0.2$ or $x = -1.2$	1.1a	M1	$25x^2 + 25x - 6 = 0$ As $x > 0$, $x = 0.2$ Radius = 1 + 0.2 = 1.2 m
	Deduces the correct radius. Condone omission of units.	2.2a	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
8(d)	States any valid limitation eg String may not be light. There may be air resistance / resistance.	3.5b	E1	String may not be light
	Subtotal		**1**	

	Question total		**8**	

	Question Paper total		**40**	