AS
FURTHER MATHEMATICS
7366/2M

Paper 2 Mechanics

Mark scheme

June 2021

Version: 1.0 Final Mark Scheme

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	100
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
2	Circles correct answer	1.2	B1	MLT^{-2}
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3(a)	Recalls the formula for gravitational potential energy and calculates the energy gained Condone missing or incorrect units Accept 14700	1.1b	B1	$mgh = 300 \times 9.8 \times 5$ $= 14700$ J $= 15000$ J
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3(b)	Forms an equation recalling that power is the rate of doing work containing expressions for KE, PE and power	3.3	M1	Work done = gain in KE + gain in PE Increase in KE = $\frac{1}{2}(300)v^2$
	Forms an expression for the correct gain in KE	1.1b	B1	Work done over 50 sec = 400 × 50
	Obtains correct value for total work done over 50 seconds	3.1b	B1	= 20000 J
	Solves the equation correctly to obtain the value of v Accept AWRT 5.94 Condone missing or incorrect units	1.1b	A1	$\frac{1}{2}(300)v^2 + 14700 = 400 \times 50$ $v = 5.9$ m s^{-1}
	Total		**4**	

	Question total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
4(a)	Uses the correct formula for the acceleration to obtain an expression for the radial force	3.3	B1	Radial force = $\frac{mv^2}{r}$ $\frac{75v^2}{15}$ = 500 $v = 10$ m s^{-1} v = 36 km h^{-1}
	Forms an equation or inequality involving an expression for the radial force, 500 and substitutes the appropriate values for m and r	1.1a	M1	
	Solves the equation or inequality to obtain v = 10 or $v \leq 10$	1.1b	A1	
	Obtains their correct greatest speed for their equation or inequality in km h^{-1}	3.2a	A1F	
	Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
4(b)	States one limitation with respect to the surface of the road For example: The road is perfectly horizontal	3.5b	E1	The road surface may not be uniform
	Total		**1**	

	Question total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
5	Recalls the dimensions for displacement, velocity, time and acceleration due to gravity	1.2	B1	$[s] = L$ $[u] = LT^{-1}$ $[t] = T$ $[\mathrm{g}] = LT^{-2}$
	Explains that ½ or 2 is a dimensionless quantity in the given equation	2.4	E1	½ is dimensionless $[ut] = LT^{-1}T = L$ $\left[\frac{\mathrm{g}t^2}{2}\right] = LT^{-2}T^2 = L$
	Substitutes 'their' dimensions into the expressions ut and $\mathrm{g}t^2$	1.1a	M1	
	Completes a reasoned argument using dimensions to verify that the dimensions of ut and $\frac{\mathrm{g}t^2}{2}$ and s are all equal to L and concludes that the formula is dimensionally consistent R1 is not dependent on E1	2.1	R1	$[ut] = \left[\frac{\mathrm{g}t^2}{2}\right] = [s] = L$ So formula is dimensionally consistent
	Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
6(a)	Uses correct formula for impulse	1.1a	M1	I = $mv - mu$ I = 0.15(14) – (0.15)(–28) I = 6.3 Ns
	Obtains correct answer of 6.3 Condone missing or incorrect units	1.1b	A1	
	Total		**2**	

Q	Marking instructions	AO	Marks	Typical solution
6(b)	Forms an equation involving appropriate integral using 'their' value from part (a)	3.4	M1	6.3 = $k\int_0^{0.05} 10t(0.05-t)dt$ $\int_0^{0.05} 10t(0.05-t)dt = \frac{1}{4800}$ k = 4800 × 6.3 = 30240
	Evaluates definite integral correctly	1.1b	B1	
	Solves equation to find 'their' value of k FT their impulse from part (a) or their incorrect value for the definite integral	1.1b	A1F	
	Total		**3**	

	Question total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
7(a)	Recalls the formula for elastic potential energy and calculates the initial stored energy in the stretched string – substituting the appropriate values Accept 47 Condone missing or incorrect units	1.1b	B1	EPE $= \frac{\lambda x^2}{2l} = \frac{125(1.5)^2}{6}$ $= 46.875$ J = 46.9 J
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
7(b)	Finds the increase in vertical height from the starting position to the point when the string becomes slack	1.1b	B1	Increase in height = 1.5sin 25^0 EPE lost = PE gained + KE gained $46.875 = \frac{1}{2}(2.5)v^2 + 2.5\mathrm{g}(1.5\sin 25^0)$ $v^2 = 25.062 \ldots$ v = 5.01 m s^{-1}
	Forms a conservation of energy equation containing expressions for EPE, KE and PE – substituting the appropriate values	3.4	M1	
	Obtains a fully correct three term equation	1.1b	A1	
	Solves the equation correctly to obtain the value of v AWRT 5.0 FT their expression or value for the increase in height	1.1b	A1F	
	Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
7(c)	Obtains or states two quantities that can be used as a basis for a comparison to reach a conclusion	3.4	M1	PE gained from start to *A* = $2.5g(4.5\sin 25^\circ) = 46.6$ J EPE at start = 46.9 J 46.6 < 46.9 This model assumes no air resistance On that basis, the block will reach *A* as there is enough initial energy
	States at least one appropriate assumption For example: • Assumes no air resistance • All energy is conserved	3.5a	E1	
	Makes an inference using the quantities that have been correctly calculated, in line with any stated assumptions Either Infers that the block will reach *A* as there is enough initial energy and the block does not experience any air resistance Or Infers that the block will not reach *A* if air resistance is taken into account Must be a correct inference from calculations and assumptions stated	2.2b	R1	
	Total		**3**	

	Question total		**8**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)(i)	Forms an equation using conservation of momentum	1.1a	M1	Velocity of *A* = v Velocity of *B* = w C of M $2(4) = 2v + 3w$ $8 = 2v + 3w$ NLR $w - v = 4e$ $8 = 2(w - 4e) + 3w$ $8 + 8e = 5w$ $w = \dfrac{8(1+e)}{5}$
	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 reasoned argument using both conservation of momentum and the coefficient of restitution to verify the correct speed of *B*	2.1	R1	
	Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)(ii)	Substitutes $\frac{8(1+e)}{5}$ into either of their equations or Subtracts original equations and eliminates the velocity of B	1.1a	M1	$v = \dfrac{8(1+e)}{5} - 4e$ $v = \dfrac{8 + 8e - 20e}{5}$ $v = \dfrac{4(2-3e)}{5}$
	Obtains the correct velocity for *A* ACF	1.1b	A1	
	Total		**2**	

Q	Marking instructions	AO	Marks	Typical solution
8(b)	Solves $v > 0$ or $v = 0$ and deduces upper bound for e provided that their answer is between 0 and 1	2.2a	M1	$\dfrac{4(2-3e)}{5} > 0$ $e < \dfrac{2}{3}$ $0 \le e < \frac{2}{3}$
	Correctly states full range of values for e	1.1b	A1	
	Total		**2**	

Q	Marking instructions	AO	Marks	Typical solution
8(c)(i)	Deduces that $I + J = 0$	2.2a	R1	$I + J = 0$
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
8(c)(ii)	Explains that corresponding impulses for any collision are equal in magnitude and opposite in direction	2.4	M1	Impulses are equal in magnitude and opposite in direction so will always have a sum of 0
	Deduces that the value of $I + J$ will not change	2.2a	R1	
	Total		**2**	

	Question total		**11**	

	Paper total		**40**	