AQA

AS
FURTHER MATHEMATICS
7366/2M

Paper 2 Mechanics

Mark scheme

June 2020

Version: 1.0 Final Mark Scheme

206A7366/2m/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	0.1 m
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
2	Circles correct answer	1.1b	B1	14 J
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
3	Finds the correct angular speed of the moon in radians per second or Finds the correct circumference of the moon's orbit ($7.84 \times 10^8 \pi\ m$) and converts 27.3 days to seconds (2358720 sec)	1.1b	B1	$\omega = \dfrac{2\pi}{27.3 \times 24 \times 60 \times 60}$ $\omega = 2.6638 \times 10^{-6}$
	Uses $v = r\omega$ with 'their' calculated value of ω or Uses speed/distance/time with '*their*' calculated values of circumference and time	3.4	M1	velocity $= r\omega$ $v = 3.84 \times 10^8 \times 2.6638 \times 10^{-6}$ v = 1020 ms^{-1}
	Obtains v = 1020 ms^{-1} AWRT 1020 Condone missing units	3.2a	A1	
	Total		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
4	Forms a correct conservation of momentum equation in either the **i** or **j** direction Either $4m + 2(-3) = k(m + 2)$ or $-2m + 2(5) = 0$ Can be embedded in a single 2D equation	1.1a	M1	$m\begin{bmatrix}4\\-2\end{bmatrix} + 2\begin{bmatrix}-3\\5\end{bmatrix} = (m+2)\begin{bmatrix}k\\0\end{bmatrix}$ $-2m + 10 = 0$ $m = 5$ $20 - 6 = 7k$ $k = 2$
	Obtains two fully correct equations	1.1b	A1	
	Obtains $m = 5$	1.1b	A1	
	Deduces value for k using '*their*' value for m and a correct momentum equation	2.2a	R1F	
	Total		**4**	

Q	Marking Instructions	AO	Marks	Typical Solution
5	Explains that maximum power occurs at maximum speed when the driving force equals the resistance. OE	2.4	E1	For maximum power the train travels at maximum speed when the driving force equals the resistance $R = F$ $F = 2400 + 8(300) = 4800$ N
	Obtains the correct driving force or resistive force of 4800 N	3.4	B1	
	Translates problem into equation by modelling power as Fv	3.3	M1	$P = Fv$
	Converts km h^{-1} to m s^{-1} correctly	1.1b	B1	$v = \frac{120\times1000}{60\times60} = \frac{100}{3}\text{ms}^{-1}$
	Finds the correct maximum power of 160 kW OE Must state units.	3.2a	A1	$P = 4800 \times \frac{100}{3} = 160000$ Max $P = 160\ kW$
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
6(a)	Recalls the dimensions for force, distance and mass to form an equation for dimensional consistency.	1.1a	M1	$[F] = MLT^{-2}$ $[d] = L$ $[m_1] = [m_2] = M$ $[G] = \dfrac{MLT^{-2} \times L^2}{(M)^2} = M^{-1}L^3T^{-2}$
	Completes a rigorous argument using both dimensions for force, distance and mass to verify that the dimensions of G are $M^{-1}L^3T^{-2}$	2.1	R1	
6(b)	Uses dimensions to form a correct expression for the dimensions of $\left[m^a r^b G^c\right]$	1.1a	M1	$[m^a r^b G^c] = (M)^a (L)^b (M^{-1}L^3T^{-2})^c$ $= M^{a-c}L^{b+3c}T^{-2c}$
	Forms three simultaneous equations in three unknowns from '*their*' $\left[m^a r^b G^c\right]$ PI by correct values of a, b, c	1.1a	M1	$a - c = 0$ $b + 3c = 0$ $-2c = 1$ $c = -0.5$ $b = 1.5$ $a = -0.5$
	Obtains correct values for a, b, c **CAO**	1.1b	A1	
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
7(a)	Uses the formula for elastic potential energy and calculates the initial stored energy in the spring – substituting the appropriate values.	3.1b	B1	EPE $= \frac{1}{2}kx^2 = \frac{1}{2} \times 60 \times 0.03^2 = 0.027J$
	Forms a conservation of energy equation containing expressions for EPE, KE and PE – substituting the appropriate values.	3.3	M1	EPE lost = PE gained + KE gained $0.027 = \frac{1}{2}(0.018)v^2 + 0.018g(0.03)$
	Obtains a fully correct three term equation.	1.1b	A1	$v^2 = 2.412$
	Solves '*their*' equation correctly to obtain the value of v – must be rounded correctly to 2 significant figures. Condone missing units	3.2a	A1F	v = 1.6 ms^{-1}
7(b)	Translates problem into finding maximum height of rocket by forming an energy equation using KE = 0	3.4	M1	EPE lost = PE gained 0.027 = 0.018 (9.8)h h = 0.153 m
	Obtains the correct maximum height of the rocket. AWRT 0.15 Condone missing units	1.1b	A1	h = 0.15 m (2sf)
7(c)	Identifies at least two assumptions which limit the model	3.5a	E1	The rocket has been modelled as a particle but has size so this needs to be taken into account.
	Evaluates the impact of at least one of 'their' assumptions in the context of the model Condone one assumption Follow through '*their*' answer to (b)	3.5b	E1F	It has been assumed that there is no air resistance, if taken into account this would reduce the height reached.
	Uses at least one of '*their*' identified limitations to infer whether or not Jo-Jo wins a prize.	2.2b	R1F	As the predicted height is only just enough to win the prize it is unlikely that the prize will be won because of the effects of air resistance, even when size is taken into account.
	Total		**9**	

Q	Marking Instructions	AO	Marks	Typical Solution
8(a)	Forms an equation using conservation of momentum with at least two terms correct	1.1a	M1	$2m(3u) + m(-2u) = 2mv + mw$ $4u = 2v + w$
	Obtains a fully correct momentum equation ACF	1.1b	A1	$w - v = 5ue$
	Forms a correct equation using Newton's law of restitution.	1.1b	B1	$4u = 2(w - 5ue) + w$ $4u + 10ue = 3w$
	Completes a rigorous argument using both conservation of momentum and the coefficient of restitution to verify the correct speed of *B*	2.1	R1	$w = \frac{2u(2+5e)}{3}$
8(b)	Substitutes the speed of *B* back into either of their equations or subtracts original equations to eliminate w	1.1a	M1	$4u = 2v + 5ue + v$ $3v = 4u - 5ue$
	Obtains '*their*' correct speed for *A* or Uses '*their*' equations to form a correct inequality involving e	1.1b	A1F	$v = \frac{u(4-5e)}{3}$ $\frac{u(4-5e)}{3} < 0$
	Deduces lower bound for e	2.2a	R1	$e > \frac{4}{5}$
	Correctly states full range of values for e Condone strict inequality	3.2a	A1	$\frac{4}{5} < e \leq 1$

8(c)	Forms an equation using a valid formula for impulse and $\pm\frac{19mu}{3}$ Accept $mv - mu = \pm\frac{19mu}{3}$	1.1a	M1	$mv - mu = \frac{19mu}{3}$ $m\left(\frac{2u(2+5e)}{3}\right) - m(-2u) = \frac{19mu}{3}$ $4u + 10e + 6u = 19u$ $e = \frac{9}{10}$
	Substitutes at least one of '*their*' velocities correctly into '*their*' impulse equation	1.1a	M1	
	Obtains a fully correct impulse expression with all signs consistent.	1.1b	A1	
	Solves '*their*' equation to obtain a valid value for e	1.1b	A1F	
	Total		**12**	

	Paper total		**40**	