A-level
FURTHER MATHEMATICS
7367/3M

Paper 3 Mechanics

Mark scheme

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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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

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)
ISW	Ignore Subsequent Workings

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 the 3rd answer.	1.1b	B1	1250 N
	Question total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
2	Circles the 2nd answer.	1.1b	B1	30 J
	Question total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
3	Circles the 2nd answer.	2.2a	B1	$\overline{x} > \overline{y}$
	Question total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
4(a)	Obtains 0.625 or $\frac{5}{8}$ Must be positive.	1.1b	B1	$e = \frac{5}{8} = 0.625$
	Subtotal		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
4(b)	Forms an equation to find the impact speed using their coefficient of restitution.	3.4	M1	$\frac{5}{8}u = 7$ $u = \frac{56}{5} = 11.2$ m s^{-1}
	Obtains 11.2 or $\frac{56}{5}$ Follow through their value for e provided that $0 \leq e \leq 1$ Condone missing or incorrect units.	1.1b	A1F	
	Subtotal		**2**	
	Question total		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(a)	Obtains 64 Condone missing or incorrect units.	1.1b	B1	$\text{KE} = \frac{1}{2}\times 0.5\times 16^2$ $= 64$ J
	Subtotal		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(b)(i)	Obtains **AWRT** 29 Condone missing or incorrect units.	1.1b	B1	GPE = 0.5 × 9.81 × 6 =29.43 = 29.4 J (to 3sf)
	Subtotal		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(b)(ii)	Forms a three term energy equation to find the minimum speed.	3.3	M1	$64 = 29.43 + \frac{1}{2}\times 0.5v^2$ $v^2 = 138.28$ v = 11.8 m s^{-1} (to 3sf)
	Obtains a correct equation. FT their GPE and initial KE.	1.1b	A1F	
	Obtains **AWRT** 12 Condone missing or incorrect units.	1.1b	A1	
	Subtotal		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(b)(iii)	States that **air** resistance has been ignored. Accept: No spin / no rotation Only gravity / only weight Do not accept: No friction No resistance. No external forces	3.5b	E1	It has been assumed that there is no air resistance acting on the ball.
	Subtotal		**1**	

	Question total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
6	Forms a dimensional analysis equation, with correct dimensions for at least two quantities.	3.3	M1	$[a] = [m]^{\alpha}\,[\rho]^{\beta}\,[v]^{\gamma}$ $LT^{-2} = M^{\alpha} \times M^{\beta}L^{-3\beta} \times L^{\gamma}T^{-\gamma}$ $0 = \alpha + \beta$ $\gamma - 3\beta = 1$ $-2 = -\gamma \Rightarrow \gamma = 2$ $2 - 3\beta = 1 \Rightarrow \beta = \frac{1}{3}$ $\alpha = -\frac{1}{3}$
	Uses dimensional analysis to deduce the value of at least one of α, β and γ correctly.	2.2a	A1	
	Uses dimensional analysis to obtain correct values for α, β and γ	1.1b	A1	
	Question total		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
7	Calculates a vector product.	3.1a	M1	$\begin{bmatrix}3\\5\\-1\end{bmatrix} \times \begin{bmatrix}2\\-4\\3\end{bmatrix} = \begin{bmatrix}11\\-11\\-22\end{bmatrix}$ $\sqrt{11^2 + (-11)^2 + (-22)^2} = \sqrt{726}$ $= 11\sqrt{6}$ $k = 11$
	Obtains $\begin{bmatrix}11\\-11\\-22\end{bmatrix}$ or $\begin{bmatrix}-11\\11\\22\end{bmatrix}$	1.1b	A1	
	Completes a reasoned argument to obtain $11\sqrt{6}$ from using $\mathbf{r} \times \mathbf{F}$	2.1	R1	
	Question total		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
8(a)	Deduces the correct value for θ or $\sin\theta$ or $\cos\theta$	2.2a	B1	$\sin\theta = \frac{0.6}{1.2} \Rightarrow \theta = 30$ $T\cos 30° = 0.2 \times 9.8$ $T = \frac{0.2\times 9.8}{\cos 30^\circ}$ $= 2.263\ldots$ $= 2.3$ N to 2sf
	Resolves vertically, with their value for θ	3.3	M1	
	Completes a reasoned argument to obtain 2.3 Must show 2.26… or $\frac{0.2\times 9.8}{\cos 30^\circ}$ **AG** Condone missing or incorrect units.	2.1	R1	
	Subtotal		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
8(b)	Resolves horizontally to form an equation of the form $T\sin\theta = \frac{mv^2}{r}$ or $T\sin\theta = mr\omega^2$	3.4	M1	$T\sin 30° = \frac{0.2\times v^2}{0.6}$ $v^2 = \frac{0.2\times 9.8}{\cos 30^\circ}\times\frac{1}{2}\times 3$ $v^2 = 3.3948...$ $= 1.8$ m s^{-1} to 2sf
	Obtains a correct equation.	1.1b	A1	
	Obtains AWRT 1.8 Allow AWRT 1.9 from use of $T = 2.3$ Condone missing or incorrect units.	1.1b	A1	
	Subtotal		**3**	

	Question total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
9(a)	Forms equation using conservation of momentum.	3.3	M1	$0.8\begin{bmatrix}5\\3\end{bmatrix}+1.2\begin{bmatrix}-2\\-3\end{bmatrix}=0.8\begin{bmatrix}1.1\\1.5\end{bmatrix}+1.2\mathbf{v}_B$
	Obtains correct vector equation.	1.1b	A1	$\mathbf{v}_B=\frac{1}{1.2}\begin{bmatrix}0.72\\-2.4\end{bmatrix}$
	Obtains $\begin{bmatrix}0.6\\-2\end{bmatrix}$ Condone missing or incorrect units.	1.1b	A1	$=\begin{bmatrix}0.6\\-2\end{bmatrix}$ m s^{-1}
	Subtotal		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
9(b)	Uses the vector form of the impulse formula.	3.4	M1	$\mathbf{I}=0.8\begin{bmatrix}1.1\\1.5\end{bmatrix}-0.8\begin{bmatrix}5\\3\end{bmatrix}$
	Obtains $\begin{bmatrix}-3.12\\-1.2\end{bmatrix}$ or $\begin{bmatrix}3.12\\1.2\end{bmatrix}$ oe	1.1b	A1	$=\begin{bmatrix}-3.12\\-1.2\end{bmatrix}$ $\mathbf{I}=\sqrt{3.12^2+1.2^2}=3.3$ N s to 2sf
	Obtains AWRT 3.3 Must be positive. Condone missing or incorrect units.	1.1b	A1	
	Subtotal		**3**	

Q	Marking Instructions	AO	Marks	Typical Solution
9(c)	Multiplies an impulse vector by 10	3.4	M1	$\mathbf{I}=\begin{bmatrix}3.12\\1.2\end{bmatrix}$
	Obtains $\begin{bmatrix}31.2\\12\end{bmatrix}$ Condone missing or incorrect units.	2.2a	A1	$0.1\mathbf{F}=\begin{bmatrix}3.12\\1.2\end{bmatrix}$ $\mathbf{F}=\begin{bmatrix}31.2\\12\end{bmatrix}$ N
	Subtotal		**2**	

	Question total		**8**	

Q	Marking Instructions	AO	Marks	Typical Solution
10(a)	States equation for circle of radius a	3.1b	B1	$y^2 = a^2 - x^2$ Mass $= \frac{\rho\pi a^2}{2}$
	Sets up an equation, including an integral to find the position of the centre of mass. Condone missing density.	3.3	M1	$\frac{\rho\pi a^2}{2} \times \bar{y} = \int_{-a}^{a} \frac{1}{2}\rho\left(a^2 - x^2\right)\mathrm{d}x$
	Obtains a correct integral. Condone missing density.	1.1a	M1	$= \frac{1}{2}\rho\left[a^2 x - \frac{x^3}{3}\right]_{-a}^{a}$ $= \frac{2\rho a^3}{3}$
	Obtains $\frac{2a^3}{3}$ or $\frac{a^3}{3}$	1.1b	A1	$\bar{y} = \frac{2\rho a^3}{3} \times \frac{2}{\rho\pi a^2} = \frac{4a}{3\pi}$
	Completes a reasoned argument to show $\bar{y} = \frac{4a}{3\pi}$ Must include the density.	2.1	R1	
	Subtotal		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
10(b)	Sets up an equation to find an angle.	3.4	M1	$\tan\theta = \frac{4a}{3\pi a} = \frac{4}{3\pi}$ $\theta = 23°$
	Obtains $\tan\theta = \frac{4}{3\pi}$ or $\tan\theta = \frac{3\pi}{4}$.	1.1b	A1	
	Obtains AWRT 23°	1.1b	A1	
	Subtotal		**3**	

	Question total		**8**	

Q	Marking Instructions	AO	Marks	Typical Solution
11(a)	Uses the EPE formula.	1.1a	M1	EPE = $\frac{1}{2} \times \frac{60}{0.8} \times 1.6^2 = 96$ J
	Obtains 96 Condone missing or incorrect units.	1.1b	A1	
	Subtotal		**2**	

Q	Marking Instructions	AO	Marks	Typical Solution
11(b)	Forms a three-term equation to find the extension of the string in equilibrium.	3.3	M1	$\frac{60}{0.8}e = 2\times 9.8\sin 30° + 0.3\times 2 \times 9.8\cos 30°$
	Obtains AWRT 0.199	1.1b	A1	$e = 0.1986$
	Obtains $0.3\times 2\times 9.8\cos 30°\times$ Their Distance	3.3	M1	$1.6 - 0.1986 = 1.4014$
	Forms a five-term energy equation with GPE including the angle of the slope.	3.3	M1	$96 = \frac{1}{2}\times\frac{60}{0.8}\times 0.1986^2 + 5.88\cos 30°\times 1.4014 + 19.6\sin 30°\times 1.4014 + \frac{1}{2}\times 2v^2$
	Obtains a correct equation.	1.1b	A1	$v^2 = 73.650...$
	Obtains AWRT 8.6 Condone missing or incorrect units.	1.1b	A1	$v = 8.6$ m s^{-1} to 2sf
	Subtotal		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
11(c)	Explains the effect of air resistance on the **tension**.	2.4	M1	Air resistance would provide an additional downward force so the maximum speed would be reached with a greater tension, so the =.distance travelled would be less.
	Concludes that the distance would be less.	3.5a	A1	
	Subtotal		**2**	

	Question Total		**10**	

	Paper Total		**50**	