AQA

AS
Further Mathematics

7366/2M - Mechanics

Mark scheme

7366

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Version/Stage: 1.0 Final

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 Assessment Writer.

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
dM	mark is dependent on one or more M marks and 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)

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

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.

Q	Marking Instructions	AO	Marks	Typical Solution
1	Circles correct answer	AO1.1b	B1	$\begin{bmatrix}1\\3\end{bmatrix}$ m s^{-1}
	Total		**1**	
2	Circles correct answer	AO1.1b	B1	45 m s^{-1}
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
3(a)	Recalls the dimensions for energy and angular speed and forms an equation for dimensional consistency	AO1.1a	M1	$[E]=\mathrm{ML^2T^{-2}}$ $[\omega]=\mathrm{T^{-1}}$ $[I]=\dfrac{\mathrm{ML^2T^{-2}}}{(\mathrm{T^{-1}})^2}=\mathrm{ML^2}$
	Completes a rigorous argument using both dimensions for energy and angular velocity to verify that the dimensions of I are $\mathrm{ML^2}$	AO2.1	R1	
3(b)	Uses dimensions to form a correct expression for the dimensions of $\left[I^{\alpha}W^{\beta}h^{\gamma}\right]$	AO1.1a	M1	$\left[I^{\alpha}W^{\beta}h^{\gamma}\right]=\left(\mathrm{ML^2}\right)^{\alpha}(\mathrm{MLT^{-2}})^{\beta}(\mathrm{L})^{\gamma}$ $=\mathrm{M}^{\alpha+\beta}\mathrm{L}^{2\alpha+\beta+\gamma}\mathrm{T}^{-2\beta}$ $\alpha+\beta=0$ $-2\beta=1$ $2\alpha+\beta+\gamma=0$ $\alpha=0.5$ $\beta=-0.5$ $\gamma=-0.5$
	Forms three simultaneous equations in three unknowns from 'their' $\left[I^{\alpha}W^{\beta}h^{\gamma}\right]$	AO1.1a	M1	
	Obtains correct values for α, β, γ **CAO**	AO1.1b	A1	
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
4(a)	Forms an equation using conservation of momentum Condone sign errors with correct terms	AO1.1a	M1	CoM $4mu - mu = mv_A + 4mv_B$ $3u = v_A + 4v_B$ NLR $v_A - v_B = 2ue$ Subtracting equations gives $5v_B = 3u - 2ue$ $v_B = \dfrac{u(3-2\mathrm{e})}{5}$
	Obtains a correct momentum equation – can be unsimplified	AO1.1b	A1	
	Forms an equation using Newton's law of restitution	AO1.1b	B1	
	Completes a rigorous argument using both conservation of momentum and the coefficient of restitution to verify the correct speed of B	AO2.1	R1	
4(b)	Substitutes the speed/velocity of B back into either of their equations	AO1.1a	M1	$v_A = \dfrac{u(3-2\mathrm{e})}{5} + 2ue$ $v_A = \dfrac{u(3+8e)}{5}$
	Obtains the correct speed for A - must be fully simplified	AO1.1b	A1	
4(c)	Uses the maximum and minimum values of e to consider the effect on the direction of motion	AO2.4	E1	Since $0 \le e \le 1$ then expressions for the speeds above are both positive
	Deduces that the spheres both travel in the same direction after the collision and justifies their conclusion	AO2.2a	R1	Hence the spheres both travel in the same direction

4(d)	Recalls the formula for impulse and substitutes a pair of corresponding velocities into the impulse formula	**AO1.1a**	**M1**	$I = 4mv_B - 4mu_B$ $I = \frac{4mu(3-2\mathrm{e})}{5} - 4mu$ $I = \frac{8mu(1+e)}{5}$ $0 \le e \le 1$ $\frac{8mu}{5} \le I \le \frac{16mu}{5}$
	Substitutes 0 or 1 for e into 'their' expression	**AO1.1a**	**M1**	
	Completes a rigorous argument using algebraic expressions for the velocities, the formula for impulse and the range of values for e to verify the stated inequality.	**AO2.1**	**R1**	
	Total		**11**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(a)	Uses correct formula to obtain an expression for the magnitude of the resultant force or the acceleration	AO3.4	M1	Force towards centre of circle = $\frac{990v^2}{48}$
	Forms a correct equation involving friction	AO1.1b	A1	Friction = $\frac{990v^2}{48}$
	Deduces the value of F to be used and substitutes to find the maximum safe speed in m s $^{-1}$	AO2.2a	M1	$v = \sqrt{\frac{48(7300)}{990}}$
	Obtains the correct maximum safe speed converting to miles per hour AWRT 40	AO1.1b	A1	v = 18.8(13..) m s^{-1} v = 42 mph
5(b)	Infers that on a wet day friction would be reduced	AO2.2b	E1	Wet conditions reduce friction
	Infers that the 10000N is incorrect and concludes that Gary's revised assumption is wrong	AO2.2b	E1	10000 N > 9200 N Gary's assumption is wrong
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
6(a)	Uses correct formula for impulse with one velocity negative	AO1.1a	M1	$I = mv - mu$ $I = 250(1.2) - 250(-1.8)$ $I = 750$
	Obtains correct answer of 750	AO1.1b	A1	
6(b)(i)	Forms an equation involving appropriate integral using 'their' value from part (a) to find k	AO3.4	M1	$750 = \int_0^{0.8} kt(4-5t)dt$ As $\int_0^{0.8} t(4-5t)dt = \frac{32}{75}$ Then $k = \frac{750}{32/75} = \frac{28125}{16}$ = 1800 (2sf)
	Evaluates definite integral correctly	AO1.1b	B1	
	Solves equation to find the value for k – follow through their '750'	AO1.1b	A1F	
6(b)(ii)	Deduces when the maximum value of the force occurs and substitutes correct value of t into the formula for the force	AO2.2a	M1	Maximum occurs at t = 0.4 Maximum value is $\frac{28125}{16} \times 0.4 \times [4-5(0.4)] = \frac{5625}{4}$ N = 1400 (2sf)
	Obtains correct value for 'their' maximum force – follow through incorrect k	AO1.1b	A1F	
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
7(a)	Forms a correct equation by applying conversation of energy with KE and PE - substituting the values given	AO3.4	M1	KE gained = PE lost $\frac{1}{2}mv^2 = mgh$ $\frac{1}{2}(75)v^2 = 75g(25)$
	Solves the equation correctly to obtain the value of v – must be rounded correctly to 2 significant figures	AO3.2a	A1	$v^2 = 50g$ Or $v^2 = 490$ v = 22 ms^{-1} (2sf)
7(b)	Forms expressions for EPE and PE	AO3.1b	M1	PE lost = EPE gained $\frac{\lambda x^2}{2l} = mgh$ $\frac{3200x^2}{2(25)} = 75(9.8)(25+x)$
	Obtains fully correct expressions	AO1.1b	A1	$64x^2 - 735x - 18375 = 0$ x = 23.6…
	Solves a three-term quadratic equation or substitutes correct distances for a total length of 50 m into both expressions.	AO1.1a	M1	23.6 + 25 = 48.6 m 48.6 m < 50 m Dominic does not get wet
	Obtains the correct maximum extension of the cord or obtains the correct values for the two energies	AO1.1b	A1	
	Compares ‘their’ results and concludes that Dominic does not get wet	AO3.2a	E1F	
7(c)	Comments that Dominic has size and considers the effect this might have on the distance fallen	AO3.2b	E1	Dominic has size so distance descended would be greater than 48.6 m
	States clearly whether Dominic does or does not get wet, justifying their conclusion	AO3.5a	E1F	He might get wet if he was taller than 1.4 m
	Total		9	
	TOTAL		40	