AQA

AS
Further Mathematics

Mechanics
Mark scheme

Specimen

Version 1.1

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)

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, only the last complete attempt should be awarded marks.

Q	Marking Instructions	AO	Marks	Typical Solution
1	Circles correct answer.	AO1.1b	B1	250 N
	Total		**1**	
2	Circles correct answer.	AO1.1b	B1	$I = \frac{1}{2} \times 0.8 \times 4 = 1.6$ Ns
	Total		**1**	
3(a)	Shows that $c = 0$ by considering the dimensions of mass and deduces that the speed does not depend on the density of the liquid	AO2.2a	M1	$LT^{-1} = (LT^{-2})^a \times L^b \times (MT^{-3})^c$ $0 = c$
	Rejects David's model because speed is shown not to depend on density	AO2.3	A1	Since $c = 0$, v does not depend on the density of the liquid. So David's model is incorrect.
3(b)	Uses dimensions to form an equation for dimensional consistency.	AO1.1a	M1	$LT^{-1} = (LT^{-2})^a \times L^b$ $1 = a + b$ $-1 = -2a$ $a = \frac{1}{2}$ $b = \frac{1}{2}$
	Obtains correct values for a and b.	AO1.1b	A1	
	Total		**4**	

<table>
<tr><th>Q</th><th>Marking Instructions</th><th>AO</th><th>Marks</th><th>Typical Solution</th></tr>
<tr><td>4</td><td>Assumes no external forces act and explicitly identifies that conservation of energy may be applied.</td><td>AO2.4</td><td>R1</td><td rowspan="5">Assuming no external forces act, I can use conservation of energy.

I will model both balls as particles so that the vertical distance moved is the same
$\frac{1}{2}m \times v^2 = \frac{1}{2}m \times 12^2 + mg \times 1.5$
$\frac{1}{2}v^2 = \frac{1}{2} \times 12^2 + g \times 1.5$
$v^2 = 144 + 3g$
$v = \sqrt{144 + 3g}$

Hence v is independent of m so both balls will hit the ground with the same speed
OR
Cricket ball:
$\text{KE} = \frac{1}{2} \times 0.156 \times 12^2$
$= 11.232\text{ J}$
$\text{PE} = 0.156 \times g \times 1.5$
$= 2.2932\text{ J}$
$\frac{1}{2} \times 0.156v^2 = 11.232 + 2.2932$
$v^2 = 173.4$

Tennis ball:
$KE = \frac{1}{2} \times 0.058 \times 12^2$
$= 4.176\text{ J}$
$PE = 0.058 \times g \times 1.5$
$= 0.8526\text{ J}$
$\frac{1}{2} \times 0.058v^2 = 4.176 + 0.8526$
$= 5.0286$
$v^2 = 173.4$

Since v^2 is the same for both balls they both hit the ground with the same speed. AG</td></tr>
<tr><td></td><td>Assumes that the balls are modelled as particles or are the same size so that they move through the same vertical distance</td><td>AO3.3</td><td>B1</td></tr>
<tr><td></td><td>Uses KE equation and PE equation correctly for one of the balls</td><td>AO3.1b</td><td>M1</td></tr>
<tr><td></td><td>Forms an energy equation and manipulates to find v or v^2 for one of the balls</td><td>AO1.1a</td><td>M1</td></tr>
<tr><td></td><td>Completes a rigorous argument using energy considerations to conclude that both balls hit the ground with the same speed, either by clearly calculating values for both balls or showing that v is independent of the mass AG</td><td>AO2.1</td><td>R1</td></tr>
<tr><td></td><td>Total</td><td></td><td>5</td><td></td></tr>
</table>

Q	Marking Instructions	AO	Marks	Typical Solution
5(a)	Forms an equation using conservation of momentum.	AO1.1a	M1	CoM $2\times 4-2\times 3=2v_C+3v_D$ $2v_C+3v_D=2$
	Forms an equation using coefficient of restitution.	AO1.1a	M1	Newton's law of restitution $v_C-v_D=-0.6(-2-4)$
	Obtains two correct equations.	AO1.1b	A1	$v_C-v_D=-3.6$
	Completes a rigorous argument using both conservation of energy and the coefficient of restitution to find speed of *D* to the specified accuracy. Only award if they have a completely correct solution, which is clear, easy to follow and contains no slips.	AO2.1	R1	$5v_D=9.2$ $v_D=1.84$ $=1.8\text{ m s}^{-1}$ to 2 sf
5(b)	Forms equation to find velocity of *C*	AO1.1a	M1	$1.84-v_C=3.6$ $v_C=-1.76$ Speed of $C=1.8\text{ m s}^{-1}$ to 2 sf
	Obtains correct speed for *C*.	AO1.1b	A1	
5(c)	Gives a valid explanation (eg collision is instantaneous, no distance travelled, no work done, no energy lost to friction during collision, etc)	AO2.4	E1	The introduction of friction will not affect my answer to **(b)** because the collision is instantaneous.
	Therefore answer to part **(b)** is not affected by the introduction of friction. (depends on E1 above)	AO2.2a	R1	
	Total		**8**	

Q	Marking Instructions	AO	Marks	Typical Solution
6(a)	Uses fact that at max speed driving force equals resistance	AO3.4	M1	$F = 30 \times 40$ $= 120$
	States or uses $P = Fv$	AO1.2	B1	$P = (30 \times 40) \times 40$ $= 48000$ W
	Obtains correct value for power	AO1.1b	A1	
6(b)	Uses resistance model in a three term equation of motion.	AO3.4	M1	$F - 30 \times 25 = 1200a$
	Obtains a correct equation of motion.	AO1.1b	A1	$F = 1200a + 750$ $48000 = 25(1200a + 750)$
	Solves 'their' equation of motion for a.	AO1.1a	M1	$a = \frac{1920 - 750}{1200}$ $= 0.975 \text{ m s}^{-2}$
	Obtains correct acceleration. FT 'their' equation provided both M1 marks awarded	AO1.1b	A1F	$= 0.98 \text{ m s}^{-2}$ to 2 sf
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
7(a)	Deduces correct value for b.	AO2.2a	B1	$b = 0.02$
7(b)	Forms an integral to find the impulse.	AO3.4	M1	$I = \int_0^{0.02} kt^2(t-0.02)^2\,dt$
	Integrates terms and uses limits or uses a calculator for definite integral (PI)	AO1.1a	M1	$= k\int_0^{0.02} (t^4 - 0.04t^3 + 0.0004t^2)\,dt$
	Obtains correct value for impulse. (AWRT 1.1 $\times 10^{-10}$)	AO1.1b	A1	$= k\left[\frac{t^5}{5} - \frac{t^4}{100} + \frac{t^3}{7500}\right]_0^{0.02}$ $= k \times 1.07 \times 10^{-10}$ N s
7(c)	Uses 'impulse equals change in momentum' to form an equation, with 'their' impulse from **(a)**.	AO3.4	M1	$k \times 1.07 \times 10^{-10} = \lvert 0.15 \times 4 - 0.15 \times (-2) \rvert$
	Obtains a correct equation for 'their' impulse.	AO1.1b	A1F	$k = \frac{0.9}{1.07 \times 10^{-10}}$
	Obtains the correct value for k. CAO	AO1.1b	A1	$= 8.4 \times 10^9$
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
8(a)	Forms an energy equation between PE and EPE	AO3.3	M1	$0.5\times2\times10=\frac{\lambda}{2\times0.2}\times0.4^2$
	Obtains correct value for λ or k	AO1.1b	A1	$\lambda=\frac{10}{0.4}$ $=25\text{ N}$
	Using Hooke's Law to find extension at equilibrium	AO3.4	M1	$2\times10=\frac{25}{0.2}e$
	Obtains correct extension at equilibrium using 'their' λ or k	AO1.1b	A1F	$e=\frac{2\times10\times0.2}{25}$ $=0.16$
	Forms equation using conservation of energy.	AO3.4	M1	$2\times10\times0.26=\frac{1}{2}\times2v^2+\frac{25\times0.16^2}{2\times0.2}$ $v^2=3.6$
	Obtains the correct speed. (Only accept $V=2\text{ m s}^{-1}$)	AO1.1b	A1	$v=1.897...$ $=2\text{ m s}^{-1}$ (to 1 sf)
8(b)	States appropriate refinement.	AO3.5c	E1	Could include air resistance.
	Total		**7**	
	TOTAL		**40**	