AQA

A-LEVEL
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	$I = 0.2\times5 - 0.2\times(-7) = 2.4\,\text{N s}$
	Total		**1**	
2	Circles correct answer	AO2.2a	B1	$Fl = mv^2$
	Total		**1**	
3(a)	Forms equation to find the centre of mass.	AO1.1a	M1	$\overline{x} = \dfrac{3.7\times20 + 2\times22.5}{42.5} = 2.8$
	Obtains correct answer.	AO1.1b	A1	
(b)	Forms an equation using moments.	AO1.1a	M1	Moments about *C*:
	Obtains correct moment equation, follow through 'their' centre of mass provided both M1 marks have been awarded	AO1.1b	A1F	$42.5\times9.8\times2.3 = 2.5R_D$
	Obtains one correct reaction force for 'their' equation. Allow more than 2 sf accuracy FT provided both M1 marks awarded	AO1.1b	A1F	$R_D = \dfrac{957.95}{2.5}$ $= 383.18\ \text{N}$ $= 380\,\text{N (2sf)}$
	Obtains both reaction forces correctly to 2 sf accuracy, follow through 'their' reaction force, provided both M1 marks have been awarded.	AO1.1b	A1F	$R_C + R_D = 42.5\times9.8$ $R_C = 416.5 - 383.18$ $= 33.32\ \text{N}$ $= 33\,\text{N (2sf)}$
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
4(a)	Uses conservation of momentum to form an equation, with correct terms. (Condone sign errors.)	AO3.1b	M1	CoM: $0.8\times 6+0.4\times(-6)=0.8\times(-1.2)+0.4v_B$ $2.4=-0.96+0.4v_B$ $v_B=8.4$ Newton's law of restitution: $-1.2-8.4=-e(6-(-6))$ $e=\frac{9.6}{12}=0.8$
	Obtains correct velocity for *B* after the collision.	AO1.1b	A1	
	Uses law of restitution to obtain an equation to find the velocity of *A*, with correct terms and 'their' velocity for *B*.	AO3.1b	M1	
	Obtains a correct equation for 'their' values, follow through their other velocity, provided all M1 marks have been awarded.	AO1.1b	A1F	
	Completes a rigorous argument to reach the correct coefficient of restitution. **AG** Must use correct signs with the velocities.	AO2.1	R1	
4(b)	States a valid refinement.	AO3.5c	E1	Include friction, which will reduce the speed of the discs as they move towards each other before the collision
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
5(a)	Resolves vertically to form an equation to find the tension.	AO3.1b	M1	$0.4 \times 9.8 = T\cos 30°$ $T = 4.5\,\text{N}$
	Finds correct tension.	AO1.1b	A1	
(b)	Finds radius.	AO1.1b	B1	$r = 0.6\sin 30°$ $= 0.3$
	Forms an equation to find angular speed with 'their' radius and 'their' tension.	AO3.1b	M1	$T\sin 30° = 0.4 \times r\omega^2$
	Obtains correct angular speed to 2 sf. FT 'their' values provided both M1 marks have been awarded	AO1.1b	A1F	$\omega = \sqrt{\dfrac{4.5\sin 30°}{0.4 \times 0.3}}$ $= 4.3\ \text{rad}\,\text{s}^{-1}$
(c)	States two appropriate assumptions.	AO3.5b	B1	Light and inextensible.
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
6(a)	Forms an integral to find mass.	AO1.1a	M1	$M = \rho\int_0^2 \frac{\pi x^4}{4}\,\mathrm{d}x$
	Obtains correct mass.	AO1.1b	A1	$= \pi\rho\left[\frac{x^5}{20}\right]_0^2$
	Forms an integral of the form $\int xy^2\,\mathrm{d}x$	AO1.1a	M1	$= \frac{8}{5}\pi\rho$
	Obtains correct value of $\int xy^2\,\mathrm{d}x$.	AO1.1b	A1	$\overline{x}\times\frac{8}{5}\pi\rho = \int_0^2 \frac{\pi\rho x^5}{4}\,\mathrm{d}x$
	Obtains correct centre of mass, follow through 'their' mass provided both M1 marks have been awarded.	AO1.1b	A1F	$= \pi\rho\left[\frac{x^6}{24}\right]_0^2$
				$= \frac{8}{3}\pi\rho$
				$\overline{x} = \frac{5}{3}$
(b)	Uses trigonometry and 'their' centre of mass to form equation to find angle.	AO3.1b	M1	$\tan\alpha = \frac{2}{2-\frac{5}{3}}$
	Finds the correct angle to the required accuracy. FT 'their' values provided all M1 marks have been awarded	AO1.1b	A1F	$\alpha = 80.5°$
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
7	Uses $P = Fv$.	AO1.2	B1	Driving force = $\frac{90\,000}{v}$
	Forms an equation with resultant force = 0, with correct terms. (Condone sign errors.)	AO3.4	M1	$\frac{90\,000}{v} + 1200g\sin\left(5.2^\circ\right) - 36v = 0$
	Obtains fully correct equation.	AO1.1b	A1	
	Rearranges 'their' equation into a quadratic equation. PI by correct answer	AO1.1a	M1	$36v^2 - 1200g\sin\left(5.2^\circ\right)v - 90000 = 0$
	Obtains correct speed to 2 sf. FT 'their' values provided both M1 marks have been awarded	AO1.1b	A1F	$v = 67\ \text{m s}^{-1}$
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
8(a)	Uses conservation of energy to form an equation.	AO3.4	M1	$\frac{1}{2}mv^2 = mg\left(\frac{r}{4} + (r - r\cos\theta)\right)$
	Forms correct equation.	AO1.1b	A1	$\frac{1}{2}v^2 = gr\left(\frac{1}{4} + 1 - \cos\theta\right)$
	Completes mathematical argument to find v. **AG** Only award if they have a completely correct solution, which is clear, easy to follow and contains no slips with the change in height shown clearly and correctly.	AO2.1	R1	$v^2 = 2gr\left(\frac{5}{4} - \cos\theta\right)$ $= \frac{gr}{2}(5 - 4\cos\theta)$ $v = \sqrt{\frac{gr}{2}(5 - 4\cos\theta)}$
(b)	Resolves radially to form equation to find θ.	AO3.4	M1	$mg\cos\theta = \frac{m}{r}\frac{gr}{2}(5 - 4\cos\theta)$ $2\cos\theta = 5 - 4\cos\theta$ $\cos\theta = \frac{5}{6}$ $\theta = 34°$
	Obtains correct value for θ from 'their' equation FT provided both M1 marks awarded	AO1.1b	A1F	
(c)	Explains that air resistance will decrease the speed	AO3.5a	E1	Air resistance would decrease the speed and therefore increase θ.
	Deduces that θ will increase	AO2.2a	R1	
(d)	Explains that the normal reaction will change as the child moves down the slope and friction is proportional to the normal reaction	AO2.4	E1	because $F = \mu N$ and N varies as child moves down the slope
	Total		**8**	

Q	Marking Instructions	AO	Marks	Typical Solution
9(a)	Calculates correct EPE.	AO1.1b	B1	EPE $= \dfrac{65\times 0.7^2}{2\times 1.3} = 12.25\,\text{J}$
	Finds correct value for friction.	AO3.1b	B1	Friction $2\times 9.8\times\cos\left(30^\circ\right)\times 0.6 = 10.184\,\text{N}$
	Forms work-energy equation, with at least two correct terms.	AO3.3	M1	$\text{EPE} = F_r\left(2-d\right)+mg\left(2-d\right)\sin\left(30^\circ\right)+\dfrac{65\left(d-1.3\right)^2}{2\times 1.3}$
	Obtains work-energy equations with correct terms and correct signs.	AO1.1b	A1	
	Solves 'their' energy equation to obtain two solutions. (PI)	AO1.1a	M1	$12.25 = 10.184\left(2-d\right)+9.8\left(2-d\right)+25\left(d-1.3\right)^2$
	Rejects $d = 2$ with a reason.	AO2.4	A1	$25d^2 - 84.984d + 69.968 = 0$ $d = 1.39936$ or 2
	Completes rigorous argument to obtain 1.4. **AG** Only award if they have a completely correct solution, which is clear, easy to follow and contains no slips. All energy terms must be included and two solutions stated for the quadratic equation.	AO2.1	R1	d = 2 represents the starting position so is not a solution given that the particle moves $d = 1.4$ m
(b)	Calculates the component of weight parallel to the plane.	AO3.1b	M1	Component of weight down plane = $2\times 9.8\sin\left(30^\circ\right) = 9.6$
	Compares 'their' (sum of) friction (and tension) with the component of weight parallel to the plane.	AO2.4	R1	Limiting value of friction = 10.184 > 9.6 (and there is tension too.)
	Determines that particle does not slide back down plane	AO2.2a	R1	∴ Particle does not slide back down the plane.
	Total		**10**	
	Total		**50**	