Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
AS Mathematics (8MA0)
Paper 22 Mechanics

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 80.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper
- ⎾ The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses <u>and indicates which response they wish to submit</u>, examiners should mark this response.
If there are several attempts at a question <u>which have not been crossed out</u>, examiners should mark the final answer which is the answer that is the <u>most complete</u>.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

• Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

• Omission or extra g in a resolution is an accuracy error not method error.

• Omission of mass from a resolution is a method error.

• Omission of a length from a moments equation is a method error.

• Omission of units or incorrect units is not (usually) counted as an accuracy error.

• DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

• Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

• Use of g = 9.81 should be penalised once per (complete) question.

N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.

• Marks must be entered in the same order as they appear on the mark scheme.

• In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

• Accept column vectors in all cases.

• Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

• Mechanics Abbreviations

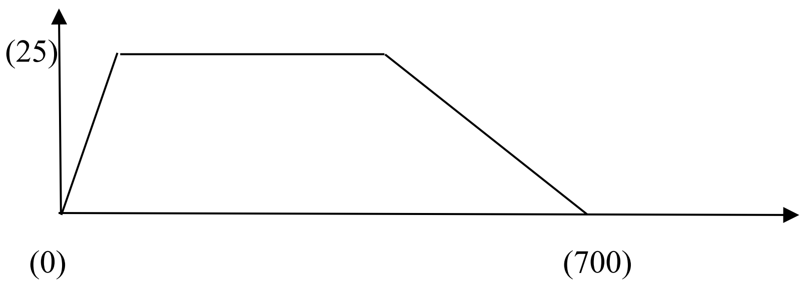
M(A)	Taking moments about A.
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS, LHS	Right hand side, left hand side.

Question	Scheme	Marks	AOs
1(a)	Complete method to produce an equation in U only	M1	3.4
	e.g. $10^2 = U^2 + 2\times g\times 1.8$ oe	A1	1.1b
	OR a **complete** method where they find T first and use it to find an equation in U only M1		
	A correct equation in U only. A1		
	$U = 8$ (only this answer)	A1	1.1b
		(3)	
(b)	Complete method to find an equation in T only: $10 = -8 + gT$ or $1.8 = 10T - \frac{1}{2}gT^2$ or $1.8 = \frac{(-8+10)}{2}T$ or $1.8 = -8T + \frac{1}{2}gT^2$ **OR** a **complete** method if they split the time. In both cases, the M1 is only earned on the final line when they try to add the two times to give an equation in T. **ALT 1**: time up + time down e.g. $0 = 8 - gt_{\text{UP}}$ $(\Rightarrow t_{\text{UP}} = 0.8)$ $h_{\text{UP}} = \frac{(8+0)}{2}\times 0.8$ $(=3.2)$ $(h_{\text{UP}} + 1.8) = \frac{(0+10)}{2}\times t_{\text{DOWN}}$ $(\Rightarrow t_{\text{DOWN}} = 1)$ $T = t_{\text{UP}} + t_{\text{DOWN}}$ **ALT 2:** time to A + time from A to ground e.g. $8 = -8 + gt_A$ $(\Rightarrow t_A = 1.6)$ $1.8 = \frac{(8+10)}{2}\times t_{AG}$ $(\Rightarrow t_{AG} = 0.2)$ $T = t_A + t_{AG}$	M1	3.4
	$T = 1.8$ oe e.g. 9/5	A1	1.1b
		(2)	
(c)	e.g. Use a more accurate (less rounded) value for g (or gravity), use $g = 9.8$ or $g = 9.81$, allow for wind effects, allow for the spin of the stone, include dimensions of stone (not a particle), shape and/or size of stone, allow for variable acceleration. If air resistance is mentioned as an extra, ignore it.	B1	3.5c

		(1)	
(d)	U would be greater. Allow without U, e.g it would be greater, or just 'greater' oe ISW	B1	3.5a
		(1)	
(7 marks)			

Notes:

1a	M1	Use the model to obtain an equation in U only, condone sign errors, but M0 if using an incorrect formula.
	A1	A correct equation in U only, g does not need to be substituted (so allow g = 9.8 or 9.81)
	A1	cao (A0 if g = 10 has not been used)
1b	M1	Use the model to obtain an equation in T only , g does not need to be substituted (so allow g = 9.8 or 9.81) condone sign errors, but M0 if using an incorrect formula. Follow through on their U where necessary
	A1	cao (A0 if g = 10 has not been used) A0 if they give two answers.
1c	B1	Any appropriate refinement. B0 if an incorrect extra is given e.g. the mass or weight is mentioned
1d	B1	cao

Question	Scheme	Marks	AOs
2(a)	 shape	B1	1.1b
		(1)	
(b)	Using *total* area = 15000 to set up an *equation* in **one unknown** Or they may use *suvat* on one or more sections (but must still be considering *all* sections) Allow an attempt at a clear explicit verification using t = 40 e.g. the following would score M1A1A1*: $4\times 40 = 160$ then $700 - 40 - 160 = 500$ $\frac{(700+500)}{2}\times 25 = 15000 = 15$ km Withhold A1* if they don't include = 15 km **N.B.** M0 if a single *suvat* formula is used for the whole journey.	M1	3.4
	$\frac{1}{2}(700+700-t-4t)\times 25 = 15000$ **OR** $\frac{1}{2}\times 25\times t + 25(700-t-4t) + \frac{1}{2}\times 25\times 4t = 15000$	A1	1.1b
	t = 40 (s)*	A1*	1.1b
		(3)	
(c)	0.63 or 0.625 or $\frac{5}{8}$ oe (m s^{-2}) isw	B1	1.1b/ (2.2a)
		(1)	
(d)	Complete method to find the speed or velocity at t = 572 e.g $\pm\left(25-(32\times\frac{5}{32})\right)$ or $\pm\left(128\times\frac{5}{32}\right)$ oe	M1	3.1b
	20 (m s^{-1})	A1	1.1b
		(2)	
(e)	e.g. (the train) cannot instantaneously change acceleration, (the train) won't move with <u>constant</u> acceleration , (the train) won't move with <u>constant</u> speed Allow negatives of these:	B1	3.5b

	e.g. (The train) moving at constant speed, or just 'constant speed' or 'constant acceleration' (is a limitation of the model) Must be a limitation of the model, so friction or air resistance or size of train is B0. **N.B.** Ignore incorrect **reasons** following a correct answer.		
		(1)	
			(8 marks)

Notes:		
2a	B1	Overall shape of graph, starting at the origin, with deceleration phase *longer* than the acceleration phase if nothing on the t-axis but ignore the relative lengths and allow if t (or 40) and $4t$ (or 160) are clearly and correctly marked. Ignore incorrect figs on the axes. This mark can be earned if the graph appears anywhere in qu 2.
2b	M1	Need *all* sections to be included, with <u>correct structure for each section,</u> with $\frac{1}{2}$'s where appropriate. <u>Allow = 15 or 150 or 1500 etc instead of 15000</u>
	A1	A correct equation **in their *t* only, seen or implied** (or with $t = 40$ for verification)
	A1*	cso. At least one line of working with brackets removed and t's collected, or equivalent
2c	B1	cao
2d	M1	Any complete method, must have correct figs, but condone sign errors
	A1	cao. Must be positive and exact i.e must not come from rounding.
2e	B1	Any appropriate limitation <u>of the model</u>. B0 if any incorrect extra **answers.**

Question	Scheme	Marks	AOs
3(a)	Differentiate s wrt t	M1	3.1a
	$(v =)\ t^2 - 5t + 6$	A1	1.1b
	Equate their v to 0 and solve	M1	1.1b
	$t = 2$ or 3	A1	1.1b
	$(a =)\ 2t - 5$	B1**ft**	2.1
	$a =$ 1 and -1 (m s^{-2}) isw (A0 if extras)	A1	1.1b
		(6)	
(b)	Attempt to find values of s for $t = 2$, 3 *and* 4 oe Correct values are $\left(s_2 = \frac{14}{3}, s_3 = \frac{9}{2} \text{ and } s_4 = \frac{16}{3}\right)$ Could be implied by correct values for: s_2 , $(s_3 - s_2)$ and $(s_4 - s_3)$ which are $\frac{14}{3}$, $(-\frac{1}{6})$ and $\frac{5}{6}$	**DM**1	1.1b
	Total distance travelled $= s_2 + (s_2 - s_3) + s_4 - s_3$ **OR** $s_2 - (s_3 - s_2) + s_4 - s_3$ **OR** $\left[\frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t\right]_0^2 - \left[\frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t\right]_2^3 + \left[\frac{1}{3}t^3 - \frac{5}{2}t^2 + 6t\right]_3^4$ **OR** $\frac{14}{3} - (-\frac{1}{6}) + \frac{5}{6}$ **OR** $s_2 + 2(s_2 - s_3) + s_4 - s_2$ $(= 2s_2 - 2s_3 + s_4)$ oe	M1	2.1
	$5\frac{2}{3}$ oe (m) Accept 5.7 or better	A1	1.1b
		(3)	
			(9 marks)

Notes:

3a	M1	Differentiate, with at least 2 powers decreasing by 1
	A1	Correct expression
	M1	Must have attempted to differentiate s to find v and be solving a 3 term quadratic
	A1	Both values needed
	B1**ft**	Follow their v (must be differentiating)

	A1	cao
3b	**DM** 1	This mark is dependent on the 2nd M1 in part (a) and their t values are between 0 and 4. Clear attempt to find all three s values (may integrate their v incorrectly) **N.B.** No penalty for extra values.
	M1	Complete method using their s values Do NOT condone sign errors.
	A1	Any equivalent fraction, 5.7 or better.
		S.C. Correct answer, with no working, scores all 3 marks, since $\int_0^4 \lvert t^2 - 5t + 6 \rvert \, \mathrm{d}t$ entered on a calculator will give $\frac{17}{3}$

Question	Scheme	Marks	AOs
	N.B. Use the mass in the '*ma*' term of an equation to determine which part of the system (cage and block, cage or block) it applies to.		
4(a)	Translate situation into the model and set up the **equation** of motion for the cage and the block to obtain an equation in T only.	M1	3.3
	$T-40g-10g=50\times 0.2$	A1	1.1b
	500 (N) Must be positive	A1	1.1b
	Some examples: $T-50=50\times 0.2$ and $T-40g-10g=50g\times 0.2$ both score M1A0A0		
		(3)	
(b)	Use the model to set up the equation of motion for the block to obtain an equation in R only.	M1	3.4
	$R-10g=10\times 0.2$ Allow $-R$ instead of R	A1	1.1b
	100 (N) Must be positive.	A1	1.1b
	OR: Use the model to set up the equation of motion for the cage to obtain an equation in R only.	M1	3.4
	$T-40g-R=40\times 0.2$ with their T substituted	A1	1.1b
	100 (N) Must be positive	A1	1.1b
		(3)	
			(6 marks)

Notes:
N.B. Only penalise the use of an incorrect value of *g* ONCE for the whole question, so max (a) M1A1A0 (b) M1A1A1

4a	M1	Correct number of terms, condone sign errors
	A1	Correct equation in T only
	A1	cao
4b	M1	Correct number of terms, condone sign errors
	A1	Correct equation in R only
	A1	cao