GCE

Further Mathematics B MEI

Y411/01: Mechanics A

AS Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed-Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

7. There is a NR (**No Response**) option. Award NR (No Response):

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
   - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response: Not applicable in F501
    To determine the level – start at the highest level and work down until you reach the level that matches the answer
    To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **Annotations**

Annotation	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

Subject Specific Marking Instructions

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c. The following types of marks are available.

M

A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words “Determine” or “Show that”, or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep*’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be ‘follow through’. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)
We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
- When a value is given in the paper only accept an answer correct to at least as many significant figures as the given value.
- When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
  NB for Specification A the rubric specifies 3 s.f. as standard, so this statement reads “3 s.f”.

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

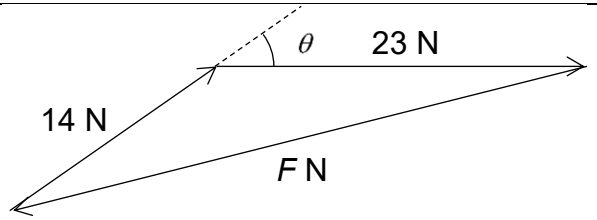
g. Rules for replaced work and multiple attempts:
- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate’s data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.
If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate’s own working is not a misread but an accuracy error.

i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold “In this question you must show detailed reasoning”, or the command words “Show” or “Determine”. Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AOs	Guidance	
1	(a)		$[k] = \mathrm{MT}^{-2}$ So $\mathrm{T} = [\lambda] \cdot \mathrm{M}^{\frac{1}{2}} \cdot \left(\mathrm{MT}^{-2}\right)^{-\frac{1}{2}}$ $\Rightarrow \mathrm{T} = [\lambda] \cdot \mathrm{T} \Rightarrow [\lambda] = 1$, so λ is dimensionless.	**B1** **M1** **A1** **[3]**	**1.2** **1.1** **2.2a**	Correct dimensions of k. *Stated or used in formula* Formulating a dimensional equation. *(or equivalent)* Correct manipulation to $\mathrm{T} = \cdots \mathrm{T}$ or better, and concluding that λ is dimensionless	
	(b)		$1.48 \times \sqrt{3} \approx 2.56$ seconds	**B1** **[1]**	**2.2b**	Accept awrt 2.56. Accept 2.6 (but not 2.60) Allow final answer in exact form	e.g. $\frac{37\sqrt{3}}{25}$

Question			Answer	Marks	AOs	Guidance	
2	(a)		$F = \frac{5}{7} \times 5g = 35$	B1 [1]	3.3	AG	
	(b)			B1 B1 [2]	1.1 1.1	Closed triangle with all forces present. Arrows are required. *Must have obtuse angle between sides 14 and 23* Either the exterior angle θ or the interior angle $180° - \theta$ given in the right place.	
	(c)		$\cos(180° - \theta) = \frac{14^2 + 23^2 - 35^2}{2 \times 14 \times 23}$ $\Rightarrow \theta \approx 39.1°$ (3 sf)	M1 A1 [2]	1.1a 1.1	Cosine rule for any angle in the triangle. Allow wrong sign for cos term *Allow awrt 39.1* *Allow recovery from e.g. using θ in place of (180 −θ)*	*The other angles are 14.6° and 24.5°* 39.068091…
	(d)		F would now be less than F_{max}, so the block would remain in equilibrium.	B1 [1]	2.4	Clear statement that the block will not move, supported by a true and relevant statement about the change, such as *F will decrease* *The resultant pulling force will be less than 35N* *It is no longer in limiting equilibrium* See Exemplars in Appendix	

Question			Answer	Marks	AOs	Guidance	
3	(a)		Driving force $D = \frac{P}{22}$	**B1**	**3.3**	Seen or implied. *Must use 22*	
			$D - 1200g\sin 3° = 1200 \times 0.4$	**M1**	**1.1**	Attempt at N2L. All terms present Allow $\sin \leftrightarrow \cos$ and sign errors Allow omission of g	$D = 1095$
			$\Rightarrow P \approx 24100$ W	**A1** **[3]**	**1.1**		24100.3586…
	(b)		$D - 1200g\sin 3° = 0 \quad (D = 615.47)$	**M1**	**3.4**	N2L with acceleration zero. Allow omission of g	
			$\Rightarrow v_{\max} = \frac{40000}{D} \approx 65$ m s^{-1}	**A1** **[2]**	**1.1**	*Correct answer www implies M1A1*	64.99089…
	(c)		$\frac{1}{2}(1200)28^2 + 1200(9.8)(600\sin 5°) + W = \frac{1}{2}(1200)15^2$	**B1** **B1**	**1.1** **1.1**	Correct GPE term. Either KE term correct	Allow use of constant acceleration: $mg\sin\theta - B = ma$
			$470400 + 614971 + W = 135000$	**M1**	**3.3**	Attempt at WEP: at least 3 work/energy terms present; allow sign errors; no extra terms	***Within*** a N2L equation, **B1** for $1200(9.8)\sin 5°$ [=1025] **B1** for $1200 \times \frac{15^2 - 28^2}{1200}$ [$= (-)559$] ($a = -0.466$) **M1** for N2L with all terms present **and** $W = 600B$ $1025 - B = -559 \quad (B = 1584)$
			$\Rightarrow W \approx (-)950000$ J	**A1** **[4]**	**1.1**	Allow positive answer	**A1** for $(-)950000$ (950370.920…) *Ignore wrong units* *Accept awrt 950000 to **3** sf* *ISW if they go on to find the force, provided the WD has been clearly identified. A0 if it is ambiguous* *Treat 3° used as a MR. In this case MR can be implied by answers (PE = 369000 WD = 705000)*
	(d)		e.g. Air resistance may be taken into account.	**B1** **[1]**	**3.5c**	Any valid mention of resistance.	*Allow friction. Ignore wrong statements such as 'friction between the car and the road'.*

Question			Answer	Marks	AOs	Guidance	
4	(a)		16 [N s] towards B (or the bumper), or to the right	**B1** **B1** **[2]**	**1.1** **2.4**	*Allow* -16 *Ignore wrong units* *Allow direction of impulse clearly indicated by an arrow*	
	(b)		In the first scenario, let the speed of AB immediately after A and B collide be w m s^{-1}.				
			$2\times 8+3\times 4=5w$	**M1***	**3.3**	Attempt at COLM. Allow one minor error, e.g. wrong sign, masses interchanged, but a missing mass is M0. Allow v used in place of w	
			$\Rightarrow w=5.6$	**A1**	**1.1**	For $(\pm)5.6$ Allow $v=(\pm)5.6$	
			$\Rightarrow v=5.6e$	**M1dep***	**3.4**	$v = e \times$ their 5.6 Allow $v=-5.6e$ oe (e.g. $e=v/5.6$). Not just $5.6e$	
			In the second scenario, B will have speed $4e$ (towards A) before collision.	**B1**	**1.1**	Seen or implied.	
			$2\times 8-3\times 4e=5v$	**M1**	**3.3**	Attempt at COLM. Allow one minor error. Must include the term $5v$ e.g. $2\times 8+3u_B=5v$ gets M1	
			So $16-12e=5\times 5.6e\Rightarrow e=\frac{2}{5}$	**A1**	**1.1**	www	
			$v=5.6\times\frac{2}{5}=2.24$	**A1** **[7]**	**1.1**	www Accept 2.2	

Question			Answer	Marks	AOs	Guidance	
5	(a)		Let the centre of mass lie at $(\bar{x}, \bar{y})$. $\bar{x}$ [$= 15 + \frac{1}{3}(90 - 15)$ or $\frac{0+30+90}{3}$] $= 40$ $\bar{y} = \frac{1}{3} \times 50 = 16\frac{2}{3}$	 B1 B1 [2]	 1.1 1.1	 Accept 17	
	(b)		$40 > 30$, so the centre of mass lies outside the base.	B1 [1]	2.4	Must refer to (their) $\bar{x}$ Accept e.g. 'CoM lies to right of A' Just 'CoM lies outside the base' is B0	
	(c)		$\tan\theta = \frac{40-30}{16\frac{2}{3}}$ $\Rightarrow \theta \approx 31°$	M1 A1 FT [2]	3.1b 1.1	Use of tan and correct dimensions. Allow reciprocal for this mark. Or complete alternative method (e.g. Pythagoras and sin or cos) FT is $\tan^{-1}\frac{\bar{x}-30}{\bar{y}}$ *provided* $30 < \bar{x} < 90$ *and* $0 < \bar{y} < 50$ *Correct (ft) answer www implies M1A1*	*Hypotenuse is* 19.4 *or* $\frac{10\sqrt{34}}{3}$ 30.96375…
	(d)		Let the weight of S be *W*. Let X be (40, 50). $R_A = W$ and $R_B = F$ $F = \mu R_A$ Moments about A: $10W = 50R_B$ $\Rightarrow 10W = 50\mu W \Rightarrow \mu = \frac{1}{5}$	 B1 B1 M1 A1 FT [4]	 1.1 3.3 1.1 1.1	*When forces are not identified on the diagram, allow implication by convention (W or mg for weight, F for friction) or by consistent use in two equations.* *Allow m or e.g. 750 for weight* *Can be implied, e.g. on diagram* *Implied by sufficient correct (ft) equations to find* F/R_A *e.g.* M(B) and $R_A = W$, *e.g.* M(X), *e.g.* M(O) and M(A) and M(B) *Stated or clearly implied at any stage, e.g. by* $F = \mu W$ Moments about any point. Allow sign errors only. FT their $\bar{x}$ M(O): $40W = 30R_A + 50R_B$ M(B): $60R_A = 50F + 50W$ M(X): $10R_A = 50F$ FT is $(\bar{x} - 30)/50$ *if* $30 < \bar{x} < 90$	

Question			Answer	Marks	AOs	Guidance	
6	(a)		We require at least as much KE at the bottom as GPE at the top, so $\frac{1}{2}mu^2 \geq mg \times 3$.	M1	3.1b	Verbal explanation not required. Might be expressed as equation rather than inequality.	
			$\Rightarrow u^2 \geq 6g = 58.8$	A1	1.1	If equation used to start with, some justification must be given as to why u^2 must be at least 58.8 (i.e. an equation cannot just become an inequality at the end). *A0 for an incomplete (or incorrect) explanation*	**AG**
			Alternative method using SUVAT $0 = u^2 - 2gs$ $\Rightarrow s = \frac{u^2}{2g} \geq 3$ so $u^2 \geq 58.8$	M1 A1		Or $v^2 = u^2 + 2(-g)(3)$ (≥ 0) **AG**	
				[2]		*e.g. After s=3 when $u^2 = 58.8$ has been established, 'Reaches 3m if $u^2 \geq 58.8$' is A0* *'Reaches **at least** 3m if $u^2 \geq 58.8$' is A1*	
	(b)		Let the speed of the particle immediately before the first floor impact be v m s^{-1}. $\frac{1}{2}m \cdot 8^2 + mg(2.5) = \frac{1}{2}mv^2$ **or** $v^2 = 8^2 + 2g(2.5)$ $v = \sqrt{113} \approx 10.63$	M1	3.3	Either WEP or SUVAT.	
			So speed immediately after first floor impact $= 0.95 \times \sqrt{113}$ ≈ 10.1	M1 A1 [3]	1.1 1.1	0.95 times their v. **AG**	
	(c)		$10.1^2 > 58.8$ so particle will reach the ceiling.	B1 [1]	1.1	Allow explanation independent of (a)	
	(d)		The only place energy can be lost is in collision with the ceiling, but $e = 1$, which means no energy is lost.	B1 [1]	2.4	Must mention $e = 1$ (or 'perfectly elastic') **and** No energy lost / Speed unaltered (at impact with ceiling)	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AOs</th><th>Guidance</th></tr>
<tr><td>6</td><td>(e)</td><td></td><td>DR
Speed after nth impact with floor is $(0.95)^n \times \sqrt{113}$
Reaches ceiling if $(0.95)^n \times \sqrt{113} \geq \sqrt{58.8}$

$0.95^n > 0.7213... \Rightarrow n\log 0.95 > \log(0.7213...)$

$n < 6.3677...$ so will hit the ceiling 6 times</td><td>M1*
A1

M1dep*

A1</td><td>3.1b
3.3

1.1

1.1</td><td>For $(0.95)^n \times \sqrt{113}$ or $(0.95)^n \times 10.1$
Comparing this with $\sqrt{58.8}$ (oe) to obtain an inequality or equation. Allow $<, \leq, =, \geq$ or $>$. Allow $n-1$ or $n+1$ instead of n
Using logs (up to this step) e.g. $\log_{0.95}(0.7213)$
$n < 6.37$ with no working is M0
Or by trial: critical values of n determined
Correctly explained</td><td></td></tr>
<tr><td></td><td></td><td></td><td><u>Alternative solution calculating successive values</u>
<table>
<tr><th>Impact with floor</th><th>Speed after impact</th><th>Squared speed</th><th>Speed at ceiling</th><th>Potential height</th></tr>
<tr><td>1st</td><td>10.10</td><td>102.0</td><td>6.57</td><td>5.20</td></tr>
<tr><td>2nd</td><td>9.59</td><td>92.0</td><td>5.77</td><td>4.70</td></tr>
<tr><td>3rd</td><td>9.11</td><td>83.1</td><td>4.93</td><td>4.24</td></tr>
<tr><td>4th</td><td>8.66</td><td>75.0</td><td>4.02</td><td>3.82</td></tr>
<tr><td>5th</td><td>8.23</td><td>67.7</td><td>2.98</td><td>3.45</td></tr>
<tr><td>6th</td><td>7.81</td><td>61.1</td><td>1.50</td><td>3.12</td></tr>
<tr><td>7th</td><td>7.42</td><td>55.1</td><td>$\boldsymbol{v^2 = -3.69}$
Or $\boldsymbol{s = 2.81}$</td><td>2.81</td></tr>
</table></td><td>M1*

A1

M1dep*

A1</td><td></td><td>Calculating at least two relevant values for the 4th impact or later

Two correct critical values, e.g. 7.81 and 7.42, found (but not necessarily identified as such)

Critical values identified and related to the number of impacts

Concluding that there are 6 impacts with the ceiling.
All calculations correct and explained</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td><td></td><td></td></tr>
</table>

Question			Answer	Marks	AOs	Guidance
7	(a)		$p-3q+10=0$ $2q+p-50=0$	**M1**	**3.1a**	Both equations needed. May be written in vector form. Allow a sign error in one component only.
			$p=26,\ q=12$	**A1**	**1.1**	
			Taking moments about, e.g. $C(0,1)$: $0.5p+2q+10-50r=13$ $13+24+10-50r=13$	**M1**	**1.1**	Moment involving r of one component (usually 50) about any (specified) point. *Ignore sign* *M0 if it arises from e.g.* $r\begin{pmatrix}10\\-50\end{pmatrix}$ O(0, 0): $-0.5p+2q+3q-50r=13$ $-13+24+36-50r=13$ A(1, 0): $-0.5p+3q-p+50(1-r)=13$ $-13+36-26+50(1-r)=13$ B(1, 1): $0.5p-p+10+50(1-r)=13$ $13-26+10+50(1-r)=13$ (1, 0.5): $1.5q-p+5+50(1-r)=13$ $18-26+5+50(1-r)=13$ (0.5, 0.5): $q+1.5q-0.5p+5-50(r-0.5)=13$ $12+18-13+5-50(r-0.5)=13$ (r, 0): $-0.5p+2q(1-r)+3q-pr=13$ $-13+24(1-r)+36-26r=13$
				A1	**1.1**	Correct moments equation. *In terms of p and q, or ft their values*
			$\Rightarrow r=0.68$	**A1**	**1.1**	cao and www
			<u>Alternative solution using moments equations</u> Considering moments about any (specified) point	**M1***		Same as for M1 above
				A1*		One correct moments equation *See above*
			Obtaining moments equations about three non-collinear points **and** solving for at least one of *p, q, r* $p=26,\ q=12,\ r=0.68$	**M1dep***		<u>Dependent on previous M1A1</u> *Or two moments equations and one resolving equation* www Give A1 for one correct
				A2		
				[5]		

Question			Answer	Marks	AOs	Guidance
7	(b)		$6\begin{pmatrix}\bar{x}\\ \bar{y}\end{pmatrix}=2\begin{pmatrix}\lambda\\ \lambda^2\end{pmatrix}+3\begin{pmatrix}1\\ 0\end{pmatrix}+1\begin{pmatrix}0\\ 1\end{pmatrix}$	**M1**	**1.1**	Correct equation for at least one of $\bar{x}$ or $\bar{y}$. Need not be written in vector form. *Allow one slip (e.g. 5 for 6). For M1, ignore any terms involving mass of the lamina*
			$\bar{x}=\frac{1}{6}(2\lambda+3)$	**A1**	**1.1**	
			$\bar{y}=\frac{1}{6}(2\lambda^2+1)$	**A1**	**1.1**	*Correct answer(s) www imply M1A1(A1)*
				[3]		
	(c)		$\lambda=\frac{1}{2}(6\bar{x}-3)$	**M1***	**3.1a**	Re-write λ in terms of the x-coordinate of the CoM
			$\bar{y}=\frac{1}{6}\left(2\left(\frac{1}{4}(6\bar{x}-3)^2\right)+1\right)$	**M1dep***	**2.1**	Obtaining an equation in terms of $\bar{x}$ and $\bar{y}$ (or x and y) only
			$y=3x^2-3x+\frac{11}{12}$	**A1**	**1.1**	Correctly obtained After M0M0, **SC1** for $k=\frac{11}{12}$
			Alternative solution using substitution $\frac{1}{6}(2\lambda^2+1)=3\left\{\frac{1}{6}(2\lambda+3)\right\}^2-3\left\{\frac{1}{6}(2\lambda+3)\right\}+k$			*Putting $\lambda=0$ at this stage, or substituting a particular CoM such as $(\frac{1}{2},\frac{1}{6})$ is M0M0,* *but they can earn* **SC1** for $k=\frac{11}{12}$
			$\frac{1}{3}\lambda^2+\frac{1}{6}=\left(\frac{1}{3}\lambda^2+\lambda+\frac{3}{4}\right)-\left(\lambda+\frac{3}{2}\right)+k$	**M1***		Substituting their $\bar{x}$ and $\bar{y}$ into the given equation **and** some manipulation (multiplying out square)
			True for all λ if $\frac{1}{6}=\frac{3}{4}-\frac{3}{2}+k$	**M1dep***		Terms in λ cancelling, and obtaining an equation for k
			$k=\frac{11}{12}$	**A1**		
				[3]		

APPENDIX

Exemplar responses for Q2(d)

Response	Mark
The block would remain stationary as F would change to oppose this change and F would actually decrease	**1**
System stays in equilibrium. Magnitude of 14N and 23N now decreases	**1**
The horizontal force is less and the block can't move	**1**
It stays in equilibrium – no longer limiting equilibrium	**1**
The block will stay where it is and no longer be in limiting equilibrium, as there is more force pulling sideways rather than straight	**1**
F_{max} = (5/7) x 5g = 35N $\sqrt{14^2 + 23^2} = 26.9$ $35 > 26.9$ Block remains stationary as frictional force is greater than pulling force *Has considered a particular case ($\theta = 90°$). BOD frictional force means F_{max}*	**1**
It will remain stationary, since the magnitude exerted by both of the strings is less than it was. The value of F_{max} is greater *Ignore the final (ambiguous) sentence*	**1**
The block is no longer in equilibrium and the pulling force is now LESS than the maximum frictional force, so the box will be stationary *Not clear; possibly meant 'no longer in limiting equilibrium'*	**0**
The block remains in equilibrium and does not move as the maximum potential F is greater *Not clear: greater than before would be B0, greater than resultant pulling force would be B1*	**0**
It won't move as friction will still be greater *The friction will actually be less*	**0**
Nothing would happen as the block's frictional force would be strong enough to hold the block still keeping it in equilibrium *This does not say anything about the effect of the change*	**0**
The block will not move as the force of friction will oppose the force *Nothing about the effect of the change*	**0**

The block will not move, and the direction the frictional force acts will change to oppose the motion *The direction of the frictional force is not relevant*	**0**
The block will stay in limiting equilibrium. Pulling force will remain lower than F_{max} *Limiting equilibrium is not correct*	**0**
35-23-14cos60 = + value. Block would remain *The numerical statement is not relevant*	**0**
The block will remain in equilibrium *No supporting statement*	**0**
The block does not move as when θ is increased $F \geq 14 + 23$ so it doesn't move *Statement about F is not true*	**0**
Nothing, as the forces haven't changed so box would remain in limiting equilibrium *Incorrect statement*	**0**
The block will get further away from point of sliding ∴ reducing friction *Does not say what happens*	**0**
The frictional force will change direction towards 14N force as the 2 forces begin to cancel each other out. Block experiences less friction *Does not say what happens*	**0**
No longer in limiting equilibrium, friction will decrease *Does not say what happens*	**0**
Frictional force decreases so block may slide *'May slide' is incorrect*	**0**

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