GCE

Mathematics B MEI

H640/01: Pure Mathematics and Mechanics

A 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.

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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”.

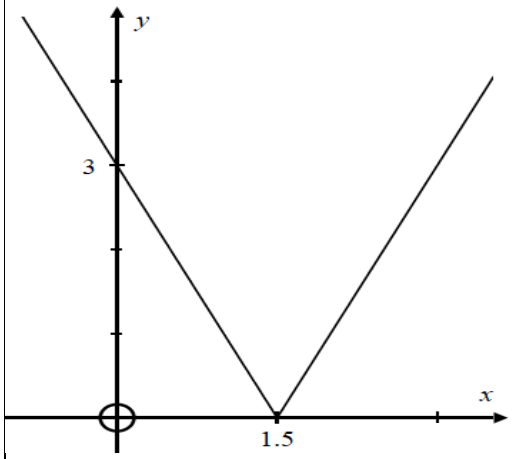
Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

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. E marks are lost unless, by chance, the given results are established by equivalent working. Note that a miscopy of the candidate’s own working is not a misread but an accuracy error.

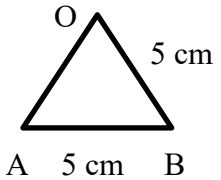
i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold “In this question you must show detailed reasoning”, 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	AO	Guidance
1	(a)		B1 B1 [2]	1.1 1.1	V shaped graph (approximately symmetric for vertical mirror line) Must be for positive and negative values of x Single vertex at (1.5, 0), and (0, 3) seen
1	(b)	**DR** $2x - 3 = 4 - x$ and $2x - 3 = -(4 - x)$ Either $3x = 4 + 3$ or $x = -4 + 3$ $x = \frac{7}{3}$ or $x = -1$	 B1 M1 A1	 1.1a 1.1 1.1	 Two correct linear equations equating $2x - 3$ to $\pm(4 - x)$ oe Attempts to solve at least one equation. Both values seen
		Alternative method $(2x - 3)^2 = (4 - x)^2$ $3x^2 - 4x - 7 = 0$ $x = \frac{7}{3}$ or $x = -1$	 B1 M1 A1		 Correct equation seen Collects terms to form 3 term quadratic and attempt to solve Both values seen
			[3]		

Question			Answer	Marks	AO	Guidance	
2			$\frac{7x-25}{(x-1)(x-4)^2} = \frac{A}{x-1} + \frac{B}{x-4} + \frac{C}{(x-4)^2}$	M1	1.1a	Sets up partial fractions of the correct form	
			$7x - 25 = A(x-4)^2 + B(x-1)(x-4) + C(x-1)$	M1	1.1	Clears the denominator (for their form with at least two fractions).	Not dependent on previous M1
			When $x = 4, 28 - 25 = 3C$ giving $C = 1$ When $x = 1, 7 - 25 = 9A$ giving $A = -2$	M1	1.1	Uses at least one value of x leading to a value for one of the constants (for their form)	Allow for equating coefficients for at least one power of x leading to a value for one of the constants
			Equate coefficients of x^2 $0 = A + B$ giving $B = 2$ $\frac{-2}{x-1} + \frac{2}{x-4} + \frac{1}{(x-4)^2}$	A1	1.1	Fully correct expression must be seen	
						SC If $\frac{7x-25}{(x-1)(x-4)^2} = \frac{A}{x-1} + \frac{Bx+C}{(x-4)^2}$ used, award M0 and up to M1 M1 SC B1 for $\frac{7x-25}{(x-1)(x-4)^2} = \frac{-2}{x-1} + \frac{2x-7}{(x-4)^2}$	
				[4]			

Question			Answer	Marks	AO	Guidance
3	(a)		$\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\frac{1}{4}=\frac{25}{12}$	B1 [1]	1.1	Must be in lowest terms. Allow $2\frac{1}{12}$ BC
3	(b)		Sum $=\sum_{r=1}^{5}(2r-1)$ or $\sum_{r=0}^{4}(2r+1)$	M1 A1 [2]	3.1a 2.5	Correct function to generate odd numbers. Condone no brackets Correct limits for their expression using sigma notation Brackets must be seen. Do not allow $\sum_{r=1}^{5}(r+(r-1))$, $\sum_{r=1}^{5}(2n-1)$ or similar
3	(c)		The series is increasing, so the sum of *n* terms forms a divergent sequence so there is not well defined sum to infinity	B1 [1]	2.4	Explains in technical language or otherwise that the sum gets bigger the more terms added in so the sum to infinity is not a number. See appendix

Question			Answer	Marks	AO	Guidance
4						
			Angle AOB $= 60°$ or $\frac{\pi}{3}$ (equilateral triangle)	**B1**	**1.1a**	May be implied by $\frac{1}{6}$ or $\frac{5}{6}$ seen
			Angle in major sector is $2\pi - \frac{\pi}{3}\left(= \frac{5\pi}{3}\right)$	**M1**	**3.1a**	Uses their AOB to find the angle in the major sector soi
			Area of major sector is $\frac{1}{2}r^2\theta = \frac{1}{2} \times 5^2 \times \frac{5\pi}{3}$	**M1**	**1.1a**	Uses sector formula with their θ soi
			$= \frac{125\pi}{6}$	**A1**	**1.1**	Accept awrt 65.4 or 65.5
			Alternative method for last 3 marks			
			Area of minor sector is $\frac{1}{2}r^2\theta = \frac{1}{2} \times 5^2 \times \frac{\pi}{3} = \frac{25\pi}{6}$	**M1**		Uses their AOB to find the area of the minor sector soi
			Area of major sector is $25\pi - \frac{25\pi}{6}$	**M1**		Subtracts from 25π soi Do not allow for the difference between the areas of the circle and the triangle
			$= \frac{125\pi}{6}$	**A1**		Accept awrt 65.4 or 65.5
				[4]		

Question			Answer	Marks	AO	Guidance	
5			Moments about A				
			$0.1 \times 0.12g = 0.11P$	**M1**	**3.1a**	Attempt to calculate a moment of at least one force about any point	Do not award for oblique distance(s) used without resolving the forces
				A1	**2.1**	Correct moment of weight about A	
			$P = 1.07$	**A1**	**2.1**	**AG** 1.07 obtained from correct total moment equation seen	1.06909… Award if full equation or $10 \times 0.12g$ and $\frac{11.76}{11} = 1.07$ seen
				[3]		Allow full credit for taking moments about another point where the correct force(s) at the hinge is seen.	

Question			Answer	Marks	AO	Guidance	
6	(a)		$v = 0$ when $t = 11$ s	B1	3.1b	soi	May be implied by $t = 6$ used in $suvat$
			Distance $= 5 \times 3 + \frac{1}{2} \times 6 \times 3 + \frac{1}{2} \times 4 \times 2$	M1	1.1	Attempt to find the area between the graph and the x-axis Allow ± 2 used for height of the triangle below the axis soi	Trapezium plus triangle gives $\frac{1}{2} \times 3(11 + 5)$ instead of the first two terms
			$[= 15 + 9 + 4] = 28$ [m]	A1	1.1	cao	
			Alternative method for M1A1				
			Distance = $5 \times 3 + \left(6 \times 3 + \frac{1}{2}\left(-\frac{1}{2}\right) \times 6^2\right) + \left\|\frac{1}{2}\left(-\frac{1}{2}\right) \times 4^2\right\|$	M1		Using $suvat$ equation(s) with $a = -\frac{5}{10}$,	Award M1 even if $t = 10$ used
			$[= 15 + 9 + 4] = 28$ [m]	A1			
				[3]			
6	(b)		Car $D - T - 400 = 1400 \times 1.5$	B1	1.1a	No extra forces Allow a used for 1.5 Any form	RHS may be 2100
			Caravan $T - 450 = 900 \times 1.5$	B1	1.1a	No extra forces Allow a used for 1.5 Any form	RHS may be 1350
				[2]			
6	(c)		Caravan $T - 450 = 900 \times 1.5$ gives $T = 1800$	B1	1.1	cao	
			Add the equations $D - 850 = 2300 \times 1.5$	M1	1.1	Solving their equations leading to a value for D soi	May see use of $T = 1800$ directly. Allow for whole system equation soi
			$D = 4300$	A1	1.1	cao	
				[3]			

Question			Answer	Marks	AO	Guidance	
7			**DR** $x^2 - 7x + 2 = 14 - 9x - x^2$	**M1**	**3.1a**	Attempt to eliminate y	
			$2x^2 + 2x - 12 = 0$ $(x+3)(x-2) = 0$	**B1**	**1.1**	Correct three term quadratic or factors seen	
			$x = -3, 2$	**A1**	**2.1**	Both correct values	
			Area $= \int_{-3}^{2}\left((14 - 9x - x^2) - (x^2 - 7x + 2)\right) \mathrm{d}x$ $= \int_{-3}^{2}(12 - 2x - 2x^2)\,\mathrm{d}x$	**M1***	**3.1a**	Attempts to integrate either function or the difference of two functions. Allow sign error and limits interchanged	Also allow for two separate integrals
			$= \left[12x - x^2 - \frac{2x^3}{3}\right]_{-3}^{2}$	**A1**	**1.1**	Correct indefinite integral	If done as two integrals, both need to be correct
			$= \left(12 \times 2 - 2^2 - \frac{2 \times 2^3}{3}\right) - \left(12(-3) - (-3)^2 - \frac{2(-3)^3}{3}\right)$	**M1(dep)**	**2.1**	Substitution of their limits into their expression seen and subtraction of results seen Allow for limits reversed or subtraction back to front Note: minimum evidence needed for full credit $\left(24 - 4 - \frac{16}{3}\right) - \left((-36) - 9 + 18\right)$	Must see substitution and subtraction in both integrals if done separately.
			$= \frac{125}{3}$	**A1**	**2.1**	**AG** From fully correct working Allow if $-\frac{125}{3}$ found if sign change justified eg "area is positive" Note $\int_{-3}^{2}(14 - 9x - x^2)\,\mathrm{d}x = \left[14x - \frac{9}{2}x^2 - \frac{1}{3}x^3\right]_{-3}^{2} = \frac{485}{6}$ and $\int_{-3}^{2}(x^2 - 7x + 2)\,\mathrm{d}x = \left[\frac{1}{3}x^3 - \frac{7}{2}x^2 + 2x\right]_{-3}^{2} = \frac{235}{6}$	
				[7]			

Question			Answer	Marks	AO	Guidance
8	(a)		Curve intersects $y = 3x + 5$ when			
			$3x + 5 = k - kx - x^2$	M1	3.1a	Attempts to solve simultaneously
			$x^2 + x(k + 3) + (5 - k) = 0$	M1	1.1	Collects terms. Must see $= 0$. May be implied by correct discriminant
			Tangent when equal roots so discriminant $= 0$			
			$(k + 3)^2 - 4(5 - k) = 0$	M1	1.1a	Forms discriminant of their equation and equates to zero
			$k^2 + 10k - 11 = 0$			
			Giving $k = -11, 1$	A1	1.1	cao
			Alternative method			
			For curve $\frac{dy}{dx} = -k - 2x = 3$ at point of contact	M1		Uses gradient of 3 to form an equation linking k and x
			$3x + 5 = k - kx - x^2$	M1		Forms second equation for the point of intersection oe
			Either substitute $x = -\left(\frac{k+3}{2}\right)$ leading to $k^2 + 10k - 11 = 0$	M1		Uses above quadratic equation and an expression for x obtained from gradient to form a quadratic in k only
			Giving $k = -11, 1$	A1		cao
			Or substitute $k = -(2x + 3)$ leading to $x^2 - 2x - 8 = 0$	M1		Uses above quadratic equation and an expression for k to form a quadratic in x only, leading to values for k
			Giving $x = -2, 4$ which gives $k = 1, -11$	A1		cao
				[4]		
8	(b)		Intersect when $-11 + 11x - x^2 = 1 - x - x^2$	M1	2.1	Uses their values for k and attempts to solve simultaneously
			$x = 1$	A1	1.1	
			$(1, -1)$	A1	2.1	Note – using any values of k will give the same point of intersection for full credit
				[3]		

Question			Answer	Marks	AO	Guidance	
9	(a)		$\log_{10} T = \log_{10} k + \log_{10} d^n$ $\log_{10} T = \log_{10} k + n \log_{10} d$	B1 [1]	2.1	Uses laws of logs to split into two terms and then to simplify the second term **AG**	This line must be seen
9	(b)		Gradient $= 1.504 = n$ Intercept $= -8.215 = \log_{10} k$ So $k = 10^{-8.215} [= 6.095 \times 10^{-9}]$	B1 M1 A1 [3]	3.3 3.3 1.1	Allow $n = 1.5$ or better seen soi Allow awrt 6.1×10^{-9} For using 2 data points from the table SC1 awrt $n = 1.5$, SC1 $5.159 \times 10^{-9} < k < 7.076 \times 10^{-9}$	
9	(c)		For Thebe $d = 221900$ Model predicts $T = k \times d^{1.504} = 0.669$ This is close to the given value 0.6761 which suggests that the model is suitable	M1 A1FT	3.4 3.5b	Uses the model to predict Appropriate comment based on similarity of their correct value and the given value. FT their k	Do not accept a comment that implies the model should give an exact match
			Alternative method $-8.215 + 1.504 \log 22190 = -0.174 \ldots$ This is close to $\log 0.6761 = -0.169989 \ldots$ which suggests that the model is suitable	M1 A1		Uses the model to predict $\log T$ Appropriate comment based on similarity of their correct values.	SC1 "Student equation would not be suitable as the data would have to be extrapolated" oe
				[2]			

Question			Answer	Marks	AO	Guidance	
10	(a)		$\frac{\mathrm{d}}{\mathrm{d}x}(\mathrm{e}^{x^2}) = 2x\mathrm{e}^{x^2}$	B1	1.1	Correct derivative of e^{x^2} seen	
			Quotient rule $u = \mathrm{e}^{x^2}$ and $v = x + 1$				
			$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{2x\mathrm{e}^{x^2}(x+1) - 1 \times \mathrm{e}^{x^2}}{(x+1)^2}$	M1	1.1	Uses quotient rule with their $\frac{\mathrm{d}u}{\mathrm{d}x}$ and $\frac{\mathrm{d}v}{\mathrm{d}x}$ oe	Also allow use of the product rule with $(x+1)^{-1}$ giving $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{2x\mathrm{e}^{x^2}}{x+1} - \frac{\mathrm{e}^{x^2}}{(x+1)^2}$
			$= \frac{\mathrm{e}^{x^2}(2x^2 + 2x - 1)}{(x+1)^2}$	A1	1.1	Fully correct. Any form	
				[3]			
10	(b)		Negative when $2x^2 + 2x - 1 < 0$ as the denominator and e^{x^2} are always positive	M1	2.1	Simplifies the problem to a quadratic inequality FT their $\frac{\mathrm{d}y}{\mathrm{d}x}$ Also allow for algebraic attempt to find the stationary point if used to define a range of values	Allow if their $\frac{\mathrm{d}y}{\mathrm{d}x}$ leads to linear or cubic inequality
				B1	1.1a	$\frac{-1+\sqrt{3}}{2}$ or 0.366 seen	
			So $-1 < x < \frac{-1+\sqrt{3}}{2}$	A1	2.5	oe $-1 < x < 0.366$ ...	Do not allow for $\leq$ used in final answer
				[3]			

10	**(c)**		$f(0) + 2(f(0.25) + f(0.5) + f(0.75)) + f(1)$ $[= 7.78014 \ldots]$ Area $\approx \frac{1}{2} \times 0.25 \times 7.78014 \ldots$ $= 0.9725 \ldots$	**M1** **B1** **A1** **[3]**	**1.1** **1.1** **1.1**	Uses 5 values in an attempt to find the total for trapezium rule with correct x-values soi Also allow for the total area of four trapeziums attempted $\frac{h}{2} = \frac{0.25}{2}$ or 0.125 soi	See table below for values

x	0	0.25	0.5	0.75	1
f(x)	1	0.851596	0.856017	1.002888	1.359141
contribution	1	1.703191	1.712034	2.005777	1.359141

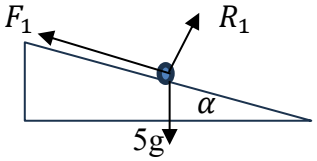
10	**(d)**		Trapezium rule gives an over-estimate because the curve is concave upwards (or convex downwards, or gradient increasing)	**B1** **[1]**	**2.4**	Also allow an explanation that involves extra area under the line that is not in the region. Condone incorrect description of the curve, if the explanation of additional area is clear. See appendix	Allow for comparing exact value of area found BC to their estimate and stating over-estimate

Question			Answer	Marks	AO	Guidance	
11	(a)		$\left(2+\frac{dy}{dx}\right)(y-1)+(2x+y)\frac{dy}{dx}=0$	M1	1.1	Attempt to differentiate both sides of the equation RHS = 0 soi	May see multiplied out (either before or after differentiation)
				M1	1.1	Attempt to use the product rule for LHS Not dependent on first M1	Or attempt to differentiate a term in xy from their multiplied-out LHS.
			$(2y+2x-1)\frac{dy}{dx}+2y-2=0$	M1	2.1	Collects terms. Independent of previous M marks	
			$\frac{dy}{dx}=\frac{2(1-y)}{2y+2x-1}$	A1	2.1	Convincing argument including RHS=0 seen above	**AG**
				[4]			
11	(b)		At (2, 2), $\frac{dy}{dx}=-\frac{2}{7}$	B1	1.1		soi
			Gradient of normal is $\frac{7}{2}$	B1FT	1.1	FT their value for $\frac{dy}{dx}$	Soi Allow $-\frac{2y+2x-1}{2(1-y)}$
			So equation of the normal is $y-2=\frac{7}{2}(x-2)$	B1	1.1	Any form eg $y=3.5x-5$	
				[3]			
11	(c)		If the tangent is parallel to the axis				
			$\frac{dy}{dx}=\frac{2(1-y)}{2y+2x-1}=0$	M1	3.1a	Equates $\frac{dy}{dx}=0$ and attempts to solve . Award if $2-2y=0$ seen	
			So $y=1$	B1	1.1	Award if seen	
			When $y=1, (y-1)=0$ $(2x+y)0=6$ which is not possible	A1	2.1	Clear evidence this is not possible	Eg $0\neq 6$ seen
				[3]			

Question			Answer	Marks	AO	Guidance	
12	(a)		$s = ut + \frac{1}{2}at^2$ with $s = -1, u = 0, t = 1.1$	M1	1.1a	Allow sign errors	
			$a = -1.65$ ms^{-2}	A1	1.1	Must be 3 sf.	Allow $a = 1.65$
				[2]			
12	(b)		$x = 25\cos 40°\, t$	B1	1.1	Oe eg $t = \frac{x}{25\cos 40°}$	$t = 0.0522x$ or $\frac{x}{19.15}$ or $\frac{x}{19.2}$
			$y = 25\sin 40°\, t + \frac{1}{2}at^2$	M1	3.3	Forms equation of motion in the vertical direction	Soi. Allow sign errors. Do not allow if $a = \pm 9.8$ used here or subsequently
			$y = 25\sin 40°\left(\frac{x}{25\cos 40°}\right) + \frac{1}{2}a\left(\frac{x}{25\cos 40°}\right)^2$	M1	2.1	Substitutes expression for t in their y equation	
			$y = 0.839x - 0.00225x^2$	A1	1.1	Cao. Coefficients must be 3sf.	
				[4]			
12	(c)		When $x = 40, y = 30.0[> 15]$	M1	3.4	Use their model and $x = 40$ (29.72 if exact values used)	
			So the ball goes over the crater's edge	A1	3.2a	Conclusion based on correct working. No FT from wrong (b)	Possible interpretation of the question gives $x = \sqrt{40^2 - 15^2} = 5\sqrt{55}$ $= 37.1$ giving $y = 28.0$
			Alternative method				
			When $y = 15, x =$18.8, 354	M1		Use the model with $y = 15$	
			So the ball is above 15m as 40 m is between these values	A1		Conclusion based on correct working No FT for wrong (b)	Possible interpretation $x = \sqrt{1375} = 37.1$ which is between these values.
				[2]		When $x = 40, t = 2.09$ when $y = 15, t = 0.983, 18.5$	

Question			Answer	Marks	AO	Guidance	
13	(a)		When $t = 10$ $\mathbf{r} = \begin{pmatrix} 500 \\ 280 + 50 - 280e^{-1.6} \end{pmatrix}$	M1	3.4	Finds displacement as vector or in two directions separately	Soi Allow use of **i** and **j** vectors throughout
			Distance $= \lvert\mathbf{r}\rvert = \sqrt{500^2 + 273.47^2}$	M1	3.1b	Pythagoras' used	
			$= 569.9$ m	A1 [3]	1.1	Must be scalar answer	
13	(b)		$\mathbf{v} = \begin{pmatrix} 50 \\ 5 + 44.8e^{-0.16t} \end{pmatrix}$	M1	3.4	Attempt to differentiate at least one component	soi
				A1	1.1	One correct component or scalar in one direction	
				A1 [3]	1.1	Both correct components in a vector	
13	(c)		[For large values of t, $e^{-0.16t} \approx 0$]				
			So velocity tends to $\mathbf{v} = \begin{pmatrix} 50 \\ 5 \end{pmatrix}$	B1 B1 [2]	3.4 2.2a	Either value seen Allow for vector or both components clear which is horizontal and which vertical	Do not allow if the final answer is scalar
13	(d)		The model should take into account a resistance in the horizontal (x) direction.	B1 [1]	3.5c	Must indicate the resistance has a horizontal component.	Do not accept "air resistance" on its own. SC1 "Factor e^{-kt} should be included" or similar

Question			Answer	Marks	AO	Guidance
14	(a)		$[-5g\mathbf{j} + R\mathbf{j} \pm F\mathbf{i} + 9\mathbf{i} + 20\mathbf{j} = \mathbf{0}]$			Allow wrong or missing vector equation
			Horizontal component $F = 9$	B1	3.1b	Soi. Allow $\boldsymbol{F} = -9\mathbf{i}$ or $F = -9$
			Vertical direction $R - 5g + 20 = 0$	M1	3.1b	Soi Vertical equation – weight and 20 involved and not 9. Allow sign errors
			$R = 5g - 20$	A1	1.1	Correct equation soi
			On the point of sliding $F = \mu R$ so	M1	3.4	Uses their F and R to evaluate μ. Where $F = \mu \times 5g$ is seen it must be explicit that $5g$ is their reaction and not weight
			So $\mu = \frac{9}{29} =$ [0.310 to 3 sf]	A1FT	1.1	FT their R and F. Final answer must follow from their working and be positive Ignore unsupported $\mu = 0.310$ seen.
				[5]		

Question			Answer	Marks	AO	Guidance
14	(b)					Condone repeated use of F and R throughout even though their values have changed
			Resolve perpendicular $R_1 = 5g\cos\alpha$	B1	3.4	Allow $R - 5g\cos\alpha = 0$ or $F = \mu \times 5g\cos\alpha$ seen explicitly
			Resolve parallel $F_1 = 5g\sin\alpha$	B1	3.3	Allow for $5g\sin\alpha = \mu \times 5g\cos\alpha$ Allow sin/cos interchange if consistent with their R_1
			$F_1 = \frac{9}{29}R_1$ so $\tan\alpha = \mu\left[= \frac{9}{29}\right]$	M1	1.1	Allow for fraction which simplifies to 0.310 or better. FT their μ or 0.310 May be a quoted formula following B0B0
			$\tan^{-1}\frac{9}{29} = 17.2°$	A1 [4]	2.1	**AG** must follow $\mu = 0.310$ correctly calculated in (a)
14	(c)		N2L up the slope $-(5g\sin 17.2° + \frac{9}{29}5g\cos 17.2°) = 5a$	B1 B1FT M1	3.3 3.4 3.1b	Correct weight term seen (Allow ± 14.5 oe) Friction term seen FT their μ (Allow ± 14.5 oe) Formulate equation of motion with their weight. Allow wrong or missing friction. Allow sign errors No extra forces.
			$a = -5.80\ldots$	A1	1.1	Soi Allow 5.8 if down the slope used as positive direction clear (eg on diagram, or $u = -5$ or $a = -5.8$ used subsequently)
			$v = u + at$ with $v = 0, u = 5$ and their a	M1	3.4	$suvat$ equation(s) leading to a value for t. Allow sign errors
			$t = 0.862$ s	A1FT [6]	1.1	FT their acceleration $\neq \pm g$ Using $\alpha = \tan^{-1}\frac{9}{29}$ gives 0.86067

APPENDIX

Exemplar responses for Q3(c)

Response	**Mark**
As it is a divergent sequence [and ever increases]	**B1**
The sequence is not convergent	**B1**
The nth term value is constantly increasing	**B1**
It is constantly increasing	**B0**
It could go on indefinitely	**B0**
Because we can't sum to infinity arithmetic sequences	**B0**
It is an arithmetic sequence	**B0**
The sequence is not geometric sequence so the sum to infinity is infinity	**B0**

Exemplar responses for Q10(d)

Response	**Mark**
Overestimate because the curve is convex/concave	**B0**
Overestimate because the trapeziums would go over the curve line	**B1**
Overestimate because there are gaps between the trapeziums and the graph	**B0**

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