Level 3 Certificate
MATHEMATICAL STUDIES
1350/2C

Paper 2C Graphical techniques

Mark scheme

June 2023

Version: 1.0 Final

236A1350/2C/MS

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 Examiner.

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

Glossary for Mark Schemes

Mathematical Studies examinations are marked in such a way as to award positive achievement wherever possible. Thus, for Mathematical Studies papers, marks are awarded under various categories.

If a student uses a method which is not explicitly covered by the mark scheme 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.

M	Method marks are awarded for a correct method which could lead to a correct answer.
A	Accuracy marks are awarded when following on from a correct method. It is not necessary to always see the method. This can be implied.
B	Marks awarded independent of method.
ft	Follow through marks. Marks awarded for correct working following a mistake in an earlier step.
SC	Special case. Marks awarded for a common misinterpretation which has some mathematical worth.
M dep	A method mark dependent on a previous method mark being awarded.
B dep	A mark that can only be awarded if a previous independent mark has been awarded.
oe	Or equivalent. Accept answers that are equivalent. eg accept 0.5 as well as $\frac{1}{2}$
[a, b]	Accept values between a and b inclusive.
[a, b)	Accept values $a \leq \text{value} < b$
3.14…	Accept answers which begin 3.14 eg 3.14, 3.142, 3.1416
Use of brackets	It is not necessary to see the bracketed work to award the marks.

Examiners should consistently apply the following principles

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.

Responses which appear to come from incorrect methods

Whenever there is doubt as to whether a student has used an incorrect method to obtain an answer, as a general principle, the benefit of doubt must be given to the student. In cases where there is no doubt that the answer has come from incorrect working then the student should be penalised.

Questions which ask students to show working

Instructions on marking will be given but usually marks are not awarded to students who show no working.

Questions which do not ask students to show working

As a general principle, a correct response is awarded full marks.

Misread or miscopy

Students often copy values from a question incorrectly. If the examiner thinks that the student has made a genuine misread, then only the accuracy marks (A or B marks), up to a maximum of 2 marks are penalised. The method marks can still be awarded.

Further work

Once the correct answer has been seen, further working may be ignored unless it goes on to contradict the correct answer.

Choice

When a choice of answers and/or methods is given, mark each attempt. If both methods are valid then M marks can be awarded but any incorrect answer or method would result in marks being lost.

Work not replaced

Erased or crossed out work that is still legible should be marked.

Work replaced

Erased or crossed out work that has been replaced is not awarded marks.

Premature approximation

Rounding off too early can lead to inaccuracy in the final answer. This should be penalised by 1 mark unless instructed otherwise.

Continental notation

Accept a comma used instead of a decimal point (for example, in measurements or currency), provided that it is clear to the examiner that the student intended it to be a decimal point.

Q	Answer	Mark	Comments
1 (a)	13 : 11	B1	

Q	Answer	Mark	Comments
1 (b)	**Alternative method 1**		
	22 + 20 + 22 or 64 or 39 + 41 + 33 or 113	M1	
	(22 + 20 + 22) ÷ 376 or 64 ÷ 376 or 0.17(0…) and (39 + 41 + 33) ÷ 613 or 113 ÷ 613 or 0.18(4…)	M1dep	condone 17.(0…)% condone 18.(4…)%
	0.17(0…) and 0.18(4…) and No	A1	condone 17.(0…)% and 18.(4…)%
	Alternative method 2		
	22 + 20 + 22 or 64 or 39 + 41 + 33 or 113	M1	
	376 ÷ (22 + 20 + 22) or 376 ÷ 64 or 5.8(75) and 613 ÷ (39 + 41 + 33) or 613 ÷ 113 or 5.4(2…)	M1dep	accept any correct rounding or truncation allow 6 and 5 from correct method
	5.8(75) and 5.4(2…) and No	A1	accept any correct rounding or truncation allow 6 and 5 from correct method

Q	Answer	Mark	Comments
1 (b) cont'd	**Alternative method 3**		
	22 + 20 + 22 or 64 or 39 + 41 + 33 or 113	M1	
	(39 + 41 + 33) ÷ (22 + 20 + 22) or 1.7(6…) or 1.77 or 1.8 and 613 ÷ 376 or 1.6(3…)	M1dep	oe inverse method 0.5(6…) or 0.57 and 0.6(1…)
	1.7(6…) or 1.77 or 1.8 and 1.6(3…) and No	A1	oe
	Additional Guidance		
	Do not accept missing brackets unless recovered		
	Any further incorrect method will lose the accuracy mark		
	Can also use comparative ratio		

Q	Answer	Mark	Comments
2 (a)	Any two valid improvements eg **General** Add axes Use a grid/graph paper **Graph 1** Do not repeat Age along the horizontal axis Move the values so they are not obscured by the lines Avoid the symbols overlapping, eg by extending the graph Join the points with straight lines Remove the lines **Graph 2** Increase the spacing between each category Remove the bars for All aged 5 – 15 or remove the word All Remove the bars for Aged 3 – 4 (from graph 2) so the All aged 5 – 15 includes all bars from the graph Make each grouping of ages cover the same number of years Use hatching/patterns to differentiate between the bars	E2	E1 for one valid improvement SC1 two or more errors identified instead of improvements
	Additional Guidance		
	Ignore any additional but non-contradictory suggestions		
	Allow two improvements in one answer space		
	Improvements must be about the graphs not the source of the graphs		
	Label the axis		E0
	Use colour to differentiate between the bars		E0
	Use a better system to differentiate between the bars		E0
	Make age ranges more realistic		E0

2 (a) cont'd	Improve the age ranges on graph 2	E0
	Go up to 18 years old	E0
	WhatsApp (or other platforms) should have been included in graph 2	E0
	Use more visibly different lines to better differentiate between the three sets of data	E0
	Use actual values rather than percentages	E0
	Grid lines	E0
	y-axis	E0
	Add grid lines	E1
	Add y-axis	E1
	Grid lines and y-axis	SC1

Q	Answer	Mark	Comments
2 (b)	(Messaging or social media is) 42(%)	B1	implied by '42% is 35' implied by correct answer
	35 ÷ their 42 or 0.83(…) or 35 ÷ their 42 × 100 or 83.(…) or 35 + 35 ÷ their 42 × 58 or 83.(…)	M1	oe their 42 must be 23 or 38
	83 or 84	A1ft	ft their 42 which must be 23 or 38 allow 80 with [83, 84] or [0.83, 0.84] seen
	Additional Guidance		
	Do not accept 83% or 84% for A1		
	Do not ignore subsequent working for M1		
	35 ÷ 42 × 99 and 82.5 or 82 or 83		B1 M0 A0
	23(%) and 35 ÷ 23 and 152 or 153		B0 M1 A1ft
	38(%) and 35 ÷ 38 and 92 or 93		B0 M1 A1ft

Q	Answer	Mark	Comments
2 (c)	4 hours and 54 minutes is not 4.54 hours or 2 hours and 54 minutes is not 2.54 hours or 0.787 has been rounded (down) from the exact value	E1	oe
	$4\frac{54}{60}$ or 4.9 or 294 (mins) or $2\frac{54}{60}$ or 2.9 or 174 (mins) or $\frac{54}{60}$ or 0.9	M1	oe
	[68.9, 69] (%)	A1	
	Additional Guidance		
	Mark the whole answer space for all three marks		
	He should have converted to minutes		E0
	The decimals are incorrect		E0
	The numbers are incorrect		E0
	He has not converted the time to a number correctly		E0
	He has not converted the time to a decimal correctly		E0
	He has not converted the time to a decimal number of hours correctly		E1
	There are not 100 minutes in an hour		E1
	4.54 hours is 4 hours and 32(.4) minutes		E1
	2.54 hours is 2 hours and 32(.4) minutes		E1
	4 hours and 54 minutes is 4.9 hours		E1
	2 hours and 54 minutes is 2.9 hours		E1
	54 minutes is 0.9 hours		E1
	0.54 hours in 32(.4) minutes		E1

Q	Answer	Mark	Comments
2 (d)	We do not know how many children there are for each age group (in the population) or Only percentages are given or The survey may not be representative (of the population) or The percentages are very close and were taken from a sample or Children may give incorrect information	E1	oe ignore extra non-contradictory reasons condone 'Parents may give incorrect information'

Additional Guidance	
We do not know how many children there are for each age group in the sample	E0
We do not know how many children were surveyed in each age group	E0
The percentages are very close	E0
The percentages were taken from a sample	E0

Q	Answer	Mark	Comments
2 (e)	Any two valid reasons eg Too much information or percentages or numbers, or information in sentence rather than table form Terms or abbreviations are not defined The article is inconsistent with mixed percentages and fractions Fractions written in words rather than using fraction notation The tense of the article is inconsistent Not clear which apps are messaging and which are social media Inconsistent age groups used Some comparisons include overlapping groups, eg 5- to 15-year-olds and 12- to 15-year-olds 12-year-olds or 16-year-olds are ignored in some sections Values in the article sometimes differ from those in the graphs	E2	E1 for each valid reason
	Additional Guidance		
	Allow two reasons in one answer space		
	Ignore incorrect but non-contradictory reasons		

Q	Answer	Mark	Comments
2 (f)	$24 \div 1.41 \times 3.2 \times \frac{2}{3} \div 1.28$ or 28.3(6…) or 24 ÷ 1.41 × 3.2 × 66 ÷ 100 ÷ 1.28 or 28.0(8…)	M4	oe **M3** $24 \div 1.41 \times 3.2 \times \frac{2}{3}$ or 36.3… or 36 (amount in $) or 24 ÷ 1.41 × 3.2 × 66 ÷ 100 or 35.9… or 36 (amount in $) or 24 ÷ 1.41 × 3.2 ÷ 1.28 or 42.55… or 42.6 or 43 (amount in £ for all children in UK) **M2** 24 ÷ 1.41 × 3.2 or 54.468… or 54.47 or 54.5 or 54 (amount in $ for all children in UK) or 24 ÷ 1.41 ÷ 1.28 or 13.297… or 13.29 or 13.3 or 13 (amount in £ per user) or $3.2 \times \frac{2}{3} \div 1410$ or 0.00151… or 0.0015 (proportion of Instagram users who are children in the UK) or 3.2 × 66 ÷ 100 ÷ 1410 or 0.00149… or 0.0015 (proportion of Instagram users who are children in the UK)

The mark scheme for Question 2(f) continues on the next page

Q	Answer	Mark	Comments
2 (f) cont'd			**M1** 24 ÷ 1.41 or 17(.0…) (income in $ per user) or 24 ÷ 1.28 or 18.75 (total income worldwide in £) or 1.41 ÷ 3.2 or 0.44(0…) (scaling factor for multiplication) or 3.2 ÷ 1.41 or 2.2695… or 2.27(0) or 2.3 (scaling factor for division) or $3.2 \times \frac{2}{3}$ or 2.1(3…) (children in UK using Instagram) or 3.2 × 66 ÷ 100 or 2.1(1…) (children in UK using Instagram)
	28	A1	accept 28 million or 28 000 000
	Additional Guidance		
	May work in billions or full dollar/pound values throughout		
	For method marks, condone use of correct digits and ignore place value eg 2.4 ÷ 1.41 × 3.2 × 66 ÷ 100 ÷ 1.28	M4	
	M4 can only be awarded for a complete method that would lead to a correct answer. Do not ignore subsequent working. eg $24 \div 1.41 \times 3.2 \times \frac{2}{3} \div 1.28 \times 0.9$	M3	

Q	Answer	Mark	Comments
3 (a)	1.47(0588…)	B1	oe eg $\frac{25}{17}$ accept 1.5 with 3 ÷ 2.04 seen

Q	Answer	Mark	Comments
3 (b) (i)	**Alternative method 1**		
	Marks their answer to **Question 3(a)** on the horizontal axis under the apex	M1	
	Suitable scale added to horizontal axis for their value	M1dep	must be calibrated using value under the apex
	Horizontal line at speed = 2 ms^{-1} or both intersections indicated at speed = 2 ms^{-1}	M1	implied by readings at intersections
	Reads off both time values at intersections correct to their scale.	M1	may be taken from an incorrectly calibrated scale
	[1.18, 1.27]	A1 ft	ft their answer to **Question 3(a)** 1.5 gives range [1.216,1.292]
	Alternative method 2		
	[36,37] small grid squares Or [7.2,7.4] cm grid squares	M1	
	Their 1.47 ÷ 36.5 or 0.04(02…) or Their 1.47 ÷ 7.3 or 0.2(01…)	M1dep	condone [36,37] small squares condone [7.2,7.4] cm squares
	[30,31] small squares identified Or [6,6.2] cm squares identified or Horizontal line at speed = 2 ms^{-1} or both intersections indicated at speed = 2 ms^{-1}	M1	implied by reading at intersections

Q	Answer	Mark	Comments
3 (b) (i) cont'd	[30,31] × their 0.04 Or [6,6.2] × their 0.2	M1	correct multiplication by their value of a grid square on the scale. may have come from incorrect calibration.
	[1.18,1.27]	A1ft	ft their answer to **Question 3(a)** 1.5 gives range [1.216,1.292]
	Alternative method 3		
	Marks their answer to **Question 3(a)** on the horizontal axis under the apex	M1	
	Suitable scale added to horizontal axis for their value	M1dep	must be calibrated using value under the apex
	[30,31] small squares identified or [6,6.2] cm squares identified or Horizontal line at speed = 2 ms^{-1} or both intersections indicated at speed = 2 ms^{-1}	M1	implied by reading at intersections
	[30,31] ÷ [52,53] × end time on their scale or [6,6.2] ÷ [10.4,10.6] × end time on their scale	M1	end time defined when the speed plot terminates for correct scale end time is [2.028,2.12]
	[1.18, 1.27]	A1	
	Additional Guidance		
	Horizontal line at 2 ms^{-1} must extend to show both intersections		
	Correct answer to **Question 3(a)** leads to horizontal calibration of Small grid squares equivalent to [0.039, 0.04] cm square grid squares equivalent to [[0.198, 0.2]		
	An answer of 6.12 for **Question 3(a)** leads to horizontal calibration of Small grid squares equivalent to [0.165, 0.17] cm square grid squares equivalent to [0.825, 0.85] Leading to a final answer of [4.95, 5.27]		

Q	Answer	Mark	Comments
3 (b) (ii)	(Slope) constant positive and (Run-out) constant negative or (Slope) constant acceleration and (Run-out) constant deceleration	B2	B1 (Slope) constant positive or (Run-out) constant negative or (Slope) positive acceleration and (Run-out) negative acceleration or (slope) acceleration and (Run-out) deceleration or (Slope) constant and (Run-out) constant
	Additional Guidance		
	Do not accept increase for positive and decrease for negative.		
	Accept deceleration for negative (acceleration) and allow it to imply acceleration is positive.		
	Do not accept descriptions of speed		
	(Acceleration) increases at constant rate and (acceleration) decreases at a constant rate.		B0
	(Speed) increases constantly and (speed) decreases constantly		B0

Q	Answer	Mark	Comments
3 (c)	$l = 1.7\,\text{m}$ $h = 1.4\,\text{m}$	B1	

Q	Answer	Mark	Comments
4 (a)	Quadratic	B1	

Q	Answer	Mark	Comments
4 (b)	Straight line with y-intercept 2.6 m or straight line with gradient -0.1	M1	must begin from the y-axis
	Correct line	A1	must extend to distance of 20m or further
	[18.4, 19]	B1ft	ft their straight line $\pm\frac{1}{2}$ square condone interpolation on/between points
	Additional Guidance		
	Points plotted but no line drawn leading to correct answer		M0 A0 B1
	Intersection reading or interpolation taken from a second non-linear curve		M0 A0 B0

Q	Answer	Mark	Comments
5 (a)	$(h =)$ 2.5	B1	
	$(w =)$ 0.7	B1	

Q	Answer	Mark	Comments
5 (b) (i)	4.79(4) or 4.8 and 3.896 or 3.9 and 3.28(2) or 3.3 and 3(.00)	B2	B1 three correct
	Their points plotted correctly	B1ft	within the correct square
	Points joined with curve for $0.4 \leqslant w \leqslant 1$	B1ft	B0 out of valid range

Q	Answer	Mark	Comments
5 (b) (ii)	The perimeter increases	B1	oe

Q	Answer	Mark	Comments
6 (a)	[14, 18]	B1	

Q	Answer	Mark	Comments
6 (b)	$A = 4.5$	B1	may be seen or implied at any stage when using the equation
	$\frac{S}{A} = e^{kd}$	M1	may be implied with substitution of numbers with their A used
	$kd = \ln\frac{S}{A}$ or $k = \frac{\ln\frac{S}{A}}{d}$	M1	oe award any correct application of ln
	Substitutes the coordinates of any point on the curve other than $d = 0$, $S = 4.5$ into their equation, correctly for variables S and d	M1	correct substitution may have taken place at any stage including into the initial equation. $\pm\frac{1}{2}$ square
	k = [0.06, 0.08]	A1ft	ft their A
	Alternative method 2 – simultaneous equations		
	Substitutes two pairs of coordinates of any point on the curve other than $d = 0$, $S = 4.5$ into their equation, correctly for variables S and d	M1	
	Eliminates one variable	M1dep	correct for their equations
	Transposes to make the remaining variable the subject	M1dep	correct for their equation
	$A = 4.5$	A1	
	k = [0.06, 0.08]	A1	

The mark scheme for Question 6 (b) continues on the next page

	Additional Guidance
6 (b) cont'd	Commonly used substitutions $(5, 6.5)$ $(6, 7)$ $(7, 7.5)$ $(11, 10)$ $(20, 19)$ $(25, 27.5)$ $(28, 33.25)$

Q	Answer	Mark	Comments
6 (c)	Any two valid statements eg Lake may become entirely covered or the model would predict unrealistic area coverage for large values of d or Plant growth may depend on season/weather/temperature or Plants may stop growing (exponentially) or die or Plants may be killed or Plant growth may depend on other external factors	B2	B1 for each valid statement condone any contextualized implication of model exceeding realistic values of S or any contextualized implications of the model trend not continuing.
	Additional Guidance		
	Should not extrapolate (beyond 28 days)		B0
	The water level will change		B0
	A change in water level may affect plant growth		B1
	A change in water level may affect the limit of plant surface area		B1

Q	Answer	Mark	Comments
7 (a)	18.6(487…)	B1	correctly rounded to 3sf or better or 19 if 18.6(487…) seen
	Additional Guidance		
	18.7 from 18.65 seen		B0

Q	Answer	Mark	Comments
7 (b) (i)	$e^t = T - 17$ or $45 - 17$ or 28	M1	$45 - 17$ may be embedded in an incorrect logarithm eg Log$(45 - 17)$ or Log(28)
	$t = \ln(T - 17)$ or ln(28)	M1	oe
	3.3(32…)	A1	implied by correct answer in minutes and seconds
	3 mins and 19.9(3…) secs or 3 mins 20 secs	B1ft	ft their 3.3(32…)
	Additional Guidance		
	3.3 leading to 3 mins 18 seconds		M1 M1 A1 B1
	3.33 leadings to 3 mins 19.8 seconds		M1 M1 A1 B1
	Correct final answer by T&I methods awards full marks		M1 M1 A1 B1
	3.3(3…) by T&I methods		M1 M1 A1 B0
	3.35 by T&I methods leading to 3 mins 21 secs		M0 M0 A0 B1

Q	Answer	Mark	Comments
7 (b) (ii)	$e^{3.33}$ or $e^{(\text{their } t)}$	M1	ft their t must not be part of an equation used to find average rate
	[27.1, 28] (degrees per minute) or [0.45, 0.47] (degrees per second)	A1ft	ft their t $t = 3.35$ gives 28.5(027…)
	Correct unit for their value	B1	condone m for minute
	Additional Guidance		
	Unit can be derived from any temperature ÷ time calculation		
	Incorrect answers with unit of degrees per second must demonstrate a correct conversion of the time-variable		
	$e^{3.34} - e^{3.33} = 0.28(0…)$ degrees per second		M0 A0 B0
	$e^{4.33} - e^{3.33} = 48(.005..)$ degrees per minute		M0 A0 B1
	Unit stated with no numerical answer or working shown		M0 A0 B0

Q	Answer	Mark	Comments
7 (c)	Tangent drawn from $T = 18$	M1	at $T = 18$ $t = 3.6$ must not cross the curve
	Gradient calculated using $\frac{\text{difference in } y}{\text{difference in } x}$ or [–23, –20] or [20, 23]	M1dep	oe correct for their tangent
	their [–23, –20] ÷ 60 or [–0.384, –0.33] or their [20, 23] ÷ 60	M1	convert minutes to seconds. may be seen at earlier stage including from a reading on the time axis.
	[0.33, 0.384]	A1	
	Additional Guidance		
	Final answer [–23, –20] awards		M1 M1 M0 A0
	Final answer [–0.33, –0.384] awards		M1 M1 M1 A0
	[0.33, 0.384] obtained by two points that approximate tangent		M1 M1 M1 A1