Level 3 Certificate
MATHEMATICAL STUDIES
1350/2A

Paper 2A Statistical techniques

Mark scheme

June 2023

Version: 1.0 Final

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 $a \leq$ 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 improvement
	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

	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 5–15 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 $24 \div 1.41 \times 3.2 \times 66 \div 100 \div 1.28$ 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 $24 \div 1.41 \times 3.2 \times 66 \div 100$ or 35.9… or 36 (amount in $) or $24 \div 1.41 \times 3.2 \div 1.28$ or 42.55… or 42.6 or 43 (amount in £ for all children in UK) **M2** $24 \div 1.41 \times 3.2$ or 54.468… or 54.47 or 54.5 or 54 (amount in $ for all children in UK) or $24 \div 1.41 \div 1.28$ 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 $3.2 \times 66 \div 100 \div 1410$ 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)	–0.983	B1	

Q	Answer	Mark	Comments
3(b)	C	B1	

Q	Answer	Mark	Comments
3(c)	No **and** suitable comment	E1	eg No and warm weather in the summer causes both correlation does not imply causation external factor affects both

Q	Answer	Mark	Comments
4(a)	95	B1	

Q	Answer	Mark	Comments
4(b)	($z =$) (1.5 – 2.5) ÷ 1.4 or –0.71(4…) or [0.76, 0.763]	M1	condone (2.5 – 1.5) ÷ 1.4 or 0.71(4…)
	[0.237, 0.24]	A1	oe probability ignore subsequent rounding that isn't incorrect

Q	Answer	Mark	Comments
4(c)	($z =$) (5.3 – 2.5) ÷ 1.4 or 2 or [0.977, 0.97725]	M1	condone (2.5 – 5.3) ÷ 1.4 or –2
	[0.02275, 0.023]	A1	oe probability ignore subsequent rounding that isn't incorrect

Q	Answer	Mark	Comments
4(d)	(–0.5 – 2.5) ÷ 1.4 or –2.14(…) or (5.5 – 2.5) ÷ 1.4 or 2.14(…)	M1	condone (2.5 – (–0.5)) ÷ 1.4 or (2.5 – 5.5) ÷ 1.4 implied by [0.9838, 0.984]
	[0.96, 0.97]	A1	oe probability ignore subsequent rounding that isn't incorrect

Q	Answer	Mark	Comments
4(e)	($z =$) [–1.8, –1.75] or [1.75, 1.8]	M1	
	$\frac{x - 12.7}{2.1}$ = [–1.8, –1.75] or $\frac{12.7 - x}{2.1}$ = [1.75, 1.8]	M1	oe equation allow [–4, 4] for [–1.8, –1.75] or [1.75, 1.8] except ±0.04 or 0
	[8.9, 9.03]	A1	

Q	Answer	Mark	Comments
5(a)	Plots the points (22.6, 131) and (24.7, 124)	B1	± ½ square

Q	Answer	Mark	Comments
5(b)(i)	h = [187.6, 188] – [2.47, 2.472]t	B2	condone y for h and or x for t allow 190 for [187.6, 188] allow –2.5 for [–2.472, –2.47] allow h = [187.6, 188] + – [2.47, 2.472]t B1 for stating or using [187.6, 188] or 190 or [–2.472, –2.47] or –2.5

Q	Answer	Mark	Comments
5(b)(ii)	Correct line drawn from the point (22, [132.6, 133.7]) to the point (25.6, [123.6, 124.8])	B2ft	correct or ft their equation ± ½ square B1 two correct points calculated or plotted using their equation or h = [187.6, 188] – [2.47, 2.472]t or correct mean point (23.68, 129.1) calculated or plotted
	Additional Guidance		
	No regression equation stated in **Question 5(b)(i)** or used in **Question 5(b)(ii)** can score B2 for fully correct regression line otherwise B0		
	Correct points if using 190 for [187.6, 188] and/or –2.5 for [–2.472, –2.47]		

	t = 22	t = 25.6
h = 190 – 2.47t	135.66	126.768
h = 190 – 2.472t	135.616	126.7168
h = 188 – 2.5t	133	124
h = 187.6 – 2.5t	132.6	123.6
h = 190 – 2.5t	135	126

<table>
<tr><th>Q</th><th>Answer</th><th>Mark</th><th>Comments</th></tr>
<tr><td rowspan="4">5(c)(i)</td><td>Substitutes $t = 20.5$ into their equation of the regression line or into
$h =$ [187.6, 188] – [2.47, 2.472]t
or
Vertical line from $t = 20.5$ to their regression line</td><td>M1</td><td>may be implied by a mark on the line or on the vertical axis</td></tr>
<tr><td>137.(365) or 137.37 or 137.4 or 137
or
Correct value from their equation or graph to the nearest whole number or better</td><td>A1ft</td><td>ft their regression line Question 5(b)(i) or $h =$ [187.6, 188] – [2.47, 2.472]t or using the line of best fit on their scatter diagram ± ½ square
must be decreasing straight line</td></tr>
<tr><td colspan="3">Additional Guidance</td></tr>
<tr><td colspan="3">Correct values if using [187.6, 188] or 190 and [–2.472, –2.47] or –2.5
<table>
<tr><td></td><td>$t = 20.5$</td></tr>
<tr><td>$h = 187.64 - 2.47t$</td><td>137.005</td></tr>
<tr><td>$h = 188 - 2.47t$</td><td>137.365</td></tr>
<tr><td>$h = 187.6 - 2.472t$</td><td>136.924</td></tr>
<tr><td>$h = 190 - 2.47t$</td><td>139.365</td></tr>
<tr><td>$h = 190 - 2.472t$</td><td>139.324</td></tr>
<tr><td>$h = 188 - 2.5t$</td><td>136.75</td></tr>
<tr><td>$h = 187.6 - 2.5t$</td><td>136.35</td></tr>
<tr><td>$h = 190 - 2.5t$</td><td>138.75</td></tr>
</table></td></tr>
</table>

Q	Answer	Mark	Comments
5(c)(ii)	It involves extrapolation or It is not within the data range or Fitness may improve over time	E1	oe

Q	Answer	Mark	Comments
6	**Alternative method 1**		
	Number the students from 1 to 180	E1	oe
	Generate random numbers	E1	oe
	Continue until 30 different numbers have been chosen	E1	oe
	Alternative method 2		
	Put names in a hat	E1	oe
	Take names from the hat	E1	oe
	Continue until 30 names have been chosen	E1	oe
	Additional Guidance		
	Accept any equivalent random method		

Q	Answer	Mark	Comments
7(a)	98% value → (±) 2.3263 or (±) 2.33	B1	condone 2.3(2…) implied by correct answer in range
	(Mean is) 33	B1	implied by correct answer in range
	their 33 ± their 2.3263 × √8 ÷ √10 or their 33 ± their 2.3263 × 0.89(…) or their 33 ± their 2.3263 × 0.9 or their 33 ± 2.08(…)	M2	M1 for one error in the equation eg no √ sign for 8 or 10 fraction reversed × √10 ÷ √8 their 33 does not count as an error if it's in the range [27, 42] their 2.3263 does not count as an error if it is in the range (0, 4]
	([30.9, 31], [35, 35.1])	A1	allow reverse order eg ([35, 35.1], [30.9, 31],) allow [30.9, 31] and [35, 35.1]
	Additional Guidance		
	If candidates use 8 or 10 instead of √8 or √10 can score B1B1M1A0 If both 8 and 10 are used instead of √8 and √10 can score B1B1M0A0		
	Not using ± and omitting either + or – in the equation counts as one error		
	Premature rounding or truncating (eg √8 = 3) leading to an inaccurate answer can score maximum B1B1M2A0		
	([30.9, 31], [35, 35.1]) seen without method or contradiction scores full mark		
	(0, 4] → 0 < value ⩽ 4		

Q	Answer	Mark	Comments
7(b)	32 lies within the (98% confidence) interval and claim is correct or not unlikely	E2ft	oe ft their answer to **Question 7(a)** E1 32 lies within the (98% confidence) interval condone 'it' for '32' condone 'range' or 'limit' for 'interval'
	Additional Guidance		
	If they didn't write a confidence interval in **Question 7(a)**, then **Question 7(b)** scores 0		

Q	Answer	Mark	Comments
7(c)	**Alternative method 1** – using their CI from Question 7(a)		
	μ has increased	E1ft	oe implied by a correct statement in context eg people are retiring later ft their answer to **Question 7(a)**
	Confidence intervals do not overlap or Sample mean is now 38.85 or 38.8 or 38.9 or 39	E1	oe Condone 'μ' for sample mean
	Alternative method 2 – using $\mu = 32$ from Question 7(b)		
	μ has increased	E1	oe implied by a correct statement in context eg people are retiring later
	32 does not lie within the new CI or The new CI is higher than 32	E1	
	Additional Guidance		
	Stating 'μ has increased' with no reason scores E1E0		

7(c) cont'd

If using alternative method 1, see different examples below

Example	First E mark	Second E mark
their CI lies entirely below 37.3	μ has increased	Confidence intervals do not overlap or Sample mean is now 38.85 or 38.8 or 38.9 or 39
their CI lies entirely above 40.4	μ has decreased	Confidence intervals do not overlap or Sample mean is now 38.85 or 38.8 or 38.9 or 39
one CI is fully inside the other CI	no change in μ or cannot tell	One CI is fully inside the other CI
their lower bound is below 37.3 and upper bound is [37.3, 40.4]	μ has increased or no change in μ or cannot tell	CI bounds increased or sample mean is now 38.85 or 38.8 or 38.9 or 39 (if they say μ has increased) or CI overlaps (if they say no change in μ or cannot tell)
their lower bound is [37.3, 40.4] and upper bound is above 40.4	μ has decreased or no change in μ or cannot tell	CI bounds decreased or sample mean is now 38.85 or 38.8 or 38.9 or 39 (if they say μ has decreased) or CI overlaps (if they say no change in μ or cannot tell)

Q	Answer	Mark	Comments
8(a)	30×36.2 and 50×41.4 and 20×38.3 and 75×38.4 or 1086 and 2070 and 766 and 2880 or 6802	M1	
	$30 + 50 + 20 + 75$ or 175	M1	
	$6802 \div 175$	M1	values must be correct
	[38.8, 38.9]	A1	condone 39 from correct working SC1 for 38.4
	Additional Guidance		
	$(36.2 + 41.4 + 38.3 + 38.4) \div 4$ or $154.3 \div 4$ or 38.575 scores 0		
	[38.8, 38.9] seen without method or contradiction scores full marks		

Q	Answer	Mark	Comments
8(b)	Increase the sample size or Increase the number of point estimates	E1	oe

Q	Answer	Mark	Comments
8(c)	–0.26(4...)	B1	
	(Weak) negative or no correlation	E1ft	oe ft their pmcc allow description in context once pmcc seen do not allow descriptions of strength which are clearly wrong
	Additional Guidance		
	No pmcc written scores 0		