GCE

Further Mathematics B MEI

Y432/01: Statistics minor

A Level

Mark Scheme for June 2023

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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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

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

   YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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. 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 a tick to confirm that the work has been seen.

5. **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
E	Explanation mark 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

PMT

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining a result or establishing a given result
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.
BP	Blank Page
Seen	
Highlighting	

6. **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.

E

A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

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)		$0.7^2 \times 0.3$	M1	3.3	For geometric
			$= 0.147$	A1	1.1	Accept 0.15
				[2]		
1	(b)		P(At least 5) $= 0.24(01)$	B1	1.1	0.7^4 or $1 - 0.3(1 + 0.7 + 0.7^2 + 0.7^3)$ oe
				[1]		
1	(c)		Mean $= \frac{10}{3}$ soi	B1	3.1b	$\frac{1}{0.3}$ Accept 3.3
			Variance $= \frac{1-0.3}{0.3^2}$	M1	1.1a	
			Standard deviation $= \frac{\sqrt{70}}{3}$	A1	1.1	(2.78886…)
			Evaluate *their* $\left(\frac{10}{3} \pm \frac{\sqrt{70}}{3}\right)$ **and** identify their correct integer range	M1	3.4	$P(0.54 < X < 6.12)$ $= P(X \le 6)$
			$(1 - 0.7^6) = 0.88(2351)$	A1 FT	1.1	**FT** their $E(X)$ and $SD(X)$ provided more than one positive integer included in their range.
				[5]		

Question			Answer	Marks	AO	Guidance
2	(a)	(i)	For example, one of: • a sample this small might not give any useful information (about the strength) • a sample this small is unlikely to be representative of the population • the sample statistics from such a small sample are unlikely to be close to the population parameters [1]	E1	2.4	**E0** if comment only refers to the sample being too small. Allow any suitable answer
2	(a)	(ii)	For example, one of: • it is wasteful as the cans cannot then be used/it is a test to destruction • a (far) smaller sample size is adequate to give useful information (about the strength) [1]	E1	2.4	**E0** if comment only refers to the sample being too large. Allow any suitable answer
2	(b)		For example, one of: • there may have been a fault earlier in the batch which then corrected itself for the later tins • if there has been a fault throughout the batch it is not sensible to only discover that at the end • this would not be **random** so it would not be appropriate to make (statistical) **inferences** (about the population) [1]	E1	2.2b	Allow any suitable answer
2	(c)		The sample should be: • unbiased • representative of the **population** • random [2]	B1 B1	1.2	Any two from these three

Question			Answer	Marks	AO	Guidance
3	**(a)**		Both cases: 2 zeroes, 1 one **and** 1 zero 2 ones seen	**B1**	**3.1a**	
			$3 \times \left(\frac{1}{4}\right)^3 + 3 \times \left(\frac{1}{4}\right)^3$	**M1**	**1.1**	Calculation needs to relate correctly to the two cases. Following **B0 M0**, **SC B1** for use of $\left(\frac{1}{4}\right)^3$ but without reference to the two distinct cases
			$= \frac{6}{64} = \frac{3}{32}$	**A1** [3]	**1.1**	**AG**
3	**(b)**		**DR** $E(X) = 3$ with justification	**B1**	**2.4**	$\left(0 \times \frac{1}{64}\right) + 1 \times \frac{3}{32} + 2 \times \frac{13}{64} + 3 \times \frac{3}{8} + 4 \times \frac{13}{64} + 5 \times \frac{3}{32} + 6 \times \frac{1}{64}$ or 'By symmetry'
			$E(X^2) = \left(0 \times \frac{1}{64}\right) + 1 \times \frac{3}{32} + 4 \times \frac{13}{64} + 9 \times \frac{3}{8}$ $+16 \times \frac{13}{64} + 25 \times \frac{3}{32} + 36 \times \frac{1}{64}$	**M1**	**1.1a**	$E(X^2) = \frac{167}{16} = 10.4375$ quoted without working is **M0** Allow one slip in calculation. Alt: **M1 M1** for $\frac{1}{64}\{(0-3)^2 + 6(1-3)^2 + 13(2-3)^2 + 24(3-3)^2 + 13(4-3)^2 + 6(5-3)^2 + (6-3)^2\}$ oe
			$Var(X) = their \left\{\frac{167}{16} - 3^2\right\}$	**M1**	**1.1**	
			$= \frac{23}{16}$	**A1** [4]	**1.1**	1.4375 allow 1.4 Must follow **M1 M1**
3	**(c)**	**(i)**	The values must be **independent**	**B1** [1]	**2.2a**	
3	**(c)**	**(ii)**	$Var(Y) = 10 \times their \ \frac{23}{16}$	**M1**	**1.1a**	$\frac{230}{16}$
			$SD(Y) = 3.79 \ \text{ or } \ \frac{1}{4}\sqrt{230}$	**A1 FT** [2]	**1.1**	Allow 3.8

	Question		Answer	Marks	AO	Guidance
4	(a)		1.3 oe	**B1** **[1]**	**1.1**	$\frac{0\times36+1\times33+2\times14+3\times10+4\times4+5\times1+8\times1+10\times1}{100} = \frac{130}{100}$
4	(b)		C4 probability = 0.2303	**B1 FT**	**3.4**	
			D5 expected frequency = 14.2888	**B1 FT**	**2.2a**	Allow 14.2911 for use of calculator probability for $x=2$ and 4dp values of $x=1$ and $x=0$
			E3 contribution $= \frac{(33-35.4291)^2}{35.4291}$	**M1**	**1.1a**	
			= 0.1665	**A1** **[4]**	**1.1**	
4	(c)		**DR**			
			H_0: Poisson model is a good fit H_1: Poisson model is not a good fit	**B1**	**2.5**	Reference to 'mean 1.3' in hypotheses scores **B0** Allow omission of context at this stage
			$X^2 = 7.0(283)$	**B1 FT**	**1.1**	**FT** $(6.8618 + their\,E3)$
			Use of $v = 2$	**M1**	**3.4**	
			Critical value at 5% level = 5.99(1)	**A1**	**1.1**	or $\chi_5^2(7.0283) = 0.9702$
			their 7.0(283) > *their* 5.99(1)	**M1**	**1.1**	$0.9702 > 0.95$ critical value must be from χ^2 table
			(Reject H_0)			
			There is sufficient evidence to suggest that the **Poisson** model is not a good fit for the number of **vehicles** (passing Eve's house each minute)	**A1** **[6]**	**3.5a**	Correct test statistic and critical value required Conclusion must follow correct hypotheses, not be too assertive and refer to **context**.
4	(d)		We would now not reject H_0 (insufficient evidence to suggest that the Poisson model is not a good fit).	**E1 FT**	**3.2a**	Comment on impact on conclusion. Allow 'accept H_0'
			It is reasonable remove these two values as they are not representative of the normal situation. (vehicles would not be travelling independently, mean rate would not be constant)	**E1** **[2]**	**2.4**	Allow alternative answers such as 'If horse-riders regularly use the lane, even if not very frequently, then the Poisson model may not be valid.'

Question			Answer	Marks	AO	Guidance
5	(a)		$m = 0.914w - 64.1$	B1 B1 [2]	3.3 1.1	First **B1** for either coefficient Second for both given correct to 3sf and m and w used in an equation, not just stated separately (so $y = 0.914x - 64.1$ scores **B1 B0**)
5	(b)		Prediction for 99 is 26(.4) Prediction for 110 is 36(.4) [2]	B1 FT B1 FT	1.1 1.1	Allow only 1 mark if either prediction is given to more than 1 decimal place
5	(c)		The prediction for 99 is (moderately) reliable as it is interpolation although the points do not appear to be close to a straight line. The prediction for 110 is not (at all) reliable as it is extrapolation and the points do not appear to be close to a straight line. [2]	B1 B1	3.5a 3.5b	First **B1** for a correct conclusion **and** reference to at least one of interpolation/extrapolation/not close to a straight line Use of 'accurate' for 'reliable' is incorrect. Second **B1** for all 3
5	(d)		It would not be sensible/appropriate For example: • Because this is the equation of the w on m regression line, not m on w. • Because this is found by minimising the squares of the horizontal (w)residuals. • Since this line should only be used to estimate wing length from the mass of a bird. • Since this line only measures the average value of the wing length for a given value of the mass. [2]	B1 B1	2.2a 2.2a	Correct conclusion (may be implied by rest of comment) Must be linked with a correct conclusion

Question			Answer	Marks	AO	Guidance
6	(a)		Because the scatter diagram does not appear to be elliptical (due to the possible outlier)	E1	3.5a	For not elliptical. Alternatively, 'the points appear to be funnel-shaped'
			so the (underlying) distribution is (probably) not bivariate Normal.	E1	2.4	For full answer (dependent on first mark) **"data** is not bivariate Normal" is **E0** "Normal bivariate" is **E0**
				[2]		
6	(b)		<table><tr><td>Rank saw</td><td>7</td><td>6</td><td>3</td><td>2</td><td>1</td><td>8</td><td>5</td><td>4</td></tr><tr><td>Rank chop</td><td>7</td><td>4</td><td>6</td><td>1</td><td>5</td><td>8</td><td>3</td><td>2</td></tr><tr><td>d^2</td><td>0</td><td>4</td><td>9</td><td>1</td><td>16</td><td>0</td><td>4</td><td>4</td></tr></table>	M1 depM1	1.1 1.1	For ranking saw or chop correctly For ranking saw and chop consistently (i.e. same way round) with at most one adjacent pair of ranks transposed. If rankings not seen they may be inferred from correct d or d^2 values or $\sum d^2 = 38$ seen
			Spearman's rank coefficient $\frac{23}{42}$ or 0.5476	A1	1.1	Accept 0.55 or better. **SC B1** only if 0.5476 stated with no working.
				[3]		
6	(c)		H_0: There is **no association** between sawing and chopping (times) in the population	B1 B1	3.3	For first **B1** need to see one correct hypothesis with context (need not have population at this point).
			H_1: There is **positive association** between sawing and chopping (times) in the population		1.2	For **B1B1** need to see two correct hypotheses with each of context and population in at least one of the hypotheses.
			Critical value 0.6429	B1	3.4	$n = 8$, 5%, 1-tailed
			$0.5476 < 0.6429$ (so do not reject H_0/accept H_0)	M1	1.1	For comparison provided $0 < r_s < 1$
			There is insufficient evidence to suggest that there is **positive association** between **sawing and chopping times** (in the population)	A1FT	2.2b	FT their r_s and sensible critical value from correct table **A0** for "(Sufficient evidence to suggest) no association". Needs to include context.
				[5]		

Question			Answer	Marks	AO	Guidance
7	**(a)**		Number of values of X is $n - 100 + 1$ or $n - 99$ soi	M1	3.1a	
			$\left(\text{Number } < \dfrac{100 + n}{2} \text{ is}\right) \dfrac{n - 100}{2}$	M1	3.1a	N.B. may see use of $n = 2k$
			Probability $= \dfrac{n-100}{2(n-99)}$ oe ISW	A1	1.1	e.g. $\dfrac{1}{2}\left(1 - \dfrac{1}{n-99}\right)$ or $\dfrac{\frac{1}{2}n - 50}{n - 99}$
				[3]		
7	**(b)**		$\text{Var}(X) = \dfrac{1}{12}\left((n - 99)^2 - 1\right)$	M1	3.1a	Accept $\text{Var}(X) = \dfrac{1}{12}\left((n - 100)^2 - 1\right)$
			Var of sum of 50 values $= 50 \times \dfrac{1}{12}\left((n - their\ 99)^2 - 1\right)$	M1	1.1	*Their* 99 must be a positive integer
			$= \dfrac{25}{6}(n^2 - 198n + 9800)$	A1	2.1	$a = \dfrac{25}{6}$ or exact equivalent
				[3]		

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