GCE

Further Mathematics B MEI

Y432/01: Statistics minor

A Level

Mark Scheme for June 2024

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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.

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 or the RM Assessor messaging system, or by email.

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	

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)		The probability of success (and/or failure) on each kick is constant (0.15).	**B1** **[1]**	**1.2**	Does not need to be in context. Does not matter if "success" is confused with "scoring a goal"	Probability of success is 'fixed', or 'remains the same', or equivalent term
1	(b)		E(X) = 1/0.15 = 20/3 or awrt 6.67 Var(X) = $0.85/0.15^2$ = 340/9 or awrt 37.8	**B1** **B1** **[2]**	**1.1** **1.1**	Accept 6.7 Accept 38	If **B0B0** then **SC1** for 20/17 (or awrt 1.18) **and** 60/289 (or awrt 0.208)
1	(c)		P(X = 3) = P(Scores, Scores, Doesn't) = $0.85^2 \times 0.15$ = awrt 0.108 ,	**M1** **A1** **[2]**	**1.1a** **1.1**	Understanding of what is required in a geometric scenario to obtain X = 3 Allow **M1** for $0.15^2 \times 0.85$ implied by awrt 0.0191 Accept 0.11	
1	(d)		P($X \geq 5$) = P($X > 4$) = 0.85^4 = awrt 0.522	**M1** **A1**	**1.1** **1.1**	Allow **M1** for 0.15^4 implied by awrt 0.000506 Accept 0.52	
			Alternative method 1 P($X \geq 5$) = 1 – P($X \leq 4$) = $1 - 0.15(1 + 0.85 + 0.85^2 + 0.85^3)$ oe = awrt 0.522	 **M1** **A1**		 Accept 0.52	
				[2]			

Question			Answer	Marks	AO	Guidance	
2	(a)		(Discrete) Uniform or U... U(12), n =12, or p=1/12 or (1,2,….,12)	**M1** **A1** **[2]**	**1.2** **2.5**	Specification of either the name or the values must make it clear that this is a discrete distribution.	If Uniform or U… absent, List (1, 2,….,12) gets **M1** with p=1/12 for **A1**
2	(b)		E(X) = (12 + 1) / 2 = 6.5 Var(X) = (12^2 – 1) / 12 = $\frac{143}{12}$	**B1** **B1** **[2]**	**1.1** **1.1**	$11\frac{11}{12}$ or $11.91\dot{6}$ or awrt 11.9	
2	(c)		$\left\|\frac{2(X-\mu)}{\sigma}\right\| > 1 \Rightarrow X > \mu + \frac{1}{2}\sigma$ or $X < \mu - \frac{1}{2}\sigma$ $X > 6.5 + \frac{1}{2}\sqrt{\frac{143}{12}}$ or $X < 6.5 - \frac{1}{2}\sqrt{\frac{143}{12}}$ $X > 8.22...$ or $X < 4.77...$ Total of 8 possible numbers (9, 10, 11, 12 or 1, 2, 3, 4) so prob = 8/12 = 2/3	**M1** **M1 FT** **A1**	**3.1a** **1.1** **2.2a**	Untangling the inequality correctly. This mark can be awarded if wrong value(s) used consistently. Condone "and" if recovered (eg by correct answer) Substituting their values into at least one of the inequalities to produce a 'decimal' inequality in X, or using one inequality to identify either (1, 2, 3, 4) or (9, 10, 11, 12)	Could use complementary event, considering $P\left(\left\|\frac{2(X-\mu)}{\sigma}\right\| \leq 1\right)$ (or <) leading to $\mu - \frac{\sigma}{2} \leq X \leq \mu + \frac{\sigma}{2}$ **M1** or $4.77.. \leq X \leq 8.22...$ **M1 FT** **SC** (1, 2, 3, 4 **and** 9, 10, 11, 12) identified without working, **B1** only Total of 4 possible numbers (5, 6, 7, 8) so required prob = 1 – 4/12 = 2/3 **A1**
			Alternative method 1 Draw table of values for n= 1, 2, 3,……,12 and attempt to calculate $\left\|\frac{2(X-\mu)}{\sigma}\right\|$ for at least four values of n Calculate at least four correct values (to 1 d.p) Identify the 8 possible values of n so prob = 8/12 = 2/3	 **M1 FT** **A1** **A1**		n: 1 2 3 4 5 6 / value: 3.2 2.6 2.0 1.4 0.9 0.3 n: 7 8 9 10 11 12 / value: 0.3 0.9 1.4 2.0 2.6 3.2 For n =1-6, condone negative values with the correct modulus provided final answer is correct.	
				[3]			

Question			Answer	Marks	AO	Guidance	
3	(a)		Both (variables)	B1 [1]	2.2a		
3	(b)		Compared to the rest of the data, A seems to have a lower average life expectancy than might be expected for its average annual income (or a higher average annual income than might be expected for its average life expectancy)	B1 [1]	2.4		
3	(c)		Such a hypothesis test is appropriate because the data is random on random... ...and the data are consistent with an underlying bivariate normal distribution since the points on the scatter diagram seem to be elliptically distributed	B1 B1 [2]	2.3 2.4	Allow 'data is random' Allow the data appear to be bivariate normal Not 'normal bivariate'	
3	(d)		S_{xx} = 14363849200 – 44*(751120/44)^2 oe soi S_{yy} = 133014.63 – 44*(2397.1/44)^2 oe soi	M1	1.1	Either S_{xx} or S_{yy} correctly written or value correctly found. Seen or used in calculation. Other values are possible e.g. 14363849200/44 – (751120/44)^2 or 44*14363849200 –(751120)^2	1541547964 2421.711591...
			S_{xy} = 42465962 – 44*(751120/44) *(2397.1/44) oe soi	M1	1.1	Seen or used in calculation. Other values are possible e.g. 42465962/44 – (751120/44) *(2397.1/44) or 44*42465962 –(751120) *(2397.1) but must be consistent throughout question	1545285.818...
			S_{xx} = awrt 1.54×10^9 S_{yy} = awrt 2420 S_{xy} = awrt 1.55×10^6	B1	1.1	For any one value correct. soi	
			r = awrt 0.80	A1 [4]	1.1	Can't be awarded without both **M1** marks	

Question			Answer	Marks	AO	Guidance	
3	(e)		$H_0: \rho = 0$ $H_1: \rho > 0$	**B1**	**3.3**	For both hypotheses Use of r for ρ is **B0**	H_0: There is no correlation between *x* and *y* in the population *or* H_0: There is no correlation between annual income and average life expectancy in the population
			Where ρ is the population pmcc between average annual income and average life expectancy	**B1**	**2.5**	For defining ρ in context. Must refer to 'population.' Could use *x* and *y* instead of income and life expectancy. Use of r for ρ is **B0**	H_1: There is positive correlation between *x* and *y* in the population *or* H_1: There is positive correlation between annual income and average life expectancy in the population If no reference to 'population' in at least one of H_0 and H_1 **B0**
			n = 44, 1-tailed critical value is 0.3496	**B1**	**3.4**	Condone 0.3457 (for *n* = 45)	
			0.800 > 0.3496 so we reject H_0	**M1 FT**	**1.1**	Making correct comparison with their values and reaching consistent inference 0 < r < 1 required	
			There is sufficient evidence (at the 1% level) to suggest that there is positive correlation between average annual income and average life expectancy (in the population)	**A1** **[5]**	**2.2b**	Correct, non-assertive conclusion from **correct** values only. Must refer to context for this mark. **A0** if subsequent assertive conclusion	

Question			Answer	Marks	AO	Guidance	
4	(a)		If a sample is random then it is valid to draw (statistical) inferences from it	**B1** **[1]**	**2.4**	No context necessary; just the ideas that if random then the sample probably represents the population and if this is so then conclusions we draw are likely to be valid.	Needs a reference to the purpose of the sample e.g. inference, investigation, analysis, test, statistic, conclusion…, and a word that qualifies validity e.g. unbiased, proper, accurate
4	(b)		$800\times(127/800)\times(m/800)$ or $127\times(m/800)$ where m = 432, 280 or 88. Brown: 68.58, Blue 44.45, Green 13.97	**M1** **A1** **[2]**	**1.1** **1.1**	Showing any one correct calculation for expected frequency. For this mark condone any confusion between eye colours At least 3 sf	If no working shown, all three must be correct to at least 3 s.f. for both marks
4	(c)		H_0: There is no association between hair colour and eye colour and H_1: There is some association between hair colour and eye colour $\nu = (4-1)(3-1) = 6$ $(\chi^2_6)_{10\%} = 10.64$ $28.62 > 10.64$ so H_0 is rejected There is sufficient evidence (at the 10% level) to suggest that there is some association between (natural) hair colour and (natural) eye colour	**B1** **B1** **B1** **M1** **A1** **[5]**	**3.3** **1.1** **3.4** **1.1** **2.2b**	or H_0: Hair colour and eye colour are independent H_1: Hair colour and eye colour are not independent Making correct comparison between given value and their CV and drawing consistent inference Non-assertive, contextual conclusion from correct critical value	p-value is 7.18 (or 7.19)$\times10^{-5} < 0.1$ so reject H_0
4	(d)		$(19 - 13.97)^2 / 13.97 = 1.811$	**B1FT** **[1]**	**1.1**	FT Their expected value from **(b)**.	Answer should be quoted to 4 sf. 1.786 comes from using 14 or 14.0.

Question			Answer	Marks	AO	Guidance	
4	(e)		The high levels of the (χ^2-) contributions implies that the number of blond people with blue eyes is **different/higher** than expected and the number of blond people with brown eyes is **different/lower** than expected	**B1**	**3.5a**		Ignore comments about blonde hair/green eyes.
			The fact that 61 > 44.45 suggests that **more** people with blonde hair have blue eyes than would be expected (if there were no association), and 47 < 68.58 suggests **fewer** people with blond hair have brown eyes than expected.	**B1** **[2]**	**3.5a**		If **B0B0** then **SC1** for **fewer** people with blonde hair have brown eyes than would be expected **and more** people with blonde hair have blue eyes than expected provided 61 > 44.45 and 47 < 68.58 is quoted
4	(f)		The test at the 1% significance level since the test statistic exceeding the critical value is less likely to have been caused by random factors (i.e. if the null hypothesis is true)	**B1** **[1]**	**3.5a**	Or the chance that H_0 is rejected when true is lower, or the chance of a false positive is less. Need a comparative like less or lower	If the conclusion to **(c)** is that there is no association then **B1** can be awarded for "The test at the 10% level since if there is a small association it is more likely be considered significant by this test so the fact that this test did not reject H_0 is more informative" oe

Question			Answer	Marks	AO	Guidance	
5	(a)		Each mistake has to be made independently of any other mistake	B1	3.3	Any one correct, **B1**	Not 'probability of a mistake is independent'
			Mistakes have to occur at a constant average rate. Mistakes occur singly, oe	B1 [2]	1.2	Any two correct, full marks	Not "average constant rate". Some context necessary
5	(b)	(i)	awrt 0.14	B1 [1]	1.1	BC. 0.1403738958...	
5	(b)	(ii)	awrt 0.12	B1 [1]	1.1	BC. 0.1246520195...	
5	(b)	(iii)	Use of Po(10) soi awrt 0.07	M1 A1 [2]	1.1 1.1	Allow **M1** for 0.1301 BC. 0.06708596288...	
5	(c)		$E(M_1) = E(Y_{AM} + Y_{PM}) = E(Y_{AM}) + E(Y_{PM}) = 5 + 5 = 10$ $E(M_2) = E(2Y_{AM}) = 2E(Y_{AM}) = 2\times5 = 10$ So the expected values would be the same for both CDs.	M1 A1 [2]	3.1b 2.4	Realising that $M_1 = Y_{AM} + Y_{PM}$ and that is $M_B = 2Y_{AM}$ and using expectation algebra accordingly Both values = 10 and statement needed	Can be implied by $E(M_1) = 5+5$ and $E(M_2) = 2*5$
5	(d)		$Var(M_1) = Var(Y_{AM} + Y_{PM})$ $= Var(Y_{AM}) + Var(Y_{PM}) = 5 + 5 = 10$ $Var(M_2) = Var(2Y_{AM}) = 4Var(Y_{AM}) = 4\times5 = 20$ For A: $s^2_{n-1} = \frac{812 - 7\times\left(\frac{70}{7}\right)^2}{6} = \frac{56}{3}$ = awrt 19 For B: $s^2_{n-1} = \frac{800 - 7\times\left(\frac{72}{7}\right)^2}{6} = \frac{208}{21}$ = awrt 10 19 is close to 20 and 9.9 is close to 10. So it is likely that critic A has been given the wrongly recorded CD. Or 9.9 is close to $Var(M_1)=E(M_1)=10$ so B has the correct CD	B1 B1 M1 A1 [4]	3.1b 3.1b 1.1 3.2a	Using correct rule for adding variances of independent RVs to obtain 10 Using correct rule for variance of a multiple to obtain 20 Writing correct calculation for at least one of these. Correct conclusion from (either set of) cvo. It is sufficient to note that A's sample variance > B's, or that B's variance is close to $Var(M_1)$, provided that values are correct.	Condone use of n rather than $n - 1$: awrt 16, awrt 8

Question			Answer	Marks	AO	Guidance	
6	(a)		$E(X) = a + 2b$	B1 [1]	1.1	Correct expression for $E(X)$	
6	(b)	(i)	$a + 2b = a + 0.4 \Rightarrow b = 0.2$ $Var(X) = 1^2 \times a + 2^2 \times 0.2 - (a + 0.4)^2$ $= a + 0.8 - a^2 - 0.8a - 0.16$ $= -a^2 + 0.2a + 0.64$ oe	B1 M1 A1 [3]	3.1a 1.1 1.1	 Correct expression for $Var(X) = 1^2*a+2^2*b - (E(X))^2$ using their b (or the symbol b) and their $E(X)$ Like terms must be collected	
6	(b)	(ii)	$Var(X) = -(a^2 - 0.2a) + 0.64$ $= -((a - 0.1)^2 - 0.1^2) + 0.64$ $= 0.65 - (a - 0.1)^2$ whose maximum value is 0.65 when $a = 0.1$	M1 A1 [2]	3.1a 2.2a	Valid method for finding TP, either by completing the square, differentiating their quadratic in a and equating to zero, or by clear use of $-b/2a$ from quadratic formula to find a	$\frac{dV}{da} = -2a + 0.2 = 0$ Solving, $a = 0.1$ and substituting, max $V = 0.65$
6	(c)	(i)	0	B1 [1]	2.2a		
6	(c)	(ii)	Probabilities must be 1, 0, 0 or 0, 1, 0 or 0, 0, 1 soi So (a, b) pairs are (0, 0), (1, 0), (0, 1)	M1 A1 [2]	3.1a 3.2a	For clear understanding that the minimum variance comes when the distribution is as concentrated as possible, implied by at least one correct pair of values All 3 pairs correct and no others. Allow any unambiguous format (eg $a = 0$ and $b = 0$ or $a = 1$ and... etc)	

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