GCE

Further Mathematics B MEI

Y432/01: Statistics minor

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. 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.

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Question			Answer	Marks	AO	Guidance	
1	(a)		4	**B1** **[1]**	**1.2**		
	(b)		0.20	**B1** **[1]**	**1.1**	0.1953668148... **B0** for 0.2	if given to more than 2sf should be correct (rounded or truncated) to the level of accuracy given
	(c)		$P(X > 3) = 1 - P(X \leq 3)$ $= 1 - 0.43347... = 0.57$	**M1** **A1** **[2]**	**1.1a** **1.1**	$P(X \geq 4)$ soi by correct answer. 0.5665298…	NB $P(X \leq 3) = 0.4334701306...$ if given to more than 2sf should be correct (rounded or truncated) to the level of accuracy given
	(d)		$(X + Y \sim)$ Po(9) $P(X + Y \leq 9) = 0.59$	**M1** **A1** **[2]**	**1.1** **1.1**	soi by correct answer. 0.5874082...	**M0** for P(9) if given to more than 2sf should be correct (rounded or truncated) to the level of accuracy given

Question			Answer	Marks	AO	Guidance	
2	(a)		$S_{tt} = 14000 - 280^2/8$ (= 4200) or $S_{tv} = 43190 - 280\times876.28/8$ (= 12520.2)	M1	3.1a	One correct or equivalent formula with correct values subbed in. soi e.g. by $b = 2.981$ Could be embedded	Ignore attempts at calculation of S_{vv}, r, etc.
			$v - 876.28/8 = (12520.2/4200)(t - 280/8)$	A1	1.1	Award mark if correct equation in v and t seen in any form.	$v = 2.981t + 5.2$ $v - 109.535 = 2.981t - 104.335$ NB $\bar{t} = 35$, $\bar{v} = 109.535$ **A0** for $y = 2.981x + 5.2$
			$t = 45 \Rightarrow v = 139$ or 140	A1 [3]	1.1	No more than 3 sf.	
	(b)		This is within the range of the input data (so is interpolation) so the estimate is (likely to be) reliable	B1 [1]	3.5a	**B0** for 'accurate' in place of 'reliable'	Allow responses that indicate the estimate may be unreliable because e.g. We cannot tell as we do not know the residuals or we do not know how strong the correlation is (N.B. $r = 0.99944\ldots$)
	(c)		(It would not be appropriate because) ***t*** is non-random.	B1 [1]	2.4	It is not appropriate to form the regression line of t on v if t is a non-random/controlled variable	Ignore additional elaboration or comments.

Question			Answer	Marks	AO	Guidance	
3	(a)		The outcome of each attempt at hitting the target with an arrow is independent of the outcome of the previous/any other such attempt.	**B1**	**3.3**	Must have some context.	Allow a correct and precise interpretation of independence to probabilities; "Whether one arrow hits or misses (the target) does not affect the probability of whether another arrow hits or misses". Do **not** allow answers which have one **probability** being independent of another **probability**.
			The probability of hitting (or missing) the target each time an arrow is fired is constant.	**B1** **[2]**	**1.2**	Must have some context. Allow 'likelihood' in place of 'probability'	
	(b)		(The sample should be) large (The sample should be) random (The sample should be) representative of the **population** oe.	**B1** **B1** **[2]**	**1.2** **1.2**	**B1** for first feature **B1** for second feature	Allow 'unbiased' in place of random. Do not allow 'reflective' in place of 'representative'.
	(c)		$\frac{1-p}{p^2}=12$	**B1**	**3.1b**		
			$12p^2 + p - 1 = 0$	**M1**	**1.1**	Rearranging to 3 term quadratic. Must be "= 0" but can be recovered by implication (ie correct solution).	
			$p = ¼$ (or $-⅓$. But $p > 0$ so $p = ¼$ oe)	**A1** **[3]**	**2.3**	cao If negative root stated it needs to be clearly rejected.	If **M0** then **SCB1** for $p = ¼$ from no working.
	(d)		4	**B1FT** **[1]**	**1.1**	FT their p from **(c)** $0 < p < 1$	$\frac{1}{\text{their } p}$

Question			Answer	Marks	AO	Guidance	
4	(a)	(i)	$P(X = x) = \frac{1}{20}$ (for $x \in \{5, ..., 24\}$)	**B1**	**2.2a**	Can be implied by the expression for $E(X)$.	
			$E(X) = 5/20 + 6/20 + ... + 24/20$ oe	**M1**	**1.1**	Using correct expression for expectation using their $P(X = x)$ e.g. $\frac{1}{20}\left(\sum_5^{24} r\right)$	If writing out separate terms need to see at least three terms
			14.5 oe	**A1** **[3]**	**1.1**	Any method for finding the sum with at least one intermediate step. e.g. use of sum of AP formula or $\frac{1}{20}\left(\sum_1^{24} r - \sum_1^4 r\right)$	**M0A0** for correct answer with no working or only (5 + 24)/2. **A0** for 15 with no evidence of 14.5
	(a)	**(ii)**	**Var(*Y*)** = $(20^2 - 1)/12 = 133/4$ (or 33.25) Or Var(X) = Var(Y)	**B1**	**2.1**	Substitution into the formula must be shown.	
			Completion bringing the two steps above together to state Var(X) = 33.25 oe	**B1** **[2]**	**1.1**	Justification must be shown. e.g. Var($X - 4$) = Var(X) with no incorrect statement seen e.g. Var($X - 4$) = Var(X) – Var(4) = Var (X) is **B0**	If **B0B0** then **SCB1** for Var(X) = 33.25 (must be unambiguously X, not just 33.25, not just Var = 33.25). **B0** for 33 with no evidence of 33.25
	(a)	**(iii)**	$P(X > 14.5) =$ $P(X \in \{15, 16, ..., 24\}) = 10/20 = ½$ AG	**B1** **[1]**	**2.1**	Some indication that the number of numbers in the event $X > E(X)$ is 10. e.g. 24 – 15 + 1	$P(X > 14.5) = P(X \geq 15) = \frac{10}{20} = \frac{1}{2}$ is sufficient Must reach "= ½".

	(b)		eg if $n = 25$ and so $E(X) = 15$ then 10 numbers. 16, 17, ..., 25 out of 21 will be $> E(X)$ so the probability will be 10/21 not ½. (The student is not correct)	**B1**	**3.1a**	Any suitable counter-example ie n an odd number > 24. Probability must be correctly calculated.	
			Alternative method: No. Since $n - 4$ is the number of numbers in the distribution if n is odd then $(n - 4)/2$ will not be an integer so it will not be possible for exactly half the numbers to be $> E(X)$ (or similar argument) (while if n is even then the statement will be true since $(n + 5)/2$ is a half-integer so exactly half the numbers will be bigger than it).	**B1**		Correct answer and some indication that it will not be true if n is odd	Correct answer and some indication that it will **only** be true if n is even
				[1]			

Question			Answer	Marks	AO	Guidance	
5	(a)	(i)	There is a fixed/constant number of eggs (in each batch) (4). Or there are 4 eggs in each batch. Each egg is either large or medium. **or** The farm manager is interested in the number of large eggs (in each batch).	**B1** **B1** **[2]**	**2.4** **2.4**	Must be some context. 4 need not be mentioned. Do not allow 'finite' for 'fixed' Must be some context.	Allow 4 to be considered context so "There is a fixed number of trials, 4." is sufficient but not just "There is a fixed number of trials". Ignore additional comments and elaboration.
		(ii)	Whether one egg is (determined to be) large or medium (i.e.the outcome) must be independent of whether another egg is (determined to have been) large or medium. The probability of an egg being (determined to be) large is the same (0.3) for all eggs.	**B1** **B1** **[2]**	**3.5b** **3.5b**	"The eggs must be independent" is insufficient; the comment must relate to the aspect of the eggs which means that the **trials** are independent of each other. Must be in context. Do **not** allow answers which have one **probability** being independent of another **probability** but allow a correct and precise interpretation of independence to probabilities Probability need not be stated. Allow statements such as "The probability of an egg being large is constant" or "does not change". Must be in context.	Allow the comment to relate to the eggs rather than the trials. Do **not** allow comments which relate to selection; eg "whether a large egg is selected is independent of whether another large egg is selected". Allow the comment to relate to the eggs rather than the trials. If there are additional irrelevant comments award at most 1/2
		(iii)	B(4, 0.3) or Bin(4, 0.3)	**B1** **[1]**	**3.3**	**B0** for B(0.3, 4)	Allow if described in words

Question			Answer	Marks	AO	Guidance	
5	(b)		6 is too small a sample to draw conclusions about the **population** from the sample.	**B1** **[1]**	**2.2a**	Such a small sample is unlikely to be representative of the **population**. **B0** if 'sample too small' only	Or "If $n = 6$ then the expected frequencies will be too small to carry out a χ^2 test."
	(c)		41.16 or 26.46 or 8.37 seen 0 | 1 | 2 | ≥ 3 24.01 | 41.16 | 26.46 | 8.37	**M1** **A1** **[2]**	**3.4** **1.1**	BC. Any one correct value calculated or in explicit uncalculated form (eg 100×0.4116). If accuracy wrong then award if intent clear. BC	Could be $\frac{4116}{100}$ etc. eg $100\times P(X=1) = 100\times 41.2$ If **M0** then **SCB1** for all correct but not to 2dp (eg 41, 26, 8).
	(d)		H_0: B(4, 0.3) fits the data H_1: B(4, 0.3) does not fit the data $\chi^2_{5\%}(3) = 7.815$ cao Test Statistic = 6.6 < 7.815 (or 0.086... > 0.05 or 0.91... < 0.95) Do not reject H_0 There is insufficient evidence for the farm manager to reject H_0. There is insufficient evidence to suggest that (B(4, 0.3)) does not fit the data. **[5]**	**B1FT** **B1** ***M1** **dep* M1** **A1FT**	**3.3** **1.1** **3.4** **1.1** **2.2b**	FT their model from **(a)(iii)** Calculate the test statistic from their table **and** correctly compare their TS to their CV or correct *p*-value to 0.05 oe TS = 6.600744314... *p*-val = 0.08577463… Reaching correct conclusion from their values and correct comparison. Correct conclusion, must now be non-assertive. Must refer to the model and whether or not it fits the data.	Must include B(4, 0.3) in at least one hypothesis, may be in words. Mark can be awarded if it is clear that $\sum\frac{(O-E)^2}{E}$ has been attempted. Can be assertive. Statement must be consistent so, for example; "Reject H_0. There is insufficient evidence to suggest that B(4, 0.3) does not fit the data" is **A0**. Similarly for statements about the statistic (not) lying in the critical region or the test result being (not) significant.

Question		Answer	Marks	AO	Guidance	
6	(a)	Because (a test using the pmcc is not appropriate here since) this is not random-on-random (since the distances are known quantities)	B1 [1]	2.4	There is no reason to believe that the data is taken from a bivariate Normal **population/distribution**.	Or: Because other factors which will affect any correlation are unknown and are likely to have different effects at each sensor. Or: There is no reason to suppose that there is a linear relationship.
	(b)	<table><tr><td>Sensor</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td></tr><tr><td>Dist rank</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr><tr><td>Conc rank</td><td>7</td><td>4</td><td>5</td><td>6</td><td>1</td><td>3</td><td>2</td></tr></table>	B1	1.1	Ranking concentration consistently with distance. Both could be reversed.	If a correlation test is incorrectly used the following marks only are available:
		$\Sigma d^2 = 36 + 4 + 4 + 4 + 16 + 9 + 25$ (= 98)	M1	1.1	Attempt to find Σd^2 using ranks, do not allow minuses.	S_{dd} = awrt612.9 or S_{cc} = awrt107600 or S_{dc} = awrt–3793. **SCM1**.
		$r_S = \left(1 - \frac{6\times98}{7(7^2-1)} =\right) - \frac{3}{4}$ or –0.75	A1	1.1		r = awrt –0.467. **SCA1**.
		H_0: There is **no association** between distance (from outfall to sensor) and concentration (of chemical at the sensor) in the population	B1	3.3	For first **B1** need to see one correct hypothesis in context. Population need not be mentioned for first **B1**.	
		H_1: There **is association** between distance (from outfall to sensor) and concentration (of chemical at the sensor) in the population	B1	2.5	For **B1B1** need to see two correct hypotheses with each of population and context mentioned in at least one of them.	
		(±)0.7857	B1	3.4	n = 7, 2-tailed, 5%. Allow just –0.7857.	n = 7, 2-tailed, 5%. (±)0.7545. Allow just –0.7545. **SCB1**.
		–0.7857 < –0.75 (< 0.7857) or $\lvert -0.75 \rvert < 0.7857$	M1	1.1	Explicit, correct and useful comparison of their values to determine whether their r_S (–1, 1) lies in the critical region.	
		So there is insufficient evidence to reject H_0. There is insufficient evidence (at the 5% level) to suggest that there is an association between concentration (of chemical at the sensor) and the distance (of the sensor from the outfall) (in the population).	A1 [8]	2.2b	Correct non-assertive and contextual conclusion. **A0** if either r_S or CV incorrect	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO</th><th>Guidance</th><th></th></tr>
<tr><td>7</td><td>(a)</td><td></td><td>$\gamma - \alpha$</td><td>B1
[1]</td><td>1.1</td><td>$E(X) = (-1)\alpha + 0\times\beta + (1)\gamma$</td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>$\text{Var}(X) = (-1)^2\alpha + 0^2\times\beta + (1)^2\gamma - (\gamma - \alpha)^2$

$= \alpha + \gamma - (\gamma - \alpha)^2$ ISW unless β introduced</td><td>M1

A1
[2]</td><td>1.1

1.1</td><td>Attempt at $E(X^2) - (E(X))^2$.
Need not see 0 term or $(-1)^2$ if 1 soi.

2/2 for correct answer with no working.</td><td>Allow if stated as $\alpha + \gamma - (\alpha - \gamma)^2$

$\alpha + \gamma - \alpha^2 - \gamma^2 + 2\alpha\gamma$</td></tr>
<tr><td></td><td>(c)</td><td></td><td>
<table>
<tr><td>w</td><td>–2</td><td>–1</td><td>0</td><td>1</td><td>2</td></tr>
<tr><td>$P(W = w)$</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

$P(W = -2) = \alpha^2$ and $P(W = 2) = \gamma^2$

$P(W = -1) = 2\alpha\beta$ and $P(W = 1) = 2\beta\gamma$
$P(W = 0) = \beta^2 + 2\alpha\gamma$ so

<table>
<tr><td>w</td><td>–2</td><td>–1</td><td>0</td><td>1</td><td>2</td></tr>
<tr><td>$P(W = w)$</td><td>α^2</td><td>$2\alpha\beta$</td><td>$\beta^2 + 2\alpha\gamma$</td><td>$2\beta\gamma$</td><td>γ^2</td></tr>
</table>
</td><td>B1

B1

B1
B1

[4]</td><td>3.1a

3.1a

1.1
1.1</td><td>Header column and 5 w options correct. Must be W but w could be any letter other than x, X or a clearly upper case W.
w could be $x_1 + x_2$

For up to two of these three B1s the probabilities could be seen in the table or in working if clear and unambiguous. But for B1B1B1 the table must be completed.</td><td>Ignore crossed out and apparently unused columns even if, say, 3 appears provided that the col's probability row is empty.

NB If discrepancy, mark probabilities in the table, if given.

These marks can be awarded after B0 provided intent is clear.

If final B0B0B0 then SCB1 for any single non-zero $P(W = w)$ clearly and unambiguously correct.</td></tr>
</table>

Question			Answer	Marks	AO	Guidance	
	(d)		$\alpha + \beta + \gamma = 1$ oe	**B1**	**3.1a**	Seen anywhere.	
			$E(W) = -2\alpha^2 + (-1)2\alpha\beta + (0)(\beta^2 + 2\alpha\gamma) + (1)2\beta\gamma + 2\gamma^2$	**M1**	**2.1**	Forming E(W) from their answer in **(c)**. $W = 0$ term need not be seen. Must be working from table with 5 w options.	$= 2(\gamma^2 - \alpha^2) + 2\beta(\gamma - \alpha)$
			$= -2\alpha^2 - 2\alpha(1 - \alpha - \gamma) + 2(1 - \alpha - \gamma)\gamma + 2\gamma^2$	**M1**	**1.1**	Eliminating β using $\alpha + \beta + \gamma = 1$	$= 2(\gamma - \alpha)(\gamma + \alpha) + 2\beta(\gamma - \alpha)$ $= 2(\gamma - \alpha)((\gamma + \alpha) + \beta)$ $= 2(\gamma - \alpha)(\alpha + \beta + \gamma) = 2(\gamma - \alpha)(1)$
			$= -2\alpha^2 - 2\alpha + 2\alpha^2 + 2\alpha\gamma + 2\gamma - 2\alpha\gamma - 2\gamma^2 + 2\gamma^2$ $= -2\alpha + 2\gamma = 2(\gamma - \alpha) = 2E(X)$ AG	**A1**	**1.1**	Showing sufficient working to get to AG convincingly. **(a)** must be correct or E(X) derived correctly here. Accept $-2\alpha + 2\gamma = 2E(X)$ as sufficient final step	$= 2(\gamma - \alpha) = 2E(X)$ Full marks available if the only error in **(c)** is in the $W = 0$ column
				[4]			
	(e)		0.1	**B1** **[1]**	**3.1a**	$\frac{P(W = 0 \cap X_1 = 1)}{P(X_1 = 1)} = \frac{0.1 \times 0.2}{0.2}$	

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