2024 Statistics

Advanced Higher – Paper 1

Question Paper Finalised Marking Instructions

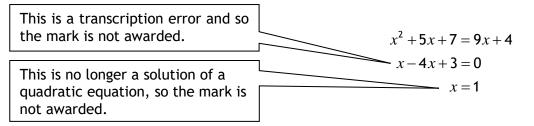**General marking principles for Advanced Higher Statistics**

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

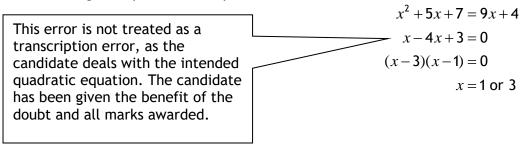*The marking instructions for each question are generally in two sections:*

- *generic scheme — this indicates why each mark is awarded*
- *illustrative scheme — this covers methods which are commonly seen throughout the marking*

In general, you should use the illustrative scheme. Only use the generic scheme where a candidate has used a method not covered in the illustrative scheme.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

(b) If you are uncertain how to assess a specific candidate response because it is not covered by the general marking principles or the detailed marking instructions, you must seek guidance from your team leader.

(c) One mark is available for each •. There are no half marks.

(d) If a candidate's response contains an error, all working subsequent to this error must still be marked. Only award marks if the level of difficulty in their working is similar to the level of difficulty in the illustrative scheme.

(e) Only award full marks where the solution contains appropriate working. A correct answer with no working receives no mark, unless specifically mentioned in the marking instructions.

(f) Candidates may use any mathematically correct method to answer questions, except in cases where a particular method is specified or excluded.

(g) If an error is trivial, casual or insignificant, for example 6 × 6 = 12, candidates lose the opportunity to gain a mark, except for instances such as the second example in point (h) below.

(h) If a candidate makes a transcription error (question paper to script or within script), they lose the opportunity to gain the next process mark, for example

This is a transcription error and so the mark is not awarded.

$$x^2 + 5x + 7 = 9x + 4$$
$$x - 4x + 3 = 0$$

This is no longer a solution of a quadratic equation, so the mark is not awarded.

$$x = 1$$

The following example is an exception to the above

This error is not treated as a transcription error, as the candidate deals with the intended quadratic equation. The candidate has been given the benefit of the doubt and all marks awarded.

$$x^2 + 5x + 7 = 9x + 4$$
$$x - 4x + 3 = 0$$
$$(x - 3)(x - 1) = 0$$
$$x = 1 \text{ or } 3$$

(i) **Horizontal/vertical marking**
If a question results in two pairs of solutions, apply the following technique, but only if indicated in the detailed marking instructions for the question.

Example:

$$\bullet^5 \qquad \bullet^6$$
$$\bullet^5 \quad x = 2 \quad x = -4$$
$$\bullet^6 \quad y = 5 \quad y = -7$$

Horizontal: $\bullet^5$ $x = 2$ and $x = -4$ Vertical: $\bullet^5$ $x = 2$ and $y = 5$
$\qquad\qquad\;$ $\bullet^6$ $y = 5$ and $y = -7$ $\qquad\qquad\;\;\;$ $\bullet^6$ $x = -4$ and $y = -7$

You must choose whichever method benefits the candidate, **not** a combination of both.

(j) In final answers, candidates should simplify numerical values as far as possible unless specifically mentioned in the detailed marking instruction. For example

$\dfrac{15}{12}$ must be simplified to $\dfrac{5}{4}$ or $1\dfrac{1}{4}$ $\dfrac{43}{1}$ must be simplified to 43

$\dfrac{15}{0\cdot3}$ must be simplified to 50 $\dfrac{4\!\!\!/_5}{3}$ must be simplified to $\dfrac{4}{15}$

$\sqrt{64}$ must be simplified to 8*

*The square root of perfect squares up to and including 144 must be known.

(k) Do not penalise candidates for any of the following, unless specifically mentioned in the detailed marking instructions:

- working subsequent to a correct answer
- correct working in the wrong part of a question
- legitimate variations in numerical answers/algebraic expressions, for example angles in degrees rounded to nearest degree
- omission of units
- bad form (bad form only becomes bad form if subsequent working is correct), for example

$\left(x^3 + 2x^2 + 3x + 2\right)\left(2x + 1\right)$ written as

$\left(x^3 + 2x^2 + 3x + 2\right) \times 2x + 1$

$= 2x^4 + 5x^3 + 8x^2 + 7x + 2$

gains full credit

- repeated error within a question, but not between questions or papers

(l) In any 'Show that…' question, where candidates have to arrive at a required result, the last mark is not awarded as a follow-through from a previous error, unless specified in the detailed marking instructions.

(m) You must check all working carefully, even where a fundamental misunderstanding is apparent early in a candidate's response. You may still be able to award marks later in the question so you must refer continually to the marking instructions. The appearance of the correct answer does not necessarily indicate that you can award all the available marks to a candidate.

(n) You should mark legible scored-out working that has not been replaced. However, if the scored-out working has been replaced, you must only mark the replacement working.

(o) If candidates make multiple attempts using the same strategy and do not identify their final answer, mark all attempts and award the lowest mark. If candidates try different valid strategies, apply the above rule to attempts within each strategy and then award the highest mark.

For example:

Strategy 1 attempt 1 is worth 3 marks.	Strategy 2 attempt 1 is worth 1 mark.
Strategy 1 attempt 2 is worth 4 marks.	Strategy 2 attempt 2 is worth 5 marks.
From the attempts using strategy 1, the resultant mark would be 3.	From the attempts using strategy 2, the resultant mark would be 1.

In this case, award 3 marks.

Marking instructions for each question

Question			Generic scheme	Illustrative scheme	Max mark
1.	(a)		•¹ appropriate comment	•¹ the database is for all films worldwide, and not just the UK	**1**

Notes:

Commonly Observed Responses:

	(b)	(i)	•² appropriate reason	•² samples of size 5 were not proportional to the number of films released per year	**1**

Notes:
1. For •², also accept responses that refer to decades, rather than years.

Commonly Observed Responses:

		(ii)	•³ appropriate explanation	•³ identify the number of films released in each year	**2**
			•⁴ appropriate explanation	•⁴ take a (simple) random sample of 1% of those films, for each year	

Notes:
1. For •³ and •⁴, also accept responses that refer to decades, rather than years.
2. For •⁴, response must refer to 1%
3. For •⁴, use of the number 220 (from 1% of 22000) is not accepted evidence of 1%, as the figure of 22000 (from line 15) was a lower bound on the number of films in the database.

Commonly Observed Responses:

Candidate A response refers to taking proportions of age ratings, rather than of years
     Mark •³ not available
     Mark •⁴ available, as an error carried forward.

Question			Generic scheme	Illustrative scheme	Max mark
1.	(c)	(i)	$\bullet^5$ correct hypotheses	$\bullet^5$ H_0: age rating and decade are not associated $\bullet$ H_1: age rating and decade are associated	**1**

Notes:
1. For $\bullet^5$, also accept phrasing of 'H_0: … are independent' and 'H_1: … are not independent'.

Commonly Observed Responses:

		(ii)	$\bullet^6$ correct statement	$\bullet^6$ check that at least 80% of the expected frequencies were at least 5 and none less than 1	**1**

Notes:
1. For $\bullet^6$, only accept precise and fully correct statements.
2. For $\bullet^6$, also accept "all expected frequencies are at least 1 and no more than 20% are less than 5"

Commonly Observed Responses:

		(iii)	$\bullet^7$ correct process	$\bullet^7$ combine at least two rows **or** at least two columns (where appropriate until the check is satisfied)	**2**
			$\bullet^8$ appropriate number of degrees of freedom	$\bullet^8$ number of degrees of freedom must be consistent with their response to mark $\bullet^7$ See notes 3 and 4.	

Notes:
1. For $\bullet^7$, do not accept ambiguous terms such as 'pooling the data', unless the response for $\bullet^8$ clearly demonstrates the combining of either rows, or columns.
2. For $\bullet^7$, also accept 'combine rows or columns together until the criteria are met'
3. For $\bullet^8$, do not accept general phrases such as 'less than 12'.
4. For $\bullet^8$, if the candidate combines two rows, there will be 8 degrees of freedom.
5. For $\bullet^8$, if the candidate combines two columns, there will be 9 degrees of freedom.

Commonly Observed Responses:

	Question		Generic scheme	Illustrative scheme	Max mark
1.	(d)	(i)	$\bullet^9$ correct proportions	$\bullet^9$ $\hat{p}_1 = \dfrac{5}{50}, \hat{p}_2 = \dfrac{37}{150}$	**3**
			$\bullet^{10}$ calculate p	$\bullet^{10}$ $p = \dfrac{5+37}{50+150} = \dfrac{42}{200}$	
			$\bullet^{11}$ appropriate substitution	$\bullet^{11}$ $z = \dfrac{\dfrac{5}{50} - \dfrac{37}{150}}{\sqrt{\dfrac{42}{200}\dfrac{158}{200}\left(\dfrac{1}{50} + \dfrac{1}{150}\right)}}$	

Notes:

1. For $\bullet^9$, do not penalise omission of 'hats' over estimated proportions.
2. For $\bullet^{11}$, if numerator is $\dfrac{37}{150} - \dfrac{5}{50}$, then z = 2.205. Hence, to gain the mark, a further explanation must be given by the candidate to explain the difference in sign between 2.205 and -2.205.
3. For $\bullet^{11}$, if an error has been made in either $\bullet^9$ or $\bullet^{10}$, then $\bullet^{11}$ is only available if the candidate does not state that their calculation is equal to -2.205

Commonly Observed Responses:

Candidate A conducts a 1-sample z test for proportion, instead of a 2-sample z test
   Mark $\bullet^9$ available.
   Mark $\bullet^{10}$ not available.
   Mark $\bullet^{11}$ not available.
   Mark $\bullet^{12}$ not available for $np > 5, nq > 5$, since the task complexity has been eased.
   Mark $\bullet^{13}$ available

		(ii)	$\bullet^{12}$ correct statement	$\bullet^{12}$ check that $n_i\hat{p}_i > 5$ and $n_i\hat{q}_i > 5$	**2**
			$\bullet^{13}$ appropriate comment	$\bullet^{13}$ the conclusion from the hypothesis test (on age rating 18 films) would be in doubt.	

Notes:

1. For $\bullet^{12}$, do not penalise omission of 'hats' over estimated proportions.
2. For $\bullet^{12}$, do not accept $np > 5, nq > 5$ as the check is not performed using the total sample size and the pooled proportion, but rather on each individual sample.
3. For $\bullet^{13}$, also accept either of the following:
   'the normal approximation to the binomial would not be a good approximation'
   'the test statistic would be less accurate'
4. For $\bullet^{13}$, do not accept conclusions that are too definite, such as 'the conclusion would be wrong'

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
1.	(e)		•[14] appropriate comment	•[14] claim about all age rating categories is not true, as U films seem unchanged over the decades.	2
			•[15] appropriate comment	•[15] claim about family friendly films is not true, as age rating 12 films are not the only category of films that might be 'family friendly' – U and PG films need included.	

Notes:

1. For •[14] and •[15] other responses are acceptable, such as:
   'we only compared the proportions of the categories for 12 and 18'
   'there is no proven link with internet streaming services'
   'numbers of films in every age rating category have changed' is not true as the report did not record the total number of films that were released in each age category, for each decade

Commonly Observed Responses:

Candidate A provides more than two comments for part (e)
   Treat each comment as using the same strategy, mark each possible combination of pairs of comments and then award the lowest mark from these combinations:

Number of comments	Number correct	Number incorrect	Marks Awarded
3	0	3	0
3	1	2	0
3	2	1	1
3	3	0	2
4	0	4	0
4	1	3	0
4	2	2	0
4	3	1	1
4	4	0	2

Question			Generic scheme	Illustrative scheme	Max mark
2.	(a)		$\bullet^1$ appropriate reason	$\bullet^1$ the distribution of each treatment group appears non-normal	**2**
			$\bullet^2$ appropriate reason	$\bullet^2$ both population variances are unknown	

Notes:

1. For $\bullet^1$ and $\bullet^2$, only accept responses that clearly communicate that there are two sets of data.
2. For $\bullet^1$ and $\bullet^2$, if both responses only refer to a single data set, then the first mark is unavailable, but the second mark is available, as an error carried forward.
3. For $\bullet^1$ and $\bullet^2$, a minimal accepted response is 'at least one sample appears non-normal, and at least one population variance is not known'
4. For $\bullet^2$, also accept 'the sample size in each treatment group is less than 20'.

Commonly Observed Responses:

Candidate A provides more than two comments for part (a)

Treat each comment as using the same strategy, mark each possible combination of pairs of comments and then award the lowest mark from these combinations:

Number of comments	Number correct	Number incorrect	Marks Awarded
3	0	3	0
3	1	2	0
3	2	1	1
3	3	0	2
4	0	4	0
4	1	3	0
4	2	2	0
4	3	1	1
4	4	0	2

	Question		Generic scheme	Illustrative scheme	Max mark
2.	(b)	(i)	$\bullet^3$ appropriate hypotheses	$\bullet^3$ H_0: The median of the population of viral loads under standard treatment is equal to the median of the population of viral loads under new treatment H_1: The median of the population of viral loads under standard treatment does not equal the median of the population of viral loads under new treatment	1

Notes:
1. For $\bullet^3$, both hypotheses must be given, and refer to medians and populations.
2. For $\bullet^3$, the two-sided alternative 'not equal' must be used.
3. For $\bullet^3$, also accept $H_0 : \eta_{standard} = \eta_{new}$ and $H_1 : \eta_{standard} \neq \eta_{new}$

Commonly Observed Responses:

	Question		Generic scheme	Illustrative scheme	Max mark
2.	(b)	(ii)	$\bullet^4$ describe ranking process	$\bullet^4$ all the values of 'Viral Load' (in Table 1) were sorted (in increasing order) and each (unique) value was assigned a rank	**3**
			$\bullet^5$ describe sums of ranks	$\bullet^5$ the sum of the ranks corresponding to the new treatment was calculated (let this value be W_{new})	
			$\bullet^6$ specify the minimum of the rank sums	$\bullet^6$ the minimum of W_{new} and $14 \times (14+15+1) - W_{new}$ is reported as W in Output 1	

Notes:
1. For $\bullet^4$ and $\bullet^6$, an alternative technique is to rank the data from low to high, as well as from high to low, calculating the rank sums of W_{new} for each ordering. Then, select the ranking order that gave the smallest value of $W_{new.}$
2. For (b)(ii), if a Wilcoxon Signed-Rank test is described, then award no marks.

Commonly Observed Responses:

		(iii)	$\bullet^7$ state critical value	$\bullet^7$ 164	**3**
			$\bullet^8$ deal with H$_0$	$\bullet^8$ as 205 > 164, we do not reject the null hypothesis	
			$\bullet^9$ appropriate conclusion	$\bullet^9$ there is insufficient evidence that the population median viral loads of the two treatments are different.	

Notes:
1. For $\bullet^9$, do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude…', or 'evidence to suggest…', or similar.
2. For $\bullet^9$, context is required.
3. For $\bullet^9$, refer back to part 2(b)(i) to establish whether 'population' was mentioned:
   If 'population' was mentioned, then do not penalise its omission here.
   If 'population' was not mentioned, then treat it as an error carried forward here.
4. For $\bullet^9$, do not accept 'evidence to suggest there is no difference' (as this is saying 'there is evidence for H$_0$')

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
2.	(c)		$\bullet^{10}$ determine the missing value	$\bullet^{10}$ 6.5	**1**

Notes:

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
	(d)		$\bullet^{11}$ calculate the sums of ranks	$\bullet^{11}$ the sum of the ranks of the negative differences (3+3+3+9) and positive differences (6.5+12+6.5+15+3+9+12+12+3+14+9) are calculated to be 18 and 102, respectively.	**2**
			$\bullet^{12}$ correct justification of W	$\bullet^{12}$ the minimum of these two values is reported as W in Output 2 (W = min(102,18) = 18)	

Notes:
1. For $\bullet^{11}$, the rank sum of positive differences can also be obtained from subtracting the rank sum of negative differences from the total rank sum.

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
	(e)	(i)	$\bullet^{13}$ state the interval	$\bullet^{13}$ (0.01, 0.02)	**1**

Notes:
1. For $\bullet^{13}$, if candidate incorrectly states the interval (0.005, 0.01) corresponding to the one-tailed test, the results and conclusions in $\bullet^{14}$ and $\bullet^{15}$ will still be the same.

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
2.	(e)	(ii)	$\bullet^{14}$ deal with H_0 $\bullet^{15}$ appropriate conclusion	$\bullet^{14}$ p-value < 0.05 we reject H_0 $\bullet^{15}$ conclude there is sufficient evidence that the (population) median viral load under the standard treatment at 3 months is not equal to that at 6 months	**2**

Notes:

1. For $\bullet^{14}$, also accept $18 \leq 25$ (the 5% critical value for two-tailed test).
2. For $\bullet^{14}$, do not accept $18 \leq 30$ (the 5% critical value for one-tailed test).
3. For $\bullet^{15}$, conclusion must mention that the viral load median differs at 3 months compared at 6 months (since output states 'alternative hypothesis: true location shift is not equal to 0').
4. For $\bullet^{15}$, do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude…', or 'evidence to suggest…', or similar.

Commonly Observed Responses:

[END OF MARKING INSTRUCTIONS]