National Qualifications 2025

2025 Statistics

Advanced Higher Paper 2

Question Paper Finalised Marking Instructions

These marking instructions have been prepared by examination teams for use by SQA appointed markers when marking external course assessments.

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.

$x^2 + 5x + 7 = 9x + 4$

$x - 4x + 3 = 0$

$(x - 3)(x - 1) = 0$

$x = 1$ 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:

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

Horizontal: $\bullet^5$ $x = 2$ and $x = -4$ Vertical: $\bullet^5$ $x = 2$ and $y = 5$

$\bullet^6$ $y = 5$ and $y = -7$ $\bullet^6$ $x = -4$ 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

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

$\frac{15}{0{\cdot}3}$ must be simplified to 50 $\frac{4/5}{3}$ must be simplified to $\frac{4}{15}$

$\sqrt{64}$ 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

$(x^3 + 2x^2 + 3x + 2)(2x + 1)$ *written as*

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

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

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.

Note: Marking from Image (MFI) annotation change from 2025

A double cross-tick is used to indicate correct working which is irrelevant or insufficient to score any marks. In MFI marking instructions prior to 2025 this was shown as **ü₂** or ü2.

From 2025, the double cross-tick will no longer be used in MFI. A cross or omission symbol will be used instead.

Marking Instructions for each question

Question			Generic scheme	Illustrative scheme	Max mark
1.	(a)		$\bullet^1$ correct mean $\bullet^2$ appropriate strategy $\bullet^3$ calculate variance	$\bullet^1$ $\mathrm{E}(X)=\frac{255}{60}=\frac{17}{4}=4.25$ $\bullet^2$ $\mathrm{E}\left(X^2\right)=\frac{1225}{60}=\frac{245}{12}=20.4167$ $\bullet^3$ $\mathrm{V}(X)=\frac{1225}{60}-\left(\frac{17}{4}\right)^2=\frac{113}{48}=2.35417$	**3**
Notes: 1. For $\bullet^3$, also accept 2.35					
Commonly Observed Responses:					
	(b)		$\bullet^4$ correct assumption $\bullet^5$ correct variance $\bullet^6$ correct strategy $\bullet^7$ calculate standard deviation	$\bullet^4$ X and Y are independent $\bullet^5$ $V(Y)=\frac{63}{12}=5.25$ $\bullet^6$ $V(X-Y)=\frac{113}{48}+\frac{63}{12}=7.6042$ $\bullet^7$ $\mathrm{SD}(X-Y)=2.76$	**4**
Notes: 1. For $\bullet^4$, also accept 'the (random) variables are independent'. 2. For $\bullet^4$, do not accept: 'scores are independent'. 'rolls are independent'. 'distributions are independent'. 3. For $\bullet^6$, also accept use of the value calculated for mark $\bullet^3$ in part (a).					
Commonly Observed Responses:					

Question			Generic scheme	Illustrative scheme	Max mark
2.	(a)		•[1] calculate either lower fence or upper fence •[2] calculate remaining fence and give appropriate comment for either highest or lowest value •[3] appropriate comment for remaining value	•[1] -15.5 or 44.5 •[2] 44.5 or -15.5, and 46 is an outlier as $46 > 44.5$ •[3] 1 is not an outlier as $1 > -15.5$	**3**
Notes: 1. For •[2] and •[3], only accept comparison of numerical values, using inequalities. 2. For •[2] and •[3], do not penalise omission of the word 'outlier'. It is sufficient to state whether or not each value is beyond a fence. 3. For •[2] and •[3], do not accept comments about data validity.					
Commonly Observed Responses:					
	(b)		•[4] appropriate hypotheses •[5] calculate expected values •[6] calculate test statistic •[7] correct critical value •[8] deal with H_0 •[9] appropriate conclusion	•[4] H_0: There is no association between type of outlet visited and distance travelled H_1: There is an association between type of outlet visited and distance travelled •[5] 42.78 | 19.22 26.22 | 11.78 •[6] $X^2 = 9.1217$ •[7] $\chi^2_{1,0.950} = 3.841$ •[8] $9.1217 > 3.841$ therefore reject H_0 at the 5% level of significance •[9] conclude that there is evidence of an association between type of outlet visited and distance travelled.	**6**
Notes: 1. For •[4], also accept hypotheses phrased with 'independent' (H_0) and 'not independent' (H_1). 2. For •[7], also accept p-value = 0.002526 3. For •[7] and •[8], also accept other significance levels, which must be clearly stated in the solution. 4. For •[8], do not accept 'accept H_1'. 5. For •[9], also accept '… type of outlet visited and distance travelled are not independent.' 6. For •[9], do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude…', or 'evidence to suggest…', or similar.					
Commonly Observed Responses:					

Question			Generic scheme	Illustrative scheme	Max mark
3.			$\bullet^1$ correct distribution $\bullet^2$ appropriate calculation $\bullet^3$ correct continuity correction $\bullet^4$ calculate probability	$\bullet^1$ $X \approx \mathrm{N}(14,14)$ $\bullet^2\,\bullet^3$ $\begin{cases}\mathrm{P}\left(Z > \dfrac{20.5-14}{\sqrt{14}}\right) \\ = \mathrm{P}(Z > 1.74)\end{cases}$ $\bullet^4$ 0.0409	**4**

Notes:

1. For $\bullet^1$, do not penalise omission of double tilde.
2. For $\bullet^1$, this mark can be awarded by implication from workings for mark $\bullet^2$.
3. If an exact Poisson calculation used, with no normal approximation, then only mark $\bullet^4$ is available for 0.0479

Commonly Observed Responses:

Candidate A

$\mathrm{P}\left(Z > \dfrac{19.5-14}{\sqrt{14}}\right) = \mathrm{P}(Z > 1.4699) = 0.0708$ award $\bullet^2\checkmark\ \bullet^3\times\ \bullet^4\checkmark$

Candidate B

$\mathrm{P}\left(Z > \dfrac{20-14}{\sqrt{14}}\right) = \mathrm{P}(Z > 1.6036) = 0.0548$ award $\bullet^2\checkmark\ \bullet^3\times\ \bullet^4\checkmark$

Question			Generic scheme	Illustrative scheme	Max mark
4.	(a)		•[1] appropriate comment	•[1] normal distribution of tip-per-customer values would give negative values within two standard deviations of the mean, which are not realistic	**1**
Notes: 1. For •[1], also accept explanations that convey similar appreciation of negative values below the mean, when the standard deviation is taken into account.					
Commonly Observed Responses:					
	(b)	(i)	•[2] correct distribution •[3] calculate z •[4] calculate probability	•[2] $\bar{X} \approx N\left(4.7, \frac{2.8^2}{50}\right)$ •[3] $z = \frac{5.5-4.7}{2.8/\sqrt{50}} = 2.0203$ •[4] 0.0217	**3**
Notes: 1. For •[2], it is required to communicate approximate normality and include $\bar{X}$.					
Commonly Observed Responses: **Candidate A** $X \approx N\left(4.7, 2.8^2\right)$ $z = \frac{5.5-4.7}{2.8} = 0.2857$ $\mathrm{P}\left(Z > 0.2857\right) = 0.3859$ award •[2]× •[3]✓ •[4]✓					

Question			Generic scheme	Illustrative scheme	Max mark
4.	(b)	(ii)	$\bullet^5$ appropriate feature $\bullet^6$ appropriate feature	$\bullet^5$ the population of tips-per-customer is not known to be normally distributed. $\bullet^6$ the sample size of 50 restaurants is greater than 20	**2**

Notes:

1. For $\bullet^6$, also accept '$n > 20$'.

Commonly Observed Responses:

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

Number of features	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
5.			$\bullet^1$ omit difference of zero from ranking $\bullet^2$ deal with tied ranks $\bullet^3$ calculate test statistic $\bullet^4$ state critical value $\bullet^5$ deal with H_0 $\bullet^6$ appropriate conclusion	$\bullet^1$ see note 1. $\bullet^2$ see note 1. $\bullet^3$ $W = \min(13.5, 22.5) = 13.5$ $\bullet^4$ for $n = 8$, 5% 2-tail cv = 3 $\bullet^5$ as $13.5 > 3$, do not reject H_0 $\bullet^6$ we have insufficient evidence to suggest that the population median is different from 40	**6**

Notes:

1. For $\bullet^1$ and $\bullet^2$, correct ranks are:

data	40.1	40.3	39.5	40.6	40.8	39.9	40	41.3	38.3
median	40	40	40	40	40	40	40	40	40
difference	0.1	0.3	−0.5	0.6	0.8	−0.1	0	1.3	−1.7
|difference|	0.1	0.3	0.5	0.6	0.8	0.1	0	1.3	1.7
ranks	1.5	3	4	5	6	1.5		7	8

2. For $\bullet^5$, do not accept 'accept H_0'.
3. For $\bullet^6$, do not accept conclusions that are in terms of H_0 (eg. 'conclude that there is evidence that the population median is 40').
4. For $\bullet^6$, do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude...', or 'evidence to suggest...', or similar.

Commonly Observed Responses:

Candidate A does not omit the difference of zero:

data	40.1	40.3	39.5	40.6	40.8	39.9	40	41.3	38.3
median	40	40	40	40	40	40	40	40	40
difference	0.1	0.3	−0.5	0.6	0.8	−0.1	0	1.3	−1.7
|difference|	0.1	0.3	0.5	0.6	0.8	0.1	0	1.3	1.7
ranks	2.5	4	5	6	7	2.5	1	8	9

Mark $\bullet^1$ not available
Mark $\bullet^2$ available for the ranks shown in the table above
Mark $\bullet^3$ available for '$W = \min(16.5, 28.5) = 16.5$'
Mark $\bullet^4$ available for '$n = 9$, 5% 2-tail cv = 5'
Mark $\bullet^5$ available for 'as $16.5 > 5$, do not reject H_0'

Question			Generic scheme	Illustrative scheme	Max mark
6.			$\bullet^1$ state hypotheses	$\bullet^1$ $H_0 : \mu_{2010\text{-}2018} = \mu_{2000\text{-}2009}$ $H_1 : \mu_{2010\text{-}2018} > \mu_{2000\text{-}2009}$	**5**
			$\bullet^2$ correct test statistic	$\bullet^2$ $z = \dfrac{4.2510 - 3.9868}{\sqrt{\dfrac{1.2342^2}{735} + \dfrac{1.3396^2}{990}}} = 4.2387$	
			$\bullet^3$ state critical value	$\bullet^3$ $z_{0.995} = 2.58$	
			$\bullet^4$ deal with H_0	$\bullet^4$ $4.2387 > 2.58$ so we have evidence to reject H_0	
			$\bullet^5$ appropriate conclusion	$\bullet^5$ and conclude that there is evidence at the 0.5% level that the mean monthly extreme tidal range has increased over time	

Notes:

1. For $\bullet^1$, also accept $H_0 : \mu_1 = \mu_2 \quad H_1 : \mu_1 > \mu_2$
2. For $\bullet^1$, if candidate states $H_1 : \mu_1 < \mu_2$, then mark $\bullet^2$'s test statistic value should be negative and it should then be compared to a negative critical value in mark $\bullet^4$. If all of these steps are consistent in terms of their signs, then all marks are available.
3. For $\bullet^3$, also accept p-value = 0.0000109
4. For $\bullet^4$, also accept '$0.0000109 < 0.005$ so we have evidence to reject H_0'.
5. For $\bullet^4$, do not accept 'accept H_1'.
6. For $\bullet^5$, also accept:
   '… mean monthly tidal range …'.
   '… mean extreme tidal range …'.
   '… mean tidal range …'.
7. For $\bullet^5$, do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude…', or 'evidence to suggest…', or similar.

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
7.	(a)		$\bullet^1$ correct distribution and parameters $\bullet^2$ appropriate justification $\bullet^3$ appropriate justification	$\bullet^1$ $X \sim B\left(10, \frac{1}{6}\right)$ $\bullet^2$ each trial outcome has constant probability … $\bullet^3$ … and fixed number of trials	**3**

Notes:

1. For $\bullet^1$, do not penalise omission of random variable letter.
2. For $\bullet^1$, do not accept $B(10, 0.16)$. Probability must be truncated or rounded to at least 3d.p.
3. For $\bullet^2$ or $\bullet^3$, also accept:
   'each trial has a binary outcome'.
   'trials are independent'.
4. For $\bullet^2$ or $\bullet^3$, do not accept justification(s) of the parameter values, as credit was given for them in mark $\bullet^1$. Responses must give justifications that are aligned with the modelling assumptions of a binomial distribution.

Commonly Observed Responses:

Candidate A

$X \sim \mathrm{U}(6)$
equal fixed probability } award $\bullet^1\times\ \bullet^2\checkmark\ \bullet^3\times$

	(b)		$\bullet^4$ correct distribution and parameters $\bullet^5$ appropriate justification $\bullet^6$ appropriate justification	$\bullet^4$ $L \sim \mathrm{U}(0, 8.0)$ $\bullet^5$ length of leftover string has a constant probability (density) of … $\bullet^6$ … being any length from 0 to 8.0 cm	**3**

Notes:

1. For $\bullet^4$, do not penalise omission of random variable letter.
2. For $\bullet^5$, also accept phrasing such as 'equally likely'.
3. For $\bullet^4$ and $\bullet^6$, do not penalise the use of exactly '8'.

Commonly Observed Responses:

Candidate A

$L \sim \mathrm{U}(8)$
equally likely lengths } award $\bullet^1\times\ \bullet^2\checkmark\ \bullet^3\times$

Question			Generic scheme	Illustrative scheme	Max mark
8.	(a)		•[1] appropriate list •[2] appropriate use of random numbers •[3] appropriate sample	•[1] assign a (unique) number to all members of the population of size N. •[2] generate n random numbers from 1 to N. •[3] select individuals corresponding to the randomly generated numbers.	**3**
Notes:					
Commonly Observed Responses:					

Question			Generic scheme	Illustrative scheme	Max mark
8.	(b)		•[4] correct conditions checked	•[4] $n_A\hat{p}_A = 14 > 5, n_A\hat{q}_A = 15 > 5$	**9**
			•[5] correct conditions checked	•[5] $n_B\hat{p}_B = 21 > 5, n_B\hat{q}_B = 9 > 5$	
			•[6] appropriate hypotheses	•[6] $H_0 : p_A = p_B$ $H_1 : p_A < p_B$	
			•[7] appropriate test statistic	•[7] $z = \dfrac{p_A - p_B}{\sqrt{pq\left(\dfrac{1}{n_A} + \dfrac{1}{n_B}\right)}}$	
			•[8] calculate pooled p	•[8] $p = \dfrac{14+21}{29+30} = \dfrac{35}{59} = 0.5932$	
			•[9] calculate z	•[9] $z = \dfrac{\frac{14}{29} - \frac{21}{30}}{\sqrt{\frac{35}{59} \times \frac{24}{59} \times \left(\frac{1}{29} + \frac{1}{30}\right)}} = -1.698$	
			•[10] correct critical value	•[10] $z_{0.050} = -1.64$	
			•[11] deal with H_0	•[11] $-1.698 < -1.64$ so we can reject H_0 at the 5% level of significance	
			•[12] appropriate conclusion	•[12] conclude that there is evidence to suggest that centre A has a lower pass rate (which means that the criticism would be justified)	

Notes:

1. For •[4] and •[5], alternatively accept:
   - •[4] $n_A\hat{p}_A = 14 > 5, n_B\hat{p}_B = 21 > 5$
   - •[5] $n_A\hat{q}_A = 15 > 5, n_B\hat{q}_B = 9 > 5$
2. For •[7], this mark can be implied from the workings for mark •[9].
3. For •[10], also accept p-value = 0.0447
4. For •[11], also accept '0.0447 < 0.05 so we can reject H_0'.
5. For •[11], do not accept 'accept H_1'.
6. For •[12], do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude…', or 'evidence to suggest…', or similar.

Question			Generic scheme	Illustrative scheme	Max mark
8.	**(b)**		**(continued)**		

Commonly Observed Responses:

Candidate A checks approximation conditions on the estimated pooled proportion
Mark •[4] not available
Mark •[5] available for $n\hat{p} = 35 > 5, n\hat{q} = 24 > 5$

Candidate B performs a t-test
Mark •[7] not available
Mark •[8] only available for $s^2 = \dfrac{(29-1)\times 29\times \frac{14}{29}\times\frac{15}{29} + (30-1)\times 30\times\frac{21}{30}\times\frac{9}{30}}{29+30-2} = 6.7624$
Mark •[9] not available

Candidate C performs a χ^2 test on a contingency table
Mark •[4] available for 'no expected frequencies should be less than 1'.
Mark •[5] available for 'at least 80% of the expected frequencies should be at least 5'.
Mark •[6] not available.
Mark •[7] not available.
Mark •[8] available for the expected frequencies of 17.20, 17.80, 11.80, 12.20
Mark •[9] available for $X^2 = 2.8839$
Mark •[10] available for $\chi^2_{1,0.95} = 3.841$ or p-value = 0.08947
Mark •[11] available for '$2.8839 < 3.841$, so do not reject H_0'.
Mark •[12] available for a conclusion that is consistent and written in terms of insufficient evidence for their stated H_1.

	(c)		•[13] appropriate aspect	•[13] data was gathered from two different months	**1**

Notes:

1. For •[13], also accept 'a different random sampling technique may have been used across the two months'.

Commonly Observed Responses:

Candidate A provides more than one aspect for part (c)
Treat each aspect as using the same strategy, mark each possible aspect on its own and then award the lowest mark from across all aspects:

Number of aspects	Number correct	Number incorrect	Marks Awarded
2	0	2	0
2	1	1	0
2	2	0	1
3	0	3	0
3	1	2	0
3	2	1	0
3	3	0	1

Question			Generic scheme	Illustrative scheme	Max mark
9.	(a)		$\bullet^1$ correct mean $\bullet^2$ correct variance	$\bullet^1$ $\mathrm{E}(Y) = 0.254$ $\bullet^2$ $\mathrm{V}(Y) = 0.635^2 = 0.403225$	**2**
Notes:					
Commonly Observed Responses:					
	(b)		$\bullet^3$ appropriate strategy $\bullet^4$ calculate z values $\bullet^5$ calculate probability $\bullet^6$ calculate expected number	$\bullet^3$ $\mathrm{P}(-1 < Y < 1)$ $\bullet^4$ $\mathrm{P}(-1.97 < Z < 1.17)$ $\bullet^5$ 0.8546 $\bullet^6$ $80 \times 0.8546 = 68.4$	**4**

Notes:

1. For $\bullet^6$, if the integer response of 68 is given, then workings must be shown.

Commonly Observed Responses:

Candidate A

If $\bullet^2$ $\mathrm{V}(Y) = 2.54 \times 0.25^2 = 0.15875$, then follow through marks are all available for:

$\bullet^3$ $\mathrm{P}(-1 < Y < 1)$

$\bullet^4$ $\mathrm{P}(-3.15 < Z < 1.87)$

$\bullet^5$ 0.9684

$\bullet^6$ 77.4

Candidate B

If $\bullet^2$ $\mathrm{V}(Y) = 2.54 \times 0.25^2 = 0.15875$, and the response is:

$\bullet^3$ $\mathrm{P}(Y < 1)$

$\bullet^4$ $\mathrm{P}(Z < 1.87)$

$\bullet^5$ 0.9693

$\bullet^6$ 77.5 then award $\bullet^3$× $\bullet^4$✓ $\bullet^5$× $\bullet^6$✓

Candidate C

If $\bullet^2$ $\mathrm{V}(Y) = 2.54^2 \times 0.25^2 = 0.403225$, and the response is:

$\bullet^3$ $\mathrm{P}(Y < 1)$

$\bullet^4$ $\mathrm{P}(Z < 1.17)$

$\bullet^5$ 0.8790

$\bullet^6$ 70.3 then award $\bullet^3$× $\bullet^4$✓ $\bullet^5$× $\bullet^6$✓

Question			Generic scheme	Illustrative scheme	Max mark
10.	(a)		•[1] appropriate assumption	•[1] assume that the **masses** of spoonfuls of powdered milk are independent	**7**
			•[2] state hypotheses	•[2] H_0: $\mu = 4.5$ H_1: $\mu \neq 4.5$	
			•[3] correct sample mean and standard deviation	•[3] $\bar{x} = 4.65 \quad s = \sqrt{0.0930} = 0.305$	
			•[4] calculate test statistic	•[4] $t = \dfrac{\bar{x} - \mu}{s/\sqrt{n}} = \dfrac{4.65 - 4.5}{0.305/\sqrt{6}} = 1.20$	
			•[5] state critical value	•[5] $t_{5,0.95} = 2.015$	
			•[6] deal with H_0	•[6] $1.20 < 2.015$ so we do not reject H_0 at the 10% level of significance	
			•[7] appropriate conclusion	•[7] and conclude that there is insufficient evidence that the mean mass per spoonful of the new recipe differs from that of the original recipe	

Notes:

1. For •[1], also accept the assumption that the sample of 6 spoonfuls is obtained randomly, or is representative of the spoonfuls that could be measured.
2. For •[5], also accept p-value $= 2 \times \mathrm{P}(t_5 > 1.20483) = 0.28218$
3. For •[6], do not accept 'accept H_0'.
4. For •[7], do not accept conclusions in terms of H_0 (eg. 'conclude that there is evidence that the mean mass per spoonful is 4.5 grams').
5. For •[7], do not accept conclusions that are too definite. Phrasing must include 'evidence to conclude…', or 'evidence to suggest…', or similar.

Commonly Observed Responses:

Candidate A uses a z-test, instead of a t-test
Mark •[4] not available.
Mark •[5] available for $z_{0.95} = 1.64$ or a p-value of 0.2283
Marks •[6] and •[7] available for consistent 'deal with H_0' and 'appropriate conclusion'

Candidate B uses a t-test for a difference in population means
Mark •[2] not available.
Mark •[4] not available.
Remaining marks are possibly available as follow through errors, pending clear communication of values used for n_1, n_2, s_1 and s_2.

Question			Generic scheme	Illustrative scheme	Max mark
10.	(b)		$\bullet^8$ appropriate comment	$\bullet^8$ the manufacturer should use a z-test (for population mean)	**1**
Notes: 1. For $\bullet^8$, if a z-test was used in part (a), then this mark is not available.					
Commonly Observed Responses:					

Question			Generic scheme	Illustrative scheme	Max mark
11.	(a)	(i)	$\bullet^1$ appropriate strategy $\bullet^2$ calculate 1 standard error $\bullet^3$ calculate lower 1σ and 3σ limits	$\bullet^1$ $0.821 = 0.92 - 2se$ $\bullet^2$ 0.0495 $\bullet^3$ 0.8705 and 0.7715	**3**

Notes:

1. Mark $\bullet^2$ can be implied from a correct response to mark $\bullet^3$.
2. For $\bullet^3$, if an incorrect standard error has been calculated, both 1σ and 3σ limit values must be calculated using same reference point of either 0.92, or 0.821. Do not accept methods which use 0.92 to obtain one limit value and then use 0.821 to obtain the other limit value.

Commonly Observed Responses:

Candidate A

$$0.821 = 0.92 - 2\sqrt{\frac{0.92 \times 0.08}{n}}$$

$$n = 30.0378$$

$$n \approx 30$$

$$1\sigma \text{ limit} = 0.92 - 1\sqrt{\frac{0.92 \times 0.08}{30}} = 0.8705$$

$$3\sigma \text{ limit} = 0.92 - 3\sqrt{\frac{0.92 \times 0.08}{30}} = 0.7714$$

award $\bullet^1\checkmark$ $\bullet^2\checkmark$ $\bullet^3\checkmark$

		(ii)	$\bullet^4$ appropriate reason	$\bullet^4$ higher success rates are good	**1**

Notes:

1. For $\bullet^4$, depending upon an (incorrect) value of 1 standard error calculated in (a)(i), candidates may give an acceptable reason here to be that 'upper limits are > 1'.

Commonly Observed Responses:

	(b)		$\bullet^5$ appropriate WECO statement $\bullet^6$ appropriate conclusion	$\bullet^5$ this results in two out of three data points falling beyond the same 2σ limit $\bullet^6$ so the process may be out of statistical control and they should be concerned	**2**

Notes:

1. For $\bullet^6$, this mark is only available if an attempt has been made at giving a reason, for mark $\bullet^5$.
2. For $\bullet^6$, also accept 'WECO rule is broken, so they should be concerned'.

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
12.	(a)		$\bullet^1$ appropriate assumption	$\bullet^1$ the sample of balls were chosen at random	**5**
			$\bullet^2$ appropriate assumption	$\bullet^2$ bounce heights are normally distributed	
			$\bullet^3$ correct strategy	$\bullet^3$ CI is given by $\bar{x} \pm t_{n-1,0.990} \frac{s}{\sqrt{n}}$	
			$\bullet^4$ corresponding critical value	$\bullet^4$ $t_{14,0.990} = 2.624$	
			$\bullet^5$ calculate interval	$\bullet^5$ (139.03, 139.97)	

Notes:

1. For $\bullet^1$ and $\bullet^2$, the context of 'bounce heights' is required for at least one assumption.
2. For $\bullet^1$, also accept 'one tennis ball's bounce height is independent of all others'.

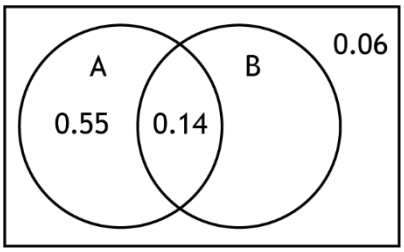
Commonly Observed Responses:

Candidate A uses a z distribution, instead of a t distribution
Mark $\bullet^3$ not available.
Mark $\bullet^4$ available for $z_{0.99} = 2.33$
Mark $\bullet^5$ available for (139.08, 139.92)

Candidate B provides more than two assumptions for part (a)
Treat each assumption as using the same strategy, mark each possible combination of pairs of assumptions and then award the lowest mark from these combinations:

Number of features	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

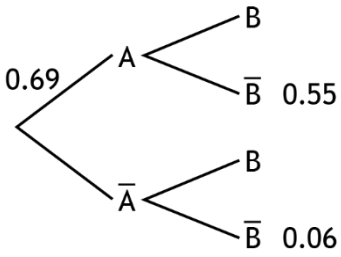
Question			Generic scheme	Illustrative scheme	Max mark
12.	(b)		•[6] appropriate observation •[7] appropriate comment	•[6] 98% confidence interval lies below 141 cm •[7] so the batch of balls would not be recommended for the tournament	**2**
Notes: 1. For •[6], also accept: '141 cm lies above the 98% confidence interval'. '141 cm does not lie within the 98% confidence interval'.					
Commonly Observed Responses:					

Question			Generic scheme	Illustrative scheme	Max mark
13.	(a)		$\bullet^1$ appropriate diagram with provided information $\bullet^2$ calculate probability	$\bullet^1$  $\bullet^2$ $1 - 0.69 - 0.06 = 0.25$	**2**

Notes:

1. For (a), the start of a tree diagram is also acceptable, using the provided information:

$\bullet^1$



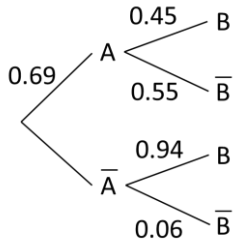
$\bullet^2$ $(1-0.69)\times\left(1-\frac{0.06}{0.31}\right)=0.25$

Question			Generic scheme	Illustrative scheme	Max mark
13.	**(a)**		**(continued)**		

Commonly Observed Responses:

Candidate A places probabilities incorrectly on tree diagram:

(a)



$P(\overline{A} \cap B) = 0.31 \times 0.94 = 0.2914$ award $\bullet^1$ × $\bullet^2$✓

(b)

$$P((A \cap B) \cup (\overline{A} \cap \overline{B})) = P(A \cap B) + P(\overline{A} \cap \overline{B})$$
$$= 0.69 \times 0.45 + 0.31 \times 0.06$$
$$= 0.3105 + 0.0186$$
$$= 0.3291$$

award $\bullet^3$✓ $\bullet^4$✓

(c)

$$P(A \mid B) = \frac{P(A \cap B)}{P(B)}$$
$$= \frac{0.3105}{0.69 \times 0.45 + 0.31 \times 0.94}$$
$$= \frac{0.3105}{0.6019}$$
$$= 0.5159$$

award $\bullet^5$✓ $\bullet^6$✓ $\bullet^7$✓

	(b)		$\bullet^3$ correct probability $\bullet^4$ calculate probability	$\bullet^3$ $P(A \cap B) = 0.14$ $\bullet^4$ 0.14 + 0.06 = 0.2	**2**

Notes:

1. For $\bullet^3$ and $\bullet^4$, also accept:

$$P((A \cap B) \cup (\overline{A} \cap \overline{B})) = 1 - P(A \cap \overline{B}) - P(\overline{A} \cap B)$$
$$= 1 - 0.55 - 0.25$$
$$= 0.2$$

Commonly Observed Responses:

Question			Generic scheme	Illustrative scheme	Max mark
13.	(c)		$\bullet^5$ appropriate strategy	$\bullet^5$ $P(A \mid B) = \dfrac{P(A \cap B)}{P(B)}$	**3**
			$\bullet^6$ calculate probability	$\bullet^6$ $P(B) = 0.14 + 0.25 = 0.39$	
			$\bullet^7$ calculate probability	$\bullet^7$ $\dfrac{0.14}{0.39} = 0.3590$	
Notes: 1. For $\bullet^7$, mark is only available as a follow-through error if $0 <$ probability < 1					
Commonly Observed Responses:					

[END OF MARKING INSTRUCTIONS]