GCE

Mathematics (MEI)

Unit **4767**: Statistics 2

Advanced GCE

Mark Scheme for June 2015

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	**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
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
awrt	Answers which round to

Subject-specific Marking Instructions for GCE Mathematics (MEI) Statistics strand

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

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 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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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
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, eg 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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 Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

Candidates are expected to give numerical answers to an appropriate degree of accuracy. 3 significant figures may often be the norm for this, but this always needs to be considered in the context of the problem in hand. For example, in quoting probabilities from Normal tables, we generally expect *some* evidence of interpolation and so quotation to 4 decimal places will often be appropriate. But even this does not always apply – quotations of the standard critical points for significance tests such as 1.96, 1.645, 2.576 (maybe even 2.58 – but not 2.57) will commonly suffice, especially if the calculated value of a test statistic is nowhere near any of these values. Sensible discretion *must* be exercised in such cases.

Discretion must also be exercised in the case of small variations in the degree of accuracy to which an answer is given. For example, if 3 significant figures are expected (either because of an explicit instruction or because the general context of a

problem demands it) but only 2 are given, loss of an accuracy ("A") mark is likely to be appropriate; but if 4 significant figures are given, this should not normally be penalised. Likewise, answers which are slightly deviant from what is expected in a very minor manner (for example a Normal probability given, after an attempt at interpolation, as 0.6418 whereas 0.6417 was expected) should not be penalised. However, answers which are *grossly* over- or under-specified should normally result in the loss of a mark. This includes cases such as, for example, insistence that the value of a test statistic is (say) 2.128888446667 merely because that is the value that happened to come off the candidate's calculator. Note that this applies to answers that are given as final stages of calculations; intermediate working should usually be carried out, and quoted, to a greater degree of accuracy to avoid the danger of premature approximation. Where over-specification is penalised, no more than two marks per question and no more than four marks in total per script should be lost.

The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h Genuine misreading (of numbers or symbols, occasionally even of text) occurs. If this results in the object and/or difficulty of the question being considerably changed, it is likely that all the marks for that question, or section of the question, will be lost. However, misreads are often such that the object and/or difficulty remain substantially unaltered; these cases are considered below.

The simple rule is that *all* method ("M") marks [and of course all independent ("B") marks] remain accessible but at least some accuracy ("A") marks do not. It is difficult to legislate in an overall sense beyond this global statement because misreads, even when the object and/or difficulty remains unchanged, can vary greatly in their effects. For example, a misread of 1.02 as 10.2 (perhaps as a quoted value of a sample mean) may well be catastrophic; whereas a misread of 1.6748 as 1.6746 may have so slight an effect as to be almost unnoticeable in the candidate's work.

A misread should normally attract *some* penalty, though this would often be only 1 mark and should rarely if ever be more than 2. Commonly in sections of questions where there is a numerical answer either at the end of the section or to be obtained and commented on (eg the value of a test statistic), this answer will have an "A" mark that may actually be designated as "cao"

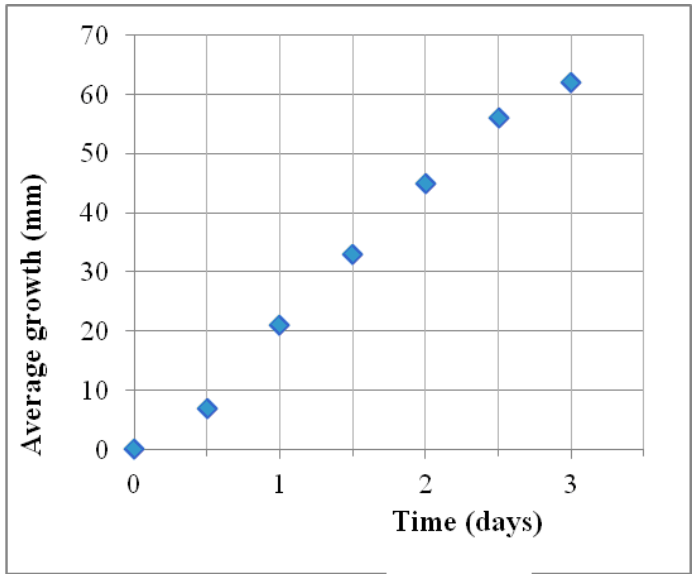
[correct answer only]. This should be interpreted *strictly* – if the misread has led to failure to obtain this value, then this "A" mark must be withheld even if all method marks have been earned. It will also often be the case that such a mark is implicitly "cao" even if not explicitly designated as such.

On the other hand, we commonly allow "fresh starts" within a question or part of question. For example, a follow-through of the candidate's value of a test statistic is generally allowed (and often explicitly stated as such within the marking scheme), so that the candidate may exhibit knowledge of how to compare it with a critical value and draw conclusions. Such "fresh starts" are not affected by any earlier misreads.

A misread may be of a symbol rather than a number – for example, an algebraic symbol in a mathematical expression. Such misreads are more likely to bring about a considerable change in the object and/or difficulty of the question; but, if they do not, they should be treated as far as possible in the same way as numerical misreads, *mutatis mutandis*. This also applied to misreads of text, which are fairly rare but can cause major problems in fair marking.

The situation regarding any particular cases that arise while you are marking for which you feel you need detailed guidance should be discussed with your Team Leader.

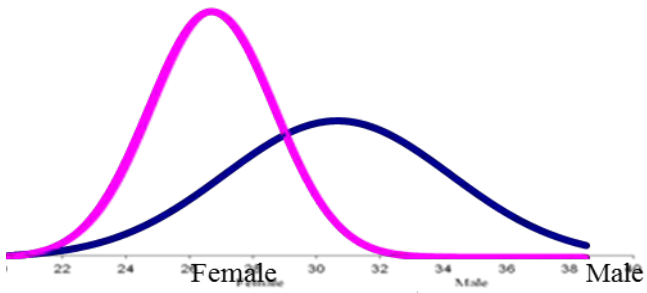
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question			Answer	Marks	Guidance	
1	(i)			G1* G1dep* G1dep* [3]	Both axes labeled (allow t and y) with indication of scale for values of time BOD if (0,0) not clearly visible for values of average growth BOD if (0,0) not clearly visible. BOD if confusion arises from points plotted for part (v).	Allow axes interchanged Condone x for t (evenly spaced) visually correct SC1 for points having the correct distribution and G0* awarded. Line through origin should appear but this is rewarded in part **(v)**
1	(ii)		$\bar{t} = 1.5,\ \bar{y} = 32$ $b = \frac{S_{yt}}{S_{tt}} = \frac{490 - (224 \times 10.5/7)}{22.75 - 10.5^2/7} = \frac{154}{7} = 22$ OR $b = \frac{490/7 - (32 \times 1.5)}{22.75/7 - 1.5^2} = \frac{22}{1} = 22$ hence least squares regression line is: $y - \bar{y} = b(t - \bar{t})$	B1 M1 A1 M1	For $\bar{t}$ and $\bar{y}$ seen or implied by final answer. For attempt at gradient (b) For 22 cao For equation of line	Seen either in calculating b or in forming the equation of the line. Correct structure needed. See additional notes. FT their $\bar{t}$ and $\bar{y}$ for M1 With their $b > 0$, $\bar{t}$ and $\bar{y}$

Question			Answer	Marks	Guidance	
			$\Rightarrow \quad y - 32 = 22\,(t - 1.5)$ $\Rightarrow \quad y = 22\,t - 1$	A1 **[5]**	CAO	A0 for $y = 22x - 1$
1	**(iii)**		$t = 2 \Rightarrow$ predicted average growth $= (22 \times 2) - 1 = 43$ Residual = 45 – 43 = 2	B1 M1 A1 **[3]**	for prediction for subtraction (either way) FT	FT their equation 45 – their prediction
1	**(iv)**		$(22 \times 5) - 1 = 109$ Likely to be **unreliable as extrapolation** (oe)	B1 B1 **[2]**	Estimate calculated using equation	FT their equation
1	**(v)**		$a = \dfrac{490}{22.75} = 21.5\,38\ldots = 21.5$ (3 s.f.) Equation is $y = 21.5t$ Line plotted on diagram	M1 A1 A1 A1 **[4]**	 Allow $y = 21.54t$ CAO For line correctly plotted CAO A0 if axes not scaled or $a \neq 21.5$ to 3 sf	 Allow $y = (280/13)t$ Through (0,0) and between (3, 64) and (3,65)
2	**(i)**		P(Exactly one) = $\binom{25}{1} \times 0.03^1 \times 0.97^{24}$ = 0.361	M1 A1 **[2]**	Binomial calculation with correct structure Allow 0.3611 and 0.36 www A0 for 0.3612	$25 \times p \times (1 - p)^{24}$
2	**(ii)**		n is large p is small.	B1 B1 **[2]**	n large or sample is large p is small, or $np \approx np(1 - p)$ B0 for the "probability" is small unless "probability" is correctly defined.	or $n > 30$ or $np < 10$

Question			Answer	Marks	Guidance	
2	(iii)	(*A*)	Mean = 250 × 0.03 = 7.5 P(exactly 10) = $e^{-7.5}\frac{7.5^{10}}{10!}$ Or from tables = 0.8622 – 0.7764 = 0.0858	B1 M1 A1 **[3]**	For mean (SOI) For Poisson probability calculation Allow 0.08583 or 0.086www	 Or using P($X \leq 10$) - P($X \leq 9$) with Poisson tables
2	(iii)	(*B*)	P(At least 10) = 1 – P($X \leq 9$) = 1 – 0.7764 = 0.2236	M1 A1 **[2]**	For **using** 1 - P($X \leq 9$) CAO	 Allow 0.224 www
2	(iv)		Mean 2000 × 0.03 = 60 Variance = 2000 × 0.03 × 0.97 = 58.2 Using Normal approx. to the binomial, $X \sim$ N(60, 58.2) $P(X \geq 50) = P\left(Z \geq \frac{49.5-60}{\sqrt{58.2}}\right)$ = P(Z > -1.376) = Φ(1.376) = 0.9157 (allow 0.9156 and 0.916)	B1 B1 B1 M1 A1 **[5]**	Normal approximation **used** For parameters (soi) For correct continuity correction For probability using correct structure. CAO **(**Do not FT wrong or omitted CC)	Award full credit for use of Normal approximation to Poisson distribution N(60, 60) N(60, 60) leads to P(Z > -1.356) = 0.9125 (or 0.913) Allow 0.9124 (or 0.912)
2	(v)		Using a Poisson approximation to the binomial the mean λ = ***np*** (= 0.002n) or λ = **n × 0.002** (= 0.002n). P(At most one fake coin) = P(zero or one fake coins) = $e^{-\lambda}\frac{\lambda^0}{0!}+e^{-\lambda}\frac{\lambda^1}{1!}=e^{-\lambda}+\lambda e^{-\lambda}$ **AG**	B1 B1 **[2]**	For evidence of using np from binomial distribution (to give λ = 0.002n) Evidence of using P(X = 0) + P(X = 1) with λ = 0.002n ***NB*** **ANSWER GIVEN**	Need to **see use of *n*×*p*** or obtaining 0.002n from B(n, 0.002)

Question			Answer	Marks	Guidance	
2	**(vi)**		$1-\frac{\lambda^2}{2}=0.995$ $\lambda^2 = 0.01$ so $\lambda = 0.1$ $n = 50$	M1 A1 A1 **[3]**	For equation in λ or **equivalent** equation in n For λ SOI or for $n^2 = 2500$ CAO	
3	**(i)**	(*A*)	P($X < 30$) $= \text{P}\left(Z < \frac{30-30.7}{3.5}\right)$ = P(Z < -0.20) = Φ(-0.20) = 1 – Φ(0.20) = (1 – 0.5793) = 0.4207	M1 M1 A1 **[3]**	For standardising For correct structure CAO	Penalise erroneous continuity corrections and wrong sd. Condone numerator reversed. **1 –** Φ(positive z) Allow 0.421 www
3	**(i)**	(*B*)	P(25 < X < 35) $= \text{P}\left(\frac{25-30.7}{3.5} < Z < \frac{35-30.7}{3.5}\right)$ = P(-1.629 < X < 1.229) = Φ(1.229) – Φ(-1.629) = 0.8904 – (1 – 0.9483) = 0.8904 – 0.0517 = 0.8387	M1 M1 A1 **[3]**	Correctly standardising both. For correct structure Use of differences column required	Penalise erroneous continuity corrections and wrong sd. Condone both numerators reversed. Φ(1.23) – Φ(-1.63) leads to 0.8907 – 0.0516 =0.8391 Only allow 0.839 if 0.8387 is seen.

Question			Answer	Marks	Guidance	
3	(ii)		P(all 5 weigh at least 30kg) $= 0.5793^5$ $= 0.0652$	M1 A1 **[2]**	Allow FT $(1 - \text{their (i)}(A))^5$ or $[\text{their P}(X \geq 30)]^5$ FT only $(1 - \text{their (i)}(A))^5$	Allow 0.06524, allow 0.065 www
3	(iii)		P(weight > 30) = 0.05 $P(Z > \frac{30-26.8}{\sigma}) = 0.05$ $\Phi^{-1}(0.95) = 1.645$ $\frac{30-26.8}{\sigma} = 1.645$ $\sigma = \frac{30-26.8}{1.645} = 1.945$ kg	 B1 M1* M1dep* A1 **[4]**	 For 1.645. B0 for 1 – 1.645 or 0.1645 For equation as seen or equivalent, with their $z > 1$. Rearranging for σ CAO	 NOTE use of -1.645 allowed only if numerator reversed. Condone use of spurious c.c. if already penalised in parts (i)(*A*) or (i)(*B*). See additional guidance notes. Allow $\sigma = 1.95$ www
3	(iv)			G1 G1 G1	For two Normal shapes including attempt at asymptotic behaviour with horizontal axis at each of the four ends For means, shown explicitly or by scale **on a single diagram** For lower max height for Male For visibly greater width for	Penalise clear asymmetry If shown explicitly, the positions must be consistent with horizontal scale if present. If not labelled, assume the larger mean represents Male If not labelled, assume the

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th colspan="2">Guidance</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Male</td><td>larger mean represents Male</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td><td></td></tr>
<tr><td>4</td><td>(a)</td><td></td><td>H_0: no association between student smoking and parent smoking
H_1: some association between student smoking and parent smoking</td><td>B1</td><td>Correct hypotheses in context

NB if H_0 H_1 reversed do not award first B1 or final B1dep*</td><td>Allow hypotheses in terms of independence, in context.
Do not allow “relationship” or “correlation” for “association”</td></tr>
<tr><td></td><td></td><td></td><td><table><tr><th>Expected frequency</th><th>Parent smokes</th><th>Parent does not smoke</th></tr><tr><td>Student smokes</td><td>15.2</td><td>32.8</td></tr><tr><td>Student does not smoke</td><td>22.8</td><td>49.2</td></tr></table></td><td>B1

B1</td><td>For at least one row/column of expected values correct
May be implied by correct contributions or correct X^2

All correct</td><td></td></tr>
<tr><td></td><td></td><td></td><td><table><tr><th>Contribution</th><th>Parent smokes</th><th>Parent does not smoke</th></tr><tr><td>Student smokes</td><td>2.213</td><td>1.026</td></tr><tr><td>Student does not smoke</td><td>1.475</td><td>0.684</td></tr></table></td><td>M1

A1</td><td>For valid attempt at $(O-E)^2/E$

All correct (to 3 d.p.)</td><td>NB These M1A1 marks cannot be implied by a correct final value of X^2</td></tr>
<tr><td></td><td></td><td></td><td>$X^2 = 5.398$</td><td>B1</td><td>Allow awrt 5.40</td><td>Do not penalise use of Yates correction, giving $X^2 = 4.51$</td></tr>
<tr><td></td><td></td><td></td><td>Refer to χ_1^2
Critical value at 5% level = 3.841</td><td>B1
B1</td><td>For 1 degree of freedom
CAO for cv.</td><td>p value = 0.02016</td></tr>
</table>

Question			Answer	Marks	Guidance	
					No further marks from here if wrong or omitted, unless *p*-value used instead.	
			Result is significant	B1*		For significant oe FT their test statistic
			There is sufficient evidence to **suggest** that there is **association between student smoking and parent smoking.**	B1dep*	NB if H_0 H_1 reverse do not award first B1 or final B1dep*	For **non-assertive** conclusion in context Allow conclusion in terms of independence FT their test statistic. Do not allow "relationship" or "correlation" for "association".
				[10]		
4	**(b)**		$\bar{x}$ = 88.2/100 = 0.882	B1	For 0.882 seen.	
			$s = \sqrt{\frac{78.68-(88.2)^2/100}{99}} = \sqrt{\frac{0.8876}{99}}$ $= \sqrt{0.0089657}$	M1	For correctly structured calculation for the sample standard deviation or variance	
			= 0.0947 (allow 0.095 www)	A1	Allow A1 for $\boldsymbol{s^2}$ = 0.0089657	or 0.00897 (allow 0.009**0**)
			H_0: $\mu = 0.87$; H_1 : $\mu > 0.87$	B1	For both correct	Hypotheses in words only must refer to population.
			Where μ denotes the **mean nicotine** content (of cigarettes of this brand in the population)	B1	For definition of μ in context.	Do not allow other symbols unless clearly defined as population mean.

Question			Answer	Marks	Guidance	
			Test statistic = $\frac{0.882 - 0.87}{0.0947/\sqrt{100}} = \frac{0.012}{0.00947}$	M1*	including correct use of $\sqrt{100}$.	FT their s (not $s = 0.87$ or $\sqrt{0.87}$ or 88.2 or $\sqrt{88.2}$ or 78.68 or $\sqrt{78.68}$)
			=1.267	A1	CAO	
			Upper 1% level 1 tailed critical value of $z = 2.326$	B1	For 2.326 **No further marks from here if wrong**	
			$1.267 < 2.326$ (Not significant.)	M1dep*	For sensible comparison leading to a conclusion (even if incorrect)	
			There is **insufficient evidence to suggest** that the **mean nicotine content** of this brand is **greater** than 0.87mg.	A1	For non-assertive conclusion in words and in context. FT only candidate's test statistic	
				[10]		

Additional Notes on Correct Structure in Q1(ii)

Equivalent calculations for finding b are allowed. For example use of $7S_{yt}/7S_{tt}$ is allowed. However, where these are mixed we award M0. e.g. use of $7S_{yt}/S_{tt}$ would earn M0. For M1 to be awarded, the calculation must be structurally equivalent to the one provided – NOTE if it is believed that the candidate has made an error in transcription of a number (for example using 244 instead of 224) we can allow M1 BOD if the structure is otherwise correct.

Additional Notes for Q3 (iii)

M1* is for forming a suitable equation using their z-value but it must be reasonably clear that the value used is a z-value – for example we do not allow 0.05 or 0.95 to be treated as z-values here. The M1dep* can be awarded if the candidate correctly rearranges their equation to find σ. Hence, use of an incorrect z-value could earn max B0M1*M1dep*A0. However, if it is clear that the z-value is from the wrong tail (e.g. -1.645 used in place of +1.645) then award 0/4. In cases where -1.645 is used and the numerator of the equation is reversed allow full credit and annotate with BOD.

Additional Notes on Sensible Comparisons

In Q4 (b) Neither 1.267 > 0.05 nor 0.1026 < 2.326 are considered sensible as each compares a z-value with a probability.
For 1.267 > 2.326 leading to a conclusion, allow M1A0.

Additional Notes on Conclusions to Hypothesis Tests

The following are examples of conclusions which are considered too assertive.

There is sufficient evidence to reject H_0 and **conclude** that…
"there is a positive association between…" or
"there seems to be evidence that there is a positive association between…" or
"the mean nicotine content is greater …."
"there doesn't appear to be association between…"

Also note that final conclusions **must refer to H_1 in context** for the final mark to be given.
e.g. In Q4 (a), a conclusion just stating that "the evidence suggests that there is association" gets A0 as this does not refer to the context.

Additional Notes on Alternative Methods in Q4 (b)

Critical value method	cv = $0.87 + 2.326 \times 0.0946 \div \sqrt{100}$	gets M1* B1 (for 2.326)
	= 0.8920	gets A1 cao (replacing the A1 for 1.267)
	0.882 < 0.8920	gets M1dep* if a conclusion is made. The final A1 available as before if 2.326 used.
Probability Method	P(sample mean > 1.267) = 0.1026	gets M1*A1 B1 (the B1 for 0.1026 (allow 0.1025), from tables, replaces the B1 for 2.326).
	0.1026 > 0.01	gets M1dep* if a conclusion is made. The final A1 available as before provided that B1 for 0.1026 awarded NOTE Condone B1 0.8974 (0.8975) if compared with 0.99 at which point the final M1dep*A1 are available. B0M0A0A0 if 0.8974 obtained from P(sample mean > -1.267).

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk