

OCR

Oxford Cambridge and RSA

Friday 5 June 2015 – Morning

A2 GCE MATHEMATICS (MEI)

4767/01 Statistics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:

- Printed Answer Book 4767/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:

- Scientific or graphical calculator

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets [] at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

- 1 A random sample of wheat seedlings is planted and their growth is measured. The table shows their average growth, y mm, at half-day intervals.

Time t days	0	0.5	1	1.5	2	2.5	3
Average growth y mm	0	7	21	33	45	56	62

- (i) Draw a scatter diagram to illustrate these data. [3]
- (ii) Calculate the equation of the regression line of y on t . [5]
- (iii) Calculate the value of the residual for the data point at which $t = 2$. [3]
- (iv) Use the equation of the regression line to calculate an estimate of the average growth after 5 days for wheat seedlings. Comment on the reliability of this estimate. [2]

It is suggested that it would be better to replace the regression line by a line which passes through the origin.

You are given that the equation of such a line is $y = at$, where $a = \frac{\sum yt}{\sum t^2}$.

- (v) Find the equation of this line and plot the line on your scatter diagram. [4]

- 2 It was stated in 2012 that 3% of £1 coins were fakes. Throughout this question, you should assume that this is still the case.

- (i) Find the probability that, in a random selection of 25 £1 coins, there is exactly one fake coin. [2]

A random sample of 250 £1 coins is selected.

- (ii) Explain why a Poisson distribution is an appropriate approximating distribution for the number of fake coins in the sample. [2]

- (iii) Use a Poisson distribution to find the probability that, in this sample, there are

(A) exactly 10 fake coins, [3]

(B) at least 10 fake coins. [2]

- (iv) Use a suitable approximating distribution to find the probability that there are at least 50 fake coins in a sample of 2000 coins. [5]

It is known that 0.2% of another type of coin are fakes.

- (v) A random sample of size n of these coins is taken. Using a Poisson approximating distribution, show that the probability of at most one fake coin in the sample is equal to $e^{-\lambda} + \lambda e^{-\lambda}$, where $\lambda = 0.002n$. [2]

- (vi) Use the approximation $e^{-\lambda} + \lambda e^{-\lambda} \approx 1 - \frac{\lambda^2}{2}$ for small values of λ to estimate the value of n for which the probability in part (v) is equal to 0.995. [3]

- 3 The random variable X represents the weight in kg of a randomly selected male dog of a particular breed. X is Normally distributed with mean 30.7 and standard deviation 3.5.
- (i) Find
- (A) $P(X < 30)$, [3]
- (B) $P(25 < X < 35)$. [3]
- (ii) Five of these dogs are chosen at random. Find the probability that each of them weighs at least 30 kg. [2]
- (iii) The weights of females of the same breed of dog are Normally distributed with mean 26.8 kg. Given that 5% of female dogs of this breed weigh more than 30 kg, find the standard deviation of their weights. [4]
- (iv) Sketch the distributions of the weights of male and female dogs of this breed on a single diagram. [4]
- 4 (a) As part of an investigation into smoking, a random sample of 120 students was selected. The students were asked whether they were smokers, and also whether either of their parents were smokers. The results are summarised in the table below. Test, at the 5% significance level, whether there is any association between the smoking habits of the students and their parents.

	At least one parent smokes	Neither parent smokes
Student smokes	21	27
Student does not smoke	17	55

[10]

- (b) The manufacturer of a particular brand of cigarette claims that the nicotine content of these cigarettes is Normally distributed with mean 0.87 mg. A researcher suspects that the mean nicotine content of this brand is higher than the value claimed by the manufacturer. The nicotine content, x mg, is measured for a random sample of 100 cigarettes. The data are summarised as follows.

$$\sum x = 88.20 \quad \sum x^2 = 78.68$$

Carry out a test at the 1% significance level to investigate the researcher's belief.

[10]

END OF QUESTION PAPER

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Candidate forename		Candidate surname	
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Centre number						Candidate number				
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1 (i)

A large grid of graph paper with a 20x20 square pattern, intended for writing answers to question 1(i).

1 (ii)

(answer space continued on next page)

1 (ii) (continued)	
1 (iii)	
1 (iv)	

1 (v)	
2 (i)	
2 (ii)	
2 (iii) (A)	

2(iii)(B)	

2(iv)	

2(v)	
2(vi)	
3(i)(A)	

3(i)(B)	
3(ii)	

3 (iii)	
3 (iv)	

4 (b)	(continued)



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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.

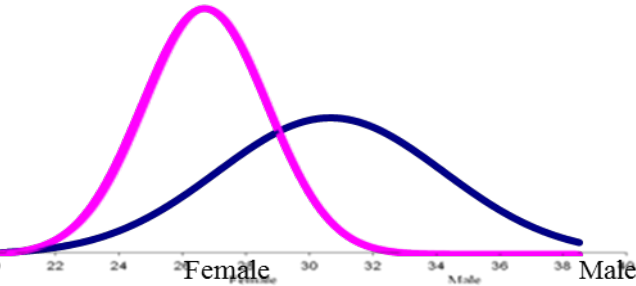
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question	Answer	Marks	Guidance
1 (i)		<p>G1*</p> <p>G1_{dep}*</p> <p>G1_{dep}*</p> <p>[3]</p>	<p>Both axes labeled (allow t and y) with indication of scale</p> <p>for values of time BOD if (0,0) not clearly visible</p> <p>for values of average growth BOD if (0,0) not clearly visible.</p> <p>BOD if confusion arises from points plotted for part (v).</p> <p>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)</p>
1 (ii)	<p>$\bar{t} = 1.5, \bar{y} = 32$</p> $b = \frac{S_{yt}}{S_{tt}} = \frac{490 - (224 \times 10.5 / 7)}{22.75 - 10.5^2 / 7} = \frac{154}{7} = 22$ <p>OR $b = \frac{490 / 7 - (32 \times 1.5)}{22.75 / 7 - 1.5^2} = \frac{22}{1} = 22$</p> <p>hence least squares regression line is:</p> $y - \bar{y} = b(t - \bar{t})$	<p>B1</p> <p>M1</p> <p>A1</p> <p>M1</p>	<p>For \bar{t} and \bar{y} seen or implied by final answer.</p> <p>For attempt at gradient (b)</p> <p>For 22 cao</p> <p>For equation of line</p> <p>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}</p>

Question		Answer	Marks	Guidance	
		$\Rightarrow y - 32 = 22(t - 1.5)$ $\Rightarrow y = 22t - 1$	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)	$a = \frac{490}{22.75} = 21.538\dots = 21.5$ (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)	$P(\text{Exactly one}) = \binom{25}{1} \times 0.03^1 \times 0.97^{24}$ $= 0.361$	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)	<p>Mean = $250 \times 0.03 = 7.5$</p> <p>$P(\text{exactly } 10) = e^{-7.5} \frac{7.5^{10}}{10!}$</p> <p>Or from tables = $0.8622 - 0.7764$</p> <p style="text-align: right;">= 0.0858</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>[3]</p>	<p>For mean (SOI)</p> <p>For Poisson probability calculation</p> <p>Allow 0.08583 or 0.086www</p>	<p>Or using $P(X \leq 10) - P(X \leq 9)$ with Poisson tables</p>
2	(iii) (B)	<p>$P(\text{At least } 10) = 1 - P(X \leq 9) = 1 - 0.7764$</p> <p>= 0.2236</p>	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>For using $1 - P(X \leq 9)$</p> <p>CAO</p>	<p>Allow 0.224 www</p>
2	(iv)	<p>Mean $2000 \times 0.03 = 60$</p> <p>Variance = $2000 \times 0.03 \times 0.97 = 58.2$</p> <p>Using Normal approx. to the binomial, $X \sim N(60, 58.2)$</p> $P(X \geq 50) = P\left(Z \geq \frac{49.5 - 60}{\sqrt{58.2}}\right)$ <p>= $P(Z > -1.376) = \Phi(1.376)$</p> <p>= 0.9157 (allow 0.9156 and 0.916)</p>	<p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>[5]</p>	<p>Normal approximation used</p> <p>For parameters (soi)</p> <p>For correct continuity correction</p> <p>For probability using correct structure.</p> <p>CAO (Do not FT wrong or omitted CC)</p>	<p>Award full credit for use of Normal approximation to Poisson distribution $N(60, 60)$</p> <p>$N(60, 60)$ leads to $P(Z > -1.356) = 0.9125$ (or 0.913)</p> <p>Allow 0.9124 (or 0.912)</p>
2	(v)	<p>Using a Poisson approximation to the binomial the mean $\lambda = np$ (= $0.002n$) or $\lambda = n \times 0.002$ (= $0.002n$).</p> <p>$P(\text{At most one fake coin}) = P(\text{zero or one fake coins}) =$</p> $e^{-\lambda} \frac{\lambda^0}{0!} + e^{-\lambda} \frac{\lambda^1}{1!} = e^{-\lambda} + \lambda e^{-\lambda} \text{ AG}$	<p>B1</p> <p>B1</p> <p>[2]</p>	<p>For evidence of using np from binomial distribution (to give $\lambda = 0.002n$)</p> <p>Evidence of using $P(X = 0) + P(X = 1)$ with $\lambda = 0.002n$</p> <p>NB ANSWER GIVEN</p>	<p>Need to see use of np or obtaining $0.002n$ from $B(n, 0.002)$</p>

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

Question	Answer	Marks	Guidance
3 (ii)	$P(\text{all 5 weigh at least 30kg}) = 0.5793^5$ $= 0.0652$	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)	$P(\text{weight} > 30) = 0.05$ $P\left(Z > \frac{30 - 26.8}{\sigma}\right) = 0.05$ $\Phi^{-1}(0.95) = 1.645$ $\frac{30 - 26.8}{\sigma} = 1.645$ $\sigma = \frac{30 - 26.8}{1.645} = 1.945 \text{ kg}$	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 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

Question		Answer	Marks	Guidance																			
				Male	larger mean represents Male																		
			[4]																				
4	(a)	<p>H_0: no association between student smoking and parent smoking H_1: some association between student smoking and parent smoking</p> <table border="1"> <thead> <tr> <th>Expected frequency</th> <th>Parent smokes</th> <th>Parent does not smoke</th> </tr> </thead> <tbody> <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> </tbody> </table> <table border="1"> <thead> <tr> <th>Contribution</th> <th>Parent smokes</th> <th>Parent does not smoke</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>$X^2 = 5.398$</p> <p>Refer to χ_1^2 Critical value at 5% level = 3.841</p>	Expected frequency	Parent smokes	Parent does not smoke	Student smokes	15.2	32.8	Student does not smoke	22.8	49.2	Contribution	Parent smokes	Parent does not smoke	Student smokes	2.213	1.026	Student does not smoke	1.475	0.684	<p>B1</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>B1</p>	<p>Correct hypotheses in context</p> <p>NB if H_0 H_1 reversed do not award first B1 or final B1dep*</p> <p>For at least one row/column of expected values correct May be implied by correct contributions or correct X^2</p> <p>All correct</p> <p>For valid attempt at $(O-E)^2/E$</p> <p>All correct (to 3 d.p.)</p> <p>Allow awrt 5.40</p> <p>For 1 degree of freedom CAO for cv.</p>	<p>Allow hypotheses in terms of independence, in context. Do not allow “relationship” or “correlation” for “association”</p> <p>NB These M1A1 marks cannot be implied by a correct final value of X^2</p> <p>Do not penalise use of Yates correction, giving $X^2 = 4.51$</p> <p>p value = 0.02016</p>
Expected frequency	Parent smokes	Parent does not smoke																					
Student smokes	15.2	32.8																					
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Question		Answer	Marks	Guidance	
		<p>Result is significant</p> <p>There is sufficient evidence to suggest that there is association between student smoking and parent smoking.</p>	<p>B1*</p> <p>B1dep*</p> <p>[10]</p>	<p>No further marks from here if wrong or omitted, unless p-value used instead.</p> <p>NB if H_0 H_1 reverse do not award first B1 or final B1dep*</p>	<p>For significant oe FT their test statistic</p> <p>For non-assertive conclusion in <u>context</u> Allow conclusion in terms of independence FT their test statistic.</p> <p>Do not allow “relationship” or “correlation” for “association”.</p>
4	(b)	$\bar{x} = 88.2/100 = 0.882$ $s = \sqrt{\frac{78.68 - (88.2)^2 / 100}{99}} = \sqrt{\frac{0.8876}{99}}$ $= \sqrt{0.0089657}$ $= 0.0947 \quad (\text{allow } 0.095 \text{ www})$ <p>$H_0: \mu = 0.87;$ $H_1: \mu > 0.87$ Where μ denotes the mean nicotine content (of cigarettes of this brand in the population)</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p>	<p>For 0.882 seen.</p> <p>For correctly structured calculation for the sample standard deviation or variance</p> <p>Allow A1 for $s^2 = 0.0089657$</p> <p>For both correct</p> <p>For definition of μ in context.</p>	<p>or 0.00897 (allow 0.0090)</p> <p>Hypotheses in words only must refer to population. Do not allow other symbols unless clearly defined as population mean.</p>

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

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)

<u>Critical value method</u>	$cv = 0.87 + 2.326 \times 0.0946 \div \sqrt{100}$ $= 0.8920$ $0.882 < 0.8920$	<p>gets M1* B1 (for 2.326) gets A1 cao (replacing the A1 for 1.267) gets M1dep* if a conclusion is made. The final A1 available as before if 2.326 used.</p>
<u>Probability Method</u>	$P(\text{sample mean} > 1.267) = 0.1026$ $0.1026 > 0.01$	<p>gets M1*A1 B1 (the B1 for 0.1026 (allow 0.1025), from tables, replaces the B1 for 2.326). 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. BOM0A0A0 if 0.8974 obtained from $P(\text{sample mean} > -1.267)$.</p>

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GCE Mathematics (MEI)			Max Mark	a	b	c	d	e	u
4751	01 C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	58	53	48	43	0
		UMS	100	80	70	60	50	40	0
4752	01 C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	50	44	39	34	0
		UMS	100	80	70	60	50	40	0
4753	01 (C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	56	51	46	41	36	0
4753	02 (C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82 (C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
		UMS	100	80	70	60	50	40	0
4754	01 C4 – MEI Applications of advanced mathematics (A2)	Raw	90	74	67	60	54	48	0
		UMS	100	80	70	60	50	40	0
4755	01 FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	62	57	53	49	45	0
		UMS	100	80	70	60	50	40	0
4756	01 FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	65	58	52	46	40	0
		UMS	100	80	70	60	50	40	0
4757	01 FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	59	52	46	40	34	0
		UMS	100	80	70	60	50	40	0
4758	01 (DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	63	57	51	45	38	0
4758	02 (DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82 (DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
		UMS	100	80	70	60	50	40	0
4761	01 M1 – MEI Mechanics 1 (AS)	Raw	72	62	54	46	39	32	0
		UMS	100	80	70	60	50	40	0
4762	01 M2 – MEI Mechanics 2 (A2)	Raw	72	54	47	40	33	27	0
		UMS	100	80	70	60	50	40	0
4763	01 M3 – MEI Mechanics 3 (A2)	Raw	72	64	56	48	41	34	0
		UMS	100	80	70	60	50	40	0
4764	01 M4 – MEI Mechanics 4 (A2)	Raw	72	53	45	38	31	24	0
		UMS	100	80	70	60	50	40	0
4766	01 S1 – MEI Statistics 1 (AS)	Raw	72	61	54	47	41	35	0
		UMS	100	80	70	60	50	40	0
4767	01 S2 – MEI Statistics 2 (A2)	Raw	72	65	60	55	50	46	0
		UMS	100	80	70	60	50	40	0
4768	01 S3 – MEI Statistics 3 (A2)	Raw	72	64	58	52	47	42	0
		UMS	100	80	70	60	50	40	0
4769	01 S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
		UMS	100	80	70	60	50	40	0
4771	01 D1 – MEI Decision mathematics 1 (AS)	Raw	72	56	51	46	41	37	0
		UMS	100	80	70	60	50	40	0
4772	01 D2 – MEI Decision mathematics 2 (A2)	Raw	72	54	49	44	39	34	0
		UMS	100	80	70	60	50	40	0
4773	01 DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
		UMS	100	80	70	60	50	40	0
4776	01 (NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	56	50	45	40	34	0
4776	02 (NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82 (NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
		UMS	100	80	70	60	50	40	0
4777	01 NC – MEI Numerical computation (A2)	Raw	72	55	47	39	32	25	0
		UMS	100	80	70	60	50	40	0
4798	01 FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0
		UMS	100	80	70	60	50	40	0

GCE Statistics (MEI)										
			Max Mark	a	b	c	d	e	u	
G241	01	Statistics 1 MEI (Z1)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
G242	01	Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
G243	01	Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
			UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)										
			Max Mark	a	b	c	d	e	u	
G244	01	Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02	Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
G245	01	Statistics 1 MEI	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
G246	01	Decision 1 MEI	Raw	72	56	51	46	41	37	0
			UMS	100	80	70	60	50	40	0