OCR
Oxford Cambridge and RSA

Wednesday 13 June 2018 – 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**. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- 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 barcodes.
- 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

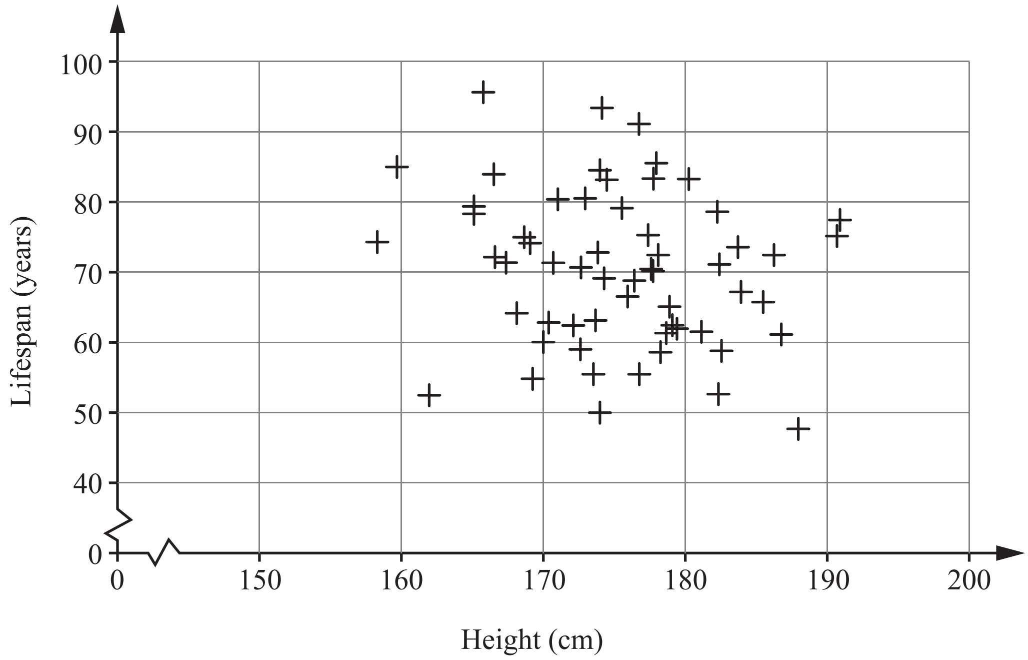
This information is the same on the Printed Answer Book and the Question Paper.

- 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 **8** 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 medical student thinks that there may be some correlation between the heights and lifespans of people in the area in which she lives. She has access to the medical records, going back many years, of deceased people. The scatter diagram below shows the heights x cm and lifespans y years of a random sample of 60 deceased people from the area.



Summary statistics for these data are as follows:

$$n = 60, \quad \Sigma x = 10\,524, \quad \Sigma y = 4219, \quad \Sigma x^2 = 1\,849\,100, \quad \Sigma y^2 = 303\,700, \quad \Sigma xy = 739\,140.$$

(i) Calculate the sample product moment correlation coefficient. **[5]**

(ii) The medical student uses these data to test her theory. Carry out a hypothesis test at the 5% significance level to investigate whether her theory may be correct. **[6]**

(iii) State the distributional assumption which is necessary for this test to be valid. State, with a reason, whether the assumption appears to be valid. **[2]**

(iv) A friend of the medical student proposes to carry out a similar test using data from a different area. However, a doctor tells the friend that it is known that the correlation coefficient between x and y for the whole population in this other area is –0.134. Explain why it is not sensible for the friend to carry out the proposed test. **[2]**

(v) The student's friend suggests that being tall causes a person to have a shorter life. Comment on this suggestion. **[2]**

2 At a manufacturing plant, work on a production line often has to be stopped due to faults with machinery.

(i) State conditions required for a Poisson distribution to be a suitable model for the number of faults which occur in a day. **[2]**

You may assume that these conditions are satisfied. You are given that the faults occur at an average rate of 8.4 per day.

(ii) State the variance of the distribution of the number of faults per day. **[1]**

(iii) Find the probability of at least 8 faults in a randomly chosen day. **[2]**

(iv) Use a suitable approximating distribution to find the probability that there are at least 40 faults in a 5-day week. Explain briefly whether any additional assumption needs to be made in order to calculate this probability. **[6]**

One of the machines on the production line produces steel rods. The length of a rod is denoted by X mm, where X has a Normal distribution with mean 103.2 and variance 0.36.

(v) (*A*) Find $P(103 < X < 104)$. **[3]**

(*B*) Rods which are shorter than 102 mm have to be rejected. It is proposed, by reducing the variance, to reduce the proportion of rods which are rejected to 0.5%. Assuming that the mean is unchanged, find the new value of the variance. **[4]**

3 A machine manufactures analgesic (pain-killing) tablets. The tablets are sold in packets. On the packet it states that each tablet contains 500 milligrams of active ingredient. The random variable X represents the amount, in milligrams, of the active ingredient in each tablet. It is known that X is Normally distributed with mean 504.7 and variance 16.

(i) Show that $P(X > 500) = 0.8800$, correct to 4 decimal places. **[2]**

(ii) Calculate the probability that in a random sample of 10 tablets, at least 9 contain more than the amount of active ingredient stated on the packet. **[2]**

(iii) Use a suitable approximation to find the probability that in a random sample of 100 tablets, at least 90 contain more than the amount stated on the packet. **[5]**

The machine which manufactures the tablets is serviced. In order to check if the mean amount of active ingredient is still 504.7 milligrams, a random sample of 25 tablets is selected. The total amount of active ingredient in the 25 tablets is 12 580 milligrams. You should assume that the variance for individual tablets is still 16.

(iv) Carry out a hypothesis test at the 5% significance level to check whether the mean amount is still 504.7 milligrams. **[9]**

(v) Given that in fact the population mean is now 503.8 milligrams, comment briefly on the result of the test. What change could have been made to the test procedure, without changing the significance level, to make it more likely to detect this change in the mean? **[2]**

4 The year in which a car was registered can often be identified from its number plate. A motoring correspondent is investigating whether there is any association between the age of cars and their location. She chooses three locations, a motorway, a supermarket car park and a housing estate, and selects a random sample of cars from each location. The correspondent classifies the ages according to year of registration, 2001–2007, 2008–2012, 2013–2017 and also 'unknown' for those cars for which the number plate does not identify the year of registration.

(i) Write down null and alternative hypotheses for a test to examine whether there is any association between location and age category. **[1]**

(ii) You are given that the value of the test statistic for the usual χ^2 test for the motoring correspondent's data is 8.752 correct to 3 decimal places. Carry out the test at the 10% significance level. **[4]**

The correspondent thinks that she should carry out another test, but this time taking a new sample which excludes the cars of unknown age. The numbers of cars for the three other age categories are given in the table below.

	2001–2007	2008–2012	2013–2017
Motorway	41	29	16
Supermarket car park	35	22	14
Housing estate	12	24	7

(iii) Calculate the expected frequency for cars on the Housing estate registered in 2001–2007. Verify the corresponding contribution, 2.5310, to the test statistic. **[3]**

The contributions to the test statistic are shown in the table below. The figures are rounded to 4 decimal places.

	2001–2007	2008–2012	2013–2017
Motorway	0.2639	0.3275	0.0005
Supermarket car park	0.4525	0.8034	0.0570
Housing estate	2.5310	3.8459	0.1146

(iv) Using the same hypotheses as in part **(i)**, complete this new test at the 10% significance level. **[3]**

(v) For each location, comment briefly on how the ages of the cars compare with what would be expected if there were no association. You should calculate any expected frequencies that you need in order to make these comments. **[4]**

(vi) A colleague suggests that the motoring correspondent should have subdivided the ages of the cars into more than three categories. Give one advantage and one disadvantage of doing that. **[2]**

END OF QUESTION PAPER

BLANK PAGE

BLANK PAGE

BLANK PAGE

OCR
Oxford Cambridge and RSA

Wednesday 13 June 2018 – Morning

A2 GCE MATHEMATICS (MEI)

4767/01 Statistics 2

PRINTED ANSWER BOOK

Candidates answer on this Printed Answer Book.

OCR supplied materials:
- Question Paper 4767/01 (inserted)
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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**. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- 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 barcodes.
- 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 **8** pages. Any blank pages are indicated.

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)	
2 (iv)	
	(answer space continued on next page)

2 (iv) **(continued)**

2 (v)(*A*)

2 (v)(*B*)

3 (i)	
3 (ii)	
3 (iii)	

3 (iv)	
3 (v)	

4 (i)	
4 (ii)	
4 (iii)	

4 (iv)	
4 (v)	
	(answer space continued on next page)

(answer space continued on next page)

4 (v)	**(continued)**
4 (vi)	**Advantage:**
	Disadvantage:

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

GCE

Mathematics (MEI)

Unit **4767**: Statistics 2

Advanced GCE

Mark Scheme for June 2018

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.

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

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.

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)		**EITHER:**			Ao1 5
			$S_{xy} = \Sigma xy - \frac{1}{n}\Sigma x \Sigma y = 739140 - \frac{1}{60} \times 10524 \times 4219$ (= -872.6)	M1*	For method for S_{xy}	
			$S_{xx} = \Sigma x^2 - \frac{1}{n}(\Sigma x)^2 = 1849100 - \frac{1}{60} \times 10524^2$ (= 3190.4)	M1*	For method for at least one of S_{xx} or S_{yy}	
			$S_{yy} = \Sigma y^2 - \frac{1}{n}(\Sigma y)^2 = 303700 - \frac{1}{60} \times 4219^2$ (= 7033.9833…)	A1	For at least one of S_{xy} S_{xx} or S_{yy} correct to 4sf. Can be implied by correct final answer.	
			$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = \frac{-872.6}{\sqrt{3190.4 \times 7033.98}}$	M1dep*	For structure of r	
			= -0.1842	A1	For answers between – 0.1840 and – 0.1850. Allow – 0.184 www and – 0.185 www	
			OR:	**[5]**		
			$\text{cov}(x,y) = \frac{\sum xy}{n} - \bar{x}\bar{y} = 739140/60 - (10524/60 \times 4219/60)$ = -14.54333…	M1*	For method for cov (x,y)	
			$\text{rmsd}(x) = \sqrt{\frac{S_{xx}}{n}} = \sqrt{(3190.4/60)} = 7.29200…$ (msd(x) = 53.173...)	M1*	For method for at least one msd or rmsd	
			$\text{rmsd}(y) = \sqrt{\frac{S_{yy}}{n}} = \sqrt{(7033.9833…/60)} = 10.8274…$ (msd(y) = 117.23...)	A1	For at least one of cov(x,y) one msd or rmsd correct to 4sf. Can be implied by correct final answer.	
			$r = \frac{\text{cov(x,y)}}{rmsd(x)rmsd(y)} = \frac{-14.54333...}{7.29200... \times 10.8274...}$	M1dep*	For structure of r	
			= -0.1842	A1	For answers between – 0.1840 and – 0.1850. Allow – 0.184 www and – 0.185 www	
					Methods mixed – max 2/5	

Question			Answer	Marks	Guidance	
1	(ii)		H_0: $\rho = 0$ H_1: $\rho \neq 0$ (two-tailed test) where ρ is the (population) correlation coefficient between height and lifespan For n = 60, 5% critical value = ± **0.2542** Since -0.1842 > -0.2542 (or 0.1842 < 0.2542) the result is not significant. Thus we have insufficient evidence to reject H_0 There is insufficient evidence at the 5% level to suggest that there is correlation between height and lifespan.	B1 B1 B1 M1 A1 A1 **[6]**	For H_0, H_1 in symbols For defining ρ in context. Allow 'between x and y'. (must use ρ. Accept other variables, but not r, if defined as the **population** correlation coefficient between height and lifespan) For critical value No further marks from here if wrong. B0 for ±0.2545 For sensible comparison leading to any conclusion. FT their |r| <1 for final 3 marks For 'not significant' oe For non-assertive result in context	**Ao1** **2** **Ao3** **3** **Ao5** **1**
1	(iii)		(Underlying population must have a) **bivariate Normal** distribution. **Yes**, since the points in the scatter diagram show a roughly **elliptical** shape.	B1 B1 **[2]**	Allow 'data comes from (a population with) a bivariate Normal distribution' but do not allow 'data has a bivariate Normal distribution' or 'both populations…' Allow **no,** since… …**not elliptical**	**Ao3** **2**
1	(iv)		As the **population parameter is known,** There is no need to carry out a test.	E1* E1dep* **[2]**		**Ao2** **2**
1	(v)		Correlation does not imply causation There could be another factor/other factors causing the relationship	B1 B1 **[2]**		**Ao3** **2**
2	(i)		**Faults** occur randomly and independently There is a **uniform**/constant **mean rate** of occurrence	B1 B1 **[2]**	**Do not allow** 'events occur randomly…' Allow **uniform**/constant **average rate**…	**Ao3** **2**
2	(ii)		Variance = 8.4	B1 **[1]**	Do not allow λ = 8.4 or Po(8.4)	**Ao3** **1**

Question			Answer	Marks	Guidance	
2	(iii)		$P(X \geq 8) = 1 - 0.3987$ (from tables) $= 0.6013$	M1 A1 **[2]**		**Ao1** **1** **Ao5** **1**
2	(iv)		Using Normal approx. to the Poisson, $X \sim N(42, 42)$ $P(X \geq 40) = P\left(Z \geq \frac{39.5-42}{\sqrt{42}}\right)$ $= P(Z > -0.3858) = \Phi(0.3858) = 0.6502$ www Assumption: No additional assumption necessary since it is a Poisson process	B1 B1 B1 M1 A1 E1 **[6]**	For Normal approximation **used**. For correct parameters (SOI) For 39.5 SOI **Beware use of 40, which gives z = - 0.3086 followed by incorrect use of tables – i.e. looking up -0.386 which leads to 0.6503.** For probability using correct tail CAO Allow 0.6503 www. Allow 0.650 www and 0.65www **(**Do not FT wrong or omitted CC)	**Ao2** **2** **Ao3** **4**
2	(v)	(*A*)	$P(103 < X < 104) = P\left(\frac{103-103.2}{\sqrt{0.36}} \leq Z \leq \frac{104-103.2}{\sqrt{0.36}}\right)$ $= P(-0.3333 < Z < 1.3333)$ $= \Phi(1.3333) - (1 - \Phi(0.3333))$ $= 0.9085 - (1 - 0.6305)$ $= 0.5390$	M1 M1 A1 **[3]**	For standardizing. M0 for using 'continuity corrections' or σ = 0.36 For correct structure Accept awrt 0.539	**Ao1** **2** **Ao5** **1**

Question			Answer	Marks	Guidance	
2	(v)	(*B*)	$\Phi^{-1}(0.05) = -\ 2.576$ $\frac{102-103.2}{\sigma} = -2.576$ $\sigma = \frac{102-103.2}{-2.576}$ (= 0.4658) So variance = σ^2 = 0.2170	B1 M1* M1dep* A1 **[4]**	For ±2.576 **1 – 2.576** gets B0M0*M0dep* if used later. For equation including *σ*, as seen or equivalent, with their *z* value which must lead to a positive value for *σ* (see additional note). M0 if c.c. used Allow other symbols for *σ*. Rearranging for σ CAO Allow 0.217 and allow 0.22 www	**Ao1** **3** **Ao5** **1**
3	(i)		P(*X* > 500) P(*Z* > -1.175) or 1 – P(*Z* < - 1.175) or P(*Z* < 1.175) = Φ(1.175) or 1 – Φ(– 1.175), leading to given answer of 0.8800(…)	B1 B1 **[2]**	For obtaining any of these probability statements involving *Z* correctly For either of these statements involving Φ leading to 0.8800(…) NOTE **AG**	**Ao1** **1** **Ao4** **1**
3	(ii)		$10 \times 0.88^9 \times 0.12 + 0.88^{10}$ = 0.6583	M1 A1 **[2]**	Allow 0.658 www	**Ao2** **2**
3	(iii)		Mean 100 × 0.88 = 88 , Var = 100 × 0.88 × 0.12 = 10.56 *X* ~ N(88, 10.56) $P(X \geq 90) = P\left(Z \geq \frac{89.5-88}{\sqrt{10.56}}\right)$ = P(*Z* > 0.4616) = 1 – Φ(0.4616) = 1 – 0.6779 = 0.3221	B1 B1 B1 M1 A1 **[5]**	For using Normal approximation. For correct parameters (SOI) For continuity corr. For probability using correct tail CAO (Do not FT wrong or omitted CC) (Answer from calculator 0.3222) Accept 0.322 www	**Ao2** **1** **Ao3** **4**

Question			Answer	Marks	Guidance	
3	(iv)		$\bar{x}$ = 12580/25 = 503.2 H_0: $\mu = 504.7$; H_1 : $\mu \neq 504.7$ Where μ denotes the mean amount of active ingredient (in the population of pills)	B1 B1 B1	For hypotheses in symbols, both correct For definition of μ in context. Accept other variables (apart from $\bar{x}$) if defined as the mean amount of active ingredient **in the population**	**Ao1** **2** **Ao2** **3** **Ao3** **2** **Ao4** **1** **Ao5** **1**
			Test statistic $= \dfrac{503.2 - 504.7}{4/\sqrt{25}} = \dfrac{-1.5}{0.8} = -1.875$	M1* A1	using their $\bar{x}$ and must include √25 M0* if numerator reversed. For – 1.875 or – 15/8	
			5% level 2 tailed critical value of z = ±1.96	B1	For (±) 1.96 but B0 if 1 ± 1.96 used later. No further marks from here if wrong. Allow B1 for -1.645 only with H_1: $\mu < 504.7$ but no further marks in this case.	
			-1.875 > -1.96 (or 1.875 < 1.96)	M1dep*	FT candidate's test statistic only if negative for final 3 marks For sensible comparison as written leading to any conclusion.	
			The result is not significant. There is insufficient evidence to reject H_0	A1	For 'not significant', oe	
			There is insufficient evidence to suggest that the **mean amount** (of active ingredient) is not 504.7 milligrams.	A1 **[9]**	For conclusion in words in **context**	
3	(v)		The test has accepted H_0, which is a wrong result as the mean is no longer 504.7. If a larger sample had been selected, it would have been more likely that the change would have been detected.	E1 E1 **[2]**	E1 for recognising wrong result (Type II error) E1 for larger sample	**Ao4** **2**

Question			Answer	Marks	Guidance	
4	(i)		H_0: no association between location and age category. H_1: some association between location and age category.	B1 **[1]**	Correct hypotheses in context. Allow hypotheses ito independence. B0 if correlation used in place of association. Ignore symbols if used.	**Ao2** **1**
4	(ii)		Refer to χ_6^2 Critical value at 10% level = 10.64 8.752 < 10.6451 so result is **not significant** There is insufficient evidence to suggest that there is association between location and age category	B1 B1 M1 A1 **[4]**	for 6 deg of f for cv allow 10.645 No further marks from here if incorrect For sensible comparison leading to a correct conclusion. Allow '**Accept H_0**' or '**Reject H_1**'. NOTE **contradictory responses**, e.g. 'not significant so reject H_0', get M0A0. For non-assertive conclusion in context referring to H_1. A0 if correlation used in place of association.	**Ao1** **1** **Ao2** **2** **Ao5** **1**
4	(iii)		Expected frequency = 88/200 × 43 = 18.92 Contribution = $(12 – 18.92)^2$ / 18.92 (= 2.5310)	M1 A1 A1 **[3]**	Method for f_e 18.92 seen For correct substitution into $(O-E)^2/E$ leading to answer of 2.5310. Condone numerator reversed. ***NB Answer given***	**Ao1** **3**
4	(iv)		X^2 = 8.396 (or 8.3963) Critical value at 10% level = 7.779 8.396 > 7.779 so result is significant (oe) - there is sufficient evidence to suggest that there is association between location and age category	B1 B1 B1 **[3]**	 No further marks from here if incorrect. No FT if incorrect test statistic used.	**Ao2** **2** **Ao5** **1**
4	(v)		Expected frequencies for housing estate for 2008 – 2012 = 16.13 (16.125) On the **housing estate,** there are two **high contributions** (or the contributions of **2.53 and 3.84**) that suggest that there are fewer cars in 2001-2007 group than expected and more cars in 2008-2012 group than expected. For the **other two locations and housing** estate in **2013 – 2017**, the **low contributions** suggest numbers are much **as expected**.	B1 M1 A1 E1	 Reference to either of these high contributions Correct interpretation for both of these groups E0 if (slightly) more/fewer mentioned. Note: comments referring to what would	**Ao1** **1** **Ao4** **3**

Question			Answer	Marks	Guidance	
				[4]	be expected get A0 and/or E0	
4	(vi)		Advantage: Having more categories might reveal association which is not revealed by the present 3 categories. Disadvantage: Some of the expected frequencies might be less than 5 so categories would have to be combined.	E1 E1 [2]		**Ao4 2**

Additional notes Re Q3(iv)

Critical Value Method
c.v. = 504.7 – 1.96×4/√25 gets M1* B1
= 503.1(32) gets A1 (replacing A1 for -1.875)
503.2 > 503.1(32) with a conclusion gets M1dep* then final A1 A1 still available
NB if H_1: μ < 504.7 used award maxB1B0B1M1* B1(for -1.645) A1(for 503.4)depM0*A0A0

Probability Method
$P(Z < -1.875) = 0.0303$ gets B1 (for 0.0303 or 0.0304 replacing B1 for ±1.96)
0.0304 > 0.025 with conclusion gets M1dep* then final A1 A1 still available
NB if H_1: μ < 504.7 used award maxB1B0B1M1*A1B1(for 0.0303 or 0.0304)depM0*A0A0

Additional Note RE Over-specification

A0 or B0 for final answers given correct to 5sf or more. NOTE do not penalise over-specification more than twice in any single question or more than 4 times in a paper.

Additional Notes for Q2(v)*B*

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, e.g. – 1.645. Do not allow 0.005 or 0.995 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.
If $z = +2.576$ is used then award B1 only to give 1/4 unless the numerator of the equation is reversed in which case the remaining marks are available.

Additional Notes on Sensible Comparisons

In Q1(ii) Writing – 0.2542 < – 0.1842 < 0.2542 or equivalent, leading to any conclusion, earns M1
In Q3 (iv) Neither – 1.875 < 0.05 nor 0.0304 < 1.96 are considered sensible as each compares a z-value with a probability.
Inequality sign reversed, e.g. – 1.875 < – 1.96, gets M0A0A0.
Comparing a negative with a positive *z*-value, e.g. – 1.875 < 1.96, gets M0A0A0, unless seen in an inequality which includes both tails, i.e. – 1.96 < – 1.875 < 1.96 which could lead M1A1A1.

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 an association between…" or
"there seems to be evidence that there is an association between…" or
"the mean amount of active ingredient has not changed …."
"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(ii) a conclusion simply stating that "the evidence does not suggest that there is an association" gets A0 as this does not refer to the context.

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

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

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Qualification Accredited

Oxford Cambridge and RSA

AS/A LEVEL GCE

Examiners' report

MATHEMATICS (MEI)

3895-3898, 7895-7898

4767/01 Summer 2018 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 4767/01 series overview

This was the final assessment series for the unitised 3895-3898, 7895-7898 GCE Mathematics (MEI) specification. There will be a resit opportunity in the summer 2019.

Statistics 2 (4767) is an A2 GCE component taken as part of the Mathematics (MEI) specification, which can be used with Statistics 1 (4766) in A Level Mathematics (7895), as one of the optional components in AS Further Mathematics (3896) or A Level Further Mathematics (7896), or (occasionally) as part of AS Further Mathematics (Additional) (3897) or A Level Further Mathematics (Additional) (7897).

To do well in this paper, candidates need an:

- ability to calculate probabilities and statistics accurately,
- awareness of any assumptions necessary for applying the statistical models,
- ability to provide concise, clear explanations when required.

Candidates also need a clear understanding of the difference between sample and population and should take care in their explanations when reference to either of these is required. Candidates should also make reference to context in explanations, definitions of parameters and in conclusions to hypothesis tests.

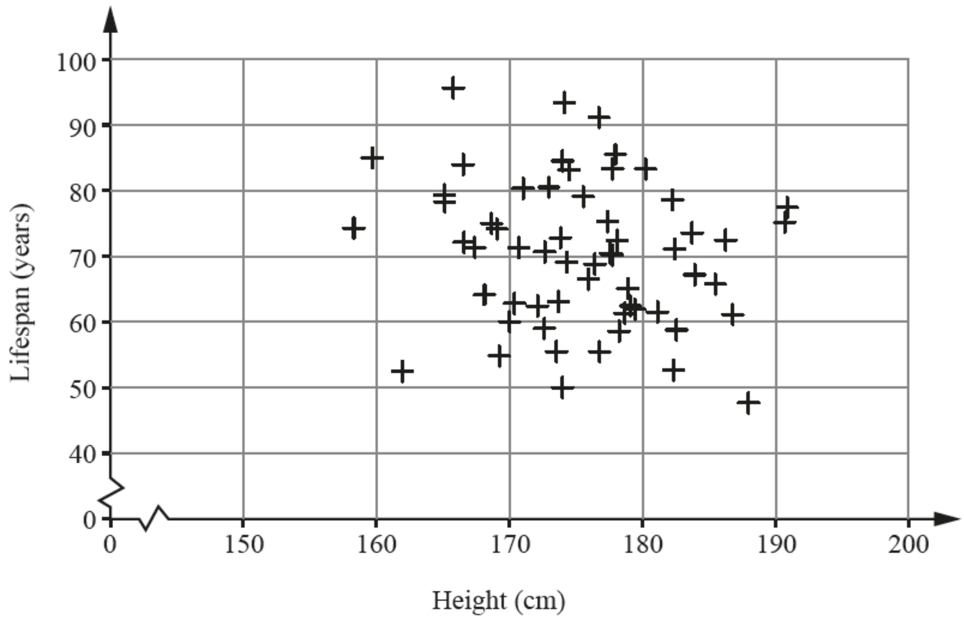
This paper proved to be readily accessible to all candidates. There was no evidence of candidates having insufficient time to complete all questions. A wide range of marks was seen. None of the four questions stood out as being either particularly difficult or particularly easy. Higher ability candidates showed both the ability to choose and apply appropriate calculations and to provide clear, concise explanations when required. Lower ability candidates had some difficulty in selecting appropriate calculations or critical values and in providing suitable wording in parts where explanations were required or in hypothesis tests. The vast majority of candidates kept to the guidelines regarding accuracy of final answers – few candidates were penalised for over-specification. Some cases of incorrect or premature rounding were seen. Premature rounding caused loss of marks for some candidates in calculation of the sample product moment correlation coefficient and in questions where accurate use of Normal probability tables was required.

Key

AfL	Guidance to offer for future teaching and learning practice.

Question 1 (i)

1 A medical student thinks that there may be some correlation between the heights and lifespans of people in the area in which she lives. She has access to the medical records, going back many years, of deceased people. The scatter diagram below shows the heights x cm and lifespans y years of a random sample of 60 deceased people from the area.



Summary statistics for these data are as follows:

$n = 60,\quad \Sigma x = 10\,524,\quad \Sigma y = 4219,\quad \Sigma x^2 = 1\,849\,100,\quad \Sigma y^2 = 303\,700,\quad \Sigma xy = 739\,140.$

(i) Calculate the sample product moment correlation coefficient. **[5]**

This question provided a routine introduction to the assessment with only the occasional arithmetic error resulting in a few candidates not scoring full marks.

Question 1 (ii)

(ii) The medical student uses these data to test her theory. Carry out a hypothesis test at the 5% significance level to investigate whether her theory may be correct. **[6]**

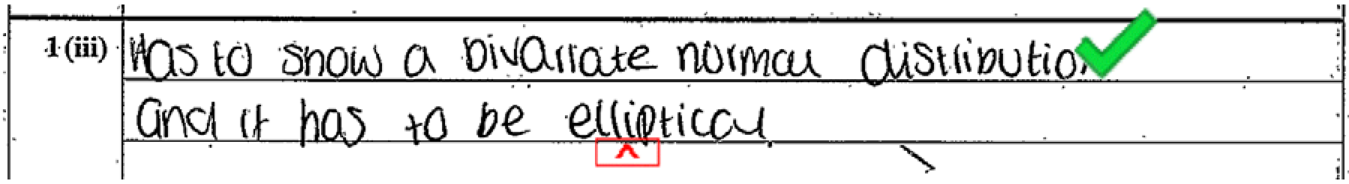
This question was well answered by most candidates. The most common reasons for losing marks include - use of an incorrect critical value, imprecise definition of rho, providing vague hypotheses in words not concise symbols and providing overly assertive conclusions.

Question 1 (iii)

(iii) State the distributional assumption which is necessary for this test to be valid. State, with a reason, whether the assumption appears to be valid. **[2]**

Most candidates understood the need for an underlying population which follows a bivariate Normal distribution and that this can be seen from the shape formed by the points in the scatter diagram. Candidates who stated that the **data** follow a bivariate Normal distribution were penalised. Some candidates who provided a suitable comment about the shape formed by the points did not complete their answers with a judgement regarding validity.

Exemplar 1



1 (iii) Has to show a bivariate normal distribution And it has to be elliptical.

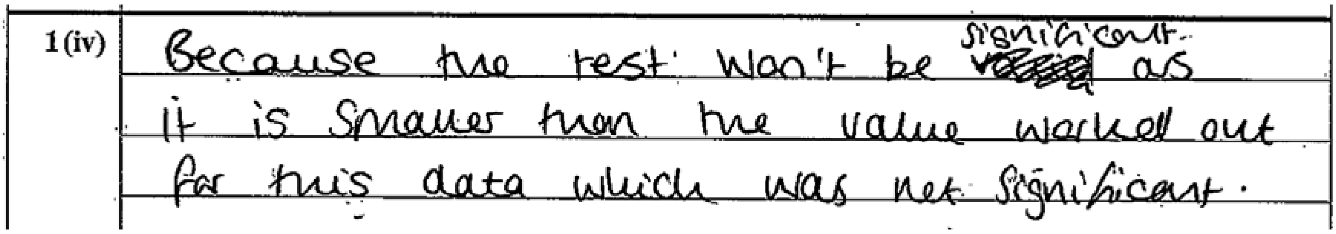
This candidate does not provide a judgement regarding whether the assumption appears to be valid.

Question 1 (iv)

(iv) A friend of the medical student proposes to carry out a similar test using data from a different area. However, a doctor tells the friend that it is known that the correlation coefficient between x and y for the whole population in this other area is -0.134. Explain why it is not sensible for the friend to carry out the proposed test. **[2]**

Very few candidates showed that they understood the significance of the word 'population' here.

Exemplar 2



1 (iv) Because the test won't be significant as it is smaller than the value worked out for this data which was not significant.

This answer is typical of many seen. The candidate appears not to appreciate that since the correlation coefficient for the whole population is known then a test would not be needed.

Question 1 (v)

(v) The student's friend suggests that being tall causes a person to have a shorter life. Comment on this suggestion. **[2]**

Candidates should reflect on the fact that just because there is a correlation, this does not imply a direct causation; there could be other factors involved.

Question 2 (i)

2 At a manufacturing plant, work on a production line often has to be stopped due to faults with machinery.

(i) State conditions required for a Poisson distribution to be a suitable model for the number of faults which occur in a day. **[2]**

This question was well answered. Candidates who referred to 'events' in their answer, in place of the word 'faults', were penalised.

Question 2 (ii)

You may assume that these conditions are satisfied. You are given that the faults occur at an average rate of 8.4 per day.

(ii) State the variance of the distribution of the number of faults per day. **[1]**

This was correctly stated by the majority of candidates.

Question 2 (iii)

(iii) Find the probability of at least 8 faults in a randomly chosen day. **[2]**

Candidates answered this part well.

Question 2 (iv)

(iv) Use a suitable approximating distribution to find the probability that there are at least 40 faults in a 5-day week. Explain briefly whether any additional assumption needs to be made in order to calculate this probability. **[6]**

Most candidates used the correct Normal approximating distribution and provided a correct answer. Some candidates did not use a continuity correction. Others found the probability for 'at most 40 faults' rather than 'at least 40 faults'. Few candidates who realised that no additional assumptions were needed managed to provide a suitable explanation.

Question 2 (v) (*A*)

One of the machines on the production line produces steel rods. The length of a rod is denoted by Xmm, where X has a Normal distribution with mean 103.2 and variance 0.36.

(v) (*A*) Find $\mathrm{P}(103 < X < 104)$. **[3]**

Most candidates managed to obtain the associated *z*-values and calculate the probability to an acceptable degree of accuracy. Some candidates did not manage to use the Normal distribution table successfully.

Question 2 (v) (*B*)

(*B*) Rods which are shorter than 102 mm have to be rejected. It is proposed, by reducing the variance, to reduce the proportion of rods which are rejected to 0.5%. Assuming that the mean is unchanged, find the new value of the variance. **[4]**

The candidates obtaining 2.576 from the table for the inverse Normal function tended to obtain full marks here. Some candidates lost marks through inaccurate working – typically writing an equation which would lead to a negative value for the standard deviation. Candidates who worked with 95% rather than 99.5% gained no more than 2 marks.

Question 3 (i)

3 A machine manufactures analgesic (pain-killing) tablets. The tablets are sold in packets. On the packet it states that each tablet contains 500 milligrams of active ingredient. The random variable X represents the amount, in milligrams, of the active ingredient in each tablet. It is known that X is Normally distributed with mean 504.7 and variance 16.

(i) Show that $\mathrm{P}(X > 500) = 0.8800$, correct to 4 decimal places. **[2]**

Since this was a "show that …" with the answer given, candidates needed to write a clear justification to gain full credit.

Question 3 (ii)

(ii) Calculate the probability that in a random sample of 10 tablets, at least 9 contain more than the amount of active ingredient stated on the packet. **[2]**

Candidates either scored full marks or zero. Candidates using their calculator without showing any working risk scoring zero if the response is incorrect.

The standard advice with regard the use of calculators should always be; to write down explicitly any expressions, parameters and variables, and to use correct mathematical notation.

Question 3 (iii)

(iii) Use a suitable approximation to find the probability that in a random sample of 100 tablets, at least 90 contain more than the amount stated on the packet. **[5]**

A good proportion of candidates scored full marks on this calculation. Errors in arithmetic resulted in some candidates dropping a couple of marks.

Question 3 (iv)

The machine which manufactures the tablets is serviced. In order to check if the mean amount of active ingredient is still 504.7 milligrams, a random sample of 25 tablets is selected. The total amount of active ingredient in the 25 tablets is 12 580 milligrams. You should assume that the variance for individual tablets is still 16.

(iv) Carry out a hypothesis test at the 5% significance level to check whether the mean amount is still 504.7 milligrams. **[9]**

This question was well answered by most candidates.

- Most candidates successfully worked out the sample mean, framed their hypotheses in terms of μ, and correctly defined μ as the mean amount of active ingredient.
- Test statistics were generally worked out correctly though some candidates did not use the correct variance.
- Some candidates went on to use a wrong critical value, usually -1.645.
- Comparisons were well done on the whole. Inappropriate comparisons were seen, e.g. -1.875 < -1.96 and -1.875 < 1.96
- Conclusions were generally very good though errors were made either in being too assertive, by claiming that the evidence showed that the value had not changed from 504.7, or in framing the conclusion in terms of H_0 by claiming that the result suggested the mean was still 504.7.

Exemplar 3

3(iv)

$X \sim N(504.7, 16)$

$\mu = 504.7 \quad \sigma = 4$

$H_0 : \mu = 504.7$ ✓ μ is the population mean

$H_1 : \mu \neq 504.7$ amount of active ✓ ingredient.

5% significance level $n = 25$ 2-tailed test

$\bar{x} = 12580/25 = 503.2$ ✓

Test statistic $= \dfrac{503.2 - 504.7}{4/\sqrt{25}} = -1.875$ ✓✓

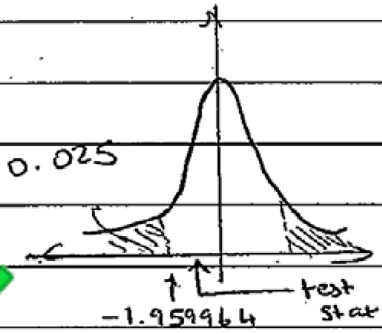
critical value: -1.959964 ✓

$= -1.960$ (4sf)

~~-1.95~~

$-1.960 < -1.875$

The result is not significant ✓✓ at the 5% significance level. There is insufficient evidence to reject H_0. There is insufficient evidence to suggest that the mean amount of active ingredient has changed. ✓



This is a model answer. It even includes a diagram showing critical values and test statistic. Such a diagram can be used to count as a sensible comparison without seeing the statement -1.96 < -1.875 though both are provided here.

Exemplar 4

3(iv)

$X \sim N(504.7, 16)$

Let μ represents mean ~~active~~ amount of active ingredient in tablets

$H_0: \mu = 504.7$

$H_1: \mu \neq 504.7$

$\bar{X} = \frac{12580}{25} = 503.2$

$z = \frac{503.2 - 504.7}{\sqrt{\frac{16}{25}}} = $ ~~-1.80~~ -1.875

Critical value at 5% significance, two tail test $= -1.960$

~~-1.875~~

~~-1.80 > -1.960 Result is insignificant~~

$-1.875 > -1.960$, Result is insignificant

There is insufficient evidence at 5% significance level to reject H_0. So we conclude that the mean amount of active ingredient is still 504.7mg because $\mu = 504.7$.

This candidate's conclusion, 'so we conclude that the mean…', is overly assertive and also refers to the null rather than alternative hypothesis.

Question 3 (v)

(v) Given that in fact the population mean is now 503.8 milligrams, comment briefly on the result of the test. What change could have been made to the test procedure, without changing the significance level, to make it more likely to detect this change in the mean? **[2]**

As with Question 1(iv) very few candidates showed that they understood the word 'population' here – many treated 503.8 as a sample mean. Most commented that increasing the sample size would make it more likely to detect the change, often without knowing why.

Exemplar 5

3 (v) $z = \frac{503.2 - 503.8}{4 \div 5} = |-0.75|$

$|-0.75| \leq 1.96$ ∴ the result would have been the same, still accept H_0

Change in proceedure: increese sample size ✓

This candidate's response is typical of many seen

Question 4 (i)

4 The year in which a car was registered can often be identified from its number plate. A motoring correspondent is investigating whether there is any association between the age of cars and their location. She chooses three locations, a motorway, a supermarket car park and a housing estate, and selects a random sample of cars from each location. The correspondent classifies the ages according to year of registration, 2001–2007, 2008–2012, 2013–2017 and also 'unknown' for those cars for which the number plate does not identify the year of registration.

(i) Write down null and alternative hypotheses for a test to examine whether there is any association between location and age category. **[1]**

This was answered well.

Question 4 (ii)

(ii) You are given that the value of the test statistic for the usual χ^2 test for the motoring correspondent's data is 8.752 correct to 3 decimal places. Carry out the test at the 10% significance level. **[4]**

Most candidates answered this well. Some candidates did not identify the correct number of degrees of freedom – possibly by looking at the table below rather than reading the information above - and were thus penalised.

Question 4 (iii)

The correspondent thinks that she should carry out another test, but this time taking a new sample which excludes the cars of unknown age. The numbers of cars for the three other age categories are given in the table below.

	2001–2007	2008–2012	2013–2017
Motorway	41	29	16
Supermarket car park	35	22	14
Housing estate	12	24	7

(iii) Calculate the expected frequency for cars on the Housing estate registered in 2001–2007. Verify the corresponding contribution, 2.5310, to the test statistic. **[3]**

Almost all the candidates scored full marks on this part, with only a couple of dropped marks due to arithmetic errors.

Question 4 (iv)

The contributions to the test statistic are shown in the table below. The figures are rounded to 4 decimal places.

	2001–2007	2008–2012	2013–2017
Motorway	0.2639	0.3275	0.0005
Supermarket car park	0.4525	0.8034	0.0570
Housing estate	2.5310	3.8459	0.1146

(iv) Using the same hypotheses as in part **(i)**, complete this new test at the 10% significance level. **[3]**

The number of degrees of freedom was identified with better success than in part (ii). Most candidates earned all three marks here. Some made mistakes when adding the contributions to produce the test statistic. Some provided overly assertive conclusions.

Question 4 (v)

(v) For each location, comment briefly on how the ages of the cars compare with what would be expected if there were no association. You should calculate any expected frequencies that you need in order to make these comments. **[4]**

Few candidates achieved all of the 4 available marks here. Some correctly commented on the large and small contributions to the test statistic and made appropriate comments regarding the observed frequencies. Some made comparisons without reference to the contributions and were thus penalised. Most candidates calculated the expected frequency of 16.125 for the housing estate for years 2008-2012 but some appeared not to notice this request. Others worked out all the expected frequencies not just the ones needed.

Exemplar 6

4(v)

fe	2001-2007	2008-2012	2013-2017
motorway	37.84	26.625	15.91
supermarket car park	31.24	26.625	13.135
Housing estate	18.92	16.125	7.955

Motorway.

· Smaller contributions of 0.2639 and 0.3275, so ~~significantly~~ only slightly more 2001-2007 and 2008-2012 than expected.

· Very small contribution of 0.0005, so n° 2013-2017 cars as expected.

Supermarket car park.

large contribution of 0.8034, so less 2008-2012 cars than expected.

small contribution of 0.0570, so n° 2013-2017 cars more or less as expected.

Housing estate.

· large contributions of 2.5310 and 3.8459, so significantly less 2001-2007 and significantly more 2008-2012 than expected

· small contribution of 0.1146, so n° 2013-2017 more or less as expected.

This candidate's response is typical of many. For cells containing low contributions, candidates are expected to state that the observed results are as expected. They should not use expressions such as 'slightly more than expected' or 'slightly less than expected'.

Question 4 (vi)

(vi) A colleague suggests that the motoring correspondent should have subdivided the ages of the cars into more than three categories. Give one advantage and one disadvantage of doing that. **[2]**

Very few candidates managed to provide acceptable comments here.

Supporting you

For further details of this qualification please visit the subject webpage.

Review of results

If any of your students' results are not as expected, you may wish to consider one of our review of results services. For full information about the options available visit the OCR website. If university places are at stake you may wish to consider priority service 2 reviews of marking which have an earlier deadline to ensure your reviews are processed in time for university applications.

Active Results offers a unique perspective on results data and greater opportunities to understand students' performance.

It allows you to:

- Review reports on the **performance of individual candidates**, cohorts of students and whole centres
- **Analyse results** at question and/or topic level
- **Compare your centre** with OCR national averages or similar OCR centres.
- Identify areas of the curriculum where students excel or struggle and help **pinpoint strengths and weaknesses** of students and teaching departments.

http://www.ocr.org.uk/administration/support-and-tools/active-results/

Attend one of our popular CPD courses to hear exam feedback directly from a senior assessor or drop in to an online Q&A session.

https://www.cpdhub.ocr.org.uk

The small print

We'd like to know your view on the resources we produce. By clicking on the 'Like' or 'Dislike' button you can help us to ensure that our resources work for you. When the email template pops up please add additional comments if you wish and then just click 'Send'. Thank you.

Whether you already offer OCR qualifications, are new to OCR, or are considering switching from your current provider/awarding organisation, you can request more information by completing the Expression of Interest form which can be found here: www.ocr.org.uk/expression-of-interest

OCR acknowledges the use of the following content:
Square down and Square up: alexwhite/Shutterstock.com

Please get in touch if you want to discuss the accessibility of resources we offer to support delivery of our qualifications: resources.feedback@ocr.org.uk

Looking for a resource?

There is now a quick and easy search tool to help find **free** resources for your qualification:

www.ocr.org.uk/i-want-to/find-resources/

www.ocr.org.uk

OCR Customer Contact Centre

General qualifications

Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk

Cambridge Assessment

CERTIFIED ISO 9001 UKAS MANAGEMENT SYSTEMS 001

Unit level raw mark and UMS grade boundaries June 2018 series

For more information about results and grade calculations, see https://www.ocr.org.uk/students/getting-your-results/

AS GCE / Advanced GCE / AS GCE Double Award / Advanced GCE Double Award

AS & Advanced GCE Mathematics				Max Mark	a	b	c	d	e	u
4721	01	C1 Core mathematics 1 (AS)	Raw	72	61	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4722	01	C2 Core mathematics 2 (AS)	Raw	72	55	49	43	37	31	0
			UMS	100	80	70	60	50	40	0
4723	01	C3 Core mathematics 3 (A2)	Raw	72	55	48	41	34	28	0
			UMS	100	80	70	60	50	40	0
4724	01	C4 Core mathematics 4 (A2)	Raw	72	54	47	40	34	28	0
			UMS	100	80	70	60	50	40	0
4725	01	FP1 Further pure mathematics 1 (AS)	Raw	72	56	50	45	40	35	0
			UMS	100	80	70	60	50	40	0
4726	01	FP2 Further pure mathematics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4727	01	FP3 Further pure mathematics 3 (A2)	Raw	72	47	41	36	31	26	0
			UMS	100	80	70	60	50	40	0
4728	01	M1 Mechanics 1 (AS)	Raw	72	60	51	42	34	26	0
			UMS	100	80	70	60	50	40	0
4729	01	M2 Mechanics 2 (A2)	Raw	72	53	46	39	32	26	0
			UMS	100	80	70	60	50	40	0
4730	01	M3 Mechanics 3 (A2)	Raw	72	50	42	34	27	20	0
			UMS	100	80	70	60	50	40	0
4731	01	M4 Mechanics 4 (A2)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4732	01	S1 – Probability and statistics 1 (AS)	Raw	72	57	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4733	01	S2 – Probability and statistics 2 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4734	01	S3 – Probability and statistics 3 (A2)	Raw	72	59	50	41	32	24	0
			UMS	100	80	70	60	50	40	0
4735	01	S4 – Probability and statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4736	01	D1 – Decision mathematics 1 (AS)	Raw	72	55	48	42	36	30	0
			UMS	100	80	70	60	50	40	0
4737	01	D2 – Decision mathematics 2 (A2)	Raw	72	58	53	48	44	40	0
			UMS	100	80	70	60	50	40	0

OCR
Oxford Cambridge and RSA

AS & Advanced GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – Introduction to advanced mathematics (AS)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – Concepts for advanced mathematics (AS)	Raw	72	53	47	41	36	31	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) Methods for Advanced Mathematics (A2): Written Paper	Raw	72	61	56	51	46	40	0
4753	02	(C3) Methods for Advanced Mathematics (A2): Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) Methods for Advanced Mathematics (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – Applications of advanced mathematics (A2)	Raw	90	63	56	49	43	37	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – Further concepts for advanced mathematics (AS)	Raw	72	55	51	47	43	40	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – Further methods for advanced mathematics (A2)	Raw	72	48	42	36	31	26	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – Further applications of advanced mathematics (A2)	Raw	72	63	56	49	42	35	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) Differential Equations (A2): Written Paper	Raw	72	61	54	48	42	35	0
4758	02	(DE) Differential Equations (A2): Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) Differential Equations (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – Mechanics 1 (AS)	Raw	72	51	44	37	31	25	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – Mechanics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – Mechanics 3 (A2)	Raw	72	61	54	48	42	36	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – Mechanics 4 (A2)	Raw	72	59	51	44	37	30	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – Statistics 1 (AS)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – Statistics 2 (A2)	Raw	72	54	47	41	35	29	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – Statistics 3 (A2)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – Decision mathematics 1 (AS)	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – Decision mathematics 2 (A2)	Raw	72	55	51	47	43	39	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) Numerical Methods (AS): Written Paper	Raw	72	57	52	48	44	39	0
4776	02	(NM) Numerical Methods (AS): Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) Numerical Methods (AS): Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – 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

AS GCE Statistics (MEI)

				Max Mark	a	b	c	d	e	u
G241	01	Statistics 1 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G242	01	Statistics 2 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G243	01	Statistics 3 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0

AS GCE Quantitative Methods (MEI)

				Max Mark	a	b	c	d	e	u
G244	01	Introduction to Quantitative Methods (Written Paper)	Raw	72	58	50	43	36	28	0
G244	02	Introduction to Quantitative Methods (Coursework)	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
G245	01	Statistics 1	Raw	72	61	55	49	43	37	0
			UMS	100	80	70	60	50	40	0
G246	01	Decision Mathematics 1	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0

OCR
Oxford Cambridge and RSA

Level 3 Certificate, Level 3 Extended Project and FSMQ raw mark grade boundaries June 2018 series

For more information about results and grade calculations, see https://www.ocr.org.uk/students/getting-your-results/

Level 3 Certificate Mathematics - Quantitative Methods (MEI)

					Max Mark	a	b	c	d	e	u
G244	A	01	Introduction to Quantitative Methods with Coursework (Written Paper)	Raw	72	58	50	43	36	28	0
G244	A	02	Introduction to Quantitative Methods with Coursework (Coursework)	Raw	18	14	12	10	8	7	0
				UMS	100	80	70	60	50	40	0
				Overall	90	72	62	53	44	35	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI)

				Max Mark	a	b	c	d	e	u
H866	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H866	02	Critical maths	Raw	60	44	39	34	29	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	109	96	83	70	57	0

Level 3 Certificate Mathematics - Quantitative Problem Solving (MEI)

				Max Mark	a	b	c	d	e	u
H867	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H867	02	Statistical problem solving	Raw	60	40	36	32	28	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	104	92	80	69	57	0

Advanced Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6993	01	Additional Mathematics	Raw	100	56	50	44	38	33	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6989	01	Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0