OCR
Oxford Cambridge and RSA

Friday 15 June 2018 – Afternoon

A2 GCE MATHEMATICS (MEI)

4768/01 Statistics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4768/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

* 7 3 1 5 1 2 2 8 3 4 *

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 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

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- 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)** A psychology experiment is designed to investigate whether the colour of the paper on which text is printed affects reading speed. Eight randomly selected participants are given two pieces of text to read, one printed on white paper and one printed on pale green paper. The two texts are different, but contain approximately the same number of words and are of equal complexity.

The table shows the length of time, in seconds, that each participant took to read each piece of text. The times have been recorded to the nearest second.

Participant	A	B	C	D	E	F	G	H
White paper	63	55	78	61	48	63	81	57
Green paper	51	61	70	59	45	65	66	50

(i) Explain why a paired test is appropriate in this context. **[1]**

(ii) Carry out a *t* test at the 5% significance level to test whether there is a difference in the population mean times taken to read the two texts. You may assume that the distributional assumptions for the *t* test hold. **[9]**

(b) A psychology textbook claims that the typical capacity for short term memory is seven items. A student believes that among college students it is higher than this. To test his hypothesis, he selects a random sample of ten college students. Each student is shown a list of thirty words and asked to repeat them two minutes later. The number of words each student could remember is given in the table.

Student	A	B	C	D	E	F	G	H	I	J
Number of words	10	15	2	18	13	6	21	3	16	5

(i) Explain why a *t* test would not be appropriate in this situation. **[1]**

(ii) Use a Wilcoxon test with a 5% significance level to test whether, among college students, the average number of words remembered is greater than 7. **[9]**

2 The number of typing errors on a page is often given as an example of a Poisson distribution.

Elaine, who is a typist, wants to investigate whether this is the case for her typing. She picks a random sample of 100 full pages she has typed over the past year and counts the number of typing errors on each page. Her results are recorded in the table.

Number of typing errors on a page	0	1	2	3	4	5	6	$\geqslant 7$
Number of pages	13	15	16	22	22	8	4	0

(i) Use the data in the table to estimate the population mean and variance of the number of typing errors per full page. Comment whether, in the light of these values, a Poisson distribution might be a suitable model for the number of typing errors on a full page of Elaine's typing. **[2]**

(ii) The table in the Answer Book shows some of the expected frequencies and contributions to the test statistic for a χ^2 test for the goodness of fit of a Poisson model for the number of errors on a full page of Elaine's typing. Calculate the missing expected frequencies and hence complete the test using a 5% significance level. **[10]**

(iii) Construct a 95% confidence interval for the mean number of typing errors per full page of Elaine's typing. Explain whether your calculation relies on the Central Limit Theorem. **[5]**

3 The table shows the mean and standard deviation of the number of calories in a single apple, a single banana and a single strawberry. It can be assumed that the number of calories in each type of fruit is Normally distributed.

Fruit	Apple	Banana	Strawberry
Mean (calories)	97.0	112.5	5.5
Standard deviation (calories)	6.3	7.5	1.3

(i) Find the probability that a randomly selected banana contains more than 100 calories. **[2]**

(ii) Write down the probability distribution of the number of calories in half a banana.

Find the probability that one apple contains at least 40 more calories than half a banana. **[6]**

(iii) Vesna makes a smoothie using two apples and seven strawberries. Assuming that the fruits are randomly and independently selected, find the probability that Vesna's smoothie contains more than 250 calories. **[5]**

'Red Ripple' is a smoothie that is sold in bottles. The amount, x millilitres, of drink in 12 randomly selected bottles of 'Red Ripple' smoothie is measured, and the results are summarised as follows:

$$\Sigma x = 2184, \quad \Sigma x^2 = 397\,851.$$

The amount of drink in a bottle is assumed to be Normally distributed.

(iv) (*A*) Construct a 95% confidence interval for the mean amount of drink in a bottle of 'Red Ripple'. **[5]**

(*B*) Explain what is meant by a 95% confidence interval in this context. **[1]**

4 The length of time, in minutes, that I have to wait in the queue for coffee in the college canteen is modelled by the random variable T with cumulative distribution function

$$\mathrm{F}(t) = \begin{cases} 0 & t < 0, \\ \frac{1}{3}t^2 & 0 \leqslant t \leqslant 1, \\ -\frac{1}{6}t^2 + t - \frac{1}{2} & 1 < t \leqslant 3, \\ 1 & t > 3. \end{cases}$$

(i) Use this model to find

(A) the probability that I have to wait for more than 2 minutes, **[2]**

(B) the median waiting time. **[3]**

(ii) Find the probability density function of T. **[3]**

(iii) Show that the expected value of T is $\frac{4}{3}$. **[4]**

You are given that the variance of T is $\frac{7}{18}$.

(iv) I record the time I have to wait in the queue on 30 randomly selected days. Calculate an estimate of the probability that the mean of these 30 waiting times is greater than 1.5 minutes. **[4]**

END OF QUESTION PAPER

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4768/01 Statistics 3

PRINTED ANSWER BOOK

Candidates answer on this Printed Answer Book.

OCR supplied materials:
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- Scientific or graphical calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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1(a)(i)	
1(a)(ii)	

1(b)(i)	
1(b)(ii)	

2(i)

2(ii)

Number of errors	Observed frequency	Expected frequency	Contributions
0	13	7.065	4.985
1	15	18.723	0.740
2	16		
3	22	21.913	0.000
4	22	14.518	3.857
5	8	7.694	0.012
6	4	3.398	
⩾7	0		

(answer space continued on next page)

2(ii)	(continued)

2(iii)

3(i)	
3(ii)	

3(iii)	

3 (iv) (*A*)	
3(iv)(*B*)	

4(i)(*A*)

4(i)(*B*)

4(ii)	
4(iii)	
	(answer space continued on next page)

4(iii)	(continued)
4(iv)	

GCE

Mathematics (MEI)

Unit **4768**: Statistics 3

Advanced GCE

Mark Scheme for June 2018

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.	a	i	There is a ‘white paper’ and ‘green paper’ time for each participant (and pairing these removes the variability in reading speed among participants.)	B1 **[1]**	
	a	ii	H_0: μ = 0, H_1: μ ≠ 0 where μ is the population mean difference between the times (white-green).	B1 B1	both hypotheses needs mean, population and context
			differences: 12, -6, 8, 2, 3, -2, 15, 7 $\bar{x} = 4.875, s = 7.019$	M1 A1	using differences both mean and sd (art 4.88, 7.02)
			$t = \dfrac{4.875}{\frac{7.019}{\sqrt{8}}}$	M1	requires $\sqrt{8}$
			$= 1.96$	A1	art 1.96
			(dof = 7) CV = 2.36 or 2.37	B1	
			1.96 < 2.36 so insufficient evidence to reject H_0.	M1	requires correct CV and $\sqrt{8}$
			There is insufficient evidence that the population mean reading times are different for white and green paper.	A1 **[9]**	f/t their *t* but not wrong CV. Needs ‘mean difference’, ‘population’ and context.
	b	i	It is not known that the number of words is normally distributed (in the population).	B1 **[1]**	Accept ‘They are not normally distributed’.

Question			Answer	Marks	Guidance
		ii	H_0: m = 7, H_1: m > 7 where m is the population median of the number of words remembered.	B1 B1	both hypotheses (can be in words) population, median and context
			see table below	M1 M1 A1	-7 ranking all ranks correct
			W_+ = 43 (W_- = 12) Critical value (for n = 10) = 10	B1 B1	either 43 or 12 seen
			12 > 10 so insufficient evidence to reject H_0.	M1	conclusion consistent with their comparison, requires correct CV
			There is insufficient evidence that the (population) median of the number of words remembered is more than 7.	A1 **[9]**	f/t their W but not wrong CV. Needs context and 'median' or 'on average'.
2.	i		mean = 2.65 variance = 2.73	B1	Both mean and variance correct to 3sf. (cao) (var = 2.73 or 2.735 or 2.74)
			Poisson could be appropriate as mean ≈ variance	B1 **[2]**	f/t their mean and variance

number of words	−7	rank	>0?
10	3	3	y
15	8	7	y
2	-5	5	
18	11	9	y
13	6	6	y
6	-1	1	
21	14	10	y
3	-4	4	
16	9	8	y
5	-2	2	

Question			Answer	Marks	Guidance
	ii		H_0: Poisson distribution is a good model for the number of errors H_1: Poisson distribution is not a good model	B1	Both hypotheses (not 'data fit a Poisson model'; not Po(2.65))
			(see table below)	M1	Expected frequencies (at least one correct or one correct Poisson formula seen)
				A1	Both 24.8 and 1.88 (the contributions don't need to be explicitly seen)
				B1	Last two rows combined
			$\chi^2 = 4.985 + 0.740 + \cdots = 13.0$ (3 sf)	M1 A1	Evidence of correct method (adding contributions) χ^2 value correct (art 13)
			dof = 7 – 1 – 1 = 5 $\chi^2_{\text{crit}} = 11.07$	M1* A1	dof = their rows – 2 critical value
			13.0 > 11.07, sufficient evidence to reject H_0. There is sufficient evidence, at the 5% significance level, that a Poisson distribution is not a good model for the number of errors on the page.	M1dep* A1 (ft) **[10]**	Conclusion consistent with their numbers, needs correct CV Conclusion in context If rows not combined: X^2=14.7, dof=6, CV=12.59; reject. can get B1M1A1B0M1A0M1A0M1A1(7/10)
	iii		$\bar{X} \approx N\left(2.65, \frac{'2.73'}{100}\right)$	M1	Use of normal, mean 2.65 seen or implied
			$2.65 \pm 1.96 \times \frac{s}{10}$	B1 B1	z=1.96 *s*/10 with their *s* from part i
			CI = [2.33, 2.97]	A1	cao, 3 or 4 sf (both biased and unbiased estimates should give the same answer)
			Yes, because the population distribution is not known to be Normal.	B1 **[5]**	Must indicate population/parent distribution

number	observed	expected	contributions
0	13	7.065	4.985
1	15	18.72	0.740
2	16	**24.81**	**3.127**
3	22	21.91	0.000
4	22	14.52	3.857
5	8	7.694	0.012
6	4	3.398	
>=7	0	**1.883**	
>=6	**4**	**5.280**	**0.310**

Question			Answer	Marks	Guidance
3.	i		$P(B>100)=1-\Phi\left(\frac{100-112.5}{7.5}\right)$ $=1-\Phi(-1.67)=0.952$	M1 A1 **[2]**	For $1-\Phi(\text{negative})$ or getting answer > 0.5 cao
	ii		$\frac{1}{2}B\sim\text{N}(56.25,3.75^2)$ Consider $A-\frac{1}{2}B>40$ $\text{Var}\left(A-\frac{1}{2}B\right)=6.3^2+{'3.75'}^2$ $=53.75$ $\text{E}\left(A-\frac{1}{2}B\right)=40.75$ $P\left(A-\frac{1}{2}B>40\right)=1-\Phi\left(\frac{40-40.75}{\sqrt{53.75}}\right)$ $=1-\Phi(-0.102)=0.541$	M1 A1 M1 M1 A1ft A1 **[6]**	Normal, mean 56.25 3.75 or 14.06 seen $A-\frac{1}{2}B>40$ oe seen or implied Variances added (their 3.75^2) Their mean and Var from $\frac{1}{2}B$ (mean is 0.75 if considering $A-\frac{1}{2}B-40$) cao
	iii		$E(A_1+A_2+S_1+\cdots+S_7)=232.5$ $Var(A_1+A_2+S_1+\cdots+S_7)=2\times6.3^2+7\times1.3^2$ $=91.21$ Consider $P(A_1+A_2+S_1+\cdots+S_7>250)$ $P(A_1+A_2+S_1+\cdots+S_7>250)=1-\Phi\left(\frac{250-232.5}{9.55}\right)$ $=1-\Phi(1.83)=0.0334$	B1 M1 A1 M1 A1 **[5]**	 NOT $4\times$ or $49\times$, but allow SD not squared or SD=9.55 $A_1+A_2+S_1+\cdots+S_7>250$ seen or implied cao (0.0334 or 0.0335)

Question			Answer	Marks	Guidance
	iv	(*A*)	$\bar{x} = \frac{2184}{12} = 182$	B1	soi
			$s_{n-1}^2 = \frac{12}{11}\left(\frac{397851}{12} - 182^2\right) = 33$ $(s_{n-1} = 5.74)$	B1	soi
			$182 \pm 2.201 \times \sqrt{\frac{33}{12}}$	M1 B1	correct structure, using t-distribution, must have $\div\sqrt{12}$ 2.201 soi
			$\text{CI} = [178.4, 185.6]$	A1 **[5]**	art [178, 186] A5 for correct answer
	iv	(*B*)	(In the long run,) around 95% of intervals constructed in this way will contain the true mean.	B1 **[1]**	Allow e.g. 'There is a 95% probability that an interval constructed in this way contains the true mean'
4.	i	(*A*)	$P(T > 2) = 1 - \left(-\frac{4}{6} + 2 - \frac{1}{2}\right)$	M1	substituting t=2 into the correct expression (e.g. 0.833 or $\frac{5}{6}$ seen)
			$= \frac{1}{6}\ (= 0.167)$	A1 **[2]**	art 0.167
		(*B*)	$\frac{1}{3} \times 1^2 < 0.5$, so the median is in $1 < t \le 3$	B1	Deciding which interval the median is in (can be implied)
			$-\frac{1}{6}t^2 + t - \frac{1}{2} = \frac{1}{2}$ $(t^2 - 6t + 6 = 0)$ $x = 3 \pm \sqrt{3}$	M1	Correct equation seen
			The median is $3 - \sqrt{3}$ (= 1.27)	A1 **[3]**	Correct of the two solutions selected
	ii		$f(t) = \begin{cases} \frac{2}{3}t, & 0 \le t \le 1 \\ -\frac{1}{3}t + 1, & 1 < t \le 3 \\ 0, & \text{otherwise} \end{cases}$	M1 A1 B1 **[3]**	Clear attempt at differentiation (e.g. kt seen) Both correct expressions f(t)=0 outside [0, 3] (can be separately for t<0 and t>3)

Question			Answer	Marks	Guidance
	iii		$E(T)=\int_0^1 \frac{2}{3}t^2\,dt+\int_1^3 -\frac{1}{3}t^2+t\,dt$	M1*	Integrate tf(t) over two separate intervals (no limits required)
			$=\left[\frac{2}{9}t^3\right]_0^1+\left[-\frac{1}{9}t^3+\frac{1}{2}t^2\right]_1^3$	B1	Both correct integrated expressions seen
			$=\left(\frac{2}{9}\right)+\left(-\frac{27}{9}+\frac{9}{2}\right)-\left(-\frac{1}{9}+\frac{1}{2}\right)$	M1dep*	Correct limits applied
			$=\frac{4}{3}$ minutes	A1 [4]	AG; some working needed, e.g. $\frac{2}{9}+\frac{10}{9}$
	iv		$\bar{T}\sim N\left(\frac{4}{3},\frac{7}{540}\right)$	B1 B1	Normal and mean, seen or implied variance $=\frac{7}{540}=0.0130$ (or SD=0.114) seen or implied
			$P(\bar{T}>1.5)=1-\Phi\left(\frac{1.5-\frac{4}{3}}{\sqrt{\frac{7}{540}}}\right)$	M1	Correct structure, their mean and var
			$=1-\Phi(1.46)=0.0716$	A1 [4]	cao, correct to 3sf. (0.0716 or 0.0715) If working in seconds: $\bar{T}\sim N\left(80,\frac{1400}{30}\right)$ (var = 46.7, sd=6.83) SC: N(80, 23.3/30) leading to $1-\Phi(11.4)$: B1B0M1A0 *Note: If working with totals,* $N\left(40,\frac{35}{3}\right)$

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Examiners' report

MATHEMATICS (MEI)

3895-3898, 7895-7898

4768/01 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 that 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 4768/01 series overview

The overall quality of the candidates for this paper was very high and a good level of preparation was evident. Almost all candidates seem able to carry out standard calculations accurately, displaying confident use of technology and also showing sufficient working. Candidates should be reminded however of the need to use an appropriate degree of accuracy, which for this component is usually three or four significant figures. They should understand that just because their calculator shows more figures, this does not mean that they are relevant or correct in every context.

The procedure for hypothesis testing was also well understood, including the need to state hypotheses and the conclusion correctly. Only a small minority lost marks for using an incorrect form of words or omitting the context. An exception to this was the χ^2 test, where the context was often left out.

The notation for combinations of random variables however is an area that requires some attention. Although the correct calculations often suggested that candidates knew the difference between (for example) $2A$ and $A_1 + A_2$, this was often not expressed using correct notation. Making the distinction explicit would not only help candidates select the correct variance calculation, but is also an essential part of correct mathematical communication, which should be given more emphasis at this level.

The weakest topic in this component remains the understanding of the Central Limit Theorem, specifically its exact statement, when it can be applied and when it is not needed. Linked to this is the understanding of the sample mean as a random variable and the distinction between the distributions of the sample mean and the original population. Simulations using technology can help candidates understand this distinction.

Although candidates generally showed good knowledge of standard definitions, conditions and assumptions, they need to be careful to answer precisely the question being asked, rather than simply repeating standard statements. For example, they should note whether a questions asks whether a certain result can be used or whether it is required.

Key

AfL Guidance to offer for future teaching and learning practice.

Misconception

Question 1(a)(i)

1 **(a)** A psychology experiment is designed to investigate whether the colour of the paper on which text is printed affects reading speed. Eight randomly selected participants are given two pieces of text to read, one printed on white paper and one printed on pale green paper. The two texts are different, but contain approximately the same number of words and are of equal complexity.

The table shows the length of time, in seconds, that each participant took to read each piece of text. The times have been recorded to the nearest second.

Participant	A	B	C	D	E	F	G	H
White paper	63	55	78	61	48	63	81	57
Green paper	51	61	70	59	45	65	66	50

(i) Explain why a paired test is appropriate in this context. **[1]**

Most candidates understood that one advantage of a paired test is that it eliminates differences between individual participants (in this case, differences in reading speed). A paired test can only be carried out if there are two pieces of information for each participant. Unfortunately, many candidates left out this important point.

Question 1(a)(ii)

(ii) Carry out a t test at the 5% significance level to test whether there is a difference in the population mean times taken to read the two texts. You may assume that the distributional assumptions for the t test hold. **[9]**

The calculations for the t test were generally done well and with sufficient detail. Many candidates scored full marks on this question, although a sizeable minority did lose one or two marks for not referring to the 'population' or 'mean times'. It is important to realise that a paired test is for the mean of the population of differences, not for the difference of the two population means. This should be reflected in the phrasing in the hypotheses, for example '$\mu = 0$, where μ is the mean of the population of the differences in reading times' and not 'where μ is the difference between the population reading times'.

Question 1(b)(i)

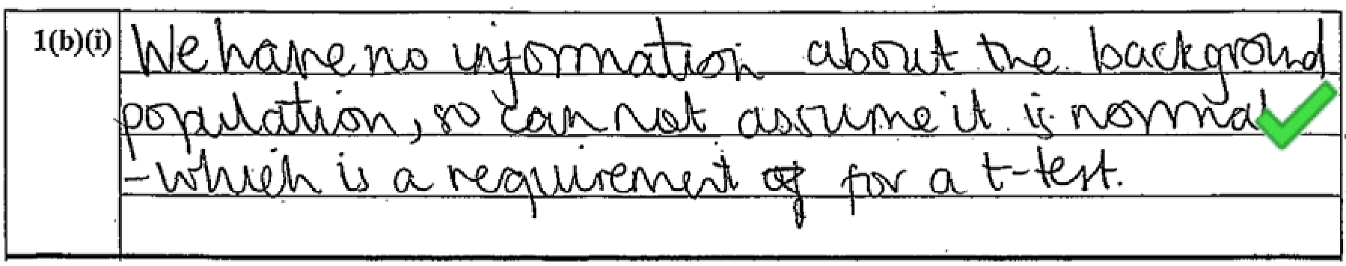
(b) A psychology textbook claims that the typical capacity for short term memory is seven items. A student believes that among college students it is higher than this. To test his hypothesis, he selects a random sample of ten college students. Each student is shown a list of thirty words and asked to repeat them two minutes later. The number of words each student could remember is given in the table.

Student	A	B	C	D	E	F	G	H	I	J
Number of words	10	15	2	18	13	6	21	3	16	5

(i) Explain why a *t* test would not be appropriate in this situation. **[1]**

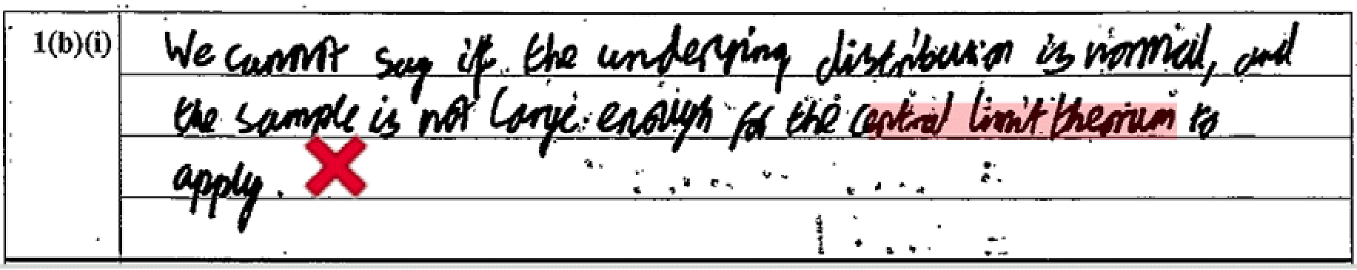
Almost all candidates scored this mark, which was given for stating that the underlying population distribution was unknown.

Exemplar 1


1(b)(i) We have no information about the background population, so cannot assume it is normal - which is a requirement of for a t-test.

The best answers, such as Exemplar 1, stated clearly the requirement for using the *t* test and explained why it is not met in this case.

Exemplar 2


1(b)(i) We cannot say if the underlying distribution is normal, and the sample is not large enough for the central limit theorem to apply.

Some answers, such as Exemplar 2, reveal the misunderstanding of the Central Limit Theorem (CLT) that was seen more widely in Q2 (iii). The CLT tells us about the distribution of the sample mean, while a *t* test requires a Normally distributed population, which cannot be changed by taking a larger sample size.

Question 1(b)(ii)

(ii) Use a Wilcoxon test with a 5% significance level to test whether, among college students, the average number of words remembered is greater than 7. **[9]**

Question 2(i)

2 The number of typing errors on a page is often given as an example of a Poisson distribution.

Elaine, who is a typist, wants to investigate whether this is the case for her typing. She picks a random sample of 100 full pages she has typed over the past year and counts the number of typing errors on each page. Her results are recorded in the table.

Number of typing errors on a page	0	1	2	3	4	5	6	⩾7
Number of pages	13	15	16	22	22	8	4	0

(i) Use the data in the table to estimate the population mean and variance of the number of typing errors per full page. Comment whether, in the light of these values, a Poisson distribution might be a suitable model for the number of typing errors on a full page of Elaine's typing. **[2]**

Most candidates knew what was required in this question, and the fact that the Poisson distribution has mean equal to the variance seems well understood. A minority of candidates lost a mark for finding the sample variance, rather than the unbiased estimate of the population variance, or by giving their answer to too many significant figures.

Question 2(ii)

(ii) The table in the Answer Book shows some of the expected frequencies and contributions to the test statistic for a χ^2 test for the goodness of fit of a Poisson model for the number of errors on a full page of Elaine's typing. Calculate the missing expected frequencies and hence complete the test using a 5% significance level. **[10]**

There was a good number of correct answers to this question. The fact that two of the rows of the table needed to be combined presented a difficulty to a sizeable minority of candidates. Some forgot to combine rows altogether. Others stated that the rows needed to be combined, but then did not recalculate the relevant contribution. It was common to see the rows combined for the purposes of the calculation, but then the original number of rows used for determining the degrees of freedom (or vice versa).

An additional difficulty arose for candidates who calculated the expected frequency for the final row incorrectly. The most common error was to use $P(X = 7)$ rather than $P(X \geq 7)$. This results in the last three rows needing to be combined and further confusion in determining degrees of freedom.

When calculating the degrees of freedom some candidates subtracted 2 from the usual $n - 1$, possibly because they were asked to calculate both mean and variance in part (i). However, the Poisson distribution only has one parameter, so subtracting 1 is correct here.

This question highlighted the importance of showing detailed working. For example, if a candidate mistakenly combined the last three rows, but then clearly stated 'dof = 6 -1 -1' they were able to get some follow-through marks that they would not gain if they just wrote 'dof = 4'. Similarly, an incorrect answer for the χ^2 statistic could gain one out of the two marks provided a clear calculation (adding the contributions) was shown.

Finally, although almost all candidates included context in their conclusion of the hypothesis tests in Q1, in this question many just wrote 'There is sufficient evidence that the model does not fit the data', which cost them the final mark.

Question 2(iii)

(iii) Construct a 95% confidence interval for the mean number of typing errors per full page of Elaine's typing. Explain whether your calculation relies on the Central Limit Theorem. **[5]**

The calculation for the confidence interval was generally done correctly. Almost all candidates attempted to explain how or why they used the Central Limit Theorem in their calculation, however from the responses it seems that the precise statement of the theorem is not very well understood.

It was good to see that only a small number of candidates thought that the CLT says something about the variance of the sample mean; the fact that the variance needs to be divided by *n* is true in general, and not a part of the statement of the CLT. A more common mistake was to claim that, for a large enough sample, the underlying population is approximately Normally distributed.

Such candidates would benefit from a better understanding of the sample mean as a random variable and how its distribution changes with the sample size. A possible way to do this is to use technology to generate lots of samples from a given distribution and build up the distribution of the means.

Those candidates who did know the statement for the CLT were often not able to express the answer to the actual question correctly. The calculation relies on the CLT because the underlying distribution is not Normal (as it is a discrete distribution), so the distribution of the sample means needs to be approximated in order to calculate the confidence interval. If the underlying distribution had been Normal, CLT would not have been required, regardless of the sample size. Many candidates explained why the CLT can be used (because the sample size is large) rather than why it is required.

Central Limit Theorem

The Central Limit Theorem (CLT) states that, when the sample size is sufficiently large, the distribution of the sample means is approximately Normal, regardless of the underlying population distribution.

The CLT only needs to be used if the underlying population is not known to be Normal.

If the underlying population is Normal, the CLT is not required as the distribution of the sample means is exactly Normal for any sample size.

Question 3(i)

3 The table shows the mean and standard deviation of the number of calories in a single apple, a single banana and a single strawberry. It can be assumed that the number of calories in each type of fruit is Normally distributed.

Fruit	Apple	Banana	Strawberry
Mean (calories)	97.0	112.5	5.5
Standard deviation (calories)	6.3	7.5	1.3

(i) Find the probability that a randomly selected banana contains more than 100 calories. **[2]**

Question 3(ii)

(ii) Write down the probability distribution of the number of calories in half a banana.

Find the probability that one apple contains at least 40 more calories than half a banana. **[6]**

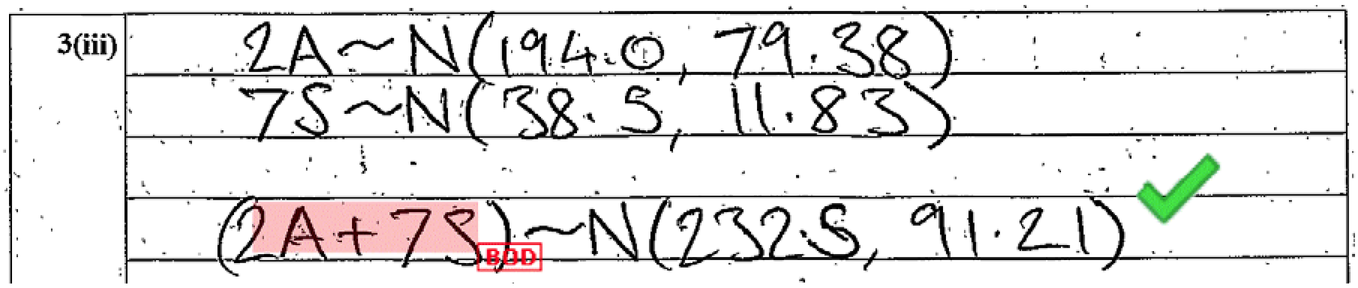
There were many correct answers to this question. It was quite common to see the variance for half a banana being divided by 2 instead of by 4, which had a knock-on effect on the final answer.

Question 3(iii)

(iii) Vesna makes a smoothie using two apples and seven strawberries. Assuming that the fruits are randomly and independently selected, find the probability that Vesna's smoothie contains more than 250 calories. **[5]**

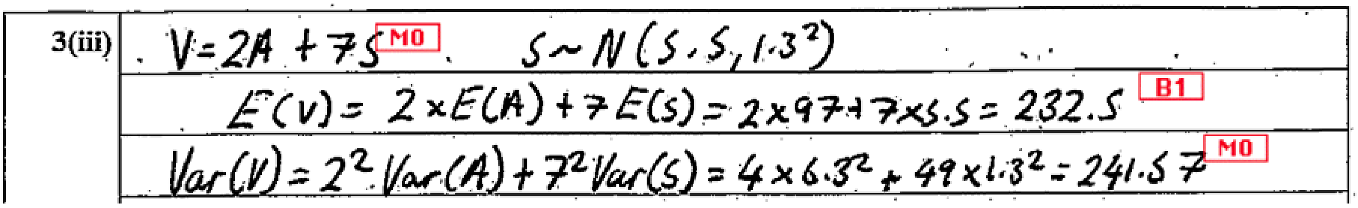
In this question the variances needed to be multiplied by 2 and 7 rather than 4 and 49, before adding. This is because there are two different, independent apples, rather than two copies of the same apple (and similarly for strawberries). The correct notation of the overall random variable is $T = A_1 + A_2 + S_1 + \ldots + S_7$ rather than $T = 2A + 7S$. The latter was condoned where it led to a correct answer, but is strictly speaking wrong.

Exemplar 3


3(iii)
2A~N(194.0, 79.38)
7S~N(38.5, 11.83)
(2A+7S)~N(232.5, 91.21)
BOD

Exemplar 3 uses incorrect notation, but is given benefit of the doubt because of finding the variance correctly.

Exemplar 4

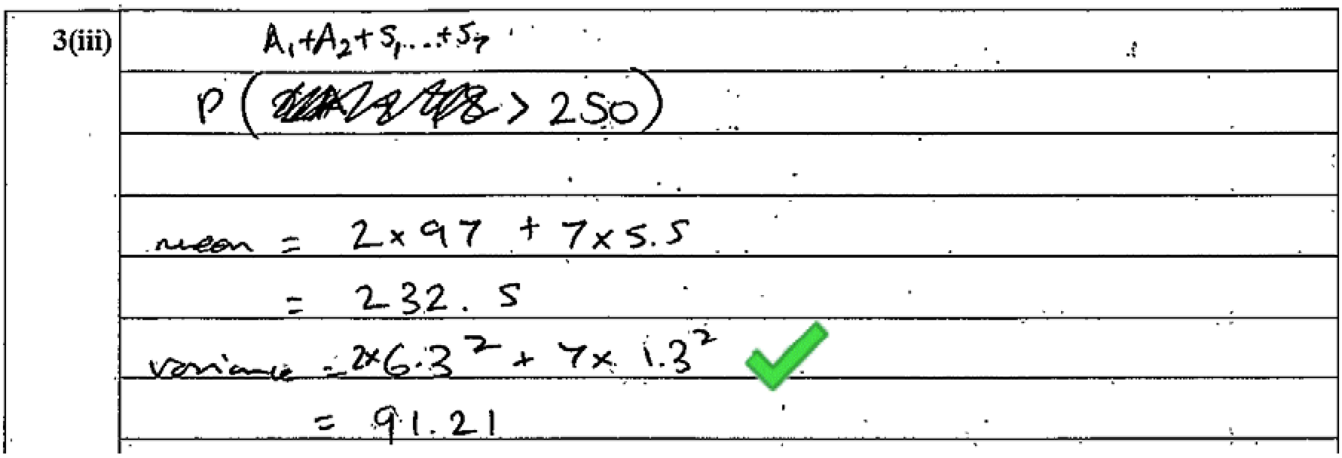

3(iii) $V = 2A + 7S$ M0 $S \sim N(5.5, 1.3^2)$

$E(V) = 2 \times E(A) + 7E(S) = 2 \times 97 + 7 \times 5.5 = 232.5$ B1

$Var(V) = 2^2 Var(A) + 7^2 Var(S) = 4 \times 6.3^2 + 49 \times 1.3^2 = 241.57$ M0

Exemplar 4 uses incorrect notation and finds variance incorrectly, so is only given one mark for the mean.

Exemplar 5


3(iii) $A_1 + A_2 + S_1 ... + S_7$

$P(\ldots > 250)$

mean $= 2 \times 97 + 7 \times 5.5$

$= 232.5$

variance $= 2 \times 6.3^2 + 7 \times 1.3^2$

$= 91.21$

Exemplar 5 uses correct notation.

Candidates should be encouraged to define their random variables correctly. This should help them decide whether the variance needs to be multiplied by 7 or by 49, for example.

Question 3(iv)(A)

'Red Ripple' is a smoothie that is sold in bottles. The amount, x millilitres, of drink in 12 randomly selected bottles of 'Red Ripple' smoothie is measured, and the results are summarised as follows:

$$\Sigma x = 2184, \quad \Sigma x^2 = 397\,851.$$

The amount of drink in a bottle is assumed to be Normally distributed.

(iv) *(A)* Construct a 95% confidence interval for the mean amount of drink in a bottle of 'Red Ripple'. **[5]**

The process for construction confidence intervals seems well understood in general. A sizeable minority of candidates used the Normal rather than the *t* distribution (possibly because it was mentioned in the question). The *t* distribution is required here because the population variance is unknown.

The fact that the bounds of the confidence interval round to 178.35 and 185.65 seems to have caused many candidates to give their answers to five significant figures, hence losing the final mark.

Question 3(iv)(B)

(*B*) Explain what is meant by a 95% confidence interval in this context. **[1]**

The meaning of a 95% confidence interval seems to be very well understood. To gain the mark, candidates needed to make it clear that they were referring to confidence intervals 'constructed in this way', rather than 'all confidence intervals'.

Question 4(i)(A)

4 The length of time, in minutes, that I have to wait in the queue for coffee in the college canteen is modelled by the random variable T with cumulative distribution function

$$\mathrm{F}(t) = \begin{cases} 0 & t < 0, \\ \frac{1}{3}t^2 & 0 \leqslant t \leqslant 1, \\ -\frac{1}{6}t^2 + t - \frac{1}{2} & 1 < t \leqslant 3, \\ 1 & t > 3. \end{cases}$$

(i) Use this model to find

(*A*) the probability that I have to wait for more than 2 minutes, **[2]**

Question 4(i)(B)

(*B*) the median waiting time. **[3]**

A majority of candidates knew what to do here and were able to select the correct equation to use. The best answers showed explicitly that the median has to be greater than 1 (since F(1) < 0.5). Some candidates seemed to find two "medians", one for $t < 1$ and one for $t > 1$.

Question 4(ii)

(ii) Find the probability density function of T. **[3]**

Question 4(iii)

(iii) Show that the expected value of T is $\frac{4}{3}$. **[4]**

Since this is a 'show that' question, all the details need to be clearly shown (the result of the integration, the substitution of limits and some calculation steps leading to the final number).

Question 4(iv)

You are given that the variance of T is $\frac{7}{18}$.

(iv) I record the time I have to wait in the queue on 30 randomly selected days. Calculate an estimate of the probability that the mean of these 30 waiting times is greater than 1.5 minutes. **[4]**

This final question was very well answered, with almost all candidates realising that the Central Limit Theorem allows them to approximate the distribution of the sample mean to Normal, using the mean from part (iii) and dividing the given variance by 30.

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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

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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

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