OCR
RECOGNISING ACHIEVEMENT

Friday 22 June 2012 – Afternoon

A2 GCE MATHEMATICS (MEI)

4768 Statistics 3

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4768
- 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 in the centre of 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.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

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

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

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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

1 Technologists at a company that manufactures paint are trying to develop a new type of gloss paint with a shorter drying time than the current product. In order to test whether the drying time has been reduced, the technologists paint a square metre of each of the new and old paints on each of 10 different surfaces. The lengths of time, in hours, that each square metre takes to dry are as follows.

Surface	A	B	C	D	E	F	G	H	I	J
Old paint	16.6	17.0	16.5	15.6	16.3	16.5	16.4	15.9	16.3	16.1
New paint	15.9	16.3	16.3	15.9	15.5	16.6	16.1	16.0	16.2	15.6

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

(ii) The mean reduction in drying time is to be investigated. Why might a *t* test be appropriate in this context and what assumption needs to be made? **[4]**

(iii) Using a significance level of 5%, carry out a test to see if there appears to be any reduction in mean drying time. **[9]**

(iv) Find a 95% confidence interval for the true mean reduction in drying time. **[4]**

2 **(a)** **(i)** Give two reasons why an investigator might need to take a sample in order to obtain information about a population. **[2]**

(ii) State two requirements of a sample. **[2]**

(iii) Discuss briefly the advantage of the sampling being random. **[2]**

(b) **(i)** Under what circumstances might one use a Wilcoxon single sample test in order to test a hypothesis about the median of a population? What distributional assumption is needed for the test? **[2]**

(ii) On a stretch of road leading out of the centre of a town, highways officials have been monitoring the speed of the traffic in case it has increased. Previously it was known that the median speed on this stretch was 28.7 miles per hour. For a random sample of 12 vehicles on the stretch, the following speeds were recorded.

32.0 29.1 26.1 35.2 34.4 28.6 32.3 28.5 27.0 33.3 28.2 31.9

Carry out a test, with a 5% significance level, to see whether the speed of the traffic on this stretch of road seems to have increased on the whole. **[10]**

3 The triathlon is a sports event in which competitors take part in three stages, swimming, cycling and running, one straight after the other. The winner is the competitor with the shortest overall time. In this question the times for the separate stages are assumed to be Normally distributed and independent of each other.

For a particular triathlon event in which there was a very large number of competitors, the mean and standard deviation of the times, measured in minutes, for each stage were as follows.

	Mean	Standard deviation
Swimming	11.07	2.36
Cycling	57.33	8.76
Running	24.23	3.75

(i) For a randomly chosen competitor, find the probability that the swimming time is between 10 and 13 minutes. **[3]**

(ii) For a randomly chosen competitor, find the probability that the running time exceeds the swimming time by more than 10 minutes. **[4]**

(iii) For a randomly chosen competitor, find the probability that the swimming and running times combined exceed $\frac{2}{3}$ of the cycling time. **[4]**

(iv) In a different triathlon event the total times, in minutes, for a random sample of 12 competitors were as follows.

103.59 99.04 85.03 81.34 106.79 89.14 98.55 98.22 108.87 116.29 102.51 92.44

Find a 95% confidence interval for the mean time of all competitors in this event. **[5]**

(v) Discuss briefly whether the assumptions of Normality and independence for the stages of triathlon events are reasonable. **[2]**

[Question 4 is printed overleaf.]

4 The numbers of call-outs per day received by a fire station for a random sample of 255 weekdays were recorded as follows.

Number of call-outs	0	1	2	3	4	5 or more
Frequency (days)	145	79	22	6	3	0

The mean number of call-outs per day for these data is 0.6. A Poisson model, using this sample mean of 0.6, is fitted to the data, and gives the following expected frequencies (correct to 3 decimal places).

Number of call-outs	0	1	2	3	4	5 or more
Expected frequency	139.947	83.968	25.190	5.038	0.756	0.101

(i) Using a 5% significance level, carry out a test to examine the goodness of fit of the model to the data. **[9]**

The time T, measured in days, that elapses between successive call-outs can be modelled using the exponential distribution for which f(t), the probability density function, is

$$f(t) = \begin{cases} 0 & t < 0, \\ \lambda e^{-\lambda t} & t \geqslant 0, \end{cases}$$

where λ is a positive constant.

(ii) For the distribution above, it can be shown that $E(T) = \frac{1}{\lambda}$. Given that the mean time between successive call-outs is $\frac{5}{3}$ days, write down the value of λ. **[1]**

(iii) Find F(t), the cumulative distribution function. **[3]**

(iv) Find the probability that the time between successive call-outs is more than 1 day. **[2]**

(v) Find the median time that elapses between successive call-outs. **[3]**

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4768 Statistics 3

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Candidates answer on this Printed Answer Book.

OCR supplied materials:
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Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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Turn over

1 (i)	
1 (ii)	
1 (iii)	
	(answer space continued on next page)

1 (iii)	(continued)

1 (iv)	
2 (a)(i)	

2 (a)(ii)	
2 (a)(iii)	
2 (b)(i)	

2 (b)(ii)	
	(answer space continued on next page)

(answer space continued on next page)

2 (b)(ii)	**(continued)**
3 (i)	

3 (ii)	
3 (iii)	

3 (iv)	
3 (v)	

4 (i)	
	(answer space continued on next page)

4 (i)	**(continued)**
4 (ii)	
4 (iii)	

4 (iv)	
4 (v)	

RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced GCE

Unit **4768:** Statistics 3

Mark Scheme for June 2012

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, OCR Nationals, 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.

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

Any enquiries about publications should be addressed to:

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E-mail: publications@ocr.org.uk

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) Pure 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, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. 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. For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

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

Question			Answer	Marks	Guidance
1	(i)		A paired sample is used in this context in order to eliminate any effects due to the surfaces used.	E1 **[1]**	Must refer to (differences between) surfaces.
1	(ii)		A t test might be used since … … the sample is small and … the population variance is not known (it must be estimated from the data). Must assume: Normality of population … … of <u>differences</u>.	 E1 E1 B1 B1 **[4]**	 Allow use of "σ", otherwise insist on "population". Allow "underlying" or "distribution" to imply "population".
1	(iii)		H$_0$: $\mu_D = 0$ H$_1$: $\mu_D > 0$ Where μ_D is the (population) mean reduction/difference in drying time. <u>MUST</u> be PAIRED COMPARISON t test. Differences (reductions) (before – after) are: 0.7 0.7 0.2 –0.3 0.8 –0.1 0.3 –0.1 0.1 0.5 $\bar{x} = 0.28 \quad s_{n-1} = 0.3852(84) \quad (s_{n-1}{}^2 = 0.1484(44))$ Test statistic is $\dfrac{0.28 - 0}{\frac{0.3853}{\sqrt{10}}}$ = 2.298. Refer to t_9. Single-tailed 5% point is 1.833. Significant. Seems mean drying time has fallen.	B1 B1 B1 M1 A1 M1 A1 A1 A1 **[9]**	Both. Accept alternatives e.g. $\mu_D < 0$ for H$_1$, or $\mu_B - \mu_A$ etc provided adequately defined. Hypotheses in words only must include "population". Do NOT allow "$\bar{X} = ...$" or similar. unless $\bar{X}$ is clearly and explicitly stated to be a <u>population</u> mean. For adequate verbal definition. Allow absence of "population" if correct notation μ is used. Allow "after – before" if consistent with alternatives above. Do not allow $s_n = 0.3655$ ($s_n{}^2 = 0.1336$) Allow c's $\bar{x}$ and/or s_{n-1}. Allow alternative: 0 + (c's 1.833) × $\frac{0.3853}{\sqrt{10}}$ (= 0.2233) for subsequent comparison with $\bar{x}$. (Or $\bar{x}$ – (c's 1.833) × $\frac{0.3853}{\sqrt{10}}$ (= 0.0566) for comparison with 0.) c.a.o. but ft from here in any case if wrong. Require 3/4 sf; condone up to 6. Use of $0 - \bar{x}$ scores M1A0, but ft. No ft from here if wrong. $P(t > 2.298) = 0.02357$. No ft from here if wrong. ft only c's test statistic. ft only c's test statistic. "Non-assertive" conclusion in context to include "on average" oe.

Question			Answer	Marks	Guidance
1	(iv)		CI is given by 0.28 ± 2.262 $\times \frac{0.3853}{\sqrt{10}}$ = 0.28 ± 0.2756 = (0.0044, 0.5556)	M1 B1 M1 A1 **[4]**	Allow c's $\overline{x}$. Allow c's s_{n-1}. c.a.o. Must be expressed as an interval. Require 3/4 dp; condone 5. If the final answer is centred on a negative sample mean then do not award the final A mark. ZERO/4 if not same distribution as test. Same wrong distribution scores maximum M1 B0 M1 A0. Recovery to t_9 is OK.
2	(a)	(i)	For example, need to take a sample because the population might be too large for it to be sensible to take a complete census. Because the sampling process might be destructive.	E1 E1 **[2]**	Reward 1 mark each for any two distinct, sensible points.
2	(a)	(ii)	For example Sample should be unbiased. Sample should be representative (of the population).	E1 E1 **[2]**	Reward 1 mark each for any two distinct, sensible points that the sample/data should be fit for purpose. Further examples include: data should not be distorted by the act of sampling; data should be relevant.
2	(a)	(iii)	A random sample … enables proper statistical inference to be undertaken …… because we know the probability basis on which it has been selected	E2 **[2]**	Award E2, 1, 0 depending on the quality of response.
2	(b)	(i)	A Wilcoxon signed rank test might be used when nothing is known about the distribution of the background population. Must assume symmetry (about the median).	E1 E1 **[2]**	Do not allow "sample", or "data" unless it clearly refers to the population. Do not allow if "Normality" forms part of the assumption.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td>(b)</td><td>(ii)</td><td>H_0: $m = 28.7$ H_1: $m > 28.7$
where m is the population median

<table>
<tr><th>Speeds</th><th>−28.7</th><th>Rank of |diff|</th></tr>
<tr><td>32.0</td><td>3.3</td><td>8</td></tr>
<tr><td>29.1</td><td>0.4</td><td>3</td></tr>
<tr><td>26.1</td><td>−2.6</td><td>6</td></tr>
<tr><td>35.2</td><td>6.5</td><td>12</td></tr>
<tr><td>34.4</td><td>5.7</td><td>11</td></tr>
<tr><td>28.6</td><td>−0.1</td><td>1</td></tr>
<tr><td>32.3</td><td>3.6</td><td>9</td></tr>
<tr><td>28.5</td><td>−0.2</td><td>2</td></tr>
<tr><td>27.0</td><td>−1.7</td><td>5</td></tr>
<tr><td>33.3</td><td>4.6</td><td>10</td></tr>
<tr><td>28.2</td><td>−0.5</td><td>4</td></tr>
<tr><td>31.9</td><td>3.2</td><td>7</td></tr>
</table>

$W_- = 1 + 2 + 4 + 5 + 6 = 18$
Refer to Wilcoxon single sample tables for $n = 12$.
Lower 5% point is 17 (or upper is 61 if 60 used).
Result is not significant.
No evidence to suggest that the median speed has increased.</td>
<td>B1
B1

M1

M1
A1

B1
M1
A1
A1
A1

[10]</td>
<td>Both. Accept hypotheses in words.
Adequate definition of m to include "population".

for subtracting 28.7.

for ranks.
ft if ranks wrong.
If candidate has tied ranks then penalise A0 here but ft from here.

($W_+ = 3 + 7 + 8 + 9 + 10 + 11 + 12 = 60$)
No ft from here if wrong.
ie a 1-tail test. No ft from here if wrong.
ft only c's test statistic.
ft only c's test statistic. "Non-assertive" conclusion in context to include "on average" oe.</td></tr>
<tr><td>3</td><td></td><td></td><td>$S \sim N(11.07,\ 2.36^2)$ $C \sim N(57.33,\ 8.76^2)$
$R \sim N(24.23,\ 3.75^2)$</td><td></td><td>When a candidate's answers suggest that (s)he appears to have neglected to use the difference columns of the Normal distribution tables, penalise the first occurrence only.</td></tr>
<tr><td></td><td>(i)</td><td></td><td>$P(10 < S < 13)$
$= P\left(\frac{10 - 11.07}{2.36} < Z < \frac{13 - 11.07}{2.36}\right)$
$= P(-0.4534 < Z < 0.8178)$
$= 0.7931 - (1 - 0.6748)$
$= 0.4679$</td><td>
M1
A1

A1
[3]</td><td>
For standardising. Award once, here or elsewhere.

Cao Accept 0.468(0), 0.4681, 0.4682, but not 0.4683.</td></tr>
</table>

Question			Answer	Marks	Guidance
3	(ii)		Want P($R > S + 10$) i.e. P($R - S > 10$) $R - S \sim$ N(24.23 – 11.07 = 13.16, $3.75^2 + 2.36^2 = 19.6321$) P(this > 10) = P($Z > \frac{10 - 13.16}{\sqrt{19.6321}} = -0.7132$) = 0.7621	M1 B1 B1 A1 **[4]**	Allow $S - R$ provided subsequent work is consistent. Mean. Variance. Accept sd = √19.6321 = 4.4308... cao
3	(iii)		Want P($S + R > \frac{2}{3}C$) i.e. P($S + R - \frac{2}{3}C > 0$) $S + R - \frac{2}{3}C \sim$ N(11.07 + 24.23 – ⅔ × 57.33 = –2.92, $2.36^2 + 3.75^2 + (\frac{2}{3} \times 8.76)^2 = 53.7377$) P(this > 0) = P($Z > \frac{0 - (-2.92)}{\sqrt{53.7377}} = 0.3983$) = 1 – 0.6548 = 0.3452	M1 B1 B1 A1 **[4]**	Allow $\frac{2}{3}L - (S + R)$ provided subsequent work is consistent. Mean Variance. Accept sd = √53.7377 = 7.3306... cao
3	(iv)		$\bar{x} = 98.484$, $s_{n-1} = 10.1594$ CI is given by 98.484 ± 2.201 $\times \frac{10.1594}{\sqrt{12}}$ = 98.484 ± 6.455 = (92.03, 104.94)	B1 M1 B1 M1 A1 **[5]**	Do not allow s_n = 9.7269. ft c's $\bar{x}$ ±. From t_{11}. ft c's s_{n-1}. cao Must be expressed as an interval. Require 1 or 2 dp; condone 3dp.
3	(v)		Normality is unlikely to be reasonable – times could well be (positively) skewed. Independence is unlikely to be reasonable – e.g. a competitor who is fast in one stage may well be fast in all three.	E1 E1 **[2]**	Discussion required. Accept any reasonable point. Accept "reasonable" provided an adequate explanation is given. Discussion required. Accept any reasonable point. This is independence between stages for a particular competitor, not between competitors.

Question			Answer	Marks	Guidance
4	(i)		H_0: The model for the number of callouts fits the data H_1: The model for the number of callouts does not fit the data.	B1 B1	Do not allow "Data fit the model" o.e for either hypothesis.

Obs'd frequency	145	79	22	6	3	0
Exp'd frequency	139.947	83.968	25.190	5.038	0.756	0.101

Question			Answer	Marks	Guidance
			Merge last 3 cells. Obs 9 Exp 5.895	M1	
			$X^2 = 0.1824 + 0.2939 + 0.4040 + 1.6355$	M1	Calculation of X^2.
			$= 2.515(8)$	A1	Cao Require 3/4 sf; condone up to 6.
			Refer to χ_2^2.	M1	Allow correct df (= cells – 2) from wrongly grouped table and ft. Otherwise, no ft if wrong. $P(X^2 > 2.5158) = 0.2842$.
			Upper 5% point is 5.991.	A1	No ft from here if wrong.
			Not significant.	A1	ft only c's test statistic.
			Suggests it is reasonable to suppose that the model fits the data.	A1 **[9]**	ft only c's test statistic. "Non-assertive" conclusion in words (+context). Do not allow "Data fit model" o.e.
4	(ii)		Mean = 5/3 $\therefore\ \lambda = 0.6$	B1 **[1]**	
4	(iii)		$F(t) = \int_0^t 0.6e^{-0.6x}\,dx$	M1	Correct integral with limits (which may be implied subsequently). Allow use of "+ c" accompanied by a valid attempt to evaluate it.
			$= \left[-e^{-0.6x}\right]_0^t$	A1	Correctly integrated.
			$= \left(-e^{-0.6t} - (-e^0)\right) = 1 - e^{-0.6t}$	A1 **[3]**	Limits used or c evaluated correctly. Accept unsimplified form. If final answer is given in terms of λ then allow max M1A1A0.
4	(iv)		$P(T > 1) = 1 - F(1)$	M1	ft c's $F(t)$.
			$= 1 - \left(1 - e^{-0.6}\right) = 0.5488$	A1 **[2]**	cao Allow any exact form of the correct answer.
4	(v)		$F(m) = \frac{1}{2} \qquad \therefore 1 - e^{-0.6m} = \frac{1}{2}$	M1	Use of definition of median. Allow use of c's $F(t)$.
			$\therefore e^{-0.6m} = \frac{1}{2} \qquad \therefore -0.6m = -\ln 2 \qquad \therefore m = \frac{\ln 2}{0.6}$	M1	Convincing attempt to rearrange to "$m = \ldots$", to include use of logs.
			$m = 1.155$ (days)	A1 **[3]**	Cao obtained only from the correct $F(t)$. Must be evaluated. Require 2 to 4 sf; condone 5.

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4768 Statistics 3

General Comments

There were 544 candidates (compared with 462 in June 2011) for this sitting of the paper. There were many very competent scripts and yet candidates (including high-scoring ones) often lost marks through carelessness. The topic "Sampling methods" continues to be one on which candidates do less well. In several places where it mattered, candidates did not make explicit the distinction between a sample and a population, many referring to "data" which, at best, seems ambiguous. The numerical work was accurate on the whole.

Comments on Individual Questions

1) (i) For this part candidates needed to identify the variable that would be eliminated by pairing; in this case the variations caused by differences between the surfaces. The majority of candidates did not seem to understand this.

(ii) This part was answered well, but full marks were relatively uncommon largely due to the imprecise nature of the responses. It was necessary to be clear that the population variance is unknown and the assumption of Normality relates to the population of differences. The unqualified use of "data" can be unhelpful since one cannot tell whether the writer is referring to the population or the sample.

(iii) The *t* test was conducted well, by and large. Some candidates need to take more care in specifying the hypotheses and the final contextual conclusion. There was a small number (more than in previous years) of candidates who chose not to attempt a paired test despite the heavy hints of the two preceding parts.

(iv) On the whole this was well answered. Some chose, incorrectly, to use 1.96 as the percentage point, forgetting that they should still be using the same *t* distribution as in part (iii). Occasionally the interval was expressed in a way that implied a negative reduction.

2) (a) There was much repetition of the same points in the answers to the 3 parts about sampling. Candidates did not seem to have read the questions carefully enough.

(i) Many candidates stated reasons for sampling that related to the size of the population. Some knew that accessibility was relevant but could not always state this clearly. Many missed the point of the question: why might one need to take a sample as opposed to a complete census of the population.

(ii) This question was about ensuring that sample data should somehow be "fit for purpose". Two possible answers were that the sample should be "representative" and "unbiased". Many candidates managed at least one of those two points.

(iii) In order to answer this part, candidates were expected to make the connection between the various statistical tests that they have studied and the assumption or requirement each time that the sample used should be a random one. Despite what many thought, a definition of random sampling and/or a description of how to select a random sample were not required here. Candidates did not display a full understand the characteristics of a random sample, nor did they seem to appreciate why a random sample might be preferred (over any other sort of sample), even though there is a risk of it being <u>un</u>representative.

(b)(i) Answers to this part were often muddled and many confused the circumstances and assumption for a Wilcoxon test with those for a *t* test. As in earlier parts, it was necessary to make it clear that the discussion referred to the population and not the sample.

(ii) This part was well answered by many candidates. Again more care was needed with the hypotheses and the final contextual conclusion.

3) Much of this question was answered well by most candidates.

(i) The vast majority were able to answer this part easily and correctly.

(ii) Most responses to this part of the question were competent and correct.

(iii) Again most responses to this part were competent and correct. A few candidates experienced difficulty either in formulating the problem from the information given or in obtaining the correct variance.

(iv) Most candidates were able to demonstrate that they could set up the basic structure of a confidence interval. However, in order to answer this part correctly candidates needed to refer to the *t* distribution and not the Normal distribution. There was then a tendency to over specify the accuracy of the final answer.

(v) Most candidates could give a plausible reason why, for a particular competitor, the times for the different stages were unlikely to be independent of each other. However the same could not be said for the assumption of Normality. Most claimed that Normality was reasonable for reasons that were either much too loose or wrong. One common wrong reason was that if a population is large then, by the Central Limit Theorem, it must be Normal. On the whole very few candidates seemed to take the trouble to think critically about this assumption.

4) (i) As with the other hypothesis tests this part was well answered by many candidates. However, there were the usual errors: hypotheses were not always expressed with due care; candidates forgot to combine the last 3 classes; they chose the wrong number of degrees of freedom. There are still some candidates (but fewer than before) who are fitting data to models rather than the other way round.

(ii) This part was answered with considerable ease.

(iii) There were many good answers to this part of the question, but there were also many unsuccessful attempts. The latter were usually due to having the wrong or no limits for the integral, or to an inability to integrate correctly or, if they used an indefinite integral, to being unable to deal with "+ *c*" correctly. On a number of occasions candidates left the final answer in terms of λ and this was penalised.

(iv) On the whole most candidates answered well. Those who had been completely successful in part (iii) were likely to experience little if any difficulty. A number of candidates, including some who had been unsuccessful in part (iii), did this part by integration and were able to get the right answer. Errors included neglecting inconvenient negative signs.

(v) The quality of response to this part was very similar to part (iv). The majority of candidates, who had found the correct cdf earlier, were successful. Among other candidates the neglectful treatment of negative signs was more extensive.

GCE Mathematics (MEI)

			Max Mark	90% cp	a	b	c	d	e	u
4753/01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	66	60	53	47	41	34	0
4753/02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	16	15	13	11	9	8	0
4753/82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	16	15	13	11	9	8	0
4753	(C3) MEI Methods for Advanced Mathematics with Coursework	UMS	100	90	80	70	60	50	40	0
4754/01	(C4) MEI Applications of Advanced Mathematics	Raw	90	73	65	57	50	43	36	0
		UMS	100	90	80	70	60	50	40	0
4756/01	(FP2) MEI Further Methods for Advanced Mathematics	Raw	72	66	61	53	46	39	32	0
		UMS	100	90	80	70	60	50	40	0
4757/01	(FP3) MEI Further Applications of Advanced Mathematics	Raw	72	61	54	47	40	34	28	0
		UMS	100	90	80	70	60	50	40	0

4758/01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	68	63	57	51	45	39	0
4758/02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	16	15	13	11	9	8	0
4758/82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	16	15	13	11	9	8	0
4758	(DE) MEI Differential Equations with Coursework	UMS	100	90	80	70	60	50	40	0
4762/01	(M2) MEI Mechanics 2	Raw	72	65	58	51	44	38	32	0
		UMS	100	90	80	70	60	50	40	0
4763/01	(M3) MEI Mechanics 3	Raw	72	67	63	56	50	44	38	0
		UMS	100	90	80	70	60	50	40	0
4764/01	(M4) MEI Mechanics 4	Raw	72	63	56	49	42	35	29	0
		UMS	100	90	80	70	60	50	40	0
4767/01	(S2) MEI Statistics 2	Raw	72	66	61	55	49	43	38	0
		UMS	100	90	80	70	60	50	40	0
4768/01	(S3) MEI Statistics 3	Raw	72	65	58	51	44	38	32	0
		UMS	100	90	80	70	60	50	40	0
4769/01	(S4) MEI Statistics 4	Raw	72	63	56	49	42	35	28	0
		UMS	100	90	80	70	60	50	40	0
4772/01	(D2) MEI Decision Mathematics 2	Raw	72	62	56	50	44	39	34	0
		UMS	100	90	80	70	60	50	40	0
4773/01	(DC) MEI Decision Mathematics Computation	Raw	72	52	46	40	34	29	24	0
		UMS	100	90	80	70	60	50	40	0
4777/01	(NC) MEI Numerical Computation	Raw	72	63	55	47	39	32	25	0
		UMS	100	90	80	70	60	50	40	0