

**Statistics (MEI)**

Advanced Subsidiary GCE

Unit **G243**: Statistics 3 (Z3)

**Mark Scheme for June 2011**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by Examiners. It does not indicate the details of the discussions which took place at an Examiners' meeting before marking commenced.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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

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**Marking instructions for GCE Mathematics (MEI): Statistics strand**

1. You are advised to work through the paper yourself first. Ensure you familiarise yourself with the mark scheme before you tackle the practice scripts.
2. You will be required to mark ten practice scripts. This will help you to understand the mark scheme and will not be used to assess the quality of your marking. Mark the scripts yourself first, using the annotations. Turn on the comments box and make sure you understand the comments. You must also look at the definitive marks to check your marking. If you are unsure why the marks for the practice scripts have been awarded in the way they have, please contact your Team Leader.
3. When you are confident with the mark scheme, mark the ten standardisation scripts. Your Team Leader will give you feedback on these scripts and approve you for marking. (If your marking is not of an acceptable standard your Team Leader will give you advice and you will be required to do further work. You will only be approved for marking if your Team Leader is confident that you will be able to mark candidate scripts to an acceptable standard.)
4. Mark strictly to the mark scheme. If in doubt, consult your Team Leader using the messaging system within *scoris*, by email or by telephone. Your Team Leader will be monitoring your marking and giving you feedback throughout the marking period.

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.

5. 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.

6. 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.
7. 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.

8. 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) 2.12888446667 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.

9. **Rules for crossed out and/or replaced work**

If work is crossed out and not replaced, examiners should mark the crossed out work if it is legible.

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 two or more attempts are made at a question, and just one is not crossed out, examiners should ignore the crossed out work and mark the work that is not crossed out.

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.

10. 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.

11. 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.

12. For answers scoring no marks, you must either award NR (no response) or 0, as follows:

Award NR (no response) if:

- Nothing is written at all in the answer space
- There is a comment which does not in any way relate to the question being asked ("can't do", "don't know", etc.)
- There is any sort of mark that is not an attempt at the question (a dash, a question mark, etc.)

The hash key [#] on your keyboard will enter NR.

Award 0 if:

- There is an attempt that earns no credit. This could, for example, include the candidate copying all or some of the question, or any working that does not earn any marks, whether crossed out or not.

13. The following abbreviations may be used in this mark scheme.

M1	method mark (M2, etc, is also used)
A1	accuracy mark
B1	independent mark
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
ft	follow through
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
sc	special case
soi	seen or implied
www	without wrong working

14. Annotating scripts. The following annotations are available:

✓ and ✖

<b>BOD</b>	Benefit of doubt
<b>FT</b>	Follow through
<b>ISW</b>	Ignore subsequent working (after correct answer obtained)
<b>M0, M1</b>	Method mark awarded 0, 1
<b>A0, A1</b>	Accuracy mark awarded 0, 1
<b>B0, B1</b>	Independent mark awarded 0,1
<b>SC</b>	Special case
<b>^</b>	Omission sign
<b>MR</b>	Misread

Highlighting is also available to highlight any particular points on a script.

15. The comments box will be used by the Principal Examiner to explain his or her marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts.

**Please do not type in the comments box yourself.** Any questions or comments you have for your Team Leader should be communicated by the *scoris* messaging system, e-mail or by telephone.

16. Write a brief report on the performance of the candidates. Your Team Leader will tell you when this is required. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.
17. Link Additional Objects with work relating to a question to those questions (a chain link appears by the relevant question number) – see *scoris* assessor Quick Reference Guide page 19-20 for instructions as to how to do this – this guide is on the Cambridge Assessment Support Portal and new users may like to download it with a shortcut on your desktop so you can open it easily! For AOs containing just formulae or rough working not attributed to a question, tick at the top to indicate seen but not linked. When you submit the script, *scoris* asks you to confirm that you have looked at all the additional objects. Please ensure that you have checked all Additional Objects thoroughly.
18. The schedule of dates for the marking of this paper is displayed under 'OCR Subject Specific Details' on the Cambridge Assessment Support Portal. It is vitally important that you meet these requirements. If you experience problems that mean you may not be able to meet the deadline then you must contact your Team Leader without delay.

Question	Expected Answer	Mark	Rationale/Additional Guidance	
1(i)	The pairing will eliminate any differences in individual subjects' aptitude in the word matching game and so will compare the before and after scores.	E1 E1		Allow E1 for partially correct answer
(ii)	Differences are 14 -2 17 -5 -10 -7 15 4 9 19 Ranks of  d  are 7 1 9 3 6 4 8 2 5 10  Test statistic is $1+3+4+6 = 14$ (or $2+5+7+8+9+10 = 41$ )  Refer to paired Wilcoxon table with $n=10$ Lower 5% 1-tailed value is 10  Not significant  Insufficient evidence to suggest that the median score after brain training is greater than the median score before brain training	B1  M1 A1  M1 A1  M1 A1  E1  E1  [9]	No marks if differences not used  FT if ranks wrong  FT if previous M1 earned No FT if wrong  No FT if wrong	No marks for two-sample test       Do not award final E1 if mention of 'sufficient evidence to suggest no difference' or similar
(iii)	Population of differences in scores is Normally distributed.  The $t$ test take into account the actual values of the differences, rather than just the ranks, so is more powerful.	E1 E1 E1 E1 [4]	For population For differences For Normally distributed For more powerful	Allow 'underlying distribution'  Allow 'more accurate' (BOD) Allow 'uses rankings rather than actual data so loses information'

Question	Expected Answer	Mark	Rationale/Additional Guidance
2(i)	$\bar{x} = \frac{3308}{50} = 66.16$ $s^2 = \frac{222020 - \frac{3308^2}{50}}{49} = \frac{3162.72}{49} = 64.55$	<b>B1</b> <b>M1</b> <b>A1</b>	For $S_{xx}$ Allow even if over-specified as used later in the question
(ii)	Because both samples are large	<b>E1</b>	Condone 'sample is large'
(iii)	$H_0: \mu_W = \mu_M$ $H_1: \mu_W > \mu_M$ Where $\mu_W, \mu_M$ denote the population mean times spent in the gym by women and men respectively  2-sample test based on $N(0,1)$  Test statistic is $\frac{66.16 - 62.68}{\sqrt{\frac{64.55}{50} + \frac{134.0}{50}}} = \frac{3.48}{1.993} = 1.746$  1-tailed 10% point of $N(0,1)$ is 1.282  $1.746 > 1.282$ Significant  There is evidence to suggest that on average women spend longer than men in the gym.	<b>B1</b> <b>B1</b> <b>B1</b>  <b>E1</b>  <b>M1</b> <b>M1</b> <b>A1</b>  <b>B1</b>  <b>M1</b> <b>A1</b>  <b>E1</b>  <b>[11]</b>	Condone absence of "population" if correct notation " $\mu$ " has been used, but do NOT accept $\bar{X}$ and $\bar{Y}$ or similar unless explicitly stated to be population means. Accept hypothesis explained in words, provided "population" appears. (Using correct version of test statistic)  Numerator Good attempt at denominator CAO  FT their test statistic provided both M1's earned No FT if CV wrong

Question	Expected Answer	Mark	Rationale/Additional Guidance																																																																									
3(i)		<p><b>G1</b></p> <p><b>G1</b></p> <p><b>G1</b></p>	<p>Linear axes, including labels</p> <p>Correct zero or clear broken scale</p> <p>All points correct (allow 2 errors)</p>																																																																									
(ii)	The points do not appear to lie in an elliptical pattern so the population may not have a bivariate Normal distribution.	<p><b>E1</b></p> <p><b>E1</b></p>	<p>For not elliptical</p> <p>For not bivariate Normal (allow opposite argument)</p>	Allow E1 for mention of outliers																																																																								
(iii)	<table border="1" data-bbox="208 930 969 1214"> <tbody> <tr><td>Lit</td><td>41</td><td>56</td><td>90</td><td>97</td><td>83</td><td>95</td><td>98</td><td>29</td><td>59</td><td>76</td><td>68</td></tr> <tr><td>Sch</td><td>67</td><td>70</td><td>78</td><td>91</td><td>84</td><td>94</td><td>92</td><td>47</td><td>75</td><td>90</td><td>83</td></tr> <tr><td>R lit</td><td>2</td><td>3</td><td>8</td><td>10</td><td>7</td><td>9</td><td>11</td><td>1</td><td>4</td><td>6</td><td>5</td></tr> <tr><td>R sch</td><td>2</td><td>3</td><td>5</td><td>9</td><td>7</td><td>11</td><td>10</td><td>1</td><td>4</td><td>8</td><td>6</td></tr> <tr><td><math>d</math></td><td>0</td><td>0</td><td>-3</td><td>-1</td><td>0</td><td>2</td><td>-1</td><td>0</td><td>0</td><td>2</td><td>1</td></tr> <tr><td><math>d^2</math></td><td>0</td><td>0</td><td>9</td><td>1</td><td>0</td><td>4</td><td>1</td><td>0</td><td>0</td><td>4</td><td>1</td></tr> </tbody> </table> <p><math>\Sigma d^2 = 20</math></p> $r_s = 1 - \frac{6 \times 20}{11 \times 120} = 1 - 0.091 = 0.909$	Lit	41	56	90	97	83	95	98	29	59	76	68	Sch	67	70	78	91	84	94	92	47	75	90	83	R lit	2	3	8	10	7	9	11	1	4	6	5	R sch	2	3	5	9	7	11	10	1	4	8	6	$d$	0	0	-3	-1	0	2	-1	0	0	2	1	$d^2$	0	0	9	1	0	4	1	0	0	4	1	<p><b>M1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> <p><b>[5]</b></p>	<p>For ranking (allow all ranks reversed)</p> <p>For <math>d^2</math></p> <p>For <math>\Sigma d^2</math></p> <p>For method for <math>r_s</math></p> <p>FT their ranks and <math>\Sigma d^2</math> provided <math> r_s  &lt; 1</math></p> <p>NB No ranking scores zero</p>	
Lit	41	56	90	97	83	95	98	29	59	76	68																																																																	
Sch	67	70	78	91	84	94	92	47	75	90	83																																																																	
R lit	2	3	8	10	7	9	11	1	4	6	5																																																																	
R sch	2	3	5	9	7	11	10	1	4	8	6																																																																	
$d$	0	0	-3	-1	0	2	-1	0	0	2	1																																																																	
$d^2$	0	0	9	1	0	4	1	0	0	4	1																																																																	

Question	Expected Answer	Mark	Rationale/Additional Guidance	
(iv)	<p><math>H_0</math>: no association between percentage attending school and adult literacy rate in the population</p> <p><math>H_1</math>: positive association between percentage attending school and adult literacy rate in the population</p> <p>One tail test critical value at 1% level is 0.7091</p> <p>Since <math>0.909 &gt; 0.7091</math>, there is sufficient evidence to reject <math>H_0</math>, i.e. conclude that there is enough evidence to suggest positive association between percentage attending school and adult literacy rate in the population.</p>	<p><b>B1</b></p> <p><b>B1</b></p> <p><b>B1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> <p><b>[5]</b></p>	<p>For both hypotheses</p> <p>For population SOI</p> <p>NB <math>H_0 H_1</math> <u>not</u> <math>\rho</math></p> <p>For 0.7091</p> <p>For comparison with c.v., provided <math> r_s  &lt; 1</math></p> <p>No FT if CV wrong</p> <p>For conclusion in words in context – FT their <math>r_s</math> and sensible cv</p>	<p>For two tail <math>H_1</math> allow B1 for c.v. of 0.7545</p>
4(i)	Treatment A is control Treatments B and C are experimental	<p><b>E1</b></p> <p><b>E1</b></p>	One mark if one error. No marks if 2 errors.	
(ii)	To check whether either fertiliser has an effect.	<b>E1</b>		
(iii)	Because there might be differences in the fertility of the three strips which would affect the results.	<p><b>E1</b></p> <p><b>E1</b></p>		
(iv)	Allocate numbers 1 to 100 to the plots. Use random numbers to choose 30 random numbers. If any repeats appear, choose further random numbers to replace them.	<p><b>E1</b></p> <p><b>E1</b></p> <p><b>E1</b></p>		Max E2 for 'numbering all plots from 1 to 100 and then selecting from a hat'

Question	Expected Answer	Mark	Rationale/Additional Guidance	
(v)	<p>Assumptions required are: Normality of both populations, equal population variances.</p> <p><math>H_0: \mu_B = \mu_A</math> <math>H_1: \mu_B &gt; \mu_A</math> Where <math>\mu_A, \mu_B</math> denote the population mean yields for treatments A and B</p> <p>Pooled <math>s^2 = \frac{(7 \times 574.2) + (6 \times 612.7)}{13} = 591.97</math></p> <p>Test statistic =  <math display="block">\frac{279 - 244.25}{\sqrt{591.97} \sqrt{\frac{1}{8} + \frac{1}{7}}} = \frac{34.75}{12.59} = 2.760</math></p> <p>Refer to <math>t_{13}</math> 1-tail 5% point is 1.771</p> <p>Significant There is sufficient evidence to suggest that the population mean for peas grown with organic fertiliser is greater than that for peas grown with no fertiliser</p>	<p><b>B1</b> <b>B1</b></p> <p><b>B1</b> <b>B1</b></p> <p><b>M1</b> <b>A1</b></p> <p><b>M1</b> <b>M1</b></p> <p><b>M1</b> <b>A1</b></p> <p><b>M1</b> <b>A1</b></p> <p><b>E1</b> <b>E1</b></p> <p><b>[14]</b></p>	<p>For both hypotheses</p> <p>For attempt at pooling</p> <p>for numerator for <math>\sqrt{591.97}</math></p> <p>for <math>\sqrt{\frac{1}{8} + \frac{1}{7}}</math> CAO</p> <p>Allow even if not all M marks earned</p> <p>FT from here if all M marks earned</p>	<p>Do not allow 'samples are Normally distributed'</p> <p>Condone 8 and 7 in place of 7 and 6 for M mark</p> <p>Condone 9 and 8 in place of 8 and 7 for M mark</p> <p>For two tail <math>H_1</math> allow A1 for c.v. of 2.16</p>
(vi)	<p><math>H_0</math>: the medians of the two populations are the same <math>H_1</math>: the medians of the two populations are different</p> <p>Critical value = 38 42 &gt; 38 so not significant Not enough evidence to suggest a difference between the population medians</p>	<p><b>B1</b> <b>B1</b></p> <p><b>B1</b> <b>M1</b> <b>A1</b> <b>[5]</b></p>	<p>Allow 1 for medians Need population for second mark</p> <p>For not significant (dep on comparison)</p>	<p>No FT if CV wrong</p>
<b>Q4</b>	<b>Total</b>	<b>[27]</b>		
	<b>Total</b>	<b>[72]</b>		

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