



**General Certificate of Education (A-level)
June 2011**

Statistics

SS03

(Specification 6380)

Statistics 3

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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Key to mark scheme abbreviations

M	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
✓ or ft or F	follow through from previous incorrect result
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
-x EE	deduct x marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Q	Solution	Marks	Total	Comments
1(a)	<p>H_0 Samples are taken from identical populations</p> <p>H_1 Samples are not taken from identical populations (or population average substance level differs)</p> <p>2 tail 5%</p> <p>Ranks</p> <p>A 1 4 5 6 8 10.5 14 15 (15) (12) (11) (10) (8) (5.5) (2) (1)</p> <p>B 2 3 7 9 10.5 12 13 (14) (13) (9) (7) (5.5) (4) (3)</p> <p>$T_A = 1 + 4 + \dots + 15 = 63.5$ (or 64.5)</p> <p>$T_B = 2 + 3 + \dots + 13 = 56.5$ (or 55.5)</p> <p>$U_A = 63.5 - \frac{8 \times 9}{2} = 27.5$</p> <p>$U_B = 56.5 - \frac{7 \times 8}{2} = 28.5$</p> <p>Test stat $U = 27.5$</p> <p>$cv = 13$</p> <p>$U > 13$</p> <p>Accept H_0</p> <p>No significant evidence at the 5% level to suggest that there is any difference in the average level of the substance for drugs A and B.</p>	B1		<p>Or equivalent hypotheses referring to population medians.</p> <p>Allow pop median A/B or η_A and η_B</p> <p>Must have 'average'; disallow mean</p>
		M1		Attempt at ranks as one group - either way
		m1		For ties
		M1		Totals (dep on ranks - any)
		m1A1		U calculated - either correct
		B1		For cv
		A1		Correct U chosen for comparison with relevant cv (27.5/13 or 28.5/43)
		A1		Only if ts/cv correct
		E1	10	In context (can ft)
	(b)	Type II error is to accept H_0 when actually H_0 is not true.	B1	
This would mean that the conclusion to the test in part (a) that there is no significant difference in the average level of the substance for drugs A and B is incorrect and there is actually a difference between the two.		E1	2	For context 2 marks only if in context and correct
	Total		12	

SS03 (cont)

Q	Solution	Marks	Total	Comments	
2(a)(i)	$H_0 \mu, \eta = 10.8$	B1		Or equivalent in words, eg 'average time spent on study' or 'population average'	
	$H_1 \mu, \eta > 10.8$				
	1 tail 5%				
	diffs 6.65 3.85 1.5 0.8 -3.7	M1			For differences from 10.8
	rank 10 6 2 1 5				
	diffs 4.35 5.4 -3.2 -4.05 -2.2	m1			Ranks as one group dep on differences (allow either way) SC1 for sign test
	rank 8 9 4 7 3				
	$T_+ = 10 + 6 + 2 + 1 + 8 + 9 = 36$	m1			Total of any ranks dep on diffs
	$T_- = 5 + 4 + 7 + 3 = 19$	A1			One correct
	Test stat $T = 19$				
$n = 10$	B1	For cv			
cv = 11					
$T > 11$	m1	Comparison lower (plausible) T (not -ve) and cv. Can ft or 44/36			
Accept H_0	A1				
There is no significant evidence to suggest that average time spent per week of term has increased from 10.8 hours.	E1	9	In context		
(a)(ii)	Conclusions cannot be generalised to whole population. Students at the college concerned may not represent a random sample of all such students in the country. Study patterns may vary at different times of the year.	E1	1	For any one point clearly explained (not 'may have lied', 'not correctly recorded')	
(b)(i)	Wilcoxon signed-rank takes into account the magnitude of the ranks of the differences whereas the sign test only considers the sign of those differences. or Wilcoxon signed-rank is more likely to detect a difference if one exists. or More powerful.	E1	1	Or 'magnitude of differences' (not 'takes data/size of data into account')	
(ii)	If a direction/preference only was given then there would be no numerical data available to find the differences in the data that need to be used for the Wilcoxon signed-rank test. An example would be if students only had to state whether they were studying more hours, less hours or the same hours this year as last year. or If data to be analysed was very asymmetrical. An example could be that the times for study were found to be skew.	B1	2	For one valid situation - a direction/preference or asymmetrical ...	
		E1		... explained clearly in context	
Total			13		

SS03 (cont)

Q	Solution	Marks	Total	Comments																																																
3(a)(i)	<table border="1"> <thead> <tr> <th></th> <th>None</th> <th>1 or 2</th> <th>> 2</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>5.74</td> <td>7.40</td> <td>2.87</td> </tr> <tr> <td>2-4</td> <td>18.64</td> <td>24.04</td> <td>9.32</td> </tr> <tr> <td>> 4</td> <td>13.62</td> <td>17.57</td> <td>6.81</td> </tr> </tbody> </table>		None	1 or 2	> 2	1	5.74	7.40	2.87	2-4	18.64	24.04	9.32	> 4	13.62	17.57	6.81	M1	3	Method for expected frequencies (16 × 38 / 106 etc); ft incorrect totals 4 correct; allow slight dp inaccuracy All correct to 1 dp																																
		None	1 or 2	> 2																																																
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		A1																																																		
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	(ii)	There is an expected frequency that is below 5.	E1	1	Must refer to expected frequency																																															
	(iii)	“More than 2 falls” pooled with “1 or 2 falls” to make 2 categories of fall: “None” or “One or more”	E1	1	Allow ‘1’ pooled with ‘2-4’ to make 2 categories of medications taken: “1 to 4” and “More than 4”																																															
	(iv)	<p>H₀ (Number of) falls is independent of number of medications taken H₁ (Number of) falls is not independent of number of medications taken</p> <p>1 tail 1%</p> <table border="1"> <thead> <tr> <th>Obs</th> <th>None</th> <th>1 or more</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>10</td> <td>6</td> </tr> <tr> <td>2-4</td> <td>21</td> <td>31</td> </tr> <tr> <td>More 4</td> <td>7</td> <td>31</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Exp</th> <th>None</th> <th>1 or more</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>5.74</td> <td>10.26</td> </tr> <tr> <td>2-4</td> <td>18.64</td> <td>33.56</td> </tr> <tr> <td>More 4</td> <td>13.62</td> <td>24.38</td> </tr> </tbody> </table> $ts = \sum \frac{(O-E)^2}{E} =$ $\frac{4.26^2}{5.74} + \frac{4.26^2}{10.26} + \frac{2.36^2}{18.64} +$ $\frac{2.36^2}{33.36} + \frac{6.62^2}{13.62} + \frac{6.62^2}{24.38}$ <p>ts = 10.4 (10.0–11.0) (SC4 ts = 10.4 NMS if (i) ok)</p> <p>df = 2 1% cv = 9.210 ts > 9.210</p> <p>Reject H₀</p> <p>Sig evidence to suggest that the number of falls is not independent of number of medications taken.</p>	Obs	None	1 or more	1	10	6	2-4	21	31	More 4	7	31	Exp	None	1 or more	1	5.74	10.26	2-4	18.64	33.56	More 4	13.62	24.38	B1	7	<p>OE eg H₀ No association H₁ Association</p> <p>Alternative if pooled rows:</p> <table border="1"> <thead> <tr> <th>Obs</th> <th>None</th> <th>1 or 2</th> <th>More 2</th> </tr> </thead> <tbody> <tr> <td>1-4</td> <td>31</td> <td>31</td> <td>6</td> </tr> <tr> <td>More 4</td> <td>7</td> <td>18</td> <td>13</td> </tr> </tbody> </table> <p style="text-align: right;">M1</p> <p>For 3E correct</p> <table border="1"> <thead> <tr> <th>Exp</th> <th>None</th> <th>1 or 2</th> <th>More 2</th> </tr> </thead> <tbody> <tr> <td>1-4</td> <td>24.38</td> <td>31.43</td> <td>12.19</td> </tr> <tr> <td>More 4</td> <td>13.62</td> <td>17.57</td> <td>6.81</td> </tr> </tbody> </table> <p style="text-align: right;">m1</p> <p>For ts; Yates used M0</p> <p>ts = 13.80 (13.5–14.5) m1A1 (SC4 ts = 13.8 NMS if (i) ok)</p> <p>E1 only if ts/cv correct and must make sense</p> <p>Allow B1E0 for 4.605, 5.991, 7.378, 10.597</p>	Obs	None	1 or 2	More 2	1-4	31	31	6	More 4	7	18	13	Exp	None	1 or 2	More 2	1-4	24.38	31.43	12.19	More 4	13.62	17.57
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	B1																																																			
	E1																																																			

SS03 (cont)

Q	Solution	Marks	Total	Comments															
3(b)(i)	<table border="1"> <thead> <tr> <th></th> <th>No falls</th> <th>At least one</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>1680</td> <td>660</td> </tr> <tr> <td>1</td> <td>448</td> <td>180</td> </tr> <tr> <td>2</td> <td>392</td> <td>192</td> </tr> <tr> <td>3+</td> <td>280</td> <td>168</td> </tr> </tbody> </table>		No falls	At least one	0	1680	660	1	448	180	2	392	192	3+	280	168	M1	3	Method for frequencies eg 0.60×2800
		No falls	At least one																
	0	1680	660																
	1	448	180																
2	392	192																	
3+	280	168																	
		m1	4 correct																
		A1	all correct																
(ii)	<p>H_0 (Number of) falls is independent of number of chronic diseases suffered</p> <p>H_1 (Number of) falls is not independent of number of chronic diseases suffered</p> $ts = \sum \frac{(O-E)^2}{E} = 18.4$ <p>df = 3 1% cv = 11.345</p> <p>ts > 11.345</p> <p>Reject H_0</p> <p>Significant evidence to suggest that the number of falls suffered is not independent of number of diseases suffered</p>	B1		OE: H_0 No association H_1 Association															
		B1		For 11.345															
		M1		Comparison with 18.4 Allow M1 for 6.251, 7.815, 9.348, 12.838															
		E1	4	Conclusion in context															
(iii)	<p>Must have attempted (i) and (ii) to gain marks in (iii)</p> <p>Women who do not suffer from any chronic diseases are less likely than expected to have a fall.</p> <p>Women who suffer from 3 or more chronic diseases are more likely than expected to have a fall.</p> <p>[Women who suffer from 2 chronic diseases are more likely than expected to have a fall.]</p>	E1		E0,0 if conclusion in (ii) is Accept H_0															
		E1	2	Or equivalent – no need to refer to expected frequencies but disallow comment referring simply to a comparison of observed frequencies															
	Total		21																

SS03 (cont)

Q	Solution	Marks	Total	Comments
4(a)	$r = 0.895$	B3	3	SC2 0.89/0.90/0.894 SC1 0.9 Allow M1 summations M1 correct use of S_{xx} S_{xy} S_{yy}
(b)	$H_0 \rho = 0$ $H_1 \rho > 0$	B1 B1		OE in words H_0 pop PMCC = 0 or H_0 no association between BMR and BMI H_1 correct direction B1
	ts $r = 0.895$ $n = 10$ cv = 0.5494 $r > 0.5494$ reject H_0	B1 M1		CAO for cv ft provided $-1 < r < +1$
	Significant evidence that there is a positive correlation between BMR and BMI. Men with a higher BMR tend to have a higher BMI.	A1	5	For Reject H_0 ts/cv correct
(c)	Ranks for BMR 10 9 8 7 6 5 4 2½ 2½ 1 or 1 2 3 4 5 6 7 8½ 8½ 10	M1 m1 A1		Ranks (can be reversed) Ties For d 2 1 2 0 3 0 3 ½ ½ 3 $\sum d^2 = 4 + 1 + \dots + 9 = 36\frac{1}{2}$
	SRCC $r_s = 0.778(11909)$ ignore sign	B2	5	SRCC = $1 - \frac{6 \times 36\frac{1}{2}}{10 \times 99} = 0.779$ Reversed ranks $\sum d^2 = 292.5$ $r = -0.773$ M1A1 must be 0.779/-0.773
	NMS SC4 $r = 0.78$ SC2 $r = 0.8$ SC0 $r = 0.5636$ SC3 $r = 0.770/0.769$ with ranks SC2 $r = 0.770/0.769$ no ranks			
(d)	There is a significant positive correlation between BMR and BMI and there is strong positive rank correlation between BMR and level of daily physical activity.	E1 (no ft)		<u>Both</u> results put together
	Men who have a high BMI tend to have a high BMR as do men who have a high level of daily physical activity.	E1	2	Interpretation in context (not just repeat of conclusion)
(e)(i)	BMR and BMI measurements are normally (or bivariate normal) distributed	B1	1	Mention of normal distribution or linear relationship seen
(ii)	Ranks only available for level of daily physical activity so SRCC is the only correlation coefficient that can be evaluate or No actual values given for DPA	E1	1	Clearly in context
	Total		17	

SS03 (cont)

Q	Solution	Marks	Total	Comments																				
5(a)	The purpose is to ensure that each participant has the same opportunity to be assigned to any one of the three methods so that each method group should be roughly equivalent. Therefore any difference observed between method groups can be linked to the effect of the method, not due to a characteristic of the individuals in the group.	E1 E1	2	'Student effect' eliminated 'bias eliminated' More likely to detect any difference as groups more equivalent E0 'more accurate'																				
(b)	H ₀ Samples from identical populations H ₁ Samples not from identical populations	B1		Or hypotheses referring to difference between at least 2 population averages (not mean)																				
	Ranks																							
	<table border="1"> <thead> <tr> <th>Prog</th> <th>Comp</th> <th>Cont</th> </tr> </thead> <tbody> <tr> <td>5 13</td> <td>17 1</td> <td>15 3</td> </tr> <tr> <td>10 8</td> <td>16 2</td> <td>11 7</td> </tr> <tr> <td>6 12</td> <td>14 4</td> <td>8 10</td> </tr> <tr> <td>1 17</td> <td>12 6</td> <td>4 14</td> </tr> <tr> <td>13 5</td> <td>7 11</td> <td>3 15</td> </tr> <tr> <td>9 9</td> <td></td> <td>2 16</td> </tr> </tbody> </table>	Prog	Comp	Cont	5 13	17 1	15 3	10 8	16 2	11 7	6 12	14 4	8 10	1 17	12 6	4 14	13 5	7 11	3 15	9 9		2 16	M1	For ranks as one group (can be reversed)
Prog	Comp	Cont																						
5 13	17 1	15 3																						
10 8	16 2	11 7																						
6 12	14 4	8 10																						
1 17	12 6	4 14																						
13 5	7 11	3 15																						
9 9		2 16																						
	Totals of ranks:																							
	T _{prog} = 44/64 T _{comp} = 66/24 T _{cont} = 43/65 n _{prog} = 6 n _{comp} = 5 n _{cont} = 6	m1 A1		Totals ft but dep on ranks 2 totals correct																				
	$\sum_{i=1}^m \frac{T_i^2}{n_i} = \frac{44^2}{6} + \frac{66^2}{5} + \frac{43^2}{6} = 1502.03$ <p style="text-align: center;">322.7 +..... m1 implied or 682.7 +.....</p>	m1 m1		Numerators correct Denominators correct																				
	H = $\frac{12}{17 \times 18} \times 1502.03 - (3 \times 18)$ = 4.90	m1 A1		H formula correctly used (need a $\sum_{i=1}^m \frac{T_i^2}{n_i}$) 4.80–5.00																				
	Critical value from $\chi^2_2 = 5.99$ H < 5.99	B1		For cv (correct cv only)																				
	Accept H ₀ No reason to doubt that samples are from identical populations. No significant difference in average scores in test for the 3 methods.	E1	10	Conclusion correct in context (must have ts/cv both correct)																				
	Total		12																					
	TOTAL		75																					