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General Certificate of Education (A-level)
January 2013

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 students' 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 students' 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.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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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				
	H_o Outcome of loan is independent of recipient H_1 Outcome of loan is not independent of recipient	B1		both
	1 tail 5%			
	Exp / **Ind** / **Small bus** / **Large bus** **Satisfac** / 39.72 / 60.38 / 42.9 **Bad debt** / 10.28 / 15.62 / 11.11	M1 A1		For E method For 3 or more correct
	$ts = \sum \frac{(O-E)^2}{E}$	m1		For ts method
	$= \frac{0.28^2}{39.72} + \frac{5.38^2}{60.38} + \frac{5.1^2}{42.9} + \frac{0.28^2}{10.28} + \frac{5.38^2}{15.62} + \frac{5.1^2}{11.1}$	A1		5.20 – 5.40
	$= 5.29$	B1		B1 cv correct
	5% df =2 cv = 9.21 ts < 9.21	A1		
	Accept H_o			
	No sig evidence to suggest that the outcome of the loan is associated with (not independent of) the type of recipient	E1	8	In context
	Total		**8**	

Q	Solution	Marks	Total	Comments
2(a)	Sibling pairs were used in order to eliminate any individual differences between students so that any difference due to birthdate is more likely to be detected, if one exists.	E1 E1	2	'Student effect' eliminated More likely to detect any difference
(b)	Ho $\eta_d = 0$ H1 $\eta_d > 0$ 1 tail test 10 % level	B1		For both
	Signs + + + + + + - - + test stat 7+ / 2 – B (9, 0.5) model P(≥ 7+) = P(≤ 2 -) = 0.090(0.0898) 0.090 < 0.10	M1A1 M1 M1		For signs Correct ts Use of B (9, 0.5) Correct comparison
	Significant evidence to reject Ho. There is significant evidence to suggest that, on average in Year 7, students with autumn birthdays gain higher CAT scores than those with summer birthdays .	E1	6	Correct conclusion in context
	Total		**8**	

Q	Solution	Marks	Total	Comments
3	H_o μ_d , η_d = 0 H_1 μ_d , η_d > 0 1 tail 5%	B1		Or equivalent in words
	diffs 4 6 2 -3 -1 3 5 7 rank 5 7 2 3½ 1 3½ 6 8	M1 m 1		For differences Ranks
	T_+ = 5 + 7 + 2 + 3½ + 6 + 8=31½ T_- = 3½ + 1 = 4½	m1 A1		Total of ranks One correct
	Test stat T = 4½ n = 8 cv = 6 T < 6 Reject H_o	B1 m1		For cv Correct comparison ts/cv with cv = 6,8,4
	There is significant evidence to suggest that average taste score for a seafood dish is higher when sounds of the seaside are played.	E1	8	In context
	Total		**8**	

Q	Solution	Marks	Total	Comments
4(a)				
	H_0 Samples from identical populations H_1 Samples not from identical populations 5% sig level	B1		Or hypotheses referring to difference between at least 2 population averages
	Ranks P: 1, 3, 4, 6, 11 — Q: 10, 12, 13, 14, 15 — R: 2, 5, 7, 8, 9	M1 A1		For ranks as one group 10 or more correct
	Totals of ranks $T_P = 25$ $T_Q = 64$ $T_R = 31$ $n_P = 5$ $n_Q = 5$ $n_R = 5$	m1		Totals can be reversed rank $T_P = 55$ $T_Q = 16$ $T_R = 49$
	$\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{25^2}{5} + \frac{64^2}{5} + \frac{31^2}{5} = 1136.4$	m1 m1		Numerators correct Denominators correct
	$H = \frac{12}{15 \times 16} \times 1136.4 - (3 \times 16)$ $= 8.82$	m1 A1		H formula correctly used AWFW (8.6, 9.1)
	Critical value from $\chi^2_2 = 5.991$ $H > 5.991$	B1		For cv
	Reject H_0 Sig evidence to doubt that samples are from identical poulations. At least two average times differ for the 3 makes of urn	E1	10	Conclusion correct in context
(b)(i)	A difference in average time taken for water to boil was found in part (a) so at least 2 urns differ. Urn Q had the lowest total/average time/ highest ranks so should be selected as Urn Q is significantly faster than Urn P.	E1 E1		Choosing Q Clear reasoning (can be lowest rank ft)
(ii)	Cost of purchasing/operating the urns Ease of use of urns Supplier availability Cost of maintenance/reliability Different sizes require	E1	3	Sensible reason
	Total		**13**	

Q	Solution	Marks	Total	Comments
5(a)	H_o Samples are taken from identical populations H_1 Samples are not taken from identical populations – population average level of impurity differs 2 tail 5%	B1		For both or equivalent hypotheses referring to population medians.
	Ranks A 1 2 3 6 8 9 10 11 12 14½ B 4 5 7 13 14½ 16 17 18 19 20	M1 m1		Attempt at ranks as 1 group 10 correct as one group/ties
	$T_A = 1 + 2 + \ldots + 14½ = 76½$ $T_B = 4 + 5 + \ldots + 20 = 133½$	m1		totals
	$U_A = 76.5 - \frac{10\times11}{2} = 21.5$ $U_B = 133.5 - \frac{10\times11}{2} = 78.5$	m1 A1		U calculated either correct
	Test stat U = 21.5 cv = 24 U < 24 Reject H_o Significant evidence at the 5% level to suggest that there is a difference in the average level of impurity for processes A and B.	B1 A1 A1 E1	10	cv correct correct choice of ts U for comparison In context
(b)(i)	<table><tr><th></th><th>A</th><th>B</th><th>total</th></tr><tr><td>**Fault**</td><td>10</td><td>6</td><td>16</td></tr><tr><td>**No fault**</td><td>36</td><td>48</td><td>84</td></tr><tr><td>**total**</td><td>46</td><td>54</td><td>100</td></tr></table>	M1 A1	2	Either A or B freq correct All correct
(ii)	H_o Number of faults is independent of process H_1 Number of faults is not independent of process. 1 tail 10%	B1		For both
	<table><tr><th></th><th>A</th><th>B</th><th>total</th></tr><tr><td>**Fault**</td><td>7.36</td><td>8.64</td><td>16</td></tr><tr><td>**No fault**</td><td>38.64</td><td>45.36</td><td>84</td></tr><tr><td>**total**</td><td>46</td><td>54</td><td>100</td></tr></table>	M1 A1		For expected freq method All correct to 1 dp (not integers)
	$ts = \sum \frac{(\lvert O-E\rvert - 0.5)^2}{E}$ $\lvert O - E\rvert = 2.64$ $= \frac{2.14^2}{7.36} + \frac{2.14^2}{8.64} + \frac{2.14^2}{38.64} + \frac{2.14^2}{45.36}$ = 1.37	M1 m1 m1 A1		Ts effort denominator Yate's effort Correct 2.14 seen AWFW (1.30, 1.42)
	df = 1 10% cv = 2.706 ts < 2.706 Accept H_o	B1 A1		cv correct
(c)	Jess should choose process B since the test in part (a) indicates that process B results in a lower level of impurity and the test in part (b) indicates no significant evidence of a difference in fault levels between A and B	B1 E1	9 2	Choice B with reasons ref parts (a) and (b)
	Total		**23**	

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>6(a)</td><td>Ranks
<table>
<tr><th></th><th>Rank mother</th><th>Rank son</th><th>Rank d'ter</th></tr>
<tr><td>1</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>2</td><td>2</td><td>5½</td><td>1</td></tr>
<tr><td>3</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>4</td><td>4</td><td>5½</td><td>4</td></tr>
<tr><td>5</td><td>5</td><td>3</td><td>4</td></tr>
<tr><td>6</td><td>6½</td><td>8</td><td>6</td></tr>
<tr><td>7</td><td>6½</td><td>7</td><td>7</td></tr>
<tr><td>8</td><td>8</td><td>10</td><td>8</td></tr>
<tr><td>9</td><td>9</td><td>9</td><td>9</td></tr>
<tr><td>10</td><td>10</td><td>4</td><td>10</td></tr>
</table></td><td>M1
M1
M1
A1</td><td>4</td><td>Any 3 correct ranks mother
Any 3 correct ranks daughter
Ties correct in any column
All correct</td></tr>
<tr><td>(b)(i)</td><td>$r_s = 0.598$ (3 sig figs)</td><td>B2</td><td rowspan="2">4</td><td>Alt diffs | d|
1, 3½, 2, 1½, 2, 1½, ½, 2, 0,6
$\sum d^2 = 66$ M1
$r_s = 1 - \frac{6 \times 66}{10 \times 99} = 0.6$ A1</td></tr>
<tr><td>(ii)</td><td>$r_s = 0.972$ (3 sig figs)</td><td>B2</td><td>Alt diffs | d|
1, 1, 1, 0, 1, ½, ½, 0, 0, 0,
$\sum d^2 = 4.5$ M1
$r_s = 1 - \frac{6 \times 4.5}{10 \times 99} = 0.973$ A1</td></tr>
<tr><td>(c)(i)(ii)</td><td>H_O no assoc in ranks in population between mother and son/daughter
H_1 positive assoc in ranks in population between mother and son/daughter

1 tail test 1 % level
cv = 0.7333

Mother/son ts $r_s = 0.598 < 0.7333$
Accept H_O
Mother/daughter ts $r_s = 0.972 > 0.7333$
Reject H_O
There is significant evidence of a positive correlation between number of years spent in full-time education for mother and daughter but no significant evidence of a positive correlation for mother and son.</td><td>B1

B1

M1
A1
M1
A1

E1</td><td>7</td><td>or equivalent
for both

for cv

conclusion correct
conclusion correct</td></tr>
<tr><td></td><td>Total</td><td></td><td>15</td><td></td></tr>
<tr><td></td><td>TOTAL</td><td></td><td>75</td><td></td></tr>
</table>