Version1.0

General Certificate of Education (A-level)
January 2011

Statistics SS03

(Specification 6380)

Statistics 3

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.

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>1(a)</td><td>
<table>
<tr><td>Male</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>x rank</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>y rank</td><td>11</td><td>9</td><td>7</td><td>12</td><td>10</td></tr>
<tr><td>Male</td><td>F</td><td>G</td><td>H</td><td>I</td><td>J</td></tr>
<tr><td>x rank</td><td>6</td><td>7</td><td>8½</td><td>8½</td><td>10</td></tr>
<tr><td>y rank</td><td>4</td><td>8</td><td>6</td><td>5</td><td>3</td></tr>
<tr><td>Male</td><td>K</td><td>L</td></tr>
<tr><td>x rank</td><td>11</td><td>12</td></tr>
<tr><td>y rank</td><td>1</td><td>2</td></tr>
</table>
</td><td>M1
M1

A1</td><td></td><td>attempt at ranks
18 correct (can be reversed)

all correct — can be reversed

alternative
d = 10, 7, 4, 8, 5, 2, 1, 2½, 3½, 7, 10, 10
$\sum d^2$ =526½ B1</td></tr>
<tr><td></td><td>r_s = –0.844 (3 sf from calc)</td><td>B3</td><td>6</td><td>$r_s = 1 - \frac{6\times 526.5}{12\times 143} = -\ 0.841$ M1, A1

SC4 –0.84 (no method seen)
SC2 –0.8 (no method seen)
SC4 0.846 (no ties)
SC4 +0.844 (inconsistent ranks)</td></tr>
<tr><td>(b)</td><td>H_0 Rank orders number of average number of hours slept and diastolic blood pressure are independent.

H_1 Rank orders are not independent.
2 tail 1%</td><td>B1</td><td></td><td></td></tr>
<tr><td></td><td>cv = ± 0.7273
test stat r_s = – 0.844 (or – 0.841)</td><td>B1</td><td></td><td>for cv — ignore sign</td></tr>
<tr><td></td><td>r_s < – 0.7273 or $|r_s| > |cv|$
Reject H_0. Significant evidence at 1% level to suggest an association between rank orders number of average number of hours slept and diastolic blood pressure.</td><td>M1</td><td></td><td>for comparison ts/cv Must be consistent = or –</td></tr>
<tr><td></td><td>Results suggests that adult males who sleep less on average tend to have a higher diastolic blood pressure.</td><td>E1</td><td>4</td><td>in context</td></tr>
<tr><td></td><td>Total</td><td></td><td>10</td><td></td></tr>
</table>

SS03(cont)

Q	Solution	Marks	Total	Comments
2(a)	$H_0 \quad \eta_{\text{difference}} = 0$ $H_1 \quad \eta_{\text{difference}} < 0$ 1 tail 5%	B1		Allow μ ; condone no difference' mentioned or $\eta_{\text{difference}} > 0$ if consistent

Burglar pair	Difference 1994 –2004	Rank –	Rank +
A	–4	2	
B	–8	7	
C	+1		1
D	–5	3	
E	–9	8	
F	+7		5½
G	–10	9	
H	–7	5½	
I	–6	4	
J	–11	10	

Q	Solution	Marks	Total	Comments
	(table above)	M1		for differences
		m1		for ranks
	Rank totals $T_- = 48½$ $T_+ = 6½$	m1		For totals (dep ranks)
	Test stat $T = 6½$	A1		One total correct
	$n = 10$ critical value = 11	B1		For cv
	$T <$ cv	M1		
	Reject H_0.	A1		
	There is significant evidence to suggest that sentence lengths have increased since 1994	E1	9	In context
(b)	Matched pairs design will eliminate individual differences between types of burglar/types of burglary and will therefore reduce experimental error and make the test more likely to detect a difference if one exists.	E1 B1	2	In context General terms
			11	

SS03(cont)

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>3(a)(i)</td><td>H_0 Type of accident is independent of whether HGV British registered or foreign registered
H_1 Type of accident is not independent of whether HGV British registered or foreign registered
1 tail 1%</td><td>B1</td><td></td><td></td></tr>
<tr><td></td><td>

	Left	Right	Over
Brit reg HGV	184.55	436.11	49.34
Foreign reg HGV	118.45	279.89	31.66

</td><td>M1
A1</td><td></td><td>E method for 3 correct
For all E correct to 1 dp
[Alt $\frac{(O-E)^2}{E}$ clearly > 9.21 at early stage]</td></tr>
<tr><td></td><td>ts = $\sum \frac{(O-E)^2}{E}$
$= \frac{108.45^2}{184.55} + \frac{124.11^2}{436.11} + \frac{15.66^2}{49.34} + \frac{108.45^2}{118.45} + \frac{124.11^2}{279.89} + \frac{15.66^2}{31.66}$</td><td>m1</td><td></td><td>ts sum with correct denominators</td></tr>
<tr><td></td><td>= 266.1</td><td>A1</td><td></td><td>For ts in range 260 ~ 270</td></tr>
<tr><td></td><td>cv df = 2 1% cv = 9.210</td><td>B1</td><td></td><td>For cv</td></tr>
<tr><td></td><td>ts > 9.210</td><td>m1</td><td></td><td>For comparison ts/cv</td></tr>
<tr><td></td><td>Reject H_0
Sig evidence to suggest type of accident is not independent of whether HGV British registered or foreign registered</td><td>A1
E1</td><td>9</td><td>[Alt Allow clear explanation ref 266 being so large therefore significant as alternative]</td></tr>
<tr><td>(ii)</td><td>Sideswipe accidents involving changing lanes to left far less likely than expected for foreign registered HGVs and accidents involving changing lanes to right far more likely than expected for foreign registered HGVs.</td><td>E1
E1</td><td>2</td><td>Or E1 relevant comment on overtaking.
Must identify association sideswipe/changing right with foreign HGV for E1, E1</td></tr>
<tr><td>(b)(i)</td><td>

	Prosecution resulted	No prosecution
35 years or under	8	20
Over 35 years	29	43

</td><td>B1
M1
A1</td><td>3</td><td>Labels correct
2 correct</td></tr>
</table>

SS03(cont)

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>3(b)(ii)</td><td>H_0 Age of driver is independent of whether prosecution resulted.
H_1 Age of driver is not independent of whether prosecution resulted.
1 tail 5%</td><td>B1</td><td></td><td></td></tr>
<tr><td></td><td><table><tr><th>Exp values</th><th>Prosecution resulted</th><th>No prosecution</th></tr><tr><td>35 years or under</td><td>10.36</td><td>17.64</td></tr><tr><td>Over 35 years</td><td>26.64</td><td>45.36</td></tr></table></td><td>M1</td><td></td><td>For E values method</td></tr>
<tr><td></td><td>ts = $\sum \frac{(|O-E|-0.5)^2}{E}$ =
$\frac{1.86^2}{10.36}+\frac{1.86^2}{17.64}+\frac{1.86^2}{26.64}+\frac{1.86^2}{45.36}$ =</td><td>M1
m1</td><td></td><td>For ts
for Yates' corr</td></tr>
<tr><td></td><td>0.736</td><td>A1</td><td></td><td>For ts 0.70 ~ 0.77</td></tr>
<tr><td></td><td>cv df = 1 5% cv = 3.841
ts < 3.841</td><td>B1</td><td></td><td>For cv</td></tr>
<tr><td></td><td>Accept H_0
No significant evidence to suggest an association. Conclude that age of driver is independent of whether prosecution resulted</td><td>E1</td><td>7</td><td></td></tr>
<tr><td></td><td>Total</td><td></td><td>21</td><td></td></tr>
</table>

SS03(cont)

Q	Solution	Marks	Total	Comments
4	H_0 samples from identical populations H_1 samples not from identical populations: taste better on average for pods produced using new method	B1		
	1 tail 5%			
	Current method ranks 10 12 6 8 11 5 New method ranks 3 2 7 1 4 9	M1		Sorting into 2 groups
	$T_{\text{current}} = 52 \quad T_{\text{new}} = 26$	M1		Totals
	$U_{\text{current}} = 52 - \dfrac{(6\times7)}{2} = 31$ $U_{\text{new}} = 26 - \dfrac{(6\times7)}{2} = 5$	M1		Method for U
	test stat = 5 (lower)	A1		Either U correct
	$n = 6$, $m = 6$ cv = lower tail 7	B1		cv
	Since 5 < 7, reject H_0	M1 A1		Comparison correct cv and ts (can be upper tail)
	Significant evidence to suggest that populations are not identical and that the taste is better, on average, for pods produced using new method.	E1	9	
	Total		**9**	

SS03(cont)

Q	Solution	Marks	Total	Comments
5(a)	H_0 Samples are taken from identical populations H_1 Samples are not taken from identical populations 1% sig level	B1		or H_0 $\eta_A = \eta_B = \eta_C = \eta_D = \eta_E$ H_1 at least two of $\eta_A, \eta_B, \eta_C, \eta_D, \eta_E$ do differ
	$T_A = 75$ $T_B = 99$ $T_C = 26$ $T_D = 31$ $T_E = 94$ $n_A = 5$ $n_B = 5$ $n_C = 5$ $n_D = 5$ $n_E = 5$	M1 A1		totals any one correct
	$\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{75^2}{5} + \frac{99^2}{5} + \frac{26^2}{5} + \frac{31^2}{5} + \frac{94^2}{5}$ $= 5179.8$	m1		$\sum_{i=1}^{m} \frac{T_i^2}{n_i}$
	$H = \frac{12}{25 \times 26} \times 5179.8 - (3 \times 26) = 17.63$	m1 A1		test stat: $H = \frac{12}{N(N+1)} \sum_{i=1}^{m} \frac{T_i^2}{n_i} - 3(N+1)$ 17.0 ~ 18.4
	Critical value from $\chi_4^2 = 13.277$ $H > 13.277$	B1 M1		for cv for comparison
	Sig evidence to reject H_0 and conclude that samples are not from identical populations. At least 2 average acidity levels are different.	E1	9	
(b)	Variety B has highest total of ranks so if a low acidity beer is desirable, this variety would be the best choice.	B1 E1	2	Identification of B Explained
(c)	Conclusion only shows that Variety B differs significantly from Variety C (highest and lowest). However, Variety B and Variety E have similar acidity level ranks. Thus Variety E is a sensible choice if popular with customers.	E1 E1	2	
	Total		**13**	

SS03(cont)

Q	Solution	Marks	Total	Comments
6(a)(i)	H_0 Women like the taste of both recipes equally, on average	B1		1 tail correct
	H_1 On average, women prefer the taste of the new recipe.	B1	2	context/wording correct — mention women H_0 no preference H_1 preference B1 only
(ii)	1 tail test 5% level			
	test stat 10+ or 5–	B1		for test stat
	B(15, 0.5) model	M1		for model B(15, 0.5) seen
	P ($\geq$ 10+) = P ($\leq$ 5–) = 0.151 Since 0.151 > 0.05 for 1 tail test	M1		correct probability and comparison with 0.05
	Accept H_0	A1		
	No sig evidence to suggest adult females prefer new recipe	E1	5	In context
(b)	B(30, 0.5) model 1 tail 5% level	M1		Use of B(30. 0.5) method must be seen
	P ($\geq n$ +) < 0.05 required from tables,	M1		Comparison of B(30, 0.5) probability with 0.05
	P($\leq$ 10 –) = P($\geq$ 20+) = 0.0494 P($\leq$ 11 –) = P($\geq$ 19+) = 0.1002	M1		Correct B(30, 0.5) probability seen
	minimum number therefore 20 adult females out of the 30 to prefer the new recipe.	A1	4	Or equivalent
	Total		**11**	
	TOTAL		**75**	