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General Certificate of Education (A-level)
June 2012

Statistics SS03

(Specification 6380)

Statistics 3

Mark Scheme

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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.

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Q	Solution	Marks	Total	Comments
1(a)	H_0 Population median purchases = 5 H_1 Population median purchases > 5 1 tail test 10% level signs	B1		Pop can be implied if fully worded in context oe η not μ
	– + + + + + + + + – + – +	M1		for signs can be reversed or incorrect (WSR diff OK)
	test stat = 3– / 9+	A1		for test stat 3 or 9
	Bin (12, 0.5) model	M1		for use of Bin model any B (12, 0.5) prob
	$P(\leq 3–) = 0.0730 < 0.10$	M1		for comparison ts and 10%
	Reject H_o Significant evidence to suggest median number of packets has increased	A1	6	cr {0,1,2,3} or {9,10,11,12} must see 0.0729/0.194 M1m1
(b)	Wilcoxon signed-rank test	B1	1	Just Wilcoxon
	Total		**7**	
2				
(a)	ranks *x* 1, 3, 5, 6, 9, 10, 4, 2, 7, 8, 10, 8, 6, 5, 2, 1, 7, 9, 4, 3	M1		for any ranks
	y 1, 3, 5, 7, 9, 10, 4, 2, 6, 8 10, 8, 6, 4, 2, 1, 7, 9, 5, 3	M1 A1		2 separate sets of ranks All correct
	r_s (from calculator) = 0.988 or 0.987 0.98/0.99 allow B2 if no method seen	B3	6	alternatively differences, *d* : 0, 0, 0, 1, 0, 0, 0, 0, 1, 0 $\sum d^2 = 2$ M1 diffs $r_s = 1 - \frac{6 \times 2}{10 \times 99} = 0.988$ or 0.987 M1, A1
(b)	H_0 no association H_1 positive association 1 tail 1%	B1		Allow $p/\rho = 0$ or words Must be 1 tail
	test stat r_s = 0.988 critical value = 0.7333 tests stat > 0.7333 so significant evidence exists to reject H_o and conclude that a positive association exists.	B1 M1		for cv comparison ts/cv; ft r_s in (a) 0.7667,0.7818/0.6485/0.700 B0 M1 E0
	This suggests that hurricanes in which there are higher numbers of injuries also result in a greater cost in property damage (or positive assoc in context)	E1	4	explanation in context
(c)(i)	see scatter diagram	M1 A1	2	8+ points effort plot OK (allow 1 small slip)
(ii)	There is evidence of a **non linear** relationship(or it is a curve)	B1	1	Must mention no (straight) line fit
	Total		**13**	

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Q	Solution	Marks	Total	Comments
3(a)	H_0 Reaction is independent of eye colour H_1 Reaction is not independent of eye colour 1 tail 5%	B1		H_0 independent /no assoc H_1 not independent/assoc
	Expected / Blue / Brown / Other **None** 19.33 12.00 8.67 **Mild** 21.75 13.50 9.75 **Strong** 16.92 10.50 7.58	M1 M1 A1		Method for expected frequencies One row/col correct All correct to 1 dp (not integers but truncated OK)
	ts = $\sum \frac{(O-E)^2}{E}$ $= \frac{6.33^2}{19.33} + \frac{5^2}{12} + ... + \frac{6.5^2}{10.5} + \frac{3.42^2}{7.58}$ 2.07 + 2.08 + .. = 13.45	M1 A1		Numerator correct Denominator correct both ts correct (12.5 -14.5)
	cv df = 4 5% cv = 9.488	B1		df = 4 row B0 M1 A0 (7.779,11.143,13.277,14.86)
	ts > 9.488 Reject H_0	M1 A1		Or p=0.00925 < 0.05; ft on ts
	Sig evidence to suggest that skin reaction is not independent of eye colour.	E1	10	In context ft conclusion
(b)	Brown-eyed people more likely than expected to have a'none' reaction (or blue-eyed people less likely than expected to have a 'none'reaction)			
	Blue-eyed people more likely then expected to have a'strong' reaction (or brown-eyed people less likely than expected to have a 'strong'reaction)	B1		Any one of these comments (ref none, mild or strong) acceptable – general idea correct
	'Other' less likely than expected to have a mild reaction (more likely to have a strong reaction)	E1	2	Fully explained. Must mention more/less than <u>expected</u> Not dep on (a)
	Total		**12**	

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Q	Solution	Marks	Total	Comments
4(a)	Ranks **A** 3, 4, 7, 9, 10 **B** 1, 2, 6, **11**, **12½** **C** 8, **12½**, **15**, **17**, **18** **D** 5, **14**, **16**, **19**, **20**	M1 A1	2	For ranks as one group – starting at 11 All correct
(b)	H_0 Samples from identical populations H_1 Samples not from identical populations 1% sig level	B1		H_0 $\eta_A = \eta_B = \eta_C = \eta_D$ or words H_1 At least 2 medians differ
	Totals of ranks $T_A = 33$ $T_B = 32½$ $T_C = 70½$ $T_C = 74$ $n_A = 5$ $n_B = 5$ $n_C = 5$ $n_D = 5$	m1		Totals-any effort at any ranks total
	$\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{33^2}{5} + \frac{32\frac{1}{2}^2}{5} + \frac{70\frac{1}{2}^2}{5} + \frac{74^2}{5}$ $= 2518.3$	m1 m1		Numerators correct Denominators correct
	$H = \frac{12}{20 \times 21} \times 2518.3 - (3 \times 21)$ $= 8.95$	m1		H formula $\frac{12}{20 \times 21}$ and –63 (8.6 – 9.2)
	Critical value from $\chi_3^2 = 11.345$ $H < 11.345$	A1 B1		For cv 11.345 only
	Accept H_0 No reason to doubt that samples are from identical populations. No significant difference in average number of injuries for the four visiting teams involved.	E1	8	Conclusion correct in context
(c)	A Type II error would be to conclude that H_0 is true, that is there is no difference between the average number of injuries for the four visiting teams involved when in fact H_0 is not true and the average numbers of injuries do differ.	B1 E1	2	Correct Type II In context
	Total		**12**	

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Q	Solution	Marks	Total	Comments
5(a)	Test A mean = 58.6 st dev = 19.2 or 20.3 Test B mean = 63.9 st dev = 16.0 or 17.0	B1 B1B1	3	B1for both means B1,B1 for st dev must be consistent, awrt
(b)	PMCC r = 0.894 0r 0.893(3 sf) (from calculator) 0.89 allow M1 M1 A0 (or B2) 0.9 allow B1 no method no ranks	B3	3	or $r = \dfrac{36140 - \dfrac{527 \times 575}{9}}{57.552 \times 48.030} = 0.894$ (3 sf) M1(36140) M1(formula),A1
(c)(i)	H_o Population median/mean/average score difference = 0 H_1 Population median/mean/average score difference $\neq 0$ 2 tail test 5 % level	B1		or symbols μ η equal or not oe
	differences 1 2 3 4 5 6 7 8 9 4 –1 –17 –11 –15 –3 –2 10 –13	M1		for differences
	ranks 4 1 9 6 8 3 2 5 7	m1		all m dep diffs for ranks- rank 1= smallest disallow –17 rank 1 M0
	T_+ = 4+ 5 = 9 T_- = 1+ 9+ 6 + 3 + 2 + 8 + 7 = 36	m1		for totals of any ranks
	test stat T = 9 critical value = 6 test stat > 6	A1 B1 m1		correct test stat for cv (11,8,3 B0 M1 E0) for comparison **lower** ts/cvft; must be seen unless **all** correct
	Accept H_0 There is no significant evidence of a difference in mean scores for the two tests	E1	8	in context
(ii)	The differences are symmetrically distributed.	E1	1	Must have differences
(d)	PMCC indicates results of tests show strong positive association – <u>consistent</u> results	E1		For PMCC result and <u>consistency/similarity</u>
	No sig difference in means so general similarity	E1		For no sig diff means and <u>similarity</u> (award for similarity once only)
	Higher st dev for test A indicates that this test may be more effective at discriminating between good/bad applicants	E1	3	for mentioning st dev and <u>discrimination</u>
(e)	If separate groups took the 2 tests so there may be differences between the level of difficulty of the tests which would affect the results.	B1		concept of pairing removing effect of differences <u>in tests</u> disallow 'fair' allow eliminates/reduces exp error more likely to detect a difference if one exists
	Half the number of people needed	B1	2	
	Total		**20**	

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<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>6</td><td>
H_0 Samples are taken from identical populations
H_1 Samples are not taken from identical populations
2 tails 5%

Separated times with Ranks
<table>
<tr><th colspan="2">M</th><th colspan="2">A</th></tr>
<tr><th>Times</th><th>ranks</th><th>Times</th><th>ranks</th></tr>
<tr><td>19.2</td><td>1 14</td><td>21.3</td><td>4 11</td></tr>
<tr><td>22.4</td><td>8 7</td><td>22.3</td><td>7 8</td></tr>
<tr><td>26.8</td><td>13 2</td><td>19.6</td><td>2 13</td></tr>
<tr><td>22.5</td><td>9 6</td><td>20.2</td><td>3 12</td></tr>
<tr><td>24.8</td><td>11 4</td><td>21.7</td><td>5½ 9½</td></tr>
<tr><td>24.6</td><td>10 5</td><td>21.7</td><td>5½ 9½</td></tr>
<tr><td>28.4</td><td>14 1</td><td>26.2</td><td>12 3</td></tr>
</table>
$T_M = 66\ 39$ $T_A = 39\ 66$
$n_M = 7$ $n_A = 7$

$U_M = 66 - \frac{7\times8}{2} = 38$
$U_A = 39 - \frac{7\times8}{2} = 11$

$U = 11$
cv = 9 for n= 7, m = 7 2 tail 5%

$U > 9$

Accept H_0

No significant evidence of any difference between average journey times when travelling for the morning shift or for the afternoon shifts
</td><td>
B1

M1
M1

A1

m1

m1
A1

B1

M1

A1

E1
</td><td>11</td><td>
H_0 $\eta_M = \eta_A$ or words ref
H_1 $\eta_M \neq \eta_A$ context
Disallow mean

Separated times effort (can be implied)
Ranks as one group (either way)

Ranks correct (5,6 or 9,10 OK)

Ranks totalled (any ranks)
m dep ranks

Attempt to find U dep ranks, totals
Either U correct

cv correct cv = 9 only

correct comparison, ft on wrong ts – must see 11/lower U oe upper tail unless all correct

only if cv = 9 and U = 11

In context. Can ft conclusion
</td></tr>
<tr><td></td><td>Total</td><td></td><td>11</td><td></td></tr>
<tr><td></td><td>TOTAL</td><td></td><td>75</td><td></td></tr>
</table>