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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Statistics 6380

SS03 Statistics Unit 3

Mark Scheme

2007 examination - January series

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Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

Jan 07

SS03

Q	Solution	Marks	Total	Comments
1	H_0 $\eta = 6$ H_1 $\eta > 6$ 1 tail 5%	B1		or H_0 population median = 6 H_1 population median > 6 or fully in words
	Difference $X - 6$ / **Rank** + / –	M1		for differences ($X - 6$ or $6 - X$)
	4 / 4½			
	2 / 2			
	– 1 / 1	m1		for ranks (1 = smallest |diff |) m0 if 0 = rank 1
	– 4 / 4½			
	5 / 6			
	. /			
	7 / 8			
	3 / 3			
	8 / 9			
	6 / 7			
	Rank totals $T_- = 5\frac{1}{2}$ $T_+ = 39\frac{1}{2}$	m1F A1		for total of +/– ranks ft if any ranks
	Test stat $T = 5\frac{1}{2}$			
	critical value = 8 $n = 9$	B1		for cv
	$T <$ cv	M1		for comparison ts/cv
	Reject H_0 There is significant evidence to suggest that the median for 18-year-old females is greater than 6.	A1	8	
	Total		**8**	

SS03 (cont)

Q	Solution	Marks	Total	Comments
2(a)(i)	H_0 Response is independent of sex H_1 Response is not independent of sex 1 tail 1%	B1		
		M1 m1		*E* method for 3 correct for all *E* correct
	$ts = \sum \frac{(O-E)^2}{E}$ $= \frac{12.3^2}{83.3} + \frac{12.8^2}{47.8} + \frac{25.1^2}{221.9} + \frac{12.3^2}{85.7} + \frac{12.8^2}{49.2} + \frac{25.1^2}{228.1}$	m1		ts sum with correct denominators
	= 16.0	A1		for ts in range 15.7 - 16.2
	cv df = 2 1% cv = 9.210	B1		for cv
	ts > 9.210	m1		for comparison ts/cv
	Reject H_0 Sig evidence to suggest response is not independent of sex	A1F	8	ft if ts is very close and method is ok
(a)(ii)	Males are much less likely than expected to disapprove of the royal wedding and females are much more likely than is expected to disapprove of the royal wedding	E1		explanation in context...
	Most noticeable differences in the sexes is that females were more likely to have an opinion of some sort about the wedding whereas males were more likely not to care	E1	2	... with reference to expected/observed
(a)(iii)	Most adults involved did not appear to care about the royal wedding	E1	1	not men/women
(b)(i)	Data in Table 2 cannot be analysed to investigate whether an association exists because the raw frequencies are not supplied, only the percentages. This means than a χ^2 test cannot be carried out.	E1	1	mention of % or not **actual** frequencies given
(ii)	The total number of males and the total number of females in the sample is required.	E1		totals required for males and females
	The raw frequencies in each category can then be found by evaluating the relevant percentage of the total eg 41% of the total number of males gives the raw frequency in the first cell (male / support monarchy)	E1	2	how total is used **SC** 'convert into frequencies' B1
	Total		**14**	

	Approve	Dis-approve	Don't care
Male	83.3	47.8	221.9
Female	85.7	49.2	228.1

SS03 (cont)

Q	Solution	Marks	Total	Comments
3(a)	('difference':weekend – weekday) H_0 $\eta_{\text{difference}} = 0$ H_1 $\eta_{\text{difference}} > 0$ 1 tail 10%	B1		direction generous if fully worded and median / average
	Signs + + + – + – + + + +	M1		signs
	$8^+ / 2^-$ signs - test values	A1		test stat correct and identified
	Binomial (10, 0.5) model	M1		binomial model used and probability attempted
	$P(\geq 8^+) = P(\leq 2^-) = 0.0547 < 0.10$ for one tail test	M1		comparison of Binomial probability with 0.10
	Reject H_0.	A1		
	There is sufficient evidence, at the 10% level, to suggest that the median difference is greater than 0 Significant evidence that standardised mortality ratio is greater at the weekend	E1F	7	interpretation in context ft conclusion
(b)	A Type II error would be to conclude that H_0 is true, that is the mortality ratio is not	B1		concept of Type II correct
	higher at weekends when, in fact H_0 is false and the ratio at weekends is higher than the weekday ratio	E1	2	in context
	Total		**9**	

SS03 (cont)

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 H_0 $\eta_A = \eta_B = \eta_C$ H_1 at least two of η_A, η_B, η_C do differ
	Ranks **Department A**: 3, 9, 11, 14, 15, 17 **Department B**: 1, 2, 4, 5, 6 **Department C**: 7, 8, 10, 12, 13, 16	M1 A2,1		some ranks A1 for 5 A2 for all
	$T_A = 69$ $T_B = 18$ $T_C = 66$	M1		totals of some ranks
	$n_A = 6$ $n_B = 5$ $n_C = 6$	A1		any one correct
	$\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{69^2}{6} + \frac{18^2}{5} + \frac{66^2}{5} = 1584.3$	M1		
	$H = \frac{12}{17 \times 18} \times 1584.3 - (3 \times 18) = 8.13$	m1		$\frac{12}{N(N+1)} \sum_{i=1}^{m} \frac{T_i^2}{n_i} - 3(N+1)$
		A1		test stat $H = 7.80 - 8.40$
	Critical value from $\chi_2^2 = 5.99$	B1		
	$H > 5.99$	M1		
	Sig evidence to reject H_0 and conclude that samples are not from identical populations. At least 2 differ.	A1	12	
(b)	Department B had the lowest median score and, as there is significant evidence that at least two of the median scores (from departments A, B or C) do differ, it would seem likely that department B	B1		identification of B
	Managers achieved lower scores on average and so this department was unlikely to have received an annual bonus payment	E1	2	explanation in context of reason B selected 'median' or 'average' required or explanation all B scores low
	Total		**14**	

SS03 (cont)

Q	Solution	Marks	Total	Comments
5	H_0 Samples are taken from identical populations			
	H_1 Samples are not taken from identical populations – population average time to become over-ripe is lower for 'chilled' bananas 1 tail 5%	B1 B1		hypotheses referring to population, averages also acceptable for direction/explanation [other alternative methods acceptable]
	Sum of ranks 'Chilled' 2+6+5+8+1 = 22 = T_C 'Stored at 10°C' 3+4+9+10+7+11 = 44 = T_S	m1		for totals of ranks in each group
	$U_C = 22 - \frac{5 \times 6}{2} = 7$ $U_S = 44 - \frac{6 \times 7}{2} = 23$	m1		for U attempted
	Test stat $U = 7$ cv = 5 $U > 5$ Accept H_0 No significant evidence at the 5% level to suggest that the population average time to become over-ripe is lower for 'chilled' bananas	A1 B1 M1 A1 E1	9	for U correct, either for consistent cv with U for comparison U /cv for any valid U /cv in context
	Total		**9**	

SS03 (cont)

Q	Solution	Marks	Total	Comments
6(a)(i)				($r = 0.927$)
		M1 A1		attempt at ranks
	$r_s =$ 0.854(5) (3 sf from calc)	B3	5	**Alternative** $d = 0, 0, 2, 3, 1, 3, 1, 0, 0, 0$ $\sum d^2 = 24$ B1 $r_s = 1 - \frac{6 \times 24}{10 \times 99}$ = 0.854(5) M1, A1 (2 sf and no working SC4, A0)
(a)(ii)	H_0 Rank orders of micro-economics marks and macro-economics marks are independent. H_1 Rank orders of micro-economics marks and macro-economics marks are not independent. 2 tail 2%	B1		H_0 no association H_1 association
	cv = ± 0.7333 test stat $r_s =$ 0.854(5)	B1		for cv
	r_s > 0.7333 or $\lvert r_s \rvert > \lvert$ cv $\rvert$	M1		for comparison ts/cv $r_s =$ 0.854(5)
	Reject H_0 Significant evidence at 2% level to suggest an association between rank orders of micro-economics marks and macro-economics marks. [Student with higher rank mark in micro-economics also has higher rank mark in macro-economics]	A1 E1	5	allow A1 if r 'close' and marks lost in (a)(i) in context

student	1	2	3	4	5
micro rank	1	2	3	4	5
macro rank	1	2	5	7	4

student	6	7	8	9	10
micro rank	6	7	8	9	10
macro rank	3	6	8	9	10

SS03 (cont)

Q	Solution	Marks	Total	Comments
6(b)	H_0 $\mu_{\text{difference}} = 0$ H_1 $\mu_{\text{difference}} \neq 0$ 2 tail 5%	B1		or η or population average or words
		M1		for differences
		m1 m1		for ranks (1 = smallest |diff|) ties
	Rank totals $T_- = 28$ $T_+ = 17$	m1F A1		for total of +/– ranks
	Test stat $T = 17$ critical value = 6 $n = 9$ $T >$ cv Accept H_0 There is no significant evidence to suggest that there is a difference between the average marks for macro-economics and micro-economics	B1 M1 A1	9	for cv for comparison ts/cv
(c)	It appears, from (a), that students who do well in micro-economics also do well in macro-economics but there is no significant evidence that students perform better in one of the exams than in the other. Good students achieve higher marks in both exams with no pattern as to which they perform better in	B1 E1	2	
	Total		**21**	
	TOTAL		**75**	

Student	**Difference** mac–mic	**Rank** –	+
1	–10	10	
2	4		4
3	6		6½
4	6		6½
5	– 2	2	
6	– 9	8	
7	– 5	5	
8	– 3	3	
9	.	Discard	
10	– 1	1	