Version 1.0: 0609

General Certificate of Education

Statistics 6380

SS03 Statistics 3

Mark Scheme

2009 examination – June series

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 meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting 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 the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting 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 candidates' 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.

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX *Dr Michael Cresswell Director Genera*

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.

Q	Solutions	Marks	Total	Comments
1(a)				
	Rank *x* | **Rank *y***	M1		attempt at ranks inconsistent (can be reversed) SC M1M1 B2
	10 | 8			
	9 | 6	M1		
	8 | 9			for 16 correct
	7 | 10	A1		
	6 | 2			
	5 | 5			
	4 | 7			
	3 | 4			
	2 | 1			
	1 | 3			
	$r_s =$ 0.673 (3 sf from calc)	B3	6	AWRT B2 0.67 B1 0.7 ft B2 from wrong ranks (small slip) No ranks seen, **SC** 0.67 B4 0.7 B3 **alternative** $d = 2, 3, 1, 3, 4, \ldots, 3, 1, 1, 2$ $\sum d^2 = 54$ B1 $r_s = 1 - \frac{6\times 54}{10\times 99} = 0.673$ M1, A1
(b)	H_o Rank orders of age and percentage body fat in females are independent.	B1		or equivalent
	H_1 Rank orders of age and percentage body fat in females are not independent – there is an association			
	2 tail 10%			
	cv = ±0.5636 $n = 10$	B1		for cv
	test stat $r_s =$ 0.673 $r_s > 0.5636$	M1		for comparison ts/cv **SC** Allow M1 0.593/0.5494 (pmcc)
	Reject H_o . Significant evidence at 10% level to suggest an association between rank orders of age and percentage body fat in females.(or positive association)	E1	4	correct and in context
	Total		**10**	

SS03 (cont)

Q	Solutions	Marks	Total	Comments
2.(a)	H_o pop median/mean η , μ = 9 H_1 pop median/mean η , μ > 9 1 tail 5% (*d* is result – 9)	B1		
	diff 0.5, -0.4, 0.2, 0.6, -0.1 **rank** 4, -3, 2, 5½, -1	M1		For differences (result -9) - ignore signs
	diff 0.7, -0.6, 0.8 **rank** 7, -5½, 8	m1 M1		For ranks For ties
	$T_+ = 4 + 2 + \ldots + 8 = 26½$ $T_- = 3 + 1 + 5½ = 9½$	m1 A1		For total attempted from ranks For one correct total
	Test stat T = 9½ *n* = 8 1 tail 5% cv = 6 T > 6	B1 M1		For cv Comparison cv/ts (consistent)
	No significant evidence at 5% level to reject H_o . Conclude that there is no significant evidence to suggest that the average time to complete the task is greater than 9 minutes.	E1	9	In context
(b)	Sample was selected at random. or Times to complete the task are symmetrically distributed.	B1	1	Disallow 'normally distributed'
	Total		**10**	

SS03 (cont)

Q	Solutions	Marks	Total	Comments
3	H_o Samples are taken from identical populations	B1		or equivalent in words implying pop averages same/ 2nd greater
	H_1 Samples are not taken from identical populations – population average percentage silver higher in second minting.	B1		
	5% 1 tail			
	Ranks First: 1, 2, 3, 5, 6½, 8, 9, 10 Second: 4, 6½, 11, 12, 13, 14, 15			(Alternative method acceptable)
		M1		Attempt at M-Whitney – ranks as one group (can be reversed)
		m1		Ties
	$T_{1st} = 44½$ $T_{2nd} = 75½$ $m = 8$ $n = 7$	m1		For total attempt
	$U_{1st} = 44½ - \frac{8\times9}{2} = 8½$			
	$U_{2nd} = 75½ - \frac{7\times8}{2} = 47½$	m1		For U formula correct
	Test stat U = 8½	A1		Either U correct
	cv = 13 $n = 7$ $m = 8$ 1 tail 5%	B1		correct/relevant cv used
	U = 8½ < 13	M1		comparison with U (consistent)
	Significant evidence to reject H_o and conclude that the percentage of silver was higher in the second minting.	A1	10	
	Total		**10**	

SS03 (cont)

Q	Solutions	Marks	Total	Comments
4(a)	$H_0\ \eta_d = 0$	B1		
	$H_1\ \eta_d \neq 0$ 2 tail 10%			
	Signs + . + + − − + +	M1		Signs (allow signed differences)
	$5^+ / 2^-$ signs – test values	A1		test stat correct and identified
	Binomial (7, 0.5) model	M1		Binomial model used and probability attempted
	$P(\geq 5 +) = P(\leq 2 -) = 0.227 > 0.05$ or $P(\geq 5 +) = P(\leq 2 -) = 0.453 > 0.10$ one tail test	m1		Comparison of Binomial probability with 0.05 (or 0.1) Identified correct critical region with probability given also M1m1
	Accept H_o There is not sufficient evidence, at the 10% level, to suggest that the average cornea thickness differs between the normal eye and the eye with glaucoma.	E1	6	Interpretation in context
4(b)	$H_0\ \eta_d = 0$			
	$H_1\ \eta_d > 0$ 1 tail 5%	B1		One tail – either way if consistent
	$10^+ / 2^-$ signs – test values Binomial (12, 0.5) model	B1		test stat identified ft incorrect ts from (a)
	$P(\geq 10 +) = P(\leq 2 -) = 0.0193 < 0.05$	M1		Binomial model used and probability attempted
	one tail test	m1		Comparison of Binomial probability with 0.05
	Reject H_o .			Identified correct critical region with probability given also M1m1
	There is sufficient evidence, at the5% level, to suggest that the average cornea thickness is greater for the normal eye than for the eye with glaucoma.	A1	5	**SC** $n = 8$ in part(a) Allow part(b) $n = 13$ M1, M1 for 0.0112 < 0.05
	Total		**11**	

SS03 (cont)

Q	Solutions	Marks	Total	Comments
5(a)	Ho Samples are taken from identical populations	B1		or $H_0 \quad \eta_A = \eta_B = \eta_C = \eta_D$
	H_1 Samples are not taken from identical populations – population average bottle cap productions differ for the 3 machines. 1 tail 1%	B1		H_1 at least two of $\eta_A, \eta_B, \eta_C, \eta_D$ do differ
	Ranks **Machine A**: 2½, 5, 10, 14, 17, 19 **Machine B**: 15, 16, 18, 20, 21 **Machine C**: 1, 2½, 4, 6, 7 **Machine D**: 8, 9, 11, 12, 13			
	$T_A = 67½ \;\; T_B = 90 \;\; T_C = 20½ \;\; T_D = 53$ $n_A = 6 \quad n_B = 5 \quad n_C = 5 \quad n_D = 5$	M1		Totals
	$\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{67.5^2}{6} + \frac{90^2}{5} + \frac{20.5^2}{5} + \frac{53^2}{5}$	m1		Method for $\sum_{i=1}^{m} \frac{T_i^2}{n_i}$
	$= \quad 3025.225$	m1		n_i correct
	$H = \frac{12}{21 \times 22} \times 3025.225 - (3 \times 22)$	m1		test stat H
	$= 12.58$	A1		12.3 – 12.9
	Critical value from $\chi^2_3 = 11.345$	B1		3 df
	$H > 11.345$	B1		cv
		M1		comparison cv/ts
	Sig evidence to reject H_0 and conclude that samples are not from identical populations	A1		
	Significant evidence at the 1% level to suggest that the population average bottle cap productions differ for the 4 machines. At least two machines have different averages	E1	12	Difference in context Mention of 'at least two'
(b)	Machine C had the lowest average rank score so it would seem likely that machine C is the lowest producer of bottle caps and therefore this machine is the most obvious one to suggest for replacement	B1		Machine C
		E1	2	Reason – must refer to the lowest average score or lowest production
	Total		**14**	

SS03 (cont)

Q	Solutions	Marks	Total	Comments
6(a)(i)	H_o No association between place of occurrence of fall and sex of person who falls. H_1 Association exists between place of occurrence of fall and sex of person who falls.	B1		
	1 tail 1%			
	Expected freqs / **Male** / **Female** **Home** 1306.75 355.25 **School, other** 31.45 8.55 **Trade and serv** 72.34 19.66 **Industrial etc** 127.37 34.63 **Farm** 29.09 7.91	M1 m1 A1		For method for E for 3 correct All correct (1dp required minimum except 1307/355)
	$ts = \sum \frac{(O-E)^2}{E}$ $= \frac{(1269-1306.75)^2}{1306.75} + \frac{(393-355.25)^2}{355.25}$ $..... + \frac{(6-7.91)^2}{7.91}$	m1		ts sum with correct denominators
	$= 38.5$	A1		for ts in range 34 - 43
	df = 4 1% cv = 13.277	B1 B1		for df = 4 for cv
	ts > 13.277	m1		for comparison ts/cv
	Significant evidence to reject H_o and conclude that there is an association between place of occurrence of fall and sex of person who falls.	A1	10	
(ii)	Far fewer than expected females have ladder-related falls in the Industrial or Construction area and far more males than expected do have falls in this area. More females were observed to have falls at home than would be expected.	E1 E1	2	Any two points made

SS03 (cont)

Q	Solutions	Marks	Total	Comments
6(a)(iii)	Many more males involved in ladder-related falls than females. Most falls occurred at home.	E1	1	Any one point made
(b)(i)	<table><tr><th></th><th>Male</th><th>Female</th></tr><tr><td>**Direct**</td><td>141</td><td>29</td></tr><tr><td>**Transfer**</td><td>28</td><td>6</td></tr><tr><td>**Other**</td><td>58</td><td>22</td></tr></table>	M1 m1 A1	 3	% of 227 or % of 57 4 correct (not necessarily integers) all correct and integers
(ii)	H_o No association between admission category and sex of person who falls. H_1 Association exists between admission category and sex of person who falls. ts = 3.84 df = 2 5% cv = 5.991 3.84 < 5.991 No significant evidence to reject H_o. Conclude that there is no evidence of association between admission category and sex of person who falls.	 B1 B1 M1 A1	 4	
	Total		**20**	
	TOTAL		**75**	