AQA

A-LEVEL

Statistics

Statistics 3 – SS03
Mark scheme

6380
June 2014

Version/Stage: Final

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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.

Further copies of this Mark Scheme are available from aqa.org.uk

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
1a	Spearman's rank correlation coefficient is the appropriate measure of correlation for these data because there are no measured values given.	E1	1	E1 <u>Ranks only</u> for 400m & <u>position</u> only for cross country or ref to <u>orders given</u>
1b	Ranks			

	Rank 400m	Rank cross country	$\lvert d\rvert$
A	3	6 3	3
B	4	1 8	3
C	7	3 6	4
D	5	2 7	3
E	1	8 1	7
F	2	7 2	5
G	8	4 5	4
H	6	5 4	1

Marks: M1 A1

Comments:
M1 for ranks attempt cross country
A1 all correct (can be reversed) can be implied by d

m1dep for $\sum d^2 = 134$

$r_s = 1 - \dfrac{6 \times 134}{8 \times 63} = -0.595$ M1 A1

$r_s = -0.595$ (3 sig figs)   B3

B1 r_s negative
B2 $0.590 \le \lvert r_s \rvert \le 0.599$

Total **5**

1c

H_0: $\rho_s = 0$ B1

H_1: $\rho_s \ne 0$ 2 tail   5%

Hypotheses oe

test stat $\lvert r_s \rvert = 0.595$ B1

$\lvert$critical value$\rvert = 0.7381$ M1

$-0.595 > -0.7381$ so no significant evidence exists to reject H_0

Correct abs value for cv 0.738(1)
Correct comparison both –ve/ +ve

This suggests that there is no correlation between rank/ position in 400m races and position in county cross country final race.   E1dep

Conclusion correct in context

Total **4**

1d H_0 accepted in error as H_0 actually untrue
Conclusion made that there is no correlation between rank/ position in 400m races and position in county cross country final race when, in reality, there is a correlation between them.   B1   E1

Correct explanation of Type II error

In context

Total **2**

1e(i)	PMCC $r = -0.904$ (3 sf) (from calculator)	B3		$(-0.905, -0.903)$ or $r =$ $$\dfrac{8671.488 - \dfrac{434.4 \times 160.07}{8}}{3.17 \times 7.08} = \dfrac{-20.3}{22.4}$$ $= -0.904$ (3 sf) M1 (num), M1(denom), A1
(ii)	sc –0.90 allow M1 M1 A0 (or B2) –0.9 sc allow B1			
	PMCC indicates a strong negative correlation between best time taken to run 400m and time taken to run cross country race final. This indicates that we would expect faster 400m runners to be slower at running the cross country race.	E1	**4**	Interpretation in context

Q	Solution	Marks	Total	Comments
2a		M1		Correct effort at % for 1 frequency(not 25)

Frequencies	AP	AV
Baseball	275	50
Basketball	475	75
Soccer	350	25

A1 — All correct — Total **2**

2b

H_0: Coping style is not associated with sport
H_1: Coping style is associated with sport
  1 tail 1%

B1

M1 — Method for expected frequencies 3 or more correct

Expected	AP	AV
Baseball	286	39
Basketball	484	66
Soccer	330	45

M1 — All correct
A1 — Can be implied by correct ts

$$ts = \sum \frac{(O-E)^2}{E}$$

M1 — Method for ts seen or implied

$$= \frac{11^2}{286} + \frac{11^2}{39} + \ldots\ldots + \frac{20^2}{330} + \frac{20^2}{45}$$

A1 — ts correct (14.9 -15.2)

$= 15.02$

cv df = 2   1%   cv = 9.21 $p = 0.00055$

B1 — for df =2 (can be implied by cv)

B1 — for cv correct or $p=0.00055$

ts > 9.21
Reject H_o

A1dep — Reject H_o

E1dep — Conclusion correct in context

Sig evidence to suggest that coping strategy is associated with sport involved.

Total **10**

2c

Soccer officials are far less likely than expected to use the AV coping style (more likely than expected to use the AP coping style).
Baseball officials are far more likely than expected to use the AV coping style (less likely than expected to use the AP coping style).

E1 — In context

E1 — In context

Total **2**

2d

Expected	AP	AV
Male	24.5	5.5
Female	24.5	5.5

M1 — Effort at expected freq seen or implied

$$ts = \sum \frac{(|O-E| - 0.5)^2}{E}$$

M1 — Yates used correctly – numerator seen correct ft

$$= \frac{3^2}{24.5} + \frac{3^2}{5.5} + \frac{3^2}{24.5} + \frac{3^2}{5.5}$$

m1

$= 4.00$

A1 — Whole ts method correct 3.9 – 4.2

Total **4**

Q	Solution	Marks	Total	Comments
3a	So that any influence of the order of taking drugs does not affect the outcome of the investigation.	B1 E1	2	Reduction of experimental error In context
3b	H_0: Population mean/median hours relief difference $= 0$ H_1: Population mean/median hours relief difference $\neq 0$ 2 tail test 2 % level	B1		H_0: η_A, $\mu_A = \eta_B$, μ_B H_1: η_A, $\mu_A \neq \eta_B$, μ_B
	Differences $B - A$ 1 2 3 4 5 6 7 8 9 10 11 12 1.5 2.1 0.2 –0.2 2.6 –0.1 –0.6 2.5 2 1.2 3 3.9 Ranks 6 8 2½ 2½ 10 1 4 9 7 5 11 12	M1 m1dep m1 dep		For differences – ignore signs Can be implied by correct ranks For any ranks For correct ranks (smallest abs diff = rank1). Ignore ties. <u>m1,1 Both dep differences</u>
	$T_+ = 6 + 8 + 2½ + 10 + 9 + 7 + 5 + 11 + 12 = 70.5$ $T_- = 2½ + 1 + 4 = 7.5$ test stat $T = 7.5$	m1dep A1		Effort at total of ranks + and/or - May not see 70.5. m1 <u>dep ranks</u> Either total correct
	critical value $= 10$ test stat < 10 Reject H_o	B1 m1dep A1dep		cv = 10 correct correct lower tail ts used/identified. Correct conclusion <u>dep ts and cv correct</u>
	There is significant evidence of a difference between the average number of hours of relief from pain gained using Drug A and Drug B. Allow 1 tail conclusion Drug B better/longer relief	E1dep	10	Conclusion correct in context dep previous A1
3c	Conclusion based on experiment in which adults self selected to take part. These adults might not be representative of **all** adult arthritis sufferers	E1	1	Or mention of volunteers/not selected at random

Q	Solution	Marks	Total	Comments
4	H_0: Samples from identical populations H_1: Samples not from identical populations	B1		H_0: $\eta_A = \eta_B$ or ref to pop median H_1: $\eta_A \neq \eta_B$
	2 tail 5% sig level Ranks A 4 7 9 10 11 12 $T_A = 53$ B 1 2 3 5 6 8 $T_B = 25$	M1 A1		Ranks separated and totalled effort One total correct
	$U_A = 53 - \dfrac{6 \times 7}{2} = 32$	m1 dep		U method
	$U_B = 25 - \dfrac{6 \times 7}{2} = 4$ ts = 4	A1		One U correct cv = 5 [or 31 upper tail] only
	$n = 6$, $m = 6$ cv = 5	B1		
	ts < 5	M1		Consistent comparison ts/correct tail cv or ts identified & compared with correct tail cv
	Significant evidence to reject H_0 and conclude that there is a difference in the average marks in the Statistics module exam for the two schools	A1 dep E1 dep		A1 dep ts and cv correct In context dep previous A1
			9	

Q	Solution	Marks	Total	Comments
5a(i)	H_0: Managers have no particular preference for either new or old company structure H_1: Managers prefer new company structure 1 tail 5%	B1		H_0: p = 0.5 H_1: p > or < 0.5
	Use of 17+ and 8 or 13 –	M1		For identifying ts
	Use of B(25, 0.5) or B(30, 0.5) $P(X \geq 17) = 0.0539$ or 0.2923 $p > 0.05$ (5%)	M1 M1		Either correct Bin prob seen Comparison Bin prob and 5%
	Or use of cr with probs Accept H_0	A1 dep		dep correct Bin prob compared 5%
	No significant evidence to suggest that managers/they prefer new company structure	E1 dep		In context dep previous A1
			6	
(ii)	There are no measurements to use – simply a judgement of prefer or not/no opinion on new structure. Wilcoxon requires symmetrically distributed measurements for preferences not just a prefer/not situation.	E1		W S-R can't be used if only preferences given, +/- given W S-R needs values
			1	

Q	Solution	Marks	Total	Comments
5b(i)	H_0: Samples from identical populations H_1: Samples not from identical populations 5% sig level	B1		H_0: $\eta_{U40} = \eta_{40\text{-}55} = \eta_{55+}$ or ref to pop medians H_1: at least 2 population medians differ oe Allow 1 pop median is different Allow ref to median occup stress if H_1 includes 'at least 2'
	Ranks | **Under 40**	**40-55**	**Over 55** | |---|---|---| | 12 6 | 17 1 | 13 5 | | 10 8 | 16 2 | 11 7 | | 7 11 | 15 3 | 9 9 | | 5 13 | 14 4 | 6 12 | | 4 14 | 8 10 | 3 15 | | 1 17 | | 2 16 |	M1		Ranks effort
	$T_{under40}$= 39 69 $T_{40\text{-}55}$=70 20 T_{over55}=44 64 $n_{under40} = 6$ $n_{40\text{-}55} = 5$ $n_{over40} = 6$	m1 A1		m1 dep ranks used Ranks totalled. At least 1 correct
	$\sum_{i=1}^{m} \dfrac{T_i^{\,2}}{n_i} = \dfrac{39^2}{6} + \dfrac{70^2}{5} + \dfrac{44^2}{6} = 1556.17$	m1 m1		Denominators correct Numerators correct and terms added ft
	$H = \dfrac{12}{17 \times 18} \times 1556.17 - (3 \times 18) = 7.03$ Critical value from $\chi_2^2 = 5.991$ $H > 5.991$ Significant evidence to reject H_0	M1 A1 B1 A1dep	10	H method correct A1 6.9 -7.2 cv correct dep ts and cv correct
5b(ii)	At least 2 groups' average scores differ. The '40-55 years' age group are significantly more stressed than the 'under 40 years' age group.	B1 E1	2	A difference between at least 2 groups exists B1 Can be implied in (i) Difference identified [40-55 most or under 40 least] in context E1 (full explanation in context gets B1 E1)