

General Certificate of Education

Statistics 6380

SS03 Statistics 3

Mark Scheme

2009 examination – January 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.

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Key to mark scheme and abbreviations used in marking

М	mark is for method						
m or dM	mark is dependent on one or more M marks and is for method						
А	mark is dependent on M or m marks and is for accuracy						
В	mark is independent of M or m marks and is for method and accuracy						
Е	mark is for explanation						
$\sqrt{100}$ or ft or F	follow through from previous incorrect result	MC					
C10		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 <i>x</i> marks for each error	G	graph				
NMS	no method shown	с	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	Solution	Marks	Total	Comments
<u>×</u> 1	H_0 : pop median/ $\eta = 76$	IVIAI KS	100001	
-	H_1 : pop median/ $\eta > 76$	B1		
	1 tail 10%			
	signs _ + + + + + +	M1		Signs (allow differences)
	n = 10			
	test stat = $7^+/3^-$	A1		test stat correct
	Model B(10, 0.5)	M1		Bin model seen to be used
	$P(\le 3^-) = P(\ge 7^+) = 0.172 > 0.10$	M1		Comparison of correct $B(10, 0.5)$ prob with 0.10 or 0.344 with 0.20 Or use of identified as with probability:
				Or use of identified cv with probability: $\{8,9,10\}$ and $0.0547 < 0.10$
	Accept H ₀			
	There is no significant evidence to suggest	A1	6	In context
	that her median heart rate increases.		6	
2(a)		B1	0	
2(a)	H ₁ : pop median/mean diff $\eta_d \neq 0$ H ₁ : pop median/mean diff $\eta_d \neq 0$ 2 tail 5%	DI		
	diff 38 11 9 -4 7 (1 - 2)	M1		For differences, +/– signs can be interchanged
	rank 9 8 7 -3 5	m1		For ranks (either way)
	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			
		m1		For total attempted
	$T_{+} = 9 + 8 + 7 + 5 + 4 + 6 + 2 = 41$ $T_{-} = 3 + 1 = 4$ Test stat $T = 4$	A1		For one correct total
	n = 9 cv = 6	B1		For cv
	<i>T</i> < 6	M1		Comparison cv/ts
	Significant evidence at 5% level to reject H_0	A1		
	Significant evidence to suggests that the number of lesions differ for preparations A and B.	E1	9	In context – can be one tail conclusion that preparation A leads to more lesions
(b)	Wilcoxon takes into account the rank order of the differences so is a more powerful test.	E1	1	or comment referring to taking size of differences into account
	Total		10	

Q	Solution	Marks	Total	Comments
3	H ₀ : Samples are taken from identical	B1		Hypotheses referring to population
	populations			averages also acceptable but require 1 tai
	H ₁ : Samples are not taken from identical	B1		alternative
	populations – population average ratios			
	differ			B1, B0 if 1 tail but not precise wording
	1 tail 5%			
	Ranks			
	Non-drinkers			
	6 9 10 12 13 14 15 16 17 18	M1		For ranks as one group
	Heavy drinkers			– at least 10 correct
	1 2 3 4 5 7 8 11	A1		All correct
				Other alternative methods acceptable (eg
	$T_{\rm non} = 6 + 9 + \ldots + 18 = 130$			ranks reversed)
	$T_{\text{heavy}} = 1 + 2 + \dots + 11 = 41$	M1		For total of ranks attempted
	$U_{\rm non} = 130 - \frac{10 \times 11}{2} = 75$			
	2	M1		For U attempted
	$U_{\text{heavy}} = 41 - \frac{8 \times 9}{2} = 5$	A1		For U correct – either
	Test stat $U = 5$			
	n = 10, m = 8 cv = 21	B1		For cv consistent with U
	<i>n</i> 10, <i>m</i> 000 21			(Upper tail $cv = 59$)
	<i>U</i> = 5 < 21	m1		For comparison U/cv
				Not negative U
	Significant evidence to reject H ₀	Al		
	Evidence to suggest that heavy drinkers			
	have a smaller average ratio of brain	E1	11	In context
	volume to skull size			
	Total		11	

Q		Soluti	on		Marks	Total	Comments
4(a)(i)	H ₀ : Result i	t of treatr	nent			or equivalent	
	H ₁ : Result r	dent of tr	eatment				
	1 tail 1%				B1		
	Expected fre						
	1	Hydro	Tai Chi	Conv			
				exercise			
	Much imp	17.73	17.41	13.86			
		17.73			M1		E method for 3 correct
	Imp		17.41	13.86	ml		7 correct
	Slight imp	10.49	10.30	8.20	A1		For all E correct
	No change	9.05	8.88	7.07	AI		
	$ts = \sum \frac{(O - E)}{E}$	$\frac{E)^2}{2}$					
	1.27^2 5	50 ²	6.03	22	m1		ts sum with correct denominators
	$=\frac{1.27^2}{17.73}+\frac{5}{17}$	+	$+\frac{0.92}{-1}$, 	m1		numerator method OK
		/.41	7.0	7			
	= 19.42				A1		For ts in range 19.00 ~ 20.00
	df = 6 1	$c_{\rm v} = 16$	5.812		B1		For cv or $p = 0.003511$
	ts > 16.812				m1		For comparison ts/cv
	13 > 10.012				1111		
	Reject H ₀						
	Sig evidence				A1	10	
	is not indepe	e treatme	ent.			SC pooled max 4/10	
							M1, m1, m1, m1 only
(a)(ii)	Main source	Main sources of association:					
	Far fewer than expected adults doing				E1		
		conventional classes reported that they					
	were much i		•	•	E1	2	For identification of any two main sourc
	these than ex	.					in context.
(b)(i)							
	Hydro Tai Chi Conv				B1		Categories correct for table
				land-	21		(allow correct 3×2)
					M1		4 correct
l	based				111		
	A 11	55	5/1	/2	Λ1	2	All correct
	All Not all	55 9	54 10	43 13	A1	3	All correct
(ii)	Not all	9	10	13	A1	3	All correct
(ii)	Not all H ₀ : Attendar	9 nce for full	10 six mont	13	A1	3	All correct
(ii)	Not all H ₀ : Attendat independent	9 nce for full of treatme	10 six mont nt	13 hs is		3	All correct
(ii)	Not all H_0 : Attendar independent H_1 : Attenda	9 nce for full of treatme nce for full	10 six mont nt six mont	13 hs is	A1 B1	3	All correct
(ii)	Not all H ₀ : Attendar independent H ₁ : Attenda independent	9 nce for full of treatme nce for full	10 six mont nt six mont	13 hs is		3	All correct
(ii)	Not all H ₀ : Attendat independent H ₁ : Attenda independent 1 tail 5%	9 nce for full of treatme nce for full of treatme	10 six mont nt six mont nt	13 hs is		3	All correct
(ii)	Not all H ₀ : Attendat independent H ₁ : Attenda independent 1 tail 5%	9 nce for full of treatme nce for full of treatme	10 six mont nt six mont nt	13 hs is		3	All correct
(ii)	Not all H ₀ : Attendar independent H ₁ : Attenda independent 1 tail 5% ts = $\sum \frac{(O - I)}{D}$	9 nce for full of treatme nce for full of treatme $\frac{E^2}{E} = 1.9$	10 six mont nt six mont nt 5	13 hs is	B1	3	
(ii)	Not all H ₀ : Attendation independentic H ₁ : Attendation independentic tail 5% ts = $\sum \frac{(O - f)}{f}$ df = 2 5%	9 nce for full of treatme nce for full of treatme $\frac{E^2}{E} = 1.9$	10 six mont nt six mont nt 5	13 hs is	B1 B1	3	For cv or $p = 0.37638$
(ii)	Not all H ₀ : Attendation independenting H ₁ : Attendation independenting tail 5% ts = $\sum \frac{(O - f_1)^2}{2}$ df = 2 5% ts < 5.991	9 nce for full of treatme nce for full of treatme $\frac{E^2}{E} = 1.9$	10 six mont nt six mont nt 5	13 hs is	B1	3	
(ii)	Not all H ₀ : Attendation independent H ₁ : Attendation independent 1 tail 5% ts = $\sum \frac{(O-T)}{P}$ df = 2 5% ts < 5.991 Accept H ₀	9 nce for full of treatme nce for full of treatme $\frac{E^2}{E} = 1.9$ cv = 5.99	10 six mont nt six mont nt 5 1	13 hs is ths is not	B1 B1 m1		For cv or $p = 0.37638$ For comparison ts/cv
(ii)	Not all H_0 : Attendatiindependent H_1 : Attendatiindependent1 tail 5%ts = $\sum \frac{(O-T)}{10}$ df = 2 5%ts < 5.991	9 nce for full of treatme nce for full of treatme $\frac{E^2}{E} = 1.9$ cv = 5.99 ence to dou	10 six mont nt six mont nt 5 1 bt that att	13 hs is ths is not endance	B1 B1	3	For cv or $p = 0.37638$
(ii)	Not all H ₀ : Attendation independent H ₁ : Attendation independent 1 tail 5% ts = $\sum \frac{(O-T)}{P}$ df = 2 5% ts < 5.991 Accept H ₀	9 nce for full of treatme nce for full of treatme $\frac{E^2}{E} = 1.9$ cv = 5.99 ence to dou	10 six mont nt six mont nt 5 1 bt that att	13 hs is ths is not endance	B1 B1 m1		For cv or $p = 0.37638$ For comparison ts/cv

5(b)(i) From calculator $r = 0.758$ Alternative $r = \frac{129553 - (\frac{358 \times 3088}{11})}{\sqrt{3160.73 \times \sqrt{464586.18}}}$ $= \frac{20052.64}{56.22 \times 681.61}$ = 0.758 (ii) From calculator $r = -0.488$ Alternative or $r = \frac{992.8 - (\frac{358 \times 106.8}{11})}{\sqrt{3160.73 \times \sqrt{3160.77}}}$ $= \frac{-483.05}{5.22 \times 17.61}$ = -0.488 $r_{ssc} = 0.758$ $r_{sy} = -0.488$ $r_{sy} = -0.853$ (b) $H_0 \ \rho = 0$ $H_1 \ \rho \neq 0$ 2 tail 5 % sig level Need only be stated once test stat $r_{sw} = 0.758$ $r_{sy} = -0.488$ cv = 0.6021 $n = 11since ts > 0.6021r_{correct} H_0test stat r_{sy} = -0.488 cv = 0.6021$ $n = 11since ts > 0.6021Reject H_0(c) There is significant evidence of a(positive) correlation between maximumIf e_{span and average daily sleep time.There is no significant evidence of a(regative) correlation between maximum lifespanand average daily sleep time.There is no significant evidence of acorrelation between maximum lifespanand average daily sleep time.There is no significant evidence of acorrelation between maximum lifespanand average daily sleep time.There is no significant evidence of acorrelation between maximum lifespanand average daily sleep time.There is no significant evidence of acorrelation between maximum lifespanand average daily sleep time.$	Q	Solution	Marks	Total	Comments
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$r = \frac{129533 - (\frac{58\times3083}{1})}{\frac{\sqrt{3160.73\times\sqrt{464586.18}}}{(510.73\times\sqrt{464586.18}}}$ $= \frac{2902.6}{56.22\times681.61}$ $= 0.758$ (ii) From calculator $r = -0.488$ Alternative $r = \frac{292.8}{\sqrt{5160.73\times\sqrt{464586.18}}}$ $= \frac{292.8}{\sqrt{5160.73\times\sqrt{310.07}}}$ $= \frac{-483.05}{56.22\times17.61}$ $= -0.488$ $r_{ex} = 0.758$ (b) H ₀ $\rho = 0$ H ₁ $\rho \neq 0.2$ tail 5% sig level Need only be stated once test stat $r_{ex} = 0.758$ $ cv = 0.6021$ Reject H ₀ $re = 0.6021$ Reject H ₀ $r_{ex} = 0.6021$ Reject H ₀ $r_{ex} = 0.7533$ (c) There is significant evidence of a (negative) correlation between maximum lifespan and average gastation time. The longer the average gastation time. There is significant evidence of a (negative) correlation between average gistation time. There is no significant evidence of a (negative) correlation between average gistation time. There is significant evidence of a (negative) correlation between average gistation time. There is no significant evidence of a (negative) correlation between average gistation time. There is no significant evidence of a (negative) correlation between average daily sleep time. There is no significant evidence of a (negative) correlation between average daily sleep time. There is no significant evidence of a (negative) correlation between average daily sleep time. There is no significant evidence of a (negative) correlation between average daily sleep time. There is no significant evidence of a (negative) correlation between average daily sleep time. There is no significant evidence of a (negative) correlation between average daily sleep time. There is no significant evidence of a (negative) correlation between average daily sleep time. The one maximum lifespan in the longer the average gestation time. The longer the average gestation time. The longer the average gestation time. The longer the average daily sleep time. The lon					-
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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		120552 (358×3088)			
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		$r = \frac{129553 - ()}{11}$			$\sum w^2 = 14812$
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		$1 - \frac{1}{\sqrt{3160.73} \times \sqrt{464586.18}}$			$\sum r^2 - 1331472$
$\begin{bmatrix} -\frac{5}{5622\times681.61} \\ = 0.758 \end{bmatrix}$ From calculator $r = -0.488$ Alternative $\begin{bmatrix} r = \frac{2992.8 - (\frac{358\times106.8}{1.1})}{\sqrt{3160.73}\times\sqrt{310.07}} \\ = \frac{-483.05}{5622\times17.61} \\ = -0.488 \\ r_{wz} = 0.758 \\ r_{wy} = -0.488 \\ r_{wz} = 0.758 \\ cv = 0.6021 n = 11 \\ since ts < 0.6021 n = 11 \\ since ts <$					$\sum x^{-1551472}$
(ii) From calculator $r = -0.488$ Alternative or $r = \frac{2992.8 - (\frac{358 \times 106.8}{11})}{\sqrt{3160.73 \times \sqrt{31007}}}$ $= \frac{-483.05}{5.52 \times 17.61}$ = -0.488 $r_{wz} = 0.758$ $r_{wy} = -0.488$ $r_{zy} = -0.853$ (b) H ₀ $\rho = 0$ H ₁ $\rho \neq 0.2$ tail 5% sig level Need only be stated once test stat $r_{wz} = 0.758$ cv = 0.6021 $n = 11since ts > 0.6021 n = 11since$					$\sum wx = 129553$ M1 m1
(ii) From calculator $r = -0.488$ Alternative $r = \frac{2992.8 - (\frac{358 \times 106.8}{11})}{\sqrt{3160.73 \times \sqrt{310.07}}}$ $= \frac{-483.05}{56.22 \times 17.61}$ = -0.488 $r_{wr} = 0.758$ $r_{wy} = -0.488$ $r_{w} = -0.853$ (b) $H_0 \rho = 0$ $H_1 \rho \neq 0.2 \tan 15.\% \text{ sig level}$ Need only be stated once test stat $r_{wr} = 0.758$ cv = 0.6021 $n = 11since s > 0.6021$ $n = 11since $					
Alternative $or r = \frac{2992.8 - (\frac{358 \times 106.8}{11})}{\sqrt{3160.73 \times \sqrt{310.07}}}$ $= \frac{-483.05}{5.622 \times 17.61}$ $= -0.488$ $r_{wr} = 0.758$ $r_{wy} = -0.887$ B1(b) $H_0 \rho = 0$ $H_1 \rho \neq 0.2$ tail 5 % sig level Need only be stated once test stat $r_{wr} = 0.758$ $ cv = 0.6021 n = 11$ since $ ts > 0.6021 n = 11$ since $ ts > 0.6021 n = 11$ since $ ts < 0.6021 n = 11$ since $ ts > 0.6021 n = 11$ <	(;;)		D2	~	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	(II)		B2	3	Second correct value
$ \begin{vmatrix} z & -483.05 \\ z & -0.488 \\ r_{wx} = 0.758 & r_{wy} = -0.488 & r_{xy} = -0.853 \end{vmatrix} $ $ \begin{cases} \textbf{b} & H_0 \ \rho = 0 \\ H_1 \ \rho \neq 0 \ 2 \ tail 5 \ \% \ sig \ level \\ Need only be stated once \\ lext stat r_{wx} = 0.758 \\ cv = 0.6021 \ n = 11 \\ since ts > 0.6021 \ n = 11 \\ since ts $					
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$ \begin{vmatrix} z & -483.05 \\ z & -0.488 \\ r_{wx} = 0.758 & r_{wy} = -0.488 & r_{xy} = -0.853 \end{vmatrix} $ $ \begin{cases} \textbf{b} & H_0 \ \rho = 0 \\ H_1 \ \rho \neq 0 \ 2 \ tail 5 \ \% \ sig \ level \\ Need only be stated once \\ lext stat \ r_{wx} = 0.758 \\ cv = 0.6021 \ n = 11 \\ since ts > 0.6021 \ n = 11 \\ since the longer the average gestation time. The longer the average gestation time. The longer the average daily sleep time. The row simificant evidence of a correlation between avaximum lifespan lettore to a correlation between avaximum lifespan lettore to a spainter to b correlation the second average daily s$		or $r = \frac{11}{11}$			$\sum y = 106.8$
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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		=			
$r_{wx} = 0.758 r_{wy} = -0.488 r_{xy} = -0.853$ B1For any pair of hypotheses Allow 1 tail for r_{wx} H ₀ $\rho = 0$ H ₁ $\rho \neq 0.2$ tail 5% sig level Need only be stated onceB1 $ked only be stated onceB1For any pair of hypothesesAllow 1 tail for r_{wx}H0 \rho = 0H1 \rho > 0.1 tail 5% sigket stat r_{wx} = 0.758 cv = 0.6021 n = 11since ts > 0.6021 n = 11since ts > 0.6021 n = 11since ts < 0.6021 n = 11since ts < 0.6021 n = 11since ts > 0.6021 n = 11since $		56.22×17.61			$\sum wy = 2992.8$ M1
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correlation between maximum lifespan			EI	3	
÷					EIEIEI can be gained in part (b)
and average daily sleep time.		-			
Total 15				1 -	

3 (cont) Q	Solution	Marks	Total	Comments
<u>(a)</u>	H ₀ : Samples are taken from identical	1.1.1.1.1.5	1000	or
	populations	B1		H ₀ $\eta_{20} = \eta_{30} = \eta_{40}$
	H_1 : Samples are not taken from identical			
	populations – population average times			H ₁ at least two of $\eta_{20}, \eta_{30}, \eta_{40}$ do differ
	differ	B1		
	5%			
	Ranks			
	20 30 40			
	1 3 5			
	2 4 7	M1		ranks
	6 9 12			
	8 11 13			
	10 14 16			
	15 17 18			
	$\begin{array}{ll} T_{20} = 42 & T_{30} = 58 & T_{40} = 71 \\ n_{20} = 6 & n_{30} = 6 & n_{40} = 6 \end{array}$	m1		totals
	$n_{20} = 6$ $n_{30} = 6$ $n_{40} = 6$	A1		any one correct
	$\sum_{i=1}^{m} \frac{T_i^2}{n_i} = \frac{42^2}{6} + \frac{58^2}{6} + \frac{71^2}{6} = 1694.83$			
	$\sum_{n} \frac{1}{n} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = 1694.83$	m1		
	l=1 l			$12 m T^2$
	$H = \frac{12}{18 \times 19} \times 1694.83 - (3 \times 19) = 2.47$	m1		test stat $H = \frac{12}{N(N+1)} \sum_{i=1}^{m} \frac{T_i^2}{n_i} - 3(N+1)$
	18×19			
	2	A1		2.2~2.7
	Critical value from $\chi_2^2 = 5.991$	B1		
	<i>H</i> < 5.991	M1		
	No significant evidence to reject H ₀	A1		No difference
	Conclude that there is no significant			
	evidence to doubt that samples are from			
	identical populations and there is no			
	difference in the average times taken to	E1	12	In context
	solve the anagram for the different levels			
	of sleep deprivation.			
	A Type II error is when an incorrect null			
(b)	hypothesis is accepted as true.	D1		
	Or H_0 false but test conclusion is that H_0 is	B1		
	true.			
	In context, conclusion would be that			
	samples are from identical populations			
	and there is no difference in average times			
	to complete puzzle but, in fact, there is a			
	difference between at least two of the	E1	2	
	average times, for different levels of sleep	EI	4	
	deprivation, to complete puzzle.			
	Total		14	
	TOTAL		75	