



**General Certificate of Education**

**Statistics 6380**

**SS06          Statistics 6**

**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.

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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.**

## SS06

Q	Solution	Marks	Total	Comments
1	<p>W So De Mar Di Sa Mah d 7 8 6 12 -3 9 -1</p> <p><math>H_0: \mu_d = 0</math>      <math>H_1: \mu_d \neq 0</math></p> <p><math>\bar{x}_d = 5.4286</math>      <math>s_d = 5.4423</math></p> <p><math>t = \frac{5.4286}{5.4423 / \sqrt{7}}</math> = 2.64</p> <p>critical value <math>t_6 \pm 1.943</math></p> <p>Reject <math>H_0: \mu_d = 0</math> — Conclude there is significant evidence of a difference in pulse rates for different bench heights (rate higher for 40cm than for 30cm)</p>	<p>M1</p> <p>B1</p> <p>B1</p> <p>M1 m1 A1 B1 B1</p> <p>A1✓</p> <p>A1✓</p>	10	<p>M1 method for differences</p> <p>B1 both hypotheses — needs <math>\mu</math> or 'population'</p> <p>B1 5.43 (5.42~5.43) and 5.44 (5.44~5.45)</p> <p>M1 use of their <math>sd / \sqrt{7}</math></p> <p>m1 clearly correct method for <math>t</math></p> <p>A1 2.64 (2.63 ~ 2.65) or -2.64</p> <p>B1 6df</p> <p>B1 1.943 — ignore sign</p> <p>A1✓ correct conclusion their figures — must be compared with correct tail of <math>t</math>. Disallow if contradicted subsequently</p> <p>A1✓ correct conclusion in context — allow arithmetic errors or numerically incorrect <math>t</math> value only. Needs previous A1✓</p>
Total			10	
2(a)	<p>Source      SS      df      MS</p> <p>Bands      3369.7      3      1123.23</p> <p>Error      2168.8      15      144.59</p> <p>Total      5538.5      18</p>	<p>B1</p> <p>B1</p> <p>M1</p>	3	<p>B1 any correct df</p> <p>B1 all correct df</p> <p>M1 method for error SS</p>
(b)	<p><math>H_0</math>: No difference between bands</p> <p><math>H_1</math>: Difference between bands</p> <p><math>F = \frac{1123.23}{144.59} = 7.77</math></p> <p>Critical value <math>F_{3,15}</math> is 5.417</p> <p>Reject <math>H_0</math> — significant evidence of a difference in average attendance for the different bands.</p>	<p>M1</p> <p>m1 A1 B1</p> <p>A1✓</p>	5	<p>M1 method for both MS — their df and +ve Error SS</p> <p>m1 method for <math>F</math>, their df — needs both Ms</p> <p>A1 7.77 (7.76~7.78)</p> <p>B1 5.417 or 5.42</p> <p>A1✓ conclusion in context — must be correct df and compared with upper tail of <math>F</math></p>
Total			8	
3(a)	<p>Wednesday      Thursday</p> <p>1      D      M</p> <p>2      M      D</p> <p>3      D      M</p> <p>4      M      D</p> <p>5      D      M</p> <p>6      M      D</p>	<p>B1</p> <p>B1</p> <p>B1</p>	3	<p>B1 6Ms 6Ds</p> <p>B1 paired</p> <p>B1 3Ms 3Ds each day</p>
(b)	<p>Don't take a break/ take same number and length of breaks</p> <p>Drive as quickly as possible consistent with safety and speed limits etc</p>	E2,1	2	<p>E1 any reasonable point</p> <p>E1 clearly explained</p> <p>Disallow drive same speed</p>
(c)	Paired $t$ -test	<p>E1</p> <p>E1</p>	2	<p>E1 paired</p> <p>E1 <math>t</math>-test</p> <p>Allow sign test, Wilcoxon signed-rank test</p> <p>Disallow 2-Factor A of V, unless some explanation included</p>
Total			7	

## SS06 (cont)

Q	Solution	Marks	Total	Comments
<b>4(a)</b>	1st 0 1 1 1 2 2 2nd 0 1 2 0 1  P(Accept) = P(0) + P(1) × P(2 or fewer) + P(2) × P(1 or fewer) = 0.2146 + 0.3389 × 0.8122 + 0.2587 × 0.5535 = 0.633	M1  m1 B1 M1 A1	5	M1 reasonable attempt at double sampling  m1 method their attempt  B1 use of B(30, 0.05) M1 completely correct method A1 0.633 (0.632~0.634)
<b>(b)</b>	E (number tested) = 30 + 30 × P(1 or 2) = 30 + 30 × 0.5976 = 47.9	M1 m1 A1	3	M1 reasonable attempt at method m1 completely correct method A1 47.9 ( 47.8~48)
<b>Total</b>			<b>8</b>	
<b>5(a)(i)</b>	$z = \frac{1001-998}{2.9/\sqrt{6}} = 2.534$	M1 m1		M1 use of $2.9/\sqrt{6}$
<b>(ii)</b>	P(accept) = 1 – 0.994 = 0.006 $z = \frac{1001-1004}{2.9/\sqrt{6}} = -2.534$	m1		m1 method for either z — ignore sign  m1 completely correct method both probabilities — allow interchanged A1 0.006 ( 0.005 ~ 0.006 ) and 0.994 ( 0.994 ~ 0.995 )
<b>(b)</b>	P(accept) = 0.994 on insert	A1 M1	4	M1 method for graph
<b>(c)</b>	999.5	A1 M1	2	A1 reasonably accurate plot — by eye M1 method — needs M1 in (b)
<b>(d)</b>	$\frac{999.5-1001}{2.9/\sqrt{n}} < -1.6449$ $\sqrt{n} > 1.6449 \times \frac{2.9}{1.5}$ $n > 3.180^2$ $n = 11$	A1 M1 B1 m1  m1  A1	2  2  5	A1 999.5 ( 999.3~999.6) M1 reasonable attempt at expression (generous) B1 1.6449 ( 1.64 ~ 1.65) m1 correct expression — allow <, >, = m1 method for manipulation of expression  A1 11 or at least 11
<b>Total</b>			<b>13</b>	
<b>6(a)</b>	Upper action $2.33 \times 2.3 = 5.359$ Upper warning $1.76 \times 2.3 = 4.048$ Lower warning $0.27 \times 2.3 = 0.621$ Lower action $0.09 \times 2.3 = 0.207$ + graph	M1 m1  A1	3	M1 method for upper limits m1 method for all limits  A1 accurate plot by eye Allow B1 if values for range charts used or if incorrect sample size (eg 7) used — but not both
<b>(b)(i)</b>	$\bar{x} = 399.0$ $s = 3.92$	B1	1	399 CAO and 3.92 (3.91~3.92)
<b>(ii)</b>	on graph	B1 B1	2	B1 accurate plot of means — by eye B1 accurate plot of sd — by eye
<b>(iii)</b>	Means — all within warning limits except sample 2 which is below lower action limit. Action appears to have been taken successfully. all 7 below target sd — all between warning limits but variability appears to be increasing over last 5 samples.	E1  E1  E1	3	an E mark for any sensible point — maximum 2 for each chart. Maximum 3 in total.

## SS06 (cont)

Q	Solution	Marks	Total	Comments																																																
6(c)	Sd between warning and action limits. Take another sample immediately if still above warning limit take action.	E1✓ E1	2	E1✓ sd <b>between</b> warning and action E1 take another sample immediately																																																
(d)(i)	$z_1 = \frac{392-396}{2.3} = -1.739$ $z_2 = \frac{408-396}{2.3} = 5.217$ proportion outside tolerance $1 - 0.959 = 0.041$	M1  A1	  2	M1 method — allow upper limit not considered  A1 0.041 (0.04~0.042)																																																
(ii)	Tolerance width $16 = \frac{16}{2.3} \approx 7sd$ Possible to meet tolerances consistently provided mean on target.	E1  E1	  2	E1 possible to meet tolerances as width $> 6\sigma$ ; needs some calculation  E1 provided mean is on target																																																
	Total		15																																																	
7(a)	<table><tr><td>P</td><td>Q</td><td>R</td><td>Total</td></tr><tr><td>J</td><td>23</td><td>33</td><td>42</td><td>98</td></tr><tr><td>Gi</td><td>46</td><td>37</td><td>79</td><td>162</td></tr><tr><td>Gw</td><td>56</td><td>44</td><td>80</td><td>180</td></tr><tr><td>N</td><td>54</td><td>60</td><td>75</td><td>189</td></tr><tr><td>Total</td><td>179</td><td>174</td><td>276</td><td>629</td></tr></table> $\text{Total SS} = 36721 - \frac{629^2}{12} = 3750.92$ $\text{Between designs SS} = \frac{179^2}{4} + \frac{174^2}{4} + \frac{276^2}{4} - \frac{629^2}{12} = 1653.17$ $\text{Between examiners SS} = \frac{98^2}{3} + \frac{162^2}{3} + \frac{180^2}{3} + \frac{189^2}{3} - \frac{629^2}{12} = 1686.25$ <table><tr><td>Source</td><td>SS</td><td>df</td><td>MS</td></tr><tr><td>Designs</td><td>1653.17</td><td>2</td><td>826.58</td></tr><tr><td>Examiners</td><td>1686.25</td><td>3</td><td></td></tr><tr><td>Error</td><td>411.5</td><td>6</td><td>68.58</td></tr><tr><td>Total</td><td>3750.92</td><td>11</td><td></td></tr></table> $H_0$ : No difference between designs $H_1$ : Difference between designs $F = \frac{826.58}{68.58} = 12.1$ Critical value $F_{2,6}$ is 5.143 Reject $H_0$ — significant evidence of difference between designs	P	Q	R	Total	J	23	33	42	98	Gi	46	37	79	162	Gw	56	44	80	180	N	54	60	75	189	Total	179	174	276	629	Source	SS	df	MS	Designs	1653.17	2	826.58	Examiners	1686.25	3		Error	411.5	6	68.58	Total	3750.92	11		M1  M1  M1  M1 B1 M1  m1 A1 B1 A1✓ A1✓	   <
P	Q	R	Total																																																	
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Gi	46	37	79	162																																																
Gw	56	44	80	180																																																
N	54	60	75	189																																																
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**SS06 (cont)**

<b>Q</b>	<b>Solution</b>	<b>Marks</b>	<b>Total</b>	<b>Comments</b>
<b>7(b)</b>	Results show significant evidence that not all means equal.	E1		E1 significant evidence of difference or Q different from R
	Hence Q (lowest mean/total) differs from R(highest mean/total).			
	However means/totals suggest P and Q similar.	E1		E1 P and Q similar
	Recommend choose design R.	E1	3	E1 Choose R
	<b>Total</b>		<b>14</b>	
	<b>TOTAL</b>		<b>75</b>	