



**General Certificate of Education (A-level)  
June 2013**

**Statistics**

**SS06**

**(Specification 6380)**

**Statistics 6**

**Final**

***Mark Scheme***

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## 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																								
1(a)(i)	H <sub>0</sub> pop mean diff $\mu_d = 0$ H <sub>1</sub> pop mean diff $\mu_d \neq 0$ 2 tail 5%	B1		Must refer to pop mean differences or $\mu_d$																								
	$d = K - EMC$																											
	<table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> </tr> </thead> <tbody> <tr> <td>d</td> <td>-0.4</td> <td>0.8</td> <td>-0.4</td> <td>-0.5</td> <td>0.1</td> </tr> <tr> <td></td> <th>6</th> <th>7</th> <th>8</th> <th>9</th> <th>10</th> </tr> <tr> <td></td> <td>-0.8</td> <td>-0.5</td> <td>0</td> <td>-0.6</td> <td>0.1</td> </tr> </tbody> </table>		1	2	3	4	5	d	-0.4	0.8	-0.4	-0.5	0.1		6	7	8	9	10		-0.8	-0.5	0	-0.6	0.1	M1		Differences – can be reversed
		1	2	3	4	5																						
	d	-0.4	0.8	-0.4	-0.5	0.1																						
		6	7	8	9	10																						
		-0.8	-0.5	0	-0.6	0.1																						
	$\bar{d} = -0.22$ $s = 0.471$ $n = 10$	m1		attempt to find $\bar{d}$ , $s$ can be implied																								
	$t = \frac{-0.22 - 0}{\frac{0.47}{\sqrt{10}}} = -1.48$	m1 m1 A1		Use of $\frac{s}{\sqrt{10}}$ ft Method for $t$ ( $\pm$ ) 1.48 (1.46 – 1.48)																								
	df = 9 $cv = -2.262$ $-2.262 < -1.48$	B1		for correct cv (or $p = 0.17 > 0.05$ B1)																								
Accept H <sub>0</sub>			*sc4 '0' ignored scores B1 M1m1m1 $\frac{s}{\sqrt{9}}$																									
<u>No significant evidence</u> to suggest that there is a difference in mean <u>measurements</u> for the two <u>devices</u> .	E1	8	correct conclusion in context																									
(ii) Assumed that <b>differences</b> in first ray <b>foot measurements</b> are <b>normally</b> distributed	E1 E1	2	Normal distribution mentioned <u>in a sentence</u> E1 Differences in foot measurements are normal gains other E1																									
(b)(i) Attempt at double ss 1 <sup>st</sup> 0 1 1 2 <sup>nd</sup> 0 1 for acceptance	M1																											
$P(\text{Acc}) = P(0) + P(1) \times P(0) + P(1) \times P(1)$ $= P(0) + P(1) \times P(1 \text{ or fewer})$ $= 0.5438 + 0.3364 \times 0.8802$ $= \mathbf{0.840}$ ( <b>0.839</b> )	M1 m1 A1	4	Use of B (20, 0.03) .5438, .3364, .8802 <u>Correct probs used in correct formula</u> cao																									
(ii) Expected number tested $= 20 + (\text{extra } 20) \times P(1)$ $= 20 + 20 \times 0.3364$  $= \mathbf{26.7}$	M1  A1	2	$20 + (20 \times \text{prob from } B(20, 0.03))$ as above  $26.5\text{--}26.8$ <u>disallow</u> integer answer																									
	<b>Total</b>		<b>16</b>																									

Q	Solution	Marks	Total	Comments															
2(a)(i)	The <b>furnace run</b>	B1																	
(ii)	The <b>dose</b> of implant material	B1																	
(iii)	To <b>eliminate bias</b> – ensures that all wafers were produced in the same way so <b>any difference detected should be due to implant dose or furnace run</b>	E1E1	4	E1 eliminate bias E1 any difference detected															
(b)(i)	Harriet’s design/Rand Block design <b>takes into account any differences</b> that result from the different <b>furnace runs</b> involved; Eric’s <b>does not take this into account</b>	E1		Harriet accounts for furnace effect															
		E1	2	Eric ignores furnace effect															
(ii)	<table border="1"> <thead> <tr> <th>F1</th> <th>F2</th> <th>F3</th> </tr> </thead> <tbody> <tr> <td>D1</td> <td>D1</td> <td>D1</td> </tr> <tr> <td>D2</td> <td>D2</td> <td>D2</td> </tr> <tr> <td>D3</td> <td>D3</td> <td>D3</td> </tr> <tr> <td>D4</td> <td>D4</td> <td>D4</td> </tr> </tbody> </table>	F1	F2	F3	D1	D1	D1	D2	D2	D2	D3	D3	D3	D4	D4	D4	B1 B1	2	Use of D1 – D4 Correctly placed – any order within each run
F1	F2	F3																	
D1	D1	D1																	
D2	D2	D2																	
D3	D3	D3																	
D4	D4	D4																	
(c)	Two factor analysis of variance	E1E1	2	ANOVA E1 Two factor E1															
	<b>Total</b>		<b>10</b>																

Q	Solution	Marks	Total	Comments																
3(a)(i)	<p><i>Low level    Medium level    High level</i>  <math>T_{\text{low}} = 85.8</math>    <math>T_{\text{med}} = 108.6</math>    <math>T_{\text{high}} = 85.6</math>  <math>n_{\text{low}} = 5</math>    <math>n_{\text{med}} = 6</math>    <math>n_{\text{high}} = 5</math></p> <p><math>T = 280</math></p> <p><math>\sum \sum x_{ij}^2 = 4910.2</math>    <math>N = 16</math></p> <p><math>\sum \frac{T_i^2}{n_i} = \frac{85.8^2}{5} + \frac{108.6^2}{6} + \frac{85.6^2}{5}</math>  <math>= 4903.46</math></p> <p><math>SS_{\text{treats}} = 4903.46 - \frac{280^2}{16}</math>  <math>= 3.46</math></p> <p><math>SS_{\text{Total}} = 4910.2 - \frac{280^2}{16}</math>  <math>= 10.2</math></p> <table border="1"> <thead> <tr> <th></th> <th>SS</th> <th>df</th> <th>ms</th> </tr> </thead> <tbody> <tr> <td>Treats</td> <td>3.46</td> <td>2</td> <td><b>1.73</b></td> </tr> <tr> <td>Error</td> <td><b>6.74</b></td> <td>13</td> <td><b>0.52</b></td> </tr> <tr> <td>Total</td> <td>10.2</td> <td>15</td> <td></td> </tr> </tbody> </table> <p><math>F = \frac{1.73}{0.52} = 3.33</math></p> <p><math>F_{13}^2 = 3.806</math></p> <p><math>H_0 \mu_{\text{low}} = \mu_{\text{med}} = \mu_{\text{high}}</math>  <math>H_1</math> at least 2 of the means differ or  One mean sig different from others</p> <p><math>3.806 &gt; 3.33</math> <b>Accept <math>H_0</math>.</b>  There is no significant evidence of a difference in mean breaking strength for the 3 thread treatment levels.</p>		SS	df	ms	Treats	3.46	2	<b>1.73</b>	Error	<b>6.74</b>	13	<b>0.52</b>	Total	10.2	15		<p>M1</p> <p>M1</p> <p>M1dep</p> <p>M1dep</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>B1</p> <p>A1</p>	<p>10</p>	<p>SS for treatments</p> <p>SS for total</p> <p>Error SS ft ( not –ve)  Either ms correct method (SS/df)</p> <p>Method for F (ft) ‘their ms treats/ms error’  3.1–3.5</p> <p>df correct 2,13  cv correct ( or <math>p = 0.068 &gt; 0.05</math> B2)</p> <p>Hypotheses</p> <p>Conclusion correct</p>
	SS	df	ms																	
Treats	3.46	2	<b>1.73</b>																	
Error	<b>6.74</b>	13	<b>0.52</b>																	
Total	10.2	15																		
(a)(ii)	<p>Since there is <b>no significant difference</b> detected between mean <b>breaking strength</b> for the <b>three</b> thread <b>treatments/levels</b>, the company should <b>not be advised</b> to use any one particular treatment level.</p>	<p>E1</p> <p>E1</p>	<p>2</p>	<p>No difference in strengths for treatments</p> <p>Could not advise company to use a specific level of treatment or choose cheapest/easiest to obtain</p>																
(b)	<p>The <b>Kruskal–Wallis</b> test as this is distribution free so <b>does not depend on assumption that breaking strengths are normally distributed.</b></p>	<p>B1</p> <p>E1dep</p>	<p>2</p>	<p>Kruskal–Wallis</p> <p>Does not require underlying normal distribution/distribution free.</p>																
	<b>Total</b>		<b>14</b>																	

Q	Solution	Marks	Total	Comments
4(a)(i)	Warning			
	$1 \pm 1.96 \times \frac{0.015}{\sqrt{4}}$ <b><u>(0.985, 1.015)</u></b>	B1		For 1.96 and 3.09
		M1		For $\frac{0.015}{\sqrt{4}}$
	Action			
	$1 \pm 3.09 \times \frac{0.015}{\sqrt{4}}$ <b><u>(0.977, 1.023)</u></b>	A1		Warning correct to 3 dp
		A1		Action correct to 3 dp
	(ii) Standard deviations			
	$0.015 \times 0.09 = 0.0013(5)$ <b><u>0.001</u></b>	M1	6	E values correct $\times 0.015$ Correct to 3 dp
	$0.015 \times 0.27 = 0.0040(5)$ <b><u>0.004</u></b>	M1		
	$0.015 \times 1.76 = 0.0264$ <b><u>0.026</u></b>	A1		
$0.015 \times 2.33 = 0.0350$ <b><u>0.035</u></b>	A1			
(b)(i)	Sample 5 Sample 6 Sample 7 Sample 8			
	$\bar{x}$ (1.010) <b><u>0.980</u></b> 1.000 <b><u>0.995</u></b>	M1 M1	3	One mean OK One sd OK All means and sd values correct
$s$ <b><u>0.041</u></b> (0.022) 0.032 <b><u>0.029</u></b>	A1			
(ii)	Since sd <b>beyond upper action limit</b> production <b>should have been stopped.</b>	M1 A1	2	A1 dep on M1 scB1 Production stopped
(iii)	Process fine up to sample 5	E1		
	Mean <b>sample 6</b> is <b><u>0.980</u></b> ( between warning and action limits)	E1		Sample 6 a warning for mean
	Sd <b>sample 5</b> a <b>problem</b> Samples <b>7 and 8</b> sd lie between <b>warning</b> <b>and action limits.</b>	E1	3	General comments on sd problems - beyond action for sample 5 or problems for samples 7 and 8.
(c)	$P(0.9853 < \bar{X} < 1.0147)$	M1		Identification of need for evaluation of probability of mean between values 0.985 – 1.015
	$z = \frac{0.9853 - 1.004}{\frac{0.02}{\sqrt{4}}} = -1.87$			
	$z = \frac{1.0147 - 1.004}{\frac{0.02}{\sqrt{4}}} = 1.07$	M1		z-values
	$P(0.9853 < \bar{X} < 1.0147) = \mathbf{0.827}$	A1	3	0.82 – 0.84
	<b>Total</b>		<b>17</b>	





Q	Solution	Marks	Total	Comments
5(b)(iii)	There is <u>no</u> significant evidence of a <u>difference in mean miles per gallon/fuel efficiency</u> between the <u>four blends of petrol</u> and also none between the <u>four models of car</u> .	E1	2	No difference in mean mpg/miles for either blends or models.
		E1		Fully explained in context using ‘mean mpg’ or ‘fuel eff’, ‘blends of petrol’ and models of car’
	(c)	Fuel efficiency <u>measurements</u> , mpg, are <u>normally distributed</u> . There is a <u>common underlying variability</u> for mpg <u>measurements</u> . There is <u>no interaction</u> between <u>petrol blend</u> , <u>car model</u> and <u>driver</u> .	E1	3
	<b>Total</b>		<b>18</b>	
	<b>TOTAL</b>		<b>75</b>	