



**General Certificate of Education**

**Mathematics 6360**

**MS2B      Statistics 2B**

**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.

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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	follow through from previous		
F	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.**

## MS2B

Q	Solution	Marks	Total	Comments																																																																								
1	<p><math>H_0</math>: No association between choice of subject and gender  <math>H_1</math>: Association between choice of subject and gender</p> <table border="1"> <thead> <tr> <th></th> <th>Bul</th> <th>CI</th> <th>Fin</th> <th>Pol</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Male</td> <td>7</td> <td>31</td> <td>25</td> <td>40</td> <td>103</td> </tr> <tr> <td>Female</td> <td>2</td> <td>24</td> <td>22</td> <td>19</td> <td>67</td> </tr> <tr> <td>Total</td> <td>9</td> <td>55</td> <td>47</td> <td>59</td> <td>170</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th><math>O_i</math></th> <th><math>E_i</math></th> </tr> </thead> <tbody> <tr> <td>7</td> <td>5.45</td> </tr> <tr> <td>2</td> <td>3.55</td> </tr> <tr> <td>31</td> <td>33.32</td> </tr> <tr> <td>24</td> <td>21.68</td> </tr> <tr> <td>25</td> <td>28.48</td> </tr> <tr> <td>22</td> <td>18.52</td> </tr> <tr> <td>40</td> <td>35.75</td> </tr> <tr> <td>19</td> <td>23.25</td> </tr> <tr> <td><b>170</b></td> <td><b>170</b></td> </tr> </tbody> </table> <p>One of the <math>E_i</math>'s <math>&lt; 5</math> <math>\therefore</math> combine cells</p> <table border="1"> <thead> <tr> <th><math>O_i</math></th> <th><math>E_i</math></th> <th><math>\alpha = (O_i - E_i)</math></th> <th><math>\alpha^2 / E_i</math></th> </tr> </thead> <tbody> <tr> <td>47</td> <td>41.20</td> <td>5.8</td> <td>0.8165</td> </tr> <tr> <td>21</td> <td>26.80</td> <td>-5.8</td> <td>1.2552</td> </tr> <tr> <td>31</td> <td>33.32</td> <td>-2.32</td> <td>0.1615</td> </tr> <tr> <td>24</td> <td>21.68</td> <td>2.32</td> <td>0.2483</td> </tr> <tr> <td>25</td> <td>28.48</td> <td>-3.48</td> <td>0.4252</td> </tr> <tr> <td>22</td> <td>18.52</td> <td>3.48</td> <td>0.6539</td> </tr> </tbody> </table> <p>Test statistic: <math>X^2 = 3.56</math>  Critical value: <math>\quad = 4.605</math></p> <p>Accept <math>H_0</math></p> <p>Insufficient evidence to suggest that the choice of subject is associated with gender.</p>		Bul	CI	Fin	Pol	Total	Male	7	31	25	40	103	Female	2	24	22	19	67	Total	9	55	47	59	170	$O_i$	$E_i$	7	5.45	2	3.55	31	33.32	24	21.68	25	28.48	22	18.52	40	35.75	19	23.25	<b>170</b>	<b>170</b>	$O_i$	$E_i$	$\alpha = (O_i - E_i)$	$\alpha^2 / E_i$	47	41.20	5.8	0.8165	21	26.80	-5.8	1.2552	31	33.32	-2.32	0.1615	24	21.68	2.32	0.2483	25	28.48	-3.48	0.4252	22	18.52	3.48	0.6539	<p>B1</p> <p>B1</p> <p>M1A1</p> <p>M1A1</p> <p>m1</p> <p>A1 B1F</p> <p>A1F</p> <p>E1</p>	<p>11</p>	<p>Totals</p> <p>E's attempted (correctly)</p> <p>Attempt at combining (correctly)</p> <p>Final column</p> <p>(AWFW 3.55 to 3.57) ft on their <math>\nu</math></p>
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## MS2B (cont)

Q	Solution	Marks	Total	Comments
<b>2(a)</b>	$H_0: \mu = 8.0$ $H_1: \mu \neq 8.0$	B1		
	$\bar{x} = \frac{84}{9} = 9.3\dot{3}$ or $9\frac{1}{3}$	B1		
	$z_{crit} = \pm 1.96$	B1		
	$z = \frac{9.33 - 8.0}{\frac{2.5}{\sqrt{9}}} = 1.60$	M1		$z = \frac{(\text{their } \bar{x}) - 8}{\frac{2.5}{\sqrt{9}}}$
	$ z  < 1.96 \quad \therefore \text{accept } H_0$	A1 A1F		AWFW 1.59 to 1.60 ft on incorrect $\bar{x}$
	Insufficient evidence to suggest that the mean completion time has changed from eight weeks.	E1F	7	
<b>(b)</b>	Neither a Type I nor a Type II error have occurred	B1		dependent
	Have accepted that $H_0: \mu = 8.0$ , when $\mu = 8.0$ .	B1	2	dependent on 'accept $H_0$ ' in (a)
	<b>Total</b>		<b>9</b>	
<b>3(a)(i)</b>	$P(X \leq 3) = 0.515$	B1	1	0.5152
	<b>(ii)</b> $P(Y = 5) = \frac{e^{-4.4} \times (4.4)^5}{5!}$ $= 0.169$	M1 A1	2	$P(Y \leq 5) - P(Y \leq 4) = 0.7199 - 0.5512$ correct values seen (0.1687)
<b>(b)(i)</b>	$T = \text{Po}(8.0)$ $X$ and $Y$ are <b>independent</b> (Poisson random variables)	B1 B1	2	
	<b>(ii)</b> $P(6 < T < 12) = P(T \leq 11) - P(T \leq 6)$ $= 0.8881 - 0.3134$ $= 0.575$	M1 A1 A1	3	(0.5747)
<b>(iii)</b>	$P(T > 14) = 1 - P(T \leq 14)$ $= 1 - 0.9827$ $= 0.0173$ $p = (0.0173)^2$ $= 0.0003$ (1sf)	M1 A1 M1 A1F	4	CAO [their $P(T > 14)$ ] <sup>2</sup> ft if $0 < \text{both } p$ 's $< 1$
	<b>(iv)</b> $P(T \leq k) > 0.99$ $\Rightarrow k \geq 15$ $\therefore$ minimum number of devices that Joe should keep in stock = 15	M1 A1	2	$\begin{cases} P(T \leq 15) = 0.9918 \\ P(T \leq 14) = 0.9827 \end{cases}$
	<b>Total</b>		<b>14</b>	

## MS2B (cont)

Q	Solution	Marks	Total	Comments
4(a)	$P\left(-\frac{3c}{4} < X < \frac{3c}{4}\right)$ $= \frac{\frac{3c}{4} + c}{4c} - \frac{\frac{-3c}{4} + c}{4c}$ $= \frac{6c}{16c}$ $= \frac{3}{8} \text{ or } 0.375$	M1		or $= \frac{3c}{2} \times \frac{1}{4c}$
(b)	For $-c \leq x \leq 3c$ $f(x) = \frac{d}{dx} \left( \frac{x+c}{4c} \right)$ $= \frac{1}{4c}$ For $x > 3c$ and $x < -c$ $f(x) = \frac{d}{dx}(F) = 0$	M1		use of $f(x) = F'(x)$
(c)(i)	Rectangular distribution: $E(X) = \frac{1}{2}(-c + 3c) = c$	B1	1	
(ii)	$\text{Var}(X) = \frac{1}{12}(3c - (-c))^2 = \frac{4c^2}{3}$	B1	1	Allow $\frac{16c^2}{12}$
<b>Total</b>			<b>6</b>	
5(a)(i)	$\bar{x} = \frac{1}{2}(70.65 + 80.35) = 75.5$	B1	1	AG
(ii)	Width of confidence interval $= 80.35 - 70.65$ $= 9.7$	B1	1	
(iii)	$t_{crit} = 2.602; \nu = 15$ $w = 2t \times \frac{s}{\sqrt{n}} \Rightarrow \frac{s}{\sqrt{n}} = \frac{9.7}{2 \times 2.602}$ $\text{Estimate of s.e.} = \frac{s}{\sqrt{n}} = 1.86$	M1		
(iv)	Unbiased estimate of $\sigma^2 = 1.86^2 \times 16$ $= 55.6 \text{ (3sf)}$	A1	2	(1.864) AG (55.589)

## MS2B (cont)

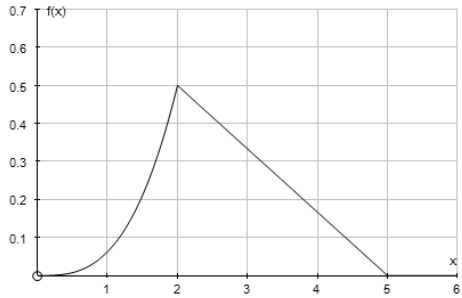
Q	Solution	Marks	Total	Comments										
5(b)	$95\% \text{ CI: } 75.5 \pm 2.131 \times \frac{s}{\sqrt{n}}$ $= 75.5 \pm 3.972$ $= (71.5, 79.5)$	M1 A1	2	(71.5 to 71.54, 79.4 to 79.5) CAO										
(c)(i)	(73.0, 78.0)	B1	1											
(ii)	$w = 2t \times \frac{s}{\sqrt{n}} \Rightarrow t = \frac{5}{2 \times 1.864} = 1.341$ $\Rightarrow \text{for } \nu = 15 \quad P(X \leq 1.341) = 0.90$ $\Rightarrow P(X \geq 1.341) = 0.10 \quad \text{and}$ $P(X \leq -1.341) = 0.10$ $\therefore P( X  \leq 1.341) = 0.80$	M1  M1		(AWFW 1.341 to 1.344)										
	Percentage confidence interval = 80%	A1	3											
<b>Total</b>			<b>13</b>											
6(a)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td><math>r</math></td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> </tr> <tr> <td><math>P(R=r)</math></td> <td><math>\frac{2}{3}</math></td> <td><math>\frac{2}{9}</math></td> <td><math>\frac{2}{27}</math></td> <td><math>k</math></td> </tr> </table> $k + \frac{2}{3} + \frac{2}{9} + \frac{2}{27} = 1 \Rightarrow k = \frac{1}{27}$	$r$	1	2	3	4	$P(R=r)$	$\frac{2}{3}$	$\frac{2}{9}$	$\frac{2}{27}$	$k$	M1 A1	2	AG
$r$	1	2	3	4										
$P(R=r)$	$\frac{2}{3}$	$\frac{2}{9}$	$\frac{2}{27}$	$k$										
(b)	$P(R \geq 3) = \frac{2}{27} + \frac{1}{27} = \frac{1}{9}$	B1	1	Allow $\frac{3}{27}$ or 0.111										
(c)(i)	$C = 27R + 5$ $E(R) = \left(1 \times \frac{2}{3}\right) + \left(2 \times \frac{2}{9}\right) + \left(3 \times \frac{2}{27}\right) + \left(4 \times \frac{1}{27}\right)$ $= 1 \frac{13}{27}$ $\therefore E(C) = 27 \times 1 \frac{13}{27} + 5$ $= 45$	B1  M1 A1F	3	(1.48) or $\frac{40}{27}$										

**MS2B (cont)**

Q	Solution	Marks	Total	Comments																				
<b>6(c)(ii)</b>	$E(R^2) = \left(1 \times \frac{2}{3}\right) + \left(4 \times \frac{2}{9}\right) + \left(9 \times \frac{2}{27}\right) + \left(16 \times \frac{1}{27}\right)$ $= 2\frac{22}{27} \text{ or } \frac{76}{27}$ $\text{Var}(R) = 2\frac{22}{27} - \left(1\frac{13}{27}\right)^2$ $= \frac{452}{729}$ $\therefore \text{St. dev}^n(C) = 27 \times \sqrt{\frac{452}{729}}$ $= 21.3$	<p>B1</p> <p>M1</p> <p>M1</p> <p>A1</p>	<p>4</p>	<p>(2.81)</p> <p>(0.62)</p> <p><math>27 \times \sqrt{\text{Var}(R)}</math> [ <math>\text{Var}(R) &gt; 0</math> ]</p> <p>CAO (21.26)</p> <p>SC: <math>\text{Var}(C) = 452</math> (CAO) (B1M1B1A0)</p>																				
<b>Total</b>			<b>10</b>																					
<p><b>Alternative (c)</b></p> <table border="1"> <tr> <td><i>C</i></td> <td>32</td> <td>59</td> <td>86</td> <td>113</td> </tr> <tr> <td><i>p</i></td> <td><math>\frac{2}{3}</math></td> <td><math>\frac{2}{9}</math></td> <td><math>\frac{2}{27}</math></td> <td><math>\frac{1}{27}</math></td> </tr> </table> <table border="1"> <tr> <td><i>C</i></td> <td>32</td> <td>59</td> <td>86</td> <td>113</td> </tr> <tr> <td><i>n</i></td> <td>18</td> <td>6</td> <td>2</td> <td>1</td> </tr> </table> <p><math>\bar{x} = 45</math> and <math>\sigma = 21.260</math> from calculator</p>		<i>C</i>	32	59	86	113	<i>p</i>	$\frac{2}{3}$	$\frac{2}{9}$	$\frac{2}{27}$	$\frac{1}{27}$	<i>C</i>	32	59	86	113	<i>n</i>	18	6	2	1			$\left( \bar{x} = \frac{\sum Cn}{27} \right)$
<i>C</i>	32	59	86	113																				
<i>p</i>	$\frac{2}{3}$	$\frac{2}{9}$	$\frac{2}{27}$	$\frac{1}{27}$																				
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<i>n</i>	18	6	2	1																				



## MS2B (cont)

Q	Solution	Marks	Total	Comments
7(a)		B1 B1 B1	3	for concave curve from (0, 0) to (2, 0.5) for straight line from (2, 0.5) to (5, 0) for axes [2, 5 ; 0.5] seen
(b)	$P(X \geq 2) = \frac{1}{2} \times 3 \times 0.5 = 0.75$ $\Rightarrow F(2) = 0.25$ $2 \leq x \leq 5$ $F(x) = F(2) + \int_2^x \frac{1}{6}(5-x) dx$ $= 0.25 + \frac{1}{6} \left[ 5x - \frac{x^2}{2} \right]_2^x$ $= 0.25 + \frac{1}{6} \left( 5x - \frac{x^2}{2} \right) - \frac{1}{6} (10 - 2)$ $= 0.25 - \frac{8}{6} + \frac{5x}{6} - \frac{x^2}{12}$ $= -\frac{1}{12} (x^2 - 10x + 13)$ $= 1 - \frac{1}{12} (5-x)^2$	M1 A1 M1 A1	4	<b>Alternatives:</b> $\int \frac{1}{6}(5-x) dx = \frac{1}{6} \times \frac{(5-x)^2 \times (-1)}{2}$ $= -\frac{1}{12} (5-x)^2$ Or $F(x) = 1 - \text{Area } \triangle (\text{base } x, 5)$ $= 1 - \frac{1}{2} (5-x) \frac{1}{6} (5-x)$ $= 1 - \frac{1}{12} (5-x)^2$
(c)	$P(X \leq 4) = F(4)$ $= 1 - \frac{1}{12} (5-4)^2 = \frac{11}{12} \quad (0.916 \text{ to } 0.917)$ $F(3) = 1 - \frac{1}{12} (2)^2 = \frac{2}{3} \quad (0.667)$ $P(X \geq 3 \text{ and } X \leq 4) = F(4) - F(3)$ $= \frac{11}{12} - \frac{2}{3} = \frac{1}{4} \quad (0.25)$ $P(X \geq 3   X \leq 4) = \frac{F(4) - F(3)}{F(4)}$ $= \frac{1/4}{11/12} = \frac{3}{11}$	B1 B1 B1 M1 A1	5	<b>Alternative:</b> $P(X \geq 3   X \leq 4)$ $= \frac{F(4) - F(3)}{F(4)} \quad (\text{M1})$ $= 1 - \frac{F(3)}{F(4)}$ $= 1 - \frac{2/3}{11/12}$ $= 1 - \frac{8}{11} \quad (\text{B1}) (0.727\bar{2})$ $= \frac{3}{11} \quad (\text{AWFW } 0.272 \text{ to } 0.273)$
	<b>Total</b>		<b>12</b>	
	<b>TOTAL</b>		<b>75</b>	