



**General Certificate of Education
June 2010**

Mathematics

MS2B

Statistics 2B

Mark Scheme

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 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.

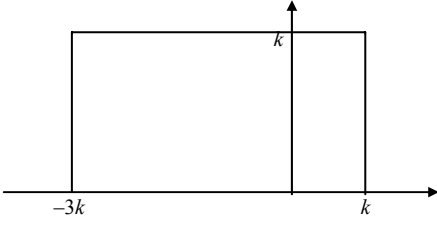
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

MS2B

Q	Solution	Marks	Total	Comments																								
1	$\bar{x} = 82$; $s^2 = 31.1$ ($s = 5.58$) Assumption: The number of customers served daily at the post office counter forms a Normal distribution. $H_0: \mu = 79$ $H_1: \mu > 79$ $t = \frac{82 - 79}{5.58 / \sqrt{12}}$ $t = 1.86$ $\nu = 11 \Rightarrow t_{\text{crit}} = 1.796$ Reject H_0 Sufficient evidence at 5% level of significance to support Judith's belief.	B1B1 B1 B1 M1 A1 B1 A1 E1	9	their $\bar{x} - 79$ their $s / \sqrt{12}$ (AWRT) Iff $t_{\text{calc}} > t_{\text{crit}}$																								
Total			9																									
2	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>O_i</th> <th>E_i</th> <th>$(O_i - E_i - 0.5)$ (α)</th> <th>α^2 / E_i</th> </tr> </thead> <tbody> <tr> <td>24</td> <td>28</td> <td>3.5</td> <td>0.4375</td> </tr> <tr> <td>56</td> <td>52</td> <td>3.5</td> <td>0.2356</td> </tr> <tr> <td>11</td> <td>7</td> <td>3.5</td> <td>1.7500</td> </tr> <tr> <td>9</td> <td>13</td> <td>3.5</td> <td>0.9423</td> </tr> <tr> <td colspan="3"></td> <td>3.3654</td> </tr> </tbody> </table> H_0 : No association between drug and prevention of sickness H_1 : Association between drug and prevention of sickness $\chi^2_{5\%} = 3.841$ Accept H_0 No evidence at the 5% level of significance to support the claim that the drug is effective against sickness.	O_i	E_i	$(O_i - E_i - 0.5)$ (α)	α^2 / E_i	24	28	3.5	0.4375	56	52	3.5	0.2356	11	7	3.5	1.7500	9	13	3.5	0.9423				3.3654	M1 M1 M1 A1 B1 B1 A1ft E1ft	8	E attempted Yates' correction attempted χ^2 attempted AFWF 3.36 to 3.37 (at least H_0 stated correctly) CAO
O_i	E_i	$(O_i - E_i - 0.5)$ (α)	α^2 / E_i																									
24	28	3.5	0.4375																									
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Total			8																									

MS2B

Q	Solution	Marks	Total	Comments
3(a)(i)		B2,1	2	Horizontal line $f(x) = k$ From $-3k$ to k If $\frac{1}{2}$ then max. B1
(ii)	$\text{Area} = 4k \times k = 1$ $k^2 = \frac{1}{4}$ $k = \frac{1}{2} \quad (k > 0)$	M1 A1	2	SC If use $k = \frac{1}{2}$ to show that the Area = 1 then \Rightarrow B1 AG
(b)	$E(X) = \frac{1}{2}(-3k + k)$ $= -k$ $= -\frac{1}{2}$	B1		CAO
	$\text{Var}(X) = \frac{1}{12}(k - -3k)^2 = \frac{16k^2}{12} = \frac{4k^2}{3}$ $= \frac{1}{3}$	M1		CAO
	$\text{st. dev}(X) = \frac{1}{\sqrt{3}} \text{ or } \frac{\sqrt{3}}{3} \text{ or } \sqrt{\frac{1}{3}}$	A1	3	OE (exact)
(c)(i)	$P\left(X \geq -\frac{1}{4}\right) = \frac{1}{2} \times \frac{3}{4}$ $= \frac{3}{8} \quad (0.375)$	M1 A1	2	
(ii)	$P\left(X \neq -\frac{1}{4}\right) = 1$	B1	1	
	Total		10	

MS2B (cont)

Q	Solution	Marks	Total	Comments
4	$\left. \begin{aligned} \bar{x} &= \frac{0.35}{10} = 0.035 \\ s^2 &= \frac{0.12705}{9} = 0.0141 \text{ or } (s = 0.1188) \end{aligned} \right\}$ $t_{\text{crit}} = 3.250$ <p>99% CI for μ:</p> $\left. \begin{aligned} 0.035 \pm 3.25 \times \frac{\sqrt{0.0141}}{\sqrt{10}} \\ 0.035 \pm 0.1221 \end{aligned} \right\}$ $(-0.087, 0.157)$	<p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>A1</p>	<p>5</p> <p>5</p>	<p>both</p> $0.035 \pm 3.25 \times \frac{\sqrt{0.012705}}{\sqrt{9}}$ <p>Iff \bar{x}, s and $t_9 = 3.25$ all correct in expression</p> <p>CAO (3dp only)</p>
	Total		5	

MS2B (cont)

Q	Solution	Marks	Total	Comments
5(a)(i)	$X \sim \text{Po}(7)$ $P(X \leq 5) = 0.301$	B1	1	AWFW 0.300 and 0.301
(ii)	$P(X = 7) = \frac{e^{-7} \times 7^7}{7!}$ $= 0.149$	M1 A1	2	$P(X \leq 7) - P(X \leq 6)$ $= 0.5987 - 0.4497$ (M1) $= 0.149$ (A1)
(iii)	$0.65 \leq p \leq 0.66$	B3		$P(X \leq 9) - P(X \leq 4)$
	$0.72 \leq p \leq 0.73$ or $0.52 \leq p \leq 0.53$	(B2)		$\left\{ \begin{array}{l} P(X \leq 10) - P(X \leq 4) \\ P(X \leq 9) - P(X \leq 5) \end{array} \right.$
	0.60	(B1)	3	$P(X \leq 10) - P(X \leq 5)$
(b)	No. telephone calls received per hour $= Y \sim P_0(0.875)$	B1	1	
(c)(i)	Maximum number = 4	B1	1	
(ii)	$P(Y < 4) = P(Y = 0, 1, 2, 3)$ $= e^{-0.875} \left(1 + \frac{7}{8} + \frac{49}{128} + \frac{343}{3072} \right)$ $= 0.4169(1 + 0.875 + 0.3828 + 0.1117)$ $= 0.987740443$	B2		Any correct expression (B2) or AFWW 0.987 to 0.988
	$P(Y \geq 4) = 1 - 0.9877$ $= 0.0123$	M1 A1	4	$1 - (\text{their } P(Y < 4))$ AWFW 0.0122 and 0.0123
(d)	λ probably not constant The number of calls in any time interval of 1 hour is likely to vary throughout the day.	E1	1	SC $P(Y \leq 4) = 0.997$ to 0.998 } B2 or any correct expression } $P(Y > 4) = 0.002$ to 0.003 M1A0 ‘System Down’ \Rightarrow not independent
	Total		13	

MS2B (cont)

Q	Solution	Marks	Total	Comments
6(a)(i)	$P(R \geq 5) = 0.3 + 0.25 + 0.1 + 0.05$ $= 0.70$	B1	1	CAO
(ii)	$E(R) = \sum rp$ $= 3 \times 0.1 + 4 \times 0.2 + 5 \times 0.3 +$ $6 \times 0.25 + 7 \times 0.1 + 8 \times 0.05$ $= 5.2$	M1 A1	2	
(iii)	$E(R^2) = 9 \times 0.1 + 16 \times 0.2$ $+ 25 \times 0.3 + 36 \times 0.25$ $+ 49 \times 0.1 + 64 \times 0.05$ $(= 28.7)$ $\text{Var}(R) = 28.7 - 5.2^2$ $= 1.66$	M1A1		(Correct expression or 28.7)
(b)(i)	$P(R + S = 6) = 0.1 \times 0.15 = 0.015$ $P(R + S = 7) = 0.1 \times 0.4 + 0.2 \times 0.15$ $= 0.04 + 0.03$ $= 0.07$ $P(R + S = 8) = 0.2 \times 0.4 + 0.1 \times 0.3$ $+ 0.3 \times 0.15$ $= 0.08 + 0.03 + 0.045$ $= 0.155$ $P(R + S \leq 8) = 0.015 + 0.07 + 0.155$ $= 0.24$	M1 A1 B1 B1 B1 M1 A1	4	AG $P(R = 3 \text{ and } S \leq 5) = 0.1 \times 0.85 = 0.085$ $P(R = 4 \text{ and } S \leq 4) = 0.2 \times 0.55 = 0.110$ $P(R = 5 \text{ and } S \leq 3) = 0.3 \times 0.15 = 0.045$ $P(R + S \leq 8) = 0.085 + 0.110 + 0.045$ $= 0.24$ (AG)
(ii)	$p = {}^5C_4 (0.24)^4 (0.76)$ $+ (0.24)^5$ $= 0.0126 + 0.000796$ $= 0.0134$	M1 M1 A1	5	First term correct + correct second term or correct numerical values (must use $p = 0.24$) (0.013 to 0.0135)
(iii)	$P(R = 4 R + S \leq 8)$ $= \frac{P(R = 4 \text{ and } R + S \leq 8)}{P(R + S \leq 8)}$ $= \frac{0.03 + 0.08}{0.24}$ $= \frac{11}{24} \text{ (0.458)}$	B1 M1 A1	3	Alternative: (using (b)(i)) $= \frac{P(R = 4 \text{ and } S \leq 4)}{P(R + S \leq 8)}$ $= \frac{0.11}{0.24} = \frac{11}{24}$ (numerator) or 0.11 seen ($\div 24$ iff numerator < 0.24)
	Total		18	

MS2B (cont)

Q	Solution	Marks	Total	Comments
7(a)	Median = 1	B1		
	Lower quartile = $\frac{1}{2}$	B1	2	
(b)	$F(1) = \frac{1}{2}$			
	For $1 \leq x \leq 4$			
	$\int \frac{1}{18}(x-4)^2 dx$	M1		ignore limits
	$= \left[\frac{1}{54}(x-4)^3 \right]_1^x$			
	$= \left[\frac{1}{54}(x-4)^3 + \frac{1}{2} \right]$	A1		Correct integration + correct limits seen or used
	$F(x) = \left[\frac{1}{54}(x-4)^3 + \frac{1}{2} \right] + \frac{1}{2}$	m1		adding $\frac{1}{2}$ or F(1)
	$= 1 + \frac{1}{54}(x-4)^3$	A1	4	CAO (AG)
	Alternative			Alternative
	$\int \frac{1}{18}(x-4)^2 dx = \frac{1}{54}(x-4)^3 + c$	(M1)		$\int \frac{1}{18}(x-4)^2 dx$ (M1)
	$F(1) = \frac{1}{2} \Rightarrow c = 1$	(m1) (A1)		$= \int_1^x \frac{1}{18}(x^2 - 8x + 16) dx$
	$F(x) = 1 + \frac{1}{54}(x-4)^3$	(A1)		$= \frac{1}{18} \left[\frac{x^3}{3} - 4x^2 + 16x \right]_1^x$ (A1)
				$F(x) = \frac{1}{2} + \frac{1}{54}[x^3 - 12x^2 + 48x]_1^x$ (m1)
				$= \frac{1}{2} + \frac{1}{54}(x^3 - 12x^2 + 48x - 37)$
				$= 1 + \frac{1}{54}(x^3 - 12x^2 + 48x - 64)$
				$= 1 + \frac{1}{54}(x-4)^3$ (A1)
(c)	$P(2 \leq X \leq 3) = \frac{53}{54} - \frac{46}{54}$	M1		F(3) - F(2)
	$= \frac{7}{54} \quad (0.130)$	A1	2	0.1296
(d)(i)	$F(q) = \frac{3}{4}$	M1		use of $F(q) = \frac{3}{4}$
	$1 + \frac{1}{54}(q-4)^3 = \frac{3}{4}$			
	$\frac{1}{54}(q-4)^3 = -\frac{1}{4}$	M1		(either)
	$(\times 54) \Rightarrow (q-4)^3 = -13.5$	A1	3	AG
(ii)	$q-4 = \sqrt[3]{-13.5} = -2.3811 \quad q = 1.619$ (3dp)	B1	1	CAO
	Total		12	
	TOTAL		75	