Version 1.0



General Certificate of Education
June 2010

Mathematics MS2B

Statistics 2B

Mark Scheme

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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.

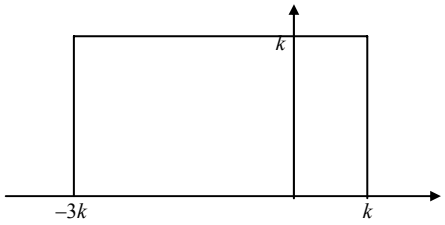
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

MS2B

Q	Solution	Marks	Total	Comments
1	$\bar{x} = 82 \ ; \ s^2 = 31.1 \ (s = 5.58)$	B1B1		
	Assumption: The number of customers served daily at the post office counter forms a Normal distribution.	B1		
	$H_0: \mu = 79$ $H_1: \mu > 79$	B1		
	$t = \dfrac{82 - 79}{5.58/\sqrt{12}}$	M1		$\dfrac{\text{their } \bar{x} - 79}{\text{their } s/\sqrt{12}}$
	$t = 1.86$	A1		(AWRT)
	$\nu = 11 \ \Rightarrow \ t_{\text{crit}} = 1.796$	B1		
	Reject H_0	A1		
	Sufficient evidence at 5% level of significance to support Judith's belief.	E1	9	Iff $t_{\text{calc}} > t_{\text{crit}}$
	Total		**9**	
2				
	O_i | E_i | $(\lvert O_i - E_i \rvert - 0.5)$ (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		E attempted Yates' correction attempted χ^2 attempted AWFW 3.36 to 3.37
	H_0: No association between drug and prevention of sickness	B1		(at least H_0 stated correctly)
	H_1: Association between drug and prevention of sickness			
	$\chi^2_{5\%} = 3.841$	B1		CAO
	Accept H_0	A1ft		
	No evidence at the 5% level of significance to support the claim that the drug is effective against sickness.	E1ft	8	
	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)	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
	st. dev$(X)=\frac{1}{\sqrt{3}}$ or $\frac{\sqrt{3}}{3}$ or $\sqrt{\frac{1}{3}}$	A1	3	OE (**exact**)
(c)(i)	$P\left(X\geq-\frac{1}{4}\right)=\frac{1}{2}\times\frac{3}{4}$	M1		
	$=\frac{3}{8}\quad(0.375)$	A1	2	
(ii)	$P\left(X\neq-\frac{1}{4}\right)=1$	B1	1	
	Total		**10**	

MS2B (cont)

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

MS2B (cont)

Q	Solution	Marks	Total	Comments
5(a)(i)	$X \sim \text{Po}(7)$ $\text{P}(X \leq 5) = 0.301$	B1	1	AWFW 0.300 and 0.301
(ii)	$\text{P}(X = 7) = \dfrac{\text{e}^{-7} \times 7^7}{7!}$ $= 0.149$	M1 A1	2	$\text{P}(X \leq 7) - \text{P}(X \leq 6)$ $= 0.5987 - 0.4497$ (M1) $= 0.149$ (A1)
(iii)	$0.65 \leq p \leq 0.66$	B3		$\text{P}(X \leq 9) - \text{P}(X \leq 4)$
	$0.72 \leq p \leq 0.73$ **or** $0.52 \leq p \leq 0.53$	(B2)		$\begin{cases}\text{P}(X \leq 10) - \text{P}(X \leq 4) \\ \text{P}(X \leq 9) - \text{P}(X \leq 5)\end{cases}$
	0.60	(B1)	3	$\text{P}(X \leq 10) - \text{P}(X \leq 5)$
(b)	No. telephone calls received per hour $= Y \sim \text{P}_0(0.875)$	B1	1	
(c)(i)	Maximum number = 4	B1	1	
(ii)	$\text{P}(Y < 4) = \text{P}(Y = 0,1,2,3)$ $= \text{e}^{-0.875}\left(1 + \dfrac{7}{8} + \dfrac{49}{128} + \dfrac{343}{3072}\right)$ $= 0.4169(1 + 0.875 + 0.3828 + 0.1117)$ $= 0.987740443$	B2		Any correct expression (B2) **or** AWFW 0.987 to 0.988
	$\text{P}(Y \geq 4) = 1 - 0.9877$ $= 0.0123$	M1 A1	4	$1 - (\text{their P}(Y < 4))$ AWFW 0.0122 and 0.0123
				SC $\text{P}(Y \leq 4) = 0.997$ to 0.998 **or** any correct expression B2 $\text{P}(Y > 4) = 0.002$ to 0.003 M1A0
(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	'System Down' $\Rightarrow$ not independent
	Total		**13**	

MS2B (cont)

Q	Solution	Marks	Total	Comments
6(a)(i)	$\mathrm{P}(R \geq 5) = 0.3 + 0.25 + 0.1 + 0.05$ $= 0.70$	B1	1	CAO
(ii)	$\mathrm{E}(R) = \sum rp$ $= 3\times0.1 + 4\times0.2 + 5\times0.3 +$ $6\times0.25 + 7\times0.1 + 8\times0.05$	M1		
	$= 5.2$	A1	2	
(iii)	$\mathrm{E}(R^2) = 9\times0.1 + 16\times0.2$ $+ 25\times0.3 + 36\times0.25$ $+ 49\times0.1 + 64\times0.05$	M1A1		(Correct expression **or** 28.7)
	$(= 28.7)$			
	$\mathrm{Var}(R) = 28.7 - 5.2^2$	M1		
	$= 1.66$	A1	4	**AG**
(b)(i)	$\mathrm{P}(R+S=6) = 0.1\times0.15 = 0.015$	B1		$\mathrm{P}(R=3 \text{ and } S\leq5) = 0.1\times0.85 = 0.085$
	$\mathrm{P}(R+S=7) = 0.1\times0.4 + 0.2\times0.15$ $= 0.04 + 0.03$ $= 0.07$	B1		$\mathrm{P}(R=4 \text{ and } S\leq4) = 0.2\times0.55 = 0.110$
	$\mathrm{P}(R+S=8) = 0.2\times0.4 + 0.1\times0.3$ $+ 0.3\times0.15$ $= 0.08 + 0.03 + 0.045$ $= 0.155$	B1		$\mathrm{P}(R=5 \text{ and } S\leq3) = 0.3\times0.15 = 0.045$
	$\mathrm{P}(R+S\leq8) = 0.015 + 0.07 + 0.155$	M1		$\mathrm{P}(R+S\leq8) = 0.085 + 0.110 + 0.045$
	$= 0.24$	A1	5	=0.24 **(AG)**
(ii)	$p = {}^5C_4(0.24)^4(0.76)$ $+ (0.24)^5$ $= 0.0126 + 0.000796$	M1 M1		First term correct + correct second term **or** correct numerical values (**must** use $p = 0.24$)
	$= 0.0134$	A1	3	$(0.013 \text{ to } 0.0135)$
(iii)	$\mathrm{P}(R=4 \mid R+S\leq8)$ $= \dfrac{\mathrm{P}(R=4 \text{ and } R+S\leq8)}{\mathrm{P}(R+S\leq8)}$			**Alternative:** (using (b)(i)) $= \dfrac{\mathrm{P}(R=4 \text{ and } S\leq4)}{\mathrm{P}(R+S\leq8)}$ $= \dfrac{0.11}{0.24} = \dfrac{11}{24}$
	$= \dfrac{0.03 + 0.08}{0.24}$	B1 M1		(numerator) **or** 0.11 seen ($\div 24$ iff numerator < 0.24)
	$= \dfrac{11}{24}\ (0.458)$	A1	3	CAO
	Total		**18**	

MS2B (cont)

Q	Solution	Marks	Total	Comments
7(a)	Median $=1$	B1		
	Lower quartile $=\frac{1}{2}$	B1	2	
(b)	$\mathrm{F}(1)=\frac{1}{2}$			
	For $1\le x\le 4$			
	$\int\frac{1}{18}(x-4)^2\mathrm{d}x$	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
	$\mathrm{F}(x)=\left[\frac{1}{54}(x-4)^3+\frac{1}{2}\right]+\frac{1}{2}$	m1		adding $\frac{1}{2}$ **or** $\mathrm{F}(1)$
	$=1+\frac{1}{54}(x-4)^3$	A1	4	CAO (AG)
	Alternative			**Alternative**
	$\int\frac{1}{18}(x-4)^2\,\mathrm{d}x=\frac{1}{54}(x-4)^3+c$	(M1)		$\int\frac{1}{18}(x-4)^2\mathrm{d}x$ (M1)
	$\mathrm{F}(1)=\frac{1}{2}\ \Rightarrow\ c=1$	(m1) (A1)		$=\int_1^x\frac{1}{18}\left(x^2-8x+16\right)\mathrm{d}x$
	$\mathrm{F}(x)=1+\frac{1}{54}(x-4)^3$	(A1)		$=\frac{1}{18}\left[\frac{x^3}{3}-4x^2+16x\right]_1^x$ (A1) $\mathrm{F}(x)=\frac{1}{2}+\frac{1}{54}\left[x^3-12x^2+48x\right]_1^x$ (m1) $=\frac{1}{2}+\frac{1}{54}\left(x^3-12x^2+48x-37\right)$ $=1+\frac{1}{54}\left(x^3-12x^2+48x-64\right)$ $=1+\frac{1}{54}(x-4)^3$ (A1)
(c)	$\mathrm{P}(2\le X\le 3)=\frac{53}{54}-\frac{46}{54}$	M1		$\mathrm{F}(3)-\mathrm{F}(2)$
	$=\frac{7}{54}$ (0.130)	A1	2	$0.1\dot{2}\dot{9}\dot{6}$
(d)(i)	$\mathrm{F}(q)=\frac{3}{4}$	M1		**use** of $\mathrm{F}(q)=\frac{3}{4}$
	$1+\frac{1}{54}(q-4)^3=\frac{3}{4}$ $\frac{1}{54}(q-4)^3=-\frac{1}{4}$	M1		(either)
	$(\times 54)\ \Rightarrow\ (q-4)^3=-13.5$	A1	3	**AG**
(ii)	$q-4=\sqrt[3]{-13.5}=-2.3811$ $q=1.619$ (3dp)	B1	1	CAO
	Total		**12**	
	TOTAL		**75**	