Version

General Certificate of Education (A-level)
January 2013

Mathematics MS2B

(Specification 6360)

Statistics 2B

Final

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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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.

MS2B

Q	Solution	Marks	Total	Comments
1(a)	Sample mean = 53.06, s = 1.140 t_5 = 2.571 Sample mean $\pm$ t × $s/\sqrt{6}$ (53.06 ± 1.20) = (51.86, 54.26)	B1 B1 M1 m1 A1	 **5**	Both. For s AWRT 1.14 AWRT 2.57 For $\sqrt{6}$ Rest of formula. Allow t_5 = 2.01 to 2.02, or t_6 = 2.45 Either form ± 0.01 in total.
(b)	Sample mean is lower than last year's mean so claim **may** be true. 53.41 lies within c.i. so **not certain** that mean time is better. Performance in competition does not depend on mean time. Times seem to be improving.	E2	**2**	E1 each for sensible comments either supporting or against statement up to a maximum of 2. Comment must be **uncertain.**
		Total	**7**	

<table>
<tr><th>Q</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>2 (a)</td><td>
<table>
<tr><th></th><th colspan="4">Expected values</th></tr>
<tr><th></th><th>F</th><th>T</th><th>S</th><th>D</th></tr>
<tr><th><3</th><td>8.736</td><td>34.944</td><td>24.192</td><td>16.128</td></tr>
<tr><th>>3</th><td>4.264</td><td>17.056</td><td>11.808</td><td>7.872</td></tr>
</table>
</td><td>M1
A1</td><td></td><td>Any two correct to 2 d.p.
All correct, here or below, to 2 d.p.</td></tr>
<tr><td></td><td>One expected value for Flat < 5
So combine first two columns to give</td><td>E1</td><td></td><td>Must be expected value, applied to this case, not just general statement.</td></tr>
<tr><td></td><td>
<table>
<tr><th></th><th colspan="3">Expected values</th></tr>
<tr><th></th><th>F+T</th><th>S</th><th>D</th></tr>
<tr><th><3</th><td>43.68</td><td>24.192</td><td>16.128</td></tr>
<tr><th>>3</th><td>21.32</td><td>11.808</td><td>7.872</td></tr>
</table>
</td><td>B1</td><td></td><td>For combining first two E columns, at least 1 correct.</td></tr>
<tr><td></td><td>H_0: No association between property type and time to sell.
H_1: Association between property type and time to sell.</td><td>B1</td><td></td><td>H_0 seen somewhere in solution

If "independent" used then must be correct way round</td></tr>
<tr><td></td><td>
<table>
<tr><th>O_i</th><th>E_i</th><th>$(O_i-E_i)^2/E_i$</th></tr>
<tr><td>38</td><td>43.68</td><td>0.7386</td></tr>
<tr><td>27</td><td>21.32</td><td>1.5132</td></tr>
<tr><td>28</td><td>24.192</td><td>0.5994</td></tr>
<tr><td>8</td><td>11.808</td><td>1.2281</td></tr>
<tr><td>18</td><td>16.128</td><td>0.2173</td></tr>
<tr><td>6</td><td>7.872</td><td>0.4452</td></tr>
<tr><td></td><td>X^2</td><td>4.7418</td></tr>
</table>
</td><td>M1

A1</td><td></td><td>For attempt at $(O_i-E_i)^2/E_i$

$4.7 < X^2 < 4.8$</td></tr>
<tr><td></td><td>2 degrees of freedom</td><td>B1</td><td></td><td>PI by 4.605, 5.991, 7.378, 9.210 or 10.597 seen</td></tr>
<tr><td></td><td>C.V. of χ^2 for 2 d.f. = 4.605</td><td>B1</td><td></td><td>AWFW 4.60 to 4.61</td></tr>
<tr><td></td><td>4.74 > 4.605 so reject H_0
significant evidence of an association between property type and time to sell.</td><td>A1</td><td>10</td><td>Context conclusion.
Dep. on B1 for H_0 , A1 for χ^2 and B1 for c.v.</td></tr>
<tr><td>(b)(i)</td><td>More in total than any other type so likely to have biggest effect</td><td>E1</td><td></td><td>Or similar referring to large number</td></tr>
<tr><td>(ii)</td><td>Far away from expected values</td><td>E1</td><td>2</td><td>Or opposite pattern to other three</td></tr>
<tr><td></td><td></td><td>Total</td><td>12</td><td></td></tr>
</table>

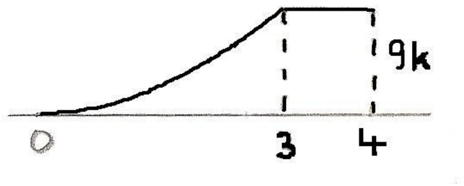
<table>
<tr><td></td><td>If Flats and Detached combined:
<table>
<tr><th></th><th colspan="3">Expected values</th></tr>
<tr><th></th><th>F+D</th><th>T</th><th>S</th></tr>
<tr><th><3</th><td>24.864</td><td>34.944</td><td>24.192</td></tr>
<tr><th>>3</th><td>12.136</td><td>17.056</td><td>11.808</td></tr>
</table>
</td><td>B1</td><td></td><td>.
For combined F and D</td></tr>
<tr><td></td><td>
<table>
<tr><th>O_i</th><th>E_i</th><th>$(O_i-E_i)^2/E_i$</th></tr>
<tr><td>22</td><td>24.864</td><td>0.3299</td></tr>
<tr><td>34</td><td>34.944</td><td>0.0255</td></tr>
<tr><td>28</td><td>24.192</td><td>0.5994</td></tr>
<tr><td>15</td><td>12.136</td><td>0.6759</td></tr>
<tr><td>18</td><td>17.056</td><td>0.0522</td></tr>
<tr><td>8</td><td>11.808</td><td>1.2281</td></tr>
<tr><td></td><td>X^2</td><td>2.9110</td></tr>
</table>
</td><td>M1

A0</td><td></td><td>For attempt at $(O_i-E_i)^2/E_i$</td></tr>
<tr><td></td><td>Accept H_0</td><td>A0</td><td></td><td>Max of 8 marks</td></tr>
</table>

MS2B (cont)

Q	Solution	Marks	Total	Comments
3 (a)(i)	$e^{-1.5} \times 1.5^3/3!$	M1		
	= 0.126	A1		0.125 to 0.126
			2	
(ii)	Using Po(1), $P(X > 1) = 1 - P(X \leq 1)$	M1		
	= 1 – 0.7358 = 0.264	A1		SC Award M1 only if obtain 0.0902 using Po(0.5)
			2	
(iii)	Weekdays Po(7.5) weekend Po(1)	M1		Weekdays = 7.5
	Total Po(8.5)	A1		
	P(Total < 10) = P(Total ≤ 9)	m1		Applied (0.7764, 0.7166, 0.6530 are evidence)
	= 0.653	A1		
			4	
(b)	Using Total Po from (a)(iii)			M1 using their total providing
	P(>15) = 0.0138, P(>16) = 0.0066	M1		supporting probabilities seen OE use of P(Total ≤ 15 & 16)
	So needs 16 tubes	A1		CAO Answer alone scores B2
			2	
(c)	Average rate of failure unlikely to be constant over the course of a day. Very little use of lights over this period.	E1		One mark for any sensible comment
			1	
		Total	**11**	

MS2B (cont)

Q	Solution	Marks	Total	Comments
4(a)		B1 B1 B1		Curve + rectangle Some indication of x values $9k$ or 0.5 indicated for vertical height
			3	
(b)	Attempt to integrate kx^2 between 0 & 3	M1		Show $\frac{kx^3}{3}$
	Obtain $9k$	A1		
	Area under rectangle = $9k$	B1		
	$9k + 9k = 1$ so $k = {}^1/_{18}$	B1		For $9k + 9k = 1$. AG
			4	
(c)(i)	3	B1		
(ii)	Attempt to integrate kx^2 between 0 & Q_1 put = 0.25	M1		
	$\frac{(Q_1)^3}{54} = 0.25$	A1		
	$Q_1 = 2.38$	A1		AWRT or any equivalent exact form $\sqrt[3]{13.5} = {}^3/(\sqrt[3]{2}) = {}^3/_2(\sqrt[3]{4})$
			4	
		Total	**11**	

MS2B (cont)

Q	Solution	Marks	Total	Comments
5(a)	Mean = $0 \times 0.1 + 1 \times 0.35$ ……	M1		AG
	= 1.85			
	$E(X^2) = 0^2 \times 0.1 + 1^2 \times 0.35$ …	M1		Full method including – 1.85^2
	= 4.75 $Var(X) = 4.75 - 1.85^2$	A1		For $E(X^2) = 4.75$
	= 1.3275	A1		For final answer AWRT 1.33
			4	
(b)(i)	$T = c + nX$	B1		
			1	
(ii)	$E(c + nX) = c + nE(X)$	M1		Getting at least as far as $c + E(nX)$
	$= c + 1.85n$	A1		CAO
	$Var(c + nX) = Var(c) + Var(nX)$	M1		Getting at least as far as (0 +) $Var(nx)$
	$= 0 + n^2 var(X) = 1.3275n^2$	A1F		FT their $Var(X)$ if $0 < Var(X) < 4$
			4	
		Total	**9**	

MS2B (cont)

Q	Solution	Marks	Total	Comments
6(a)	Putting $\frac{t^3}{216} = 0.9$	M1		
	$t = 5.793$	A1		5.79 to 5.80
	41 days.	A1		Accept 40 days in this context
			3	
(b)	Attempt to differentiate F(t)	M1		ct^2 seen
	$f(t) = \frac{1}{72}t^2 \quad 0 \le t \le 6$	A1		Condone domain missing here
	$= 0 \quad$ otherwise	A1		For **complete** function
			3	
(c)	Attempt to integrate tf(t) from 0 to 6	M1		Using their f(t) from **(b)** ct^4 seen
	$E(T) = 4.5$	A1		
	Attempt to integrate t^2f(t) from 0 to 6	M1		Using their f(t) from **(b)** ct^5 seen
	$E(T^2) = 21.6$	A1		
	$\text{Var}(T) = E(T^2) - E(T)^2$	m1		**Applied** in this case. Dependent on both M1
	$= 21.6 - 4.5^2 = 1.35$	A1		
			6	
(d)	S.d. $= \sqrt{1.35} = 1.162$	M1		For $\sqrt{}$ (their Var) $0 < \text{Var}(T) < 9$
	Use of F(5.662)	m1		For F(their s.d. + their E(T)) provided 0 < Total < 6
	$1 - \frac{5.662^3}{216}$	m1		
	$= 0.160$	A1		AWFW 0.159 to 0.161
			4	
		Total	**16**	

MS2B (cont)

Q	Solution	Marks	Total	Comments
7(a)	H_0: $\mu_y = 20$ $\mu_x = 3020$ H_1: $\mu_y \neq 20$ $\mu_x \neq 3020$	B1		Both
	$\bar{y} = 18.47$ $\bar{x} = 3018.47$ s = 8.00	B1 B1		x or y.
	$z = (18.47 - 20)/\left(\frac{8}{\sqrt{100}}\right)$ o.e. for x	M1 m1		$\sqrt{100}$ rest of formula for z (either way round in numerator)
	$= -1.9125$	A1		AWFW –1.93 to –1.91.
	c.v. = ±1.96 (or ±1.98 from t_{99})	B1		Sign consistent with z value.
	So test statistic not in critical region. Accept H_0, no significant evidence that mean has changed.	A1		Comparison not just with opposite C.V. Mention of water not necessary. Dep on B1 for H_0 & H_1, A1 and B1 for c.v.
			8	
(b)	No error if (a) is "Accept H_0 " Type I if (a) is "Reject H_0 "	B1F	**1**	MUST FOLLOW THROUGH
	Alternatives: $(3018.47 - 3020)/\left(\frac{8}{\sqrt{100}}\right)$ for z p value is 0.0558 and must be compared with 0.05 Critical values for $\bar{y}$ are 18.43 or 18.44 and 21.56 or 21.57			
		Total	**9**	
	TOTAL		**75**	