



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

Mathematics

MS03

(Specification 6360)

Statistics 3

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.

Q	Solution	Marks	Total	Comments
1(a)	98% $\Rightarrow z = \underline{2.32 \text{ to } 2.33}$	B1	5	AWFW (2.3263)
	Approximate CI for λ : $\hat{\lambda} \pm z\sqrt{\hat{\lambda}}$	M1		Used
	$392 \pm 2.3263 \times \sqrt{392}$	AF1		F on z
	Per shift $\Rightarrow \div 12$	M1		
	Thus: $\underline{32.7 \pm 3.8 \text{ or } (28.8, 36.5)}$	A1		AWRT
(b)	Per hour (weekday night) \Rightarrow $\underline{(2.05 \text{ to } 2.06, 2.6 \text{ to } 2.61)}$	BF1	3	F on (a)
	Per hour (weekend) = $\frac{136.8}{48} = \underline{2.85}$	B1		
	Thus evidence to agree with claim	BF1		F on comparison of value with CI Definitive conclusion \Rightarrow BF0
	Total		8	

Q	Solution	Marks	Total	Comments																					
2(a)	<table style="border-collapse: collapse; margin-left: 20px;"> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;">A</td> <td style="padding: 2px 5px;">B</td> <td></td> </tr> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;"> -----</td> <td style="padding: 2px 5px;">E(0.15)</td> <td style="padding: 2px 5px;">0.135</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;"> -----</td> <td style="padding: 2px 5px;">T(0.9)</td> <td style="padding: 2px 5px;">0.675</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;"> -----</td> <td style="padding: 2px 5px;">L(0.10)</td> <td style="padding: 2px 5px;">0.090</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;"> -----</td> <td style="padding: 2px 5px;">T(0.35)</td> <td style="padding: 2px 5px;">0.035</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;"> -----</td> <td style="padding: 2px 5px;">L(0.1)</td> <td style="padding: 2px 5px;">0.065</td> </tr> <tr> <td style="border-right: 1px solid black; padding: 2px 5px;"> -----</td> <td style="padding: 2px 5px;">L(0.65)</td> <td style="padding: 2px 5px;">0.065</td> </tr> </table>	A	B		-----	E(0.15)	0.135	-----	T(0.9)	0.675	-----	L(0.10)	0.090	-----	T(0.35)	0.035	-----	L(0.1)	0.065	-----	L(0.65)	0.065	B1 B1 B1	3	Correct shape Correct labels Correct probabilities
	A	B																							
	-----	E(0.15)	0.135																						
-----	T(0.9)	0.675																							
-----	L(0.10)	0.090																							
-----	T(0.35)	0.035																							
-----	L(0.1)	0.065																							
-----	L(0.65)	0.065																							
(b)(i)	$P(E \cup T @ B) = 0.9 \times 0.9 + 0.1 \times 0.35$ $= \underline{\underline{0.84 \text{ to } 0.85}}$	M1 A1	2	1 – (0.09 + 0.065) AWFW (0.845)																					
(ii)	$P(T @ A T @ B) = \frac{0.9 \times 0.75}{(0.9 \times 0.75 + 0.1 \times 0.35)}$ $= \frac{0.675}{0.71} = \underline{\underline{0.95 \text{ to } 0.951}}$	M1 m1 A1	3	P(A B) used in (ii) or (iii) $a \div (a + b)$ with at least a correct AWFW (0.95070)																					
(iii)	$P(L @ A L' @ B) = \frac{0.1 \times 0.35}{(i)}$ $= \frac{0.035}{0.845} = \underline{\underline{0.04 \text{ to } 0.042}}$	AF1 A1	2	F on (i) AWFW (0.04142)																					
(c)	$P((T @ A L @ B) \cap (T' @ A L @ B))$ $\frac{0.9 \times 0.1}{1 - 0.845} \times \frac{0.1 \times 0.65}{1 - 0.845} \times 2$ $= \underline{\underline{0.486 \text{ to } 0.49}}$	M1 M1 M1 A1	4	First expression (18/31) Second expression (13/31) $\times 2$ AWFW (0.48699)																					
Total			14																						

Q	Solution	Marks	Total	Comments
3(a)	95% $\Rightarrow z = \underline{1.96}$	B1		AWRT
	$\bar{x} = \underline{1026}$ $\bar{y} = \underline{1045}$	B1		Both CAO
	CI for $\mu_Y - \mu_X$ is	M1		Used
	$(\bar{y} - \bar{x}) \pm z \sqrt{\frac{\sigma_Y^2}{n_Y} + \frac{\sigma_X^2}{n_X}}$	m1		Accept $(\bar{x} - \bar{y})$ throughout SD term
	ie			
	$(1045 - 1026) \pm 1.96 \sqrt{\frac{30^2}{8} + \frac{25^2}{10}}$	AF1		F on \bar{x} , \bar{y} and z
	ie 19 ± 25.9 or $(-6.9, 44.9)$	A1		CAO & AWRT or AWRT
ie $\underline{20 \pm 25}$ or $(-5$ or $-10, 45)$	B1	7	Rounding answer to nearest 5 kg	
(b)	Fred used: machine X for sand and machine Y for gravel	B1		Apparent rounding to nearest 5 kg
	Use each machine for both	B1	2	OE
Total			9	
4	$H_0: p_M - p_D = 0.10$ $H_1: p_M - p_D > 0.10$	B1 B1		If B0 B0, then award B1 for $p_M - p_D = 0$
	95% $\Rightarrow z = \underline{1.64}$ to $\underline{1.65}$	B1		AWFW (1.6449)
	$z = \frac{(\hat{p}_M - \hat{p}_D) - 0.10}{\sqrt{\frac{\hat{p}_M(1 - \hat{p}_M)}{n_M} + \frac{\hat{p}_D(1 - \hat{p}_D)}{n_D}}} =$	M1 m1		Used; allow pooling and/or 'no -0.10' Denominator
	$\frac{(0.38 - 0.21) - 0.10}{\sqrt{\frac{0.38 \times 0.62}{250} + \frac{0.21 \times 0.79}{100}}} =$	A1		Correct expression but allow 'no -0.10'
	$\frac{0.07}{0.051} = \underline{1.37}$	A1		AWRT (1.3724)
	No evidence , at 5% level, to suggest that the difference is more than 10 per cent	AF1	8	F on CV and z -value Definitive conclusion \Rightarrow AF0
Total			8	

Q	Solution	Marks	Total	Comments
5(a)(i)	$L = X + Z$ $E(L) = 68 + 73 = \underline{141}$	B1	2	CAO
	$V(L) = 10^2 + 15^2 = \underline{325}$	B1		CAO
(ii)	$M = X + Y$ $E(M) = 68 + 25 = \underline{93}$	B1	3	CAO
	$V(M) = 10^2 + 5^2 + 2 \times 10 \times 5 \times (-0.8)$ $= 100 + 25 - 80 = \underline{45}$	M1 A1		Allow 'no 2' CAO
(b)(i)	Require: $P(L < 150) =$ $P\left(Z < \frac{150 - 141}{\sqrt{325}}\right)$	M1	2	Standardising 150 using c's $E(L)$ & c's $V(L)$ from (a)(i)
	$= P(Z < 0.5)$ $= \underline{0.69 \text{ to } 0.692}$	A1		AWFW (0.49923) (0.69119)
(ii)	Require: $P(X + Y > 105) = P(M > 105)$ $= P\left(Z > \frac{105 - 93}{\sqrt{45}}\right)$	M1	3	Standardising 105 using c's $E(M)$ & c's $V(M)$ from (a)(ii)
	$= P(Z > 1.79) = 1 - P(Z < 1.79)$	m1		Correct area change (1.78885) May be implied by a correct answer or by an answer < 0.5
	$= \underline{0.036 \text{ to } 0.038}$	A1		AWFW (0.03682)
Total			10	

Q	Solution	Marks	Total	Comments
6(a)(i)	$\lambda = 6 \times 2.5 = \underline{15}$	B1		CAO
	$P(W \leq 18) = \underline{0.819 \text{ to } 0.82}$	B1	2	AWFW (0.8195)
(ii)	$P(W > w) \leq 0.05 \Rightarrow P(W \leq w) \geq 0.95$	M1		Implied by a value of 21, 22 or 23
	$w = \underline{22}$	A1	2	CAO
(b)(i)	$F \sim \underline{N(30, 30)}$	B1		May be implied
	$P(F > 35) =$	M1		Standardising (34.5, 35 or 35.5)
	$P\left(Z > \frac{35.5 - 30}{\sqrt{30}}\right) = P(Z > 1.00)$	B1		with $\mu = \sigma^2$ 35.5 (1.00416)
	$= \underline{0.157 \text{ to } 0.16}$	A1	4	AWFW (0.15765)
(ii)	$P(F > f) \leq 5\% \Rightarrow$			
	$P\left(Z > \frac{(f + 0.5) - 30}{\sqrt{30}}\right) \leq 0.05$	M1		Standardising ($f - 0.5$, f or $f + 0.5$) with $\mu = \sigma^2$
	$5\% \Rightarrow z = \underline{1.64 \text{ to } 1.65}$	B1		AWFW (1.6449)
	So $f = \underline{39}$	Adep1	3	CAO Dependent on ($f + 0.5$) and on B1
	Total		11	

Q	Solution	Marks	Total	Comments
7(a)	$H_0: p = 0.50$ $H_1: p > 0.50$	B1 B1		Here or in (b)(i)
	$P(X \geq 29 B(50, 0.50)) =$ $1 - (0.8389 \text{ or } 0.8987)$ $= \underline{0.16 \text{ to } 0.165}$	M1 M1 A1		Use of $B(50, 0.50)$; may be implied AWFW (0.16112)
	No evidence to support the claim	AF1	6	F on 10% and (p -value > 0.10) Definitive conclusion \Rightarrow AF0
(b)(i)	10% $\Rightarrow z = \underline{1.28}$	B1		AWRT (1.2816)
	$z = \frac{\frac{271}{500} - 0.5}{\sqrt{\frac{0.5 \times 0.5}{500}}} = \underline{1.87 \text{ to } 1.89}$	M1 A1		Accept use of \hat{p} in denominator giving $z = 1.88511$ AWFW (1.87830)
	Evidence to support the claim	AF1	4	F on CV and z -value Definitive conclusion \Rightarrow AF0
(ii)	Power = $1 - P(\text{Type II error})$ = $1 - P(\text{accept } H_0 H_0 \text{ false})$ or $P(\text{reject } H_0 H_0 \text{ false})$ or $P(\text{accept } H_1 H_1 \text{ true})$	B1		Any one stated or used
	$P(\hat{p} > 0.529 B(500, 0.55)) =$ $P\left(Z > \frac{0.529 - 0.55}{\sqrt{\frac{0.55 \times 0.45}{500}}}\right) = P(Z > -$ $\underline{0.94})$ $= \underline{0.82 \text{ to } 0.83}$	M1 M1 A1 A1		Use of $B(500, 0.55)$ M0 for use of 0.529 or 0.5 Accept use of 0.529 in denominator giving $z = 0.94075$ but not use of 0.5 Ignore inequality and sign AWRT (0.94388) AWFW (0.82738)
	Total		15	
	TOTAL		75	