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General Certificate of Education (A-level)
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Mathematics MS03

(Specification 6360)

Statistics 3

Final

Mark Scheme

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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 = **2.32 to 2.33**	B1		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: **32.7 ± 3.8 or (28.8, 36.5)**	A1	5	AWRT
(b)	Per hour (weekday night) $\Rightarrow$ **(2.05 to 2.06, 2.6 to 2.61)**	BF1		F on (a)
	Per hour (weekend) = $\frac{136.8}{48}$ = **2.85**	B1		
	Thus evidence to **agree with claim**	BF1	3	F on comparison of value with CI Definitive conclusion $\Rightarrow$ BF0
	Total		**8**	

Q	Solution	Marks	Total	Comments
2(a)	**A** **B** E(0.15) 0.135 T(0.9) T(0.75) 0.675 L(0.10) 0.090 T(0.35) 0.035 L(0.1) L(0.65) 0.065	B1 B1 B1	3	Correct shape Correct labels Correct probabilities
(b)(i)	$P(E \cup T \text{ @ } B) = 0.9 \times 0.9 + 0.1 \times 0.35$	M1		$1 - (0.09 + 0.065)$
	$= \underline{\mathbf{0.84 \text{ to } 0.85}}$	A1	2	AWFW (0.845)
(ii)	$P(T \text{ @ } A \mid T \text{ @ } B) = \dfrac{0.9 \times 0.75}{(0.9 \times 0.75 + 0.1 \times 0.35)}$	M1 m1		P(A | B) **used in (ii) or (iii)** $a \div (a + b)$ with at least a correct
	$= \dfrac{0.675}{0.71} = \underline{\mathbf{0.95 \text{ to } 0.951}}$	A1	3	AWFW (0.95070)
(iii)	$P(L \text{ @ } A \mid L' \text{ @ } B) = \dfrac{0.1 \times 0.35}{\text{(i)}}$	AF1		F on (i)
	$= \dfrac{0.035}{0.845} = \underline{\mathbf{0.04 \text{ to } 0.042}}$	A1	2	AWFW (0.04142)
(c)	$P((T \text{ @ } A \mid L \text{ @ } B) \cap (T' \text{ @ } A \mid L \text{ @ } B))$			
	$\dfrac{0.9 \times 0.1}{1 - 0.845} \times \dfrac{0.1 \times 0.65}{1 - 0.845} \times 2$	M1 M1 M1		First expression (18/31) Second expression (13/31) $\times 2$
	$= \underline{\mathbf{0.486 \text{ to } 0.49}}$	A1	4	AWFW (0.48699)
	Total		**14**	

Q	Solution	Marks	Total	Comments
3(a)	95% $\Rightarrow$ z = **1.96**	B1		AWRT
	$\overline{x}$ = **1026** $\overline{y}$ = **1045**	B1		Both CAO
	CI for $\mu_Y - \mu_X$ is $(\overline{y} - \overline{x}) \pm z\sqrt{\frac{\sigma_Y^2}{n_Y} + \frac{\sigma_X^2}{n_X}}$	M1 m1		Used Accept $(\overline{x} - \overline{y})$ throughout SD term
	ie $(1045 - 1026) \pm 1.96\sqrt{\frac{30^2}{8} + \frac{25^2}{10}}$	AF1		F on $\overline{x}$, $\overline{y}$ and z
	ie 19 ± 25.9 or (–6.9, 44.9)	A1		CAO & AWRT or AWRT
	ie **20 ± 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 = **1.64 to 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'
	$\frac{0.07}{0.051}$ = **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)	$L = X + Z$			
	$E(L) = 68 + 73$ **<u>141</u>**	B1		CAO
	$V(L) = 10^2 + 15^2 =$ **<u>325</u>**	B1	2	CAO
(ii)	$M = X + Y$			
	$E(M) = 68 + 25 =$ **<u>93</u>**	B1		CAO
	$V(M) = 10^2 + 5^2 + 2 \times 10 \times 5 \times (-0.8)$	M1		Allow 'no 2'
	$= 100 + 25 - 80 =$ **<u>45</u>**	A1	3	CAO
(b)(i)	Require: $P(L < 150) =$			
	$P\left(Z < \frac{150-141}{\sqrt{325}}\right)$	M1		Standardising 150 using c's $E(L)$ & c's $V(L)$ from (a)(i)
	$= P(Z < 0.5)$			(0.49923)
	$=$ **<u>0.69 to 0.692</u>**	A1	2	AWFW (0.69119)
(ii)	Require: $P(X + Y > 105) = P(M > 105)$			
	$= P\left(Z > \frac{105-93}{\sqrt{45}}\right)$	M1		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**
	$=$ **<u>0.036 to 0.038</u>**	A1	3	AWFW (0.03682)
	Total		**10**	

Q	Solution	Marks	Total	Comments
6(a)(i)	$\lambda = 6 \times 2.5 =$ **15**	B1		CAO
	$P(W \leq 18) =$ **0.819 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
	$w =$ **22**	A1	2	CAO
(b)(i)	$F \sim$ **N(30, 30)**	B1		May be implied
	$P(F > 35) =$			
	$P\left(Z > \frac{35.5-30}{\sqrt{30}}\right) = P(Z > 1.00)$	M1		Standardising (34.5, 35 or 35.5) with $\mu = \sigma^2$
		B1		35.5 (1.00416)
	= **0.157 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 $\mu = \sigma^2$
	$5\% \Rightarrow z =$ **1.64 to 1.65**	B1		AWFW (1.6449)
	So $f =$ **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)
	$P(X \geq 29 \mid B(50, 0.50)) =$ **1 – (0.8389 or 0.8987)**	M1 M1		Use of B(50, 0.50); may be implied
	= **0.16 to 0.165**	A1		AWFW (0.16112)
	No evidence to support the claim	AF1	6	F on 10% and (p-value > 0.10) Definitive conclusion ⇒ AF0
(b)(i)	10% ⇒ z = **1.28**	B1		AWRT (1.2816)
	$z = \dfrac{\frac{271}{500} - 0.5}{\sqrt{\frac{0.5 \times 0.5}{500}}}$ = **1.87 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 ⇒ AF0
(ii)	Power = 1 – P(Type II error) = 1 – P(accept H_0 | H_0 false) or P(reject H_0 | H_0 false) or P(accept H_1 | H_1 true)	B1		Any one stated or used
	$P\left(\hat{P} > 0.529 \mid B(500, 0.55)\right)$ =	M1		Use of B(500, 0.55) M0 for use of 0.529 or 0.5
	$P\left(Z > \dfrac{0.529 - 0.55}{\sqrt{\frac{0.55 \times 0.45}{500}}}\right)$ = P(Z > – **0.94**)	M1 A1		Accept use of 0.529 in denominator giving z = 0.94075 but not use of 0.5 Ignore inequality and sign AWRT (0.94388)
	= **0.82 to 0.83**	A1	5	AWFW (0.82738)
	Total		**15**	
	TOTAL		**75**	