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MATHEMATICS

MA04

(9660/MA04) Unit S2 Statistics

Mark scheme

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Key to mark scheme abbreviations

M	Mark is for method
m	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**	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
sf	Significant figure(s)
dp	Decimal place(s)
ISW	Ignore subsequent working

Q	Answer	Marks	Comments
1(a)	The **set of values** for the test statistic which lead to **rejection** of the **null hypothesis**	B1	**oe**
		1	

Q	Answer	Marks	Comments
1(b)(i)	$\mathrm{P}(X \leq 5) = 0.0480 (< 5\%)$ $\mathrm{P}(X \leq 6) = 0.1034 (> 5\%)$	M1	Any one correct or correct CR
	$\mathrm{CR}\ (X \leq 5)$	A1	Need both probabilities **oe**
	$\mathrm{P}(X \geq 15) = 0.0607 (> 5\%)$ $\mathrm{P}(X \geq 16) = 0.0308 (< 5\%)$	M1	Any one correct or correct CR
	$\mathrm{CR}\ (X \geq 16)$	A1	Need both probabilities **oe**
		4	

Q	Answer	Marks	Comments
1(b)(ii)	As 17 is in the CR we reject H_0	B1ft	**oe** (must define a CR in (b)(i))
		1	

Q	Answer	Marks	Comments
1(c)(i)	n must be large **and** p must be small	B1	**oe**
		1	

Q	Answer	Marks	Comments
1(c)(ii)	$[np =] 80 \times 0.05 = 4$	**B1**	**oe**
		1	

Q	Answer	Marks	Comments
1(d)(i)	$P(W = 0) = 0.0183 (< 5\%)$ $P(W \leq 1) = 0.0916 (> 5\%)$ CR $\{0\}$	**M1** **A1**	Any one correct Allow $P(Y \leq 0)$ Need both probabilities **oe**
		2	

Q	Answer	Marks	Comments
1(d)(ii)	As 1 is not in the CR we do not reject H_0	**B1ft**	**Oe** (must define a CR in (d)(i))
		1	

	Question 1 Total	**11**	

Q	Answer	Marks	Comments
2(a)	$\int_2^4 ct^3\,\mathrm{d}t+\int_4^6 \frac{1}{10}\,\mathrm{d}t=1$	**M1**	Correct integral set equal to 1 with at least 1 correct integration **oe**
	$\left[\frac{ct^4}{4}\right]_2^4+\left[\frac{t}{10}\right]_4^6=1$	**M1**	Arriving at a linear equation for c
	$\left[64c-4c\right]+\left[\frac{6}{10}-\frac{4}{10}\right]=1$		
	$60c+\frac{1}{5}=1$		
	$c=\frac{1}{75}$	**A1**	**AG** Requires immediate line after integration
		3	

Q	Answer	Marks	Comments
2(b)(i)	$\left[\int t\times \mathrm{f}\left(t\right)\mathrm{d}t\right]=\int_2^4 ct^4\,\mathrm{d}t+\int_4^6 \frac{1}{10}t\,\mathrm{d}t$	**M1**	**PI** Identifies correct integral **oe**
	$=\frac{1}{75}\left[\frac{t^5}{5}\right]_2^4+\left[\frac{t^2}{20}\right]_4^6$	**M1**	**PI** Correct integration with an attempt to substitute limits Allow with 'c'
	$\frac{992}{375}+1=\frac{1367}{375}$	**A1**	**oe**
		3	

Q	Answer	Marks	Comments
2(b)(ii)	$4-5\mathrm{E}(T)$ $=4-5\times\dfrac{1367}{375}$ $=-\dfrac{1067}{75}$	**M1** **A1ft**	**PI** **oe**
		2	

Q	Answer	Marks	Comments
2(c)(i)	$\left[\mathrm{E}\left(T^2\right)=\int t^2\times \mathrm{f}\left(t\right)\mathrm{d}t\right]=\int_2^4 ct^5\mathrm{d}t+\int_4^6\dfrac{t^2}{10}\mathrm{d}t$	**M1**	Identifies correct integral
	$=\dfrac{1}{75}\left[\dfrac{t^6}{6}\right]_2^4+\left[\dfrac{t^3}{30}\right]_4^6$	**M1**	Correct integration
	$=\dfrac{1}{75}\left[\dfrac{4^6}{6}-\dfrac{2^6}{6}\right]+\left[\dfrac{6^3}{30}-\dfrac{4^3}{30}\right]$		
	$\mathrm{E}\left(T^2\right)=\dfrac{1052}{75}$	**A1**	**PI**
	$\mathrm{Var}\left(T\right)=\mathrm{E}\left(T^2\right)-\mathrm{E}\left(T\right)^2$		
	$=\dfrac{1052}{75}-\left(\dfrac{1367}{375}\right)^2$	**M1**	**ft** Their $\mathrm{E}\left(T^2\right)$
	$=0.738211\ldots$ $=0.738$ [3 sf]	**A1**	Must see both fractions used correctly or the value to 4 or more significant figures **AG**
		5	

Q	Answer	Marks	Comments
2(c)(ii)	$25\,\text{Var}(T)$ $=25\times0.738...$ $=18.5$ [3 sf]	**M1** **A1**	Allow use of 0.738 **AWRT** 18.5
		2	

	Question 2 Total	**15**	

Q	Answer	Marks	Comments
3	$H_0 : \mu = 205$ $H_1 : \mu > 205$	**B1**	Condone mu or other letters except $\bar{x}$
	$\overline{X} \sim N\left(205, \frac{30^2}{10}\right)$	**B1**	**PI** by correct standardisation formulae
	$z = \frac{220.5 - 205}{\frac{30}{\sqrt{10}}}$	**M1**	**PI** by correct z
	$z = 1.633(843458)...$	**A1**	**AWRT** 1.63 or exact value $\frac{31\sqrt{10}}{60}$ **or** $P\left(z > \frac{31\sqrt{10}}{60}\right) = 0.9489$ allow
	$z_{critical} = 1.6449$	**B1**	allow – 1.6449 **or** 0.94845 from tables or comparison of $P(\overline{T} > 220.5) = 0.0511$ to 0.05155 with 5% Allow 'accept H_0'
	Do not reject H_0 as $z < z_{critical}$ **or** 1.63…< 1.64…	**A1ft**	Comment about H_0 and 0.0511 to 0.05155 > 0.05 Allow $\lvert z \rvert < 1.6449$ Correct conclusion based upon ft their z (signs need to be compatible)
	Insufficient evidence to support the claim that Nok's lap times have increased at the 5% level of significance	**E1**	Correct statement must be in context and must follow from fully correct solution

	Question 3 total	**7**	

Q	Answer	Marks	Comments
4(a)	$\frac{e^{-\lambda}\times\lambda^8}{8!}=\frac{125}{2688}\times\frac{e^{-\lambda}\times\lambda^5}{5!}$	**M1**	**PI** by simplified equation
	$\lambda^3=\frac{125}{8}$	**M1**	Forms a simplified equation for λ **or** λ^3
	$\lambda=2.5$	**A1**	**CAO**
		3	

Q	Answer	Marks	Comments
4(b)(i)	$P(X<5)=P(X\leq 4)$	**M1**	**PI**
	$= 0.0293$ [3 sf]	**A1**	**CAO**
		2	

Q	Answer	Marks	Comments
4(b)(ii)	$\lambda=5$	**B1**	**PI** by 0.9980 or 0.8666
	$P(7<X<13)=P(X\leq 12)-P(X\leq 7)$ $= 0.9980 – 0.8666$	**M1**	**PI** Allow sight of one correct probability for the method mark
	$= 0.131$	**A1**	**CAO**
		3	

Q	Answer	Marks	Comments
4(c)	$\lambda_e = \frac{1}{3}$ (number of advertisements per minute)	B1	**PI (or** $\lambda_e = \frac{5}{3}$**)** (number of advertisements per 5 minutes)
	$P(X > 5) = 1 - \left(1 - e^{-\frac{1}{3}\times 5}\right)$	M1	**PI** $P(X > 1) = 1 - \left(1 - e^{-\frac{5}{3}}\right)$
	$= 0.189$	A1	**CAO**
		3	

	Question 4 total	**11**	

Q	Answer	Marks	Comments
5(a)	$\mathrm{P}(z < a) = 0.1 \Rightarrow a = -1.2816$ and/or $\mathrm{P}(z > b) = 0.2 \Rightarrow b = 0.8416$	**B1**	Allow $a = \pm 1.2816$
	$-1.2816 = \dfrac{1.9-\mu}{\sigma}$ or $0.8416 = \dfrac{3.8-\mu}{\sigma}$	**M1**	Signs must be compatible
	$-1.2816 = \dfrac{1.9-\mu}{\sigma}$ and $0.8416 = \dfrac{3.8-\mu}{\sigma}$	**A1**	
	Attempt to solve simultaneously eg $\dfrac{3.8-\mu}{0.8416} = \dfrac{\mu-1.9}{1.2816}$	**M1**	Reduction to one unknown
	$\mu = 3.05$ [3 sf]	**A1**	**CAO**
	$\sigma = 0.895$ [3 sf]	**A1**	**CAO**
		6	

Q	Answer	Marks	Comments
5(b)	$\mathrm{P}(z > k) > 0.74 \Rightarrow k = 0.6433$	**B1**	**PI** By correct standardisation formula
	$\dfrac{0.82-0.80}{\frac{0.25}{\sqrt{n}}} > 0.6433$	**M1**	
	$\sqrt{n} > \dfrac{0.6433 \times 0.25}{0.02}$	**m1**	Rearranged to find n or $\sqrt{n}$
	$\sqrt{n} > 8.04125 \Rightarrow n > 64.66... \Rightarrow n = 65$	**A1**	**CAO**
		4	

	Question 5 total	**10**	

Q	Answer	Marks	Comments
6(a)(i)	(through symmetry) $k = 13$	B1	
		1	

Q	Answer	Marks	Comments
6(a)(ii)	$5\times\left(\frac{0.125+h}{2}\right)=0.5$		
	$h = 0.075$	B1	
	$m=\frac{0.125-0.075}{8-3}=0.01$	M1	
	$\left[\mathrm{f}(8)=\right]\ 0.01\times 8+c_1=0.125$	M1	
	$c_1 = 0.045$		
	$\left[\mathrm{f}(8)=\right]\ -0.01\times 8+c_2=0.125$	M1	**oe** Use of $\mathrm{f}(8)$ to find a correct equation when $8 < x \leq 13$ or $-m$
	$c_2 = 0.205$		
	$\mathrm{f}(x)=\begin{cases}0.01x+0.045 & 3\leq x\leq 8\\ -0.01x+0.205 & 8<x\leq 13\\ 0 & \text{otherwise}\end{cases}$	A1	**ACF**
		5	

Q	Answer	Marks	Comments
6(b)(i)	$a = 1$	B1	CAO
		1	

Q	Answer	Marks	Comments
6(b)(ii)	$\mathrm{G}(t) = \frac{1}{5}t - 4$	M1	PI oe
	$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G}(t) = \frac{1}{5}$	M1	Differentiation of their $\mathrm{G}(t)$
	$\mathrm{g}(t) = \begin{cases} \frac{1}{5} & 20 \leq t \leq 25 \\ 0 & \text{otherwise} \end{cases}$	A1	
		3	

	Question 6 total	10	

Q	Answer	Marks	Comments
7(a)(i)	$\left[\dfrac{\sum x}{n}\right] = \dfrac{7187}{800}$ [g]	B1	**oe** 8.98375 Condone **AWRT** 8.984
		1	

Q	Answer	Marks	Comments
7(a)(ii)	$\dfrac{1}{7}\left(645.6661 - \dfrac{71.87^2}{8}\right)$	M1	**PI**
	$= \dfrac{319}{560000}$ $\left[\text{g}^2\right]$	A1	**oe** Allow **AWRT** 0.00057
		2	

Q	Answer	Marks	Comments
7(b)	$H_0 : \mu = 9$ $H_1 : \mu < 9$	**B1**	Both hypotheses
	$\overline{X} \sim N\left(9, \frac{319/560000}{8}\right)$	**M1**	$\overline{X} \sim N\left(\mu, \frac{s^2}{8}\right)$ **PI**
	$t = \frac{8.98375 - 9}{\frac{\sqrt{\frac{319}{560000}}}{\sqrt{8}}} =$	**M1**	Calculates with their s^2
	$= -1.925737248$	**A1**	**AWRT** –1.93
	$t_7(0.05) = -1.895$	**B1**	Allow $\pm$ provided signs are consistent
	Reject H_0 as $-1.92(57\ldots) < -1.895$	**A1ft**	Implied by correct conclusion in context. Follow through their t and t_7
	Sufficient evidence to suggest that the mass of the packets is less than advertised at the 5% level of significance	**E1**	Must not be definitive
		7	

	Question 7 total	**10**	

Q	Answer	Marks	Comments
8(a)	$1-\mathrm{e}^{-\lambda m}=0.5$ $\mathrm{e}^{-\lambda m}=0.5$	**M1**	**PI**
	$-\lambda m=-\ln 2 \Rightarrow m=\dfrac{\ln 2}{\lambda}$	**A1**	
	$\ln 2<1 \Rightarrow \dfrac{\ln 2}{\lambda}<\dfrac{1}{\lambda} \Rightarrow m<\mathrm{E}(X)$	**A1**	Allow 0.693… < 1 **AG** must be convincingly show
		3	

Q	Answer	Marks	Comments
8(b)	$0.75=1-\mathrm{e}^{-\lambda u} \Rightarrow u=\dfrac{\ln 4}{\lambda}$ or $0.25=1-\mathrm{e}^{-\lambda s} \Rightarrow s=\dfrac{\ln\left(\frac{4}{3}\right)}{\lambda}$	**B1**	**oe** A correct expression for u or a correct expression for s
	$u-s=\dfrac{\ln 4}{\lambda}-\dfrac{\ln\left(\frac{4}{3}\right)}{\lambda}$	**M1**	
	$u-s=\dfrac{\ln 3}{\lambda}$	**A1**	
		3	

	Question 8 Total	**6**	