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Statistics 4

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)	Sample proportion = $\frac{1029}{2450} = 0.42$	B1		Either form
	$z = (\pm)2.5758$	B1		2.57 ~ 2.58
	Use of $\frac{(0.42)(0.58)}{2450}$ $\left(= 0.00009943\right)$	M1		
	99%CI: $0.42 \pm 2.5758\sqrt{\frac{(0.42)(0.58)}{2450}}$	M1		Their proportion, z and variance (M's are independent)
	$= 0.42 \pm 0.0257$ or (0.394, 0.446)	A1	5	Either form. $0.42 \pm (0.0256 \sim 0.026)$ Or AWRT (0.394, 0.446)
	Alternative (using numbers)			
	Final CI symmetrical about 0.42	(B1)		
	$z = (\pm)2.5758$	(B1)		
	Use of $2450 \times 0.42 \times 0.58$ (= 596.82)	(M1)		
	$1029 \pm (\text{Their } z) \times \sqrt{\text{Their } \sigma^2}$	(M1)		1029 ± 62.9 or (966.1,1091.9)
	Answer as above	(A1)	5	
(b)	Readers of newspaper likely to have similar backgrounds/opinions Self-selected phone-in	E1E1	2	For any two essentially different reasons
	Total		**7**	

Q	Solution	Marks	Total	Comments
2(a)	$H_0 : \lambda = 27$ $H_1 : \lambda \neq 27$	B1		For both (allow μ)
	Use of Normal	M1		
	$z = \frac{34.5 - 27}{\sqrt{27}} = 1.44$ (1.4434)	M1		Ignore signs, unless inconsistent For $\frac{(34.5 or 35 or 35.5) - 27}{\text{Their SD}}$
	OR $z = \frac{35 - 27}{\sqrt{27}} = 1.54$ (1.5396)	A1dep		AWRT 1.44 from use of 34.5 or AWRT 1.54 from use of 35
	10% critical value = 1.6449	B1		1.64 ~ 1.65
	Do not reject H_0 at the 10% level	Adep1		Requires accept H_0, previous A1 and comparison with a z value
	No evidence that the mean is different during January	AF1	7	ft conclusion from their calculated z compared with their critical z in context.
				Alternatives p = 0.0745 (from use of 34.5) or p = 0.0618 (from use of 35) for M1 A1dep. Compared to 0.05 for B1. Then A1dep AF1 as before May also use 90% intervals
(b)	Type II error	Bdep F1		Correct error type their conclusion
	We accepted H_0 when it could be false	Bdep F1	2	Correct interpretation their error type (dependent). Requires reference to H_0.
	Total		**9**	

Q	Solution	Marks	Total	Comments
3(a)(i)	$\bar{x} = 95.625$	B1		95 ~ 96
	$s = 9.1798$	B1		9.1 ~ 9.2 or 8.5 ~ 8.7
	Use of $t_7 = 2.365$	B1		For 7df either here or in part (b)(i). (May be implied)
		B1		For t = (2.36 ~ 2.37)
	95%CI: $95.625 \pm 2.365 \times \frac{9.1798}{\sqrt{8}}$	M1		Their $\bar{x}, s, t$. Needs $\frac{s_{n-1}}{\sqrt{8}}$ or $\frac{s_n}{\sqrt{7}}$
	$= 95.625 \pm 7.67$ or 7.68			Depends on rounding. Need not be seen
	= (87.9, 103.3) or (88.0, 103.3)	A1	6	cao and cwo Note: 88.0 results from using t = 2.3646…from a calculator
(ii)	92 is within the interval	Bdep F1		Correct conclusion and reason for their CI.
	So mean time has *not* changed	Bdep F1	2	
(b)(i)	$H_0 : \mu \neq 92$	B1		Both
	$H_1 : \mu \neq 92$			
	$t = \frac{94.5 - 92}{4.2/\sqrt{8}}$	M1		M1 for use of $\frac{4.2}{\sqrt{8}}$
		m1		Correct formula, ignore sign for m1. Condone "z =". Alternatively may use CI
	= 1.68	A1		1.68 ~ 1.69 or 94.5 ± 3.51 or (9.0, 98.0)
	Critical value $t_7 = (\pm)2.365$	BF1		For use of same t-value as in part (a)(i) **or** p = 0.136 (AWFW 0.1345 to 0.137) Note: p = 0.092 ~ 0.093 is a normal prob for BF0 AF0 E0
	Cannot reject H_0 at 5% level	AF1		ft their t and critical t with consistent signs OR ft their p-value and 0.05. Requires M1 and m1.
	No evidence that **mean** task time has changed from 92 seconds	E1	7	All correct including conclusion in context
(ii)	Use z-test/normal distribution/normal tables	E1	1	Any of these. (Normal approximation gets E0)
(c)	Times are more variable/ have higher SD under flashing lights compared to loud noises	E1 E1	2	For considering SDs (oe) I dentifying the **distractor** with **greater/smaller variability**. Just "higher/lower SD" is not enough
	Total		**18**	

Q	Solution	Marks	Total	Comments
4(a)(i)	$C \sim B(8, 0{,}45)$	M1		For correct Binomial used
	$P(C > 4) = 1 - 0.7396$	M1		For attempting to find Prob>4 from any binomial. Allow M1 also for 1–0.4770 = 0.523
	$= 0.2604$	A1	3	0.26 ~ 0.2604
(ii)	$F \sim B(120, 0.45) \approx N(54, 29.7)$	M1		Use of normal approximation
		B1		For 54 and 29.7 (or 5.45). Ignore labels
	$P(F < 50) = P\left(Z < \frac{49.5 - 54}{\sqrt{29.7}}\right)$	m1		Standardising with their mean and $\sqrt{\text{var}}$. Disallow just 29.7(→0.44 or 0.45). Allow missing or wrong CC and sign error.
	$= P(Z < -0.82(57))$	m1		For correct CC, sign and area change. Requires previous m1
	$= 0.204(48)$	A1	5	0.203 ~ 0.2065 (Using -0.83 in tables gives 1 – 0.79673 = 0.20327)
(b)(i)	Friends are logged on independently of each other.	E1		
	All friends have the same probability (0.45) of being logged on.	E1	2	Or equivalent
(ii)	**Either** contextualised reason for lack of independence of log-ons	E1	1	eg Hannah's friends may be out together or arranged to meet up on the site etc
	or contextualised reason for different probabilities between friends			eg Different habits, commitments etc
	Total		**11**	

Q	Solution	Marks	Total	Comments
5(a)(i)	Use of U~Poisson(2.5×3) = Poisson(7.5)	B1		For 7.5
	$P(U \leq 6) = 0.378$(2)	B1	2	
(ii)	Use of Y~Poisson(2.5×15) = Poisson(37.5)	B1		For 37.5
	which is approximately N(37.5, 37.5)	M1		Use of normal
	Then $P(Y \leq 42) = P(Z < \frac{42.5-37.5}{\sqrt{37.5}})$	m1		Standardising with their mean and variance. Allow missing/wrong CC
	$= P(Z < 0.81(65))$			
	$= 0.794$ (0.792892)	A1	4	0.792 ~ 0.794
(b)(i)	$E(T) = 4 \times 40 = 160$	B1		oe (eg 2.67 minutes)
	$V(T) = 4 \times 10^2$ (= 400)	M1		
	$SD(T) = \sqrt{400} = 20$	A1	3	oe (eg 0.333 minutes). May be earned in (b)(ii)
(ii)	$T \sim N(160, 20^2)$			May equivalently work in minutes throughout.
	Then $P(120 < T < 180)$			
	$P(\frac{120-160}{20} < Z < \frac{180-160}{20})$	M1		Standardising once with their mean and SD. Allow sign error and seconds/minutes confused. Condone continuity corrections
	$= P(-2 < Z < 1)$			
	$= 0.84134 - (1 - 0.97725)$	m1		Completely correct method for 2 z-values AND 2 probabilites used correctly ie $p_1 - (1 - p_2)$
	$= 0.81859$	A1	3	0.818 ~ 0.819
(iii)	Let D be the time for 2 dedications. Then $E(D) = 200$ and $V(D) = 15^2+15^2 = 450$	B1		For 200 and 450 or 21.2. May be implied
	Require $P(D < T)$ ie $P(D - T < 0)$	M1		For using a difference in rv's
	$D - T \sim N(40, 850)$	B1		For 40 and 850 or 29.2 cao
	Then $P(D - T < 0) = P(Z < -1.37(2))$	m1		Correct method for standardising and area change
	$=0.0853$ (0.085033)	A1	5	0.085 ~ 0.0854
(c)	Mean not constant as queues will depend on flight times;	E1		E1 for identification of any one correct Poisson condition
	People tend to arrive/leave queue in groups	E1	2	E1 for contextualising
	Total		**19**	

Q	Solution	Marks	Total	Comments
6(a)(i)	$H_0 : p = 0.02$ $H_1 : p > 0.02$ Under H_0 , number breaking ~ B(14, 0.02)	B1		For both (accept in words)
	Then $p(X \geq 2) = 1 - 0.9690$	M1		For finding $P(X \geq 2)$ or $P(X > 2)$ from any binomial distribution. (eg allow for $1 - 0.9975$)
	$= 0.03(10)$	A1		
	Can reject H_0 at the 5% level	AF1		ft their prob compared with 0.05 (or 0.025 if 2-tailed test) **or** cumulative prob compared with 0.95 (0.975 for 2-tailed)
	There is evidence that Pluckwell top-E strings are less reliable	E1	5	Correct conclusion in context. Needs previous 3 marks and correct form for H_0/H_1 **Alternative** Using critical value (= 1) can score full marks (see notes)
(ii)	Price; sound quality; etc	E1	1	Any relevant comment
(iii)	Implication that *n* is too small / breakage is relatively rare	E1		Needs *some* explanation for this E mark.
	Supported by use of $P(X = 0) = 0.7536$ for B(14, 0.02) so cannot be < 0.05	B1	2	For 0.753 ~ 0.754 and reference to 0.05
(b)	If all 6 strings have the same prob of breaking (= 0.02) then P(doesn't break any) = $(0.98)^6$	B1		For multiplying any 6 probabilities p_i such that $0 < p_i \leq 1$
	= 0.886	B1		For multiplying 6 probabilities such that $0.98 \leq p_i < 1$. (Implies previous B1)
	However, for other 5 strings P(break) < 0.02 Hence, probability > 0.886 ie will be greater than 0.88	E1	3	*Clear* argument leading to a probability > 0.88 (likely to be but not necessarily 0.886) For example, $(0.98)^6$ (= 0.886) > 0.88 gets B1 B1 but E1 requires reference to P(not break) for the other 5 strings is > 0.98 (oe)
	Total		**11**	
	TOTAL		**75**	