Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE
In Statistics (9ST0)
Paper 03

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question	Scheme	Marks	AO	Notes
1	Lower Quartile=58	B1	1.1	
	Upper quartile=75	B1	1.1	
	Inter quartile range=17	M1	1.1	Their UQ-LQ
	$75 + 1.5 \times 17 = 100.5$ $58 - 1.5 \times 17 = 32.5$	M1	1.1	Using outlier formula with their UQ/LQ and IQR
		A1	1.1	Either bound correct
	$100.5 > 91 \; and \; 32.5 < 45$ Therefore there are no outliers	E1dep	2.1b	Dep on both bounds correct and comparison
	Total	**6**		

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th><th>AO</th><th>Notes</th></tr>
<tr><td>2(a)</td><td>H_0: $\mu_S = \mu_M = \mu_L$
H_1: At least two of the means differ</td><td>B1</td><td>1.3</td><td>oe
Or $\mu_i = \mu$
for i = S,M,L
Other subscripts accepted if properly declared</td></tr>
<tr><td></td><td>T = 1683
$SS_T = 182\ 569 - \frac{1683^2}{23}$
$= 59\ 417.3$</td><td>M1</td><td>1.3</td><td>SS_T method
PI</td></tr>
<tr><td></td><td>$SS_B = \frac{256^2}{8} + \frac{346^2}{7} + \frac{1081^2}{8} - \frac{1683^2}{23}$
$= 48\ 212.7$</td><td>M1</td><td>1.3</td><td>SS_B method
PI</td></tr>
<tr><td></td><td></td><td>M1dep</td><td>1.3</td><td>SS_E method
No negative SS values.
Dep one previous M1</td></tr>
<tr><td></td><td><table><tr><th></th><th>SS</th><th>df</th><th>MS</th></tr><tr><td>Between times</td><td>48 213.7</td><td>2</td><td>24 106.4</td></tr><tr><td>Error</td><td>11 204.6</td><td>20</td><td>560.2</td></tr><tr><td>Total</td><td>59 417.3</td><td>22</td><td></td></tr></table></td><td>B1</td><td>1.3</td><td>PI
df 2 and 20</td></tr>
<tr><td></td><td></td><td>M1dep</td><td>1.3</td><td>PI
MS divide SS by df
Dep all previous M marks but ft on df values</td></tr>
<tr><td></td><td>$F = \frac{24\ 106.4}{560.2} = 43.03$</td><td>M1dep</td><td>1.3</td><td>PI
F method
awrt 43
or
p = 0.000000056/57
Dep on all previous M marks but ft on df values</td></tr>
</table>

	F^2_{20} = 3.493	B1	1.3	
	"43" > "3.493" Reject Ho	M1ft	2.1b	Comparison of their ts and cv and correct decision Or $p < 0.05$
	There is significant evidence to suggest that **mean** IGF-I levels vary between at least two of the lengths of time of insulin treatment.	E1dep	2.1a	Correct conclusion in context Dependent on correct solution apart from first B1
2(b)	Age of cat Other health problems Breed of cat Diet of cat	E1,E1	2.1b, 2.1b	Any two reasonable factors
2(c)	IGF-I levels are normally distributed The distributions from which the three samples are taken have equal variance The selected cats must be independent of each other	E1, E1	3.1a, 3.1a	
2(d)	Because the variance of long-term,1350.4, is much larger than the variance of the other two categories ,128.6 and 142.0	E1	3.1a	
	Total	**15**		

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th><th>AO</th><th>Notes</th></tr>
<tr><td>3(a)</td><td>Ewa does not have paired data</td><td>E1</td><td>3.1a</td><td>oe</td></tr>
<tr><td>3(b)</td><td>The Wilcoxon Rank-Sum is a non-parametric test so does not require knowledge of the distribution of numbers of ticks</td><td>E1</td><td>3.1a</td><td></td></tr>
<tr><td>3(c)</td><td>$H_0: \eta_T = \eta_G$
$H_1: \eta_T \neq \eta_G$</td><td>B1</td><td>1.3</td><td>H_0: Samples from identical populations
H_1: Samples from different populations
oe
do not accept use of η_d</td></tr>
<tr><td></td><td><table><tr><th>Timber Acquisition (T)</th><th>Growing (G)</th></tr><tr><td>2 9
4 7
5 6
9 2</td><td>1 10
3 8
6 5
7 4
8 3
10 1</td></tr></table></td><td>M1</td><td>1.3</td><td>Attempt at ranking as one group</td></tr>
<tr><td></td><td>T_A=20 or T_B=35</td><td>A1</td><td>1.3</td><td>Both T correct (reverse totals 24,31)</td></tr>
<tr><td></td><td>$U_A = 20 - \frac{1}{2}(4)(5) = 10$</td><td>M1</td><td>1.3</td><td>Attempt at either U</td></tr>
<tr><td></td><td>$U_B = 35 - \frac{1}{2}(6)(7) = 14$</td><td>A1</td><td>1.3</td><td>Either U correct</td></tr>
<tr><td></td><td>Cv = 2</td><td>B1</td><td>1.3</td><td>or 22</td></tr>
<tr><td></td><td>“2” < ”10” Do not reject H_0</td><td>M1ft</td><td>2.1b</td><td>or 22>(14), comparison, and correct decision for their t.s. and cv (correct tail)</td></tr>
</table>

	There is no significant evidence that the average numbers of ticks per 1 m^2 differs between locations	E1dep	2.1a	Correct conclusion in context Dependent on correct solution apart from first B1
	Total	**10**		

Question	Scheme	Marks	AO	Notes
4(a)	$X \sim N(1800, 100^2)$ $P(X > 2000) = 0.02275$	B1	1.2	awfw 0.0227-0.0228
4(b)	$\bar{X} \sim N\left(1800, \frac{100^2}{10}\right)$	M1	1.2	PI for use of ÷10 oe
	$P(\bar{X} < 1700) = 0.000783$	A1	1.2	
4(c)	$H_0: \mu = 1750$ $H_1: \mu < 1750$	B1	1.3	Both hypotheses correct oe
	$\bar{X} \sim N\left(1750, \frac{100^2}{10}\right)$	M1	1.3	PI correct model used
	$\frac{1700 - 1750}{\frac{100}{\sqrt{10}}} = -1.58$	A1	1.3	awrt -1.58 ignore sign **or** p = awrt 0.057
	"-1.58" > -1.6449 Do not reject H_0,	M1	2.1b	Correct comparison of ts and cv **or** p value compared to sig level 0. 057 > 0.05
	There is not significant evidence to suggest the mean weight of packaged pumpkins is less than 1.75kg when harvested after 19 weeks	E1dep	2.1a	Correct conclusion in context Dependent on correct solution apart from first B1

Question	Scheme	Marks	AO	Notes
	Alternative			
	H_0: $\mu = 1750$ H_1: $\mu < 1750$	(B1)		Both hypotheses correct oe
	$\bar{X} \sim N\left(1750, \frac{100^2}{10}\right)$	(M1)		PI correct model used
	$1750 - 1.6449 \times \frac{100}{\sqrt{10}} = 1698$	(A1)		awrt 1698
	1700>1698 Do not reject H_0,	(M1)		Correct comparison
	There is no significant evidence to suggest the mean weight of packaged pumpkins is less than 1.75kg when harvested after 19 weeks	(E1dep)		Correct conclusion in context Dependent on correct solution apart from first B1
4(d)	Assumption is sample is random	E1	2.1a	
	So not valid as all from same location	E1	3.1b	oe e.g. only valid if that corner is representative of the whole field Must include context
4(e)	A parameter is a numerical property of a population	E1	1.1	
	Such as the mean of 1.8kg or the standard deviation of 100g	E1	2.1a	
	A statistic is a numerical property of a sample and is a function only of the values in the sample and contains no unknown parameters	E1	1.1	
	Such as the mean of 1.7kg	E1	2.1a	
4(f)	z=1.88079	B1	1.2	PI
	$\frac{(2000 - 1880)}{\sigma} = 1.88079$	M1	1.2	PI Allow full marks for evidence of trial and improvement
	$\sigma = 63.8$ g (0.0638kg)	A1	1.2	oe awrt 64g

Question	Scheme	Marks	AO	Notes
4(g)	Approximately bell shaped No outliers Or Mean (peak) is around 1880g Or All values within 3 s.d. of mean	E1 E1	3.1a 3.1a	Accept symmetric about the mean
	Total	**19**		

Question	Scheme	Marks	AO	Notes
5(a)	$2X$ represents twice change in value of a share of the company on a single day.	E1	2.1a	oe e.g. the change in price of two shares
5(b)	$X_1 + X_2$ represents the total change in price of a share on two randomly chosen days	E1	2.1a	
5(c)	$T = X_1 + X_2 + X_3 + X_4 + X_5$ $T \sim \mathrm{N}(3.25, 23.9)$	M1 M1	1.2 1.2	PI Mean Variance
	$\mathrm{P}(T > 5) = 0.360$	A1	1.2	awrt 0.36
5(d)	Linus has missed the possibility that the price could decrease by more than \$5 The price could increase on one day and decrease on another which results in a total change of more than five dollars, while the overall change is less than five dollars Changes happen across the day, not just at the end and Linus is missing the possibility that a share increases and decreases on the same day The model is for 2023 only and not for any working week.	E1, E1	3.1a, 3.1a	Any two reasons
5(e)	This implies that price changes on different days are **not independent,** so the calculation is **not valid**	E1	3.1a	
		E1	3.1a	Fully correct in context
5(f)	Linus should use data from over a longer period of time	E1	3.1a	Allow Linus should use a random sample of dates instead of just one month

Question	Scheme	Marks	AO	Notes
	As this will be a better representation of the change per day and ignore short term trends	E1	3.1a	
	Total	**11**		

Question	Scheme	Marks	AO	Notes
6(a)(i)	Unrestricted random sampling	E1	1.1	Sampling with replacement
6(a)(ii)	(Restricted) Simple random sampling	E1	1.1	Sampling without replacement
6(b)	Sampling with replacement (unrestricted) allows the same song to be chosen more than once but sampling without replacement (simple) has no repetition	E1	1.1	
6(c)	Number her songs 001-145	E1	1.1	oe
	Generate 3 digit random numbers…			
	Ignore numbers out of range	E1	1.1	
	Ignore repeats	E1	1.1	
	Keep going until you have 30 numbers and **select the matching songs**	E1	1.1	
6(d)(i)	$\frac{1}{145}$ (=0.006897)	B1	1.2	Awrt 0.00690
6(d)(ii)	$1 \times \frac{144}{145} \times \frac{143}{145} \times \frac{142}{145}$	M1	1.2	PI
	$= 0.959$	A1	1.2	
6(d)(iii)	0	B1	1.2	
6(e)	After it plays every song on a list once and shuffles the whole library again, the first song of the new list could be the same as the last song of the first list	B1	2.1b	

Question	Scheme	Marks	AO	Notes
6(f)	H_0: $p = \frac{35}{145}$ (=0.241) H_1: $p > \frac{35}{145}$	B1	1.3	oe
	$X \sim B\left(30, \frac{35}{145}\right)$	M1	2.1a	Use of binomial distribution, n = 30, and their Ho value PI
	$P(X \geq 11) = 0.0862$	A1	1.3	PI or critical region {12, ...30} oe
	"0.0862">0.05 Do not reject H_0,	M1	2.1b	Comparison of their probability with 0.05 or comparison of 11 with their critical region and correct decision
	Not significant evidence the music player is biased	E1dep	2.1a	Correct conclusion in context Dependent on correct solution apart from first B1
6(g)	Suji's probability of selecting a song by the singer would not be constant	E1	3.1a	oe
	So binomial distribution would not be suitable	E1	3.1a	
	Total	**19**		

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