Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE
In Statistics (9ST0)
Paper 02: Statistical Inference

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General Marking Guidance

Total marks

The total number of marks for the paper is 80.

Mark types

The Edexcel Statistics mark schemes use the following types of marks:

- **M** **Method** marks,
  awarded for 'knowing a method and attempting to apply it',
  unless otherwise indicated.
- **A** **Accuracy** marks can only be awarded if the relevant method (M) marks have been earned.
- **B** **Unconditional accuracy** marks are independent of M marks
- **E** **Explanation** marks

NOTE: Marks should not be subdivided.

Abbreviations

These are some of the marking abbreviations that will appear in the mark schemes.

- ft follow through
- PI possibly implied
- cao correct answer only
- cso correct solution only
  (There must be no errors in this part of the question)
- awrt answers which round to
- awfw answers which fall within (a given range)
- SC special case
- nms no method shown
- oe or equivalent
- dep dependent (on a given mark or objective)
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper

Further notes

- 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.
- All A marks are 'correct answer only' (cao), unless shown, for example, as A1ft to indicate that previous wrong working is to be followed through.
- All M marks are 'possibly implied' (PI) unless specifically stated otherwise in the 'Notes' column.
- After a **misread**, the subsequent A marks affected are treated as A1ft, but manifestly absurd answers should never be awarded A marks.
- **Crossed out** work should be marked UNLESS the candidate has replaced it with an alternative response.
- If **two solutions** are given, each should be marked, and the resultant mark should be the mean of the two marks, rounded down to the nearest integer if needed.

Question	Scheme	Marks	AO	Notes
1(a)				Both correct d=B-A
	$H_0: \mu_d = 0$ $H_1: \mu_d > 0$	B1	1.3	Allow $H_1: \mu_d < 0$ If differences are consistent
	$\bar{d} = 1.5916$ ... $s_d = 2.42279$ ... $s_d^2 = 5.8699$ ... (d = 3.1, 1.2, 4.1, 0, -1.3, 1.8, 4.5, -1.8, 2.8, 5.4, -1.2, 0.5)	M1	1.3	PI Differences found and attempt to find their mean and standard deviation
	$t = \frac{"1.5916 \ldots."}{"2.42279 \ldots"/\sqrt{12}}$	M1	1.3	PI ts method correct accept use of variance
	=2.276	A1	1.3	awrt 2.28 (ignore sign) **or** p = awrt 0.022
	cv=1.796	B1	1.3	Alternatively comparing p value with sig level 0.022<0.05 Correct comparison of their ts and cv
	"2.276" > "1.796" Reject H_0	M1	2.1b	Condone: $-2.276 < -1.796$ or comparing p value with sig level 0.022<0.05
	There is significant evidence to suggest there has been a **decrease** in the average eye fatigue score with regular yoga practice.	E1dep	2.1a	Correct conclusion in context dependent on correct solution apart from first B1

Alternative				
1(a)	$H_0: \mu_d = 0$ $H_1: \mu_d > 0$	(B1)		Both correct d=B-A Allow $H_1: \mu_d < 0$ If differences are consistent
	$\bar{\bar{d}} = 1.5916$ ... $s_d = 2.42279$ ... $s_d^2 = 5.8699$ ... (d = 3.1, 1.2, 4.1, 0, -1.3, 1.8, 4.5, -1.8, 2.8, 5.4, -1.2, 0.5)	(M1)		PI Differences found and attempt to find their mean and standard deviation
	cv = $0 + 1.796 \times \frac{"2.42..."}{\sqrt{12}}$	(M1)		Accept use of variance
	1.256	(A1)		awrt 1.26
	t = 1.796	(B1)		A t value of 1.796 seen
	"1.592" > "1.256" Reject H_0	(M1)		Correct comparison of their ts and cv Condone: 1.256 < 1.592
	There is significant evidence to suggest there has been a **decrease** in the average eye fatigue score with regular yoga practice.	(E1dep)		Correct conclusion in context dependent on correct solution apart from first B1

1(b)	Students self-selected their own scores so results are subjective Only included students from Brenda's yoga class not other yoga teachers. Could have completed the questionnaire straight after a relaxation session/lesson focusing on eye fatigue Might be completing questionnaire at the same time so peer pressure might lead to lower/similar scores Links between eye fatigue and yoga might have been discussed in recent lessons.	E1 E1	3.1b 3.1b	Influencing responses Any two sensible reasons
	Total	**9**		

Question	Scheme	Marks	AO	Notes
2	$H_0: p = 0.75$ $H_1: p > 0.75$	B1	1.3	oe
	Selecting correct test statistic of 249 (or 248.5)	B1	1.3	Or 63 with $H_0: p = 0.25$ $H_1: p < 0.25$
	Use of $X \approx Y \sim N(234, 58.5)$	M1	2.1b	PI Use of normal approx. $s = 7.649^2$ If using 63or (63.5) $N(78, 58.5)$
	$z = \frac{249-234}{\sqrt{58.5}}$	M1	1.3	PI Ignore use of continuity correction in probability **or** calculation of test statistic
	"1.961" > "1.645" Reject H_0	M1	2.1b	Comparison of their ts and cv or comparing p value with sig level 0.0249 < 0.05 <u>Using CC</u> $z = 1.8957$ p-value$= 0.0289$
	There is significant evidence to suggest that the proportion of under 18s who agree with the statement 'I am worried about the impact of climate change' is more than 75%	E1dep	2.1a	Conclusion in context dep correct cv and ts

Alternative 1				
2	$H_0: p = 0.75$ $H_1: p > 0.75$	(B1)		oe
	Selecting correct test statistic of 249 (or 248.5)	(B1)		Or 63 (63.5) with $H_0: p = 0.25$ $H_1: p < 0.25$
	Use of $X \approx Y \sim N(234, 58.5)$	(M1)		PI Use of normal approx
	cv = 246.6	(M1)		PI Ignore use of continuity correction in probability **or** calculation of test statistic awrt 247
	"249" (or 248.5) > "246.6" Reject H_0	(M1)		Comparison of their ts and cv
	There is significant evidence to suggest that the proportion of under 18s who agree with the statement 'I am worried about the impact of climate change' is more than 75%	(E1dep)		Conclusion in context dep correct cv and ts

Alternative 2				
2	$H_0: p = 0.75$ $H_1: p > 0.75$	(B1)		oe
	Selecting correct test statistic of 249 (or 248.5)	(B1)		Or 63 (63.5) with $H_0: p = 0.25$ $H_1: p < 0.25$
	$ts = \frac{\frac{249}{312} - 0.75}{\sqrt{\frac{0.75(1-0.75)}{312}}}$	(M1)		Attempt at formula with numerator correct, ignore signs Ignore use of continuity correction in probability **or** calculation of test statistic
		(M1)		Attempt at formula with denominator correct, ignore signs
	"1.961" > "1.645" Reject H_0	(M1)		Comparison of their ts and cv
	There is significant evidence to suggest that the proportion of under 18s who agree with the statement 'I am worried about the impact of climate change' is more than 75%	(E1dep)		Conclusion in context dep correct cv and ts
	Total	**6**		

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th><th>AO</th><th>Notes</th></tr>
<tr><td>3(a)</td><td>
<table>
<tr><th colspan="2"></th><th colspan="5">Supermarket</th></tr>
<tr><th colspan="2"></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td rowspan="4">Age category</td><td>Student</td><td>10.6</td><td>7.1</td><td>2.3</td><td>1.8</td><td>1.2</td></tr>
<tr><td>Young adult</td><td>10.1</td><td>6.8</td><td>2.2</td><td>1.8</td><td>1.1</td></tr>
<tr><td>Older adult</td><td>13.8</td><td>9.3</td><td>3.0</td><td>2.4</td><td>1.5</td></tr>
<tr><td>Retired</td><td>11.5</td><td>7.8</td><td>2.5</td><td>2.0</td><td>1.3</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>M1</td><td>1.3</td><td>At least 3 correct to 1dp</td></tr>
<tr><td></td><td></td><td>A1</td><td>1.3</td><td>All correct to 1dp</td></tr>
<tr><td>3(b)</td><td>Expected frequencies are less than 5 so columns C, D & E need to be combined for both observed and expected frequencies so that they can be compared.</td><td>B1</td><td>2.1a</td><td></td></tr>
</table>

3(c)

		Supermarket		
		A	**B**	**Other**
Age category	**Student**	10.6	7.1	5.3
	Young adult	10.1	6.8	5.1
	Older adult	13.8	9.3	6.9
	Retired	11.5	7.8	5.8

H_0: No association between age and preferred supermarket. H_1: An association exists between age and preferred supermarket.	B1	1.3	oe
	M1	1.3	Combine their expected and observed frequencies from (a) PI
e. g. $\frac{(15-10.6)^2}{10.6}$ ...	M1	1.3	Attempt at $\frac{(O-E)^2}{E}$ PI
1.83 2.37 0.017 0.0802 0.0941 0.00196 0.0029 0.569 0.639 2.63 6.646 0.559			
$\frac{(15-10.6)^2}{10.6}+\cdots+\frac{(4-5.8)^2}{5.8}$	M1	1.3	Intention to sum PI
ts=15.439	A1	1.3	awfw 15.3 ~ 15.7 awrt 12.6
cv = 12.592	B1	1.3	**or** *p*-value = 0.016 ~ 0.018
"15.439" > "12.59" Reject H_0	M1	2.1b	Correct comparison of their ts and cv or comparing *p* value with sig level *p*-value <0.05 PI

	Significant evidence to suggest an association exists between age and preferred supermarket.	E1dep	2.1a	Dep on ts/ cv or *p*-value correct
3(d)	**Improvements in bold (not exhaustive)** Explanations not bold (not exhaustive) **Use given age groups rather than asking people to self-select age category.** This would avoid self-selection bias. **Share the survey more widely than just her local town.** This would avoid bias due to the area in which she lives. **Use alternative method to just social media.** This would allow people who do not use social media to also take part. **Randomly select people to take part.** This would give everyone in the chosen population an equal chance to be selected.	B1 B1 E1 E1	3.1a 3.1a 3.1b 3.1b	Any sensible way to avoid bias Any associated explanation
	Total	**15**		

Question	Scheme	Marks	AO	Notes
4(a)	$H_0: p_L - p_S = 0$ $H_1: p_L - p_S > 0$	B1	1.3	oe
	$\hat{p} = \frac{13+9}{77+64}$ $\left(= \frac{22}{141}\right)$	M1	1.3	0.156…
	Test statistic	M1	1.3	Attempt at formula with numerator correct, ignore signs
	$= \frac{\frac{13}{77} - \frac{9}{64}}{\sqrt{\frac{22}{141} \times \left(1 - \frac{22}{141}\right) \times \left(\frac{1}{77} + \frac{1}{64}\right)}}$	M1	1.3	PI $\left(\frac{1}{77} + \frac{1}{64}\right)$ seen
		M1ft	1.3	PI Denominator of correct form with their $\hat{p}$ used
	0.45952	A1	1.3	Awrt 0.46
	"0.45952" < "1.6449" Do not reject H_0	M1	2.1b	Comparison of their ts and cv **or** $0.323 > 0.05$
	Insufficient evidence to suggest the proportion of larger businesses using homeworking was higher than the proportion of smaller businesses.	A1	2.1a	No context required Requires correct ts and cv

Alternative				
4(a)	$H_0: p_L - p_S = 0$ $H_1: p_L - p_S > 0$	(B1)		oe
	$\hat{p} = \frac{13+9}{77+64} = \frac{22}{141}$	(M1)		0.156…
	ts = $\frac{13}{77} - \frac{9}{64}$ = 0.0282…	(M1)		awrt 0.28
	Var = $\frac{22}{141} \times \left(1 - \frac{22}{141}\right) \times \left(\frac{1}{77} + \frac{1}{64}\right)$	(M1)		PI $\left(\frac{1}{77} + \frac{1}{64}\right)$ seen
		(M1ft)		PI Variance of correct form with their $\hat{p}$ used
	0.00376…	(A1)		awrt 0.0038
	"0.0282" < "0.101" Do not reject H_0	(M1)		Comparison of their ts and cv **or** $0.323 > 0.05$
	Insufficient evidence to suggest the proportion of larger businesses using homeworking was higher than the proportion of smaller businesses.	(A1)		No context required Requires correct ts and cv

4(b)	For businesses in NI the percentage using or intending to use homeworking is not greater for businesses with more than 100 employees than for businesses with fewer than 100 employees.	E1ft E1ft	2.1a 2.1a	Conclusion in context Can be awarded in 4(a) Audience No difficult statistical vocabulary used. No oversimplification.
4(c)	That the **sample** of **businesses** can be considered to be **random** That the **responses** from **businesses** were **independent** from one another.	E1	3.1a	Either response accepted Must have some context
4(d)	Since only one area of the UK was used to select the businesses for the survey it is likely the results of (a) are not valid for all businesses across the UK.	E1	3.1b	
	Total	**12**		

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th><th>AO</th><th>Notes</th></tr>
<tr><td>5(a)</td><td>Assume that cortisol measurements are symmetrically distributed.</td><td>E1</td><td>2.1a</td><td>Context required</td></tr>
<tr><td></td><td>$H_0: \eta = 3.82$
$H_1: \eta > 3.82$</td><td>B1</td><td>1.3</td><td>oe
accept μ</td></tr>
<tr><td></td><td><table><tr><th>Differences</th><th>Ranks</th><th>Reverse</th></tr><tr><td>0.38</td><td>10</td><td>3</td></tr><tr><td>0.3</td><td>8</td><td>5</td></tr><tr><td>-0.06</td><td>3</td><td>10</td></tr><tr><td>0.03</td><td>2</td><td>11</td></tr><tr><td>-0.18</td><td>5</td><td>8</td></tr><tr><td>0.53</td><td>11</td><td>2</td></tr><tr><td>-0.09</td><td>4</td><td>9</td></tr><tr><td>0.7</td><td>12</td><td>1</td></tr><tr><td>0</td><td></td><td></td></tr><tr><td>0.31</td><td>9</td><td>4</td></tr><tr><td>0.2</td><td>6</td><td>7</td></tr><tr><td>0.28</td><td>7</td><td>6</td></tr><tr><td>-0.02</td><td>1</td><td>12</td></tr></table></td><td>M1</td><td>1.3</td><td>Attempt at differences</td></tr>
<tr><td></td><td></td><td>M1</td><td>1.3</td><td>Attempt at ranking
Condone reverse ranks</td></tr>
<tr><td></td><td>$T^+ = 65$
$T^- = 13$</td><td>A1</td><td>1.3</td><td></td></tr>
<tr><td></td><td>$cv = 17$ (or) 65</td><td>B1</td><td>1.3</td><td></td></tr>
<tr><td></td><td>“13” < “17” or 65 = 65
Reject H_0</td><td>M1</td><td>2.1b</td><td>Correct comparison of their ts and cv</td></tr>
<tr><td></td><td>There is significant evidence to suggest that the average cortisol level in first-time skydivers is greater than in those who have skydived previously</td><td>E1dep</td><td>2.1a</td><td>Conclusion in context dep correct cv and ts</td></tr>
</table>

<table>
<tr><td>5(b)</td><td>The population median/average for those who have skydived before may be a different value to 3.82 $\mu g/dL$ so the differences/ranks/test statistic will likely change</td><td>E1</td><td>3.1b</td><td>oe</td></tr>
<tr><td>5(c)</td><td>H_0: No association
H_1: Positive association</td><td>B1</td><td>1.3</td><td>oe
Condone ‘correlation’</td></tr>
<tr><td></td><td>Use of Spearman’s rank correlation coefficient</td><td>M1</td><td>2.1a</td><td>PI
Sight of SRCC, Spearman’s, any ranks</td></tr>
<tr><td></td><td>Rank each separately
<table><tr><td>3</td><td>2</td><td>1</td><td>5</td><td>4</td><td>6</td><td>8</td><td>9</td><td>7</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>
Reverse ranks
<table><tr><td>7</td><td>8</td><td>9</td><td>5</td><td>6</td><td>4</td><td>2</td><td>1</td><td>3</td></tr><tr><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table></td><td>A1</td><td>1.3</td><td>cao either</td></tr>
<tr><td></td><td>ts = $|r_s| = 0.8667$

|cv| = 0.6000</td><td>B1</td><td>1.3</td><td></td></tr>
<tr><td></td><td>“0.8667” > “0.6000”
Reject H_0</td><td>M1</td><td>2.1b</td><td>Consistent comparison of their ts and cv</td></tr>
<tr><td></td><td>There is significant evidence to suggest that there is a positive association between cortisol levels in sweat and saliva</td><td>E1dep</td><td>2.1a</td><td>Conclusion in context dep correct cv and ts</td></tr>
</table>

5(d)	Although there is a positive association between the sweat and saliva levels…	M1	2.1b	Uses the results from (c)
	…this does not mean that the sweat and saliva levels are the same value	E1	3.1a	Evidence the student understands the association does not imply the exact same value. **Do not accept** correlation does not imply causation
	Therefore, the test in (a) is still likely to not be valid or Miku is therefore not correct	E1dep	3.1b	Dependent on M1
	Total	**18**		

Question	Scheme	Marks	AO	Notes
6(a)	$s_p^2 = \frac{(20-1)\times 4.57^2+(20-1)\times 4.41^2}{20+20-2}$ [= 20.1665]	M1	1.2	PI Attempt to use the correct formula for s_p^2
	$d = \frac{41.3-39.0}{\sqrt{20.1665}}$ = 0.512	A1ft	1.2	awrt 0.51
6(b)	The *p*-value > 0.05, suggest that there is insufficient evidence of a difference in the **mean** [VO2 max levels for the HIIT and recommended exercise…]	E1	2.1a	oe correct interpretation of *p*-value No context required
	…whereas Cohen's *d* suggests that the effect is 'medium' thus indicating a difference in the **mean** [VO2 max levels for the HIIT and recommended exercise]	E1ft	2.1a	oe correct interpretation of their Cohen's *d* No context required
		E1	2.1a	Fully correct in context Must have attempted to use both the *p*-value and Cohen's *d* to conclude oe
	Total	**5**		

Question	Scheme	Marks	AO	Notes
7(a)	**FILTER**	B1	1.1	
	'Branch' to 'Manchester' 'Branch' to 'Liverpool'	B1	1.1	oe Accept 'Column D' in replace of 'Branch'
7(b)	$H_0: \mu_M - \mu_L = 0$ $H_1: \mu_M - \mu_L \neq 0$	B1	1.3	oe
	$\bar{m} = \frac{268800}{42} = 6400$ $\bar{l} = \frac{314250}{50} = 6285$	M1	1.3	PI
	ts $= \frac{6400-6285}{\sqrt{\frac{511^2}{42}+\frac{425^2}{50}}}$	M1	1.3	PI Numerator correct PI
		M1	1.3	$\sqrt{\frac{511^2}{42}+\frac{425^2}{50}}$ oe
	ts = 1.1599	A1	1.3	awrt 1.16
	cv = $\pm$1.9600	B1	1.3	
	"-1.9600" < "1.1599" < "1.9600" Do not reject H_0	M1	2.1b	Comparison of their ts and cv with consistent signs or comparing *p* value with sig level 0.123 > 0.025
	There is insufficient evidence to suggest that the average level of savings differs in Manchester and Liverpool	E1dep	2.1a	Conclusion in context dep correct cv and ts Accept population mean

Alternative				
7(b)	$H_0: \mu_M - \mu_L = 0$ $H_1: \mu_M - \mu_L \neq 0$	(B1)		oe
	$\bar{m} = \frac{268800}{42} = 6400$ $\bar{l} = \frac{314250}{50} = 6285$	(M1)		PI
	ts = 6400 – 6285 = 115	(M1)		PI
		(M1)		$\sqrt{\frac{511^2}{42} + \frac{425^2}{50}}$ or $\frac{511^2}{42} + \frac{425^2}{50}$
	cv = 194.31…	(A1)		awrt 194
	Evidence of using inverse normal to find cv with a mean of 0 and two tails	(B1)		
	"-194" < "115" < "194" Do not reject H_0	(M1)		Comparison of their ts and cv or comparing *p* value with sig level 0.123 > 0.025
	There is insufficient evidence to suggest that the average level of savings differs in Manchester and Liverpool	(E1dep)		Conclusion in context dep correct cv and ts Accept population mean
7(c)(i)	Since the conclusion of the hypothesis test was 'do not reject H_0' the only error type which could be made is a Type II	E1ft	3.1a	Evidence the student links the result of their hypothesis test to the correct error type
7(c)(ii)	Type II error would be accepting that there is no difference in the population average level of savings in Liverpool and Manchester when in fact there is a difference	E1ft	3.1a	Accept population mean Context required

7(d)	$= \frac{270}{\sqrt{\frac{511^2}{42}+\frac{425^2}{50}}} = 2.767\ldots$	M1	1.3	PI Standardising of μ oe
	$P(-1.96 < \bar{x} < 1.96 \mid \mu = 2.72)$	M1	1.3	PI Probability of Type II attempted
	= 0.223	A1	1.3	awfw 0.21 ~ 0.23
Alternative				
7(d)	Use of $\mu = 270$	(M1)		PI
	$P(-194 < \bar{x} < 194 \mid \mu = 270)$	(M1)		PI Probability of Type II attempted
	= 0.223	(A1)		awfw 0.21 ~ 0.23
	Total	**15**		

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