



Mark Scheme (Results)

Autumn 2020

Pearson Edexcel GCE In A Level Statistics
(9ST0/03)

Paper 3: Statistics in Practice

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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.
- 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)	Teru is not correct	B1	3.1b	Clear statement that Teru is incorrect
	because Figure 1 shows proportions not numbers.	E1	3.1b	oe Indication that information is missing on how many people worked in each civil service grade in these years.
1(b)	Between 2010 and 2017 the proportion of women employed in most grades of the civil service increased.			General increase in proportion of women. Could be expressed as decrease in proportion of men.
	The change was greatest in the senior grades.			Change greatest for senior grades
	Between 2010 and 2017 the proportion of men/women employed in the junior grades of the civil service remained stable.			Relatively stable for junior grades
	But the proportion of women employed in the senior grades increased.			Increase of women in the senior grades
	There have been consistently more women at the lower grades and more men at the higher grades throughout this time period.			Consistency in gender/seniority imbalance.
	But the proportion of men in the higher grades has decreased.			Decrease of men in the senior grades
		E1 E1	1.1 1.1	Any sensible pair of comments ISW

Question	Scheme	Marks	AO	Notes
1(c)	The information is included as a benchmark against which the person reading the graph can compare the proportions shown.	E1	3.1a	oe Coherent explanation about comparison and/or baseline/benchmark
1(d)	Possible comments:			Must be coherent
	The proportion of civil servants from an ethnic minority has generally increased between 1988 and 2017...			oe
	...but took a dip around 2000.			oe
	The proportion of senior civil servants from an ethnic minority generally rose between 2006 and 2014 (or 2015) ...			oe could be more detailed
	...but then continued to fall until 2017.			oe subsequent fall
	In 2011 the proportion of civil servants from an ethnic minority was about $\frac{2}{3}$ of the proportion in the UK population.			oe Might quote both proportions from graph to compare.
	In 2011 the proportion of senior civil servants from an ethnic minority was about $\frac{1}{3}$ of the proportion in the UK population.			oe Might quote both proportions from graph to compare.
		E1, E1, E1	1.1 1.1 1.1	Any three distinct correct comments. Detailed year-on-year description can only earn E1, E1 maximum.
		E1	1.1	For an appropriate style suitable for a news website
Total		9		

Question	Scheme	Marks	AO	Notes
2(a)	0.991	B1	1.2	cao
2(b)	H ₀ : Independent H ₁ : Not independent	B1	1.3	OE Both. Allow one or two tailed. Accept H ₀ : $\rho = 0$ H ₁ : $\rho \neq 0$ or $\rho > 0$ Mark completely independent of the rest of the question
	cv 0.6215 1-tail (or 0.7067 2-tail)	M1	1.3	Correct cv to 3 s.f. or <i>p</i> -values awrt 9×10^{-7} (1-tail) awrt 2×10^{-6} (2-tail)
	Reject H ₀	A1dep	2.1b	Conclusion dep correct 2(a) and M1
	There is significant evidence that (cricket) chirp rate is not independent to/associated with air temperature.	E1dep	2.1a	Full context dep correct values and conclusion.
2(c)	Because parts (a) and (b) have shown that there is a strong association between (crickets') chirp rate and (air) temperature ...	E1	2.1a	oe Could explain that as chirp rate goes up so does temp
	this suggestion seems reasonable	B1dep	2.1b	oe dep on E1 mark
2(d)	When (a snowy tree cricket) is not chirping, the (air) temperature is 4.44(°C).	E1	2.1a	oe Allow "when <i>x</i> is 0, <i>y</i> is 4.44"
	For every 1 chirp (per minute) increase, the air temperature is 0.102(°C) higher.	E1	2.1a	oe Allow "as chirps go up by 1, temp goes up by 0.102"
		B1	2.1a	All gradient comment correct with units "per minute" and °C

Question	Scheme	Marks	AO	Notes
2(e)	$y = 0.102 \times 159 + 4.44 (= 20.66)$ (residual =) $19.7 - y$ -value	M1	1.2	PI sub $x = 159$ into reg. equation and find difference with $y = 19.7$ (either sign) Implied by 0.92-1
	-0.96	A1	1.2	awfw $-1 \sim -0.92$
	Alternative			
	Direct solution from calculator -0.917	(M1) (A1)		-0.917 NMS scores M1A1
2(f)(i)	The residuals are small implying (Juliana's use of) the regression line is valid			
	Residuals for (D, E &) F (are) is positive/above the line and residual for (G and) H (are) is negative/below the line implying the relationship between x and y is not linear and (Juliana's use of) the regression line is not valid			
		B1	3.1b	Either comment on the residuals linked to validity
2(f)(ii)	The sample size was very small so (Juliana's use of) the regression line might not be valid.			
	The correlation is very strong so (Juliana's use of) the regression line is valid.			
	The scatter diagram indicates a linear relationship so (Juliana's use of) the regression line is valid.			
	The data might not be bivariate normal so (Juliana's use of) the regression line is not valid.			
	The five readings at the highest rate of chirp may indicate a non-linear relationship so (Juliana's use of) the regression line is not valid.			

Question	Scheme	Marks	AO	Notes
	Large gap in data from $x=50$ to $x=110$ so trend may be non linear			
	Thomas' sample is only from California and results may differ in other states			
		B1	3.1b	Any valid comment

Question	Scheme	Marks	AO	Notes
2(g)	Suggestion			
	Corresponding explanation			
	Make multiple recordings (for each cricket) and use the average			Indication of more data
	to improve reliability of results/eliminate variance/reduce experimental error.			
	Take a larger sample			Indication of more data
	because more data would demonstrate the pattern of the relationship better.			
	Conduct the study in a laboratory			
	so that the conditions can be controlled/reduce experimental error.			
	Sample (snowy tree crickets) in regions other than California			
	to reduce the bias in the sample.			
		B1	3.1a	Any correct suggestion
		E1	3.1a	correctly paired with the relevant explanation ISW Context not required.
	Total	16		

Question	Scheme	Marks	AO	Notes
3(a)	$H_1: \mu < 0$	B1	1.3	
	$(ts =) \frac{-0.163-0}{\left(\frac{1.37}{\sqrt{251}}\right)}$	M1	1.3	PI correct working (ignore sign) Condone 1 slip
	$= -1.885$	A1	1.3	awrt 1.88 ~ 1.89 (ignore sign)
	cv = -1.6449 or p -value = 0.0297 < 0.05	B1	1.3	cv awrt 1.64 (ignore sign) or comparison p -value awrt 0.0297 with 0.05
				Allow t-test cv awrt (-)1.65 (ignore sign) or p -value awrt 0.0303
	Reject H_0 (significant evidence that the BASF share price has a negative daily percentage change on average)	A1dep	2.1a	oe Context not required Dependent on correct ts & cv with matching signs or correct p -value compared with 0.05
3(b)	(A is correct because Chidi had) all of the data for 2018 and the population mean was known (to be -0.163)	E1	3.1a	Explanation that 2018 population is fully known.
	(B is correct because Chidi) used a biased sample that was from one year only			Sample biased/not random or not representative of all years.
	Or (B is correct because) past performance does not necessarily predict future performance			oe Allow “extrapolation is unreliable”
		E1	3.1b	Either comment for B

Question	Scheme	Marks	AO	Notes
3(c)	$\frac{183}{251} = 0.729 = 72.9\%$ $\frac{241}{251} = 0.960 = 96.0\%$	M1	1.2	Calculate both proportions as decimals or % awrt 0.73, 0.96 or awrt 73%, 96%
	73% (is more than) 68% 96% (is almost the same as) 95%	A1	2.1b	oe Compare both proportions <i>correctly</i> as decimals or % to 2s.f. or better.
				SC1 one proportion correctly calculated and compared.
	The histogram is (approximately) bell-shaped, centred on the mean.			Description of shape wrt the mean.
	Or The histogram shows a (slight) negative skew.			Correct comment on the skew.
		B1	2.1b	Either
	(Use of) the model is just about valid.			oe
	(Use of) the model is not quite valid.			oe
		E1dep	3.1a	Either response in summation, as appropriate to candidate's argument.
				At least 2 of the 3 previous marks must have been gained. Do not penalise more sophisticated answers with e.g. reference to kurtosis or the log normal dist.
	Total	11		

Question	Scheme	Marks	AO	Notes
4(a)	Cluster sample	B1	1.1	or Multi-stage (sample)
4(b)(i)	Some element of randomness which reduces bias.			Refer to the advantage of random selection of offices/agents as long as not implying fully random sample.
	Easier/quicker than a random sample			oe
	Restricts the geographical area that Donal has to cover.			oe e.g. "less travel is cheaper"
		B1, B1	1.1, 1.1	Two advantages
4(b)(ii)	Not a fully random sample.			
	Not all samples have a (equal) chance of being selected.			
	There could be bias in the sample because it is taken from only 3 offices			oe Restricting the sampling pool can lead to bias.
		B1	1.1	One disadvantage

Question	Scheme	Marks	AO	Notes
4(c)	There is a fixed number of trials per month ($n = 40$).			oe
	There is a fixed probability of success ($p = 0.4$).			oe
	(Outcomes of) trials/cases are independent (of each other).			oe
	There are only two possible outcomes to each trial/case.			oe e.g. "two mutually exclusive outcomes"
		B1, B1, B1	2.1a, 2.1a, 2.1a	Any three
4(d)	$(P(\text{resolved cases} \leq 14) =) 0.317$	B1	1.2	awrt 0.317 oe 31.7%
4(e)	0.317^3	M1ft	1.2	PI ft <i>their</i> 4(d)(i) if working shown
	$0.0319 \sim 0.0320$	A1	1.2	awrt 0.032 oe 3.2%
	Alternative			
	Use of $X \sim B(120, 0.4)$	(M1)		
	$P(X \leq 45) = 0.3225$	(A1)		awfw 0.322-0.323

Question	Scheme	Marks	AO	Notes	
4(f)	H ₀ : The model is appropriate H ₁ : The model is not appropriate	B1	1.3	oe Both	
		M1	1.3	PI Attempt to calculate <i>p</i> -values for B(40,0.4)	
		A1	1.3	PI all correct to 2d.p.	
		M1dep	1.3	PI Attempt to calculate E-values. Dep previous M1	
		A1	1.3	PI All E-values correct to 1d.p.	
		M1ft	1.3	PI sum of (O – E) ² /E ft if working shown	
		A1	1.3	awrt 6.1	
				Incorrect pooling: awrt t.s. = 4.8 (4.84) obtains M1A1M1A0M1A0	
		df = 4	B1	1.3	PI
		cv = 9.488 or <i>p</i> -value = 0.192 compared with 0.05	B1	1.3	cv or awfw <i>p</i> -value = 0.18~0.20
		Do not reject H ₀ . There is no significant evidence that the model B(40, 0.4) is not appropriate (for the number of legal cases resolved by an agent by the end of the month).	E1 dep	2.1a	Correct conclusion dep on all values correct.

Question	Scheme	Marks	AO	Notes
4(g)	Accepting that the model $B(40, 0.4)$ is appropriate for the number of cases resolved (by an agent) within one month when, in fact, it is not.	B1	1.3	Accepting H_0 when H_0 is not, in fact correct. No context required Accept false positive
		E1	2.1a	oe Must include full context: $B(40, 0.4)$ oe <i>and</i> “number of cases resolved within one month”
Total		22		

Question	Scheme	Marks	AO	Notes
5	$(p_C =) \frac{12}{947}$ or 0.0127 and $(p_M =) \frac{4}{75}$ or 0.0533	B1	1.2	PI Forming both prop correctly fraction or decimal awrt 0.013 & 0.053
	$H_0: \pi_C = \pi_M$ $H_1: \pi_M > \pi_C$ or $H_1: \pi_C \neq \pi_M$	B1	1.3	Both, accept two-tail or <i>correct</i> one-tail. Condone use of p. Other subscripts must be clearly defined. Mark independently.
	$(\hat{p} =) \frac{12 + 4}{947 + 75} = \frac{8}{511} = 0.0157$	M1	1.3	PI \hat{p} effort
	test statistic	M1	1.3	PI Attempt at formula with $p_M - p_C$ correct
	$= \frac{\frac{4}{75} - \frac{12}{947}}{\sqrt{\left\{ \frac{8}{511} \times \left(1 - \frac{8}{511}\right) \times \left(\frac{1}{75} + \frac{1}{947}\right) \right\}}}$	M1	1.3	PI $\sqrt{\frac{1}{75} + \frac{1}{947}}$ used
		M1dep	1.3	PI their \hat{p} used
	$= 2.73$ or p -value = 0.00632 two-tail or p -value = 0.00316 one-tail	A1	1.3	awrt $z = 2.7$ (ignore sign) or p -value = 0.0063 2-tail or p -value = 0.0032 1-tail
	$cv = 1.96$ (2-tail) or 1.645 (1-tail) or $0.0063 < 0.025$ or $0.0032 < 0.05$	B1	2.1b	cv or comparison of p -value appropriate α
	(Reject H_0) There is significant evidence that a greater/different proportion/percentage/fraction of (Miocene) digs/sites in Montana (that) yield teleoceras/rhinoceros fossils.	E1dep	2.1a	oe Conclusion correct and in context dep test all correct.
So Sharon/she should choose Montana.	E1ft	2.1b	Advice: Only allow ft if advice is based on outcome of their hypothesis test.	

Total	10
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Question	Scheme	Marks	AO	Notes																												
6(a)	<table border="1"> <thead> <tr> <th colspan="2">Knits in a group</th> <th colspan="2">Does not knit in a group</th> </tr> <tr> <th>Calmness rating</th> <th>Rank</th> <th>Calmness rating</th> <th>Rank</th> </tr> </thead> <tbody> <tr> <td>...</td> <td>...</td> <td>...</td> <td>...</td> </tr> <tr> <td>90</td> <td>18</td> <td>...</td> <td>...</td> </tr> <tr> <td>95</td> <td>20</td> <td>93</td> <td>19</td> </tr> <tr> <td>98</td> <td>21</td> <td></td> <td></td> </tr> <tr> <td>100</td> <td>22</td> <td></td> <td></td> </tr> </tbody> </table>	Knits in a group		Does not knit in a group		Calmness rating	Rank	Calmness rating	Rank	90	18	95	20	93	19	98	21			100	22					
	Knits in a group		Does not knit in a group																													
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100	22																															
		B1	1.2	All rankings correct																												
6(b)	<p>H_0: population median_{group} = population median_{not group}</p> <p>H_1: population median_{group} > population median_{not group}</p> <p>or</p> <p>H_0: Samples come from identical distributions.</p> <p>H_1: Samples do not come from identical distribution. Knitters who attend knitting groups find knitting more calming on average than those who do not.</p>	B1	1.3	<p>oe</p> <p>Allow η</p> <p>H_0: $\eta_{\text{group}} = \eta_{\text{not group}}$</p> <p>$H_1$: $\eta_{\text{group}} > \eta_{\text{not group}}$</p> <p>Both hypotheses</p> <p>H_1 must be one-tailed.</p> <p>Subscripts must be clearly defined.</p>																												
	$T_{\text{group}} = 166$ $T_{\text{not group}} = 87$	M1	1.3	Totals of ranks																												
	$U_{\text{group}} = 166 - \frac{12 \times 13}{2} = 88$	M1ft	1.3	Method correct for U																												
	$U_{\text{not group}} = 87 - \frac{10 \times 11}{2} = 32$	A1	1.3	Either U correct																												
	cv = 34 or 86	M1	1.3	cv correct (either)																												
	(32 < 34 or 88 > 86) Reject H_0 .	A1	2.1b	Correct conclusion from matching pair of cv and ts.																												
	There is significant evidence that those (knitters) who attend (knitting) groups find knitting more calming on average than those who do not.	E1	2.1a	Explanation in context Dependent on correct ts and cv.																												

Question	Scheme	Marks	AO	Notes
6(c)	Betsan could not make the assumption that the ratings followed normal distribution(s).			oe Allow “not normally distributed” <i>Not symmetrical</i>
	Her samples sizes were too small to apply the Central Limit Theorem.			oe Reference to both small sample size <i>and</i> CLT
	The ratings are not scientific measurements of calmness but they can be ranked against one-another.			oe Reference to ratings being ordinal data.
		E1,E1	3.1a, 3.1a	Any two of the above. Context not needed for full marks.
6(d)	The sample(s) might be biased/not representative.	E1	3.1a	oe More than “sample(s) not random” required. Context not needed.
	It could be that happier knitters (are more likely to) join knitting groups (than those who are not so happy when knitting).	E1	3.1b	oe Causation reversed Context needed.
Total		12		