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EDEXCEL A LEVEL FURTHER MATHEMATICS: QUESTIONS BY TOPIC

Confidence Intervals and Tests Using the t-distribution (7)

Further Statistics 2 · Topic 7

3 questions · 34 marks · Mark schemes included

Pearson Edexcel A Level Further Mathematics (9FM0), June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
7.1 T-TESTS AND CONFIDENCE INTERVALS FOR A MEAN		1 Qs · 13 marks	3
1. Q4 <i>also Topic 6</i>	Option 4B: Further Statistics 2 June2025	13	4
7.2 PAIRED T-TESTS		1 Qs · 9 marks	8
2. Q5	Option 4B: Further Statistics 2 June2023	9	9
7.3 T-TESTS FOR A DIFFERENCE OF MEANS		1 Qs · 12 marks	11
3. Q6 <i>also Topic 6</i>	Option 4B: Further Statistics 2 June2024	12	12



QUESTIONS

3 questions · 34 marks · 3 sub-topics



SUB-TOPIC 7.1

T-TESTS AND CONFIDENCE INTERVALS FOR A MEAN

Sub-topic 7.1 · 1 question · 13 marks · lowest tariff first



Question 4 continued



Question 4 continued



Question 4 continued

SUB-TOPIC 7.2

PAIRED T-TESTS

Sub-topic 7.2 · 1 question · 9 marks · lowest tariff first



(Total for Question 5 is 9 marks)



SUB-TOPIC 7.3

T-TESTS FOR A DIFFERENCE OF MEANS

Sub-topic 7.3 · 1 question · 12 marks · lowest tariff first



6. A researcher set up a trial to assess the effect that a food supplement has on the increase in weight of Herdwick lambs. The researcher randomly selected 8 sets of twin lambs. One of each set of twins was given the food supplement and the other had no food supplement. The gain in weight, in kg, of each lamb over the period of the trial was recorded.

	Set of twin lambs	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>
Weight gain (kg)	With food supplement	4.1	5.3	6.0	3.6	5.9	4.2	7.1	6.4
	No food supplement	5.0	4.8	5.2	3.4	5.1	3.9	7.0	6.5

- (a) State why a two sample t -test is not suitable for use with these data. (1)
- (b) Suggest 2 other factors about the lambs that the researcher may need to control when selecting the sample. (2)
- (c) State one assumption, in context, that needs to be made for a paired t -test to be valid. (1)

For a pair of twin lambs, the random variable W represents the weight gain of the lamb given the food supplement minus the weight gain of the lamb not given the food supplement.

- (d) Using the data in the table, calculate a 98% confidence interval for the mean of W . Show your working clearly. (5)

The researcher believes that the mean of W is greater than 200 g

- (e) Stating your hypotheses clearly, use your confidence interval to explain whether or not there is evidence to support the researcher's belief. (3)





Question 6 continued

(Total for Question 6 is 12 marks)



MARK SCHEMES

official mark schemes



Qu	Scheme	Mark	AO
4. (a)	(Prob =) 0.68268... = awrt 0.683 or awrt 68.3% (o.e.)	B1	1.1b
		(1)	
(b)	$H_0 : \sigma^2 = 6^2 \quad H_1 : \sigma^2 < 6^2$ $s^2 = \frac{422\,862 - 25 \times \left(\frac{3250}{25}\right)^2}{24} = (15.0833...)$ Test statistic = $\frac{24 \times "15.0833..."}{6^2} =, 10.0555... \text{ awrt } \underline{\underline{10.1}}$ 5% critical value (lower tail) $\chi_{24}^2(5\%) = 13.848$ (Significant result so reject H_0) there is evidence that the <u>treatment works</u> oe or <u>variance of weights is lower</u> oe	B1 M1 M1,A1 B1 A1	2.5 2.1 1.1b,1.1b 3.4 2.2b
		(6)	
(c)	$\bar{x} \pm t_{24} \frac{s}{\sqrt{25}} =, 130 \pm 2.064 \times \frac{"3.88..."}{\sqrt{25}}$ = (128.4..., 131.6...) = awrt (128, 132)	M1A1ft A1	3.3, 3.4 1.1b
		(3)	
(d)(i)	Yes (or treatment worked) since 131 is in CI (and σ reduced)	B1	2.4
(ii)	Assume $\sigma = "3.9"$ (or better) and suitable μ e.g. 131 Proportion in range (79% ~ 88%)	M1 A1 (3)	3.5a 1.1b
(13 marks)			
Notes			
(a)	B1 for awrt 0.683 or awrt 68.3% o.e. Do not accept a fraction		
(b)	1 st B1 for correct hypotheses in terms of σ or σ^2 Do not accept in words. 1 st M1 for a correct expression for s or s^2 Implied by $\frac{181}{12}$ or 15.0833... 2 nd M1 for a correct expression for ts (ft their 15.0833...) May be implied by awrt 10.1 1 st A1 for awrt 10.1 or may see $\frac{181}{18}$ 2 nd B1 for the correct cv of 13.848 (accept 13.8 or better or allow 13.85) 2 nd A1 for a correct conclusion in context (independent of hypotheses but dep on M2 and their ts < cv where $12 < cv < 15$). Incorrect comparison or contradictory statement is A0		
(c)	M1 for an attempt at a correct formula with 130 or their 3.88... and $\sqrt{25}$ and $t > 2$ 1 st A1ft for a correct expression using $t = 2.064$ (or better) can ft their 3.88... = their s 2 nd A1 for awrt (128, 132) provided M1 clearly scored.		
(d)(i)	B1 dep on a CI in (c) which includes 131 and concluding variance lower in (b). For stating treatment was successful (o.e. condone e.g. yes) and mentioning 131 (or referred to as the mean) is inside CI. Do not allow reference to critical region for CI.		
(ii)	M1 for evidence of a suitable σ used (ft their s) and a value of μ from their CI. Must see their values for μ and σ to score. A1 dep on $\sigma =$ awrt 3.9 and $\mu = [\text{awrt } 128, \text{awrt } 132]$ for an answer in the range 0.79 to 0.88 inclusive (decimal or %)		
NB	$\sigma = 3.9, \mu = 128.4$ gives 79.5%; $\sigma = 3.9, \mu = 131.6$ gives 87.2% $\sigma = 3.9, \mu = 131$ gives 87.6%		



Question	Scheme	Marks	AOs
5(a)	e.g. for each person the scores before and after are <u>not independent</u>	B1	2.4
		(1)	
(b)	The differences in scores are normally distributed.	B1	2.4
		(1)	
(c)	$d: 4 \ -3 \ 4 \ 2 \ 2 \ 6 \ 3 \ 0$	M1	3.1b
	$\bar{d} = \pm 2.25 \quad s_d = \sqrt{7.642857\dots} = 2.76457\dots$	M1	1.1b
	$H_0: \mu_d = 0 \quad H_1: \mu_d > 0$	B1	3.3
	$t = \pm \frac{''\pm 2.25''}{\frac{''2.76\dots''}{\sqrt{8}}}$	M1	1.1b
	$= \pm 2.3019\dots$ awrt ± 2.30	A1	1.1b
	Critical value $t_7 = \pm 1.895$	B1	1.1b
	$2.30 > 1.895$, therefore (reject H_0) there is sufficient evidence to: support an <u>increase in the percentage of words recalled</u> or <u>support psychologist's claim</u>	A1ft	2.2b
		(7)	
(9 marks)			
Notes			
(a)	B1: correct explanation		
(b)	B1: correct modelling assumption		
(c)	M1: for setting up paired t-test with at least 5 correct differences consistent in direction M1: complete method for $\bar{d}$ and s_d or s_d^2 B1: Use of t-distribution for differences with both hypotheses correct in terms of μ / μ_d Allow $\mu_d < 0$ if candidate does test with negative test statistic M1: method for finding test statistic with their values A1: awrt ± 2.30 B1: correct critical ± 1.895 (or better) with compatible sign A1ft: drawing a correct inference in context Must be consistent with their CV and a standardised test statistic from t-distribution Must mention “percentage” and “words” or “psychologist’s claim” SC: If they have carried out a t-test for two independent samples they can potentially score: M0M0B0M1A0B1A1ft If they do follow this path, they can score: 3rd M1 for standardising with difference of their means and a pooled variance 2nd B1 for a CV of 1.761 A1ft for a correct contextual conclusion for their test statistic and 1.761		



Question	Scheme	Marks	AOs
6(a)	The samples are not independent	B1	3.5b
		(1)	
(b)	They should consider the birth weight, gender, or whether or not the lambs are premature. oe	B1 B1	2.4 2.4
		(2)	
(c)	Need the assumption that the underlying distribution of the difference between the weight gains must be normally distributed .	B1	2.4
		(1)	
(d)	Difference -0.9 0.5 0.8 0.2 0.8 0.3 0.1 -0.1	M1	3.1b
	$\bar{w} = 0.2125$ $s^2 = 0.3041...$ ($s = 0.551...$)	M1	1.1b
	Confidence interval : $0.2125 \pm t \times \sqrt{\frac{0.3041}{8}}$	M1	2.1
	$0.2125 \pm 2.998 \times \sqrt{\frac{0.3041}{8}}$	A1ft	1.1b
	$= (-0.37202..., 0.79702...) \text{ oe}$	A1	1.1b
		(5)	
(e)	$H_0 : \mu_w = 0.2$ $H_1 : \mu_w > 0.2$	B1	2.5
	200g = 0.2 kg is in the interval	M1	2.1
	There is no evidence that μ_w is greater than 0.2 oe	A1ft	2.2b
		(3)	
Total 12			
Notes			
(a)	B1	The idea that samples are not independent. Condone other irrelevant comments provided they do not contradict this.	
(b)	B1	For one suitable comment on twins being identical relating to selecting the sample. Condone start weight. Do not accept age / diets of the lambs	
	B1	For a second suitable comment.	
(c)	B1	Need the emboldened words.	
(d)	M1	attempting differences (at least 4 correct) implied by awrt 0.304 or 0.551 but not 0.2125	
	M1	attempt to find $\bar{w}$ and s or s^2 for their differences implied by 0.2125 and either awrt 0.304 or 0.551	
	M1	For using the correct formula their $\bar{w} \pm t \times \sqrt{\frac{\text{their } s^2}{8}}$ where $ t > 2$ all values need to be substituted in.	
	A1ft	for their $\bar{w} \pm$ awrt $2.998 \times \sqrt{\frac{\text{their } s^2}{8}}$ all values need to be substituted in	
	A1	dependent on all previous method marks (awrt -0.372, awrt 0.797)	
	SC	If they have carried out a CI for two independent samples allow 3 rd M for using their difference of their means and a pooled variance and A1ft using correct formula with awrt 2.624	
(e)	B1	For both hypotheses correct in terms of μ or μ_w Condone 200	
	M1	For changing 200 g to 0.2 kg (ignore units for this mark) and comparing to their CI	
	A1ft	Independent of hypotheses. Drawing a correct inference following through on their CI provided 0.2 is within their confidence interval, with no contradictory statements. Does not need to be in context. Accept “insufficient evidence to support the (researcher’s) belief”.	

