A Level Statistics

AQA Past Exam Questions

TOPIC: Hypothesis Testing
Two Way ANOVA

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have retrievable mathematical formulae stored in them.

Instructions

• Use **black** ink or ball-point pen.

• If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.

• **Fill in the boxes** at the top of this page with your name, centre number and candidate number.

• Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.

• Answer the questions ***on paper***

• You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

• Unless otherwise stated, statistical tests should be carried out at the 5% significance level.

• When a calculator is used, the answer should be given to three significant figures unless otherwise stated.

Information

• ***You may use the*** booklet 'Statistical Formulae and Tables'

• There are **8** questions in this question paper. The total mark for this paper is ***49***

• The marks for **each** question are shown in brackets – use this as a guide as to how much time to spend on each question.

Advice

• Read each question carefully before you start to answer it.

• Try to answer every question.

• Check your answers if you have time at the end.

• If you change your mind about an answer, cross it out and put your new answer and any working underneath.

• Check your answers if you have time at the end.

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Q	Solution	Marks	Total	Comments
5(a)(i)	A B C D E F G $T_A=13$ $T_B=33$ $T_C=45$ $T_D=16$ $T_E=18$ $T_F=21$ $T_G=17$ $n_A=3$ $n_B=3$ ..... $n_G=3$ T = 163 $\sum\sum x_{ij}^2 = 1705$ N = 21 Making $\sum \frac{T_j^2}{n_j} = \frac{73^2}{7} + \frac{54^2}{7} + \frac{36^2}{7} = 1363$ Tea Brands $\sum \frac{T_i^2}{n_i} = \frac{13^2}{3} + \frac{33^2}{3} + ... + \frac{17^2}{3} = 1531$ $SS_{makings} = 1363 - \frac{163^2}{21}$ $= 97.81$ $SS_{teas} = 1531 - \frac{163^2}{21}$ $= 265.81$ $SS_{Total} = 1705 - \frac{163^2}{21}$ $= 439.81$ | | SS | df | ms | | Makings | 97.81 | 2 | 48.91 | | Tea Brands | 265.81 | 6 | 44.30 | | Error | 76.19 | 12 | 6.35 | | Total | 439.81 | 20 | | M1ft M1ft M1ft M1ft m1ft		SS for makings attempt SS for teas attempt SS for total attempt Error SS ft (not –ve) Method for ms (not –ve) Condone only one correct or clear method seen ft
	H_O $\mu_{first} = \mu_{second} = \mu_{Third}$ H_1 at least 2 of the means differ $Ts = \frac{48.91}{6.35} = 7.70$ $F_{12}^{2} = 3.885 < 7.70$ Reject H_O . H_O $\mu_A = \mu_B = ... = \mu_G$ H_1 at least 2 of the means differ $= \frac{44.30}{6.35} = 6.98$ $F_{12}^{6} = 2.996 < 6.98$ Reject H_O .	B1 m1ft B1 A1dep m1ft B1 (A1)	Correct hypotheses seen once Method for F for makings cv correct 3.885 or p = 0.007 A1 dep ts/cv or p correct Method for F for teas cv correct 2.996 or p = 0.0022
	There is a significant difference between at least two of the making orders and between at least two of the brands	E1dep	**12**	A1 for Reject **for both** E1 In context for both dep A1 Might see in earlier conclusions
(ii)	First making is significantly preferred to the third making. Don't use a tea bag more than twice, preferably only once Brand C seems to be the favourite tea brand and Brand A the least favourite	E1 or E1 or E1	**2**	For any two relevant comments
(b)(i)	There is no interaction [between tea brand and making order.] One brand is not better/worse at particular making.	B1 E1		
(ii)	The population of ratings is normal and the ratings have a common variance	B1 E1	**4**	Normal and common variance Reference to context/ratings somewhere
(c)	H_o pop mean/median diff = 0 H_1 pop mean/median diff ≠ 0 Ranks | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | 9 | 2 | 5 | . | 1 | 3½ | 7 | 6 | 8 | 3½ | | 1 | 8 | 5 | | 9 | 6½ | 3 | 4 | 2 | 6½ | | - | + | - | | - | - | - | - | - | + | $T_- = 9 + 5 + 1 + 3½ + 7 + 6 + 8 = 39½$ $T_+ = 2 + 3½ = 5½$ ts $T_+ = 5½$ cv = 6 $T_+ < 6$ Reject H_0 There is a significant difference the brands – C preferred	M1 m1 A1 B1 E1dep	or μ_d, η_d used ranks – any effort totals of ranks +/- correct cv correct and correct comparison with lower ts in context ts and cv correct and hypotheses effort
			5	

Q	Solution	Marks	Total	Comments
5(a)(i)				
	O M R Tot A 42 29 19 90 B 37 33 24 94 C 24 29 18 71 D 25 22 13 60 Tot 128 113 74 315			
	$\Sigma x^2 = 9019$			
	Between Models SS $\left(\frac{90^2+94^2+71^2+60^2}{3}\right)-\frac{315^2}{12}=256.92$	M1		method between models SS
	Between Campers SS $\left(\frac{128^2+113^2+74^2}{4}\right)-\frac{315^2}{12}=388.5$	M1		method between campers SS
	Total SS $= 9019-\frac{315^2}{12}=750.25$	M1		method total SS
	Source / SS / DF / MS **Models** 256.92 3 85.64 **Campers** 388.50 2 194.25 **Error** 104.83 6 17.47 **Total** 750.25 11	M1 B1 m1		method Error SS df 3,2,6 MS - their df
	H_0: no difference between models $F = 85.64/17.47 = 4.90$	M1		method for F - their positive SS and df
	cv $F_{[3,6]}$ is 4.757 reject H_0 - not all models take same time to pitch on average	B1		4.757 and 5.143 (2dp)
	H_0: no difference between campers $F = 194.25/17.47 = 11.1$	A1√		conclusion - must be compared with upper tail of F
	cv $F_{[2,6]}$ is 5.143 reject H_0 - not all campers take same time to pitch a tent on average	M1		method for F - their positive SS and df
		A1		4.90 (4.85 - 4.95) and 11.1(11.0 to 11.2)
		A1√		conclusion- must be compared with upper
		A1√		with upper tail of F both conclusions in context – needs both previous A1√ marks
5(a)(ii)	D appears to take least time to pitch but this could be because it is always pitched last after practice on other models.	B1 E1		D CAO because always pitched last

	Solution	Marks	Total	Comments
5(b)	H_0 $\mu_{Run} = \mu_{Cycle} = \mu_{Swim}$ H_1 at least 2 of the means differ			
	$T_{Male} = 26.0$ $T_{Female} = 23.6$ $n_{Male} = 3$ $n_{Female} = 3$			
	$T_{Run} = 14.7$ $T_{Cycle} = 17.5$ $T_{Swim} = 17.4$ $n_{Run} = 2$ $n_{Cycle} = 2$ $n_{Swim} = 2$			
	$T = 49.6$ $\sum\sum x_{ij}^2 = 413.78$ $N = 6$			
	Total SS $413.78 - \frac{49.6^2}{6} = 3.753$	M1		Total SS method (can be implied in table)
	Sex SS $\frac{26.0^2}{3} + \frac{23.6^2}{3} - \frac{49.6^2}{6} = 0.96$	M1		Sex SS method
	Sport SS $\frac{14.7^2}{2} + \frac{17.5^2}{2} + \frac{17.4^2}{2} - \frac{49.6^2}{6} = 2.523$	M1		Sport SS method
		M1		Error SS ft (not –ve)
		B1		Error df correct $\upsilon = 2$
		m1		Method for MS ft (dep SSe)
		m1		Method (dep prev Ms) for F (sex/error or sport/error) Not –ve
	$F = \frac{1.26}{0.135} = 9.35$ $F_{2}^{2} = 19.0$	A1		Sports F correct 9.2–9.5
	$9.35 < 19$ Accept H_0	B1		cv correct CAO or $p = 0.117$
	There is no significant evidence of a difference in mean training times for the the 3 sports.	E1	10	Correct conclusion in context, ft small arithmetic error in F
	Total		**22**	

	SS	df	MS
Sex	0.96	1	0.96
Sport	2.523	2	1.26
Error	0.27	2	0.135
Total	3.753	5	

(b)

source	SS	DF	MS
alcohol	9348	2	4674
weights	7980	3	2660
residual	3214	6	535.67
total	20542	11	

	B1		2, 3, 6 df
	M1		method for all MS (including method for residual SS), their df
H_0: no difference between amounts of alcohol			
$F = \frac{4674}{535.67} = 8.73$	m1		method for F (either) – their figures
reject H_0: significant evidence differences in mean times to do Sudoku between groups drinking different amounts of alcohol			
H_0: no difference between weights			
$F = \frac{2660}{535.67} = 4.97$	A1		$8.73(8.72\sim8.73)$ and $4.97(4.96\sim4.97)$
c.v. $F_{[3,6]} = 4.757$	B1		$5.143(5.14\sim5.15)$ and $4.757(4.75\sim4.76)$
reject H_0: significant evidence differences in mean times to do Sudoku between groups of different weights	A1√	6	both conclusions – their figures – must be compared with upper tail of F