OXFORDAQA

INTERNATIONAL QUALIFICATIONS

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	I declare this is my own work.

INTERNATIONAL A-LEVEL FURTHER MATHEMATICS

(9665/FM04) Unit FS2 Statistics

Thursday 16 January 2025 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

- For this paper you must have the OxfordAQA Booklet of Formulae and Statistical Tables (enclosed).
- You may use a graphical calculator.

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer all questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- Show all necessary working; otherwise marks may be lost.



For Exam	iner's Use
Question	Mark
1	
2	
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8	
TOTAL	



			Answe	er all questions in the	spaces provided.	
1		A researd soft drink	cher asks a ra and their pre	ndom sample of 500 ferred brand of biscui	customers to name th ts.	neir preferred brand of
		Some of	the researche	r's values are shown	in the table below.	
				Preferre	d biscuits	
				Brand X	Brand Y	Total
			Brand A	84		160
		Preferred soft drink	Brand B	56	120	
			Brand C			
			Total	220		500
1	(b)	The research brand of s Test the r	archer claims soft drink and researcher's c	that there is an assoc the preferred brand o laim using the 0.5%	ciation between the cus of biscuits. level of significance	stomers' preferred [7 marks]



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2
 A random sample of size 12 is taken from a normal distribution with unknown population mean
$$\mu_1$$
 and known population variance σ_1^2
 This random sample has sample mean 90.2

 A random sample also of size 12 is taken from a different normal distribution with unknown population mean μ_2 and known population variance σ_2^2
 This random sample has sample mean 89.8

 The two normal distributions are independent.
 A hypothesis test is carried out with the hypotheses

 $H_0: \mu_1 = \mu_2$
 $H_1: \mu_1 = \mu_2$
 $H_1: \mu_1 = \mu_2$
 The value of the test statistic is $\frac{4\sqrt{5}}{5}$

 2 (a)
 Show that $\sigma_1^2 + \sigma_2^2 = \frac{3}{5}$

 [3 marks]
 [3 marks]



2	(b)	It is given that $\sigma_1 = 4\sigma_2$	Do not write outside the box
		Find the value of σ_1^2 and the value of σ_2^2 [3 marks]	
		$\sigma_1^2 = $ $\sigma_2^2 = $	
2	(c)	The hypothesis test used the 10% level of significance.	
		Determine the outcome of the test. [3 marks]	
			9



A company employs 8 members of staff to sell its cars.

3

The company has recently changed the layout of its car showroom.

6

Before the layout change, a week is chosen at random and the total sales, in thousands of dollars, made by each member of staff is recorded.

After the layout change, a week is chosen at random and the total sales, in thousands of dollars, made by each member of staff is recorded.

The results are summarised in the following table.

	Total sales (thou	sands of dollars)
Member of staff	Before layout change	After layout change
А	115	121
В	94	92
С	101	105
D	89	91
E	48	53
F	104	101
G	68	68
Н	92	97

The company claims that total sales per member of staff have increased following the layout change.

3 (a) State a necessary assumption for a hypothesis test using the *t*-distribution to test the company's claim to be carried out.

[1 mark]

3	(b)	Test the company's claim using the 5% level of significance.	Do not write outside the box
		[9 marks]	
			10





4	The score obtained by players in a game is known to have a normal distribution
	A random sample of n players is taken where $5 < n < 10$
	The unbiased estimator of the population variance is calculated using the sample and found to be $s^2 = 151.29$
	A 95% confidence interval for the population mean score is calculated using the sample.
	The width of the confidence interval is 20.6 correct to three significant figures.
(a)	Find the value of <i>n</i>
	Fully justify your answer. [3 marks]



4 (b)	The complement entry of the completie EE 7 points	Do not writ outside the
4 (D)	Find the OS ⁽) confidence interval for the nervelation mean scene	DOX
	Find the 95% confidence interval for the population mean score.	
	Give your values to three significant figures. [1 mark]	
	Answer	
4 (c)	A player obtains a score of 40 in the game.	
	The player claims that their score is equal to the population mean score.	
	Explain whether the confidence interval found in part (b) supports the player's claim	
	[1 mark]	
		<u> </u>
		5
	Turn over for the next question	

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ultiple-choice section are independent of istribution.	

5	An exam has a multiple-choice section.
	The total marks that students obtain on the multiple-choice each other and are known to have a normal distribution.

A random sample of 41 students is taken and their total marks on the multiple-choice section are recorded.

The unbiased estimator of the population variance for the total marks on the multiple-choice section is calculated using the sample and found to be 25.4

A hypothesis test is carried out to test the claim that the population standard deviation is different from k where k is a positive constant.

The hypothesis test is carried out at the 5% level of significance and the null hypothesis is not rejected.

5 (a) Find the range of possible values of k

Give your values to three significant figures.

[5 marks]

Answer



5 (b) The exam also has a written response section.

The total marks that students obtain on the written response section are independent of each other and are known to have a normal distribution.

The total marks that students obtain on the multiple choice and written response sections are independent.

A random sample of 11 students is taken and their total marks on the written response section are recorded.

The unbiased estimator of the population variance for the total marks on the written response section is calculated using the sample and found to be 66.1

It is claimed that the population variance of the total marks on the written response section is greater than the population variance of the total marks on the multiple-choice section.

Use both random samples to test the claim at the 1% level of significance.

[6 marks]

Turn over ►



	Customers who have bought a particular product can use an online chat service if they need support.
	The time T minutes between one customer starting to use the online chat service and
	the next customer is modelled by a random variable with mean $\frac{m}{2}$ and variance $\frac{m^2}{12}$
	T_1 , T_2 ,, T_n are <i>n</i> independent observations of <i>T</i> where $n > 2$
	The random variable X is given by $X = \sum_{i=1}^{n} T_i$
(a)	Show that X is a biased estimator of m
(b)	It is given that kX is an unbiased estimator of m where k is a constant.
(b)	It is given that kX is an unbiased estimator of m where k is a constant. Find k in terms of n
(b)	It is given that kX is an unbiased estimator of m where k is a constant. Find k in terms of n [2 marks
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(b)	It is given that kX is an unbiased estimator of m where k is a constant. Find k in terms of n [2 marks
(b)	It is given that <i>kX</i> is an unbiased estimator of <i>m</i> where <i>k</i> is a constant. Find <i>k</i> in terms of <i>n</i> [2 marks



6 (d) Sana measures the time in minutes between one customer using the online chat service and the next customer on 5 random occasions. Her results are 0.5 1.2 1.5 3.2 7.1 She uses her data and the unbiased estimator kX to calculate an estimate for m [2 marks]	6 (c)	Use your express consistent estima	sion for <i>k</i> in te	erms of <i>n</i> from	n part (b) to de	etermine wheth	ier <i>kX</i> is a [3 marks]
Her results are 0.5 1.2 1.5 3.2 7.1 She uses her data and the unbiased estimator kX to calculate an estimate for m Find Sana's estimate for m [2 marks]	6 (d)	Sana measures and the next cus	the time in min	nutes between o	one customer u	using the online	e chat service
She uses her data and the unbiased estimator <i>kX</i> to calculate an estimate for <i>m</i> Find Sana's estimate for <i>m</i> [2 marks] Answer		Her results are	12	15	32	7 1	
Find Sana's estimate for m [2 marks]		She uses her da	ta and the unb	iased estimato	kX to calcula	ate an estimate	e for m
Answer		Find Sana's estir	mate for <i>m</i>				[2 marks]
				Answer			



The daily maximum height of river *A* has population mean μ_A cm and a known population standard deviation of 3.04 cm

The daily maximum height of river *B* has population mean μ_B cm and a known population standard deviation of 2.09 cm

Random samples of the daily maximum heights are taken for both rivers and the results are shown in the following table

River	Sample size	Sample mean (cm)
А	478	$\overline{x}_{A} = 18.3$
В	437	$\overline{x}_{B} = 17.9$

It is claimed that the population means of the daily maximum heights in cm of the two rivers μ_A and μ_B are different.

7 (a) Test the claim using the 2% level of significance.

7

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7	(b)	The daily maximum heights of the two rivers are not normally distributed.	Do not write outside the box
		Explain why the test carried out in part (a) is valid.	
		[1 mark]	
7	(c)	The hypothesis test in part (a) is repeated using random samples of the same sizes as in part (a) .	
		It is given that $\mu_A - \mu_B = 0.2$	
7	(c) (i)	Find the probability that a Type II error is made.	
		Answer	
7	(c) (ii)	Find the power of the test.	
		[1 mark]	
			13



8 The random variable X has moment generating function $M_X(t)$ where	
$\mathbf{M}_{X}(t) = \frac{\mathrm{e}^{pt}}{1 - qt^{2}} \text{for} \left t\right < \frac{1}{\sqrt{q}}$	
where p and q are constants.	
It is given that the mean of X is 0 and the variance of X is $\frac{1}{2}$	
8 (a) (i) Show that the value of p is 0	[3 marks]
8 (a) (ii) Find the value of <i>q</i>	[4 marks]







8	(b) (ii)	The random variable B has an exponential distribution with parameter λ	outside the box
		A and B are independent.	
		Write down the moment generating function $M_{-B}(t)$ of $-B$	
		[1 mark]	
		Answer	
8	(b) (iii)	The random variable $A - B$ has the same distribution as X	
		Find the value of λ	
		Answer	15
		END OF QUESTIONS	



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